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Effect of Pre-germination seed treatments on germination of seeds and initial growth of Mango (*Mangifera indica L*)

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Abstract

An experiment was conducted to find out the effects of some pre-germination seed treatments on germination of mango (Mangifera indica L.) seeds and initial growth of mango. Seeds obtained from a local mango variety at Nyankpala were sown in polyethylene bags filled with topsoil for the experiment. The four treatments used were; seeds sown without seed coats (SW), seeds without seed coats soaked in cool water of 5ºC for 12 hours before sowing (SSC), seeds without seed coats soaked in warm water of 15ºC for one minute before sowing (SSW) and seeds with seed coats sown to serve as the control (SC). Randomized Complete Block Design was used and each treatment was replicated three times. The parameters measured were germination percentage, height of seedlings, leaf length of seedlings, number of leaves and stem diameter of seedlings. Data obtained were analyzed using Analysis of Variance and the differences were determined by using Tukey-Kramer multiple comparison test. All the treated seeds recorded more than 80% of germination three weeks after sowing, with SSW recording the highest value of 91%. In general, the treated seeds performed significantly ($p < 0.05$) better than the control for the parameters studied. SSW is recommended for adoption since it performed optimally better than the other treatments in terms of number of leaves (7.67), leaf length (14.71 cm), leaf width (4.41 cm), stem diameter (1.82 cm) and plant height 20.86 cm).

Keywords: *Mango, seeds, pre-germination treatments, germination percentage, seedling vigour*

INTRODUCTION

Mango (*Mangifera indica* L.) is a fruit crop and a member of the *Anacardiaceae* family, which are flowering plants capable of producing fruits. Mango is believed to be native to Asia, the largest producing area, producing 77% of global annual supply. In India, Pakistan as well as the Philippines it is considered to be the national fruit. Although most of the mango production is in India, China, Pakistan, Thailand and Mexico, there are over 90 countries that are presently producing mangoes on commercial basis. These are basically countries in Africa and the Americas which produce approximately 13% of annual global mango supply. In the last thirty years, world mango production has doubled (WIFSS, 2016). In terms of nutritional and economic worth, fruit appeal, flavour and exotic demand brand it as one of the most predominantly-produced tropical fruits worldwide and classified among the first five most popular fruits with respect to production levels (FAO, 2013) of up

to 24.72 10^6 metric tons in 2000 and 50.65 x 10^6 metric tons in 2017 (Shahbandeh, 2019). It is so revered that it is termed the "King of Tropical Fruits" and for thousands of years grown in countries such as India. Producing about 45.1% of global supply, India is regarded as the largest mango producer worldwide, where over a thousand varieties are cultivated, with output of 7.9 t ha^{-1} in some parts of the country, and supplies to countries such as the United Kingdom, United Arab Emirates and Kuwait (NHB, 2014). Mango is generally well-thought-out to be one of the premium fruits and vital crops in the tropics as well as the subtropical climates worldwide (Krishnan *et al*., 2009). Mango production is becoming a key agricultural activity in some regions of Ghana as it has been recognized to have a comparative advantage for mango production as the other countries. Among the suitable and exportable cultivars are Kent, Palmer, Keitt, Alphonso, Haden and Jaffina. Although mango fruits mature between May and August, in some parts of Ghana most varieties also fruit between December and February depending on the weather. Among the suitable places where mango can be cultivated are Guinea Savannah (Northern, Savannah, North-East, Upper East and Upper West Regions), Transitional (Brong, Brong East, Ahafo, and upper portions of the Ashanti, Eastern, Volta and Oti Regions) as well as the Coastal Savannah parts of the Greater Accra, Central and Volta Regions. Forest areas are however considered to be unsuitable for mango production (MoFA, 2013).

Most often, however, farmers complain about the prolonged period mango seeds take to germinate. The seeds, when nursed, take about four months to germinate before they are transplanted in the field or container. Cultivation of mango always involves buying of seedlings for direct transplanting in the field or germinating one's own seeds over a long period of time for raising rootstock for grafting or budding. Any of these involves cost (in terms of money, time or both). These costs could considerably be reduced if mango seeds are subjected to some pre-germination treatments before nursing to enhance faster germination and higher germination percentages. According to Rajesh *et al*. (2012), pre-germination treatments have a substantial effect on the time taken for the seed to germinate, germination percentage, number of leaves and height of seedlings of many species of crops. Patel *et al*. (2016) also opined that, improvement in seed germination and seedling growth are very vital for producing vigorous mango plants in a short time. The objective of the study was to find out the effect of pre-germination seed treatments on germination of seeds and initial growth of mango.

MATERIALS AND METHODS

Location of the experiment

The experiment was conducted between May and October 2018 at the Department of Horticulture Nursery on Nyankpala campus of the University for Development Studies. Nyankpala is located between latitudes 9˚24' N and 9˚40' N and longitudes 0˚59' W and 0˚98' W (Tolon District Assembly Report, 2015) and above sea level it has 183 m altitude in the Northern Guinea Savannah Zone of Ghana (Kombiok, 2013). Temperature generally fluctuates between 15˚C (minimum) around December-January and 42˚C (maximum) around March-April with a mean annual temperature of 28˚C and mean annual relative humidity of 54%. The rainfall pattern of the area is unimodal, starting around April/May and gets to the peak in August and stops in October (SARI, 2004).

Land preparation

Land preparation was carried out using hoe and cutlass. Hand-pulling of weeds and collection of unwanted materials such as stones and debris, were done. Polybags were filled with topsoil and the bags arranged on a prepared ground of size 19.6m^2 (7 m by 2.8 m) in the open.

Growth medium
Top (loamy) soil was used as the growth medium for the experiment. The soil was obtained from the Nursery of the Department of Horticulture, University for Development Studies.

The soil was developed from voltarian sandstone and under the USDA system of classification, it is described as an alfisol and classified as Nyankpala series. It is brown, moderately drained sandy loam, shallow and devoid of concretion (NAES, 1984). The soil has pH 4.96-5.23; Effective CEC of 2.70-3.87 C mol/kg; 0.15 g / kg available N; 2.94 mg / kg P; 9.0- 9.2 mg / kg K; and 0.86% organic matter (Nyarko *et al*., 2011).

Experimental design
The treatments used in the experiment were: SW: - seeds sown (without seed coats); SSC: - seeds (without seed coats) soaked in cool water of 5°C for 12 hours before sowing; SSW: - seeds (without seed coats) soaked in warm water of 15°C for a minute before sowing and; SC: - seeds (with seed coats) sown to serve as the control

Randomized Complete Block Design (RCBD) was used with each treatment in each block. There were four treatment plots measuring 2 m x 1.75 m in each block. The treatments were replicated three times. The distance between replicate and treatment plots was 0.5 m. Each replicate contained 15 polybags, totaling 180 polybags in all with a planting distance of 15 cm x 15 cm.

Nursery practices
Seeds used for the experiment were of a local cultivar collected from Nyankpala. Coats of seeds, which were to undergo pre-germination treatments, were removed using a knife, while the control ones had their coats intact. The seeds (both the treated and untreated seeds) were planted with the 'eye' part or the concave part facing downwards. Watering and hand-pulling of weeds from the polybags were done.

Data collection
Data collection began with the emergence of each seedling in each treatment. Data were taken on the following parameters:
Germination Percentage; this was determined by finding the ratio of germinated seeds to total seeds planted per treatment and multiplied by 100. Germination percentage of seeds was determined on a weekly basis.
Height of the seedlings; this was determined by measuring from soil level to the stem apex of each seedling.
Number of leaves on the seedlings; the total number of leaves per plant were counted and recorded.
Leaf length of seedlings; four leaves in each treatment (except in SC where the leaves were less than four and so data were taken on all of them) were identified, tagged and data taken on them. The measurement was taken between the point of attachment of the leaf petiole to the stem and the apex of the leaf.
Leaf width of seedlings; this was measured with a millimetric ruler across the mid-section of the leaf blade
Stem diameter of the seedlings - This was measured at a base reference point 5 cm above the soil level in the polybags.

Measurements (except the number of leaves) were taken using a pair of Vernier calipers for three weeks at a weekly interval.

Data analysis

Analysis of variance from GenStat statistical package was used to analyze the data. Significant difference was declared at $p < 0.05$. Tukey-Kramer multiple comparison test was used to separate means among treatments.

RESULTS

Germination percentage

As indicated in Table 1 below, SSW recorded 91%, SW 89%, SSC 87%, and SC 16% of germination at the end of the experiment. Analyzed results of the experiment indicate that although there were no significant differences among the treated seeds (SW, SSC and SSW) in terms of germination percentage, they were significantly different ($p < 0.05$) from the control (SC).

Table 1. Seed germination percentage of the treatments 3 weeks after sowing

Treatment	Number of seeds per treatment	Number of germinated seeds	Percentage (%)
SW	45	40	89[a]
SSC	45	39	87[a]
SSW	45	41	91[a]
SC	45	7	16[b]
LSD	-		11

SW: seeds sown without seed coats; SSC: seeds without seed coats soaked in cool water of 5ºC for 12 hours before sowing; SSW: seeds without seed coats soaked in warm water of 15ºC for a minute before sowing and; SC: seeds with seed coats sown to serve as the control; Means that have different superscripts within a column are significantly different ($p < 0.05$).

Leaf parameters

Table 2. Mean leaf parameters of mango seedlings three weeks after sowing

Treatment	Leaf Parameters								
	Number of leaves			Leaf length (cm)			Leaf width (cm)		
	Week 1	Week 2	Week 3	Week 1	Week 2	Week 3	Week 1	Week 2	Week 3
SW	6.00[a]	6.33[a]	7.67[a]	8.71[a]	12.79[a]	13.67[a]	2.28[a]	3.27[a]	3.62[a]
SSC	6.00[a]	7.33[a]	8.00[a]	8.98[a]	13.13[a]	14.28[a]	2.02[a]	5.81[a]	3.73[a]
SSW	6.00[a]	6.33[a]	7.67[a]	10.52[a]	14.26[a]	14.71[a]	2.67[a]	4.15[a]	4.41[a]
SC	0.00[b]	1.33[b]	2.00[b]	0.00[b]	0.70[b]	3.00[b]	0.00[b]	0.60[b]	0.83[b]
LSD	1.0	1.7	1.2	3.7	3.4	3.6	1.3	3.0	0.1

SW: seeds sown without seed coats; SSC: seeds without seed coats soaked in cool water of 5°C for 12 hours before sowing; SSW: seeds without seed coats soaked in warm water of 15°C for a minute before sowing and; SC: seeds with seed coats sown to serve as the control; Means that have different superscripts within a column are significantly different ($p < 0.05$).

The results of the experiment indicate that (Table 2) there were significant differences ($p < 0.05$) between the treated seeds and the control for all the leaf parameters studied at three weeks after sowing. In addition, the differences among the treated seeds were not significant ($p > 0.05$).

Stem diameter of seedlings

Similarly, there were significant differences between the control and the treated seeds in terms of diameter of seedlings. However, there were no differences ($p > 0.05$) among the treated seeds Table 3.

Table 3. Mean stem diameter of mango seedlings 3 weeks after sowing

Treatment	Week 1	Week 2	Week 3
SW	1.44^{a}	1.61^{a}	1.76^{a}
SSC	1.31^{a}	1.66^{a}	1.93^{a}
SSW	1.47^{a}	1.65^{a}	1.82^{a}
SC	0.00^{b}	0.27^{b}	0.27^{b}
LSD	1.4	0.3	0.2

SW: seeds sown without seed coats; SSC: seeds without seed coats soaked in cool water of 5°C for 12 hours before sowing; SSW: seeds without seed coats soaked in warm water of 15°C for a minute before sowing and; SC: seeds with seed coats sown to serve as the control; Means that have different superscripts within a column are significantly different ($p < 0.05$).

Height of seedlings

There were significant differences between the control and the treated seeds. SC recorded the shortest seedlings (4.37 cm) at the end of the experiment, while SSW produced the tallest seedlings (20.86 cm) followed by 20.08 cm for SSC and 19.08 cm for SW (Table 4).

Table 4. Mean height (cm) of mango seedlings 3 weeks after sowing

Treatment	Week 1	Week 2	Week 3
SW	12.70^{a}	15.88^{a}	19.08^{a}
SSC	13.71^{a}	18.08^{a}	20.08^{a}
SSW	16.22^{a}	18.16^{a}	20.86^{a}
SC	0.00^{b}	2.17^{b}	4.37^{b}
LSD	1.8	3.0	4.0

SW: seeds sown without seed coats; SSC: seeds without seed coats soaked in cool water of 5°C for 12 hours before sowing; SSW: seeds without seed coats soaked in warm water of 15°C for a minute before sowing and; SC: seeds with seed coats sown to serve as the control; Means that have different superscripts within a column are significantly different ($p < 0.05$).

DISCUSSION

Germination percentage

At the end of the experiment, SSW recorded the highest seed germination percentage of 91%, followed by SW (89%) and SSC (87%), with SC recording the least value of 16%. This is an indication that the germination percentage was affected by the type of pre-germination treatment carried out on the mango

seeds. As temperature plays a key role in the germination of seeds, low temperature can generally limit the germination of warm season crops and vice versa. SSW recorded the highest germination percentage due to the fact that, mango being a warm season crop produced in the tropics (Perea-Moreno *et al*., 2018), the germination of its seeds was favoured by the warm water treatment. In that regard, although the treated seeds recorded different germination percentages due to the different pre-germination treatments carried out on the seeds, those differences were not significant. SW, SSW and SSC had the highest germination percentage due to the exposure of their testa to imbibe water (Debeaujon *et al.,* 2018). It was observed that, SSW germinated first followed by SW, since their testa had ready access to water from the soil which facilitated their germination (Hartmann *et al.,* 1997). Stratified seeds are usually pre-conditioned at temperature of 3-10°C although the specific temperature and duration of exposure may vary. For some species low temperature is an absolute requirement for the germination while in others it may hasten germination and increase speed of growth (Copeland and Macdonald, 1995; and Rosbakh and Poschlod, 2015).

Growth parameters

In terms of the results obtained on the parameters of the mango seedlings, there were significant differences ($p < 0.05$) between the treated seeds (SSW, SSC and SW) and the control (SC). The differences among the treated seeds were however not significant. Generally, among the treated seeds, SSW performed better than SSC and SW. The control (SC) performed poorly against the treated seeds. All these could probably be due to osmotic priming and access of growth factors such as moisture and oxygen to the treated seeds that enhanced seed vigour and leaf performance (Hartmann *et al.,* 1997).

There was a significant difference between the treated seeds and the control for all the growth parameters. There were no significant differences among the treated seeds probably due to ready access to growth factors such as moisture. SSC produced the highest stem diameter (1.93cm), while SSW, SW and SC respectively recorded 1.82 cm, 1.76 cm and 0.27 cm. This could probably be due to the pre-germination seed treatments that enhanced germination and subsequent improvement in growth, including satisfactory increases in stem diameter as reported by Hartmann *et al.* (1997) and Patel *et al*. (2017).

The significant differences between the control and the treated seeds could probably be due to the fact that the treated seeds had ready access to water from the soil and had higher germination and subsequently vigorous growth, possibly as a result of the removal of their seed coats. On the other hand the hard testa of SC prevented the imbibition of water and other growth factors to facilitate growth and development. Inhibition of germination in SC was based on a high degree of impermeability of the seed coat to water and/or oxygen (Boesewinkel and Bouman, 2017). Seeds soaked in water overnight imbibe water, facilitating the formation of new proteins within some hours, and these are responsible for seed germination (Kwarteng and Towler, 1986; Nawaz *et al.,* 2013; and Lopez and Barclay, 2017) There were however no significant differences among the treated seeds as the absence of their seed coats facilitated the imbibition of water and easy access to other growth factors.

CONCLUSION

All treated seeds (SSW, SSC, and SW) performed better than the control in terms of germination percentage, leaf performance, stem diameter and seedling height. Any of the three seed treatment process could be adopted by farmers. However, treating seed by soaking in warm water (15°C) for a minute before sowing (SSW) is recommended based on its superior performance.

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