# Development of a control method for the exotic invasive species *Artocarpus heterophyllus* Lamk. (Moraceae) in Ilha Grande State Park, RJ, Brazil.

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## 1. Introduction

Nowadays, with the increasing number of studies in biological invasions (Oliveira, unpublished data) we know better how the process occurs, what causes it and its inherent consequences (Lowe *et al*., 2002). Prevention is still the best way to limit and slow the increasing number of problems associated with non native species and biological invasions (ESA, 2004; Richardson and Thuiller, 2007). Predicting the ecological behavior of a species in a new environment is difficult and may be effectively impossible (Williamson, 1999). It occurs because many biological, environmental, and anthropogenic factors interact to determine the distribution and the success of invasive species (Wilson *et al.* 2007).

*Artocarpus heterophyllus L*. (Moraceae) commonly known as jack fruit tree is a large evergreen late successional shade-tolerant species, that exists in three contrasting light conditions which gives it perfect conditions to grow and spread (Khan, 2004). It grows naturally in the sub-canopy of moist tropical and subtropical forests in India in up to 1300 m elevation (Khan, 2004). Jackfruit tree was introduced in Brazil during the XVIII century and nowadays it is spreaded in almost all of the Brazilian territory (Lorenzi *et al.*, 2003). Jackfruit tree can produce up to 100 fruits per year, and some of them weighing over 36 kg (Khan, 2004). In the Atlantic forest the frugivores eat a large diversity of small fruits. Despite the biodiversity of the Atlantic forests, there are no equivalent fruits with the size of jackfruit (Lorenzi et al., 2003; Pizo *et al*., 2010).

At Ilha Grande, jackfruit tree has an asynchronous fruiting throughout the year, although most of the trees produce fruit during the summer months (December-February) (Raíces *et al.*, 2008). In a study that has been conducted by the Laboratory of Small Mammal Ecology at Rio de Janeiro State University (UERJ), in Ilha Grande, the results showed that the small mammal community changed among areas with and without jackfruits (D. Raíces and H.G. Bergallo, unpublished data). Seed-dispersion is a fundamental process for the maintenance of tree diversity, especially in high competitive forests where it may reduce sibling competition by removing seeds from high mortality areas, decrease genetic-relatedness of patches and enable the species to colonize gap (Armelim and Mantovani, 2001). Lizards, monkeys, bats and small mammals are amongst the main consumers, dispersers and hoarders of jackfruit seeds (Raíces *et al*., 2008, Khan, 2004). These interactions between fruit dispersers and jackfruit affect the native trees dispersal and recruitment (Galetti, 2001), since dispersers change their foraging habits and disperse jackfruit seeds instead of native seeds. Considering the process of an ecological meltdown, another step of this was studied by Rohr (2008) who observed a loss of soil fertility especially nitrogen, when he compared the litter layer of areas with jackfruit and without jackfruit.

In this context and using the TNC Weed Control Methods Handbook (2001), the aim of our study is to propose a method to control jackfruit in Ilha Grande. We tested the hypothesis that the chemical method (injecting herbicide in the bark) would be more efficient than the mechanical method (ringing the tree, removing the basal bark).

## 2. Methods

2.1.Area of study

The study was carried out in Ilha Grande, municipality of Angra dos Reis, Rio de Janeiro (11'07"S and 23 ° 44 ° 12'02"W). Ilha Grande is an island that is covered by Atlantic Forest in different stage of regeneration. Its area has about 190 km² with elevation ranging from 0 to 1031 m. The climate is hot and humid, with an average annual rainfall of 1,500 mm and average annual temperature of 22.5 ° C (Modesto e Bergallo, 2009). We used 10 plots with different densities of jackfruits measuring 80 x 80 m each (6,4 ha). Each plot was treated with only one of the treatments.

2.2. Describing the new method to controlling jack fruit.

The TNC Weed Control Methods Handbook (2001) recommends developing an adaptative management diagram for making any decisions (see Figure 1):

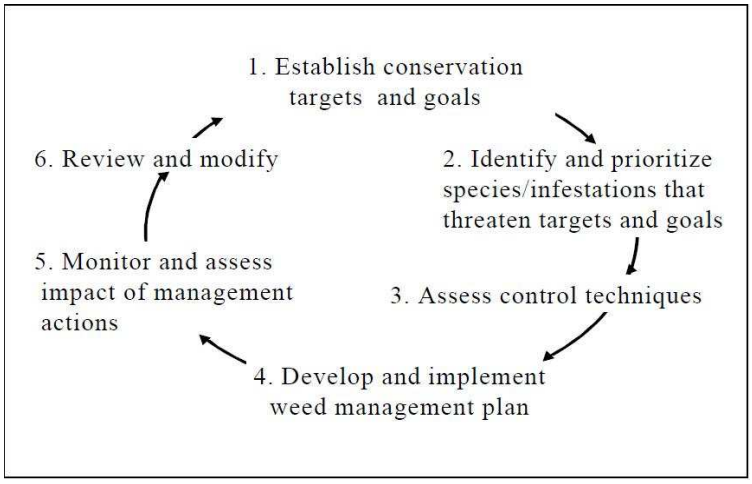


Figure 1: Adaptive management approach (TNC, 2001).

Until today the most common strategy used in Brazil to control *A. heterophyllus* has been the basal bark method. We decide to use this established method and compare it to the new method of drilling a hole and apply injected herbicide into the inner bark to control the jackfruit tree populations. Tu *et al.*. (2001) recommended using the drill treatment rather than cutting, for trees with DBH greater than 3 inches or 7,62 cm. We opted to test the methods only in the adults considering the diameter of breast high DBH>15cm (Abreu, 2005). For every tree measured we use the following parameters: DBH using a diametric tape and converting circumference at breast high - CBH to DBH, trunk high (TH) estimated as the height of the first branch which represents the commercial trunk and number of fruits in every tree. All trees were marked with a number to be measured after the treatment. Campos *et al.* (2002) used a similar method in his study and presented the results after 4 months. Because of the climate in the tropics and specially of this site where the climate is hot and humid, with an average annual rainfall of 1,500 mm and average annual temperature of 22.5 ° C, the inspections occurs in a period 60 days after the first treatment and was carried out every 60 days during a 12 month period.

Three states were adopted as a protocol for monitoring the treatment: normal (tree that not responded to the treatment); senescent (tree with leaf loss due to the treatment) and dead (tree without leaves, fruits and sprouts).

A. Mechanical method – Ringing the basal bark

This method consists in remove the bark around all the circumference of the trunk (ring) of the target plant, as close as possible to the ground to prevent re-sprouts below the ring. The removed bark must be cut deep enough at least 1/2" into the trunk to remove the vascular cambium, or inner bark, the thin layer of living tissue that moves sugars and other carbohydrates between areas of production (leaves), storage (roots), and growing points. This inner cambium layer also produces all new wood and bark. The cuts were done using a machete or an axe.

Figure 2 – Ringing the basal bark method: removing the bark around all the circumference of the trunk.

B. Chemical method – Drill hole

Each tree was drilled with a power drill, a metal screw or other drilling tool that has a 3/8 drill bit for steel use. Herbicide is then immediately applied into the hole with a 50 ml syringe for veterinary use. In an attempt to make it easier in field, we tested a new method drilling one hole for each 10 cm in DBH so a 28 cm DBH tree would require at least 3 holes (Jack McGowan-Stinski, personal communication). Holes should be drilled at a slight downward angle to prevent the herbicide from running out, and should be deep enough to penetrate the inner bark or growing tissue approximately 5 cm. The holes were filled immediately after drilling with 1 mL of the herbicide dilluted in water in 4% concentration which was applied using a synthetic plaster for carpentry use. The plaster worked like a sign that ensures that no holes are overlooked by the herbicide applicator.

Figure 3 – Using the power drill.

Figure 4 – Hole after the drill. The white color is from the synthetic plaster.

The ESA, 2004 describes that chemical control (using pesticides, herbicides, or fungicides) can be effectively used to kill invasive species, but it can be problematic due to impacts on non-target organisms, including humans. In our case we opted to use the drill hole method recommended by Tu *et al.* (2001) to avoid the remote possibility of some of these negative effects to occur. These authors presents a long list of herbicides with properties (band names, chemical name, herbicide family, target weeds, mode of action), their behavior in soils and water, degradation mechanism and toxicity. The chosen herbicide was the Triclopyr - [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid used at the dilution 4% of concentration using water as vehicle. We used analysis of variance (ANOVA) to test the differences between both methods in the survival of the trees.

## 3. Results

The basal bark method was done in 196 trees, whilst the chemical method in 120 trees. The results showed that the chemical method was more efficiency than the mechanical method. After 60, 150 and 240 days since the beginning of the treatment, we could observe that the methods differed significantly only after 60 days (ANOVA, F= 9.001, p=0,017 - 60 days, F=5.719, p=0.004 – 150 days, F=0.961, p=0.356 – 240 days, Figure 4).

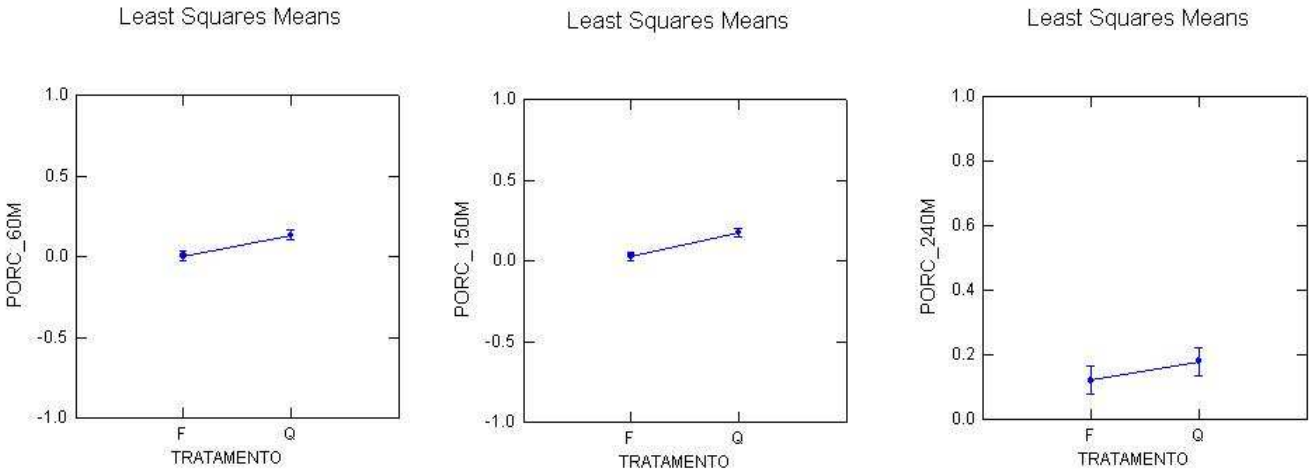


Figure 5: Percentage of dead trees after 60, 150 and 240 days since the beginning of the treatment.

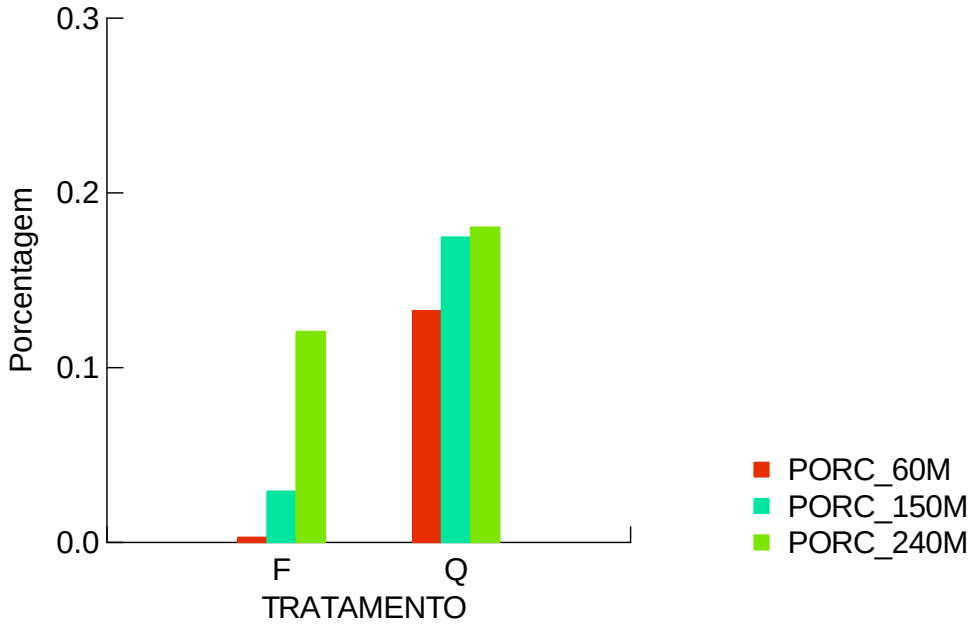


Figure 6 – Percentage of dead trees after 60, 150 and 240 days since the beginning of the physical and chemical treatments. The differences were significantly (p=0.017) after 60 days.

The analysis of the percentages of trees during the experiment (60, 150 and 240 days) described a pattern of response time is different among the treatments. State changes in the chemical treatment occurs prematurely (60 days) compared with the physical treatment (Figure 7).

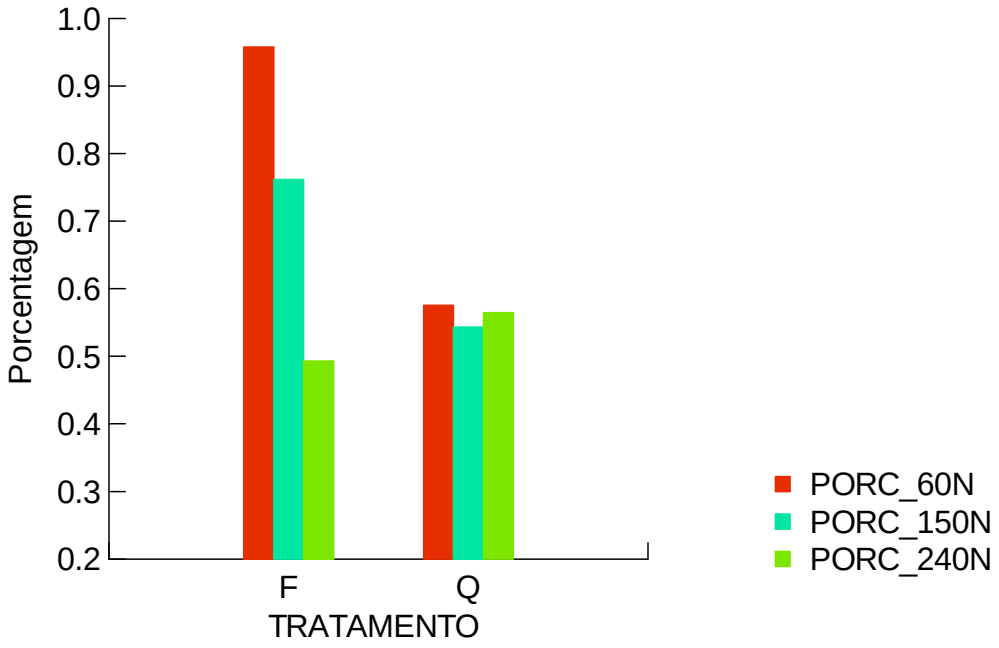


Figure 7 – Percentage of normal trees after 60, 150 and 240 days since the beginning of the physical and chemical treatments. The differences were significantly (p=0.014) only after 60 days.

The result shows no correlation of mechanical method to DBH. The results had no significance with the passage of time 60 days (p = 0,415), 150 days (p = 0,975) and 240 days (p = 0.804), after analysis with the statistical test of Kruskal -Wallis.

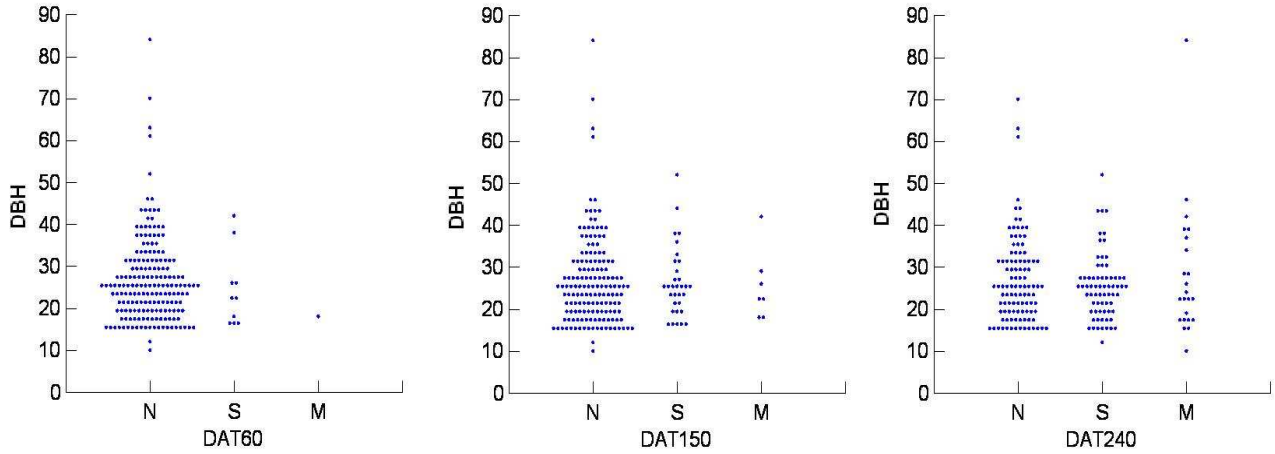


Figure 8 – Response to mechanical method after 60, 150 and 240 days since the beginning of treatment on dependence of DBH.

However the chemical method is dependent of DBH. The results showed significance with time 60 days (p = 0,009), 150 days (p = 0,039) and 240 days (p = 0.013), after analysis with the statistical test of Kruskal -Wallis

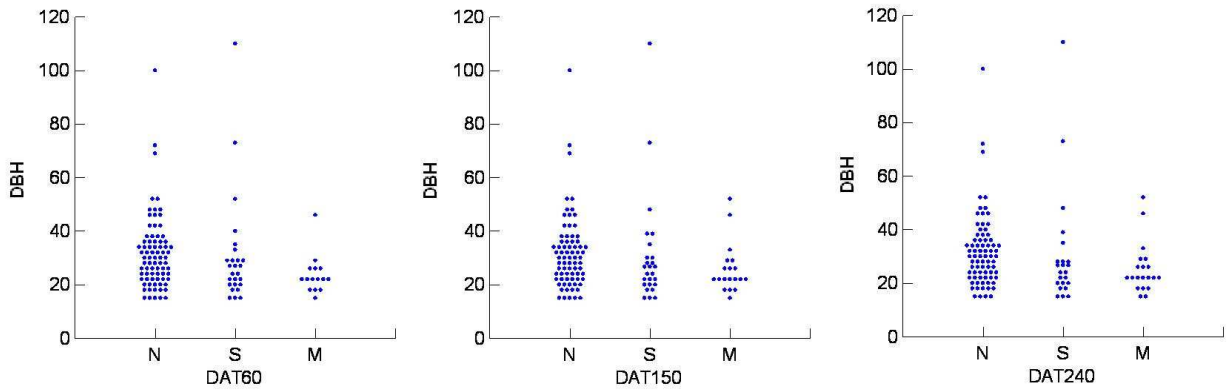


Figure 9 – Response to chemical method after 60, 150 and 240 days after the beginning of treatment on dependence of DBH.

Considering the ecological and physiological differences of each species, Campos *et al*. (2002) noted that for *Acacia dealbata* application of Garlon 4% in stump, after the overthrow led to a satisfactory rate of mortality (mt > 85%). The same result was found for the species *Acacia melanoxylon* by Santos and Monteiro (2007) using the same methodology of Campos (2002) where it reached a mortality rate of 95% for *A. dealbata*. In this sense the rate achieved for this study tends to evolve with the implementation of further experiments, testing higher concentrations and different application methods. Marching and Marching (2004) recommend to the species *Robinia pseudoacacacia* the use of triclopyr at 25% of concentration. Also in this sense the authors recommends that monitoring is essential because although apparently dead, the species can resprout even years after treatment with herbicide.

## 4. Conclusions

It's now clear the vantages of the drill hole method are when comparing to the basal bark method. Less money is spent, more results are generated and one of the most important things that we can't measure in this paper is the perception of the community. In this study the jackfruits are part of the forest with densities ranging between 25 to up 200 individual per hectare (H. G. Bergallo, unpublished data). Non trained observer (tourist or inhabitant) can not perceive the jackfruit as something damaging the environment, and can get angry with the control of plants. As the control is not accompanied by proper information from the park administration and because the people does not have a proper environmental education, the physical killing of the jackfruit tree is commonly attacked by journals and other medias, as well as by people who love nature passionately but who do not understand the whole process. This may sometimes be because the people who take the decisions don't inform the public properly or engage in any kind of environmental education of the local community (and public in general) before starting to control the invading species. In some cases the efforts to calm down local communities are greater and more difficult than the control by itself. The sight of the forest after the basal bark treatment can be disheartening especially in high densities areas like we mentioned before because the white ring formed when bark has been removed can be spotted from far. All of these perceptions concepts are objective and idiosyncratic but this is the reality. Here is important to remember that this particular work was done within a park and the plots are often crossed by trails or run besides trails which tourists passing by everyday. In contrast the drill hole method is almost imperceptible and can be considered a less invasive method.

Considering the opinion and the performance of the workers in the 4 days during the activity to cut the bark using a machete or an axe the activity is exhaustive and can cause repetitive stress injury.

Workers complained of pain in the shoulders and arm muscles because the energy of the impact of the tool on the wood is absorbed by the worker's body. The jackfruit is slow growing tree, typical of the late stages of the rain forests and it has a high density wood 0,66 g/cm³, even a chainsaw expend more energy than normaly in order to cut it. The same happens with the power drill, the efficiency of the batteries is impaired by the resistance of the wood. The use of a drill bit 3/8" for steel use seems to be better than the drill bit for wood and the diameter is big enough. A drill bit with a large diameter means less performance in time and energy but a small drill bit may brake easily. One important abut use of herbicides is related to the contamination of the environment not because the herbicide by itself but because the chosen vehicle that can be more toxic as for example petroleum oil or ammonium.

## 5. **References**


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