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Spin-priming - A novel and a crucial treatment to enhance the seed quality of roselle (*Hibiscus sabdariffa)* seeds

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Abstract

Seed vigour being an important physiological parameter is important indeed in medicinal plant like roselle in which it is increased significantly by standardization of conventional priming (hydro-priming) duration and spin-priming duration of (*Hibiscus sabdariffa*) then compared with the non - primed seeds. The standardisation of hydropriming was performed by soaking of seeds in equal volume of water for various soaking durations *viz.,* 2-5 h and restored to its initial state of moistness revealed that hydropriming of roselle seeds for 5 h registered higher physiological seed quality parameters. The best performed hydropriming duration of 5 h was taken for standardisation of spin - drying duration by adopting several drying timings *viz.,* 1-5 min. The results indicated that the seeds hydro-primed (5 h) and spin-dried for 4 min had a significant improvement in physiological parameters, seed anatomical structure namely length (8.4 cm) and width (2.33 cm) of the embryo and root growth was seen evident through root architecture analysis. The % increase in germination over control in hydro-priming and spin-drying for 5 h and 4 min was 51 and the expresses the maximum vigour index of 1612.

Keywords

medicinal plants; spin drying; priming; germination

Introduction

Throughout history, humans have relied on nature's bounty to alleviate ailments and promote well-being (1). Medicinal plants have played a central role in traditional healing practices across cultures worldwide. Medicinal plants are botanical species that possess pharmacological properties, offering compounds with therapeutic effects on human health. Roselle (*Hibiscus sabdariffa*) is an annual herb (2). According to FAO the calyces of roselle were popular in making infused herbal tea which is known for its cranberry like flavour and the stems are known for making bast fibres which are further manufactured into ropes, twines and textile materials (3). With a long history of conventional utilization, roselle is known for an extensive spectrum of pharmacological traits such as such as antihypertensive, spasmolytic, microbicidal and more. The seeds are also diuretic, laxative and tonic. Those are used in treatment of debility. Roselle is propagated through seed. The initial variable influencing a plant's future development is its seed (4).

There is a clear mention in ancient literature Yajurveda "May the seed viable, may the rains plentiful and may the grains ripe days and nights". The efficiency of crop production is greatly improved by the quality of the seed. Enhancing seed quality before sowing is essential to achieve optimal plant population in field conditions. In medicinal plants seed quality enhancement studies are meagre. Seed quality enhancement is defined as postharvest treatments that improve germination of crop seed (5). The concept of "seed enhancement" pertains to a multitude of seed treatments, which include film coating, pelleting, hardening and priming. They enhance the vigour and physiological condition of the seed to augment seed establishing, germination and seedling growth (6).

Seed priming is a vital seed quality enhancement technique and one of the easiest and most cost-effective methods to improve crop seed emergence. Seed priming promotes the tolerance for abiotic stress, quicken up emergence and boosts the rate of germination of seeds (7). For the "seed enhancement technique" to be utilized readily by the seed industry as well as farmers, the seed priming process must be streamlined. While access to household appliances like top-loading washing machines is growing in India, affordability remains a challenge, particularly for marginal and small-scale farmers who make up a significant portion of the agricultural workforce. Farmers may effortlessly procure top loading laundry machines, which are ubiquitous for home use through the subsidy, or it can be made available as for a group of farmers in a village. This machine's features include spin-drying choices and automatic priming solution drainage, 2 essential tasks that are laborious to carry out in a conventional manual priming methodology. This facilitates the hassle-free handling for farmers as the process is completely automated (8). Standardizing the duration for spinning soaked seeds to dry and automating the drainage of the priming solution are two key aspects of the adaptation process. This study simplifies the process by standardizing the spin-drying time and hydro-priming of roselle seeds

Materials and Methods

Fresh seeds of roselle (local cultivar) were used for the experiments. For hydro priming of roselle seeds, the duration of priming was standardised by soaking of seeds in equal volume of water by adopting various durations *viz.,* 2-5 h. The hydro- primed seeds were dried for 6 h at ambient temperature to bring them back to original moisture content and observed for the following physiological specifications *viz.,* Speed of germination, germination %, seedling length, dry matter production and vigour index.

Results

Speed of emergence

The rate at which seeds from various treatments emerged was measured using 4 replicates, each containing 25 seeds. From the first day following sowing until the last day of emergence, the number of seeds displaying radicle protrusion was tallied every day (9).

$$Speed\ of\ germination = \frac{X1}{Y1} + \frac{X2 - X1}{Y2} + \cdots \frac{Xn - X(n-1)}{Yn}$$

X_1 - Number of seeds germinated at first count

Y_1 - Number of days from sowing to first count

Germination (%)

Using the roll towel method, 4 replications of 100 seeds each were germinated under test conditions of 25 ± 2 °C and 90 ± 3 % humidity ratio maintained in a germination room with fluorescent lighting of 1250 lux throughout the daylight of 15 h and dark period for 9 h. of Following a 14 days test period, the proportion of normal seedlings in each replication was tallied and documented (10).

Seedling length (cm)

At the time of germination count, 10 random seedlings were selected and measured for seedling length and the mean values are expressed in cm.

Dry matter production (g /10 seedlings)

Ten standard seedlings, which were to be used in the measurement of seedling length, were first dried for 24 h in the shade, then for 48 h in a hot air oven that was kept at 85 °C and finally for 30 min in a desiccator. The seedlings were weighed and the mean results were reported in g/10 seedlings (11).

Vigour index

The findings were reported as a whole number and the vigour index of the seedling was determined using the technique (12).

Vigour index = Germination (%) × Seedling length (cm)

Based on the result obtained from the above experiment, 5 h is considered as suitable hydropriming duration for roselle seeds. To automize the seed priming technology, seed priming cabinet (13) was used. The machine's main benefit is that it instantly drains the priming solution and partially dries the seeds "hands free," making it easy to operate the priming process of seeds and return them to their original moisture content.

Once the soaking period is completed the solution is let to drain and now the machine starts to spin. Subsequently, the soaked seeds were subjected to 'spin drying' for different duration *viz.,* 1-5 min. Along with the hydro-primed and non-primed seeds, the spin primed seeds were shade dried at room temperature to restore their original moisture content. They were analysed for the physiological parameters of seed quality, such as germination speed, proportion of germination, seedling length, dry matter production and vigour index.

Anatomical structure

Using Euromex Microscope Hollands IMAGE VERSION 1.0, the anatomical alterations of hydro primed (5 h) and spin primed (4 min) seedlings as well as non- primed seeds were assessed. This high-end zoom microscope is ideal for conducting biological sample preparations and material surface analysis. The length and width of the embryo (mm) in the seeds have been measured using Euromex software, which was calibrated with respect to the picture magnification at 20.0 x (8).

Root architecture

The seeds were prepared in accordance with the treatment details as mentioned (14) and placed over a sponge in a test tube filled with nutrient solution.

The data obtained from the experiments were analysed as described (15) and wherever necessary, the % values are transformed into arc - sine values by Agres software and the critical difference (CD) was calculated at 5 % (P= 0.05).

Effect of hydropriming on physiological parameters of roselle seeds

The results on germination speed showed significant differences based on soaking durations. Seeds that were hydro-primed for 5 h exhibited the fastest germination, with a value of 13.26, followed by other treatments with values ranging from 9.21 to 11.49. The non primed seed germinated slowly and recorded the least value of 7.89 (Table 1). The germination % was statistically significant in 5 h hydro primed seed which recorded 80 % germination and 60 % was registered by non-primed seed. Significant difference was observed for seedling length (cm) due to hydropriming durations. Among the duration, seeds hydro primed for 5 h recorded highest mean seedling length of 25.3 cm. The results revealed significant difference in dry matter production. It was more in 5 h hydro primed seed (0.205 g/10 seedlings) as against non- primed seed (0.129 g/10 seedlings). Among the several treatments, the vigour index values were significant. Hydro-primed seeds had the highest possible vigour index value (1443), though non-primed seeds acquired the lowest value (1097) (Table 1).

Effect of 'hydropriming and spin drying' on physiological parameters roselle seeds

The acceleration of germination revealed a significant distinction brought forth by the spin-drying procedures. The seeds hydro primed for 5 h and spin dried for 4 min germinated rapidly by registering the value of 14.86. The non primed seed recorded the value of 7.86 and germinated slowly. The seeds hydro primed and spin dried for 4 min recorded highest germination % of 91 followed by the seeds spin dried to 5 min as 88 % (Table 2). The results revealed significant difference in seedling length Fig. 1, among treatments. It was more (30.2 cm) in seeds hydro primed and spin dried for 4 min. The lowest seedling length was recorded by non-primed seed (13.2 cm) followed by hydro-primed seed (25.3 cm) compared to other treatments. A significant increase in the dry matter production was registered in seeds hydro primed and spin dried for 4 min (0.329 g/10 seedlings) as against hydro-primed and non- primed seed (0.205 and 0.130 g/10 seedlings respectively). Across different treatments, the calculated vigour index values were significant. The highest vigour index value of 1612 registered by seeds hydro primed and spin dried for 4 min remained superior to all the treatments.

Effect of 'hydropriming and spin drying' on anatomical structure roselle seeds

The anatomical structure namely average length and width of embryo was statistically significant among the treatments. The seeds hydro primed (5 h) and spin dried for 4 min reported maximum average embryonic length (8.4 mm) Fig. 2 followed by hydro primed seed (6.4 mm) and non- primed seed (5.0 mm). Similarly, the width of embryo is in line with the length of embryo by registering 2.33, 2.27 and 1.09 mm of hydro-primed + spin dried, hydro primed and non- hydro-primed seeds respectively (Table 3).

Table 1. Effect of hydro-priming on physiological parameters of roselle *(Hibiscus sabdariffa)* seeds.

Treatments	Speed of germination	Germination (%)	Seedling length (cm)	Dry matter production (g/10 seedlings)	Vigour index
Nonprimed seed	7.89	60(50.8)	12.3	0.129	1097
Hydroprimed 2 h	9.21	65(53.7)	14.7	0.133	1128
Hydroprimed 3 h	10.32	70(56.8)	17.2	0.242	1276
Hydroprimed 4 h	11.49	75(60.2)	19.6	0.156	1378
Hydroprimed 5 h	13.26	80(63.4)	25.3	0.205	1443
Mean	10.43	70(56.8)	19.6	0.173	1344
SEd	0.521	0.998	1.79	0.006	46.5
CD(P=0.05)	1.154	2.225	3.99	0.013	103.8

(Figures in parentheses are arc sin values), (CD - Critical difference, SEd - Standard Error of Deviation)

Table 2. Effect of 'hydro-priming and spin-drying' on physiological parameters of roselle *(Hibiscus sabdariffa)* seeds.

Treatments	Speed of germination	Germination (%)	Seedling length (cm)	Dry matter production (g/10 seedlings)	Vigour index
Nonprimed seed	7.86	60(50.8)	13.2	0.130	1095
Hydro primed seed	13.26	80(63.4)	25.3	0.205	1443
HP 5 h + SD 1 min	13.41	82(64.9)	26.7	0.268	1475
HP 5 h + SD 2 min	13.57	85(67.2)	27.4	0.279	1523
HP 5 h + SD 3 min	13.67	89(70.6)	28.7	0.283	1579
HP 5 h + SD 4 min	14.86	91(72.5)	30.2	0.329	1612
HP 5 h + SD 5 min	13.79	88(69.7)	29.8	0.294	1574
Mean	12.87	82(64.9)	25.9	0.255	1471
SEd	0.621	2.131	1.85	0.017	60.35
CD (P=0.05)	1.129	4.341	3.76	0.042	128.95

(Figures in parentheses are arc sin values), (HP - Hydro- primed, SD - Spin- dried), (CD - Critical difference, SEd - Standard Error of Deviation)

Table 3. Effect of 'hydro-priming and spin-drying' on anatomical structure roselle *(Hibiscus sabdariffa)* seeds.

Treatments	Average length of embryo (mm)	Average width of embryo (mm)
Non primed seed	5.0	1.09
Hydroprimed seed (5 h)	6.4	2.27
HP (5 h) +SD seed (4 min)	8.4	2.33
Mean	**6.7**	**1.89**
SEd	0.577	0.276
CD (P=0.05)	0.141	0.067

(HP - Hydro primed, SD - Spin dried) (CD - Critical difference, SEd - Standard Error of Deviation)

Assessing the effect of hydropriming and spin drying with root architecture under hydroponics

The root architecture characters *viz.,* average root width (cm), network length distribution, network depth (cm) was statistically different due to treatments. Seedlings obtained from hydro-primed (5 h) + spin dried (4 min) seeds registered highest average root width (6.425 cm), network length distribution (0.286), network width (973 cm) and network depth (1744 cm) followed by hydro-primed and non- primed seedlings (Table 4).

Discussion

The study highlights the benefit of performing spin drying for roselle seeds. The results clearly indicate that seeds that are hydro-primed for 5 h and spin dried for 4 min has significantly increased the quality of seed by a statistical increase on all the physiological parameters of the seed. It promotes uniform and rapid germination, increases the seedling length and overall increase in seed vigour is clearly noticed.

The speed of emergence, germination and seedling length increased by 7 %, 48 % and 4 % correspondingly, for the roselle seeds that were hydro-primed and spin dried for 4 min Fig. 1. When contrasted with untreated seed, the corresponding increase in the computed vigour index after the optimal spin-drying duration was 90 %. This result correlates with the study undertaken (16), who found that Guangxi 5 watermelon seeds revealed the greatest % of germination and the shortest mean germination time when dried quickly (20 % RH (Relative humidity), 20 °C temperature). This implies that spin drying and hydropriming simultaneously are a useful combination to strengthen seed vigour and germination efficacy.

The hydro-primed seeds also demonstrated improved seed quality parameters compared to untreated seeds, highlighting the significance of priming as an effective technique. This may be due to the hydropriming process, which speeds up the hydration of proteins and membranes, triggering various metabolic reactions (17). When imbibed seeds are dried back to their original moisture content, the metabolic processes within the seeds are temporarily halted. This is because the drying process essentially puts the seeds in a dormant state where metabolic activity is significantly reduced or stopped. However, when these seeds are soaked in water again, the metabolic reactions quickly resume. This is due to the reactivation of enzyme systems and other biochemical processes that were paused during the drying phase. The ability of seeds to recover and resume metabolic activity upon rehydration is a key factor in their germination and overall vigour (18).

Table 4. Effect of spin-drying on root architecture of the roselle *(Hibiscus sabdariffa)* seeds.

Treatments	Average root width (cm)	Network length distribution	Network width (cm)	Network Depth (cm)
Control	2.673	0.020	364	354
Hydro primed Seed (5 h)	5.399	0.224	516	1088
HP (5 h) +SD seed (4 min)	6.425	0.286	973	1744
Mean	**4.832**	**0.176**	**617.6**	**1062**
SEd	0.171	0.036	58.45	129.4
CD (P= 0.05)	0.372	0.078	127.36	282

(HP - Hydro- primed, SD - Spin- dried) (CD - Critical difference, SEd- Standard Error of Deviation)

Fig. 1. Effects of hydro-priming and spin- drying on physiological growth of seedling (HP - Hydro-primed, SD - Spin- dried).

Predominant goal of priming is to ensure uniformity in germination and high vigour. The spinning action can induce mechanical stress that may enhance the seed's structural integrity or alter its anatomical features in ways that improve seedling growth (19). This stress can lead to changes in the seed coat or embryo, potentially making it easier for the seed to germinate and establish itself (8). The results obtained from this experiment shows that both in anatomical Fig. 2 as well as physiological Fig. 1 spin priming has increased the growth and germination % of the seedling in roselle seeds. Though there is no evidence in medicinal crop seeds that anatomical structural changes help in growth and development, the increase in size of the embryo is due to cell division that takes place during priming and drying.

The root architecture also paves the way that root structure and network components are dense in spin primed seeds Fig. 3. The cumulative data of root architecture obtained from the analysis through Gia software showed that all the parameters like root width, specific root area and the supporting major and minor ellipse axes are increased in spin primed seeds Fig. 4. The study also indicates that seed dehydration is also an important factor in which spin drying practically plays role to support rapid germination.

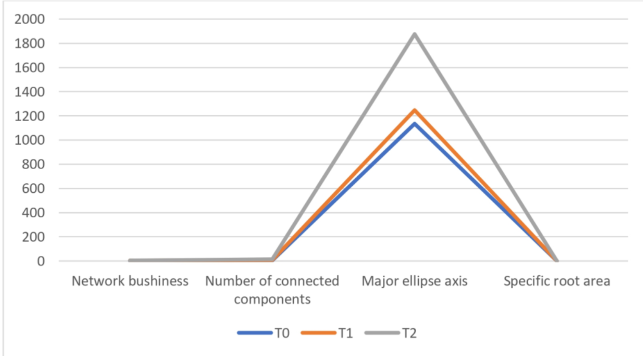

Fig. 4. Effect of hydro-priming and spin-drying on root architecture of roselle seeds.

(T_1 - Non - primed seeds, T_2 - Hydro-primed seeds, T_3 - Hydro-primed 5 h and spin-dried 4 min seeds)

Conclusion

Significant advancements in the parameters of seed quality were noticed in the hydro primed seeds after five hours and four minutes of spin drying, in comparison to the hydro primed and shade dried seeds. The prospect for mechanized priming by farmers and seed corporations is highlighted by the faster activation of embryo growth and architecture of roots in spin dried seeds as compared to traditional shade dried seeds and the cumulative influence on improved seed physiological specifications.

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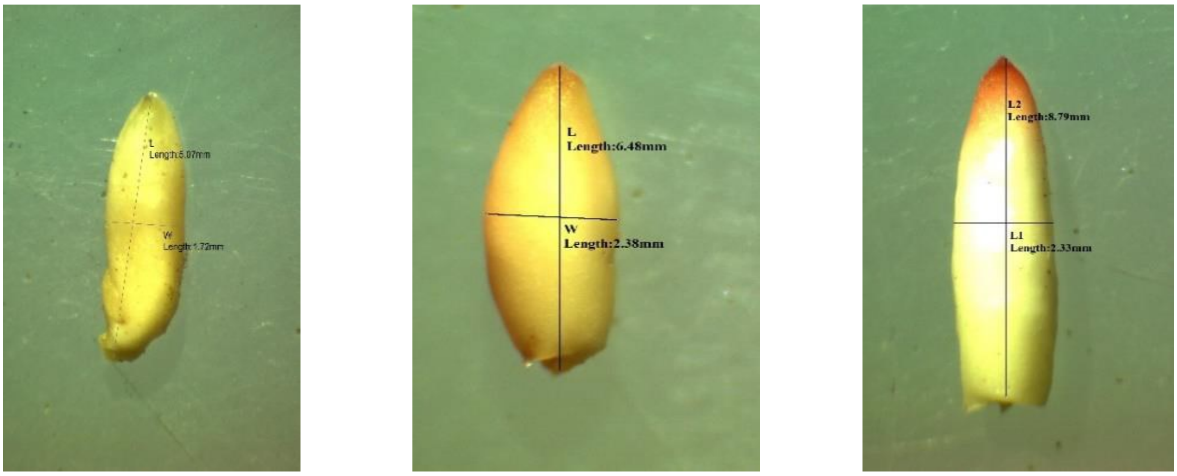

Fig. 2. Effect of hydro-priming and spin priming on anatomical changes of roselle (HP - Hydro-primed, SD - Spin- dried) (Magnification- 20.0x).

Fig. 3. Effect of spin priming and hydro-priming on root architecture of roselle seedling (HP - Hydro- primed, SD - Spin- dried).

Authors' contributions

TM conducted the experiments and prepared the original draft of the manuscript. KM contributed to the conceptualization of the study. GS, MV and TA supervised the work, drafted and reviewed the manuscript. TM and KM participated in sequence alignment and manuscript editing. SK was responsible for visualization. KN and MB supervised the final version. All authors have read and approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical issues: None.

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