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Short Communication

Effects of soil texture on germination and survival of non-toxic *Jatropha curcas* seeds

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ABSTRACT

Toxic oil seeds of *Jatropha curcas* have been widely propagated in tropical and subtropical regions for biofuel production. However, very little is known about the non-toxic seeds of *J. curcas* and their germination. This paper describes the germination and survival of non-toxic *J. curcas* seeds over two consecutive years. Non-toxic seeds native from south-eastern Mexico (600–800 mg weight) were sown in three soils with different texture (sandy; sandy-loam and clay-loam) in order to assess germination, speed of germination and survival rates of the emerged seedlings. Sandy soil had the lowest organic matter (OM) content with 1.68 g-kg^{-1} of dry soil, followed by sandy-loam soil (39 g-kg^{-1}) and clay-loam soil with the highest OM (72.63 g-kg^{-1}). The highest germination rate was obtained in sandy-loam (76%), followed by sandy (75%) and clay-loam soil (24%). The highest survival rates were obtained in sandy (99%) and sandy-loam (99%) soils followed by clay-loam soil (87%). The highest average speed of germination index was recorded in sandy (155), followed by sandy-loam (125) and clay-loam soil (23). It can be concluded that sandy and sandy-loam soil textures, with bigger pore size and low organic matter content, were the more suitable substrates to germinate non-toxic *J. curcas* seeds; clay loam as substrate was not suitable for non-toxic *J. curcas* seeds due to the low germination rate and speed.

1. Introduction

Jatropha curcas is widely grown as a commercial crop in many developing countries for its potential as a bioenergy source, due to the rich oil content of its seeds [1–3]. However, this plant is still undergoing domestication [4] and one limitation in large-scale cultivation is the scarcity of scientific research on *Jatropha* germination [5]. One significant factor for seed germination and good seedling establishment in the field is soil type. Studies on *Jatropha*, relating to germination and survival in various substrates, indicate that sandy soil is the most commonly used and is suitable for achieving high germination rates [6,7]. Information for the Mexican non-toxic *Jatropha* has not being found yet. These seeds do not contain detectable phorbol esters, identified as toxic agents with insecticidal, antimicrobial and cytotoxic properties [8,9]. Such compounds may affect the germination performance of *Jatropha* seeds. The objective of this research was to determine the effect of three types of soils on seed germination rates and seedling survival in non-toxic *J. curcas*.

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2. Materials and methods

2.1. Seed source and phorbol ester determination

Seeds from Papantla, in the southeast region of Mexico (20°15′17″N, 97°15′32″W; 71 masl), were collected during June 2009 and 2010. For each collection, ripe fruits (yellow) were harvested and the seeds obtained manually. Seeds were dried in a shaded and aerated location for one week and then stored inside glass bottles in a cool and dry location (18 °C) until be used. Prior to experimentation, all seeds were weighed and seed selection was based on the range of the highest frequency of weights of the total harvested seeds (the range was 700–799 mg in 2009 and 600–699 mg in 2010). Phorbol ester contents were determined by the method of [10], which did not detect any equivalence to phorbol 12-myristate 13-acetate (PMA) in the seeds.

2.2. Soil selection and characterization

Three different soils were selected for their granulometric characteristics. Sandy-loam and clay-loam soils were obtained from a deciduous forest (19°11′41″ N, 96°20′19″ W; 16 masl), while sandy soil was obtained from a natural dune (19°11′04″ N, 96°14′21″ W; 4 masl). The upper 30 cm of soil was extracted and one 10 kg sub-sample was taken from each soil for each year and for chemical and physical analysis. Granulometric characterization was performed following Bouyoucos; analysis of pH by electronic potentiometer; and organic matter (OM) determined by the Walkley-Black method.

2.3. Experimental site

The experimental site was located in the city of Veracruz (19° 11′ 55″ N, 96° 9′ 7″ W; 2 masl). The site consisted of an open yard and a 25% mesh shade was hung over the experimental units. The climate in the region is hot sub-humid. Plant material and site conditions are summarized in Table 1.

2.4. Experimental design and sowing

Two experiments were carried out: one, labeled 2009, starting on August 7th, 2009; and the other, labeled 2010, starting on July 10th, 2010. The treatments evaluated were: sandy, sandy-loam and clay-loam soil texture. During each experiment and for each treatment, two wooden boxes of 46 × 32 × 15 cm length by width by depth were filled with the corresponding soil and randomly placed within the experimental area. 120 seeds per treatment were soaked in tap water for 12 h and then sown in the corresponding soil in a vertical position with the caruncle downwards, at a depth corresponding to their length (about 2 cm) and about 4 cm apart. The soil in each box was watered daily up to the field capacity of each soil type in order to maintain constant soil moisture levels in each container.

2.5. Germination and survival rates

The germination account was registered from day two until day 22, when no further germination was observed. The survival rate was calculated from the number of seedlings surviving for a period of 20 days following germination.

2.6. Speed of germination index (SGI)

On the day when the last germination was recorded, the SGI was estimated according to [11]:

$$SGI = \sum (n_i/t_i)$$

where n_i = number of germinated seeds; t_i = i number of days for n_i.

2.7. Statistical analysis

Statistical analysis was performed using one-way analysis of variance (ANOVA) with multiple comparison tests. Normality and equal variance tests were conducted. Normally distributed data were analyzed with parametric tests, while non-normally distributed data were analyzed by applying the non-parametric Kruskal–Wallis method. Tukey tests were used to make post hoc comparisons between conditions. The level of significance used was 0.05.

3. Results

3.1. Soil characteristics

Granulometric characterization determined that the sandy soil consisted of 96% sand, 2.5% silt, and 1.5% clay; the sandy-loam soil had 66% sand, 21% silt, and 13% clay; and the clay-loam soil had 30% sand, 35% silt, and 35% clay. Analysis of

Table 1 – Experimental conditions during the germination experiments.

Soil texture	Experiment and period	Seed weight range (mg)	Environmental conditions			
			Minimum Temperature (°C)	Maximum Temperature (°C)	% Relative humidity	Precipitation during the full month (mm)[a]
Sandy Sandy-loam	2009: August	700–799	23.0 ± 2.16	31.8 ± 2.6	73.8 ± 9.3	217.0
Clay-loam	2010: July	600–699	24.6 ± 1.1	30.3 ±1.7	83.9 ± 6.6	432.2

a Data from the National Mexican Meteorological Base for the state of Veracruz.

Table 2 – Germination rates in three different soils during August-2009 and July-2010.

Soil	Experiment	SGI	% Of germination	% Of survival
Sandy	2009	177	77[a]	99[a]
Sandy-loam	2009	159	83[a]	100[a]
Clay-loam	2009	30	25[b]	85[b]
Sandy	2010	133	72[c]	100[c]
Sandy-loam	2010	91	72[c]	98[c]
Clay-loam	2010	16	22[d]	89[d]

a, b, c, d Different letters indicate statistical differences (Tukey; $P < 0.05$).

registered similar temperatures; and to [12] who considered 25–30 °C as an optimum temperature range for *J. curcas* seeds. [6,7,13] have found that mixtures of sand and manure, containing higher levels of OM, decreased germination rates; which indicates that higher levels of OM and moisture retention provided by the clay substrate may have influenced the proliferation of bacteria and fungus that attacked the seeds and reduced their germination and survival rates [14]. Additionally, high clay contents in this soil reduced its ability to induce gas exchange with external air, decreasing seed respiratory activity and increasing germination time [15]. By the other side, due to their bigger pore size, sandy and sandy-loam substrates had lower water retention and

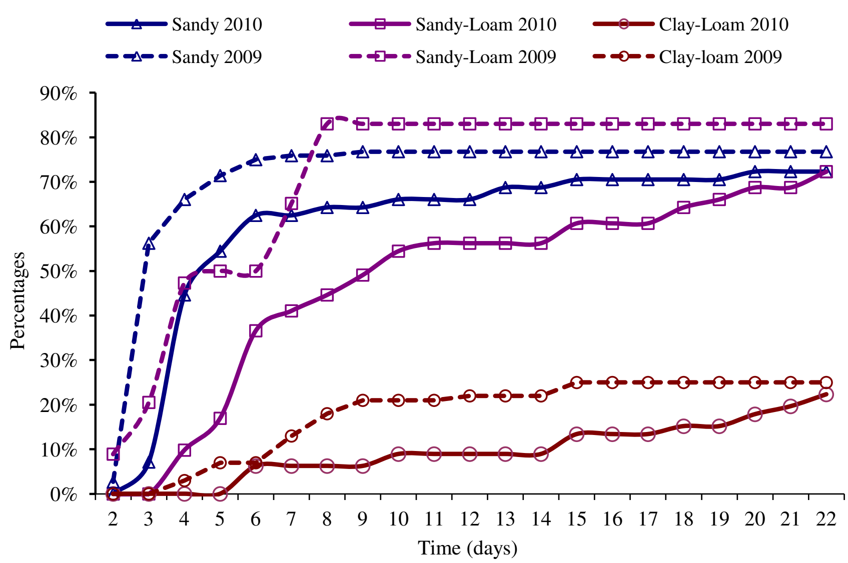

Fig. 1 – Accumulative germination by soil texture and experiment.

pH showed that the three soils were slightly alkaline: sandy 7.81, sandy-loam 7.26 and clay-loam 7.43. The highest OM content (expressed in g-kg^{-1} of dry soil) was found in clay-loam (72.63), followed by the sandy-loam (39.0), and the sandy soil had the lowest OM content (1.68).

3.2. *Germination, survival rate and speed of germination*

The higher germination and survival rates occurred in sandy and sandy-loam soils, significantly decreasing in clay-loam (Tukey; $P < 0.05$) in both years (2009 and 2010). The highest germination speed was found in sandy soil, followed by sandy-loam, while the lowest germination speed was obtained in clay-loam soil (Table 2; Fig. 1).

4. Discussion

The germination rates obtained from these non-toxic seeds were about 20% lower than those reported by [6] and [7] for toxic seeds in sandy substrates at similar environmental humidity and temperature. However, they were similar to those of [5], who did not report humidity values, but provided better aeration to the seeds, which may favored both germination rates and speed of germination, which was highest in the substrate with the largest pores and lowest nutritional contents. The lower germination rate and SGI obtained during 2010 could be related to the increased environmental humidity registered during this period, which was 10% higher in 2010 as compared to 2009 (Table 1). In this regard [6], and [17] reported that germination rates in *J. curcas* seeds decreased with increased humidity. Survival rate was high during both experiments for the three types of soils, but it decreased in clay-loam soil; this result is congruent with the reports of [7,14,16] and [17], who indicate that seeds and seedlings are sensitive to excessive humidity in the soils.

5. Conclusion

Non-toxic *J. curcas* seeds have been shown to be sensitive to fine soil textures, higher organic matter and higher environmental humidity, factors that significantly decrease their germination, survival and speed of germination. Therefore, sandy and sandy-loam textures are widely recommended over clay-loam textures in order to achieve better germination and survival rates.

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