Thermal plasticity and maturation-induced dormancy in *Anadenanthera macrocarpa* seeds

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Anadenanthera macrocarpa is an ecologically and economically valuable tree native to Brazilian dry forests. Despite its importance in ecological restoration, understanding how seed maturation stages and thermal regimes interact to regulate germination and dormancy remains limited. This study evaluated the germination behavior, vigor, and dormancy patterns of mature and immature *A. macrocarpa* seeds subjected to suboptimal (10°C), moderate (30°C), and supra-optimal (40°C) temperatures. Seeds were classified by maturation stage based on physical parameters and incubated for nine days. The results demonstrated a strong interaction between maturation and temperature. Mature seeds exhibited zero germination across all thermal regimes, indicating deep physiological dormancy as an adaptive strategy to avoid germination under unpredictable seasonal conditions. Conversely, immature seeds germinated but were highly temperature-dependent. Optimal performance occurred at 30°C, where immature seeds achieved the highest germination percentage (69%) and germination speed index (3.44), demonstrating synchronized enzymatic activation and efficient reserve mobilization. Suboptimal temperature (10°C) reduced germination to 60%, likely due to restricted hydrolytic enzyme activity and reduced membrane fluidity. Exposure to 40°C drastically inhibited germination (10%), presumably causing protein denaturation and severe oxidative stress. While regression analysis estimated an optimal germination threshold near 22–25°C, the high vigor observed at 30°C highlights the species' broad thermal plasticity. In conclusion, *A. macrocarpa* germination is strongly modulated by dormancy status and temperature, with moderate thermal regimes favoring metabolic coordination, providing crucial data for silvicultural management and climate adaptation strategies.