












PERFORMANCE OF DISTINCT STRATEGIES ON OVERCOMING DORMANCY IN *Senna obtusifolia* SEEDS

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Abstract

Senna obtusifolia presents structures favorable to the effects of the dormancy phenomenon, presenting low germination rates for a certain period. This panorama can be solved by the dormancy-breaking process, which is caused by the exposure of the seed to adverse conditions that stimulate the germination process. Accordingly, this study aimed to evaluate the efficiency of different methods to overcome dormancy in *Senna obtusifolia* (L.) H. S. Irwin & Barneby seeds. A completely randomized design (CRD) was the experimental design adopted, with four treatments and eight replications of 25 seeds. The treatments consisted of mechanical scarification, water imbibition, and immersion in hot water. In this study, a statistically significant difference was seen between treatments for all parameters, where the treatment under mechanical scarification was the most effective for promoting germination ($99 \pm 1.51\%$ of germinated seeds). Furthermore, the treatment presented the most promising results for average shoot length (ASL) (43.95 ± 8.66 mm), root length (ARL) (28.09 ± 5.27 mm), total fresh mass (MF) (1.97 ± 0.10 g), and total dry mass (MS) (0.37 ± 0.03 g). The mechanical scarification of seeds favored germination and this treatment was the most efficient for the process of overcoming the dormancy of *S. obtusifolia* seeds.

Palavras-chave:

Dormência de sementes
Escarificação mecânica
Germinação
Qualidade fisiológica

DESEMPENHO DE ESTRATÉGIAS DISTINTAS NA SUPERAÇÃO DA DORMÊNCIA EM SEMENTES DE SENNA OBTUSIFOLIA

RESUMO

Senna obtusifolia apresenta estruturas favoráveis aos efeitos do fenômeno de dormência, apresentando baixas taxas de germinação por um determinado período. Este panorama pode ser contornado pelo processo de quebra de dormência, causado pela exposição da semente a condições adversas que estimulem o processo de germinação. Adequadamente, este trabalho teve como objetivo avaliar a eficiência de diferentes métodos para superação de dormência em sementes de *Senna obtusifolia* (L.) H. S. Irwin & Barneby. O delineamento experimental adotado foi o delineamento inteiramente casualizado (DIC), com quatro tratamentos e oito repetições de 25 sementes. Os tratamentos foram compostos por: escarificação mecânica, embebição em água e imersão em água quente. Neste estudo, observou-se, estatisticamente, diferença entre os tratamentos para todos os parâmetros avaliados, onde o tratamento sob escarificação mecânica foi o mais eficaz para promoção da germinação ($99 \pm 1.51\%$ de sementes germinadas). Ainda, o tratamento apresentou os resultados mais promissores para comprimento médio da parte aérea (CPA) (43.95 ± 8.66 mm) e radicular (CRP) (28.09 ± 5.27 mm), massa fresca total (MF) (1.97 ± 0.10 g) e massa seca total (MS) (0.37 ± 0.03 g). Apropriadamente, concluiu-se que a escarificação mecânica das sementes favoreceu a germinação e o tratamento foi o mais eficiente para o processo de superação de dormência de sementes de *S. obtusifolia*.

INTRODUCTION

The species *Senna obtusifolia* (L.) H. S. Irwin & Barneby, popularly known as “mata-pasto”, is an annual subshrub from the Fabaceae family. This species is established spontaneously in the Brazilian biomes of the Amazon, Caatinga, Pantanal, and Atlantic Forest. Scientific studies report that the species is commonly widespread in areas with annual, perennial crops, and pastures, and also occupied areas with fruit species, vacant lots, and edges of forest fragments (GEBREKIRO; TESSEMA, 2018).

Moreover, mata-pasto has significant productive potential, generating a high number of fruits with dehiscent seeds that are easy to collect in the different ecosystems of occurrence. Nonetheless, when disposed into the soil, part of these seeds does not germinate, although viable and under adequate environmental conditions, allowing them to remain in the soil and germination to occur over time (TOPANOTTI; PEREIRA; BECHARA, 2014). This phenomenon is called seed dormancy, and it is a decisive mechanism that governs the germination process in plants, allowing the seeds to delay germination until periods of optimal conditions for plant growth, such as temperature, light, and water availability (PENG *et al.*, 2021).

High seed production and a notable rate of dormant seeds are the main factors for weed survival in constantly disturbed environments, which contributes to the perpetuation of interfering species in crops (TRAVLOS *et al.*, 2020). Nevertheless, controlling all weeds present in a field is not enough to eliminate these invasive species, since seed dormancy is the main survival mechanism in constantly infested environments (KLUPCZY, 2021).

The seeds of species belonging to the Fabaceae family have dormancy due to the impermeability of the tegument to water, called tegumental dormancy. Widely observed in the *Senna* genus, this scenario makes it temporarily difficult to germinate, prolonging viability and germination over time, occurring only in periods with adequate conditions for seedling survival (MEDEIROS *et al.*, 2019).

Seed dormancy in weeds makes it difficult to

conduct a significant scientific investigation related to the ecophysiology of germination and directed to the management and control of these species in agricultural areas. Accordingly, studies involving the adequacy and definition of effective methods of overcoming dormancy will promote uniformity and speed in germination, allowing consistent results to be obtained (MAHAJAN *et al.*, 2018; GANDÍA; DEL MONTE; SANTÍN-MONTANYÁ, 2022). Additionally, for seed germination of species that present tegumental dormancy, it is necessary to use strategies that promote tegument disruption. Among the methods, the most widely explored has been mechanical scarification, which consists of rubbing the seeds against an abrasive surface, such as sandpaper or scraping a small part of the seed coat (CARRUGGIO *et al.*, 2020).

Finally, valuable information on the management of weed seeds is scarce, therefore, knowledge of the behavior of germination of these species is extremely important to providing physical and physiological characteristics, as well as establishing appropriate management techniques and control (KIM, 2019). Appropriately, due to the lack of information on seed management, this study aimed to evaluate different strategies for overcoming seed dormancy of *Senna obtusifolia* (L.) H. S. Irwin & Barneby seeds.

MATERIAL AND METHODS

The assays were conducted at the Biotec Factory[®], Department of Chemical Engineering, Federal University of Santa Maria (UFSM), Santa Maria, Brazil. Initially, *Senna obtusifolia* (L.) HS Irwin & Barneby seeds were collected in a pasture area located in Cuité de Mamanguape, Paraíba, Brazil. The municipality is located at 75 m altitude, at latitude 06°55'15.4" S and longitude 35°17'12.8" W. After collection, the seeds were transported to the Biotec Factory[®] and they were processed and manually selected, discarding those that showed injuries or were deformed.

For the mechanical scarification method, 120 sandpaper was applied, where 200 seeds were scarified in the region opposite the micropyle until the beginning of the endosperm exposure, according to the methodology mentioned by Bortolini *et al.* (2011).

For the water imbibition technique, 200 seeds were deposited in a beaker, immersed in distilled water, and sustained at an ambient temperature of 25 °C for an imbibition period of 48 hours (ADEGAS; VOLL; PRETE, 2003).

The strategy of immersion in hot water consisted of the deposition of distilled water in a beaker, which was heated until reaching a temperature of 96 °C. After reaching the specific temperature, the beaker was removed from the heating and the seeds were immersed in the container, where they remained soaked for 18 hours (TOPANOTTI; PEREIRA; BECHARA, 2014). After the application of the dormancy overcoming treatments, the seeds were treated with a 2% sodium hypochlorite solution for 3 minutes and, posteriorly, submitted to the germination test, according to the methodology described by Bortolini *et al.* (2011).

The germination percentage (GP) test was conducted in eight repetitions of 25 seeds per treatment (dormancy overcoming method). The seeds were sown in transparent Gerbox-type boxes (11 x 11 x 4 cm) on two sheets of filter paper (Germitest®) moistened in the proportion of 2.5 times the dry paper mass, with the different treatments. The boxes were maintained in a Biochemical Oxygen Demand (BOD) germination chamber with a photoperiod of 12/12 hours of light/dark, at a temperature of 25 °C, according to the criteria established by the International Rules for Seed Testing (ISTA, 2022). The number of germinated seeds was verified daily until stabilization, using as a criterion the minimum root protrusion of 2 mm in length with characteristics of normal plants (FERREIRA; AQUILA, 2000).

The determination of germination speed (GS) was performed based on the daily data of the germination test, based on equation 1 developed by Borella; Garbin; Zanatta, 2011:

$$GS = \frac{\sum\left(\frac{G_i}{D}\right)}{\sum\left(\frac{G_c}{D}\right)} \times 100 \quad (1)$$

Where,

GS = seed germination speed (seed day⁻¹);

G_i = number of seeds germinated daily from the treatment (seed day⁻¹);

G_c = number of seeds germinated daily from the control (seed day⁻¹);

D = number of days after sowing in which counting was performed.

The germination speed index (GSI) was performed with the germination test, by quantifying the germinated seeds daily after the installation of the treatments, based on equation 2 established by Maguire, 1962:

$$GSI = \left(\frac{N_1}{D_1}\right) + \left(\frac{N_2}{D_2}\right) + \dots + \left(\frac{N_n}{D_n}\right) \quad (2)$$

Where,

GSI = seed germination speed index (%);

N = number of seedlings computed on the day of counting (seed day⁻¹);

D = number of days after sowing in which counting was performed.

Accordingly, the treatment efficacy (TE, %) was determined according to an adaptation of the formula proposed by Abbott (1925):

$$TE = \left(\frac{CT - T}{CT}\right) \times 100$$

Where,

TE = percentage of effectiveness of each evaluated treatment (%);

CT = average percentage in control treatment (%);

T = average percentage in treatments (%).

The measurement of the shoot length (ASL, mm) and primary root (ARL, mm) of seedlings was performed at the end of the germination test, with a digital caliper (Within 300 mm). For the length of the shoot, the distance between the insertion of the basal portion of the primary root to the apex of the shoot was considered. For the length of the primary root, the distance between the apical and basal parts was considered. Results were expressed in millimeters (mm) per seedling (NAKAGAWA, 1999).

The total fresh mass (g) of seedlings was performed by weighing all the seedlings, obtained at the end of the germination test of all repetitions of each treatment, on an analytical balance (A42207c, Bel Engineering, Italy) with a precision of 0.0001 g. The results were expressed in grams per seedling (SILVA *et al.*, 2016). The determination of total fresh mass was necessary for the quantification of dry mass (g) after the drying process in forced ventilation, based on the difference by gravimetry between the two parameters, establishing the real weight of seedlings.

According to the total dry mass (g) of seedlings, the procedure was determined from the mass of all seedlings, obtained at the end of the germination test of all repetitions of each treatment. The seedlings were placed in duly identified Kraft paper bags and subjected to drying in a forced ventilation oven at a temperature of 70 °C, until constant mass. The results were expressed in grams per seedling (SILVA *et al.*, 2016).

Finally, the assays were conducted using a completely randomized design (CRD), with four treatments (control, mechanical scarification, soaking in water, and immersion in hot water) and eight replications of 25 seeds, totaling 32 experimental units with 200 seeds per treatment. The results were submitted to tests of normality and homogeneity of errors, then the data were analyzed by variance (ANOVA) and the means were compared by Tukey's test at 5% error probability ($p \leq 0.05$), using the statistical software SISVAR® 5.1.

RESULTS AND DISCUSSION

According to Figure 1, it was observed that germination occurred in all treatments to overcome

dormancy, with a significant difference between treatments. The best germination result was for the treatment in which the mechanical scarification method of overcoming dormancy was applied, presenting 99% of germinated seeds (Table 1), indicating that the seeds of *S. obtusifolia* present tegumental dormancy.

The mechanical scarification mechanism showed a significant difference between the immersion in hot water treatments ($52 \pm 4.41\%$ germinated seeds), water imbibition ($8.88 \pm 1.46\%$ germinated seeds), and the control treatment ($4 \pm 1.85\%$ germinated seeds). The same behavior was observed for the GS parameter, in which the mechanical scarification treatment presented a GS of 1.77 ± 0.78 seeds day⁻¹, statistically differing from the immersion in hot water (1.01 ± 0.44 seeds day⁻¹), water imbibition (0.12 ± 0.05 seeds day⁻¹), and control treatment (0.06 ± 0.01 seeds day⁻¹). Finally, for GSI, the mechanical scarification ($21.1 \pm 3.8\%$ seeds day⁻¹) mechanism showed a significant difference between the treatments immersion in hot water ($18.04 \pm 1.72\%$ seeds day⁻¹), water imbibition ($1.45 \pm 1.46\%$ seeds day⁻¹), and control ($0.81 \pm 0.34\%$ seeds day⁻¹).

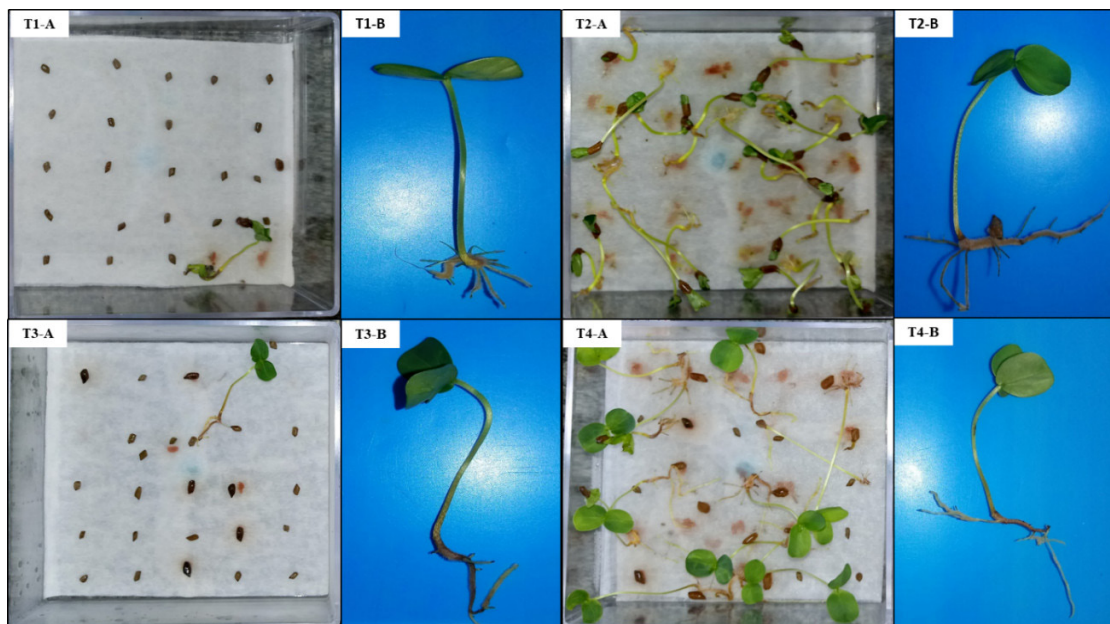


Figure 1. Germination test of *Senna obtusifolia* (L.) H. S. Irwin & Barneby submitted to different dormancy overcoming methods: (T1A) Germination test for the control treatment; (T1B) Detail of the aerial part and root for the control treatment; (T2A) Germination test for the mechanical scarification; (T2B) Detail of the aerial part and root for the mechanical scarification; (T3A) Germination test for the water imbibition; (T3B) Detail of the aerial part and root for the water imbibition; (T4A) Germination test for the immersion in hot water at 96 °C; and (T4B) Detail of the aerial part and root for the immersion in hot water at 96 °C

This result can be visualized in Figure 1. In the treatment with mechanical scarification (Figure 1 – T2-A), the germination was visibly superior to the other methods. Moreover, it was observed that the seedlings developed healthy, without the presence of necrosis, bending or thickening of the root, or anomalies in the epicotyl, which also allowed the observation of the hairy zone and root ramifications (Figure 1 - T2- B).

Considering the parameters of shoot length and primary root length, an effect of treatments (Table 2) was seen. The mechanical scarification showed the highest average for the shoot and primary root length (43.95 ± 8.66 mm and 28.09 ± 5.27 mm, respectively), differing statistically from the immersion in hot water (20.03 ± 8.13 mm and 14.64 ± 5.22 mm, respectively), water imbibition (1.80 ± 7.19 mm and 1.32 ± 3.09 mm, respectively), and the control (1.25 ± 8.02 mm and 0.54 ± 5.97 mm) treatments.

Analyzing the parameters of total fresh mass and total dry mass of seedlings (FM and DM), an

effect of treatments on these characteristics was observed (Table 3). The treatment with mechanical scarification with sandpaper n° 120 obtained higher FM and DM (1.97 ± 0.10 g and 0.37 ± 0.03 g, respectively), differing statistically from the immersion in hot water (0.72 ± 0.05 mm and 0.14 ± 0.02 mm, respectively), water imbibition (0.16 ± 0.01 mm and 0.04 ± 0.01 mm, respectively), and the control (0.15 ± 0.04 mm and 0.03 ± 0.01 mm) treatments.

In general, mechanical scarification was the most efficient in overcoming dormancy, with a germination percentage higher than 99%, indicating that *S. obtusifolia* seeds have tegumental dormancy. According to Avelino *et al.* (2012), the most common type of dormancy among species of the Fabaceae family is the tegumental dormancy phenomenon. These same authors report that this type of dormancy is related to the integument's impermeability to water and oxygen and the mechanical resistance of the integument to embryo growth, inhibiting seed germination.

Table 1. Germination percentage (GP), treatment efficacy (TE), germination speed (GS), and germination speed index (GSI) of *Senna obtusifolia* (L.) HS Irwin & Barneby seeds after different dormancy overcoming methods at 8 days of evaluation

| Treatment | GP (%) | TE (%) | GS (seed day ⁻¹) | GSI (%) |
|--------------------------|--------------------|--------|------------------------------|--------------------|
| Mechanical scarification | $99 \pm 1.51^{a*}$ | 95.96 | 1.77 ± 0.78^a | 21.1 ± 3.8^a |
| Water imbibition | 8.88 ± 1.46^c | 54.93 | 0.12 ± 0.05^b | 1.45 ± 1.46^c |
| Immersion in hot water | 52 ± 4.41^b | 92.31 | 1.01 ± 0.44^b | 18.04 ± 1.72^b |
| Control | 4 ± 1.85^d | 0 | 0.06 ± 0.01^c | 0.81 ± 0.34^c |

*Means followed by the same letter in the column do not differ statistically from each other by Tukey's test at 5% probability

Table 2. The average shoot length (ASL) and primary root length (ARL) of seedlings obtained from *Senna obtusifolia* (L.) HS Irwin & Barneby seed germination test, submitted to different dormancy overcoming methods at 8 days of evaluation

| Treatment | ASL (mm) | ARL (mm) |
|--------------------------------------|-----------------------|--------------------|
| Mechanical scarification | $43.95 \pm 8.66^{a*}$ | 28.09 ± 5.27^a |
| Water imbibition | 1.80 ± 7.19^c | 1.32 ± 3.09^c |
| Immersion in hot water | 20.03 ± 8.13^b | 14.64 ± 5.22^b |
| Control | 1.25 ± 8.02^c | 0.54 ± 5.97^c |
| Minimum significant difference (MSD) | 4.45 | 3.18 |
| Coefficient of variation (CV) | 17.75 | 18.28 |

*Means followed by the same letter in the column do not differ statistically from each other by Tukey's test at 5% probability

Table 3. The average shoot length (ASL) and primary root length (ARL) of seedlings obtained from *Senna obtusifolia* (L.) HS Irwin & Barneby seed germination test, submitted to different dormancy overcoming methods at 8 days of evaluation

| Treatment | FM (g) | DM (g) |
|--------------------------------------|---------------------------|--------------------------|
| Mechanical scarification | 1.97 ± 0.10 ^{a*} | 0.37 ± 0.03 ^a |
| Water imbibition | 0.16 ± 0.01 ^c | 0.04 ± 0.01 ^c |
| Immersion in hot water | 0.72 ± 0.05 ^b | 0.14 ± 0.02 ^b |
| Control | 0.15 ± 0.04 ^c | 0.03 ± 0.01 ^c |
| Minimum significant difference (MSD) | 0.08 | 0.02 |
| Coefficient of variation (CV) | 8.27 | 12.93 |

*Means followed by the same letter in the column do not differ statistically from each other by Tukey's test at 5% probability

Furthermore, there is dormancy present in seeds of several plant species, including weeds. Tegumental dormancy is a type of dormancy imposed by the tegument, in which the tissues surrounding the seeds exert an impediment that cannot be overcome (VIVIAN *et al.*, 2008). Promising results on the efficiency of the mechanical scarification method were also described by Zucareli *et al.* (2010). When comparing mechanical and chemical scarification with sulfuric acid to break the dormancy of *Dioclea violacea* seeds, the authors found that the most efficient method was mechanical scarification. Nevertheless, different results were obtained by Bandeira *et al.* (2018), that identified that the mechanical scarification method with sandpaper was one of the least effective in overcoming *S. obtusifolia* seed dormancy, with 31% germination.

According to Zucareli *et al.* (2010), mechanical scarification is the safest and most economically viable method. Compared to the acid scarification method, mechanical scarification presents higher viability, since the acid elements provide a significant release of sugars resulting from the degradation of cellulose, which causes higher availability of substrate for the development of fungi (Rocha *et al.*, 2011). Cangussu *et al.* (2018) when evaluating the biometric characteristics and efficiency of treatments using mechanical scarification and immersion in water at different temperatures to break the dormancy of surucucu (*Piptadenia viridiflora* (Kunth) Benth) seeds, found that mechanical scarification with sandpaper showed a higher percentage of germination. Freire *et al.* (2016), when evaluating the efficiency of

different methods of breaking dormancy in *Albizia pedicellaris* seeds, concluded that scarification was the most efficient method for dormancy overcoming.

The results of GS of *S. obtusifolia* (L.) H. S. Irwin & Barneby seeds found in this study were similar to those observed by Bortolini *et al.* (2011). When evaluating different methods to overcome the dormancy of *Gleditschia amorphoides* Taub. seeds, the authors established a higher GS for the treatment with mechanical scarification, of up to 0.47 seeds day⁻¹.

The SGI observed in this study showed that mechanical scarification directly influences this germination evaluation parameter. Similar results were cited by Seleguini *et al.* (2012). When evaluating the influence of scarification and seed imbibition on the emergence and development of "buritizeiro" (*Mauritia flexuosa* L.f.) seedlings, observed that seed scarification provided an increase in the emergence speed.

The shoot and root length of *S. obtusifolia* (L.) H. S. Irwin & Barneby seedlings were higher in seeds submitted to mechanical scarification with sandpaper since these seeds germinated faster and these values agreed with GS and SGI. According to Cangussu *et al.* (2018), this behavior is related to the inefficiency of the germination method and also to the absence of a dormancy overcoming process in the control treatment. Therefore, the seeds demanded longer to germinate, and when they germinate, root growth is lower due to the shorter growth period compared to seeds whose dormancy was overcome.

Similar results were observed by Santos *et al.*

(2013). These authors reported that the longest shoot and root length of *Erythrina velutina* seedlings were in seeds submitted to mechanical scarification, and also highlighted that immersion in hot water did not promote the overcoming of dormancy. Among the treatments for overcoming dormancy of *Piptadenia viridiflora* (Kunth) Benth seeds, Cangussu *et al.* (2018) observed that treatments with mechanical scarification and hot water immersion resulted in higher values of shoot length (4.50 and 4.59 cm, respectively) of seedlings.

CONCLUSIONS

- The mechanical scarification treatment was the most promising according to the germination characterization ($99 \pm 1.51\%$ % of germinated seeds). The treatment manifested up to 43.95 ± 8.66 mm and 28.09 ± 5.27 mm, for ASL and ARL, respectively. Accordingly, dormancy overcoming strategies allow dormant seeds to initiate germination in periods of adequate edaphoclimatic conditions, promoting mechanical scarification as one of the main mechanisms to overcome dormancy of *S. obtusifolia*.

AUTHORSHIP CONTRIBUTION STATEMENT

CHAVES NETO, J.R.: Data curation, Formal Analysis, Investigation, Software, Writing – original draft; **RODRIGUES, F.S.:** Validation, Visualization, Writing – review & editing; **LUFT, L.:** Data curation, Formal Analysis, Investigation; **CONFORTIN, T.C.:** Data curation, Formal Analysis, Investigation; **TODERO, I.:** Data curation, Formal Analysis, Investigation; **SANTOS, M.S.N.:** Validation, Visualization, Writing – review & editing; **ZABOT, G.L.:** Conceptualization, Investigation, Supervision; **MAZUTTI, M.A.:** Conceptualization, Investigation, Supervision; **TRES, M.V.:** Conceptualization, Methodology, Project administration, Supervision, Visualization.

DECLARATION OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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