Effect of the soaking time of moringa (*Moringa oleífera*) seeds on the germination and growth indicators of the plant

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Through an experimental design in random blocks with factorial arrangement and five replicates, the effect of soaking the seeds of this plant during 0, 24 and 48 h on the percentage of germinated seeds and on growth indicators of the plant (percentage of leaves/plant, length and thickness of the stems, root length, length of leaves and stems and volume of the air biomass) was studied in periods of 11-15, 16-21 and 22-26 d after sowing. During the first stage, the highest germination percentage ($P < 0.001$) was between the 11-15 d for the seeds soaked for 24 h (86 %), without differing from those soaked for 48 h. The percentage of the germinated plants was higher ($P < 0.05$) between 16-21 d, and happened in the control without soaking and did not differ from the treatment with 48 h of soaking. From 20 d after sowing on, the treatments with soaked seeds did not affect significantly the number of leaves/plant (5.0-6.0), the stem length (10.7-11.2 cm.), the root length (3.4-3.9 cm.), the stem thickness (0.20-0.22 cm.), the stem weight (0.40-0.46 g), that of the leaves (0.60-0.76 g) and the air biomass volume (5.12-5.36 cm^3). It is concluded that the moringa seeds should be soaked in running water for 24 h before sowing to fasten their germination on the field. Validating these results under the field conditions is recommended.

Key words: *moringa, seeds, soaking, germination, growth*.

The *Moringa oleífera*, native from the south of Himalaya, in the northeast of India, may be found in Pakistan, Bangladesh, Saudi Arabia and Afghanistan. It is a plant that has been introduced in most of the tropical countries. In Central America was introduced in 1920 as ornamental tree. It is also used as living fence, as windbreak (Rocha 1998 and Carballo 2011).

The natural extension range of this tree is from Arabia to India. Nowadays, moringa is commonly seen in landscapes of all tropics of the old world of South Africa and Western Africa. It is more seen in east and south parts of Africa. It may also be found in allotments of many pacific islands, from Kiribati to Northern Mariana (Carballo 2011).

The sowing may be conducted with seeds or sticks. The first germinate after 10 d. The plagues affecting the plants immediately after germination are ants, zoompopos, meter warms and the false mediator. They normally attack once and do not return to the crop, although controls should be applied always to diminish the damages. In Cuba, the leaf-cutting ant (*Atas insulares*) and species of the Fusarium genus attack severely during the young stages of the plant.

The moringa requires clayish soils. It does not tolerate those loamy or of bad drainage. The plant adapts to hard or heavy soils as well as to poor sandy. The proper drainage is very important because the plant does not tolerate pooling. It accepts acid soils, with pH up to 6.5. It is resistant to long drought periods and grows under arid and semi-arid conditions (optimum rainfall of 500 mm well distributed in the year).

Its germination is rapid when the seeds are new, but the percentage decreases as their obtainment time passes. The moringa seeds do not have latency periods and may be planted as soon as they are mature. This is a very important datum to be considered by the producer when buying them. Soaking the seeds for 24 h at room temperature is recommended.

The moringa is a plant of rapid growth and easy propagation, whether by seeds or asexual reproduction (sticks). Each kilogram of seed represents from 3.200 to 3.500 units. The germination is between 70 and 98 %. It diminishes notably when the sowing height is superior to 1.200 m a.s.l.

The seeds can be planted directly on the soil or in recipients. No treatment is needed and they germinate rapidly in the first 6-10 d after the sowing and they can reach up to 5 m of height in one year under controlled environmental conditions. Therefore, before the direct manual sowing, soaking the seed in water for 24 h at room temperature is recommended.

When the seed breaks and starts germinating, the growth rate is amazing. These conditions show the need of their immediate transplant, as the root, for being pivotal, growth in only one direction and can twist and make the rooting process difficult. The average weight of each seed is of 0.3-0.4 g, so there are at about 3000 seeds per kilogram. The seeds can be sown without previous treatment. The peeling is not necessary; it may even weaken the germination process.

Germination is rapid if new seeds are used, but the percentage diminishes as their obtainment time passes. This is a very important datum to be considered by the producer when buying the seeds. Soaking the seed in water for 24 h at room temperature is recommended. As previously referred, this is a plant of rapid growth and easy propagation, whether by seeds or asexual reproduction (sticks). A kilogram of seeds represents at about from 3.200 to 3.500 units. The germination is between 70 and 98 %. It diminishes notably

when the sowing height surpasses the 1.200 m a.s.l.

Although the moringa seeds achieve a good germination and its growth is rapid, there is not a defined criterion in respect to pre-germinations with room temperature before the sowing. Some authors state the necessity of soaking the seeds before sowing (Anon 2011), some others do not consider necessary the treatments previous to the sowing to achieve a good germination (Pérez *et al*. 2010 and Caraballo 2011). There is also the criterion about the physical treatments and their weakening to the germination.

From the previous criteria and according to the sowing program of the country for the next years, deepening in the treatments favoring the germination of this plant is necessary. The objective of this experiment was to assess the effect of three soaking times of the germination seeds and survival of moringa under controlled conditions.

Materials and Methods

Treatments and design. Three treatments were established: 1) control, sowing of the seeds without soaking; 2) soaking of the seeds with running water for 24 h; 3) soaking for 48 h. A random block design with five replicates was applied.

Procedure. Seeds of Creole Cuban moringa from Alamar, Havana province were used. They were harvested in September 2011 and stored two months before the sowing. During that time, they were kept in an air-conditioned room at 18 ºC.

The soaked seeds were divided into two lots of 500 seeds each. The seeds were soaked in a jute sack with running water to guarantee their total covering and eliminate the substances that could affect them. The first day, 500 seeds were soaked and another 500 the second day. The two pre-germinated treatments were formed and they planted the same day. Once the seeds were soaked, they were spread out on jute sacks in the shade to drain for 12 h and make the sowing easier. After eliminating the humidity of the seeds, the sowing of the three treatments was conducted on January 12 2012.

The sowing was conducted in rectangular tin bowls, 75 x 75 cm, at 17 cm of height. The germination bed was a red ferralitic soil, properly sieved and irrigated before the sowing. Five furrows of 100 seeds were planted of each treatment. Irrigations were applied every other day during the first 21 d after the sowing. Later, it was applied every 3 d until the soil had the field capacity.

Germination was measured from 11 to 15 d, 16 to 21, and 21 to 26 every other day once it started. At 20 and 40 d after germination, the number of leaves/plant, stem length (cm), root length (cm), stem width (cm), stem weight (g) stem leaves (g) and volume of the air biomass (cm^3) were measured in five plants per replicate.

The theoretical assumptions of the analysis of variance were verified from the Shapiro and Wilk (1965) test for the normality errors. The Levene (1960) test was applied for variance homogeneity. The variables did not achieve the theoretical assumptions of ANAVA, so the transformations $\sqrt{x}$ were used for the variable counting and arc sin $\sqrt{x}$ for those expressed in percent. However, they did not improve the achievement of such assumptions. Therefore, the non-parametric analysis of variance of Friedman's random blocks was conducted. The Conover (1999) test was applied for comparing the mean ranges.

Results

During the first stage, the highest germination percentage ($P < 0.001$) was presented between the 11-15 d in the seeds soaked for 24 h (86%), that did not differ from that obtained with the soaking for 48 h. The amount of germinated plants was higher ($P < 0.05$) between the 16-21 d and corresponded to the control treatment without soaking, that did not differ from that obtained with the soaking for 48 h.

From the 20 d after sown in bowls on, the soaking treatments did not affect significantly the number of leaves/

Table 1. Effect of pre-germination on the germination percentage of moringa

Treatments	Percentage of germination			
	11 - 15 d	16-21 d	21-26 d	Total
Central	0.589 (33.2)	2.8 (29.0) DE=1.52	1.9 (2.8) DE=2.17	1.0 (94.5)
Moistening 24 h	1.14 (80.6)	1.29 (5.0) DE= 4.12	1.7 (40) DE=2.83	2.7 (93.4)
Moistening 48 h	0.98 (67.6)	1.7 (4.0) DE=2.8	2.4 (4.8) DE=4.55	2.3 (86.4) 0.08**
SE ± SIG	11.52***			

Table 2. Effect of seed soaking on the stem length and volume of the root after 40 d of germination.

Treatment	Stem length	Root volumen (cm^3)
Control	11.72^b	6.46^b
Soaking 24 hours	10.48^a	6.46^b
Soaking 45 hours	10.56^a	6.12^a
SE ± Sig	0.20*	0.08*

*P<0.05

plant (5.0-6.0), stem length (10.7-11.2 cm), root length (3.4-3.9 cm), stem width (0.20-0.22 cm), stem weight (0.40 - 0.46 g), leaves weight (0.60-0.76 g) and volume of the air biomass (5.12-5.36 cm^3). Soaking the moringa seeds with running water for 24 h before the sowing is recommended to accelerate their germination in the field.

Discussion

Although certain scientific experiences show that soaking is an option for improving the moringa seeds germination, there are some criteria considering this practice unnecessary. (Medina *et al*. 2007). This study indicated that the pre-germination for 24 h fastened the seed germination. This treatment allowed that 86 % of the germination occurred between the 11 and 15 d after the sowing. This condition propitiated the young plant to accelerate growth in respect to the undesired species. This result is interesting if knowing that this plant grows fast, favoring the competition between plants for an ecological niche in grassland ecosystems. Besides, it was demonstrated that the pre-germination for 48 h affects the percentage of total seed germination. This last could be because when the seeds are soaked for a long time they can be affected and fungi provoking putrefaction may appear (Febles *et al*. 1998). In this study, such conditions got worse because the sowing was controlled and the soil was moistened every other day, so the seeds were always wet. When the total germination was analyzed, the control surpassed 90 %. This confirms that the seeds of this plant achieve a high germination percentage, in spite of the treatments (Medina *et al*. 2007).

The absence of response by the yield components, measured at 20 and 40 d posterior to the sowing, can be linked with the size of the flowerpot used for r this test. Although the proposal of this study was to accelerate germination and achieve higher height and root length in young plants of moringa and favor other yield components (number of branches, leaves/plant, stem width, among others), the results were not as expected. In studies of Medina *et al*. (2007), conducted under greehouse conditions, no significant differences were either found for plant height, amount of branches and growth rate during germination and the initial growth stage of moringa. However, they did find response in other growth indicators of this plant.

This performance could be due to the flowerpots used for the test that only had 17 cm depth for accumulating earth. This condition did not facilitate higher growth of the roots either the development of the air part of the plants. Other influencing factor could the soaking of the germination bed every other day until reaching the field capacity. In this sense, Pardos (2004) stated that the excess of humidity on the soil may provoke germination losses and diminishing of the root growth and the air part of some tree species. This author considers that the excess of humidity may have a positive effect due to the cleaning of inhibitor substances of germination. If this study would have been conducted in field conditions, where rainfall is more erratic, better response of the plant indicators could have been expected by effect of the seed pre-germinations. These conditions favor the young plants in the competitions during the growth stage for water, light and nutrients.

In this study, the total germination surpassed 90 % of germination in the control. This confirms the criterion that this plant achieves high germination percentage in spite of the treatments used (Medina *et al*. 2007).

It is concluded that the moringa seeds should be soaked with running water for 24 h before sowing to accelerate the germination in the field. Further similar studies under field conditions are recommended.

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