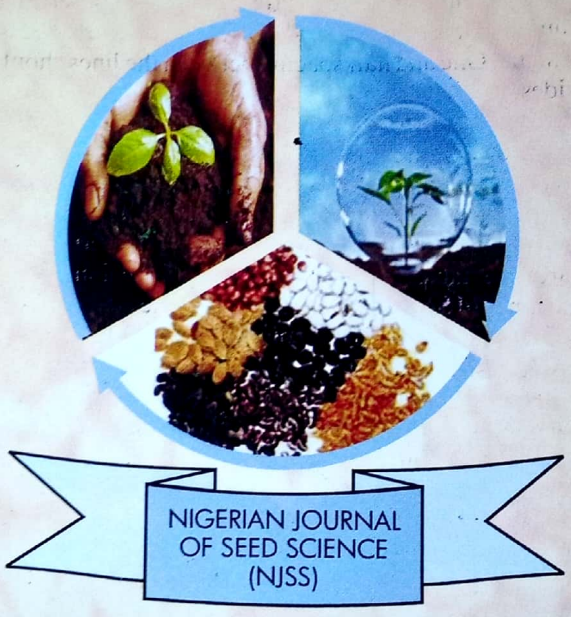
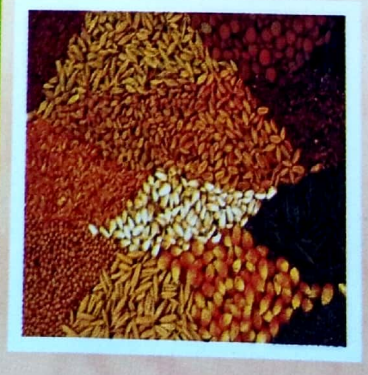
# NIGERIAN JOURNAL OF SEED SCIENCE (NJSS)

*A Scientific Journal Serving Seed Scientists and Technologists*

Volume 2, 2018



PUBLISHED BY
Association of Seed Scientists' of Nigeria (ASSN)

# NIGERIAN JOURNAL OF SEED SCIENCE

**Scope of the Journal:** Nigerian Journal of Seed Science (NJSS) is a peer review journal published by The Association of Seed Scientists' of Nigeria (ASSN). The journal is published regularly and is available as paper copies. The scope of the journal covers all basic and applied research in all aspects of seed science including seed biology, physiology, production, processing, testing, certification, storage, pathology etc. Short communications from seed experts and technologists may also be published as Seed technical notes if such notes depict new laboratory techniques, anatomical and pathological observations of seed and seedling development etc. The journal may also accept review articles in all areas of seed science and technology relating to agriculture and seed system development.

**Instructions to Authors:**

***General condition for accepting papers:*** The main conditions for paper acceptance are originality, quality of research and interest to readers. Articles are accepted on the understanding that they have not been published or submitted to any other scientific journal for consideration. Submitted manuscripts will be subjected to blind peer-review by at least two anonymous reviewers while final acceptance will be determined by the Editorial Board.

***Manuscript preparation:*** Manuscripts must be clearly written in proper English and should not exceed 15 pages or 15,000 words (including tables, figures and references). It should be typed on A4 format page with 12 font size of "Times news roman". One and half spacing between the lines should be used with 2.5cm margin on top, bottom, right and left sides.

*Manuscript Style*: Three types of submissions will be considered for publication. These include:

a. **Full-length research article:** This is a report of new information of conducted research into the subject area or an expansion of an established knowledge that will contribute additional knowledge to science. Such manuscripts will undergo peer review to determine that adequate scientific methods were applied and are repeatable; interpretations and conclusions are well presented and valid.
b. **Short communication and Seed technical notes**: These are manuscripts reporting of seed laboratory or seed production research that may not justify a full paper, but provide important technical information that could assist seed system/industry development.
c. **Review articles:** These are articles that cover a summary of seed technology topic or evaluation of seed science or technology related publications addressing a specific subject matter. The content should have a strong technical and/or scientific base.

*Manuscript format*:

Each manuscript should be arranged in the following order: Title, Author(s), Affiliations, Abstract, Text (separated into introduction, methodology, results (including tables and figures), discussion and conclusion), Acknowledgments and References.

***Title:*** The title should be concise and informative, containing key words which describe the subject matter. It should not exceed 15 words.

***Author/s's name:*** The name of the author(s) should be written starting with the surname followed by initials and placed below the title. Numbers in superscript are placed at the end of last initial to indicate affiliation of each author. Also an asterisk (*) is placed after the name of the corresponding author.

***Author/s affiliation:*** Full address/es of the author/s are clearly written with the corresponding superscript number in front of the full address of each author. All the address must be in *italics*

H. M. Ibrahim CRP

NIGERIAN JOURNAL
OF SEED SCIENCE

VOL. 2 2018

# Nigerian Journal Of Seed Science

*A Scientific Journal Serving Seed Scientists and Technologists*

*Published by the*

**Association of Seed Scientists' of Nigeria (ASSN)**

H. M. I

# Nigerian Journal of Seed Science

VOL. 2 2018

## Content

*Nigerian Journal of Seed Science (NJSS) Vol. 2: 69 - 79, 2018*

# Germination and seedling growth of golden shower (*Cassia fistula* L) as influenced by method of breaking hard seed coat dormancy and dipping duration

*** Olosunde O. M.[1], Ibrahim H. M.[2], Hammed[1] L. A., Adebisi M. A.[3]**

[1]*Department of Horticulture, Federal University of Agriculture Abeokuta Ogun State, Nigeria*
[2]*Department of Crop Production, Federal University of Technology, Minna, Niger State, Nigeria.*
[3]*Department of Plant Breeding and Seed Technology, Federal University of Agriculture Abeokuta Ogun State, Nigeria*
**Corresponding author. olatundeolosunde@yahoo.com.*

## Abstract

Laboratory and field experiments were conducted at the Federal University of Agriculture, Abeokuta on Latitude 7o 14' N and longitude 3o 21' E to determine the best method of breaking hard seed coat dormancy and duration of dipping for rapid and complete germination and growth of golden shower seedlings. Seeds of golden shower (*Cassia fistula*) soaked in H2SO4 (95%); Gibberelic acid (-GA3) (0.5 g/L); hot water (100 0C) for 5, 10 and 15 minutes and untreated (control) were arranged in a Completely Randomized Design with three replications. Data collected on germination and seedling growth parameters were subjected to Analysis of Variance and treatment means separated using Least Significant Difference (LSD) at 5% level of probability. In the laboratory experiment, seeds soaked in GA3 had highest germination percentage (100%), followed by those soaked in hot water (87%), H2SO4 (81%) and untreated seeds did not germinate (0%) at 19 days after sowing. Seeds soaked for 5, 10 and 15 minutes had germination percentages of 100, 87 and 81 %, respectively. On the field, seeds treated with H2SO4 had significantly ($P \leq 0.05$) higher seedling emergence (100% and 79%), followed by seeds treated with hot water (87% and 53%) while seeds treated with GA3 and untreated had zero germination. Soaking of seeds for 5 and 10 minutes resulted in highest (87 and 68%) and least (58 and 53%) seedling emergence, respectively for the two field trials. Dry matter of seedlings from seeds soaked in either H2SO4 or hot water was not different, but seeds soaked for 5 minutes had seedlings with higher values. Therefore, soaking of seeds of *Cassia fistula* in hot water for 5 minutes is the best practicable and economical procedure for nurserymen to induce rapid germination and seedling growth.

**Keywords:** Seed scarification, Seed dormancy, Chemical treatment, Seed soaking

## Introduction

Cassia fistula Linn, commonly called golden shower belongs to the genius Cassia subfamily Caesalpiniacaea and family fabaceae (Sartorelli, 2009). It is a native of Southern Asia, Indian, and Malaysia but now widely grown in tropical areas as flowering ornamental plant. Golden shower is primarily grown for its beautiful bright yellow flowers, shade for relaxation and has many medicinal values (Bhakta, 1999; Grupta *et al.*, 2000; Duraipardiyan and Idnacimuthu, 2007). It could also be used to conserve soil, prevent erosion, improve soil fertility, as wind breaker and source of industrial raw materials in tanning and dye stuff production (Perry and Hay, 1982). However, presence of hard seed coat hinders quick germination of seeds of Cassia fistula, thereby affecting attainment of uniform establishment of seedlings in the nursery. Rapid germination and proper management of the seedlings in the nursery is very crucial for the uniform

production of seedlings for transplanting. The inability of viable seeds to germinate in the presence of all necessary external environmental factors that are required for seed germination poses a serious bottleneck to commercial production of seedlings of ornamental plants. Seed scarification with hot water, acid treatment, hormonal treatment and heat among others have been previously reported to break hard seed coat dormancy in order to ensure quick and proper germination, seedling emergence and growth in many plants (Kim et al., 2017; Ahmed et al., 2006 and Fagbayide and Fawusi, 1994).

*Cassia fistula* seeds exhibit hard seed coat dormancy which prevents water imbibition, exchange of oxygen and activation of embryo for germination, resulting in poor germination rate (Ramamoorthy, 2005). However, information on the best seed treatment methods and duration of the treatment to overcome seed dormancy in Cassia fistula is scanty. Hence this study seeks to investigate the best dipping duration in H2S04, GA3, and hot water to attain optimum and even germination, seedling emergence, and growth in Cassia fistula.

## Materials and Methods

The experiments were carried out in 2014 and 2015 at the laboratory and the nursery of the Department of Horticulture, Federal University of Agriculture, Abeokuta, Ogun state, Nigeria, located on Latitude 7o 14' N and longitude 3o 21' E. The annual rainfall was 1200 mm and the vegetation was mainly secondary forest.

In both experiments, treatments consisted of scarification methods (H2SO4 (95%), GA3 (0.5g/l), hot water (100 °C) and untreated seeds as control) and dipping durations (5, 10 and 15 minutes) factorially combined in a Completely Randomized Design (CRD) in five replications and there were twenty five seeds each per replicate. In the laboratory, Petri-dishes lined with 7 g of cotton wool were arranged on a flat surface and treated seeds were placed in each Petri-dish with 25 seeds per Petri-dish at 1cm depth for observation. On the field, 14 kg of the air dried soil was weighed into each perforated planting pot to prevent water logging. Then 25 treated seeds were sown per pot at 3 cm depth at 5 x 5 cm spacing and each planting pot separated by 75 x 45 cm.

Mature brown pods of *C. fistula* were collected from the fully grown trees used for avenue planting at Federal University of Agriculture, Abeokuta. The pods were broken to release the seeds and seeds were washed with distilled water and the clean seeds were air dried and tested for germination. Seed germination was determined by placing seeds in Petri-dishes under laboratory conditions and seeds were sown in planting pots after treatment in the nursery.

Three sets of 100 seeds of *Cassia fistula* were soaked in 3 different glass beakers containing equal volume (20 ml) each of H2SO4, hot water and GA3 at dipping durations of 5, 10 and 15 minutes, respectively. As the duration of dipping lapsed, the acid solution was poured away and seeds were thoroughly rinsed with

distilled water to remove remnant of H2SO4, blotted dry before sowing. The control was direct germination of untreated seeds.

Though the experiment was rain fed, watering was done occasionally and weed control was done manually within the pots as required.

Data collected on the days to first emergence, days to 50% germination, percentage germination and dry weight (g) of leaves, stem and root were subjected to analysis of variance (ANOVA) using GenStat discovery and means were separated using Least Significant Difference (LSD) at 5% level of probability.

**Results**

Statistical analysis of the result showed that effect of method of breaking hard seed coat dormancy was significant ($p < 0.05$) on germination of golden shower across sampling period (Figure1). It took seeds treated with GA3 and hot water four days (4) to start germinating followed by those treated with H2SO4 that took seven days (7) while none of the untreated seeds germinated 16 days after sowing (DAS). Similarly, seeds treated with GA3 attained 50% germination within 9 days, followed by those treated with H2SO4 in 12 days and hot water in 14 days. Seeds of golden shower dipped in GA3 had significantly ($p < 0.05$) highest germination percentage (100%), followed by those dipped in hot water (87%), then those dipped in H2SO4 (81%) and none of the untreated seeds germinated at 16 DAS (Figure1). However, total germination percentage of seeds treated with H2SO4 or hot water was statistically similar.

Dipping duration significantly ($p < 0.05$) influenced germination of golden shower (Figure 2). Seeds treated for 5 minutes attained 50% germination in 12 days and completed germination (100%) in 14 days, while seeds dipped for 10 minutes attained 50% germination in 13 days and maximum germination of 85% in 15 days. Seeds dipped for 15 minutes attained 50% germination in 14 days and maximum germination of 77% in 16 days. Effect of dipping duration on earliness to germination and 50% germination was not significant ($p < 0.05$).

Also, the interactive effect of method of breaking hard seed coat dormancy and dipping duration on germination percentage of golden shower showed seeds were significant ($p < 0.05$) indicating that they were dependent (Table 1). With seeds dipped in H2SO4, highest germination percentage (81%) was recorded with 5 minutes dipping while those treated for 10 minutes had the least (68%) at 16 DAS. Conversely, seeds treated with GA3, for 5, 10 or 15 minutes had 100% germination. However, seeds dipped in hot water for 5 and 10 minutes had the highest of 87% and lower value of 82% (Table 1).

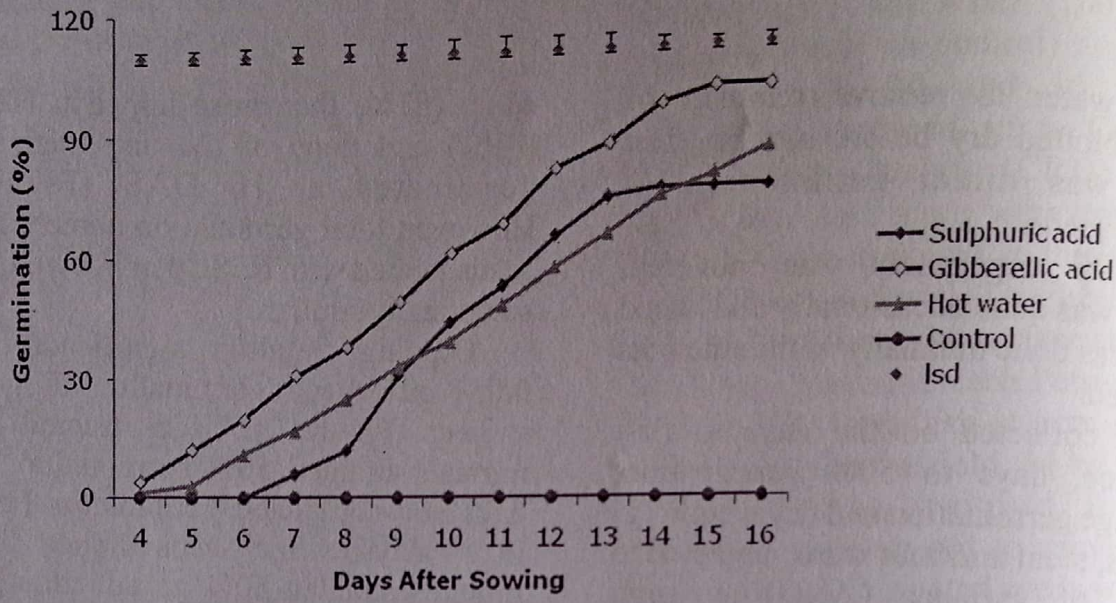



**Figure 1:** Effects of method of breaking hard seed coat dormancy on seed germination (%) of *Cassia fistula* in the laboratory

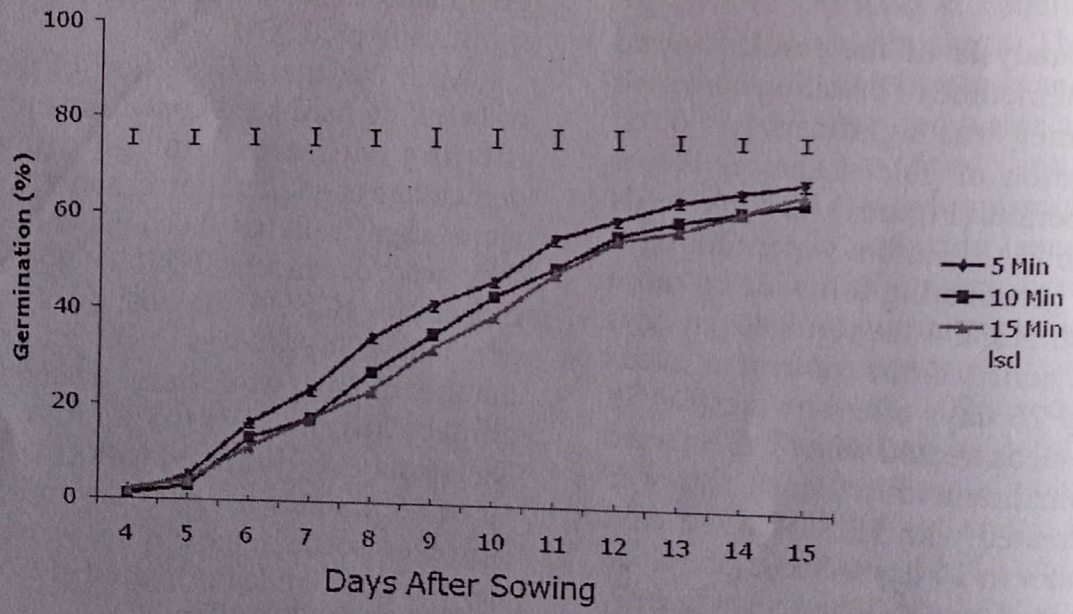



**Figure 2:** Effects of dipping duration on seed germination (%) *Cassia fistula* in the laboratory

**Table 1: Effects of method of breaking hard seed coat dormancy and dipping duration on germination (%) of golden shower**

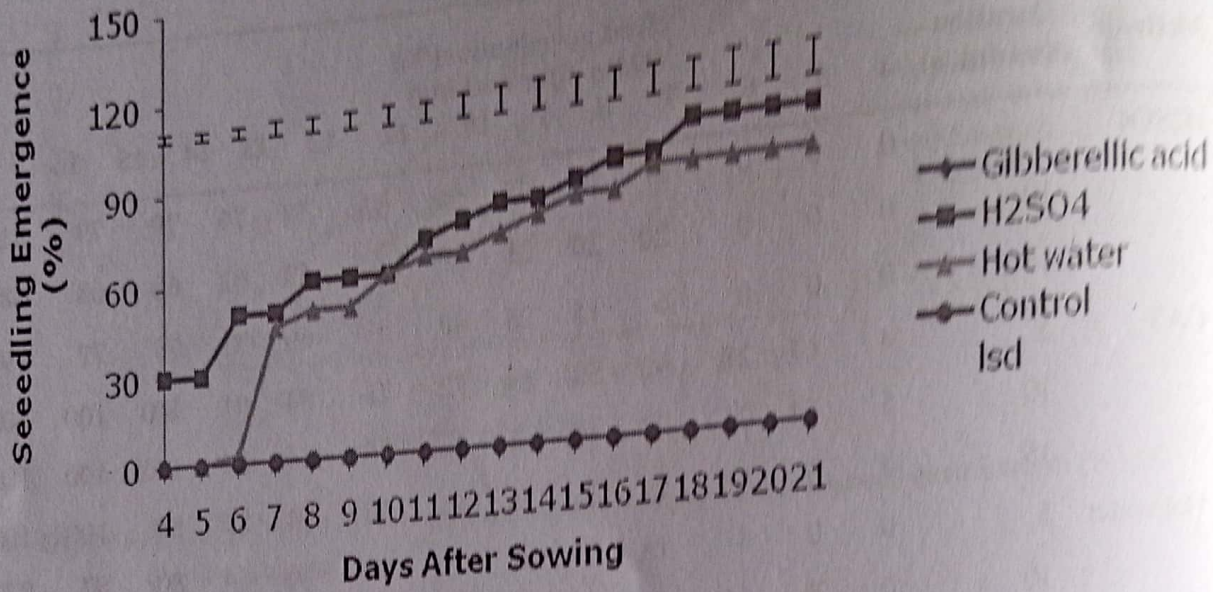
| Methods | Dipping duration (minutes) | Seed germination(%) (Days after soaking) 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H2SO4 | 5 | 0 | 0 | 0 | 6 | 17 | 43 | 54 | 62 | 78 | 79 | 79 | 79 | 81 |
| | 10 | 0 | 0 | 0 | 20 | 20 | 21 | 29 | 39 | 48 | 62 | 68 | 68 | 68 |
| | 15 | 0 | 0 | 0 | 6 | 15 | 28 | 48 | 59 | 69 | 71 | 75 | 77 | 79 |
| GA3 | 5 | 4 | 17 | 28 | 42 | 50 | 59 | 72 | 73 | 84 | 91 | 100 | 100 | 100 |
| | 10 | 5 | 14 | 21 | 33 | 40 | 51 | 66 | 76 | 84 | 89 | 100 | 100 | 100 |
| | 15 | 4 | 6 | 10 | 19 | 25 | 36 | 45 | 56 | 74 | 80 | 88 | 100 | 100 |
| Hot water | 5 | 0 | 0 | 8 | 14 | 24 | 33 | 39 | 47 | 56 | 64 | 80 | 87 | 87 |
| | 10 | 0 | 3 | 11 | 17 | 24 | 36 | 44 | 56 | 65 | 72 | 78 | 82 | 82 |
| | 15 | 4 | 6 | 14 | 20 | 24 | 29 | 35 | 42 | 49 | 59 | 63 | 69 | 85 |
| Control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LSD (P= 0.05) | | 3.0 | 3.1 | 4.1 | 4.8 | 5.0 | 4.8 | 5.7 | 5.7 | 5.7 | 5.7 | 4.2 | 3.6 | 3.8 |

Effect of method of breaking hard seed coat dormancy on seedling emergence of golden shower was significant ($p < 0.05$) in both trials (Figure 3). Seeds dipped in $H_2SO_4$ and hot water attained 50% emergence in 9 and 12 days, respectively. However, seeds dipped in $H_2SO_4$ reached the highest of 100% in 19 days and those dipped in hot water reached highest of 80% in 21 days in the first and second trials, respectively. Seeds treated with $GA_3$ and the untreated seeds did not emerge at 21 DAS.

Dipping duration significantly ($p < 0.05$) affected seedling emergence of golden shower in the first and second trials (Figure 4). Seeds of golden shower treated for 5 minutes attained 50% seedling emergence in 9 days and had highest of 100% and 80% seedling emergence, respectively in 19 days in the first and second trials, followed by those dipped for 15 and 10 minutes that attained 50% seedling emergence in 12 days and had highest of 86% and 79%, and 77% and 74% in the first and second trials, respectively.

However, the interactive effect of method of breaking hard seed coat dormancy and dipping duration on seedling emergence of golden shower seeds was significant ($p < 0.05$) in the first

*first trial*




*second trial*

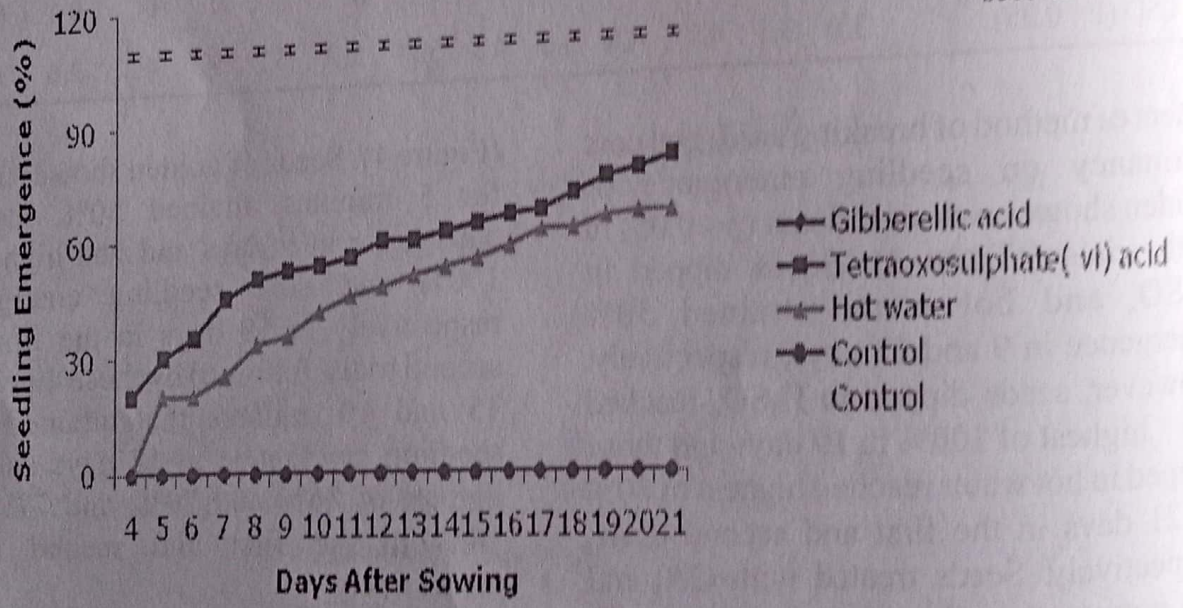



**Figure 3:** Effects of method of breaking hard seed coat dormancy on seedling emergence of golden shower.

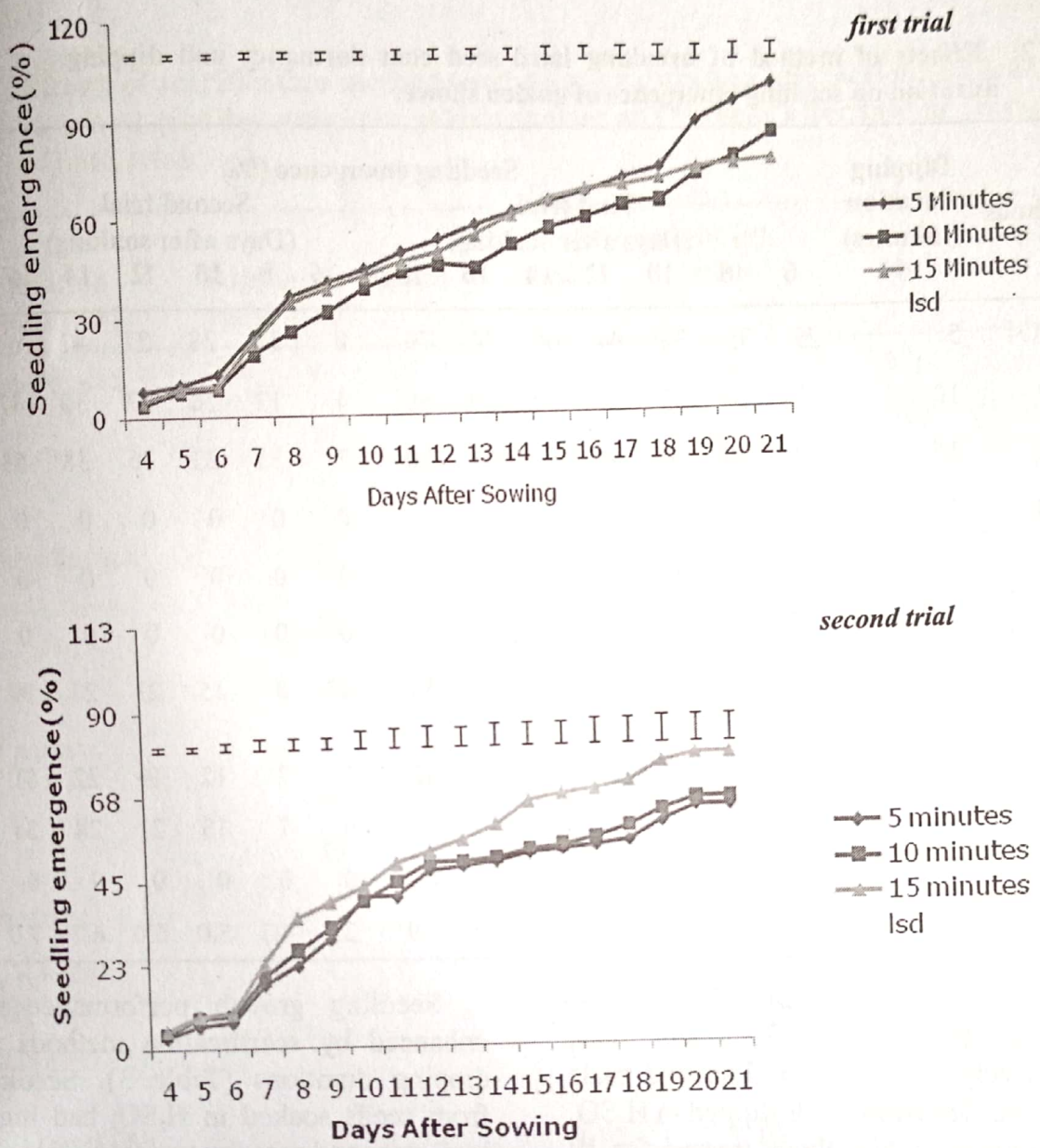



**Figure 4:** Effects of dipping duration on seedling emergence of golden shower.

**Table 2: Effects of method of breaking hard seed coat dormancy and dipping duration on seedling emergence of golden shower**

| Methods | Dipping duration (minutes) | Seedling emergence (%) First trial (Days after soaking) | | | | | | | Second trial (Days after soaking) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| H2SO4 | 5 | 25 | 35 | 36 | 44 | 66 | 74 | 79 | 8 | 18 | 28 | 37 | 41 | 61 | 70 |
| | 10 | 17 | 24 | 25 | 35 | 50 | 59 | 66 | 4 | 13 | 20 | 27 | 30 | 47 | 53 |
| | 15 | 19 | 28 | 34 | 41 | 57 | 64 | 70 | 7 | 15 | 23 | 36 | 38 | 53 | 61 |
| GA3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hot water | 5 | 12 | 17 | 20 | 30 | 42 | 47 | 53 | 4 | 8 | 15 | 23 | 27 | 39 | 44 |
| | 10 | 9 | 14 | 18 | 25 | 35 | 38 | 42 | 2 | 7 | 12 | 19 | 22 | 31 | 37 |
| | 15 | 10 | 15 | 18 | 27 | 36 | 40 | 44 | 4 | 7 | 13 | 21 | 24 | 34 | 38 |
| Control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LSD (P= 0.05) | | 4.8 | 5.4 | 5.7 | 6.9 | 8.4 | 8.8 | 8.9 | 2.7 | 4.2 | 5.0 | 6.0 | 6.7 | 7.9 | 8.5 |

and second trials (Table 2). Highest seedling emergence of 79% and 70%, respectively in the first and second trials were recorded from seeds dipped in $H_2SO_4$ for 5 minutes while those treated for 10 minutes had the least of 66% and 53%, respectively at 18 DAS. Seeds dipped in hot water for 5 minutes had highest seedling emergence of 53% and 44% followed by those dipped for 15 minutes with 44% and 38%, while seeds dipped for 10 minutes had the lowest of 42 and 37% in the first and second trials, respectively. Seeds treated with gibberellic acid and the untreated (control) seeds did not emerge.

Seedling growth performance was enhanced by scarification methods and dipping durations (Table 3). Seedlings from seeds soaked in $H_2SO_4$ had higher leaf, stem and root dry weight values than those soaked in hot water. Soaking of seeds for 5 minutes resulted in superior seedlings growth with higher leaf and stem dry weight than other treatments, but was not different in terms of dry root weight. The interactive effects show that increase in soaking duration in either $H_2SO_4$ or hot water resulted in lower leaf, stem and root dry weight except for dry root weight of seedlings from seeds soaked in hot water.

**Table 3: Effects of scarification methods and dipping duration interactions on leaf, stem and root dry weight of golden shower at 18 weeks after sowing (mean of both trials)**

| Scarification Methods (SM) | Dipping Duration (min) (DD) | Dry weight (g) Leaf | stem | root |
|---|---|---|---|---|
| Sulphuric acid | 5 | 2.7 | 1.3 | 3.2 |
| | 10 | 2.2 | 1.1 | 2.6 |
| | 15 | 2.0 | 0.9 | 2.6 |
| Gibberellic acid | 5 | 0.0 | 0.0 | 0.0 |
| | 10 | 0.0 | 0.0 | 0.0 |
| | 15 | 0.0 | 0.0 | 0.0 |
| Hot water | 5 | 1.5 | 0.7 | 0.5 |
| | 10 | 1.3 | 0.6 | 0.6 |
| | 15 | 1.2 | 0.4 | 0.6 |
| Control | 0 | 0.0 | 0.0 | 0.0 |
| LSD(p=0.05) SMXDD | | 0.25 | 0.16 | 0.77 |
| LSD (p= 0.05) SM | | 0.14 | 0.09 | 0.44 |
| LSD (p= 0.05) DD | | 0.12 | 0.08 | ns |

should be given to concentration and duration of soaking in chemical acids to avoid possible damage of embryo which may result in deformed seedlings.

Soaking in hot water is economical and eliminates problem of scorching and death of emerged seedlings. Previous works (Seiler, 1994; Fagbayide and Fawusi, 1994; Rehman and Park, 2000 and Chuanren *et al.*, 2004) emphasize pre-treating seeds of legumes with hard seed coat at a specified dipping duration for faster and complete germination. Chuanren *et al.*, (2004) described seeds of *Cassia fistula* as similar to those of many other hard coated legumes and that scarification could enhance its germination ability. Past studies have been inconclusive or at best requesting further investigation on appropriate duration of soaking for chemical treatment of seeds with hard seed coat. This study established soaking period of 5 minutes as adequate for rapid germination of *Cassia fistula* seeds.

Germination success of golden shower seeds soaked in $GA_3$ in the laboratory was unique compared with poor observation on the field. This might be due to prevailing environmental factors that may inhibit germination. Application of growth regulators such as $GA_3$ has a positive effect on germination and could double the germination rate of dormant seeds with hard seed coat (Seiler, 1994; Borghetti *et al.* (2002)). However, Li *et al.*, (2005) suggested that gibberellins synthesis and perception are often affected by light and temperature among other numerous environmental signals that can influence release from seed dormancy. Better seedling performance of *Cassia fistula* seeds treated with $H_2SO_4$ and hot water suggests positive relationship between rapid germination and superior seedling establishment.

## Conclusion

Based on the result from the experiment, it could be concluded that, highest germination was recorded in seeds treated with $GA_3$ acid for 5 minutes in the laboratory while optimum seedling emergence occurred in seeds treated with $H_2SO_4$ on the field. However, soaking seeds of *Cassia fistula* in hot water for 5 minutes is the most practicable and economical procedure for faster germination and uniform growth of seedlings in the nursery.

## References

Bhakta T, Mukherjee P.K, Mukherjee K, Bam Saha BP (1999). Evaluation of hepatoprotective activity of *cassia fistula* leaf extracts. *Journal of Ethnopharmacol* 66:227-282

Borghetti, F. F., Nakamura N and Martins de Sá, C. 2002. Possible involvement of proteasome
activity in ethylene-induced germination of dormant sunflower embryos. *Brazilian Journal of Plant Physiology* 14: 125-131.

Chuanren, D. W., Bochu, L.,Wanqian, C., L.J. and Huan, Z. 2004. Effect of chemical and physical factors to improve the germination rate of

*Echmacea angustifalia* seeds. Colloids surface B, *Biointerfaces*, 37:101-105

Duraipardiyan, V. and Idnacimuthu, S. 2007. Antibacterial and antifungal activity of *cassia fistula*.an ethnomedicinal plant. *Journal of Ethnopharmacology*, 112:590-594,

Fagbayide, J.A. and Fawusi, M.O.A. 1994. Comparative studies in seed germination and seedling management in *Cassia fistula*. (L) and *Cassia nodosa* (Buch. Ham a Roxb). *Indian journal of Agricultural research* 28 (2): 133 - 140

Grupta, M., Mazumder, U.K., Rath, N., Mukho, P. DK. 2000. Antitumour activity of methanolic extract of *Cassia fistula* seed against Ehrilich *Ascites carcinoma*. *Journal of Eyhnopharmacol* 72: 151-156.

Kim, J. He., Kim, K. Ok., Lee, Ae. K., Roh, M. S., and Suh, J. K. 2017. Germination of Corylopsis seeds evaluated by x-ray imaging and cold stratification. *Horticultural Science*. (Prague) 44(2):105-111

Li W.Q., Liu X.J., Khan M.A., Kamiya Y., Yamaguchi S. 2005. Hormonal and environmental regulation of seed germination in flixweed (*Descurainia sophia*). *Plant Growth Regulator*. 45 (3): 199–207.

Perry, F and Hay, R. 1982. A field guide to tropical and subtropical plants. Van Nostrand Reinhold Co. N.Y.

Ramamoorthy, K.C. Rajendran and Sivasubramanian, S. 2005. Seed treatment for alleviation of hard seededness in senna (*Cassia angustifolia*). *Advances in Plant Sciences*, 1861): 429-430.

Rehman, S. and Park, I.H. 2000. Effect of scarification, GA and chilling on the germination of golden rain-tree (*Koelreuteria paniculata* Laxm.) seeds. *Scientia Horticulturae* 85: 319-324.

Sartorelli, P., C.S. Carvalho, J.Q. Reimao, M.J.P. Ferreira and A.G. Tempone, 2009. Antiparasitic activity of biochanin A, an isolated isoflavone from fruits of *Cassia fistula* (Leguminosae). *Parasitol Res*earch, 104: 311-314.

Seiler, G.J. 1994. Dormancy and germination of wild *Helianthus* species. In: P.D.S. Calligan and D.J.N. Hind(eds.). Compositae: Biology Utilization. Proceedings Internatinal Compositae Conference 1994;213-222. Royal Botanic Garden, Kew..

Tzortzakis,N.G.2009. Effect of pre-sowing treatment on seed germination and seedling vigour in endive and chicory. *Horticultural Science* (Prague):36(3):117-125.