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Short Communication

Establishing *Cratylia argentea* in an Ultisol in the West of Acre, Southwestern Amazon, Brazil

Establecimiento de Cratylia argentea *en un Ultisol en el oeste del estado de Acre, Amazonia Suroccidental, Brasil*

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Abstract

Cratylia argentea is a multi-purpose shrub with potential as a source of protein for livestock, but is rarely used in production units. This study aimed to monitor the establishment of a stand of this plant in a sandy Ultisol (Red-Yellow Argisol), in an area of 4,000 m^2 on a rural property in Cruzeiro do Sul, Acre, Brazil, comparing 2 planting methods: (i) transplanting seedlings (78 in total); and (ii) direct seeding (3,820 seeds in 1,910 pits). The existing pasture was sprayed with glyphosate before planting *C. argentea*. Subsequently, herbicide and mechanical methods were used to control weeds, while fertilizer was applied and the area was mulched. In the first year after planting, activities performed and inputs were recorded along with costs in order to create a reference model for those intending to cultivate this species in the humid tropics. At 10 months after planting, average height of plants was 162 cm (range 70–240 cm) with no effect of planting method. Ninety-seven per cent of plants established from seedlings survived, while 81% of pits established from direct seeding in the field had surviving plants. The cost of establishing a hectare of *C. argentea* was US$ 1,654.17, with 85.8% of the cost for labor and only 14.2% for other inputs, although costs of producing seedlings and hand-planting them were not considered. Studies to develop planting systems using less labor seem warranted.

Keywords: Direct seeding, establishment costs, humid tropics, legumes, novel forage, seedlings.

Resumen

Cratylia argentea es un arbusto multipropósito con potencial como fuente de proteína para animales, pero su uso en unidades de producción no es común. Este estudio tuvo como objetivo monitorear el establecimiento de un cultivo de esta planta en un Ultisol arenoso, en un área de 4,000 m^2 en una finca en Cruzeiro do Sul, Acre, Brasil, comparando 2 métodos de siembra: (i) trasplante de plántulas (78 en total); y (ii) siembra directa (3.820 semillas en 1.910 puntos). La pastura existente en el área experimental fue tratada con glifosato antes de plantar *C. argentea*. Posteriormente, se utilizaron métodos mecánicos y químicos para controlar las malezas, mientras se aplicaba fertilizante y material orgánico ('mulch') alrededor de las plantas. En el primer año después de la siembra, se registraron todas las actividades e insumos junto con sus costos, a fin de crear un modelo de referencia para quienes pretenden establecer esta especie en el trópico húmedo. Diez meses después de la siembra, la altura promedio de las plantas era de 162 cm (rango 70–240 cm), sin

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efecto del método de siembra. El 97% de las plantas trasplantadas sobrevivieron, mientras que el 81% de los sitios con siembra directa tenían plantas sobrevivientes. El costo de establecer una hectárea de *C. argentea* fue de US$ 1,654.17, de los cuales el 85.8% fue por mano de obra y solo el 14.2% por insumos, sin considerar los costos de producción de las plántulas y su trasplante manual. Estudios para desarrollar sistemas de establecimiento con menos mano de obra parecen justificados.

Palabras clave: Costos de establecimiento, forraje nuevo, leguminosas, siembra, trasplante, trópico húmedo.

Introduction

Cratylia is a neotropical genus from the Fabaceae family and is widely distributed in South America, especially in Brazil, Peru, Bolivia and northeastern Argentina. In Brazil, *Cratylia argentea* (Desv.) Kuntze is found in various environments such as Cerrado, Amazon and Caatinga. It is a shrub that branches at the base of the stem and reaches up to 3 m in height, with a high capacity for regrowth due to its vigorous root development (Queiroz 1991; Lascano et al. 2002).

The species has potential as a source of forage for both ruminants and non-ruminants, with emphasis on its low concentration of tannin (Sarria and Martens 2013; Silva et al. 2017; Valles-De la Mora et al. 2017; Pereira et al. 2018). It forms a symbiotic relationship with nitrogen-fixing bacteria (Calazans et al. 2016; Mattar et al. 2018), an advantageous characteristic, considering the potential reduction in the acquisition of chemical fertilizers and the importance of N in animal nutrition. The species is recommended for silvopastoral systems (Valles-De la Mora et al. 2014), which are commonly established in some areas of the humid tropics.

Despite its promising characteristics, *C. argentea* develops slowly in the initial stages, an obstacle to its commercial use. Information about the time and cost of establishing the species in different environments is scarce. Therefore, the aim of this study was to monitor the establishment of this species on a rural property located in Cruzeiro do Sul (Acre), in the Brazilian Amazon. Here, we present the methodology used for establishment, its costs and the outcomes.

Materials and Methods

The study was carried out at the Boa Esperança Ranch (07º48'16" S, 72º26'37" W), a private property in the Brazilian Amazon, at the Santa Luzia Settlement Project (PAD Santa Luzia), Cruzeiro do Sul municipality, Acre.

The region has 2 distinct seasons: a rainy season extending from October to April, with an average relative humidity of 88%; and a dry season extending from June to August, with an average relative humidity of 75%. In Cruzeiro do Sul, average annual rainfall is 2,166 mm, while average annual temperature is 25.3 °C, with a mean maximum temperature of 32.7 °C and a mean minimum temperature of 17.1 °C (Duarte 2006).

The performance of 2 planting systems for establishing a 4,000 m^2 stand of *C. argentea* was observed: (i) transplanting seedlings; and (ii) direct seeding in the field. Activities and inputs involved were monitored to calculate the cost of establishment. The soil was a sandy Ultisol, moderately drained (Figure 1A), and originating from sediments of the Cruzeiro do Sul formation in transition to the Solimões formation (Governo do Estado do Acre 2010). This area was planted with *Urochloa brizantha* 15 years ago and was grazed by cattle, remaining unfertilized or renovated during that time. The routine analysis of physical and chemical attributes of soil samples from the 0–20 cm layer revealed that the soil was dystrophic and had medium acidity, with very low rates of exchangeable bases and phosphorus, and very low cation-exchange capacity. These characteristics are typical of the low soil fertility of the region, resulting from intense surface leaching and prevailing production systems.

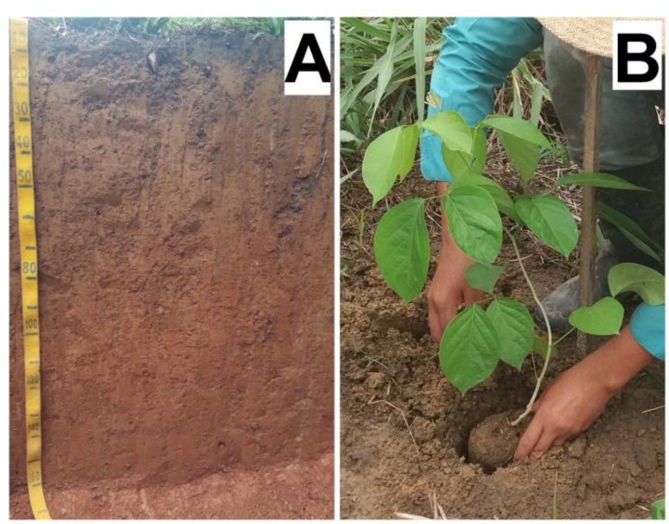

Figure 1. A) Profile of the soil where the study was done, showing its depth; B) Transplanting a *Cratylia argentea* seedling in the field.

Although a cultivar of *C. argentea* has been registered in Brazil (BRS Ceci), commercial seed is not yet available and the seeds used in the experiment were provided by Embrapa Milho e Sorgo, harvested in October 2018 at the Sete Lagoas unit, Minas Gerais. Germination percentage was 84%. Seeds were not inoculated with rhizobia.

For the seedling planting system, seedlings were prepared in 1 L plastic bags filled with a mixture of forest topsoil and sand (2:1 ratio, respectively). A single seed was planted in each bag and seedlings grown out for 4 months before being transplanted into the field (Figure 1B). For the direct seeding treatment (direct seeding into pits), 3,820 seeds were planted in 1,910 pits, with 2 seeds per pit.

In October 2018, at the beginning of the rainy season (Figure 2), the area was sprayed with the non-selective herbicide, glyphosate, at 4 L/ha (450 g a.i./L). After 15 days, small pits (20 cm deep and 16 cm diameter, with an approximate volume of 4 L) were made using a digger and 35 g of dolomitic limestone was incorporated into the soil in each pit. The pits were demarcated with wooden stakes, and a further 15 days later the total area was sprayed again with glyphosate at 4 L/ha.

At the end of January 2019 (approximately 65 days after the pits were prepared) with high levels of rainfall (Figure 2), field planting of seedlings and seeds was carried out. In order to take advantage of the high rainfall in this region, planting would normally occur during October and November if seeds or seedlings were available (Figure 2). The spacing adopted was 2 m between rows and 1 m between plants within rows.

Weeds in inter-row spaces and between plants within rows were removed using a brush cutter (Stihl 220) at 50, 135 and 175 days after planting, in March, June and July 2019, respectively. In addition, at 125 days after planting (June), weeds close to *C. argentea* plants were removed by manual hoeing. Growth of seedlings for the first 6 months was slow, so plants remained small and to reduce competition, the producer should control invasive species (Figure 3A). At 140 days after planting, the plants were fertilized with NPK (5-30-15) (20 g/seedling) at a depth of 4 cm using a manual planter (Figure 3B). At 10 months of age, plants were sufficiently developed (Figure 3C) to allow limited grazing by livestock on a temporary basis.

At the beginning and end of July (middle of the dry season in the Amazon) (Figure 2), in order to conserve soil moisture and to suppress invasive plants, mulch was applied around *C. argentea* plants (diameter of 50 cm). When labor is available, this practice is recommended immediately after clearing as decomposition of plant biomass makes nutrients available to the seedlings.

In September, at the end of the dry period (Figure 2), glyphosate was applied again at 4 L/ha, focusing on the control of weeds between the rows.

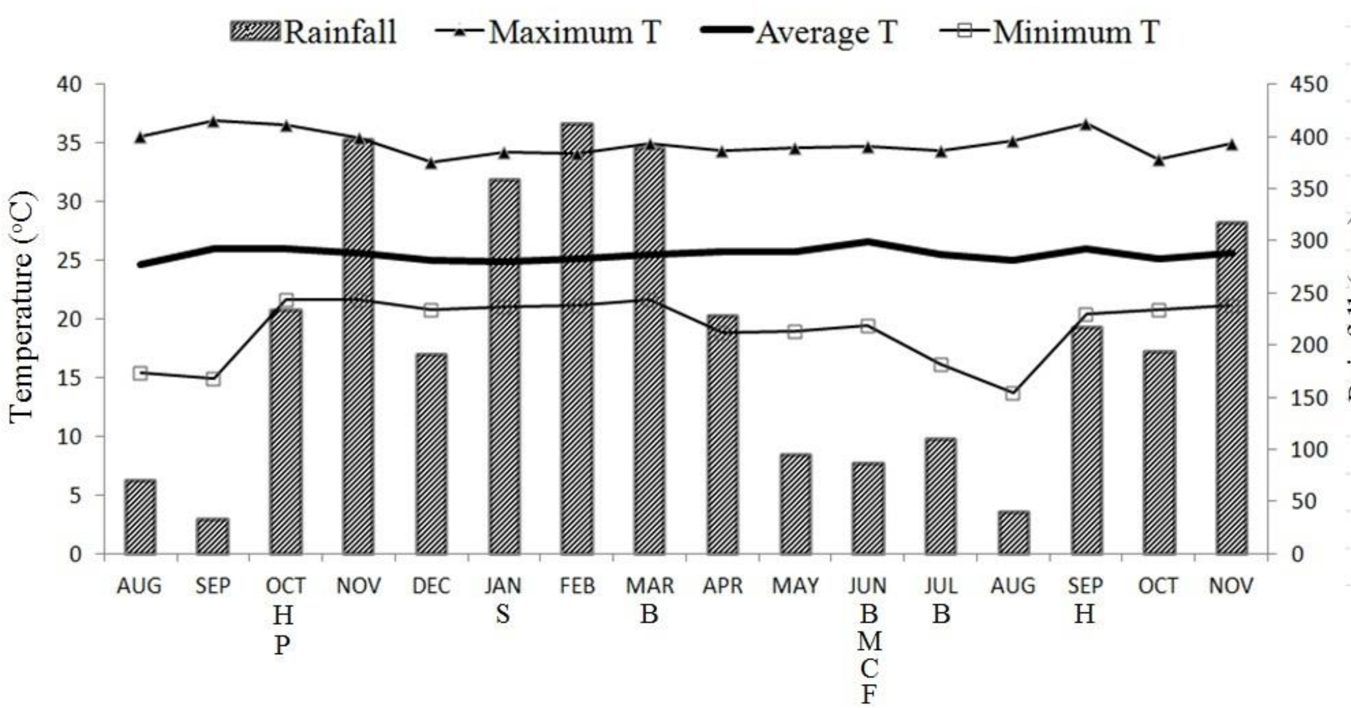

Figure 2. Climatic information of Cruzeiro do Sul, Acre (source: National Institute of Meteorology, INMET): rainfall (mm), mean maximum temperature (°C), average temperature (°C) and mean minimum temperature (°C) in the period August 2018–November 2019. Activities conducted: chemical control of weeds (H); preparation of pits (P); seeding/transplanting (S); brush cutter use (B); manual control of weeds (C); mulch application (M); NPK fertilizer application (F).

Figure 3. A. Size of *Cratylia argentea* plants at 6 months after direct seeding; B. Manual planter; C: Size of the plants at 10 months after planting.

Ten months after field planting (both systems), 30 individual sites were randomly selected for each planting method (seedlings and direct seeding), plant height was measured and the numbers of surviving plants per pit were counted.

To estimate establishment costs, the following values were adopted, based on prices at Cruzeiro do Sul: 80 reais (R$)/man/day, R$ 5.00/L gasoline, R$ 3.00/kg chemical fertilizer (NPK), R$ 1.00/kg dolomitic limestone and R$ 35.00/L herbicide. Costs of equipment depreciation and seeds were not estimated. Seed is not commercially available in Brazil, so there is no reference value. To convert the cost into US dollars, an exchange rate of R$ 5.07/US$ was used, quoted on 27 March 2020.

Results and Discussion

Flowering occurred only in plants established as seedlings (Figure 4), and started at 5 months after transplanting in the field (June 2019), during the period of lowest rainfall (Figure 2). This was not surprising as plants established from seedlings were 4 months older than plants established from seed sown in the field. Flowering possibly delayed the vegetative development of plants due to the translocation of carbohydrates to the reproductive organs, which drained nutrients normally available for growth. Although the plants established from seedlings appeared larger in the first months after planting, this difference disappeared over time. Ten months after planting, there was no height difference between the plants from transplanted seedlings and those from direct seeding. Plants from seedlings had an average height of 160 cm (range 70–240 cm), while plants from direct seeding had an average height of 163 cm (range 105–213 cm). In pits from direct seeding, 81% (1,547 pits) had at least one plant of *C. argentea* per hole, while 66.7% presented 2 plants from the originally sown 2 seeds/pit. This establishment method was obviously successful and acceptable as well as being simple and practical.

Figure 4. Row of flowering and mulched *Cratylia argentea* 6 months after transplanting.

In the seedling system, only 2 of the 78 transplanted seedlings died, resulting in a survival rate of 97.4%. While this system resulted in a higher success rate, it is much more labor-intensive and therefore more expensive. In this study we did not quantify the additional cost of planting seedlings relative to planting seed in the field, which would consist of costs of substrate, plastic bags, production of seedlings, maintenance of seedling stocks in the nursery, transporting of seedlings to the planting area and, finally, planting in the field.

Despite the area being fenced to exclude grazing cattle, animals fed on parts of the plants near the fence. When branches were cut and made available to cattle, the animals congregated readily and consumed the edible parts, indicating that foliage is palatable (Figure 5).

Establishing the 4,000 m^2 stand involved a total cost of R$ 3,355 (US$ 661.74), with 85.8% of this cost being for labor and 14.2% for other inputs (Table 1). This cost breakdown may be favorable for family farmers, who often have limited investment capital available, but might have family labor. Preparation of the pits incurred more than 50% of the labor cost. The use of agricultural implements for opening furrows or pits should be considered if available.

Figure 5. Beef cattle feeding on *Cratylia argentea* forage cut from the area.

Table 1. Costs for establishing 4,000 m^2 and 1 ha of a *Cratylia argentea* stand in reais (R$ - official currency of Brazil) and in US dollars (US$ - official currency of the USA).

Type of cost	Cost per unit			4,000 m^2			1 ha		
	Unit	R$/Unit	US$/Unit	Amount	R$ Total	US$ Total	Amount	R$ Total	US$ Total
1. Inputs									
Gasoline	L	5	0.99	15	75	14.79	37.5	188	36.98
Herbicide	L	35	6.90	6	210	41.42	15	525	103.55
Limestone	kg	1	0.20	70	70	13.81	175	175	34.52
Fertilizer	kg	3	0.59	40	120	23.67	100	300	59.00
Subtotal					475	93.69	-	1,188	234.05
2. Services									
Spraying	Man/day	80	15.78	2	160	31.56	5	400	78.90
Pit preparation	Man/day	80	15.78	20	1,600	315.58	50	4,000	788.95
Planting	Man/day	80	15.78	2	160	31.56	5	400	78.90
Hoeing	Man/day	80	15.78	6	480	94.67	15	1,200	236.69
Mowing	Man/day	80	15.78	3	240	47.34	7.5	600	118.34
Fertilizing	Man/day	80	15.78	1	80	15.78	2.5	200	39.45
Mulching	Man/day	80	15.78	2	160	31.56	5	400	78.90
Subtotal				36	2,880	568.05	90	7,200	1,420.13
Total				-	3,355	661.74	-	8,388	1,654.18

Conclusions

The study has demonstrated that *C. argentea* can be established readily in the study area by the use of seedlings produced in a nursery or from direct seeding in the field. Plants established by both methods were similar after 10 months, so the choice of establishment method would depend on personal preference. Since about 86% of the cost of establishment consisted of labor costs, development of a system for greater use of machines and reduction of labor inputs should be a matter of priority. Since costs of labor for producing and planting seedlings were not included in this assessment, actual establishment costs for the seedling method would be higher than those listed. While survival of plants established from seedlings was higher than from sowing seed in the field, the greater labor requirement for the seedling planting system could be an important limitation to adopting this strategy.

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