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ENHANCING CASTOR BEAN (*Ricinus communis*L.) GROWTH WITH WATER SOAKING: A SUSTAINABLE APPROACH

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Abstract
The castor bean (Ricinus communis L.) is a vital oilseed crop with significant economic and industrial importance due to its oil-rich seeds, which have diverse applications, including biodiesel production. This study evaluated the impact of water-soaking treatments on the germination and early growth of two castor bean varieties (Indian Brown and Brazilian White) under different watering frequencies. The study was laid out in a randomized complete block design (RCBD) as a factorial experiment in a screen house of the Faculty of Agriculture, Chukwuemeka Odumegwu Ojukwu University, Igbariam Campus, Anambra State, Nigeria. The research investigated the germination percentage, mean germination time, and early growth parameters of the two varieties. Results indicate that soaked seeds (T_2) exhibited significantly higher germination rates and reduced dormancy periods compared to non-soaked seeds (T_1). Brazilian White showed a more pronounced improvement in germination metrics following water soaking, highlighting the potential for optimized seed treatments in enhancing the establishment and productivity of castor bean crops, particularly under variable water conditions. The findings underscore the importance of tailored seed treatments in improving crop establishment, especially in regions with water stress challenges.
Keywords: *Castor oil plant, Ricinus communis, Seed treatment, Germination, Water stress, Crop establishment.*

Introduction

Castor bean (*Ricinus communis* L.) is an important oilseed crop belonging to the family Euphorbiaceae and indigenous to the Southeastern Mediterranean Basin, Eastern Africa, and India. The castor plant is known for its large, glossy leaves and attractive colorful fruits, which contain seeds that are rich in oil. In addition, the plant is used for medicinal purposes and as a biopesticide (Duke, 1981). It is a fast-growing, suckering shrub that can reach the size of a small tree, around 12 meters (39 feet), but it is not cold hardy (Phillips, & Rix, 1999). Castor bean (*Ricinus communis* L.) holds considerable economic and industrial significance due to its oil-rich seeds, which contain a unique composition of fatty acids with various applications. As the global demand for sustainable resources increases, castor bean has garnered attention as a potential feedstock for biodiesel production and other bio-based industries (Carrino*et al.*, 2020; Rivas *et al.*, 2023).

The successful establishment of castor bean plants depends significantly on germination and early growth responses, especially under water stress conditions. Additionally, seed treatments can play a pivotal role in enhancing these responses by influencing factors such as seed coat permeability, nutrient availability, and hormonal regulation. However, to harness its full potential, understanding the intricate relationship between castor bean varieties, water stress, and seed treatments is essential. Seed treatments offer an avenue to improve the establishment of crops under various conditions. This practice is particularly relevant in *Ricinus communis*, where seed dormancy and uneven germination are often challenges faced by growers (Akinyele and Ibeh, 2020; Ribeiro*et al.,* 2014). By altering seed coat permeability, modifying nutrient availability, or triggering hormonal responses, seed treatments can significantly influence germination rates and early growth. Seed treatments, including methods such as soaking, scarification, priming, and coating, have demonstrated their potential to enhance germination and seedling establishment across various crops. These treatments influence the physiological and biochemical processes within seeds, unlocking their inherent potential to withstand environmental challenges. However, the effectiveness of different seed treatments on castor bean germination and early growth remains to be systematically explored.

Specific germination and early growth responses of different castor bean varieties to water stress and seed treatments remain insufficiently explored. Addressing this gap is crucial for optimizing cultivation practices and ensuring sustainable crop production. This study aims to compare the germination rate of establishment of crops under various conditions. This practice is particularly relevant in *Ricinus communis*andto evaluate the effect of different seed treatments on Indian brown and Brazilian white seed germination.

Materials and Methods

Study Area: This research was conducted at the screen house of the Faculty of Agriculture, Chukwuemeka Odumegwu Ojukwu University (COOU), Igbariam Campus, Anambra State, Nigeria. The study area is located in South-Eastern Nigeria between longitude 6.94869° to 6.98174° E and latitude 6.27321° to 6.31003° N on elevation of 76 m above sea level. It has a table to gently sloppy terrain with streams some of which dry up at the peak of dry season (Ibeh and Nworji, 2022).

Experimental Design: The Experiment was carried out in a randomized complete block design (RCBD) as a 2x2x3 factorial experiment replicated 3 times. Factor A (seed types) was studied at two (2) levels which are; Indian brown Var. (IB) and Brazilian White Var. (BW). Factor B (seed treatments) was studied at two (2) levels: non-soaking in water (T_1), and soaking in water for 12 hours (T_2).Factor C (watering frequencies) was studied at three (3) levels which are; Daily watering as control (W_o), watering once in 3 days (W_1), and watering weekly (W_2).A total of 72 viable seeds were divided into six batches with each batch representing a treatment containing 12 seeds. The treated seeds were planted in a total of 36 poly pots (17 cm width and 22 cm depth) filled with a mixture of sandy-loam soil, and poultry manure, and were properly labeled.

Data Collection: Germination count was taken daily and the variables examined were in line with Akinyele and Ibeh (2020). These include:

Germination percentage (GP) = $\frac{\text{Total seed germinated}}{\text{Total number seeds}}$ x 100 (1)

Mean germination time (MGT) = $\frac{\text{ni X di}}{N}$ (2)

Where: *ni* is Number of germinated seeds at di days, *di* is Incubation period in days and *N* is Total number of seeds germinated in the treatment.

Complete dormancy period (CDP) = Number of days from sowing to the start of germination.

Peak period of germination (PPG) = Period of maximum number of seed germination.

Peak germination percentage (PGP) =

$$\frac{\text{Total number of seeds at peak period}}{\text{Total number of seeds germinated per treatment}} \times 100 \quad (3)$$

Twelve uniformly growing seedlings were selected and subjected to each of the varying watering frequency (W_0, W_1, and W_2). Data were collected on seedling growth parameters such as; seedling height, leaf count, and stem diameter. A meter rule was used to measure seedling height, an electronic veneer caliper for measuring the stem diameter, and the number of leaves per plant was also counted. Data were collected at 2 weeks intervals starting after 2 weeks of seed sowing at week 2, week 4, and week 6.

Data Analysis: The data were analyzed using R version 4.4.0 (R Core Team, 2023). We performed descriptive statistics, Analysis of Variance (ANOVA), and significant means separation using Tukey's HSD test to determine significant differences among the varieties and growth parameters.

Results and Discussion

The germination responses for both varieties *Ricinus communis* (Brazilian White and Indian Brown) under different seed treatments revealed significant variations (Figure 2 a and b). For both varieties, soaked seeds exhibited a higher germination percentage compared to non-soaked seeds, with Brazilian White showing a peak germination percentage slightly higher than Indian Brown. The mean germination times for both Brazilian White and Indian Brown castor beans are shown in Figure 3 (a and b). Soaked seeds (T1) of both varieties germinated more quickly than their non-soaked counterparts. Specifically, Brazilian White seeds had a mean germination time of 4.88 days (soaked) compared to 5.625 days (non-soaked), while Indian Brown seeds showed a mean germination time of 4.81 days (soaked) versus 5.54 days (non-soaked). This comparison demonstrates that soaking reduced the germination time in both varieties, though the reduction was slightly more pronounced in Brazilian White.

Table 1 presented the effects of different seed treatments on the germination parameters *R. communis*.T_2demonstrated 100% and 88.9% germination rates for Brazilian white and Indian Brown respectively, compared to 88.9% and 72.2% for the non-soaked (T_1) seeds. The complete dormancy period (CDP) was reduced from 10 days in T_1 to 8 days in T_2 in Brazilian white while Indian brown had shorter CDP (7 days) in T_2 compared to 12 days in T_1. The peak period of germination (PPG) also occurred earlier in the soaked seeds, and the peak germination percentage (PGP) was higher for T_2 (61.1%) than for T_1(56.25%) in Brazilian white. Similar trends were found in the Indian brown var. which was also more favorable in soaked seeds, further confirming the positive impact of soaking on seed germination.

The differences observed in the germination percentage of the two castor bean varieties (Brazilian white and Indian brown) under different seed treatments indicated a significant effect of the various seed treatments. Seeds soaked in water recorded higher germination rates while lower germination rate was recorded for non-soaked seeds. Soaked seeds have the maximum germination rate while non-soaked seeds recorded the least germination rate. The results indicated that seed treatment greatly influenced Brazilian white and Indian brown ability to emerge. Non-soaking can significantly reduce seedling emergence while soaking significantly increased seedling emergence. Seeds not soaked before planting might have faced certain barriers during germination process such as seed dormancy, which could inhibit water absorption thereby delaying the germination process (Baskin and Baskin, 2014). Higher germination rates recorded at Soaking may be as a result of the seeds effectively mitigating the barriers posed by hard seed coats and seed dormancy which could be due to the process of soaking results in imbibition, which triggers the release of certain enzymes that breaks down the inhibitors present in the seed coat and promote the activation of growth hormones necessary for germination (Kucera *et al*., 2005; Baskin and Baskin, 2014; Zhang *et al.*, 2015).

Conclusion

This study has shown that water soaking significantly enhanced germination and early growth of castor bean seeds, and especially under varying watering regimes. The results revealed that soaked seeds of both Indian Brown and Brazilian White varieties of castor beans had higher germination percentages, reduced dormancy periods, and improved early growth compared to non-soaked seeds. Brazilian White, in particular, showed greater responsiveness to soaking, indicating its suitability for cultivation under water-limited conditions when treated appropriately. The findings emphasize the critical role of seed treatments in mitigating the challenges associated with seed dormancy and uneven germination in *Ricinus communis*, thereby improving the crop's establishment and potential yield. The study therefore recommended the adoptionof tailored seed treatment protocols as a means tooptimizing castor bean cultivation, making it a more viable crop for biodiesel production and other industrial applications, especially in areas prone to water stress. Future research should focus on the long-term effects of these treatments on crop yield and the potential for scaling up these practices to broader agricultural systems.

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Table 1. Effect of different seed treatments on the germination parameters of Brazilian whiteand Indian Brown.

Treatment	Variety	GP (%)	CDP (Days)	PPG (Days)	PGP (%)
Non-soaking (T_1)	Brazilian white	88.9	10	10	56.25
Soaked Seeds (T_2)	Brazilian white	100	8	8	61.1
Non-soaking (T_1)	Indian brown	72.2	12	12	46.15
Soaked Seeds (T_2)	Indian brown	88.9	7	7	68.5

Where; GP = Germination Percentage, CDP = Complete Dormancy Period, PPG = Peak Period of Germination, and PGP = Peak Germination Percentage

Table 2. Effect of the different water stress on the growth parameters of Brazilian white at 2, 4, 6 weeks after sowing (WAS).

Treatment	Plant Height(cm)			Leaf Count			Stem Diameter		
	2WAS	4WAS	6WAS	2WAS	4WAS	6WAS	2WAS	4WAS	6WAS
Watering daily (W_0)	15.37	26.43	30.36	4.83	10.0	12.0	1.38	2.43	3.12
Once in 3 days(W_1)	11.30	24.45	29.30	2.67	8.0	9.0	0.67	1.33	2.62
Once in a week(W_2)	9.45	20.5	25.23	1.67	5.67	7.0	0.30	0.58	1.72
LSD *<0.05*	0.33	0.27	0.22	0.57	0.73	0.38	0.25	0.22	0.29

Note: WAS= Weeks after sowing.

Table 3. Effect of the different water stress on the growth parameters of Indian brown at 2, 4, 6 weeks after sowing (WAS).

Treatment	Plant Height(cm)			Leaf Count			Stem Diameter		
	2WAS	4WAS	6WAS	2WAS	4WAS	6WAS	2WAS	4WAS	6WAS
Watering daily (Wo)	14.43	15.38	27.37	4.00	5.67	13.00	0.85	1.67	2.52
Once in 3 days (W1)	11.30	12.37	22.45	3.00	4.00	11.00	0.53	0.83	1.47
Once in a week (W2)	6.45	10.57	21.38	2.00	2.80	7.83	0.25	0.52	0.43
LSD *<0.05*	0.33	0.31	0.27	0	0.56	0.45	0.05	0.16	0.16

Note: WAS= Weeks after sowing.

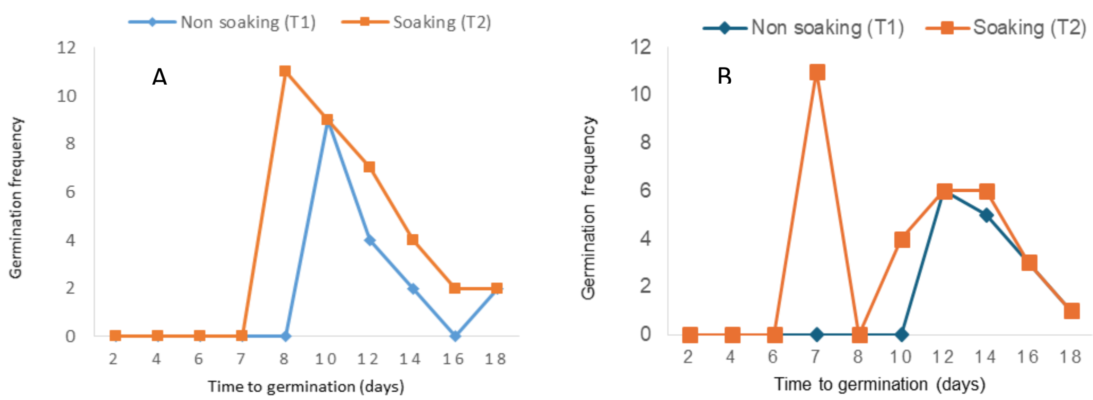

Figure 1. Frequency Distribution of the germination of Brazilian white (a) and Indian brown (b) among treatments

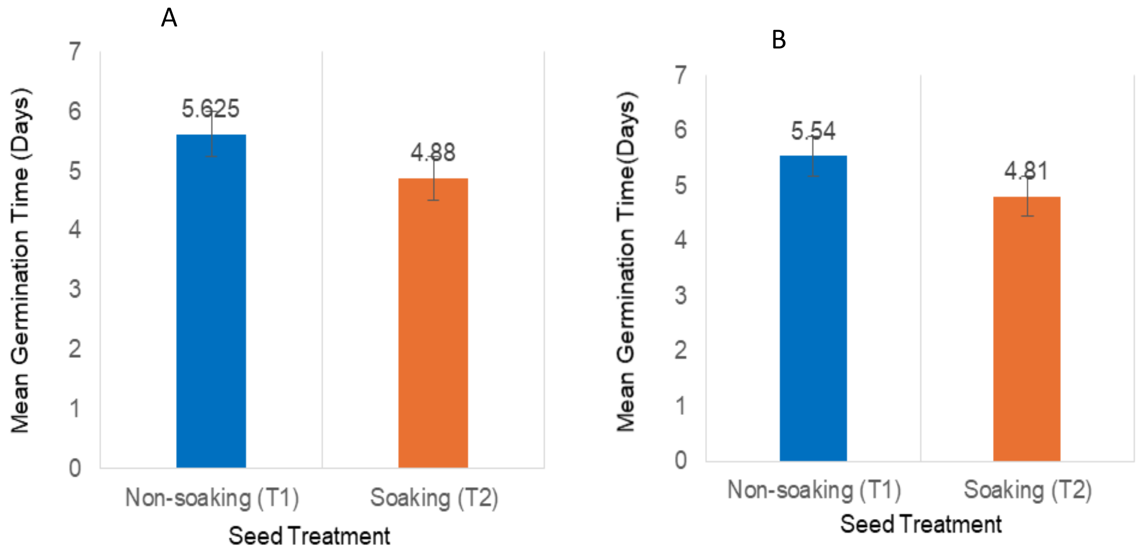

Figure 2.Treatment effects on mean germination time of the two R. communisvarieties; Brazilian