Boehmeria nivea *(L.) Gaud.*

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ABSTRACT

Ramie (*Boehmeria nivea* L. Gaud.), native species to Eastern Asia, produces the most ancient textile fiber cultivated in China or Japan. The Egyptians already imported it from the East, in the predynastic period (5 000 to 3 000 B.C.). The high protein content of its leaves led researchers from tropical and subtropical countries (Guatemala, Brazil and Southern United States) to study its forage capacity and to consider it a plant with high feeding potential, because of the production and quality of its forage. In different experiences with cattle, sheep, pigs, horses and poultry, this species proved to be feasible of being used as nutritional resource in the form of green forage and/or meal. In this review its uses, as well as a brief history and the agronomy of this crop, are commented.

Key words: *Boehmeria nivea*, agronomic characteristics

INTRODUCTION

Boehmeria nivea (ramie, from Malaysian *rami*), species from the family *Urticaceae*, has herbaceous stems which grow up to 3 m of height and leaves with hairs on the underside, from which a textile fiber more resistant than flax is obtained and used −alone or mixed− in the manufacturing of fabrics and for other purposes, such as: irrigation hoses, non-combustible fabrics, banknotes, gas lamp mantles and parachutes. This plant is native to Eastern Asia and it has been ancestrally cultivated in China and Japan. The Egyptians imported it from the East in the predynastic period ─5 000 to 3 000 B.C. ─ (CIDTA, 2005; Anon, 2008).

The high protein content of its leaves drove researchers from tropical and subtropical countries (Guatemala, Brazil and southern United States) to study its forage capacity and consider it a plant with high feeding potential, due to the production and quality of its forage (Corzo *et al*., 2004).

In this regard, several authors have reported protein averages between 24 and 28 %; as well as calcium and magnesium values of 5,8 and 0,78 %, respectively, which exceed the highest ones found in any other forage plant (Calle and Uribe, 1969; Godinho, 1995a, 1995b). It is important to emphasize that when the cutting age increases the fiber content rises; thus, the best values of protein and other nutrients are found in the ramie which is cut every 30 days, as compared with the one cut every 45 and 60 days (Acosta, 1997).

According to Rubens (2008), the young leaves and regrowths –unlike what occurs with the stems─ are poor in fiber and rich in protein, minerals, lysine and carotene. The nutritional value of ramie has been described as similar to that of alfalfa, although the former has the capacity to highly exceed the latter in yield.

The ramie foliage is attractive and it has been proven to be valuable not only for cattle, but also for pigs and rabbits (Patiño, Salazar and Londoño, 2006). It can be grazed, used as green forage, ensiled along with molasses, or be artificially dried to turn it into leaf meal. With concentrate feed satisfactory mineral levels are obtained and the ramie meal is valuable for poultry, because it contributes carotenoids and riboflavin.

Due to the uses of *B. nivea* in different countries, this review presents some of the most important aspects about the history and agronomy of this crop.

History, origin, scientific classification and description of ramie

Ramie is a native plant to the subtropical zone of China. It is a dicotyledonous species belonging to the family *Urticaceae*, with herbaceous consistency of 1,5 to 2,0 m of height (Campos *et al*., 1995).

It has excellently adapted to the Central and South American tropic, especially in zones with altitudes between 200 and 1 800 m.a.s.l. and with temperatures from 17,5 to 28,0 ºC.

In the Dominican Republic, the agricultural technician Víctor Ramírez has a project about this plant since 46 years ago, in which he has continuously kept studies and rhizome fields (Rubens, 2008). This farmer states that the technical name of ramie emerged in Santo Domingo in 1757, when the austrian Nicolás Joseph Jaquin published his famous work *Enumerativo Plantarum, Quas en Insulis Carubaeis Detextis*, in which he named it *B. nivea* in honor of the Salesian Boehmer –author of the first European book about the industrialization of this plant.

Singh (1996) described ramie as an herbaceous, perennial and rhizomatous plant, with stems that vary between 1 and 2 m of height, depending on the growth conditions. Its leaves –whitish and hairy– are large, heart-shaped and velvety; from 7 to 15 cm wide and from 7 to 15 cm long. Its small yellowish flowers are arranged in panicles in the leaf axillae; its fruits are oval, small and very numerous; and one gram can have up to 7 000 seeds, because they are very small (figure 1).

According to Singh (1996), the genus *Boehmeria* Jacq. has more than 100 species, most of them tropical and subtropical, including herbaceous and shrubby plants. The most important are the following: *B. malabarica, B. sidaefolia, B. nivea, B. macrophylla, B. platyphylla, B. platyphylla* Don var. tomentosa, *B. platyphylla* Don var. longissima Hook. f., *B. platyphylla* Don var. cinerasens Wedd., *B. platyphylla* Don var. zeylenica Wedd., *B. platyphylla* Don var. rugossima Wedd., *B. platyphylla* Don var. rotundifolia Wedd., *B. hamiltoni* Wedd., *B. polystachya* Wedd., *B. rugulosa* Wedd., *B. kurzi* Hook. f., *B. scabrella* Gaud. and *B. utilis*. The last one is very similar to *B. nivea*, except because the lower surface of the leaves is gray and it is found mainly in China, The Philippines and Malaysia.

According to Wikipedia (2009), ramie belongs to: kingdom *Plantae*, division Magnoliophyta, classes Magnoliopsida, order Urticales, family *Urticaceae*, genus *Boehmeria,* and species *B. nivea*.

Figure 1a. Leaf and inflorescence of ramie.

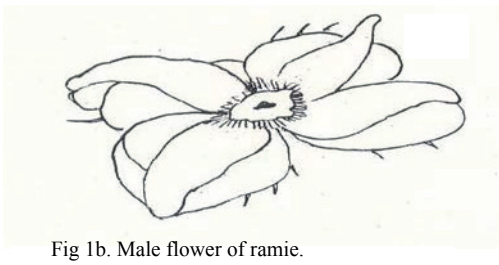

Fig 1b. Male flower of ramie.

Fig 1c. Female flower of ramie.

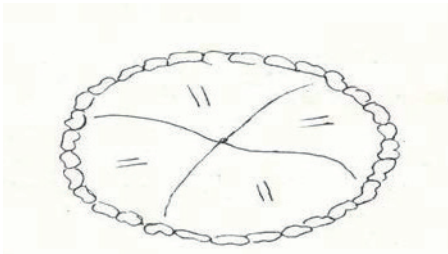

Fig 1d. A fruit of ramie.

Multiplication forms of ramie

Ramie is reproduced through rhizomes, cuttings and/or seeds. Propagation by seeds is not the most convenient, because the small seedlings show slow growth since implantation until the first cut (100 to 120 days); on the contrary, by rhizomes, the growth time in the above-mentioned period is significantly lower (70 to 90 days). The rhizomes should be cut in pieces from 10 to 15 cm long, be placed in rows 10 to 12 cm deep and be adequately covered (Elizondo and Boschini, 2002). The planting distance oscillates from 0,60 to 1,20 m between rows and from 0,30 to 0,60 m between plants.

B. nivea has two implantation seasons: autumn and early spring; it is advised to be performed in the autumn so that the plant roots well before the winter and emerges strongly in the spring (Elizondo and Boschini, 2002).

Its cycle is spring-summer-autumn. Every two to three years it is important to reinforce the soil fertility through the application of nitrogen, potassium and calcium. After each forage cutting or during long dry periods, one irrigation session should be carried out. A good weed control is necessary during the first growth stage of the crop, until the plants produce sufficient shade to eliminate weeds by themselves.

Crop ecology or demands

Boschini and Rodríguez (2002) sustain that ramie is a tropical plant, which tolerates moderate drought and grows better between 200 and 1 800 m.a.s.l. Likewise, it is susceptible to temperatures below 17 ºC, for which it grows well in a range from 18 ºC to 33 ºC (Manual Agropecuario, 2002).

Gómez and Rivera (1987) indicate that it is a very rustic plant and that it adapts well to soil with a loam, loam-clayey or loam-marsh-clayey texture; they should have large quantities of organic matter and good drainage, with a slightly acid pH, which tends to be neutral. Its water needs are important, because it requires rainfall between 800 and 1 000 mm, or complementary irrigation.

The atmospheric dryness and warm and desiccating winds limit green matter production in this species.

Ramie is a crop which has shown high resistance to diseases and pests during several years of evaluation. According to Rubens (2008), its adaptation in some zones and its productive qualities turn it into an alternative that should be taken into consideration for animal production.

Forage quality

Studies conducted in Tucumán, Mexico (Patiño *et al*., 2006), with a rainfall of 950 mm and an average annual temperature of 19,7 ºC, proved that it is possible to cut this species for forage every 45, 60 and 75 days.

The total green matter values oscillated between 96 t/ha and 121 t/ha when the cutting frequency was 45 and 75 days, respectively. Regarding the dry matter contents, the highest percentage was obtained in the cuts every 75 days (whole plant: 23,9 %; stem: 22,8 %; and leaf: 25,3 %). However, it should be emphasized that the material with the best nutritional quality and digestibility was obtained from the harvests every 45 days, and that in this stage the stems are less fibrous and better utilized.

According to Elizondo (2004), the dry matter percentage increases as the age of regrowth or the time interval between successive cuttings increases. The nutritional quality of the leaves decreases when the regrowth age increases, because the crude protein percentage and the neutral detergent fiber also diminish. This author indicates that the leaves and top part of the plant constitute the raw material to produce a meal comparable to that from alfalfa, with 21-24 % of protein and abundant carotene content (140 mg/kg).

The ramie foliage shows crude protein contents higher than most balanced feedstuffs found in the markets, for which it constitutes an excellent source of animal feeding. In general terms, the leaves show a higher dry matter and crude protein content than the stems, for which they represent the best part to feed the animals. According to Boschini and Rodríguez (2002), the nutritional value decreases as age increases, and its composition is similar between 30 and 45 days of regrowth (dry matter: 19,88 %; protein: 26,22 %; fat: 4,74 %; fiber: 24,41 %; ash: 15,15 %; NNE: 29,39 %). In addition, they state that its high fiber content could be a limiting factor for feeding monogastric animals; it contributes volume to the feedstuff, which inhibits assimilation of other nutrients in the pig or bird.

Use of B. nivea in livestock production

There are different studies related to the use of this plant for animal feeding. According to Rubens (2008), when ramie is cultivated for forage up to 14 cuts per year can be obtained, with a production of 300 t of fresh material (42 tons of dry matter) per hectare per year. The foliage is palatable and it has

been proven to be valuable not only for cattle, but also for pigs and poultry.

Ramie can be used as a forage source when its protein content increases between 45 and 60 days after sowing or the last cut (Manual Agropecuario, 2002; Burgos *et al*., 2011).

In this sense, Santos *et al*. (1995) refer to the importance of this plant, due to its excellent fiber production and for constituting a good protein source for animal production, and they recommend its use in goat feeding for milk production.

Some studies about the use of chopped fresh ramie in pig feeding, supplemented with rations of fortified corn (96 % corn; 3,3 % bone meal; 0,5 % iodized salt and 0,2 % pre-mixture of vitamins and ten minerals), reported a daily weight increase of 303, 462 and 503 g in the weaning, pre-fattening and fattening stages, respectively (Castedo, 2004).

In livestock production farms of Guatemala, ramie was tested as meal, elaborated from 0,50 cm-tall plants, and the addition of 5 % of this meal in mixtures of balanced feed for poultry was determined to provide sufficient quantities of vitamin A and riboflavin (Rubens, 2008).

On the other hand, Murgueitio (2000), Murgueitio and Ibrahim (2001) and Murgueitio, Rosales and Gómez (2001) reported that *B. nivea* is widely used in cut and carry systems, as well as in pure protein banks and in gardens, for food security in different zones of Latin America. Many families and farmers use it as feedstuff in different animal categories. The only problem associated with the supply of ramie to livestock is its high absorption of minerals, especially molybdenum, in soils rich in this element; this can be corrected by adding copper sulfate to the animal ration in adequate doses.

Acosta (1997) carried out acceptability trials in poultry feeding and evaluated feed intake at 2, 4, 8, 12 and 24 hours (table 1). Since the 2 hours, intake significantly decreased ($p \leq 0,01$) as the level of ramie in the ration increased. Thus, with 5 % of ramie the intake was 58,6 g, which was reduced to 28,5; 17,3; 15,6; 4,4; 2,0; 0,9 g, with ramie levels of 10, 20, 30, 40, 50 and 100 %, respectively. A similar performance was obtained at 4, 8, 12 and 24 hours of evaluation. The intake decrease was ascribed, among other reasons, to the high fiber content present in the plant (19,2 %). Fiber contributes volume to the feedstuff and thus it prevents the bird from consuming the adequate quantities.

In studies with rabbits, Burgos *et al*. (2011) used several diets as treatments: treatment 1 (T1): 100 % of ramie *ad libitum*; treatment 2 (T2): ramie *ad libitum* and commercial concentrate (CC) as 0,5 % of the live weight (LW); treatment 3 (T3): ramie *ad libitum* and CC as 1,0 % of the LW; and treatment 4 (T4): ramie *ad libitum* and CC as 1,5 % of the LW. The evaluated variables were: forage intake, feces excretion, DM and protein digestibility, fat, non-nitrogen extract (NNE) and crude fiber (CF). In addition, the total digestible nutrients (TDN), digestible energy (DE) and metabolizable energy (ME) were calculated.

The results showed that the palatability of *B. nivea* is excellent, which allows high intakes by the animal; this turns it into a choice as feeding basis in rabbit production. In addition, the importance of concentrate in the diet for rabbits was proven, because a positive associative effect of ingredients is achieved, as the nutritional content of the concentrate increases the utilization of the ramie nutrients, especially that of DM and protein.

Table 1. Cumulative feed intake (g).

Ramie level (%)	Hours				
	2	4	8	12	24
5	58,6^{a}	77,3^{a}	119,8^{a}	146,3^{a}	167,7^{a}
10	28,5^{ab}	46,7^{ab}	105,2^{a}	140,1^{ab}	170,7^{a}
20	17,3^{b}	31,9^{ab}	62,1^{ab}	77,2^{abc}	92,4^{abc}
30	15,6^{b}	35,6^{ab}	52,7^{ab}	60,5^{abc}	61,5^{abc}
40	4,4^{b}	13,4^{b}	24,5^{ab}	26,0^{bc}	39,3^{bc}
50	2,0^{b}	2,5^{b}	3,7^{b}	4,6^{c}	5,4^{c}
100	0,9^{b}	1,5^{b}	3,07^{b}	3,3^{c}	6,0^{c}

a, b, c: different letters in the same column indicate significant differences ($p \leq 0,01$).
Source: Acosta (1997).

In pig feeding, Herrera (2012) also obtained acceptable results in Cuba by substituting 30 % of the protein of the conventional diet (commercial concentrate) by sorghum meal and ramie foliage. Although the individual gains of the animals were lower than in the concentrate-based treatment, more than 86 kg of this feedstuff per pig, as well as $ 22,0 USD per animal, could be saved during the fattening cycle.

Similar results were obtained by Claure *et al.* (2011), when showing that ramie forage intake minimizes the balanced feed intake. In this sense, the total weight gain and daily gain in the growth and finishing stages were higher in the pigs that consumed the diet composed by concentrate feed plus green leaf of ramie.

Regarding the feed conversion, the pigs that received this diet were more efficient than those fed with concentrate feed. It was also proven that the treatment with green leaf of ramie, which shows a higher weight gain, was the most economical.

Industrial uses

B. nivea is used as ornamental plant in the Far East, and from its bark a textile fiber is obtained. Ramie is used since ancient times, as shown by its use in the bandages of mummies in Egypt.

In studies and trials conducted at the Institute of Innovation in Biotechnology and Industry (IIBI) of the Dominican Republic (Salazar, 2006), the fiber is processed to elaborate tablecloths, hammocks, cloths, dolls and others. Syrup and foodstuffs for human consumption are also obtained, paper is produced and food is prepared, mixed with other plants, for children and undernourished pregnant women. Likewise, Kim *et al*. (1993) ascribe importance to the fiber, but they state that obtaining it is affected by the harvest frequency.

CONCLUSIONS

Ramie is an excellent feeding alternative for the different animal species, as proven by the presented results about its nutritional value, the weight gain, feed conversion and favorable economic effect obtained when using adequate forage levels.

In spite of its uncountable uses in feeding and industry, as well as its apparent adaptation to the edaphoclimatic conditions of the tropic, its potential is little utilizable in Cuba, for which it is recommended to study this plant further, mainly concerning animal feeding, and to disseminate the results among livestock producers.

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