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APPLYING NENDO DANGO TECHNIQUE FOR GERMINATION AND PRE-ESTABLISHMENT OF NATIVE SPECIES ON DEFORESTED AREAS

SUMMARY

Nendo Dango is a planting technique created by the agriculturist and microbiologist Masanobu Fukuoka, around the 1940's decade, to reforest some zones of the Asiatic continent with tendency to desertification, while developing the Fukuoka method with no-tillage, also called wild agriculture. This paper's goal was to evaluate this technique's efficiency on germination and pre-establishment of native species seeds in a deforested area in the Brejo Comprido's stream riverbank, in Palmas, state of Tocantins, Brazil. Eight types of native species seeds were selected, arranging them into lake-originated-clay balls around 2 to 3 cm large, disposed in 0.5 meters interspacing, forming an experiment field of 8 m², designed with 5 sample lines and 3 repetitions for statistical analysis, totalizing a 24 m² area. Nine data acquisitions were made to input into calculation the parameters germination percentage (GP), germination velocity rate (GVR) and required germination time (RGT). Results had shown a GP varying from 26.7% to 100%, where 5 of the 8 species seeds well-thrived the environment conditions applied, as well as a GVR varying from 0.36 to 1.35 individuals per day and an RGT varying from 0.17 to 0.26 seeds per day. In a general picture, the technique proved to be efficient for the proposed experiment and chosen native species, supplying the seeds with a good pre-environment for successful germination and pre-establishment.

Keywords: No-tillage, Seeds germination, Clay balls, Cerrado biome, Reforestation, Wild agriculture

INTRODUCTION

Human activities have become more frequently the reason of degraded environments appearance nowadays, in terms of deforestation, pollution, agriculture and a serie of other many economic-related actions required to sustain modern life. The recovery of these areas, direct or indirectly, demand priority on reestablish the biota's natural conditions, throughout initiatives and projects whose are less expensive and based on sustainability, primarily (Bastos &

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Ferreira, 2010). Speaking of recovery, since the 1940's decade Masanobu Fukuoka, an agriculturist and microbiologist known by his minimally invasive planting methods, has developed a technique called "Nendo Dango", which consists of placing seeds into clay balls and release these into the environment for replant once-loss threes in deforested or with desertification tendency areas (Fukuoka, 1985). The main purpose of this technique is to protect the seeds from predators and inclement weather, without using any pesticides or herbicides, while involving the seed onto a clay ball, which provides a secure and stable environment for it to germinate and pre-establish into the soil (Fukuoka, 1991). This technique has been used all around the world for the most variated motives, as recovering green urban areas or filling green protected areas in underdeveloped countries in South America, Africa and Asia (Torres, 2010).

The area chosen for the experiment procedures was previously base for a sewage treatment plant, in the city of Palmas, which the degradation became from deforestation and soil pollution, altering the local ecosystem and affecting punctually the Brejo Comprido's riverbank, as well as the water. Once the plant was disabled, the area was abandoned and turned into a place for irregular domestic residues disposal. For the technique to work, the area was cleaned up from all the residues disposed and they were sent to the Palmas' landfill. Thus, this paper's main goal was to evaluate "Nendo Dango" efficiency on germination and pre-establishment of native species' seeds on a deforested area in the Brejo Comprido's stream riverbank, at the city of Palmas, state of Tocantins, Brazil.

MATERIAL AND METHODS

Species Selection and Management

Considering factors as species' genetic variability, most occurrence in remaining riparian wood and easy collection, eight native species, which occur in Cerrado biome, were selected. The seeds were cleaned, let exposed 2 days to dry and stored under temperature between 16°C and 18° at the Laboratory of Environmental Impacts Characterization.

Table 1. Chosen species for the experiment

SCIENTIFIC NAME	SUCCESSIONAL CLASSIFICATION
<i>Tabebuia roseoalba</i> (Ridl.) Sandwith	Secondary
<i>Sterculia chicha</i> A. St.-Hil. ex Turpin	Pioneer
<i>Tabebuia heptaphylla</i> (Vell.) Toledo	Secondary
<i>Anadenanthera falcata</i> (Benth.) Speg	Pioneer
<i>Calophyllum brasiliense</i> Cambess	Secondary/Intermediary
<i>Guazuma ulmifolia</i> Lam.	Pioneer
<i>Hymenaea stigonocarpa</i> Mart. ex Hayne	Late Secondary and Climax
<i>Bowdichia virgilioides</i> Kunth	Secondary

For the Nendo Dango technique it is not necessary to scarify or break dormancy of the seeds. Table 1 shows the scientific name and successional classification of the chosen species.

Clay Origins and Management

For the experiment was used clay originated from the drain work of a lake within the Cesamar Park (Figure 1), also localized at the city of Palmas, under license and supervision of the park's authorized staff. To obtain the material was used pottery shovel and three tow bags.



Figure 1: Source of the clay for the experiment

Procedures for Clay Balls Production

For the method execution, the soil where the clay balls with seeds were released was not plowed, pruned or weeded, as well as applied any type of pesticide, fertilizer or herbicides, as essentially demanded by Fukuoka (1985). The clay removed from the drain work was previously arranged into blocks, which were broken down into smaller pieces with an octave hammer and sifted with a 0.005 mm sieve. After sifted, four kilos of the clay powder were set aside into a plastic tray, measuring 9.7 x 30 x 49 cm. The humidification process was executed by adding half a liter of water onto the powder and hand-mixed until form a consistent and homogeneous mass, enabling it to produce disks to insert the seed and then mold it into firm balls (Figure 2).



Figure 2: Clay mass and some of the clay balls already seeded

Each ball weighted an average of 70 g and had 2 to 3 cm diameter. This variance of size was dictated by the size of the seed, in order to supply enough clay mass for it to not crack and/or get external exposure for predators or inclement weather. Once ready, the seeded-clay-balls rested in room conditions to get some drying and prevent sudden cracking under the overheated external temperature. The release period occurred 30 days before rainy season in the city of Palmas, state of Tocantins, Brazil, as recommended by Fukuoka (1991).

Experiment Disposal onto the Soil

The Nendo Dango method essentially says that it must be applied through no-tillage and randomly sowing the seeded-clay-balls onto the soil, which are subject for recovery/reforestation, but, in order to get research control and data acquisition, the experiment had to be designed with clear guidelines and field markings. For that, the chosen disposition was the zig-zag rule (Figure 3) and the field was isolated with zebra ribbon.

Each ball was interspaced only by 0.5 m, whereas the experiment did not expect them to grow into full form, i.e., just germination and pre-establishment period. At the end, the area was constituted by experiments of 8 m², with 5 sample lines, 8 treatments (species) and 3 repetitions, totalizing 24 m². The data acquisition occurred during 37 days, 3 times per week, using caliper rule, scaler and notepad. In the last day of counting/collecting data, the germination average rate was calculated.

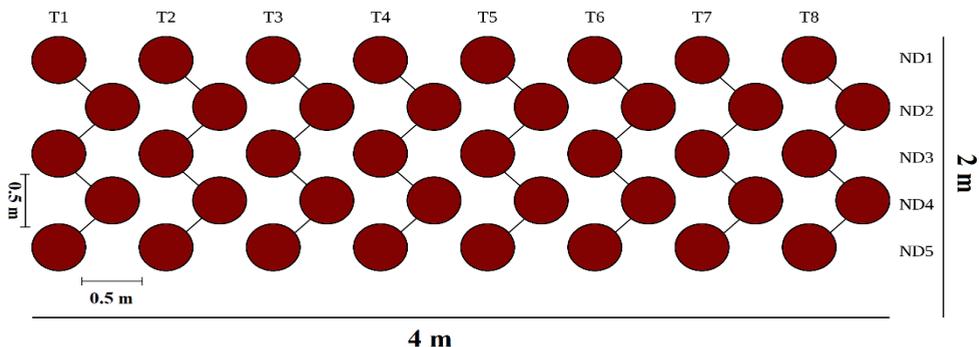


Figure 3: Design of the experimental field

Statistical Analysis

The treatments were outlined through completely randomized design with three repetitions/blocks, each repetition/block had eight treatments/species (Table 2) and each treatment had five samples, totalizing 40 clay balls for each repetition and 120 for the experiment.

For purposes of germination, the analyzed parameter was the number of germinated samples of each specie during the data acquisition period. Seeds which emerged seedlings elevating the cotyledons 5 cm above the soil were considered germinated (Brown, 1992).

Table 2: Indication for treatment into statistical terms

TREATMENT (T)	SCIENTIFIC NAME
T1	<i>Tabebuia roseoalba</i> (Ridl.) Sandwith
T2	<i>Sterculia chicha</i> A. St.-Hil. ex Turpin
T3	<i>Tabebuia heptaphylla</i> (Vell.) Toledo
T4	<i>Anadenanthera falcata</i> (Benth.) Spig
T5	<i>Calophyllum brasiliense</i> Cambess
T6	<i>Guazuma ulmifolia</i> Lam.
T7	<i>Hymenaea stigonocarpa</i> Mart. ex Hayne
T8	<i>Bowdichia virgilioides</i> Kunth

The data of germination percentage (GP) (Eq. 1), germination velocity rate (GVR) (Eq. 2) and required germination time (RGT) (Eq. 3) were analyzed under Tukey test with 5% of probability, using the software Assisat 7.7 (Maguire, 1976; Labouriau & Valadares, 1976; Silva & Azevedo, 2006). The GVR is a rate calculated by means of counting the germinated seeds and has the goal of establish the differences in the germination velocity on accesses, groups and batches of seed, i.e., the greater the GVR value is, greater will be the daily germination, indication good treatment choice (Brasileiro *et al.*, 2008).

$$GP = \frac{N}{A} \times 100 \quad (\text{Eq. 1})$$

Where GP means percentage of germination, N means total of germinated seeds and A means total of seeds sown to germinate.

$$GVR = \frac{G1}{N1} + \frac{G2}{N2} + \frac{G3}{N3} + \dots + \frac{Gn}{Nn} \quad (\text{Eq. 2})$$

Where GVR means germination velocity rate, G means number of seedlings in each counting, and N means number of days after clay balls release.

$$RGT = \frac{\sum \frac{Ni}{Ti}}{\sum Ni} \quad (\text{Eq. 3})$$

Where RGT means required germination time, Ni means number of seeds germinated in the nth day, and Ti means time (in days).

RESULTS AND DISCUSSION

Germination Percentage (GP), Germination Velocity Rate (GVR) and Required Germination Time (RGT)

Table 3 shows results obtained from the experiment after 37 days. The data indicated a slight variation among the species, whereas they presented, in general, a different behavior because of the conditions induced by the clay ball and/or the external environment. These differences may also be explained by the

necessities that each specie has in order to germinate, as said before, because of scarification and/or dormancy break, which any of those were made/required by the technique.

Table 3: Amount (N), Germination Percentage (GP), Germination Velocity Rate (GVR) and Required Germination Time (RGT) for the species in the experiment

SPECIE	N	GP	GVR	RGT
<i>Tabebuia roseoalba</i> (Ridl.) Sandwith	10/15	66.67%	0.90	0.22
<i>Sterculia chicha</i> A. St.-Hil. ex Turpin	12/15	80.00%	1.08	0.26
<i>Tabebuia heptaphylla</i> (Vell.) Toledo	8/15	53.33%	0.72	0.17
<i>Anadenanthera falcata</i> (Benth.) Speg	15/15	100.00%	1.35	0.26
<i>Calophyllum brasiliense</i> Cambess.	12/15	80.00%	1.08	0.26
<i>Guazuma ulmifolia</i> Lam.	4/15	26.67%	0.36	0.18
<i>Hymenaea stigonocarpa</i> Mart. ex Hayne	15/15	100.00%	1.35	0.26
<i>Bowdichia virgilioides</i> Kunth	11/15	73.33%	0.99	0.24
TOTAL	87/120	72.5%	-	-

Among the germinated species, only *Calophyllum brasiliense* Cambess and *Hymenaea stigonocarpa* Mart. ex Hayne are classified as secondary, which can indicate that even needing shading to grow within the ecological succession, they distinctly presented satisfactory outcomes when put under the “Nendo Dango” technique. This may have occurred because of the microclimate generated within the clay ball, protecting the seeds on their early stages of development under the local high temperatures, turning to be a positive factor for their fixation in reforestation projects using this method.

The table data also shows that the species presented very similar RGT, i.e., even all the seeds did not have turn into seedlings, their timing to germinated was almost the same. It is noticeable when looking at *Guazuma ulmifolia* Lam and *Tabebuia heptaphylla* (Vell.) Toledo, which had the lowest GP, but, even so, presented a high RGT.

Experiment Yields and Statistical Analysis

As mentioned before, the experiment counted with 3 repetitions. In the first (R1) there was a total of 40 seeds which 33 had germinated, yielding 82.5%. R2 had 40 seeds as well, germinating 30 and yielding 75%. Repetition R3 also had 40 seeds and had germinated 24, yielding 60%. The results from the Nendo Dango technique indicated differences when analyzing the yields of each repetition and of each specie. An example for that is the R3 yield of 60%, when compared to the 100% germination of *Hymenaea stigonocarpa* Mart. ex Hayne, within this same repetition. Table 4 shows the statistical analysis of the data obtained from GP, GVR and RGT. The species *Anadenanthera falcata* (Benth.) Speg. and *Calophyllum brasiliense* Cambess did not presented significant differences on the GP and GVR, and the main hypothesis may be because the results' similarity and the way that the seeds were disposed next to each other, i.e., under the same external environment conditions.

Table 4: Statistical analysis for GP, GVR and RGT at the end of 37 days*

TREATMENT (T)	GP	GVR	RGT
T1	66.67 ^b	0.90 ^b	0.22 ^a
T2	80.00 ^a	1.08 ^a	0.26 ^a
T3	53.33 ^b	0.72 ^b	0.17 ^a
T4	100.00 ^a	1.35 ^a	0.26 ^a
T5	80.00 ^a	1.08 ^a	0.26 ^a
T6	26.67 ^b	0.36 ^b	0.18 ^a
T7	100.00 ^a	1.35 ^a	0.26 ^a
T8	73.33 ^b	0.99 ^b	0.24 ^a

*Tukey test at 5% probability. Data followed by the same letter did not differ statically among each other.

The other species from the experiment had shown significant differences when analyzed under the parameters of GP and GVR. An explanation for it is the results' difference related to the GP, influenced by the same variables. Overall, the experiment did not show significant differences related to RGT when compared among the species, possibly explained by the similar beginning time for germination, early in the 37 days of experimentation.

According to Santos *et al.* (2004), in a study carried out for *Sterculia chicha* A. St.-Hil. ex Turpin germination analysis, when adopted scarification, the GP results were between 20% and 60%, and, when not scarified, 50%. Silva *et al.* (2015), in a similar study, obtained GP between 20% and 40%. The same authors reported that the seed takes within 20 to 30 days to germinate. With the Nendo Dango technique it took 17 days.

Studies carried out by Oliveira *et al.* (2012) and Sena *et al.* (2017), using the *Anadenanthera falcata* (Benth.) Speng., registered GP varying from 68% to 100%, when treated with vermiculite, sand and humus, without any light, applying temperature around 25° to 30°C. NCPI - Northern Center of Plants Information (2003) found out the germination time to be within 2 to 33 days. Using Nendo Dango, this specie took 2 days to germinate.

Grabias *et al.* (2013) performed an experiment using *Calophyllum brasiliense* Cambess, sown with vermiculite, obtaining GP between 60.83% and 63.33%. Nery *et al.* (2007) tested seeds of the same specie, scarifying it and putting under thermic conditions of 25 to 30°C, also using as substratum a Germitest® paper roll wet with distilled water, which has resulted GP between 70% and 88%. Carvalho (1994) says that this specie's germination normally occurs within 6 months, and, for the experiment developed, the Nendo Dango technique presented germination in 17 days.

Figliolia *et al.* (2009) tested *Guazuma ulmifolia* Lam putting the seed under treatment with vermiculite in laboratory and registered GP of 55 to 66%. Barboza *et al.* (2014) says that the GP for this specie, when put under treatment with thermal shocks around 80°C and 100°C, can vary from 73% to 76%. Scalon *et al.* (2004) observed in seeds of *Guazuma ulmifolia* Lam GP from 71.7% to 73.3%, when treating it with infusions on boiling water during 5 and 10 minutes.

Nunes *et al.* (2006) verified that when exposing the seed to 70°C heat and staying still until reaches 50°C (taking approximately 30 minutes), it presented GP of 66.8%. Barroso *et al.* (1993) and Ramos *et al.* (1998) indicate that this specie takes within 6 to 14 days to germinate, and, when using Nendo Dango, it took 19 days.

In early studies, *Hymenaea stigonocarpa* Mart. ex Hayne presented GP between 7% to 78.3% (Moraes *et al.*, 2001), taking between 9 to 60 days to germinate after sown, under conditions of pre-germination treatment, with manual scarification, using emery paper on the opposite side of the germinal axis (Carvalho, 2007). Using Nendo Dango this specie took 13 days to germinate. Other studies using different types of scarification obtained GP results from 37% to 52% in vegetation houses and 52% to 86% in laboratory (Carvalho *et al.*, 2005).

In the experiment of Duarte *et al.* (2010), the germination of *Tabebuia roseoalba* (Ridl.) Sandwith occurred between 8 to 18 days, considering that they were scarified, and presented GP of 40%. Lorenzi (1992) argues differently saying that its dormancy only breaks within 3 months, and, in his study, his experiment's goal was to confront some germination data and verify if, in natural conditions, the GP would occur using the same Duarte *et al.* (2010) applied methodology. In this experiment, using Nendo Dango, the specie took 15 days to germinate.

Lorenzi (1992) also tested the germination of *Tabebuia heptaphylla* (Vell.) Toledo and said that, if scarified, the specie germinates within 10 to 12 days. In his experiment the GP was 60%. Applying Nendo Dango enabled this specie to germinate in 20 days.

For *Bowdichia virgilioides* Kunth, according to Marcos Filho (2005), the main cause of its seed dormancy is the tegument impermeability and hardness. Studies made for this specie's germination presented GP from 2.1% to 11%, when manually or chemically scarified (Schatral & Fox, 1994; Allen & Meyer, 1998). The same authors point out that it takes up 5 to 20 days to germinate, and, in this study, Nendo Dango made it happen within 16 days.

CONCLUSIONS

The Nendo Dango technique, in this study, considering all the taken conditions, well proved its efficiency on germination and pre-establishment of the seeds and seedlings into the deforested area used as experimental field. Comparing to the literature, most of the chosen species for this experiment had similar germination time and percentage. Not specific studies for GVR (germination velocity rate) and RGT (required germination time) were found to compare the results to, which opens up possibilities to expand the literature data about this subject. Speaking of further studies, it's fundamental that improvements must be done to enhance the technique in terms of inserting scarification, breaking of dormancy and/or pre-treatment of the seed before sown at the field, helping it to be even more successful.

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