ISSN 2316-9281

Scientific Electronic Archives
Issue ID: Vol.19 (4), Jul/Aug 2026, p. 1-6
DOI: http://dx.doi.org/10.36560/19420262242
+ Corresponding author*:* babicostav@gmail.com

Germination of native forest species planted by direct seeding

Barbara Vale da Costa[1] + & Nelson Augusto dos Santos Junior [2]

[1] Agricultural Engineer
[2] Seed Research Laboratory - Institute for Environmental Research

Abstract. Direct seeding has increasingly emerged as an alternative and/or complementary technique for ecological restoration. In this sense, several factors have been explored to make the process viable, such as the use of germination protectors, which would increase the temperature and humidity of the seedbed, in addition to protecting the seeds against herbivory. In the present study, the effect of a protector on the germination of seeds of three native forest species was tested. For this purpose, three species were selected (*Enterolobium contortisiliquum*, *Handroanthus impetiginosus*, and *Sapindus saponaria*). Initially, the seeds were evaluated in the laboratory, being subjected to germination conditions in a BOD-type chamber at 25ºC and a 12-hour photoperiod. From these results, two seeding densities per seedbed were defined in the field. Thus, the seeds of each species were tested with and without the germination protector and with two seeding densities, in a 2x2 factorial scheme. The germination protector was effective in increasing the total value and speed of germination of *Enterolobium contortisiliquum* and *Handroanthus impetiginosus* seeds. *Sapindus saponaria* seeds, although not benefiting from the use of the germination protector, germinated well under field conditions. The densities studied, it seems, had little influence on the germination process of the species studied, indicating that excessive densities do not guarantee the formation of individuals. Direct sowing for enrichment purposes proved viable, especially for *Enterolobium contortisiliquum* and *Sapindus saponaria*.
Keywords: ecological restoration, native brazilian seeds, germination protector

Introduction

Conservation and restoration of riparian forests have been matters of great importance in the context of environmental quality. The benefits of riparian forests for supporting fauna, increasing landscape connectivity (Marinho Filho and Gastal, 2000), maintaining aquatic habitats (Barrela *et al.*, 2000) and water quality (Crestana *et al.*, 1993; Lima and Zakia, 2000) have been some of the strongest arguments for their conservation.

However, despite the relevance of this vegetation formation and the fact that it has been considered a Permanent Preservation Area by the Forest Code since the 1960s, it has been and continues to be suppressed by various sources of degradation. This situation generates a strong demand for conservation actions for what remains and for the recovery of what has already been degraded.

Therefore, the implementation or restoration of ecosystems, as well as their management, requires the use of appropriate techniques, generally defined based on detailed assessments of local conditions and the use of existing scientific knowledge (Barbosa, 2000).

There are several models for the implementation of native tree vegetation, recommended by various researchers, which differ in the composition, arrangement, and spacing of native forest species from different successional stages. Generally, the models used in the study of forest restoration are based on the concept of secondary succession, which, for the most part, are carried out through the planting of seedlings, associated with different successional groups. However, alternatives, such as direct seeding, are promising in the process of restoring degraded riparian forests, due to their practicality, economy, and speed of implementation (Santos Júnior, 2000; Ferreira *et al.*, 2007). Resolution SMA 08/08 itself, which establishes guidelines on the recovery process in the state of São Paulo, provides for the use of this technique as a complement to the restoration process.

The success of direct seeding, however, depends on the creation of a microsite with conditions favorable to rapid germination (Ferreira *et al.*, 2009). Drought, burial of seeds by heavy rains, and intense cold are the main climatic elements that cause problems for direct seeding (Derr and Mann, 1971; Rietveld and Heidmann, 1976; Mattei, 1997). It is necessary to protect the seeds to avoid losses due to predation by ants and birds, which occur from the seedling stage, and also losses due to soil movement (Mattei, 1997).

In this approach to seed protection, one of the points studied in the direct sowing of native forest species refers to the use of germination protectors (Mattei and Rosenthal, 2002; Santos Junior *et al.*, 2004; Ferreira *et al.*, 2007; Brachtvogel *et al.*, 2008; Santos Junior and Ferrreira, 2018). Some studies show that these produce a microenvironment at the sowing points that helps maintain temperature and reduce evaporation, in addition to protecting seedlings against torrential rains, excessive irrigation, and temperature fluctuations during the critical period when roots have not yet penetrated the deeper layers to ensure water supply (Mattei, 1997). The predatory effect of ants and birds, described as one of the biggest problems in establishing new stands using seeds, was reduced with the use of protectors, which provide a significant decrease compared to stands where no protective materials were used. (Mattei, 1995; Schneider *et al.*, 1999; Serpa and Mattei, 1999). Another point that has been extensively studied in recent years refers to the seed density used in direct seeding, which aims to establish itself with the smallest possible quantity of seeds necessary to form at least one individual per planting hole (Santos Junior *et al.*, 2004).

Material and Methods

Species Selection and Preliminary Laboratory Tests

For the direct seeding tests, three species were selected: *Enterolobium contortisiliquum* (Vell.) Morong., *Sapindus saponaria* L., and *Handroanthus impetiginosus* (Mart. ex DC.) Mattos. Seeds of these species were obtained from various parent plants located in the Parque Estadual das Fontes do Ipiranga (PEFI). The seed lots used were initially characterized in the laboratory through water content tests in an oven at 105ºC/24 hours (Brazil, 2009).

According to need, the seeds received pre-germination treatments, according to the recommendations of Davide *et al.* (1995): *E. contortisiliquum* (chemical scarification with concentrated sulfuric acid for 5 minutes) and *S. saponaria* (scarification with sandpaper and immersion in water for 2 days). The seeds of *H. impetiginosus* did not require pre-germination treatment.

The seeds of the three species were also characterized in the laboratory regarding germination parameters, adopting an average temperature of 25ºC and a photoperiod of 12 hours, in Mecplant® substrate, in Eletrolab® BOD type germination chambers.

The number of germinated seeds was evaluated daily until the period in which no additional germinated individual was added for at least 20 days, which occurred at most 4 months after the installation of the trial. Percentage values for germination, normal seedlings, and abnormal seedlings were then obtained. Based on the germination data, the germination speed index (GSI) was calculated, according to the formula proposed by Popinigs (1977).

Area Characterization and Experiment Description

The experimental area is located next to the Secretariat of Agriculture and Supply of the state of São Paulo and belongs to the Botanical Institute. A large part of the area has established undergrowth and individuals taller than 10 meters. On November 18 and 19, 2009, each of the three selected species was sown (Figure 1), testing the effect of the germination protector (which consisted of 400 ml plastic cups without the bottom), with two sowing densities, adopting a 2x2 factorial scheme (protector x density). The design adopted was randomized blocks (RCBD), where each treatment contained three blocks with five holes each (Figures 2 and 3).

Based on the germination percentages obtained in the laboratory analysis, the sowing density per planting hole was established. Thus, the densities of *E. contortisiliquum* and *H. impetiginosus* were determined as two seeds/plant (density 1) and four seeds/plant (density 2), and for *Sapindus saponaria*, the densities of three seeds/planting hole (density 1) and six seeds/planting hole (density 2) were adopted. The number of seeds germinated per planting hole was evaluated weekly, obtaining the germination percentage values.

As a parameter to compare the effect of using the germination protector, soil temperature and moisture were measured on its surface, inside and outside the protector, using a GulTerm® thermometer and a Minipa® MV331 moisture analyzer, respectively.

From the stagnation of the germination process, biometric parameters of the seedlings were evaluated weekly by collecting data on the height and diameter of the seedling collar, with the aid of a digital caliper.

The experiment was subjected to transplanting 110 days after germination, in order to obtain at least one seedling per planting hole, a procedure always carried out within the same block and the same treatment to which they belonged. In this same stage of the experiment, the evaluation of the sowing environment continued to be carried out.

At the end of the experiment, the data were tabulated and the final averages were statistically analyzed using Tukey's test at a significance level of 5% using the SISVAR program. (Ferreira, 2000).

Figure 1. General view of the area in PEFI, highlighting "in blue" the location where direct seeding was carried out.

Figure 2. General view of a plot, where it is possible to see sowing points with and without the presence of germination protectors.

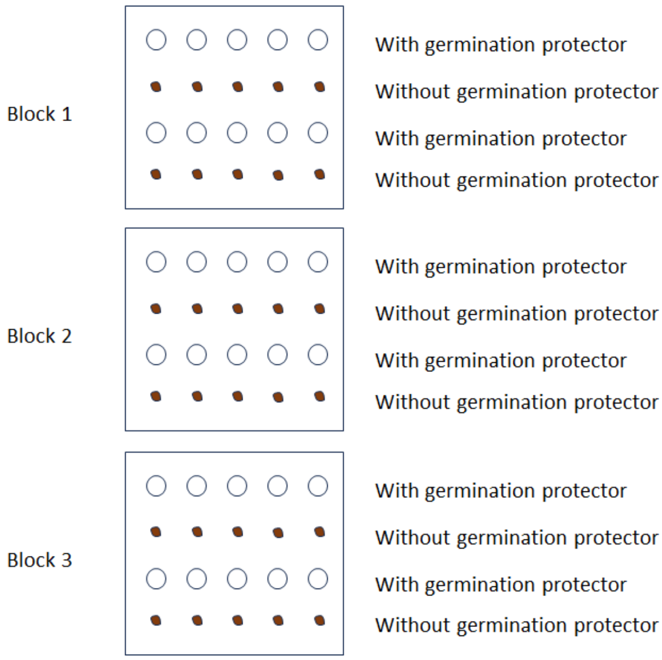

Figure 3. Diagram of the blocks showing the treatments and repetitions adopted for each of the species.

Results and discussion

On average across all assessments, the temperature in the surface layer of the soil inside the protector was 25.3ºC, while outside it remained at 22.1ºC. The humidity inside the protector averaged 76.7%, while outside it was 48.3%. This pattern of increased humidity and temperature in the surface layer was also verified by Santos Junior *et al.* (2004).

The seeds of the species showed good physiological quality, with high germination rates, ranging from 60 to 100%, and a capacity for normal seedling formation between 40 and 80% (Table 1). *E. contortisiliquum* seeds stood out under laboratory conditions, germinating completely and rapidly, which is highly desirable under field conditions.

Table 1. Average values of water content (W.C.), germination percentages (GP), percentage of normal seedlings (PN) and abnormal seedlings (AP), and germination speed index (GSI) of seeds of secondary and climax species studied, under laboratory conditions.

Species	WC(%)	GP(%)	NS(%)	AS(%)	GSI
Enterolobium contortisiliquum (Vell.) Morong	11,3	100	85	2,5	9,25
Handroanthus impetiginosus (Mart. ex DC.) Mattos	12,7	82,5	62,5	12,5	1,095
Sapindus saponaria L.	16,8	60	40	12,5	0,604

Based on the results obtained (Table 2), it can be observed that the germination protector was effective in increasing the germination of *E. contortisiliquum* and *H. impetiginosus* seeds., although, in the latter species, the germination values were generally quite low. In the case of *E. contortisiliquum*, the average germination rate was almost double with the use of protectors compared to their absence, reaching over 80%, and there was also an increase in the speed of germination. This gain in germination rates in *E. contortisiliquum* seeds resulting from the use of protectants was also verified by Malavasi *et al.* (2010) and higher than that found by Jesus *et al.* (2021), where the germination achieved in the laboratory was 90% and, in the field, the emergence rate with the seed exposed without protection was 20%.

This increase in germination was also verified in seeds of riparian species by Santos Júnior *et al.* (2004) and Ferreira *et al.* (2007), who also tested the effect of protectors on germination. In *H. impetiginosus*, the protector was also effective in seedling survival. In this sense, Santos Júnior *et al.* (2004) also verified the positive effect of the germination protector in reducing seedling loss. Regarding seeding densities, no clear effect of this factor was found, since its effect is expected as the seedlings grow.

For *S. saponaria*, there was no effect of the factors tested; however, under field conditions, the seeds of the species showed germination values close to those found in the laboratory.

Of the three species subjected to field sowing, only *Sapindus saponaria* maintained individuals in all blocks and treatments, as many losses occurred due to excessive rainfall and herbivory. Carvalho *et al.* (2022) highlight the species' ability to survive in adverse conditions and its potential for use in restoration.

Mattei (1995) cites the burial of seeds and seedlings by terrestrial rainfall as one of the climatic elements detrimental to direct seeding. Brachtvogel *et al.* (2008), in a literature review on the role of physical protectors in direct seeding, states that herbivory exerts strong pressure on the planted species and, in this context, protectors play a fundamental role.

Table 2. Average values for germination percentage (G) and Germination Speed Index (GSI) with and without the use of a germination protector at the two sowing densities.

	SP			CP		
	D1	D2	X	D1	D2	X
Species			**% G**			
Enterolobium contortisiliquum (Vell.) Morong	53,33	41,7 b	47,51 B	80 a	81,7 a	80,85 A
Handroanthus impetiginosus (Mart. ex DC.) Mattos	0 a	0 a	0 B	20 a	10 b	15 A
Sapindus saponaria L.	66,6a	23,3 b	44,95 A	62,2 a	27,7 b	44,95 A
			GSI			
Enterolobium contortisiliquum (Vell.) Morong	0,133b	0,209 a	0,171 B	0,192 b	0,381 a	0,286 A
Handroanthus impetiginosus (Mart. ex DC.) Mattos	0 a	0 a	0 B	0,019 a	0,005 a	0,012 A
Sapindus saponaria L.	0,046a	0,023 a	0,034 A	0,046 a	0,037 a	0,041 A

*Lowercase letters compare seeding densities, and uppercase letters compare the effect of the protectant within each species.
**Means followed by the same letter do not differ from each other at the 5% probability level by Tukey's test.

Conclusion

The germination protector was effective in increasing the total value and speed of germination of *Enterolobium contortisiliquum* and *Handroanthus impetiginosus* seeds. *Sapindus saponaria* seeds, although not benefiting from the use of the germination protector, germinated well under field conditions. The densities studied, it seems, had little influence on the germination process of the species studied, indicating that excessive densities do not guarantee the formation of individuals. Direct sowing for enrichment purposes proved viable, especially for *Enterolobium contortisiliquum* and *Sapindus saponaria*.

Acknowledgment

The authors thank the National Council for Scientific and Technological Development (CNPq) for the scholarship awarded to the first author.

References

ACCHILE, S. et al. Biometria de frutos e sementes e determinação da curva de absorção de água de sementes de Sesbania virgata (Cav.) Pers. Scientific Electronic Archives, v. 10, n. 5, p. 26-34, 2017.

BARBOSA L.M. Considerações gerais e modelos de recuperação de formações ciliares. In: Rodrigues, R.R.; Leitão Filho, H.F. (eds). Matas Ciliares: Conservação e Recuperação. São Paulo, Edusp: Fapesp, p.280-312.2000.

BARRELA, W.; PETRERE JUNIOR, M.; SMITH, W.S.; MONTAG, L.F.A. As relações entre as matas ciliares, os rios e os peixes. In: RODRIGUES, R.R.; LEITÃO– FILHO, H.F. (Eds). Matas ciliares: conservação e recuperação. São Paulo: Editora Universidade de São Paulo/Fapesp, 2000. p.187-207

BARTNETT, J. P.; BAKER, J. B. Regeneration methods. In: DUREYA, L.; DOUGHERTY, P.M.; PHILIP, M., (Eds) Forest regeneration manual. Dordrecht: Kluver, 1991. P. 35-50.

BERTOLO, Raissa Presotto et al. Water content in Annona squamosa seeds under different temperature and relative humidity conditions of storage environment. Scientific Electronic Archives, v. 15, n. 5, 2022.

BRACHTVOGEL, E. L.; KLEIN, J.; MALAVASI, U. C. Uso de protetores físicos na semeadura direta de espécies florestais. Guarapuava, v.4, n.3, p.519-527, 2008

BRASIL. Regras para análise de sementes. Ministério da Agricultura, Pecuária e Abastecimento, Brasília 2009. 399 p.

CARLOS, T.; SILVA, L. L. Accelerated aging test for quality evaluation of surfasse (Lactuca sativa L) and arugula seeds (Eruca sativa M). Scientific Electronic Archives, v. 14, n. 1, p. 1-7, 2021.

CARVALHO, J. M. DE.; CALDEIRA, D. S. A.; VIEIRA, C. L.; DA SILVA, G. V. B.; ROCHA, R. R.; DE CAMPOS, I. Crescimento inicial de mudas de *Sapindus saponaria* com uso de hidrogel e lâminas de água. Scientific Electronic Archives, 15(1), 2021. https://doi.org/10.36560/15120221489

CRESTANA, M.S.M.; TOLEDO FILHO, D.V.; CAMPOS, J.B. Florestas: sistemas de recuperação com essências nativas. Campinas: CATI, 1993. 60p.

DAVIDE, A.C.; FARIA, J. M. R., BOTELHO, S. A. Propagação de espécies florestais. Belo Horizonte: CEMIG/FAEPE, 1995. 40 p.

DERR, H.J.; MANN JR., W.F. Direct seeding pines in the South. Washington: U.S.D.A. Forest Service, 1971. 68p. (Agric. Handb., 391).

DOUGHERTY, P.M. A field investigation of the factors which control germination and establishment of loblolly pine seeds. Separata de Georgia Forestry Commission, n. 7, 1990. 5 p.

DUBOIS, M. R.; CHAPPELKA, A.H.; ROBBINS, E.; SOMERS, G.; BAKER, K. Tree shelters and weed control: Effects on protection, survival and growth of cherrybark oak seedlings planted on a cutover site. *New Forests,* v.20, p. 105–118, 2000.

DUTRA, F. V. et al. Biometric parameters of fruits and seeds of Sesbania virgata (cav.) Pers. Scientific Electronic Archives, v. 12, n. 5, p. 51-56, 2019.

FARIAS, C. B. M. et al. Estimation and analysis of particles from seeds of maximiliana maripa (aubl.) drude (arecaceae). Scientific Electronic Archives, v. 13, n. 10, p. 28-32, 2020.

FERREIRA, D. F. SISVAR – Sistema de análise de variância. Lavras: Universidade Federal de Lavras, 2000. 1 CD.

FERREIRA, R. A.; DAVIDE, A. C.; BEARZOTI, E.; MOTTA, M. S. Semeadura direta com espécies arbóreas para recuperação de ecossistemas florestais. Revista Cerne, Lavras, v.13, n.3, p.271-279, 2007

FERREIRA, R. A.; SANTOS, P. L.; ARAGÃO, A. G.; SANTOS, T. I. S. *et al.* Semeadura direta com espécies florestais na implantação de mata ciliar no Baixo São Francisco em Sergipe. Piracicaba, v.37, n.81, p.037-046, 2009

JESUS, J. B. DE; FERREIRA, R. A.; GAMA, D. C.; TORRES, M. F. O. Physical and physiological attributes of native forest seeds and their influence on direct seeding for restoration of ciliary forest. Floresta, 51(2), 255–262, 2021. https://doi.org/10.5380/rf.v51i2.58181

LIMA, W.P.; ZAKIA, M.J.B. Hidrologia de matas ciliares. In: RODRIGUES, R.R.; LEITÃO–FILHO, H.F. (Eds). Matas ciliares: conservação e recuperação. São Paulo: Editora Universidade de São Paulo/Fapesp, 2000. p.33-44.

LORENZI, H. Árvores brasileiras: Manual de Identificação e Cultivo de Plantas Arbóreas Nativas do Brasil. Plantarum, Nova Odessa, 352 p, 1992.

MALAVASI, C.U.; KLEIN, J; MALAVASI, M.M. Efeito de um protetor físico na semeadura direta de duas espécies florestais em área de domínio ciliar. Revista Árvore, Viçosa, v.34, n.5, p. 781-787. 2010.

MARINHO-FILHO, J.; GASTAL, M.L. Mamíferos das matas ciliares dos cerrados do Brasil Central. In: RODRIGUES, R.R.; LEITÃO–FILHO, H.F. (Eds). Matas ciliares: conservação e recuperação. São Paulo: Editora Universidade de São Paulo/Fapesp, 2000. p.209-222.

MATTEI, L. V. Avaliação de protetores físicos em semeadura direta de *Pinus taeda* L. Ciência Florestal, Santa Maria, v. 7, n. 1, p. 91-100, nov. 1997.

MATTEI, V. L. Preparo de solo e uso de protetor físico, na implantação de *Cedrela fissilis* V. E *Pinus taeda* L., por semeadura direta. Revista Brasileira de Agrociência. v.1. n. 3, p. 127 - 132, 1995.

MATTEI, V. L.; ROSENTHAL, M. D. Semeadura direta de canafístula (*Peltophorum dubium* (Spreng.) Taub.) no enriquecimento de capoeiras. Revista Árvore, Viçosa, v.26, n.6, p.649-654, 2002.

OLIVEIRA, A. M. S. et al. Physiological quality of osmoprimed Eremanthus erythropappus (DC) MacLeish seeds. Scientific Electronic Archives, v. 13, n. 5, p. 18-26, 2020.

PANISSON, Ana Carolina et al. Qualidade fisiológica e sanitária de sementes comerciais e salvas de soja (Glycine max.) produzidas na região do meio oeste de Santa Catarina. Scientific Electronic Archives, v. 15, n. 6, 2022.

POPINIGIS, F. Fisiologia da semente. Brasília: Ministério da Agricultura, 1977. 232 p.

RIETVELD, W.J.; HEIDMANN, L.J. Direct seeding ponderosa pine on recent burns in Arizona. Washington: USDA, Forest Service, 1976. 8p. (Research Note, 312).

SANTOS JUNIOR, N.A.; BOTELHO, S. A.; DAVIDE, A. C. Estudo da germinação e sobrevivência de espécies arbóreas em sistema de semeadura direta, visando à recomposição de mata ciliar. Revista Cerne, Lavras, v. 10, n.1, p. 103-117, 2004.

SANTOS JUNIOR, N.A.; FERREIRA, R.A. Fatores determinantes para a eficiência no uso das sementes. In: BARBEDO, C.J.; SANTOS JUNIOR, N.A. (Org). Sementes do Brasil: produção e tecnologia para espécies da flora brasileira. São Paulo: Instituto de Botânica, 2018. p.139-160.

SANTOS, D. et al. Biometry of fruit, germination and morphogenesis in vitro of citrus after asepsis of seeds in different concentrations of sodium hypochlorite. Scientific Electronic Archives, v. 13, n. 3, p. 14-23, 2020.

SCHNEIDER, P. R.; FINGER, A. C.; SCHNEIDER, P. S. P. Implantação de povoamento de *Dodonae viscosa* L. Jacq. com mudas e semeadura direta. Ciência Florestal, v.9, n.1, 1999.

SERPA, M. R.; MATTEI, V. L. Avaliação de diferentes materiais de cobertura e de um protetor físico, no estabelecimento de plantas de *Pinus taeda* L., por semeadura direta no Campo. Ciência Florestal, Santa Maria, v.9, n.2, p. 93-101. 1999.