Combined Proceedings IPPS 73:273-282. 2023.

Germination and Seedling Growth Under Different Sowing Depths for Green and Silver Saw Palmetto (*Serenoa repens*)

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Keywords: palm production, seed depth, plant vigor

Summary

Saw palmetto is a native palm of the Southeast United States, present in green and silver forms, of high ornamental value for native landscapes and of potential commercial importance because of its phytotherapeutic properties. This project evaluated the influence of sowing seed depths (1, 2, 4, 6, and 8 cm) in the germination and seedling growth of silver and green forms of saw palmetto - based on nursery growers' assertions that greater depths would yield higher plants. Green saw palmetto achieved 50% maximum germination around 89 days after sowing at any sowing depth, while silver germination occurred within 149 days - and only differed between 1 and 8 cm sowing depth. The green forms had greater seedling height and leaf area one year after sowing – due to earlier germination. As sowing depths increased, seedling height and visual quality increased, but there was no difference in the number of seedling leaves. Root length decreased as sowing depth increased - but there was no effect on the root dry weight; the root biomass was similar at any depth. The green form provided taller plants

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in a shorter period due to faster germination. However, silver may be preferable due to glaucous coloration of leaves. One year after sowing, seedling height was greater at the deeper sowing depth (8 cm) - confirming nursery growers' observations; however, even with decreased root length - root biomass was unaffected.

INTRODUCTION

Saw palmetto (*Serenoa repens* Bartr.) is a small shrub rhizomatous palm species endemic and widely spread to the southeastern United States, covering coastal areas, pinelands, and prairies (Hilmon, 1985). The species has two forms, the green form found inland and the silver (form glauca), native to the eastern coast of Florida in scrub locations (Moldenke, 1967). Saw palmetto is an essential food source for Florida's fauna, and over 300 insect species visit saw palmetto inflorescences (Carrington et al, 2003; Maehr and Layne, 1996). Besides its food source value, saw palmetto provides medicinal properties (Bennett and Hicklin, 1998; Gilman, 2015).

The landscape uses of saw palmetto started around the 1970s due to the high adaptability (Smith, 1972). Saw palmetto provides excellent soil tolerance from alkaline to acidic soils, drought tolerance, and salt endurance. However, transplanting for landscapes is difficult and becomes more complex as the plants grow older. As transplanting recovery is low, the planting recommendation is twice the final number of plants desired (Gilman, 2015). Due to increased ornamental importance and low transplanting recovery, nursery propagation is essential to meet plant demand. Propagation of saw palmetto occurs by seed germination, with low and slow germination rates and growth (Gilman, 1999). Reports on seed germination studies on saw palmetto have varying results on temperature and pre-germination treatments (Carpenter, 1987; Makus, 2006; Makus).

Seed depth is also essential in seed germination (Murphy et al, 2016). Seed depth varies according to the seed size and species grown. A standard recommendation is to use the seed's diameter as the depth measure to sow (Meerow and Broschat, 2021). As the drying potential increases, seeds should be placed deeper in the soil (Broschat and Donselman, 1986).

In visits to nurseries in the region, a common practice shared was placing saw palmetto seeds deeper in the soil, where it would provide taller plants in shorter periods. Based on this information, this research focused on elucidating the grower's claim and determining the best sowing depths for silver and green saw palmetto for yielding the best quality and taller plants in a shorter period, considering this slow-growth palm. The objectives of this project were to evaluate the influence of seed sowing depth of saw palmetto in germination rate and seedling growth one year after sowing for both forms.

MATERIALS AND METHODS

Green and silver saw palmetto (**Fig. 1A, 1B**) seeds were collected in October 2021. The green form was from Felda, FL, and the silver form was from Gainesville, FL. The endocarp was removed before seed sterilization (2.26% NaCl for 20 min with three

rinses in deionized water (DI)) and soaked for 24h, based on Makus, 2006, in 250 ml Erlenmeyer flasks with 150 ml of deionized water with moderate vibration (161 rpm) on a platform shaker. Seeds were placed with operculum downward in contact with the soil (**Fig. 1C**).

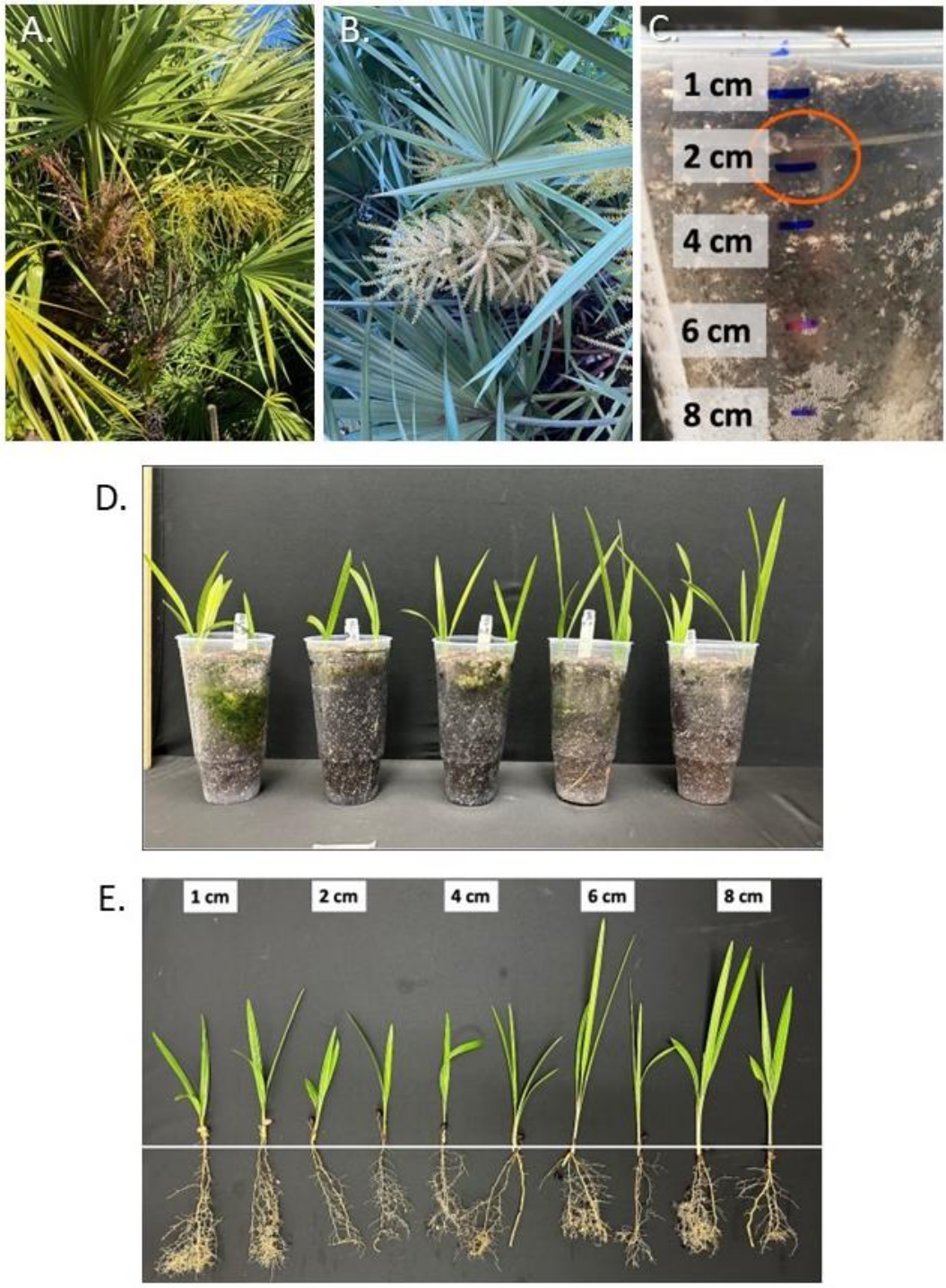

Figure 1. **A)** Green saw palmetto form; **B)** Silver saw palmetto form; **C)** Seed position at containers to facilitate germination reading; **D)** Green form seedlings one year after sowing.

Containers were adapted from clear 50 oz. Drive Thru Bantam Cup. (22.8 x 11.4 cm) with six circular holes (1 cm each) in the bottom, wrapped in two layers of black plastic per plot, filled with general-purpose soilless media (Promix BX, Premier Tech Horticulture, Quebec). Plants were grown under controlled conditions in a greenhouse (30.5 – 22 °C) on the University of Florida campus for one year. Plants were manually irrigated as needed. This study used five blocks in a randomized complete block design; each block contained all treatment combinations in plots, and each plot consisted of 10 containers with two seeds each on opposite sides of the container (500 seeds for each form) (**Fig. 1D**). A 2 x 5 factorial design was used to evaluate the influence of saw palmetto forms (2 levels: green vs. silver) and sowing depth of the seed (5 levels: 1, 2, 4, 6, and 8 cm) on germination and seedling growth.

Germination data collection occurred weekly and seedling growth after a year (November 2021 to 2022). Germination was scored as emerging cotyledonary petiole 2 mm out of the seed coat. Seedling data collection at the end of the experiment included plant height, number of leaves, leaf area (cm^2), SPAD (Minolta Camera Co., Osaka, Japan), root length, visual rate (1-10), canopeo, shoot and root fresh and dry mass (48 h in a forced air 70 °C oven). Statistical analyses were conducted using the software SAS version 9.4 (SAS Institute Inc). For testing of form and/or sowing depth influenced the germination or seedling growth, NLmixed and Glimmix with Anova at (P=0.05) were used.

RESULTS

Considering germination, forms significantly influenced days to achieve 50% of maximum germination (LD50%) (P-value: <.0001) at any depth (**Fig. 2**).

The silver form had a higher LD50%, taking longer to germinate and achieving the 50% of germination, in average 149±10 days. The green form germinated faster within an average of 89±7 days. The estimated difference between both forms was 60±13 days. The maximum germination did not differ between forms or depths, with greater than 70% germination at any treatment combination. The silver form had nearly 90% germination - with no significant differences among sowing depths of 4, 6, or 8 cm (**Fig. 3**).

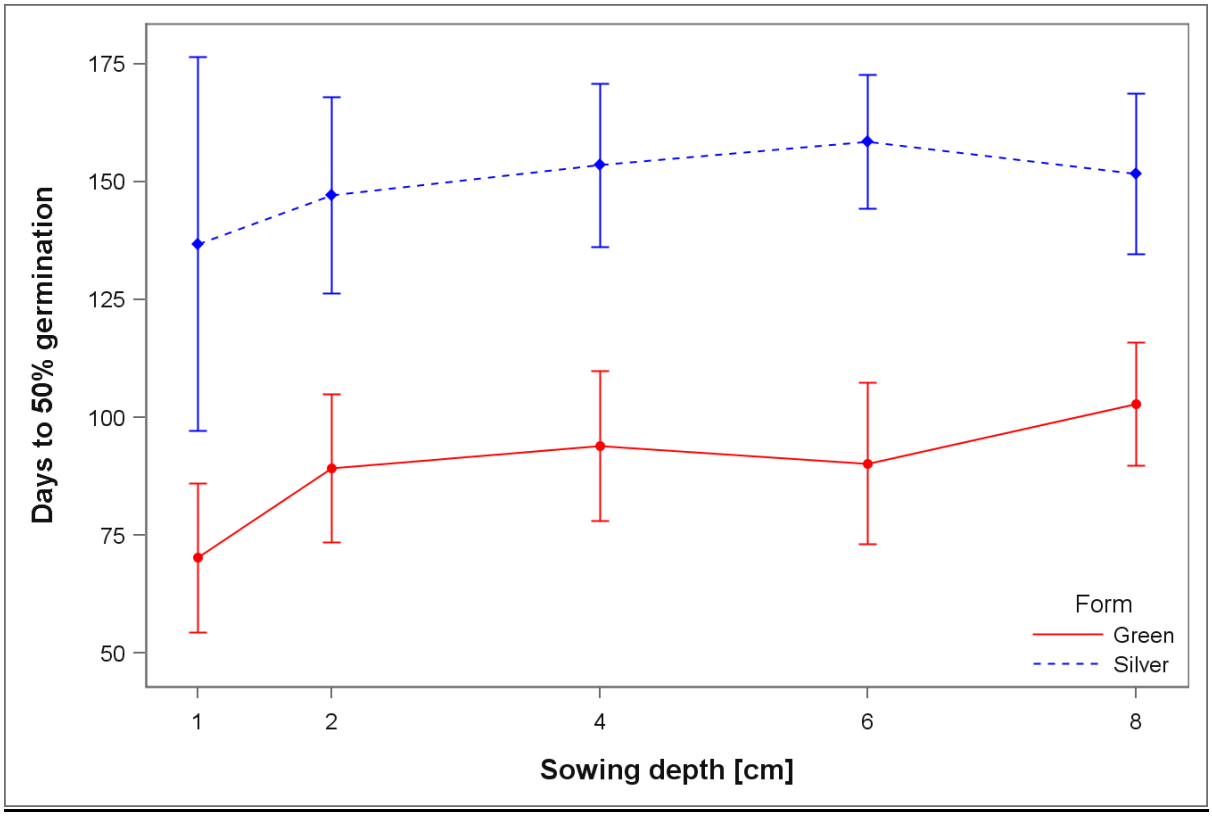

Figure 2. Days to achieve 50% of germination from total germination achieved since sowing. On red, green form, and in blue silver form. The lower and upper 95% confidence intervals are shown as error bars at each sowing depth point. Forms were significantly different while sowing depth was not significantly different for both forms.

Due to germination occurring at different times for both forms, seedling growth data was selected for the seeds that germinated at the peak of germination in March, April, and May (N: 388 seedlings, minimum of three containers (treatment combination) per plot, on each block). Seedling height was significantly affected by sowing depth (P-value: 1.45E-18) and form (P-value: 2.87E-06) with no interaction. Sowing depth differences caused a plant height differential of 10cm between the green and silver saw palmetto forms. For green saw palmetto sown at 8cm depth, seedling height was 31.8±0.5 cm while a 1 cm depth was 21.5±0.8 cm; while for silver saw palmetto, sowing depths of 1- and 8-cm led to seedlings heights of, respectively, 18.9±0.53 cm and 29.8±0.5 cm (**Fig. 4**). Comparing both forms (P-value: 2.87E-06), the green form produced taller seedlings than the silver form, with respectively, plants than silver, 27.0±0.61 cm and 24.48±0.62 cm respectively.

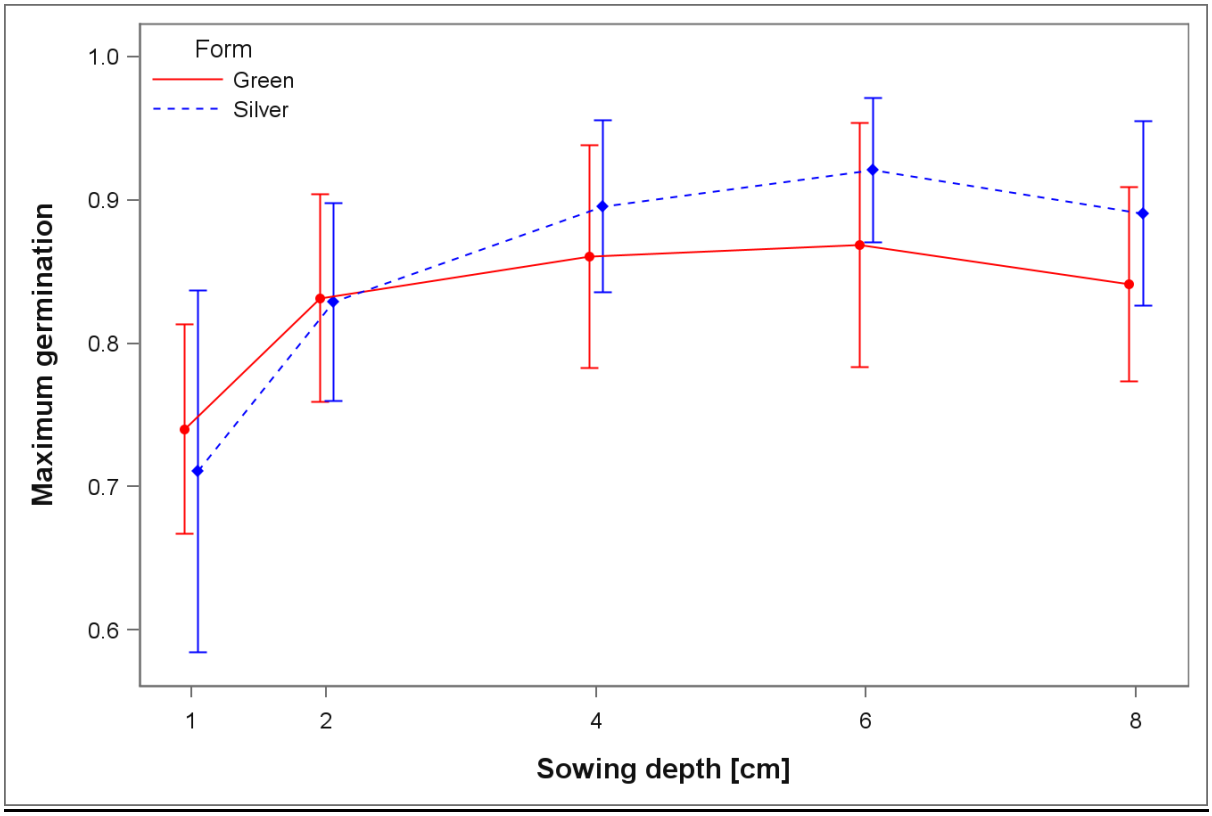

Figure 3. Maximum germination achieved for each form. On red green form, and on blue silver forms. The lower and upper 95% confidence intervals are shown as error bars at each sowing depth point. Even though tough forms or sowing depth were not significantly different, silver form (in blue) presents a trend of increasing maximum germination as the sowing depth increases.

As expected, the root length decreased due to reduced root-growth space in the container as the sowing depth increased from 1- to 8-cm (P-value: 1.45E-18). For green saw palmetto at 1- and 8- cm sowing depths had seedling root lengths of, respectively, 19.2±0.5 cm and 12.4±0.3 cm; for silver saw palmetto, 1- and 8- cm sowing depths had seedling root lengths of, respectively, of 20.3±0.3 cm and 13.4±0.3 cm (**Fig. 5**). However, the dry weight of roots was not affected for the silver form, while differences of the green form at 2, 4, and 8 cm sowing depths were, respectively, 0.60±0.03 g/plant, 0.45±0.03 g/plant, and 0.39±0.02 g/plant (P-value: 0.03). Dry root weight differed between the silver form (0.41±0.03 g/plant) and green form (0.50±0.03 g/plant) (P-value: 0.0006), (**Fig. 6**).

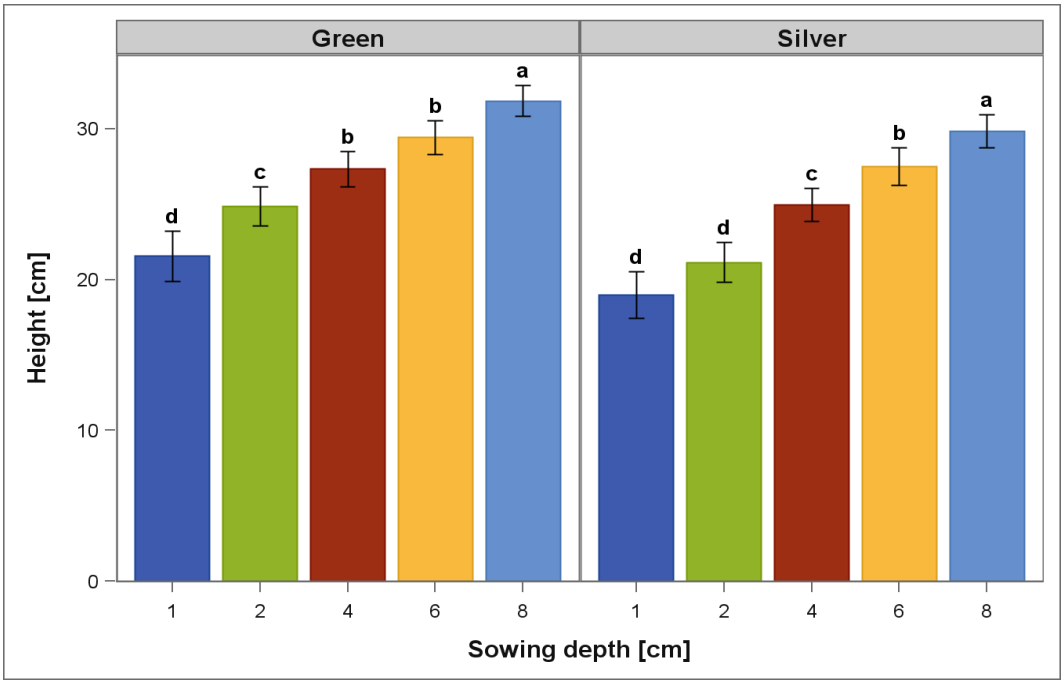

Figure 4. Seedling height (cm) one year after sowing for green and silver saw palmetto forms. The lower and upper 95% confidence intervals are shown as error bars at each sowing depth point. Different letters indicate significant differences between sowing depth based on LSMeans (P=0.05). Increase of sowing depth has increased the seedling height one year after sowing.

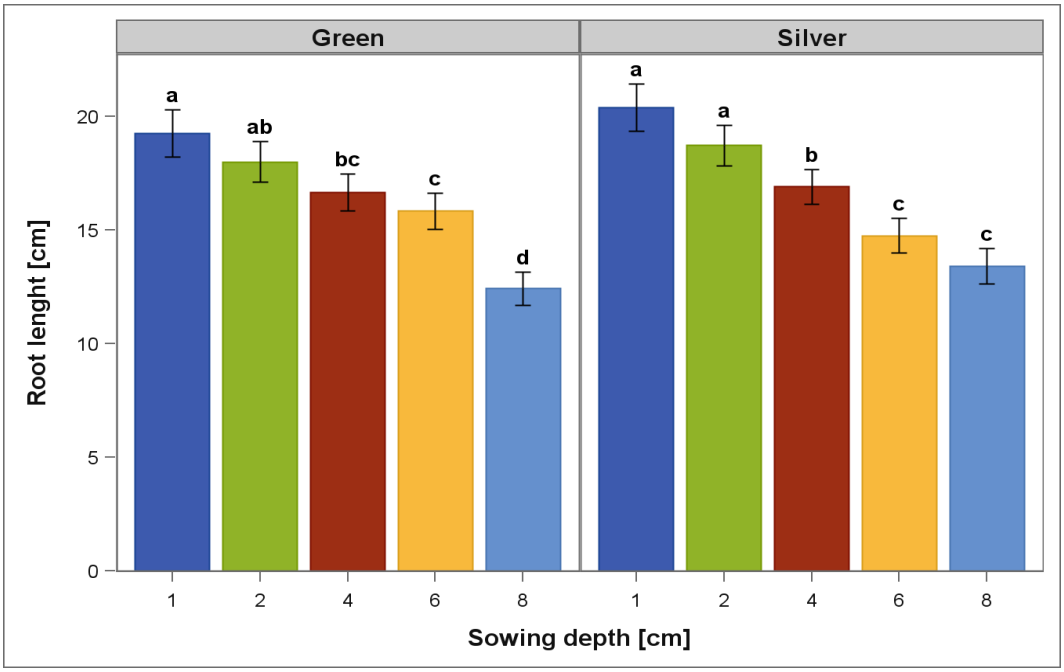

Figure 5. Root length (cm) one year after sowing for green and silver saw palmetto forms. The lower and upper 95% confidence intervals are shown as error bars at each sowing depth point. Different letters indicate significant differences between sowing depth based on LSMeans (P=0.05). Increase of sowing depth has decreased the seedling root length one year after sowing, related to less space in the container.

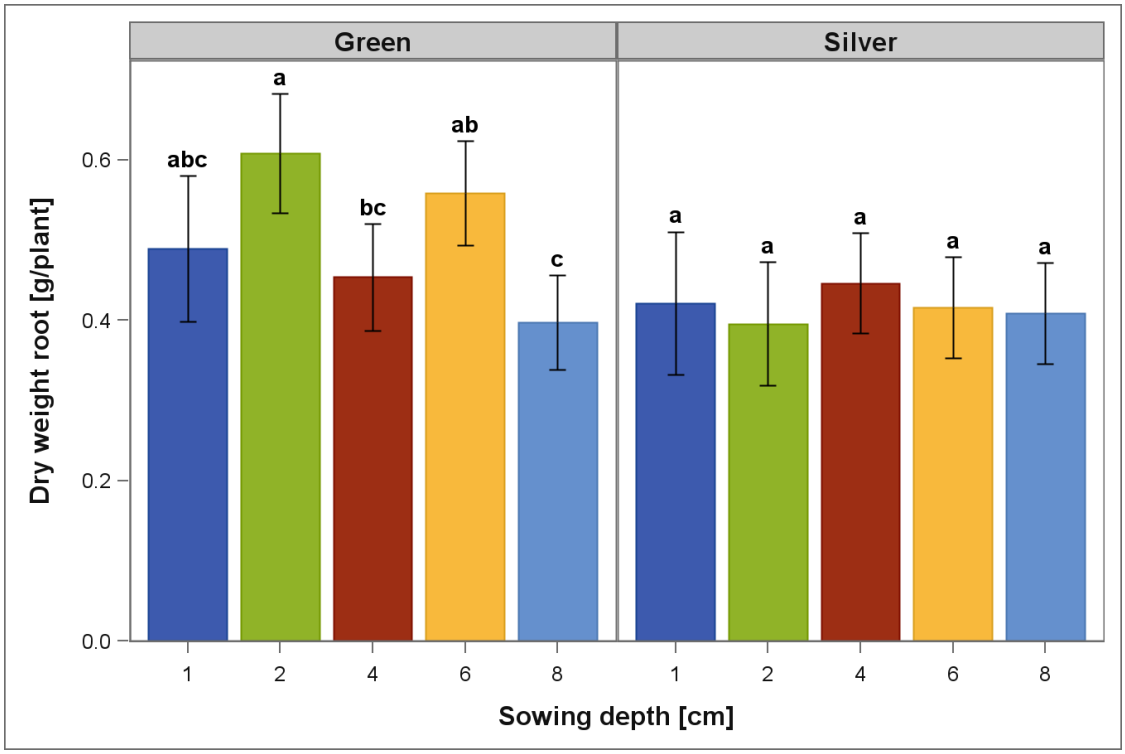

Figure 6. Dry weight root (g/plant) one year after sowing for green and silver saw palmetto forms. The lower and upper 95% confidence intervals are shown as error bars at each sowing depth point. Different letters indicate significant differences between sowing depth based on LSMeans (P=0.05). An increase in sowing depth did not affect root biomass one year after sowing, even though the root length decreased.

DISCUSSION

The results confirmed the grower's claim that increasing sowing depth saw palmetto seedlings will increase plant height. Considering the effects on germination, the sowing depth did not affect the time to achieve 50% of maximum germination for both forms. However, forms were significantly different, with green saw palmetto germinating around 60±13 days before silver saw palmetto at any depth. One hypothesis for this effect could be related to the providence of the seeds and mother plant conditions. Green seeds originated from the south of Florida state, and silver from the north region. This difference in germination response occurs on several species and even in geographically close locations (Baskin and Baskin, 2014). Harper's beauty (*Harperocallis flava*) presented germination variability between populations within 8 km from three seed collection locations (Gardner, 2021). This variability is usually associated with genotypes and environmental heterogeneity in maternal plants (Baskin and Baskin, 2014). Seeds achieved high germination rates (>70%) at any depth for both forms. A standard recommendation is to use the seed's diameter as the depth measure to sown, varying according to the environmental conditions, ranging from 1 to 2 cm for most palm species (Broschat and Meerow, 2000).

Seed depth affected germination percentage and time on areca palm (*Chysalidocarpus lutescens*). In full sun, germination at 1 cm achieved 74%, against 30% in surface or 6 cm. Seed depth effects on germination for areca palm varied according to the environmental conditions, as embryo desiccation is a significant cause of seeds not germinating (Broschat and Donselman, 1986); contrary to their report, sowing depth in our study did not alter germination rates or speed for both forms of saw palmetto.

Seedling growth of the green form produced taller plants one year after sowing, correlated to its earlier germination than the silver form. Increased sowing depth led to taller plants (**Fig. 1D**). Better seedling vigor was also visualized on seeds of Yarey Palm (*Copernicia breweriana*). Seeds sown at 1.27 cm had the greatest germination (79.5%), increase in leaf emergence at 3-month seedling, and higher seedling survival at seven months - when compared to seed sown in the substrate surface (Murphy et al, 2016). On the orchid tree (*Bauhinia retusa* and *Bauhinia variegata*), seeds were sown at 2, 4, and 6 cm, seedling emergence, length, and biomass for *B. retusa* occurred at 4 cm sowing depth. In comparison, *B. variegata* at 2 cm (Yadav et al, 2023). Root length was decreased, associated with the smaller area for root growth in the containers as seeds are set lower in the substrate. However, the biomass (root dry weight) was not affected; seedlings were able to produce a similar amount of root mass even in smaller areas.

CONCLUSION

Green and saw palmetto forms differed in germination timing. However, germination was not affected by sowing depth. Green saw palmetto provided taller plants one year after sowing, which correlated with earlier germination—the deeper sowing depths produced taller seedlings with shorter root lengths - but no effect on root biomass. Future research should evaluate seeds of both forms from other populations for geographical impact and deeper sowing depths. Moreover, the persistence of sowing depths results in increased seedling growth rates.

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