Cultivar Mulato

(Brachiaria hybrid CIAT 36061)

A high-yielding, high-quality forage grass for the tropics

Pedro J. Argel, John W. Miles,
Jorge D. Guiot and Carlos E. Lascano

grupo papalotla

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

The International Center for Tropical Agriculture (CIAT) is a not-for-profit organization that conducts socially and environmentally progressive research aimed at reducing hunger and poverty and preserving natural resources in developing countries. CIAT is one of the 15 centers funded mainly by the 58 countries, private foundations, and international organizations that make up the Consultative Group on International Agricultural Research (CGIAR).

CIAT also receives funds for research and development services provided under contract to a growing number of institutional clients.

Information and conclusions reported in this document do not necessarily reflect the position of any donor agency.

Cultivar Mulato

(*Brachiaria* hybrid CIAT 36061)

A high-yielding, high-quality forage grass for the tropics

Pedro J. Argel, John W. Miles,
Jorge D. Guiot, and Carlos E. Lascano

grupo papalotla

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

Argel, Pedro J.

Cultivar Mulato (*Brachiaria* hybrid CIAT 36061): A high-yielding, high-quality forage grass for the tropics/Pedro J. Argel, John W. Miles, Jorge D. Guiot, and Carlos E. Lascano – Cali, CO : International Center for Tropical Agricultural (CIAT), 2006.

24 p.

AGROVOC Descriptors:

1. *Brachiaria*. 2. *Brachiaria ruziziensis*. 3. *Brachiaria brizantha*. 4. High yielding varieties. 5. Hybrids. 6. Feed grasses. 7. Genetic stability. 8. Adaptation. 9. Nutritive value. 10. Plant breeding. 11. Acid soils. 12. Drought resistance. 13. Pest resistance. 14. Disease resistance. 15. Crop yield. 16. Fertilizer application. 17. Animal production. 18. Crop management. 19. Colombia. 20. Central America. 21. Mexico. 22. Philippines.

Local Descriptors
1. Forage

AGRIS Subject Categories: F30. Plant genetics and breeding.

Descriptores AGROVOC:

1. *Brachiaria*. 2. *Brachiaria ruziziensis*. 3. *Brachiaria brizantha*. 4. Variedades de alto rendimiento. 5. Híbridos. 6. Gramíneas forrajeras. 7. Estabilidad genética. 8. Adaptación. 9. Valor nutritivo. 10. Fitomejoramiento. 11. Suelo ácido. 12. Resistencia a la sequía. 13. Resistencia a plagas. 14. Resistencia a enfermedades. 15. Rendimiento de cultivos. 16. Aplicación de abonos. 17. Producción animal. 18. Manejo del cultivo. 19. Colombia. 20. América Central. 21. México. 22. Filipinas

Descriptores Locales
1. Forrajes

Categoría de Materia AGRIS: F30 Genética vegetal y Fitomejoramiento.

I. Miles, John W. II. Guiot, Jorge D. III. Lascano, Carlos E. IV. Tit.

Contents

Page

Resumen 1

Summary 2

Introduction 3

Origin 4

Morphological Description 5

Forage Adaptation and Production 7

Establishment 9

Response to Fertilization 13

Tolerance to Pests and Diseases 14

Production and Seed Quality 15

Forage Quality 16

Animal Production 17

Use and Management 19

Attributes of Mulato Compared with Those of Other *Brachiaria* Cultivars 22

References 22

Acknowledgments 24

GRUPO PAPALOTLA

PAPALOTLA HYBRIDS

Papalotla Group is determined to be at the forefront of tropical agricultural research and is financing the research of new solutions to today's problems.

Through our strategic alliance with the International Center for Tropical Agriculture (CIAT) we are guaranteeing our access to tomorrow's hybrids under Plant Variety Protection (PVP).

- Mulato I (CIAT 36061) and Mulato II (CIAT 36087), as well as the hybrids we will multiply in coming years as part of the agreement with CIAT, are the product of nearly 20 years of genetic improvement research in *Brachiaria* carried out by CIAT.

- Since 2000 we have continuously validated and multiplied Mulato and Mulato II. Each one of these Papalotla hybrids is backed up with five years of ongoing evaluation.

- We have conducted multi-regional trials on different continents to ensure not only the quality of our hybrids, but also their adaptation and response to different climates and soil types.

Resumen

El *Brachiaria* híbrido cultivar (cv.) Mulato (CIAT 36061) es el primer híbrido comercial obtenido por el Proyecto de Forrajes Tropicales del Centro Internacional de Agricultura Tropical (CIAT). A partir de 1988, el cultivar se desarrolló a partir de cruces realizados en la sede principal de dicha institución en Cali, Colombia, entre el clon sexual tetraploidizado 44-6 de *B. ruziziensis* y la especie tetraploide *B. brizantha* CIAT 6294 (= CIAT 6780), que corresponde al cv. Marandú en Brasil, cv. Insurgente en México y al cv. Diamantes 1 en Costa Rica. A partir de 2000 el CIAT cedió derechos exclusivos de multiplicación y comercialización de semillas de este híbrido a la compañía Semillas Papalotla S. A. de México, manteniendo los derechos de obtentor del mismo. El cv. Mulato es una gramínea perenne de naturaleza apomíctica, lo que significa que es estable genéticamente. Evaluaciones agronómicas de adaptación, iniciadas a partir de 1994 en varios sitios de Colombia y otros países del trópico, lo describen como una planta de crecimiento semi-erecto que produce tallos cilíndricos vigorosos, algunos con hábito semi-decumbente capaces de enraizar en los nudos cuando entran en estrecho contacto con el suelo; hojas lanceoladas con alta pubescencia y espiga terminal de 40 a 60 cm de longitud. Los resultados de varias pruebas de adaptación han mostrado buen crecimiento del cv. Mulato desde el nivel del mar hasta los 1800 m.s.n.m. Esta gramínea crece bien en el trópico húmedo, con altas precipitaciones y períodos secos cortos, y en condiciones subhúmedas con 5 a 6 meses secos y precipitaciones anuales mayores de 700 mm. También se reporta buen crecimiento del pasto en condiciones subtropicales como las de Florida en los Estados Unidos, donde ocurren heladas periódicas. El pasto crece bien en suelos ácidos (pH 4.2) y también en alcalinos (pH 8.0), siempre y cuando sean de mediana a buena fertilidad y bien drenados. El cv. Mulato no sobrevive en suelos pesados con pobre drenaje interno o que se inunden periódicamente. La manera más práctica para establecer la gramínea es con semilla, aunque la propagación vegetativa es viable sobre todo si se escogen para siembra cepas enraizadas. El cv. Mulato tiene floración abundante y muy sincronizada, pero el llenado de espiguillas es bajo, lo cual se traduce en rendimientos pobres de semilla (entre 100 y 150 kg/ha de semilla pura en el mejor de los casos). La producción de forraje del cv. Mulato varía con las características del sitio, pero puede oscilar entre 10 y 25 t de MS/ha por año. Entre 17% y 20% de este rendimiento se puede producir durante el período seco. La gramínea no tiene resistencia antibiótica al salivazo, mión de los pastos, mosca pinta o baba de culebra (Homoptera: Cercopidae), pero hasta la fecha ha mostrado alta tolerancia a algunas especies del insecto en condiciones de campo, tales como *Aeneolamia varia*, *Zulia carbonaria*, *Z. pubescens* y *Mahanarva trifissa*, aunque altas poblaciones de adultos y ninfas del insecto pueden causar mortalidad de plantas. El cv. Mulato es susceptible al añublo foliar causado por el hongo *Rhizoctonia solani* en zonas humedas, aunque hasta la fecha no se ha realizado una evaluación económica sobre los efectos del

daño, el cual tiende a disminuir en potreros bajo pastoreo. En condiciones similares de crecimiento, el cv. Mulato produce mayor forraje que otros cultivares conocidos de *Brachiaria*, particularmente cuando se cosecha con 28 días de rebrote. La calidad forrajera del cv. Mulato es alta comparada con otras gramíneas tropicales. Se han reportado valores de proteína cruda entre 9% y 16% y digestibilidad in vitro entre 55% y 62% para el cv. Mulato en rebrotes de 25 a 30 días en la época de lluvias. Bajo pastoreo el consumo de forraje (bovinos) es alto, lo cual se traduce en producciones significativamente mayores de leche en condiciones similares de uso, en relación con otros cultivares de *Brachiaria* como Toledo y Basilisk. Por su alta producción de forraje, el cv. Mulato permite mayor carga animal. También ha sido exitoso el ensilaje de la gramínea así como la producción de heno y henolaje. De este último se reportan rendimientos de 48 silopacas/ha de 600 kg cada una para un pasto fertilizado y con 30 días de rebrote.

Summary

Cultivar (cv.) Mulato (CIAT 36061) is the first commercial hybrid of *Brachiaria* obtained by the Forage Project of the Centro Internacional de Agricultura Tropical (CIAT) in Cali, Colombia. It originated from crosses initiated in 1988 between the sexual tetraploidized clone 44-6 of *B. ruziziensis* and the tetraploid apomictic *B. brizantha* CIAT 6294 (= CIAT 6780), which corresponds to the cv. Marandú in Brazil, cv. Insurgente in Mexico and cv. Diamantes 1 in Costa Rica. Since the year 2000, CIAT granted to the Mexican seed company Semillas Papalotla S.A. exclusive rights for seed multiplication and commercialization of this hybrid while maintaining the intellectual property rights of the hybrid. Cultivar Mulato is a semi-erect perennial apomictic grass, which means that it is genetically stable. Agronomic studies initiated in 1994 at several locations in Colombia and other countries of the tropics showed that plants of cv. Mulato produce vigorous cylindrical stems, some with a semi-prostrate habit, capable of rooting at the nodes when they come into close contact with the ground. Plants have lanceolate and highly pubescent leaves, and terminal spikes of 40 to 60 cm long. Results on adaptation evaluations showed a good growth of cv. Mulato from sea level to 1800 m.a.s.l. The hybrid performs well in humid tropics with high rainfalls and short dry periods, and in sub-humid conditions with 5 to 6 dry months and annual rainfalls above 700 mm. Also, it has been reported that cv. Mulato grows well in subtropical conditions where periodical frosts occurs, such as Florida in the United States. The grass grows well in acid soils (pH 4.2) as well as in alkaline soils (pH 8.0), but with medium to high fertility and good drainage. Cultivar Mulato doesn't survive in heavy soils with poor internal drainage, or soils that flood periodically. The most practical method to establish the grass is by seed, although vegetative propagation is also viable, particularly if rooted stems are selected for planting. Cultivar Mulato has profuse and well-synchronized flowering, but caryopsis formation is poor.

which leads to poor seed yield (between 100 and 150 kg/ha of pure seed in the best cases). Forage yield depends on site characteristics, but it can vary from 10 to 25 t DM/ha per year; between 17% to 20% of this yield may be produced during the dry period. The grass does not have antibiotic resistance to spittle bug insects (Homoptera: Cecopidae), but up to now the cv. Mulato has shown tolerance to some species of this insect under field conditions, such as *Aeneolamia varia*, *Zulia carbonaria*, *Z. pubescens*, and *Mahanarva trifissa*, although high adult and nymph populations of the insect may cause plant mortality. The grass in humid areas is susceptible to foliar blight caused by *Rhizoctonia solani* fungus but the damage decreases in paddocks under grazing. The economical significance of losses in forage yield due to the disease has not been determined. In similar growing conditions cv. Mulato yields more forage than other known *Brachiaria* cultivars, particularly when harvested with 28 days of re-growth. Forage quality of cv. Mulato is good and crude protein values range between 9% and 16%, and in vitro digestibility between 55% and 62% for forage of 25 to 30 days re-growth during the wet period. Animal intake (bovine) of the grass is high, which results in significantly greater milk production compared with other *Brachiaria* cultivars such as Toledo and Basilisk. Similarly, the high forage production of cv. Mulato allows more carrying capacity than other grasses. Also, silage making of the grass has been successful, as well as the production of hay.

Introduction

One of the challenges faced by tropical forage researchers is the search for highly nutritious species with outstanding agronomic characteristics that not only respond well to the diversity of landscapes found in cattle-raising regions, which cover a range of climates and soils, but also show resistance to common pests and diseases that affect grasses and cause losses in these pastures.

Over the last decades, the cultivars of *Brachiaria* spp., which are native to Africa, have dominated the available tropical forage species, allowing the incorporation of extensive areas into livestock production, including areas previously considered marginal because of their poor soils. Current commercial cultivars of *Brachiaria* belong to four well-known species: *B. brizantha* (cv. Marandu, Toledo, and La Libertad), *B. decumbens* (cv. Basilisk), *B. humidicola*, formerly *B. dictyoneura* (cv. Humidicola and Llanero), and *B. ruziziensis* (cv. Kennedy). Except for cv. Kennedy, which is a sexual diploid (as are all natural *B. ruziziensis*), the other cultivars are polyploid apomicts, which give them genetic stability. In the past, however, these traits have been obstacles to genetic crossbreeding. In the early 1980s, the Catholic University of Louvain (Belgium) developed an artificial tetraploid biotype of *B. ruziziensis*, making it possible to launch hybridization and genetic improvement programs between related species of *Brachiaria* (Swenne et al., 1981; Ndikumana, 1985).

Brachiaria hybrid cv. Mulato (CIAT 36061) is the first commercial hybrid developed by the Tropical Forages Project of the International Center for Tropical Agriculture (CIAT, its Spanish acronym), headquartered in Cali, Colombia. This cultivar is well adapted to a broad range of localities and presents high forage yield, good forage quality, and ease of establishment by seed.

CIAT granted the Mexican company Semillas Papalotla S.A. de C.V. the right to multiply and market cultivar Mulato, but CIAT retain its rights of obtentor.

Origin

Mulato is a hybrid of the genus *Brachiaria* and apomictic, which means that even though it's a hybrid, it is genetically stable and, as a result, does not segregate from one generation to the next. The cultivar originated from crosses performed in 1988 at CIAT between the sexual clone 44-6 of *Brachiaria ruziziensis*[1] and the apomictic tetraploid species *B. brizantha* CIAT 6294 (= CIAT 6780), which corresponds to cv. Diamantes 1 in Costa Rica, cv. Marandú in Brazil, and cv. Insurgente in Mexico. These crossings produced eight first-generation clones, including clone 625-06, which was identified as sexual by embryo-sac analysis (Miles, 1999).

In 1991 clone 625-06 was included as female parent in new crosses carried out by open pollination in a recombination block that contained apomictic accessions as well as sexual and apomictic *Brachiaria* hybrids (Miles, 1999). Six progenies resulted from these crosses, one of which was identified as clone FM9201/1873 and subsequently established for study in 1993 in Montañita (Caquetá, Colombia) on the La Rueda Farm of the Livestock Fund of Valle del Cauca.

The morphological uniformity observed among plants of this progeny indicated apomictic reproduction. Since then, this clone has been included in agronomic trials to evaluate its adaptation and productivity.

The first field results obtained in 1994 indicated that FM9201/1873 was promising in the Colombian localities of Carimagua, Caquetá, and in Villavicencio, at the La Libertad Research Center, which belongs to the Colombian Corporation for Agricultural Research (CORPOICA). From 1996 to 1998, the FM9201/1873 clone was evaluated with 19 other *Brachiaria* accessions and hybrids at 13 different sites across Colombia, through the Colombian *Brachiaria* Evaluation Network which was financed by the Colombian Federation of Livestock Producers, FEDEGAN, with the

[1] A tetraploid biotype developed at the Catholic University of Louvain (Belgium) and introduced to CIAT in 1988 by Dr. C. B. do Valle from CNPGC/EMBRAPA (Brazil).

participation of CORPOICA and other Colombian public and private entities (CIAT, 1999).

In 1996, experimental seed of clone FM9201/1873 was sent to several Central American countries, as well as to the Philippines, China, and Mexico, to evaluate its adaptation. It was introduced to Costa Rica in 1997 and the first plots were established at the headquarters of the Central American School of Animal Husbandry (ECAG) located in Balsa de Atenas, under the umbrella of the Collaborative Agreement between the Ministry of Agriculture and Livestock (MAG), the Tropical Agricultural Research and Higher Education Center (CATIE), the ECAG, and CIAT's former Tropical Forages Project.

Using CIAT's germplasm classification system, this clone was later identified as accession *Brachiaria* hybrid CIAT 36061. In 2000, CIAT granted the Mexican company Semillas Papalotla S.A. de C.V. exclusive rights to multiply and market the aforementioned hybrid. The company released the accession under the cultivar name Mulato. The hybrid has already been registered in several countries of Central America, especially Panama, as well as Australia, the United States, Ecuador, Brazil, Mexico, and Thailand. It is in process of registration in others.

Figure 1 shows, in a simplified manner, the process of crosses and screenings that led to the identification and subsequent evaluation of Mulato. Because the hybrids come from a sexual female parent (*B. ruziziensis*) and an apomictic male parent (*B. brizantha*), hybrid generations are either sexual (segregating) or apomictic. However, towards the end of the evaluation and screening process, only apomictic progenies are advanced in order to guarantee their genetic stability. Promising sexual hybrids are used in open recombination schemes to establish desirable agronomic characteristics, but eliminated from the agronomic screening process to release potential cultivars.

Morphological Description

Cultivar Mulato is a perennial grass with initial tufted growth habit. It reaches heights up to 1.0 m or more, produces vigorous, cylindrical stems, some with semi-decumbent habit, and is capable of rooting at the nodes when these stems come into close contact with the soil either because of the effect of animal trampling or because of mechanical compaction, which favors full soil coverage in paddocks under grazing (Photo 1). Its highly pubescent, lanceolate leaves are up to 40 cm long and between 2.5-3.5 cm wide (Guiot and Meléndez, 2003a). Its inflorescence is a panicle 30 to 40 cm long, usually with 3 to 8 racemes, each with a double row of spikelets that are 2.4 mm wide and 6.2 mm long, with dark red stigmas at anthesis (Loch and Miles, 2002). Each stem produces a terminal inflorescence,

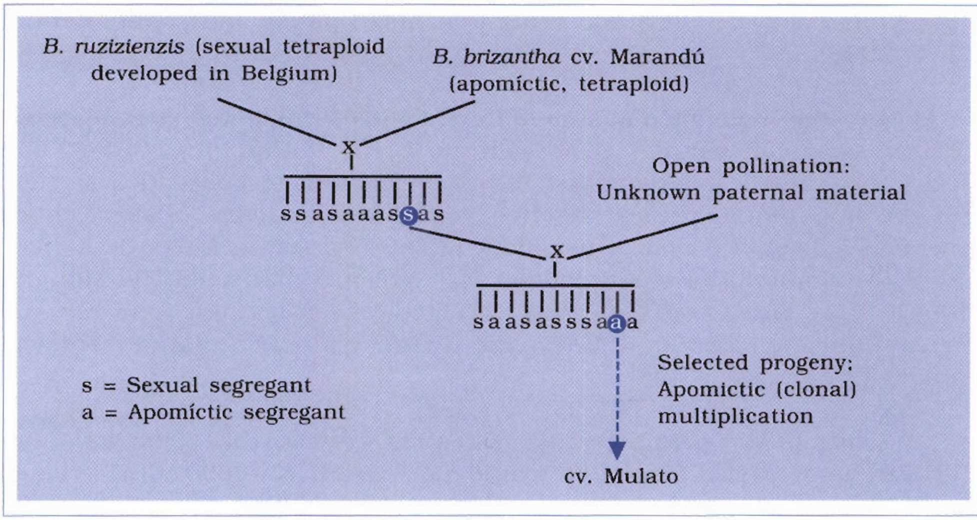

Figure 1. Simplified sequence of crosses between *Brachiaria* species and selected sexual and apomictic hybrids that produced cultivar Mulato.
SOURCE: Miles (1999).

although a second spikelet has been observed to emerge from intermediate nodes on the same stem, especially when the main panicle has been severed.

Photo 1. Forty-day-old Mulato plant (insert) and complete soil cover in a paddock after more than one year of grazing in Huimanguillo, Mexico.
SOURCE: Jorge Guiot

One of the most outstanding characteristics of this plant is its profuse tillering—up to 30 tillers at 2.4 months after establishment—which begins a few weeks after plant emergence and proves advantageous during establishment, especially at sites with high weed incidence (Pinzón and Santamaría, 2005a).

Forage Adaptation and Production

Cultivar Mulato grows well from sea level up to 1800 m above sea level (m.a.s.l.) in the humid tropics, characterized by abundant precipitation and short dry periods, and in subhumid conditions, with 5-6 dry months and an annual precipitation above 700 mm. Reports, however, indicate that Mulato grew poorly at sites in Chiriqui, Panama, located at 700 m.a.s.l., but with high moisture and high cloudiness (B. Pinzón, personal communication). Reduced light intensity apparently affects plant development.

Good growth of cv. Mulato is also reported under subtropical conditions, such as those of Florida in the United States and Torreón in Mexico, where the grass normally recovers after sporadic frosts. The grass grows well in acid (pH 4.2) to alkaline soils (pH 8.0), if well drained and of intermediate to high fertility. Cultivar Mulato does not survive in heavy soils with poor internal drainage or soils that are periodically flooded.

Mulato's tolerance to soil acidity is less than that reported for *B. decumbens* Basilisk[2], but is higher than that observed for *B. brizantha* Marandú, one of the parental materials of this hybrid. Figure 2 shows that, under greenhouse conditions, total root growth of Mulato is intermediate between that of the two *Brachiaria* cultivars, with nearly 9 m/plant in a non-acid solution (without Al) and 5 m/plant in an acid medium (pH 4.2) containing Al. The extrapolation of this condition to the natural environment explains why the productivity and persistence of Mulato are limited in the poor, acid soils, with high Al content, found in many cattle-raising areas of the tropics. Furthermore, Mulato's superior root system in absence of Al explains the cultivar's tolerance to drought.

Like other grasses, the forage yields of Mulato depend on soil fertility and drainage, local climatic conditions, and pest and disease incidence. Results of several trials indicate that yields range between 10 and 25 t dry matter (DM)/hectare per year. Higher yields are obtained at sites with deep, fertile, loam soils without drainage problems, especially when the pasture is fertilized. For example, Cuadrado et al. (2005) reported yields of 18.1 t DM/hectare per year for Mulato in alluvial soils without fertilization (pH 5.3, 5.9% organic matter (OM), 25.8 ppm P), in Cereté, Colombia, whereas

[2] *B. decumbens* cv. Basilisk is also known as 'pasto peludo' in Costa Rica, Señal in Panama, and Chontalpo in Mexico.

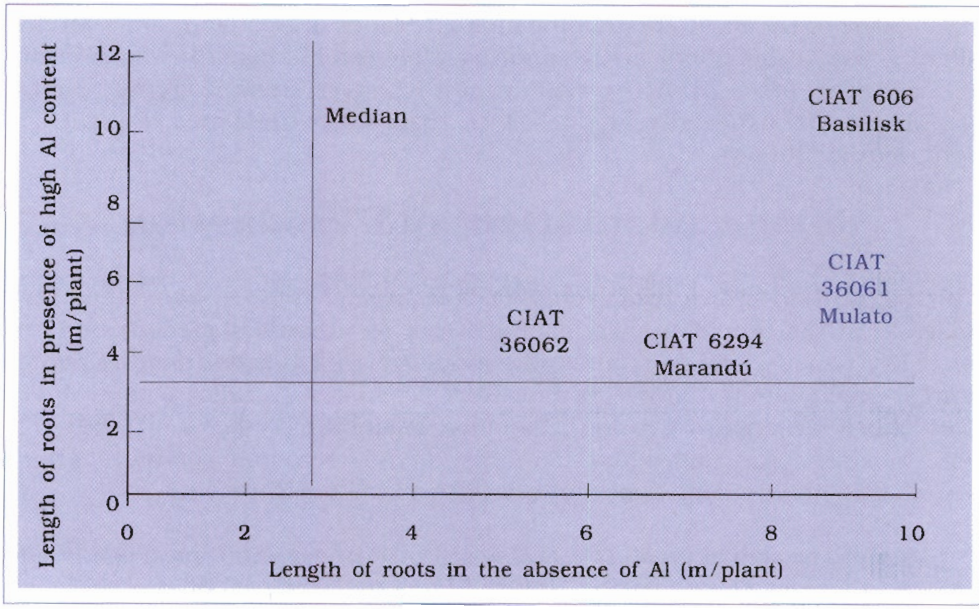

Figure 2. Length of roots of *Brachiaria* species and hybrids grown in nutritive solutions without or with high Al content, 21 days after planting. Solutions contained 0 or 200 µM of $AlCl_3$ with 200 µM of $CaCl_2$ (pH 4.2).
SOURCE: Adapted from CIAT (2001).

Pinzón and Santamaría (2005a) recorded yields of 20.1 t DM/hectare per year for the same grass in an acid Inceptisol (pH 4.5, 3.8% OM, 2.0 ppm P) at Gualaca, Panama, that had been fertilized. At Atenas, Costa Rica, in a medium-fertility Inceptisol (pH 5.9, 7.6% OM, 3.6 ppm P), but with 5-6 dry months, Mulato yielded 13.6 t DM/hectare per year (Argel and Pérez, 2003). Similar or higher yields have been reported in Mexico (Guiot and Meléndez, 2003a) and elsewhere in Colombia (CIAT, 1999).

One of the most desirable characteristics of Mulato is its tolerance to prolonged periods of drought and its regrowth capacity and forage-on-offer (green) during this critical time of the year. According to estimates, this grass produces between 17% and 20% of its total forage yield during the dry season, obviously depending on local climatic characteristics. Forage production therefore tends to be less seasonal than that of other *Brachiaria* cultivars, owing to its deep rooting in absence of Al, high content of nonstructural carbohydrates in leaves (152 mg/kg) and stems (161 mg/kg), and low ash levels in leaf tissue (CIAT, 1999).

In similar growth conditions, Mulato has shown a clear trend to higher forage yields than other tropical grasses. Table 1 indicates that, at three different sites in Honduras with a similar precipitation of 1000 mm/year, Mulato significantly ($P<0.05$) surpassed the yields of *Panicum maximum* (Tobiatã) and *Digitaria eriantha* (Transvala), expressed in g DM/m²

Table 1. Average production of Tobiatã (*Panicum maximum*), Transvala (*Digitaria eriantha*) and Mulato (*Brachiaria* hybrid) grasses at three different sites in Honduras.

Cultivar	Site	Altitude (m.a.s.l.)	Average temperature (ºC)	g DM/m² per day
Mulato	Choluteca	25	29.0	**28.1 a***
Tobiatã				22.2 b
Transvala				18.3 c
Mulato	El Zamorano	800	24.0	**15.1 d**
Tobiatã				12.6 d.e
Transvala				12.3 a
Mulato	Uyuca	1650	18.4	**9.6 f**
Transvala				7.7 fg
Tobiatã				5.8 g

* Means in the column followed by the same letter do not differ (P<0.05) according to the standard error test.
SOURCE: Adapted from Estrada (2004).

per day. It is also clear that yields tend to be lower with increasing altitude above sea level at the different sites and lower mean temperature (from 29ºC to 18.4ºC). But even under average temperature conditions as in Uyuca, Mulato outyields grasses such as Tobiatã guineagrass, which is characterized as being a vigorous high-yielding forage species (Estrada, 2004).

Cutting height and frequency can also affect grass yields. Forage yields of Mulato were higher when cut at 28-day intervals as compared with cutting every 21 or every 35 days. On the other hand, modifying cutting height from 10 cm to 20 cm did not influence yields in conditions of El Zamorano, Honduras (Hidalgo, 2004).

Establishment

Although Mulato can be propagated vegetatively, we recommend that Mulato be established using seed, given its commercial availability. In case vegatative planting material is used, rooted stems should be selected to ensure better establishment.

Seed can be broadcasted, hill-plot planted using a long tapered stick or the point of the machete, or seed drilled in rows spaced 0.50-0.70 m apart, either on land prepared conventionally with plow and harrow or after controlling vegetation with non-selective herbicides (minimum tillage). The latter is recommended for hillside areas or rocky land where mechanization is not possible. Greater seedling emergence and land coverage have been observed in hill-plot plantings at distances of approximately 0.5 m x 0.5 m, with the seed placed no deeper than 2 cm, than in broadcasted plantings, especially at sites with limited or erratic rainfall after planting. The above can be attributed to an increased contact of the seed with soil moisture, which does not always occur with broadcasted seed. Regardless of land conditions, moisture after planting and the coverage or not of seed with soil affected seedling emergence and subsequent development of the grass.

Seeding rate varies with seed quality, especially percentages of purity and germination, and the method of establishment used. Broadcasted plantings require higher seeding rates, for example between 5 and 6 kg/ hectare, with a 60% «cultural value» (pure germinable seed), which could be obtained from seed with 80% purity and 75% germination. Hill-plot plantings require smaller amounts of seed since losses due to predators, such as ants or birds, is lower. Also, less seed is washed away by subsequent rain.

Table 2 presents data related to the establishment of Mulato in Costa Rica. Results show the number of plants/m^2 recommended for hill-plot plantings and for minimum tillage (herbicide application) and zero tillage (burning)[3]. Seed was broadcasted in San Jerónimo, reducing plant emergence and delaying by one month the initiation of the first grazing, which was carried out at the early age of 2.5 months at the localities of San Miguel and Miramar. The above can be attributed to the high establishment vigor of Mulato, which produces much more vigorous seedlings than the traditional *Brachiaria* cultivars. In these plantings, 3.5 kg seed was used per hectare, with a 60% cultural value.

Despite the good initial vigor of Mulato, the criterion for the first grazing should be based on plant development and on the experience of each livestock producer. Submitting the grass to grazing too early, using a high stocking rate, can affect its growth and subsequent development. Ideally, the first grazing should be conducted with a low stocking rate and only for a couple of days. This way the animals only consume grass tips and force the

Table 2. Localities, type of soil preparation, plants/m^2, and date of first grazing *Brachiaria* hybrid cv. Mulato established in Costa Rica.

Locality	Soil preparation	Plants/m^2 (2-3 months later)	First grazing (months after planting
San Jerónimo	Conventional	7.2	3.5
San Miguel	Minimum tillage	15.0	2.5
Miramar	Zero tillage	17.0	2.5

SOURCE: Sandoval and Mesén (2001); Lobo and Sandoval (2002).

[3] The terms 'minimum' and 'zero' tillage refer to different practices depending on the country. In this case, 'zero' tillage means that the cost of controlling existing vegetation was minimum, but does not imply in any way that the use of fire is recommended as a practice prior to pasture establishment.

stems to come into close contact with the soil to promote rooting. Photo 2 shows the state of development of Mulato 40 days after establishment in furrows, using conventional soil preparation, in a farm in Sulaco, Honduras. In this case the seed was covered slightly with soil after planting and the rains during seedling emergence were sufficient.

Data in Table 3 also show the good establishment of Mulato. Less than two months after planting, this grass reached an average height of 80 cm (ranging from 40 cm to 110 cm) and 83% soil cover (ranging from 65% to 90%) on five farms of the department of Yoro, Honduras. In all cases, seed was drilled in furrows spaced 50 cm apart, at seedling rates ranging from 3.5 to 4.0 kg/hectare. Seed purity and germination were above 80%. The variation among farms in plant height and cover were attributed to soil fertility.

Cultivar Mulato has been established successfully in simultaneous plantings with maize, as demonstrated in experiments reported in Colombia, Guatemala, Ecuador, and Honduras. In Colombia, 15 hectares were machine planted simultaneously with maize-Mulato, after conventional soil preparation with plow and harrow and fertilization (Camilo Plazas, personal communication). In this case, maize was machine-harvested at 138 days, yielding 3.7 t grain/hectare, which covered 80% of total costs incurred during

Photo 2. Cultivar Mulato, 70 days after planting at the CIAT Experiment Station in Quilichao, Colombia, showing high vigor and good plant development.
SOURCE: Belisario Hincapié.

Table 3. Number, plant height, and cover of *Brachiaria* hybrid cv. Mulato, established on dual-purpose farms in Honduras.

Farm/Site	Days after planting	Plants/m² (no.)	Average plant height (m)	Cover (%)
La Laguna/Yorito	54	17	0.4	65
Las Brisas/Sulaco	54	23	1.1	95
Las Delicias/Victoria	51	28	1.0	90
Ojo de Agua/Victoria	48	12	0.8	85
Don Pedro/Victoria	49	20	0.8	80
Average	**51**	**20**	**0.8**	**83**

SOURCE: Conrado Burgos and Heraldo Cruz from DICTA (CIAT, 2003).

pasture establishment. As illustrated in Photo 3, the pasture is well established and is currently yielding 4.2 t fresh forage/hectare.

The cost of establishing one hectare of Mulato depends on whether it is planted in monoculture or with a companion crop such as maize. In the Colombian altillanura, the cost was US$692/hectare. This sum covered the cost of machinery and inputs (maize seed, grass seed, fertilizers, herbicides, and fungicides), the drying of maize, and transportation. The sale of the maize covered 80% of this cost. Therefore, it cost US$139 to establish 1 hectare of Mulato, with a companion crop (Camilo Plazas, personal communication). In Panama, Pinzón and Santamaría (2005b) reported a cost of US$219 to establish 1 hectare of Mulato, using a minimum tillage system. Among inputs, the highest cost was the grass seed (4 kg/hectare at a value of US$100), followed by fertilizers, herbicides, and labor. In terms of expenditures, the value of the grass seed represented 46% of total establishment costs reported for Panama and 52% of those reported for Colombia.

Overall, it is evident that it costs more to establish paddocks with Mulato than with other *Brachiaria* cultivars, mainly because of the higher cost of the seed. However, given the high forage production of this grass and the possibility of using higher stocking rates, the income generated after only 8 months of grazing Mulato surpasses by US$301/hectare the income obtained in similar conditions with *B. brizantha* (Marandú), as reported by Antonio Kaupert (personal communication) in the conditions of São Paulo, Brazil.

Photo 3. Successful establishment of cultivar Mulato planted simultaneously with maize in the Colombian 'altillanura' (high, well-drained savanna).
SOURCE: Camilo Plazas.

Response to Fertilization

As mentioned before, for best results, Mulato requires fertile or moderately fertile soils, which means that the adaptation of the grass to poor soils is marginal because of limited nutrient availability. Preliminary evaluations carried out in Colombia (CIAT, 1998) showed that the yields of Mulato increase from 4.8 to 8.7 t DM/hectare during the establishment phase when fertilization increases from (kg/hectare) 20 P, 20 K, 33 Ca, 14 Mg, and 10 S to 80 N, 50 P, 100 K, 66 Ca, 28.5 Mg, and 20 S on a poor, acid Oxisol. Moreover, the leaf index increased from 3.3 to 5.0 m^2/m^2, and root length went from 154 m to 320 m/pot in plants harvested at 142 days of growth.

Although Mulato is known to respond well to fertilization, the grass does not seem to require significant applications of N to develop well during its first months of growth. For example, in the conditions of Pucallpa, Peru, where soils are Ultisols with pH 4.4, 1.0% OM, and 2 ppm P, Mulato achieved complete soil cover 12 weeks after planting, regardless of whether it had been fertilized or not with 150 kg N and 50 kg P/hectare (Miguel Ara, personal communication). These observations coincide with others made at different sites where Mulato has been established and is obviously associated with the natural state of fertility of the soil and nutrient reserve during emergence of seedlings and initial plant growth. Under controlled field conditions, the grass responds significantly to fractional applications of N up to 100 kg/hectare. Application rates above this dose—up to 300 kg/hectare—did not increase yields at El Zamorano, Honduras (Hidalgo, 2004).

Tolerance to Pests and Diseases

Unlike *B. brizantha* (Marandú), Mulato does not have antibiotic resistance to the attack of cercopids (Homoptera: Cercopidae), commonly known as spittlebugs (froghoppers). Reports, however, indicate that it is very tolerant to insect attacks under field conditions, especially to *Aeneolamia varia, Zulia carbonaria, Z. pubescens*, and *Mahanarva trifissa* (CIAT, 2004). In Nueva Concepción, Guatemala, moderate plant mortality was observed in Mulato when subject to high nymph and adult insect populations (Elder Fajardo, personal communication).

Overall, Mulato plants appear to be healthy, resisting the attacks of the common grass pests of economic importance. However, there are reports of attacks of the chinch bug (*Blissus leucopterous*) in Gualaca, Panama (B. Pinzón, personal communication), and a moderate attack of the grassworm (*Mocis* sp.) was recently observed in a paddock of Mulato beginning regrowth, at the onset of rains in Guanacaste, Costa Rica. The Rhodesgrass mealybug *Antonina graminis* has been observed on Mulato leaves in Colombia, Panama, and Costa Rica, causing foliage chlorosis that may be confused with nutrient deficiency in the grass. The incidence of this insect seems to increase with decreasing plant vigor. Nevertheless, the mealybug tends to disappear when the grass is submitted to grazing, especially if fertilized to increase pasture vigor. In all these cases, the damage caused by these insects in Mulato has not been of economic importance to date.

Leaf blight, caused by the fungus *Rhizoctonia solani*, is the most widespread problem affected Mulato foliage. The nematode *Pratylenchus* sp. has also been reported on roots, and fungi of the genera *Fusarium* and *Curvularia* have been observed on leaves and stems in Gualaca, Panama (B. Pinzón, personal communication). Leaf blight causes necrosis in foliage, as illustrated in Photo 4, and appear as burnt patches in paddocks, especially during active growth periods of the grass and during periods of high temperatures and high relative humidity.

The incidence of foliage blight, however, is less frequent in grazed paddocks where the foliage is periodically consumed by animals, and tends to disappear with paddock use. The economic losses caused by leaf-attacking fungi have not been quantified to date.

Photo 4. Leaf blight in Mulato caused by the fungus *Rhizoctonia solani*, in a paddock under use in Upper Sinú, Colombia.
SOURCE: Pedro J. Argel and Belisario Hincapié.

Production and Seed Quality

In the lowland tropics of the Northern Hemisphere, Mulato begins to flower at the beginning of September, which is at the end of the rainy season. Its time of flowering is therefore similar to that of *B. brizantha* cv. Toledo, but later than that of other *Brachiaria* cultivars, for example *B. decumbens* cv. Basilisk and *B. humidicola (*formerly *B. dictyoneura)* cv. Llanero in Colombia, which flower between May and June of each year, at the onset of rains. This characteristic of Mulato is desirable because it allows a longer grazing period, without the loss of forage quality because of early flowering. However, manual harvesting of seed can be difficult because of the high environmental moisture during October, and a loss of mature spikelets can occur because of the rains. Furthermore, high relative humidity during spikelet development favors the presence of fungi on the spikelets, particularly those of the genera *Phoma* and *Drechslera*, as reported in other *Brachiaria* species (García and Pineda, 2000).

Cultivar Mulato is characterized by its highly synchronized flowering and high panicle production. However, caryopsis formation is poor, which results in low seed yields per unit area (between 50 and 80 kg pure seed/ hectare in manual harvests). These yields can increase if the crop is allowed to mature and the fallen spikelets are recovered from the ground, but at any rate seed yields are only moderate, reported to be between 100-150 kg/ hectare. The low seed yields of Mulato determine its high market value; nevertheless, the seed produced is of good quality, with moderate dormancy. Seed harvested and stored under appropriate moisture conditions (50%-60% relative humidity), at temperatures ranging from 18 ºC to 20 ºC, can present more than 60% germination four months after harvest, especially if scarified with sulfuric acid.

Forage Quality

One of the most outstanding characteristics of Mulato is its high forage quality, especially crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) contents, as well as its in vitro dry matter digestibility (IVDMD). These values vary, however, depending on plant age, plant part analyzed, season, and growing conditions.

In recent years, the information on the quality of Mulato has been collected mainly from lowland tropical pastures. Whole-plant CP values range between 9% for 30-day-old Mulato plants and 16% for 23-day-old plants, and the IVDMD between 55% and 62%, respectively, during the rainy season. The Forage Laboratory located in Ithaca (USA) and the Laboratory of the Universidad Tecnológica Equinoccial, located in Santo Domingo de los Colorados, Ecuador, have reported CP values of 21.6% and 18.6% (in this case in Mulato plants that were 40 days old), and ADF values of 29.6% and 23.8%, which confirms the outstanding quality of this tropical grass (Alejandro Bravo, personal communication). The IVDMD and CP are higher in leaves than in stems, as reported by Guiot and Meléndez (2003a) in samples of Mulato grown at Huimanguillo, Mexico. In this case, leaf or stem digestibilities were, respectively, 66% or 65% and CP contents, 10% or 5%.

Cultivar Mulato tends to present better nutritive quality indices than conventional *Brachiaria* cultivars in similar growth and management conditions. For example, Cuadrado et al. (2005) report average CP contents of 9.8% for Mulato and 8.3% for *B. decumbens* cv. Basilisk during the rainy season at Cereté, Colombia. Similar results were observed in Quilichao, Colombia, where the quality of Mulato was significantly superior ($P<0.05$) to that of cv. Basilisk and *B. brizantha* cv. Toledo during two consecutive years under grazing (CIAT, 2000; CIAT, 2001).

Similarly, the quality of Mulato has been reported to be superior to that of Transval digitgrass or Tobiatã guineagrass. Results obtained by Estrada (2004) at three sites in Honduras (Table 4) indicate that, except for Uyuca (intermediate climate, with a mean temperature of 18.4 ºC), where Tobiatã presented lower DM yields (Table 1), Mulato's CP contents were significantly higher. However, its NDF percentages—which relate negatively to animal intake—were the lowest at all sites, a potential indicator of the high animal intake of this grass.

Table 4. Contents of neutral detergent fiber (NDF) and crude protein (CP) of *Panicum maximum* Tobiatã, *Digitaria eriantha* Transval, and *Brachiaria* hybrid Mulato in Choluteca, El Zamorano, and Uyuca (Honduras).

Cultivar	Place	NDF (%)	CP (%)
Tobiatã	Choluteca	61.2 a*	7.7 c
Transvala		59.8 b	8.7 b
Mulato		**52.2 c**	**10.1 a**
Tobiatã	Zamorano	55.4 a	8.4 c
Transvala		55.7 a	8.9 b
Mulato		**50.0 b**	**10.3 a**
Tobiatã	Uyuca	51.9 a	16.0 a
Transvala		52.0 a	15.8 a
Mulato		**49.4 b**	**13.4 b**

* ($P<0.05$). Grasses cut every 28 days to 10 cm and fertilized with 300 kg N, 100 kg P, and 200 kg K/hectare, in split applications after the standardization cut and the second and fourth cut.

SOURCE: Adapted from Estrada (2004).

Nitrogen fertilization rates between 0 and 300 kg/ha did not affect the quality of Mulato in Honduras (Hidalgo, 2004), where the average CP was 10% and NDF, 59%, for the different levels of fertilizer. However, the cutting frequency affected these parameters ($P<0.05$). The CP contents decreased from 10% to 9% and the NDF increased from 58% to 60% when cutting interval increased from 21 to 35 days.

The ranges of other mineral components of Mulato in samples harvested during the rainy season were as follows: Ca (0.25%-0.46%), P (0.18-0.36%), Mg (0.24%-0.65%), and K (1.05%-3.11%) (Cuadrado et al., 2005), and 256 ppm Fe and 0.11% S (Guiot and Meléndez, 2003b). Other results show levels of 15 ppm Cu and 30 ppm Zn (Laboratory of the Universidad Tecnológica Equinoccial de Santo Domingo de Los Colorados, Ecuador).

Animal Production

Milk

The excellent forage quality of Mulato is reflected in high animal intake, which, in turn, results in higher milk and meat production. Table 5 presents the milk production of crossbred cows grazing pastures of *B. decumbens* cv. Basilisk, *B. brizantha* cv. Toledo or Mulato, under experimental conditions. The daily milk production of cows in paddocks of Mulato was higher ($P<0.05$) than that of cows grazing Toledo in 2000 and Basilisk in 2001. The above was related to higher levels of milk urea nitrogen (MUN) in cows grazing Mulato during the years reported, which is an indicator of the good energy:protein ratio of the forage consumed by the animal.

Table 5. Milk production of crossbred cows in contrasting *Brachiaria* pastures in Quilichao, Colombia.

Pastures	Milk (kg/cow per day)		MUN (mg/dL) **	
	Years		Years	
	2000	2001	2000	2001
Basilisk	7.6 a *	7.0 b	4.1 b	4.4 b
Toledo	6.5 b	8.5 a	4.3 b	3.8 b
Mulato	8.1 a	8.1 a	9.7 a	5.7 a

* P<0.05;
** MUN (milk urea nitrogen)
SOURCE: Adapted from CIAT (2000); CIAT (2001).

The results in dual-purpose farms of Central America, Colombia, Panama, and Mexico also show the higher milk production of Mulato as compared with other types of *Brachiaria* and other tropical grasses. However, the main effect of Mulato at the farm level has been in terms of the higher stocking rate that paddocks can maintain, which results in significant increases in milk production per unit area (CIAT, 2004). Table 6 compares the daily milk production of crossbred cows grazing different grasses—Swazi, Toledo, *Andropogon*, Jaragua, and Mulato—on 6 different farms in Honduras from January to June 2004.

Table 6. Stocking rate and milk production of crossbred cow grazing *Brachiaria* hybrid cv. Mulato and other forage species in dual-purpose farms in Honduras.

Farm/grasses	Stocking rate (cows/ha)	Daily milk production (kg/cow)	Average milk production (kg/ha per day)
Mulato	5.1 a **	7.1 ns	37.5 a
Swazi *	1.6 b	6.8 ns	8.6 b
Mulato	5.6 a	5.2 ns	32.1 a
Swazi	2.7 b	4.8 ns	13.5 b
Mulato	9.4 a	3.8 ns	36.0 a
Toledo	3.7 b	3.8 ns	14.0 b
Mulato	5.0 a	13.1 ns	64.5 a
Toledo	2.7 b	12.7 ns	33.3 b
Mulato	6.1 a	10.7 ns	65.3 a
Andropogon	3.4 b	10.5 ns	36.7 b
Mulato	4.7 a	6.3 ns	29.9 a
Jaragua	2.1 b	5.7 ns	12.3 b

* Swazi (*Digitaria swazilandensis*), Toledo (*Brachiaria brizantha*), Andropogon (*Andropogon gayanus*), and Jaragua (*Hyparrhenia rufa*).
** Within farms, means followed by the same letter do not differ (P<0.05).
SOURCE: Conrado Burgos, Herald Cruz, and Marisabel Caballero of DICTA, Honduras (CIAT, 2004).

Individual cow production did not differ among the monitored pastures, but the stocking rates of Mulato pastures were always significantly higher ($P<0.05$) and, as a result, the daily milk production/hectare was higher. In several cases, milk production/area was four times higher in Mulato pastures, as was the case of the first farm presented in Table 6 on which Swazi grass was compared with Mulato grass. The differences in milk production of individual cows on different farms are obviously related to herd management and herd genetic quality. The more 'dairy genes' the cows have, the higher milk production can be expected.

Meat

Meat production with Mulato has been evaluated by the Panamanian Institute for Agricultural and Livestock Research (IDIAP, its Spanish acronym) in Gualaca and by the Colombian Corporation for Agricultural and Livestock Research (CORPOICA, its Spanish acronym) in Cereté. A rotational grazing system was used with 3 days occupation and 21 days rest in Gualaca (Pinzón and Santamaría, 2005b), and 2 days occupation and 22 days rest during the rainy season and 3 days occupation and 33 days rest during the dry season in Cereté (Cuadrado et al., 2005). In Gualaca (acid Inceptisol), paddocks were fertilized at an annual rate of 80-30-20 kg/hectare N, P_2O_5, and K_2O, respectively, whereas no fertilizer was applied to paddocks in Cereté (fertile alluvial soils). Table 7 summarizes the results. The average stocking rate was similar at both sites for Mulato, although weight gain per animal and per hectare were slightly superior in Gualaca, where young crossbred zebu bulls, with an initial liveweight of 183-206 kg, were used. In Cereté, young zebu bulls and young crossbred zebu x *Romo sinuano* bulls (F1), with an initial average liveweight of 285 kg, were used. The crossbred bulls presented a higher ($P<0.05$) daily weight gain (569 g/animal per day) than zebu bulls (410 g/animal per day). In Cereté, Mulato surpassed cv. Basilisk in stocking rate and meat production/ha per year, under similar management conditions, although daily weight gains were similar for both pastures.

Table 7. Stocking rates and weight gains of cattle grazing Mulato and *B. decumbens* (Basilisk), under controlled conditions in Gualaca (Panama) and Cereté (Colombia).

Site	Pastures	Stocking rate (AU/ha)	Weight gain		Source
			(g/day)	(kg/ha per year)	
Gualaca*	Mulato	3.4	544	879	Pinzón and Santamaría, 2005b
Cereté	Mulato	3.5 a **	503 a	796 a	Cuadrado et al., 2005
	Basilisk	2.0 b	532 a	580 b	

* Evaluations performed at 683 days in Gualaca and at 525 days in Cereté.
** $P<0.05$.

In Huimanguillo, Mexico, average weight gains of 435 g/animal per day were observed in Mulato pastures, with a stocking rate of 4 AU/year (Guiot and Meléndez, 2003b), this weight gain being lower than that observed in Panama and Colombia.

Use and Management

To date, Mulato has been mainly used for the grazing of beef cattle and superior dual-purpose crossbred dairy cows, although reports indicate that sheep readily consume Mulato, and anecdotal reports suggest that horses also consume Mulato.

Reports also indicate the use of Mulato as silage, as well as its successful use as hay and haylage (see Photo 5). In Mexico, one hectare of fertilized Mulato pasture, with 30 days regrowth, yielded 48 silo bales, each weighing 600 kg. This same lot yielded between 850 and 1100 bales of hay, each weighing 20-25 kg (Guiot and Meléndez, 2003b). Lower hay yields were reported in Honduras (around 480 bales/hectare, each weighing 10 kg), harvested at 28-30 days regrowth. At these same sites, higher yields have been obtained with other *Brachiaria* species (Conrado Burgos, personal communication). Also, hay was successfully made from Mulato on irrigated dairy farms in Florida, United States (Alejandro Bravo, personal communication).

Several producers in Honduras use Mulato as cut-and-carry forage, transporting it daily to dairy cows in artisan troughs built at strategic sites on the farm. Producers argue that the grass is more efficiently used this way and, given its high quality and forage production, milk yields remain high, exceeding those obtained with traditional cut-and-carry grasses such as king grass or forage sorghum.

Optimal stocking rate and occupation/rest period of paddocks established with Mulato will depend on the site and on specific fertility characteristics of the soil; however, this grass has a rapid rate of recovery after grazing during the rainy season, such that rest periods of between 21 and 28 days have been successfully used on farms validating the grass with dual-purpose cattle in Costa Rica and other countries of the area.

Cultivar Mulato responds very well to fertilization and, depending on the level of soil fertility, an annual application of manure, with high N content, could be necessary. At sites with poor soils, such as the Oxisols of the Colombian altillanura or the Inceptisols of Gualaca, Panama, the initial application of 80-30-20 kg/hectare of N, P_2O_5, and K_2O allowed good pasture establishment at this last site (Pinzón and Santamaría, 2005b), whereas in Colombia the application of 250 kg/ha Calfos (4% P and 37% Ca) at planting and 50 kg/ha urea and 50 kg/ha Triple 15 (15% N, 6.5% P, 12.5% K) at 57

Photo 5. Haylage made from Mulato and its conservation in silo bales (insert).
SOURCE: Jorge Guiot.

days after establishment has been successful when the grass is planted simultaneously with maize on marginal soils (Camilo Plazas, personal communication). However, subsequent fertilizations of the grass with N at this site showed an adequate response to the nutrient, but the effect of the fertilizer on the grass dissipated rapidly (less than 3 months).

Depending on soil conditions, Mulato can require maintenance fertilization, an uncommon practice in tropical livestock systems. However, the high productivity of the grass justifies periodic fertilizations to exploit its potential for producing abundant, high-quality forage. Mulato is an excellent option for rotational grass-crop systems, where Mulato exploits the residual of the fertilizer applied to the crop.

Because of Mulato's initial growth habit (tufted), it can be grown in association with stoloniferous legumes, for example forage peanut (*Arachis pintoi*). To date, however, only one successful commercial planting of Mulato-Kudzu in association has been reported in the Llanos piedmont region of Colombia (Camilo Plazas, personal communication).

Attributes of Mulato Compared with Those of Other *Brachiaria* Cultivars

Considerable amounts of seed of several *Brachiaria* cultivars, which present acceptable forage qualities but are susceptible to pests and diseases, require specific soil characteristics, or present poor forage quality, are currently marketed in Latin America. Cultivar Mulato is the first commercial *Brachiaria* hybrid with highly desirable forage qualities, but it also has limitations (Table 8).

Table 8. Comparison of the characteristics of *Brachiaria* hybrid Mulato with *Brachiaria decumbens* cv. Basilisk and *B. brizantha* cv. Marandu.

Characteristic	Mulato	Basilisk	Marandu
Tolerance to drought	Very high	High	High
Tolerance to moisture	Very low	Intermediate	Very low
Tolerance to leaf fungi	Low	Intermediate	Low
Resistance to the spittlebug	Tolerant	Susceptible	Resistant
Recovery under grazing	Very quick	Quick	Quick
Forage quality	Very high	High	High
Synchronization of flowering	High	Poor	Poor
Seed quality	Good	Good	Good
Establishment by seed	Easy	Easy	Easy
Seedling vigor	Very high	Intermediate	Intermediate
Compatibility with forage legumes	Good	Good	Good
Soil requirements	Intermediate-high fertility	Intermediate-low fertility	Intermediate fertility

References

Argel, P. J. and Pérez, G. 2003. Pasto Mulato. Una Nueva Opción Forrajera para la Ganadería. Revista Oficial de la Escuela Centroamericana de Ganadería (ECAG). Edición No. 26. October-December 2003. p. 22-25.

Cuadrado, H.; Torregrosa, L. and Garcés, J. 2005. Producción de carne con machos de ceba en pastoreo del pasto híbrido Mulato y *B. decumbens* en el Valle del Sinú. Corporación Colombiana de Investigación Agropecuaria (CORPOICA). Informe Mimeografiado. 9 p.

CIAT (Centro Internacional de Agricultura Tropical). 1998. Annual Report 1998. Project IP-5. Tropical Grasses and Legumes: Optimizing genetic diversity for multipurpose use. p. 88-90.

CIAT (Centro Internacional de Agricultura Tropical). 1999. Annual Report 1999. Project IP-5. Tropical Grasses and Legumes: Optimizing genetic diversity for multipurpose use. p. 142-144.

CIAT (Centro Internacional de Agricultura Tropical). 2000. Annual Report 2000. Project IP-5. Tropical Grasses and Legumes: Optimizing genetic diversity for multipurpose use. 191 p.

CIAT (Centro Internacional de Agricultura Tropical). 2001. Annual Report 2001. Project IP-5. Tropical Grasses and Legumes: Optimizing genetic diversity for multipurpose use. p. 110-112.

CIAT (Centro Internacional de Agricultura Tropical). 2003. Annual Report 2003. Project IP-5. Tropical Grasses and Legumes: Optimizing genetic diversity for multipurpose use. p. 132.

CIAT (Centro Internacional de Agricultura Tropical). 2004. Annual Report 200. Project IP-5. Tropical Grasses and Legumes: Optimizing genetic diversity for multipurpose use. p. 24-26.

Estrada, J. E. 2004. Efecto de la temperatura sobre la producción y el contenido de proteína cruda y fibra neutro detergente de *Panicum maximum* cv. Tobiatã, *Digitaria eriantha* cv. Transvala y *Brachiaria* híbrido cv. Mulato. Thesis presented for the degree of Agricultural Engineer at the Escuela Agrícola Panamericana El Zamorano (Honduras). 11 p.

García, S. X. and Pineda L., B. 2000. Reconocimiento de enfermedades fungosas transmitidas por semillas en germoplasma de *Brachiaria* spp. Fitopatología Colombiana 24(2): 34-96.

Guiot, J. D. and Meléndez, F. 2003a. Pasto Mulato. *Brachiaria* híbrido (CIAT 36061). Excelente alternativa para producción de carne y leche en zonas tropicales. Publication of the State of Tabasco, Semillas Papalotla, and ISPROTAB. Villahermosa, Tabasco (Mexico). November 2003. 23 p.

Guiot, J. D. and Meléndez, F. 2003b. Producción anual de forraje de cuatro especies de *Brachiaria* en Tabasco. XVI Reunión Científica Tecnológica Forestal y Agropecuaria. Villahermosa, Tabasco (Mexico). 27 and 29 November, 2003. p. 126-128.

Hidalgo, J. G. 2004. Producción de materia seca y contenido de proteína cruda y fibra neutro detergente del pasto *Brachiaria* híbrido Mulato. Thesis presented for the title of Agricultural Engineer at the Escuela Agrícola Panamericana El Zamorano (Honduras). 14 p.

Lobo, M. and Sandoval, B. 2002. Informe preliminar del proyecto Evaluación del pasto Mulato en fincas de doble propósito en la región Pacífico Central de Costa Rica. Ministerio de Agricultura y Ganadería (MAG). Mimeograph. 3 p.

Loch, D. S. and Miles, J. W. 2002. *Brachiaria ruziziensis* x *Brachiaria brizantha*. Brachiaria 'Mulato'. Plant Varieties Journal 5(3): 20-21.

Miles, J. 1999. Nuevos híbridos de *Brachiaria*. Pasturas Tropicales 21(2): 78-80.

Ndikumana, J. 1985. Etude de l'hybridation entre espèce apomictiques et sexuées dans le genere *Brachiaria*. Ph.D. Dissertation. Université Catholique de Louvain, Louvain-La-Neuve, Belgium. 210 p.

Pinzón, B. and Santamaría, E. 2005a. Valoración del comportamiento agronómico de nuevos híbridos y variedades de *Brachiaria*. Instituto Panameño de Investigación Agropecuaria (IDIAP). Mimeographed Report. 5 p.

Pinzón, B. and Santamaría, E. 2005b. Evaluación del pasto *Brachiaria* híbrido cv. Mulato en producción de carne. Instituto Panameño de Investigación Agropecuaria (IDIAP). Mimeographed Report. 7 p.

Sandoval, B. and Mesén, M. 2001. Informe de avance del proyecto de evaluación de 2 ecotipos del género *Brachiaria*: cv Toledo e híbrido CIAT 36061 en la localidad de Piedras Negras, San José, Costa Rica. Ministerio de Agricultura y Ganadería (MAG). Mimeographed Report. 3 p.

Swenne, A., Louant, B.-P. and Dujardin, M. 1981. Induction par la colchicine de formes autotétraploides chez *Brachiaria ruziziensis* Germain et Evrard (Graminée). Agron. Trop. 36(2): 134-141.

Acknowledgments

The evaluation, selection, formal release, and promotion of new forage cultivars are the outcome of the joint undertaking of stakeholders—both individuals and national and international research, promotion and development institutions of both public and private livestock sectors. Semillas Papalotla S.A. de C.V. of Mexico and CIAT's Tropical Grasses and Legumes Project (Project IP-5) express their special thanks to all those individuals and institutions of the Latin American tropics, who contributed, in one way or another, to the evaluation and commercial release of Mulato.

Our special gratitude goes to the following research institutions:

- INIFAP, Mexico's National Institute for Forestry, Agriculture, and Livestock Research
- DICTA, Directorate of Agricultural and Livestock Science and Technology, Honduras
- ICTA, Institute of Agricultural Sciences and Technology, Guatemala
- INTA, Nicaraguan Institute of Agricultural and Livestock Technology
- INTA, National Institute of Innovation and Transfer of Agricultural and Livestock Technology, Costa Rica
- IDIAP, Panamanian Institute for Agricultural and Livestock Research
- CORPOICA, Colombian Corporation for Agricultural Research
- University of Córdoba in Montería, Colombia.