Tikrit Journal for Agricultural Sciences (2023) 23 (1): 141-157
https://doi.org/10.25130/tjas.23.1.17

IRAQI Academic Scientific Journals
العراقية المجلات الأكاديمية العلمية

ISSN:1813-1646 (Print); 2664-0597 (Online)
Tikrit Journal for Agricultural Sciences
Journal Homepage: http://www.tjas.org
E-mail: tjas@tu.edu.iq

TJAS
Tikrit Journal for Agricultural Sciences

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KEY WORDS:

Gemination; Environment; Plant; Technology; Soaking.

ARTICLE HISTORY:

Received: 18/10/2022
Accepted: 12/12/2022
Available online: 31/03/2023

A novel approach for improving germination rate of Mucuna bracteata

ABSTRACT

To ascertain the best possible method for deed treatment that would enable germination and seedling growth of Mucuna bracteata, the experiment was carried out at the experimental farm of Institute of sustainable Agro technology, University Malaysia Perlis, Padang Besar, Perlis, Malaysia. The design of the experiment was based on the Completely Randomised Design and it consisted of four replications. The results of the experiment indicated that when the seeds are treated in a blender for 2 minutes, it considerably improves the speed of germination, percentage of germination, mean daily germination, fresh shoot, dry shoot weight, and shoot to root fresh weight ratio. On the other hand, when the seeds were soaked in H2SO4 for 30 minutes, there was an improvement in the total fresh weight, mean germination time, dry root weight and total plant dry weight. When the seeds were treated in a blender for 4 minutes, it substantially improved the germination value, the peak value, and the total number of leaves per plant.

INTRODUCTION

Cover crops form a significant aspect of sustainable cropping systems. Cover crops can enable reduction of nutrient leaching in the soil, prevention of soil erosion, improvement of soil health, addition of organic matter to the soil, suppression of weeds, reduction in insect, pests and diseases, and nitrogen fixation. Therefore, it is important to select a cover crop species that is suitable for a certain season and climatic condition, so that maximum advantages from cover cropping can be achieved. Earlier studies indicate that the advantages of cover crops for sustainable cropping systems are more when cropping is done at lower elevation (Radovich, 2010; Wang, 2012; Mara et

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al., 2020). The main objective of a cover crop is to cover and safeguard the soil, and to harvest the left-over nutrients that were not depleted by the previous crop. Cover crops can either include crops that are grown between cash-crop cycles, such as vegetables, or crops that are intercropped with the cash crops to provide shelter to the bare ground in groves, orchards, and to other crops grown perpetually. Cover crops are also grown as green manure; these crops are generally incorporated with the other crops (Salon, 2012; McDaniel et al., 2014; Meagan et al., 2014; Zhou et al., 2017; Finney and Kaye, 2017; Finney et al., 2017; Murell et al., 2017).

For sustaining and improving soil fertility and for soil conservation in tropical plantations, the planting of leguminous cover crops (LCC) has been a standard practice. During periods of long harvesting intervals or during fallowing periods, the plantation of leguminous cover crops enabled suppression of many common resilient or noxious weeds and pests (Olorunmaiye, 2010; Dorn etal., 2015; Wittwer et al., 2017). Some of the frequently used genera of LCC include Calapogonium, *Mucuna, Pueraria*, *Stylosanthes*, *Centrosema, Crotalaria* and *Cajanus* (Goh et al., 2015). The five most commonly used LCC in rubber plantations and oil palms of Malaysia are *Calapogonium caeruleum*, *Mucuna bracteata*, *Calopogonium mucunoides*, *Centrosema pubescens*, and *Pueraria javanica* (Samedani et al., 2015; Abdul Rahman and Kassim, 2019; Muhammad, 2019). These varieties were newly introduced to plantations in both Indonesia and Malaysia because of their necessary characteristics that provide fast, perennial, assiduous, shade tolerant growth, and also enable repression of frequent noxious weeds (Muhammad, 2019). These varieties have the potential to generate up to three to four times more biomass than other LCC, and hence are particularly beneficial for oil palm plantations (Samedani et al., 2015; Abdul Rahman and Kassim, 2019; Muhammad, 2019).

For the plantation industry, *Mucuna bracteata* is an ideal leguminous cover crop. It was introduced to Malaysia from India in 1991 and since then, the interest on this cover crop has only increased. The primary characteristics that make this cover crop highly desirable and the object of great attention is its exceptional potency in growth and ability to generate three to four times more biomass than traditional leguminous cover crops (*Pueraria javanica*). In this variety, the roots extend for more than 3 metres into the soil, and hence the crops can survive well under shaded environments. However, unlike the conventional leguminous cover crops, it is imperative to purchase good quality seeds for *Mucuna bracteata*. The seeds of *Mucuna bracteata* are large, weighing 99 to 190 mg each and are black in colour with a hard seed cover. Due to the hard seed cover, the seeds are difficult to germinate under normal conditions. The objective of this research is to study the possibility of treating the seeds of *Mucuna bracteata* with a new method that will improve the rate of seed germination and speed of seed germination and enhance other growth parameters, and will not exhibit the disadvantages of the usual conventional chemical and mechanical methods.

MATERIALS AND METHODS

The treatments

This research was conducted in the field at Agrotechnology Research Station, University Malaysia Perlis, Padang Besar, Perlis, Malaysia.

The control and treated seeds of *Mucuna bracteata* were planted in seedling tray, under greenhouse condition. The study contained ten treatments:

1-Control: untouched.
2-Manual: scarification in sand paper by hand one by one.
3-Soaking in H_2SO_4: The seeds had put in H_2SO_4 concentration 98% solution for 30 minutes.
4-Soaking in H_2SO_4: The seeds had put in H_2SO_4 concentration 98% solution for 45 minutes.
5-Soaking in H_2SO_4: The seeds had put in H_2SO_4 concentration 98% solution for 60 minutes.
6-Soaking in H_2O: The seeds had put in water 24 hours.
7-Blender shaking: Shaking by blender for 2 minutes (Rotational Speed: 1700 r/min.).
8-Blender shaking: Shaking by blender for 4 minutes (Rotational Speed: 1700 r/min.).
9-Hand shaking: The seeds had put in a metal can lined with sandpaper for 5 minutes.
10-Hand shaking: The seeds had put in a metal can lined with sandpaper for 10 minutes.

The parameters

The measurement was taken after one month. The measurements were taken as average of 5 (plants) of experimental unit. The following measurements were carried out:

Germination percent (%): Germination percent was determined each 5 days for 30 days.

Speed of germination: Speed of germination was calculated by the following formula given by (Czabator, 1962).

Speed of germination= n1/d1+n2/d2+n3/d3+----------

Where, n = number of germinated seeds, d= number of days.

Mean of germination time (MGT): Mean germination time was calculated by the formula given by (Ellis and Roberts, 1981).

MGT = n1 x d1 + n2 x d2 + n3 x d3 + --------/ Total number of days

Where, n= number of germinated seed, d = number of days.

Mean daily germination (MDG): Mean daily germination was be calculated by the following formula given by (Czabator, 1962).

MDG = Total number of germinated seeds/ Total number of days.

Peak value (PV): Peak value was calculated by the following formula given by (Czabator, 1962).

PV = Highest seed germinated/ Number of days.

Germination value (GV): Germination value was calculated by the following formula given by (Czabator, 1962).

GV = PV X MDG

Seedling length (cm): Seedling length was measured from the start stem in soil to the top of the plant.

Number of leaves (leaf/seedling): Total leaf number was calculated based on the first leaves on the stem to last leaf developing from top of the plant.

Fresh shoot weight (g): Calculated after separating the shoot and root. Fresh shoot weight was taken by using precision scale.

Fresh root weight (g): The root fresh weight was determined following the same procedure as in dry shoot weight.

Total fresh seedling (g): Total fresh seedling was the sum of fresh shoot weight and fresh root weight.

Shoot: root fresh weight ratio: Shoot: root fresh ratio was calculated based on fresh shoot weight / fresh root weight.

Dry shoot weight (g): The sample was dried using oven at 70 °C for two days. Dried weight shoot was taken by using precision balance.

Dry root weight (g): The root dry matter weight was determined following the same procedure as in dry shoot weight.

Total dry plant (g): Total dry plant was calculated based on the sum of dry shoot weight and dry root weight.

Shoot: root dry weight ratio: Shoot: root dry ratio was calculated based on dry shoot weight / dry root weight.

Data analysis

The analysis of variance (ANOVA) was derived from the common diverse model for a CRD architecture. The one-way analysis of variance (ANOVA) using the SAS statistical program (Version 9) was employed to test for mean differences in the number of seedlings germinated between treatments. In order to determine the differences between the treatments, the Duncan's was used.

RESULT AND DISCUSSION

Germination percent

One of the primary objectives of plant physiology is to understand seed germination. There are a number of conditions that would impact this important phenomenon. As seen in Table. 1, the percent germination in all cases and all treatments is more than that of control. But out of all the treatments, the blender treatment for 2 minutes generated the highest germination percent, possibly

because of the mechanical scarification of seeds achieved by colliding the seeds with sandpaper on one side and rotating the blender another side. The observations of Okunlola et al. (2011) also indicate that the seeds that are mechanically scarified exhibit high seed germination and seedling growth. The results showed that the seeds of *P. biglobosa* that are mechanically scarified with sandpaper had a germination of 83.3%. As per the findings Yazdanpanah et al. (2012) of a high percentage of germination is achieved through scarification of seeds with sandpaper (65%). The same observations were also made by Sanjana and Jeya (2013); Lopes et al. (2015), who reported that the seeds that were mechanically scarified exhibited very high germination percentage compared with any other seed treatment.

Table (1): Germination percent of *Mucuna bracteata* seeds under different treatments.

Treatments	Average Germination (%) After					
	5 days	10 days	15 days	20 days	25 days	30 days
Control	0.00 c	0.00 e	3.67 g	7.98 e	9.07 e	9.07 e
Manual	2.81 b	31.82 a	38.98 c	40.06 bc	42.15 bc	42.15 bc
Soaking in H_2SO_4 30M.	0.00 c	12.78 b	28.59 d	38.98 c	41.56 bc	43.74 bc
Soaking in H_2SO_4 45M.	0.00 c	13.83 b	32.23 d	36.13 c	39.16 c	39.16 c
Soaking in H_2SO_4 60M.	0.00 c	5.85 d	11.69 f	12.78 de	12.78 de	12.78 de
Soaking in H_2O 24H.	0.00 c	8.12 cd	8.21 f	12.96 de	14.05 de	14.91 de
Blender shaking 2M.	3.45 b	38.08 a	52.17 a	56.07 a	56.07 a	56.07 a
Blender shaking 4M.	8.21 a	33.95 a	45.87 b	47.07 b	47.07 b	47.07 b
Hand shaking 5M.	0.00 c	14.13 b	18.47 e	18.47 d	18.47 d	18.47 d
Hand shaking 10M.	0.00 c	10.87 bc	16.30 e	16.30 d	18.47 d	18.47 d

(Different alphabets show significant difference using Duncan's Multiple Range test ($P \leq 0.05$))

Speed of Germination

There is a lot of variation in the response of seeds depending on the treatments. Usually, the variation occurs in the advent of germination or in the emergence of the seedling. Either there will be a period for adaptation or the seedlings will start emerging on the very first day. The time needed for adaptation is studied by ascertaining the speed of germination, which is in turn determined based on the day the germination starts, multiplied by other applicable factors. Similar to the response seen in percent germination, the speed of germination also significantly increased with the treatments and it was considerably higher than that of control conditions. The blender treatment for 2 minutes led to a huge improvement in the speed of germination, and it was possibly because of the mechanical scarification that enabled water to permeate *mucuna* seed coats and homogeny scarification of seed coats that impacted the seed germination speed (Penfield, 2017). According to Meziou and Merabet (2014), mechanical scarification for the seed of *Pistacia atlantica* was enough to increase its speed of seed germination. Scarification of seeds enables the seed coats to break the dormancy and this is achieved by exposing the embryo to water. Water plays a crucial role in activating the biochemical changes that regulate the protein synthesis during seed germination (Siddiqui and Khan, 2010). The significance of water in seed germination was studied in a number of plant species including the family fabaceae (Long et al., 2012; Arruda et al., 2015), affirmed that the speed and percentage of seed germination of the *Acacia polyphylla* can be significantly improved through mechanical scarification.

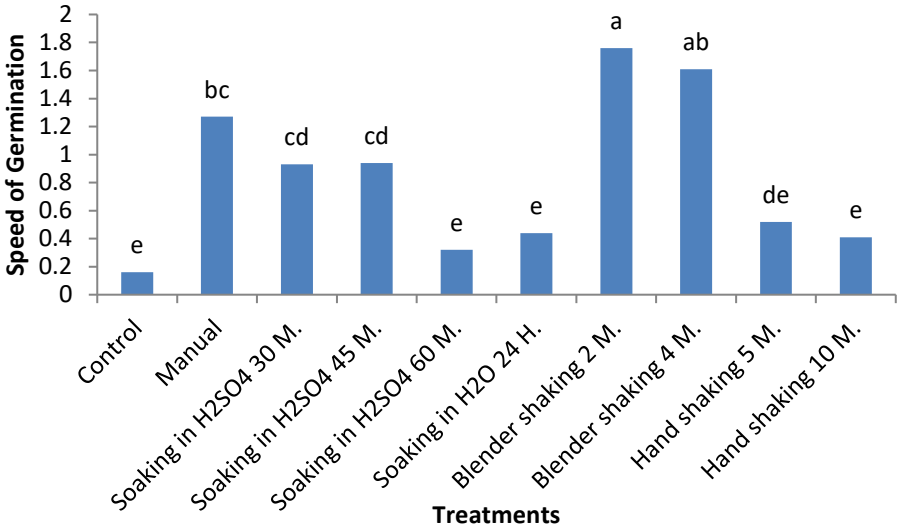

Figure (2): Speed of germination of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Mean of germination time

A seed's mean time for germination for different treatments ranged from 1.22 minimum at control treatment to the maximum value of 5.28 when soaked in H_2SO_4 and the variations in the treatments were numerically highly significant at a level of 0.05%. It is probably because of infusing the seeds in concentrated H_2SO_4 that breaks the coating of the seed which hampers the intact seeds' germination even though they are put under conditions apt for germination (Imani et al., 2014). The process of scarification breaks the coating of the seed and reveals the lumens of the macrosclereids cells, letting the seed soak water. The imbibing of water when the seed coat breaks is known to initiate germination (Fariyike et al., 2011 ; Boitsshwarelo et al., 2014), whereas water may not be available to the embryo in the untreated seeds. It is important to limit the period of the seed being soaked in the concentrated H_2SO_4 because longer duration may burn the seed coat excessively and in turn damage the embryo which is seen in another studies (Likoswe et al., 2008; Mel and Yakandawala, 2016; Chauhan, 2016). The soaking of seeds in solution has also been done in Australia[35] which showed that *Hibiscus tridactylites* seed need soaking in concentrated sulphuric acid for 20 minutes, so as to break down the seed coats. Soaking the *Hibiscus tridactylites* seed in the solution more than 20 minutes reduces seed germination. Treatment in concentrated H_2SO_4 has also proved efficient for *Caesalpinia leiostachya* (Biruel et al., 2010), *Colubrina glandulosa* (Brancalion et al., 2011) and *Ornithopus pinnatus* (Zad et al., 2014) demonstrated that the greatest mean germination time is taken by sulphuric acid, 10 minutes in vivo.Boitshwarelo et al. (2014) investigated the effects of pre-soaking techniques on the germination of the pod of mahogany (mechanical, concentrated H_2SO_4 for subsequently 3, 6, 9 and 12 minutes, and 3, 6, 9 and 12 minutes treatments of boiling water), and the results proved that soaking in sulphuric acid (98%) for 6 minutes made a significant increase in the mean time for germination.

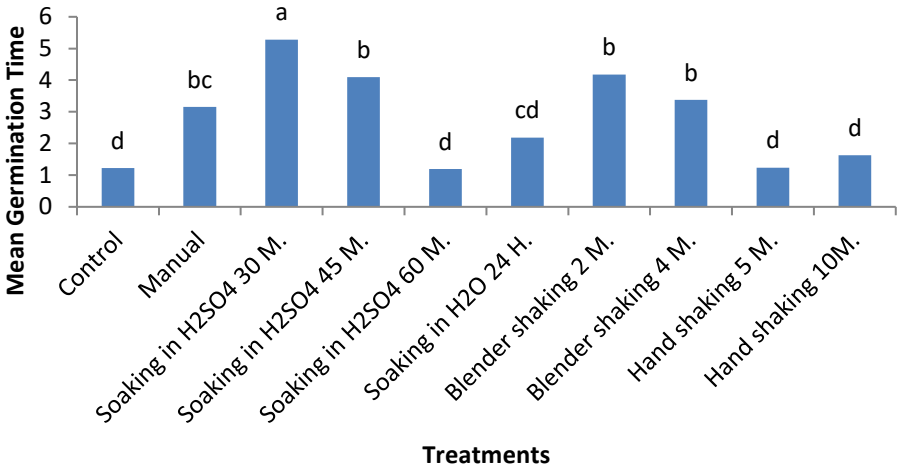

Figure (3): Mean of germination time of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Mean daily germination

The amount of mean daily germination was registered to be maximum 0.48 at blender stirring for 2 minutes and it was recorded minimum 0.08 at treatment for control, probably because some seeds failed to germinate and they could not germinate unless the solid seed coat was ruptured by the process of mechanical scarification Beikmohammadi et al. (2012); Salvi et al., (2015) mentioned that the pre-treated seed with scarification performed better with regards to mean daily germination in comparison with other treatments. Mirzaei et al. (2013) reported in a study that three levels of sulphuric acid (0, 50 and 90% v/v) for duration of 30 minutes, gibberellic acid (0, 0.5 and 1mM) for period of 48 hours and warm water of 85ºC (0, 20 and 40S) were employed. The lowest value for mean daily germination was obtained for the control treatment.

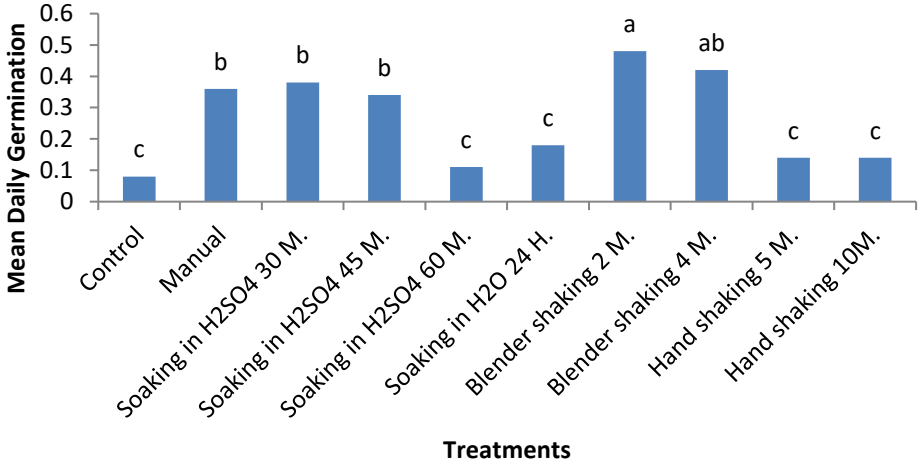

Figure (4): Mean daily germination of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Peak value

Peak value was recorded in blender stirring for 4 minutes – maximum 0.89 and minimum 0.15 in control treatment. This is possibly because of the fact that the scarification process might have facilitated the physical weakening of the seed coating's impermeable layer letting air and water to enter the seeds and thus allowing the embryo to destroy the mechanical constraint of surrounding tissues (Babalola et al., 2014). Salvi et al. (2015) recorded that the pre-treated seed with scarification process performed better in regard to peak value in comparison with other treatments.

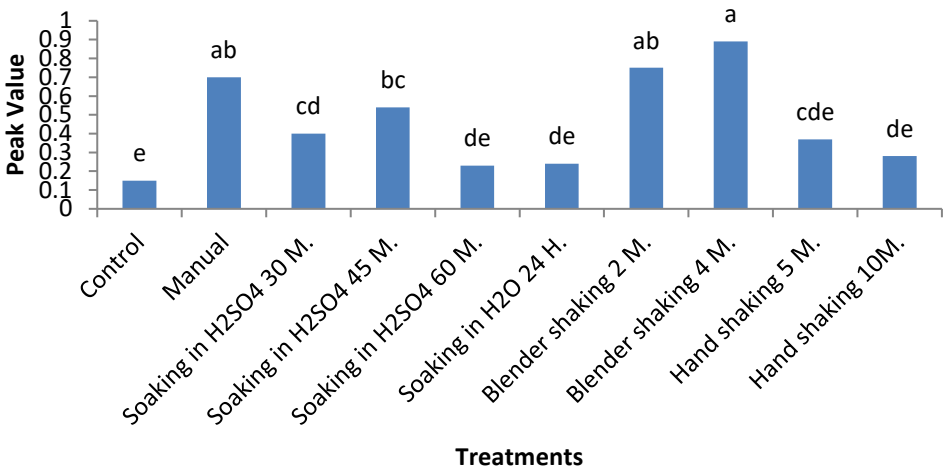

Figure (5): Peak value of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Germination value

The amount of germination value was registered maximum at stirring of blender for period of 4 minutes and minimum 0.02 at control treatment. The variations in the value of germination were numerically highly significant at a significance level of 0.05, because of stirring the blender for 4 minutes which gave the greatest value in peak value character which did not significantly differ with a blender stirring of 2 minutes for the mean daily germination value which caused the highest value. Gehlot and Kasera (2012) reported that the highest germination value was achieved in mechanical and concentrated H_2SO_4 scarification process for 2 min. Salvi et al. (2015) stated that the pre-treated seed with scarification process performed better in respect to germination value in comparison with other treatments.

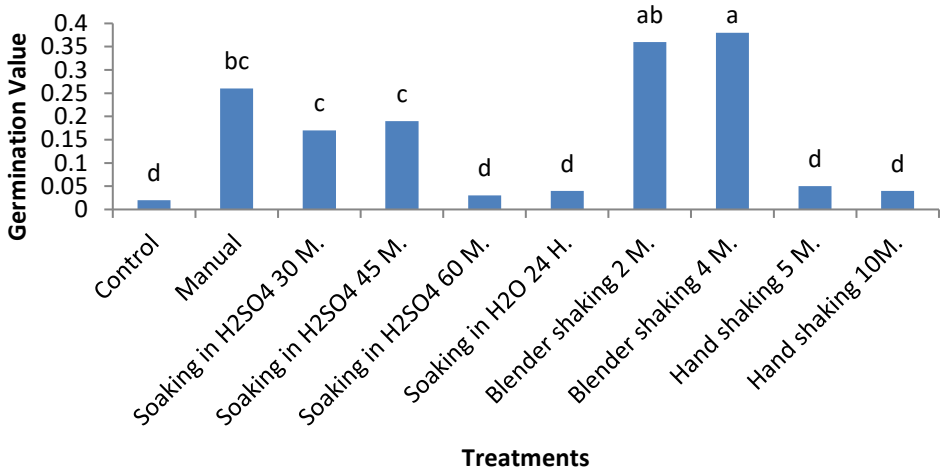

Figure (6): Germination value of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Seedling height

Fig. 7 presents the seedling height for all treated and untreated varieties of *Mucuna bracteata*. According to Fig. 7, under control conditions, the seedling height of untreated plants was found to be at 6.20 cm, which was the lowest of all plants. On the other hand, the seedling height of plants that were soaked in H_2SO_4 for 45 minutes was found to be at 11.68 cm. However, no substantial difference was observed in all the treatments, except control and manual. This noteworthy reduction in seedling height under control treatment may be ascribed to delayed seed germination of treated seeds and less shoot length of the seedlings (Fig.2). In an experiment that was carried out to assess the impact of sulphuric acid on the seedling growth of *Parkia biglobosawere*, it was found that the length of the radicle and plume was the highest when the *Parkia biglobosawere* seeds were soaked

sulphuric acid (Adeyemi et al, 2013). In an experiment to evaluate the impact of various pre-sowing treatments on seed germination of Bladder-Senna, Beikmohammadi et al. (2012) observed that the highest shoot length was attained when the seeds were treated with concentrated (98%) H_2SO_4 for 15 minutes. Another study conducted by Imani et al. (2014) presented the same observation where the maximum shoot length was seen for seeds treated with H_2SO_4.

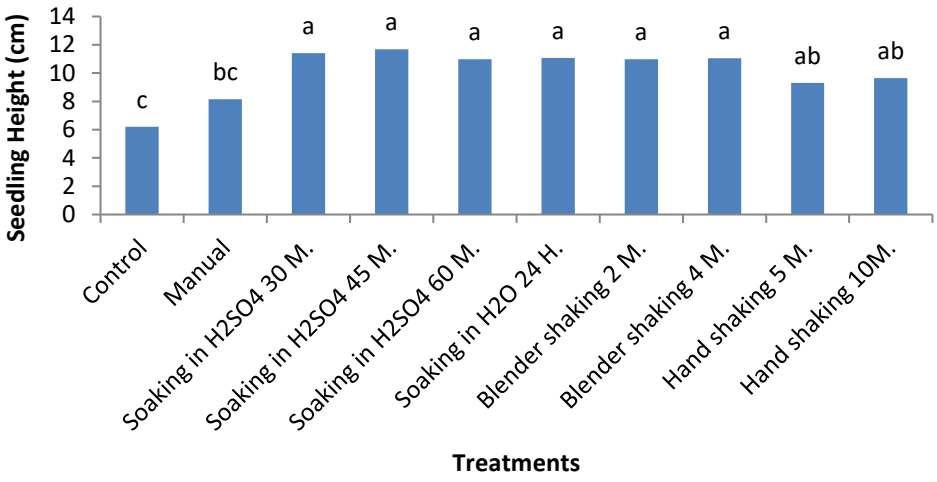

Figure (7): Seedling height of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Number of leaves

As shown in Fig. 8, the number of leaves in plants that were manually treated was found to be 5.90 leaf plant^{-1}, which was the lowest of all plants. On the other hand, the number of leaves for plants that were treated in a blender for 4 minutes was found to be 8.72 leaf plant^{-1}. It was observed that there is a positive and important correlation between the number of leaves and all germination and shoot length characteristics, except mean of germination time (refer to Figs. 2, 4, 5, 6 and 7). Also, there is a positive and important correlation between number of leaves and shoot length. According to the study conducted by Rostami and Shasavar (2009) on olive cultivars, it was found that mechanical and chemical scarification treatments can considerably increase seedling growth, where root length, stem height and number of leaves are all positively affected. Edward et al. (2014) conducted a study to analyse the survival rate and seedling growth of *Acacia polyacantha*, after the seeds have been exposed to various pre-sowing treatments at Malawi College of Forestry and Wildlife Nursery, Malawi. The five pre-sowing treatments that the seeds were subjected to included immersion in hot water (100°C) for 5 minutes, immersion in cold or room temperature water for 24 hours, scarification through mechanical nicking using secateurs, immersion in concentrated sulphuric acid (0.3 M H_2SO_4) for 20 minutes, and a control where seeds were sown without undergoing any treatment. The outcomes of this experiment showed that the pre-sowing seed treatments had a positive and significant effect on the number of leaves compared to other pre-sowing treatments. Hence, in order to improve the speed and extent of early seedling growth at the nursery stage for *Acacia polyacantha* seeds, mechanical nicking was suggested as a pre-sowing treatment.

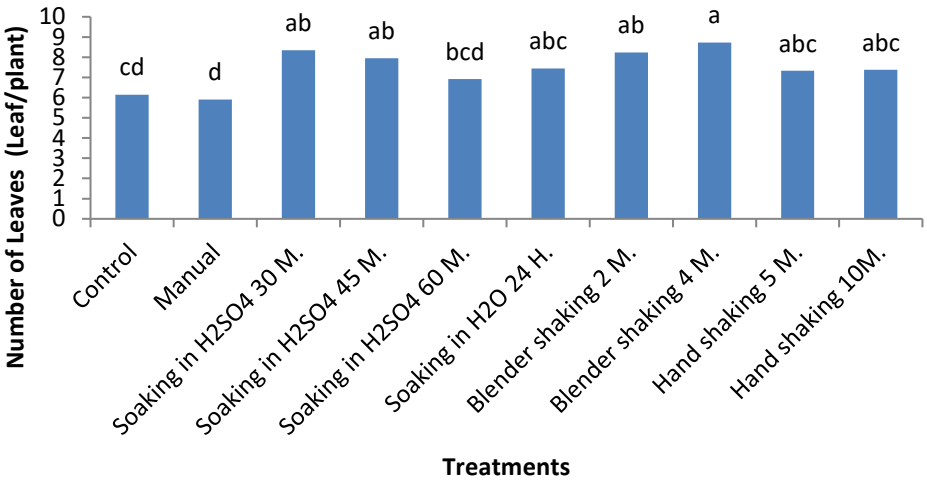

Figure 8 Number of leaves of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Fresh shoot weight

Fig. 9 presents the fresh shoot weight of the treated and untreated seedlings of *Mucuna bracteata*. In this study, it was found that the plants exposed to control conditions attained a fresh shoot weight of 0.28 g, which was the lowest when compared with all other environmental conditions. Seeds that were treated in a blender for 2 minutes attained the highest fresh shoot weight at 0.75 g. It was observed that there is a positive and an important relation between fresh shoot weight and shoot length and number of leaves (refer to Figs. 7 and 8). However, this observation is not in agreement with the observation made by Salvi et al. (2015).

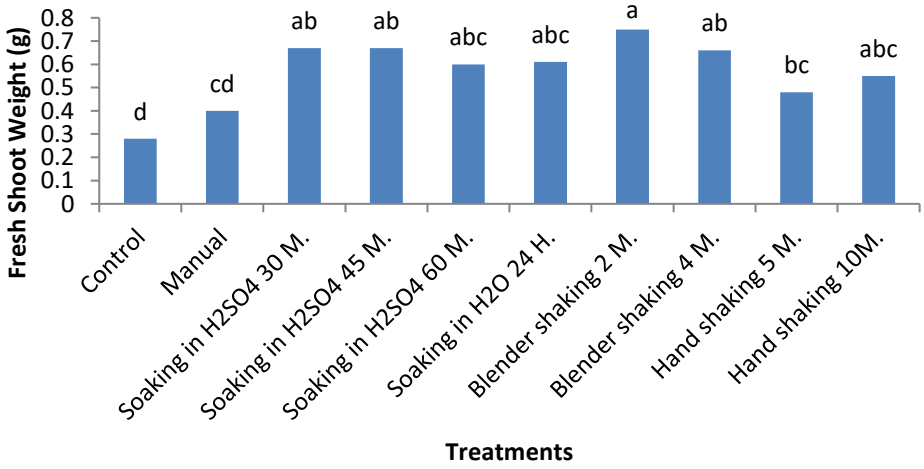

Figure (9): Fresh shoot weight of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Fresh root weight (g)

Fig. 10 presents the data for fresh root weight. It was found that the fresh root weight (0.12 g) was the lowest for plants treated under control conditions, compared to plants treated under all other experimental conditions. On the other hand, the fresh root weight was the highest at 0.49 g for cases where the seeds were soaked in H_2O for 24 hours. This considerable reduction in fresh root weight for plants under control treatment may be because of the delay in germination, which resulted in less fresh root weight than that of other treatments (Fig. 2). However, this result is not in line with the observations made by Mabundza et al. (2010) who found that passion fruit seeds when fermented in 10% sucrose resulted in the highest fresh root weight at 2.4 g, where the value was recorded after six weeks of germination. The second highest fresh root weight was at 2.2 g, for seeds that were treated in sulphuric acid. This was followed by the results seen in plants where the

seeds were soaked in water for 7 days and 14 days. The plants under control treatment exhibited the lowest fresh weight of roots at 1.6, 1.8 and 1.1 g, respectively.

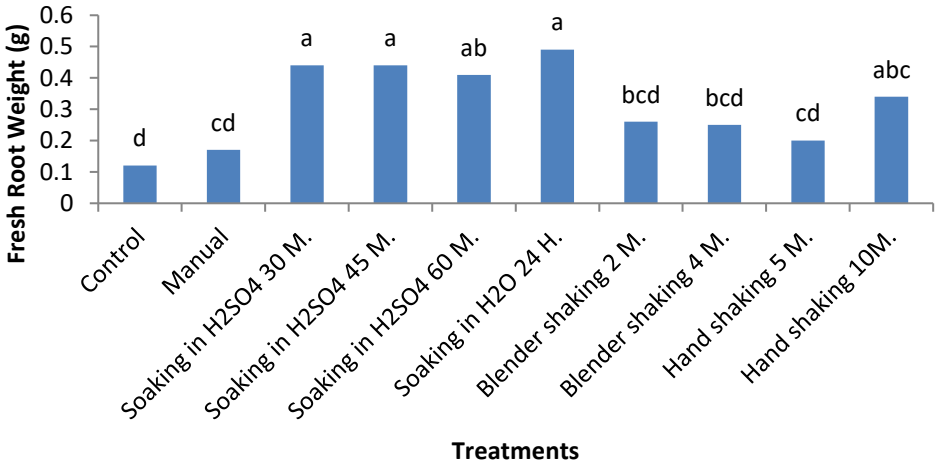

Figure (10): Fresh root weight of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Total fresh plant

Fig. 11 presents that the plants under control conditions had the lowest total fresh plant weight at 0.40 g, compared with the plants treated under all other environmental conditions. The highest total fresh plant weight at 1.11 g was found in plants, the seeds of which were soaked in H_2SO_4 for 30 and 45 minutes. The lowest fresh shoot weight and root shoot weight values were found in plants that underwent the control treatment. Eyob (2009) conducted a study to analyse the impact of various seed treatments on seed germination and seedling growth of korarima. The seeds were exposed to seven pre-sowing treatments that include control (no pre-treatment), soaking in 50% sulphuric acid (H_2SO_4) for 60 min, soaking in tap water for 24 h., soaking in 50% sulphuric acid (H_2SO_4) for 60 min, soaking in 250 mg gibberellic acid (GA3) for 24 h., cold stratification at 4±1 ^oC for one week, cold stratification at 4±1 ^oC for two weeks and cold stratification at 4±1 ^oC for three weeks. According to the results of the study, the treatment in which the seeds were soaked in 50% sulphuric acid (H_2SO_4) for 60 mins was the most effectual treatment for improving the fresh plant weight (0.81 g).

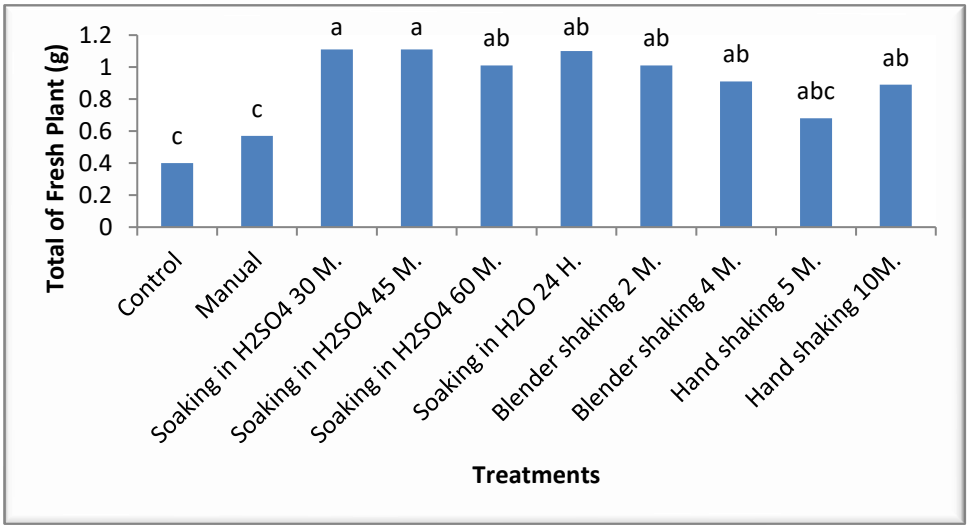

Figure (11): Total fresh plant of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Shoot:root fresh ratio

The shoot to root ratio in *Mucuna bracteata* was found to be relatively higher at 2.89 after it was treated in blender for 2 minutes, while the shoot to root ratio in *Mucuna bracteata* was found to be relatively lower at 1.25 after the seeds were soaked in H_2O for 24 hours. The difference in the values was statistically substantial (refer to Fig. 12) because the shoot and root ratio is directly proportional to the increase in shoot fresh weight compared with the root fresh weight, and the other way round (refer to Figs. 9 and 10).

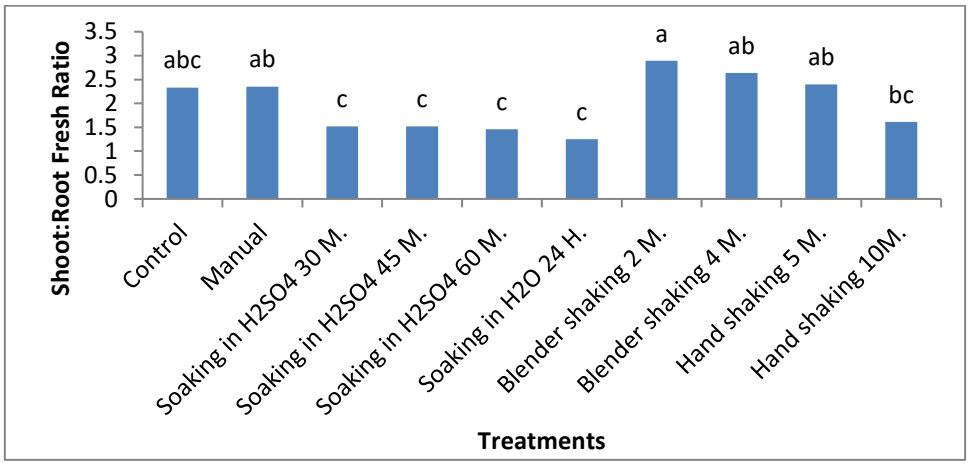

Figure (12): Shoot to root fresh ratio of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Dry shoot weight

Fig. 13 shows the dry shoot weight of *Mucuna bracteata* seedlings. It showed that the plants under control conditions had remarkably low dry shoot weight at 0.049 g. The plants that underwent the blender shaking treatment for 2 minutes exhibited the highest dry shoot weight at 0.140 g. This study explains the synergistic effect between fresh shoot weight and dry shoot weight (refer to Fig. 9). However, this result is not in agreement with the findings made by Salvi et al. (2015).

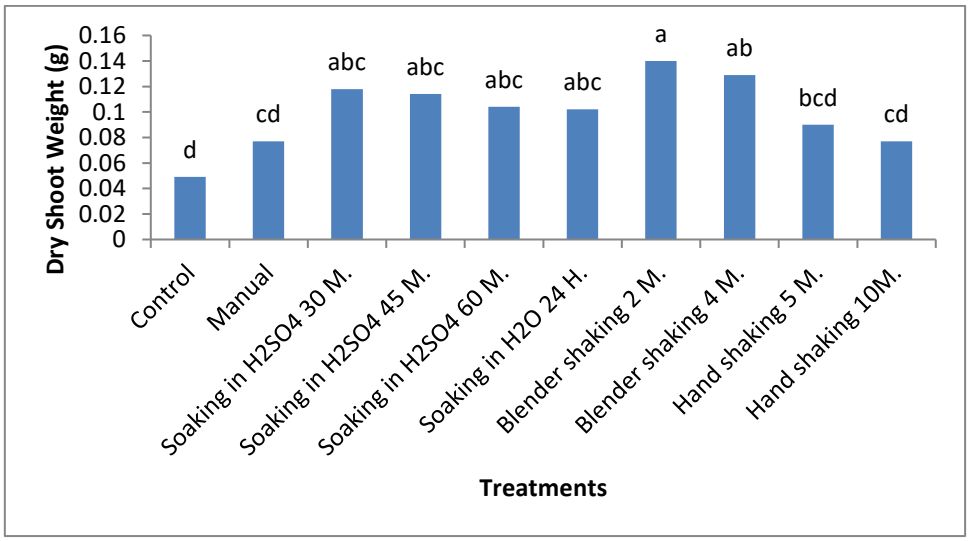

Figure (13): Dry shoot weight of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Dry root weight

Fig. 14 presents the dry root weight of *Mucuna bracteata* seedlings under experimental conditions. It was found that the seedlings under control conditions (untreated) had the lowest dry root weight at 0.030 (g), which was considerably lower than that of any other treatment. The dry root weight was found to be the highest at 0.108 (g) for plants that underwent the soaking treatment in H_2SO_4 for 30 minutes. The values were found to be the lowest for plants under the control treatment because the control treatment significantly impacted the relationship between the fresh root weight and the dry root weight (refer to Fig. 10). According to Zubairu (2014), soaking *Acacia senegal* seeds in 50% sulphuric acid results in significantly higher growth attributes in the seedlings, along with a high dry root weight (3.32 g).

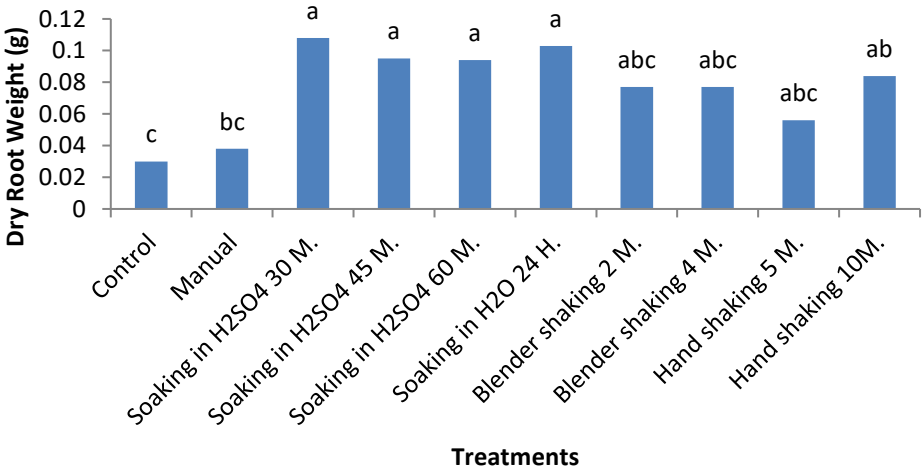

Figure (14): Dry root weight of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Total dry plant

As shown in Fig. 15, the plants treated under control conditions had the lowest total dry plant weight at 0.079 g, which was considerably less compared with that of plants treated under all other environmental conditions. On the other hand, the plants where the seeds were soaked in H_2SO_4 for 30 mins yielded the highest dry plant weight at 0.226 g. As shown in Figs. 13 and 14, the dry shoot weight and the dry root weight were both found to be the lowest for plants treated under control conditions. These results are in line with the observations made by Nath et al. (2007), who found that the seedling dry weight was impacted considerably by various treatments. The highest seedling dry weight at 0.518 g was obtained for cases where the seeds were treated in boiling water for 3 minutes, while the lowest seedling dry weight was attained for seedlings that underwent the 7 minutes H_2SO_4 treatment.

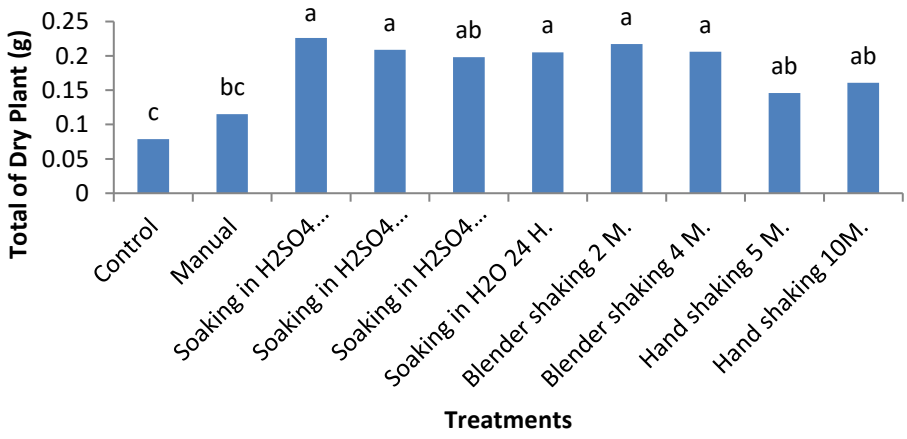

Figure (15): Total Dry plant of Mucuna bracteata seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

Shoot:root dry ratio

Mucuna bracteata had a comparatively high shoot to root dry weight ratio of 2.026, while *Mucuna bracteata* had a relatively low shoot to root dry weight ratio of 0.917 at hand shaking for 10 minutes. The difference in the values was statistically substantial (refer to Fig. 16) because the shoot and root dry weight ratio is directly proportional to the increase in shoot dry weight compared with the root dry weight, and the other way round (refer to Figs. 13 and 14).

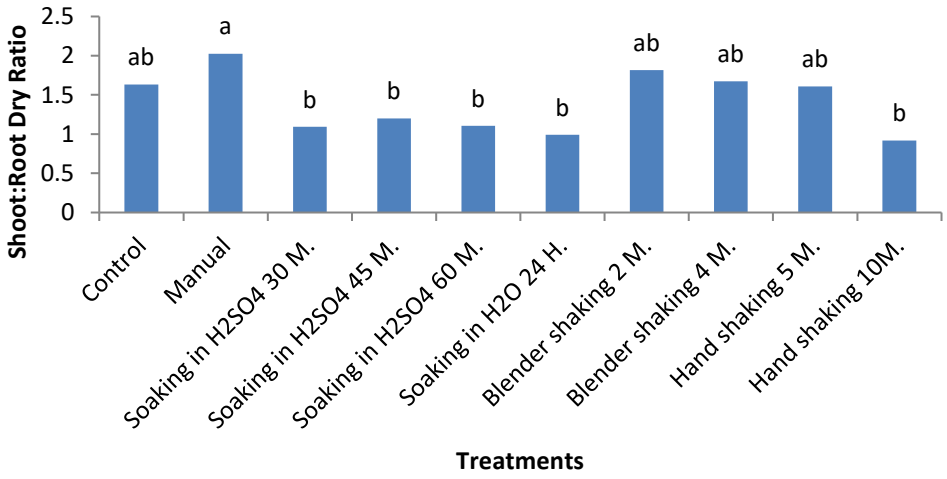

Figure (16): Shoot to root dry ratio of *Mucuna bracteata* seedlings under different treatments. (Different alphabets show significant difference using Duncan's Multiple Range test (P≤ 0.05))

CONCLUSIONS

The study of seed morphology is deemed to be fundamental to understand the variability of seeds, which in turn is an essential adaptation phenomenon in the life of desert plants. There is an ecological significance of seed variability for their long-term propagation in the existing areas and for their successful introduction to new areas. The pre-sowing treatments of seeds remarkably enhance the germination percentage and germination rate of seeds, which is significantly higher when compared to untreated seeds. The structures and mechanisms that regulate germination show considerable variance in different species and even across plants of the same species. Through chemical scarification, the seed coat becomes permeable to water, which in turn induces germination. On the basis of the outcomes of this study, it can be concluded that the seeds of *Mucuna bracteata* require pre-sowing treatments in order to attain a high germination rate and germination percentage. For *Mucuna*, mechanical scarification proved to be extremely effectual in enhancing the seed germination and seedling growth. For some other varieties, the treatment with sulphuric acid for 30 mins proved to be effective in improving the seedling growth. This implies that shaking or scarification of seeds can be a very appropriate, cost–effective and eco-friendly mechanism to improve the seed germination and seedling growth, and these mechanisms are simple enough to be implemented by unskilled, local farmers who otherwise find it challenging to combat the seed dormancy of *Mucuna* seeds. The procedure of shaking seeds using a blender is reasonably easy and inexpensive compared with any other method, and hence can be widely practised.

Acknowledgments

The author would like to thank the University of Perilis (UniMAP) and the Tikrit University for providing the laboratory equipment to conduct this research. Thanks to the anonymous reviewers for helping improve the manuscript.

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طريقة جديدة لتحسين معدل إنبات Mucuna bracteata

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الخلاصة

للتأكد من أفضل طريقة ممكنة تساعد على زيادة إنبات ونمو شتلات Mucuna bracteata ، أجريت تجربة في محطة التجارب العائدة لمعهد التكنولوجيا الزراعية المستدامة ، جامعة ماليزيا بيرليس ، بادانج بيسار ، بيرليس ، ماليزيا. نفذت التجربة حسب تصميم العشوائي الكامل (CRD) و بأربعة مكررات. أشارت نتائج التجاربة إلى أنه عند معاملة البذور في الخلاط لمدة دقيقتين، فإنها تحسن بشكل كبير من سرعة الإنبات ، ونسبة الإنبات ، ومتوسط الإنبات اليومي ، و الوزن الطري للمجموع الخضري، و الوزن الجاف للمجموع الخضري ، ونسبة الوزن الطري للمجموع الخضري الى الجذور. من ناحية أخرى ، عندما تم نقع البذور في حامض الكبريتيك H2SO4 لمدة 30 دقيقة ، كان هناك تحسن في الوزن الطري الكلي للشتلة ، ومتوسط وقت الإنبات ، ووزن الجذر الجاف ، ومجموع الوزن الجاف للشتلة. عندما تمت معاملة البذور في الخلاط لمدة 4 دقائق ، أدى ذلك إلى تحسن كبير في الإنبات و عدد الأوراق في الشتلة.

الكلمات المفتاحية:
إنبات؛ بيئة؛ نبات؛ تكنولوجيا؛ نقع.