Asian Journal of Plant Sciences

ISSN 1682-3974

OPEN ACCESS Asian Journal of Plant Sciences
ISSN 1682-3974
DOI: 10.3923/ajps.2023.458.464

Research Article
Effects of Seed Priming for Accelerating Germination of Paniculata, Black Sesame and Okra Seeds

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Abstract
Background and Objective: Medicinal plants are widely used in Thailand, so seed production cannot meet demand. Often these plants have seed dormancy and this delays seed germination. Therefore, if there is a way to stimulate the germination rate of medicinal seeds faster, it will increase the production of those plants. The objective of this research was to find suitable methods to stimulate seed germination for three medicinal plants. **Materials and Methods:** There were three species of medicinal plants used: Paniculata (*Andrographis paniculata* (Burm. f.) Wall. ex Nees), black sesame (*Sesamum indicum* L.) and okra (*Abelmoschus esculentus* (L.) Moench.). Seeds were treated with four methods: Control, hydropriming, osmopriming and auxin hormone for 12 hrs before sowing. Seeds were monitored until they germinated and the results were recorded and analyzed. The experiments were performed using a Completely Randomized Design (CRD) with four replicates of 10 seeds. **Results:** For the paniculata Phichit 4-4 cultivar it was found that hydropriming by soaking in water at 25°C, osmopriming and auxin treatments resulted in increased germination indexes (GI). For the Phitsanulok 5-4 cultivar, soaking in water at 40°C reduced the days to emergence (DTE). Black sesame seeds, UB-2 cultivar, it was found that hydropriming and osmopriming treatments increased the GI. For UB-2, B-15-3-1 and B-15-2-1 cultivars, mean germination time (MGT) was reduced when soaked in water at 25°C and under osmopriming. For the B-15-1-3 cultivar, osmopriming, soaking seeds in water at 60°C and IAA at 20 and 60 mg increased the GI. The okra Maneemaejo cultivar soaked seeds in water at 60°C increased the GI and for the No. 49 cultivar, it decreased under IAA 20 mg. **Conclusion:** For paniculata, every seed priming treatment increased the germination index in the Phichit 4-4 cultivar, while soaking sesame seeds in Potassium Nitrate (KNO_3) had a positive effect on the germination index and mean germination time in all four cultivars. In addition, for okra, both Maneemaejo and No. 49 cultivars, a low concentration of IAA resulted in reduced MGT.

Key words: Paniculata, black sesame, okra, hydropriming, osmopriming, medicinal plants

Citation: Chookhampaeng, S., S. Juntho, P. Hongsawong and C. Chookhampaeng, 2023. Effects of seed priming for accelerating germination of paniculata, black sesame and okra seeds. Asian J. Plant Sci., 22: 458-464.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Medicinal plants are classified as economic crops. In Thailand, there are many important medicinal plants. Paniculata (*Andrographis paniculata* (Burm. f.) Wall. ex Nees)[1] is a medicinal plant that is demanded in large quantities for the production of many medicines as it contains the active substance Andrographolide[2]. It inhibits the multiplication of various microorganisms. It helps to improve the body's immunity and reduce inflammation, so it has been popular to use paniculata to treat patients infected with COVID-19, thereby reducing the severity of the disease, while it can inhibit the growth of bacteria that causes diarrhea[3] and gives liver toxicity protection[4]. Black sesame (*Sesamum indicum* L.) is a very widely consumed plant with high nutritional value. Sesame seeds are rich in protein and fat beneficial to health and black sesame seeds are rich in lignan-like active substances, antioxidants lower cholesterol, protect the liver, kidneys and cardiovascular system and are anti-inflammatory and anti-cancer[5,6]. Okra (*Abelmoschus esculentus* (L.) Moench.) is an economically important plant. It is a plant with high nutritional value and medicinal effects. Therefore, it plays an important role in being a healthy food for human beings[7].

Most seeds have dormancy, which results in slower germination times than typical seeds and today's environment, agricultural soils are prone to problems[8]. This affects the germination of the seeds, causing the seeds to germinate more slowly, so seed priming is used to prepare the seeds before planting. To stimulate changes within the seed, various metabolic processes occur, which result in the seeds being ready for germination. Seed preparation and priming can reduce the time for planting crops farmers[9]. Therefore, several tests must be conducted before germination to determine the appropriate method for each plant species.

Hydro priming is an easy and cost-effective method. It does not leave toxic residues on seeds or the environment while solving the problem of seed dormancy. This makes the seeds sprout faster and germinate evenly. It also results in seedlings that are strong and of good quality that can withstand abusive environments, but two factors must be taken into account: Temperature and soaking time[10]. Osmopriming is a method where seeds are immersed in a solution with a low water potential to control or slow down the absorption of water into the seed and then the process of seed germination occurs[11]. Seed priming in field crops, such as wheat, can increase the efficiency of germination. In addition, it was found that seedlings from osmopriming grew faster and stronger, even under inappropriate conditions, such as salinity stress[12]. Osmopriming chemicals, such as Potassium Nitrate (KNO_3), can improve seed germination[13]. Seed priming using the hormone auxin (IAA) is another method that can promote seed germination. This is because auxin regulates plant growth and development, by playing a role early in seed germination and seedling growth[14].

For many seeds, it takes a long time for them to germinate, especially black sesame seed which takes several days to germinate, resulting in a longer crop production time. If the time can be reduced, it will make crop production faster which will reduce the cost and time. Therefore, this research aims to find suitable methods to stimulate the seed germination of seed plants using hydropriming, osmopriming and IAA for the preparation of the seeds of three medicinal plants and eight cultivars.

MATERIALS AND METHODS

Study area: The research was conducted from December, 2022 to April, 2023 in the Greenhouse of the Biology Department, Faculty of Science, Mahasarakham University, Thailand.

Materials: Seeds of paniculata (*Andrographis paniculata* (Burm. f.) Wall. ex Nees) of two cultivars, Phichit 4-4 and Phitsanulok 5-4, were obtained from Phichit Agricultural Research and Development Center, black sesame (*Sesamum indicum* L.) of four cultivars, UB-2, B-15-3-1, B-15-2-1 and B-15-1-3, were obtained from the Faculty of Agriculture, Ubon Ratchathani University and okra (*Abelmoschus esculentus* (L.) Moench.) of two cultivars, Maneemaejo and No. 49, were taken from the Department of Horticulture, Faculty of Agricultural Production, Mae Jo University. The experiments were performed using a Completely Randomized Design (CRD) with four replicates of 10 seeds.

Methodology: Seeds were treated using four methods: (1) Control, (2) Hydropriming, in which the seeds were soaked in water at 25, 40 and 60°C for 12 hrs before sowing, (3) Osmopriming, in which the seeds were soaked in Potassium Nitrate (KNO_3) at concentrations of 0.2, 0.5 and 1% for 12 hrs before sowing and (4) Hormone, in which the seeds were soaked in the hormone auxin (Indole -3-acetic acid, IAA) at 20, 60 and 80 mg per 1000 mL distilled water for 12 hrs before sowing. The seed was placed on three layers of seed paper, dampened in a glass Petri dish and then covered with two layers of seed paper and kept at room temperature. The seeds were watered every day to maintain humidity. Seeds were grown until they germinated to determine the days to emergence (DTE), germination index (GI) and mean germination time (MGT).

Days to emergence (DTE): The number of seeds with roots at least 2 mm long were counted daily for 21 days after sowing. Then the number of seeds that had roots each day was calculated[15]:

$$DTE = \frac{\text{Sum of seeds} \times (\text{Number of germinated seeds} \times \text{Number of germinated days})}{\text{Number of rooted seeds}}$$

Germination index (GI): The number of seeds that had germinated each day for 14 days after sowing were counted and the germination speed was calculated[16]:

$$GI = \frac{\text{Sum of seeds} \times \text{Number of normal seedling germinated each day}}{\text{Number of days for normal sprouts to germinate each day}}$$

Mean germination time (MGT): The number of seeds that germinated each day was counted for 14 days after sowing. Then the average time to germination was calculated[17]:

$$MGT = \frac{G1 \times D1 + G2 \times D2 + ... + Gn \times Dn}{\text{Total number of normal seedling}}$$

where, G1, 2, ..., n is the number of normal seeds that germinated on day 1, 2, ..., n (n = 14) and D1, 2, ..., n is the number of days 1, 2, ..., n (n = 14) after the sowing day.

Statistical analysis: Data were analyzed using the SPSS software and the mean was compared using Duncan's new multiple range method at p = 0.05[18]. Then, the seed germination results for all cultivars of the three medicinal plant seeds were summarized.

RESULTS

For both paniculata cultivars, it was found that hydropriming seeds soaked in water at 40°C significantly reduced the days to emergence (DTE). For the Phichit 4-4 cultivar, the seed soaked in water at 25°C, osmopriming and auxin treatments all resulted in a significantly increased germination index (GI). For the Phitsanulok 5-4 cultivar it was found that Potassium Nitrate (KNO_3) at a concentration of 1% significantly reduced the mean germination time (MGT) by almost double. All seed priming treatments reduced the GI in the Phitsanulok 5-4 cultivar (Table 1).

For black sesame seeds, the UB-2 cultivar found that hydropriming and osmopriming for all treatments statistically increased the GI. For the B-15-3-1 cultivar, soaking in water at 25°C significantly reduced the DTE. Soaking in Potassium Nitrate (KNO_3) at a concentration of 0.5% significantly increased the GI. For both cultivars, the seeds soaked in water at 25°C and all osmopriming treatments significantly reduced the MGT. Overall, it was seen that the seeds soaked in water at 25°C and osmopriming affected germination in both cultivars (Table 2).

For black sesame cultivar B-15-2-1, it was found that seeds soaked in water at 25°C significantly reduced the DTE and for seeds soaked in KNO_3 at a concentration of 1% the GI was significantly increased over the control. It was also found that seeds soaked in water at 25°C and all osmopriming treatments significantly reduced the MGT in the UB-2 cultivar and B-15-3-1 cultivar. For the B-15-1-3 cultivar, all osmopriming treatments, seeds soaked in water at 60°C and IAA at 20 and 60 mg significantly increased the GI. Seeds soaked in KNO_3 at a concentration of 1% increased the MGT, but not significantly (Table 3).

Table 1: Days to emergence (DTE), germination index (GI) and mean germination time (MGT) values of paniculata seeds for Phichit 4-4 and Phitsanulok 5-4 cultivars

Cultivar	Phichit 4-4			Phitsanulok 5-4		
Treatment	DTE	GI	MGT	DTE	GI	MGT
Control	15.00 ± 0.00^{b}	0.64 ± 0.39^{a}	6.01 ± 3.48^{a}	15.00 ± 0.00^{b}	3.00 ± 0.41^{cd}	12.08 ± 0.24^{b}
Hydropriming						
25°C	20.00 ± 0.00^{cd}	4.44 ± 0.33^{d}	20.00 ± 0.00^{b}	20.00 ± 0.00^{c}	3.47 ± 0.68^{d}	12.78 ± 0.21^{b}
40°C	14.25 ± 0.48^{a}	1.21 ± 0.21^{a}	14.25 ± 0.48^{b}	14.25 ± 0.50^{a}	1.99 ± 0.26^{bc}	12.03 ± 0.21^{b}
60°C	15.25 ± 0.25^{b}	1.21 ± 0.41^{a}	15.25 ± 0.25^{ab}	15.25 ± 0.25^{b}	1.65 ± 0.15^{b}	13.19 ± 0.12^{b}
Osmopriming (KNO_3)						
0.2%	20.00 ± 0.00^{cd}	4.17 ± 0.36^{cd}	11.75 ± 0.27^{b}	20.00 ± 0.00^{c}	2.97 ± 0.69^{cd}	13.11 ± 0.90^{b}
0.5%	20.50 ± 0.29^{cd}	3.83 ± 0.38^{cd}	11.69 ± 0.07^{b}	20.00 ± 0.41^{c}	3.10 ± 0.19^{cd}	11.90 ± 0.09^{b}
1%	20.75 ± 0.25^{d}	3.20 ± 0.24^{cd}	12.23 ± 0.27^{b}	19.75 ± 0.25^{c}	0.50 ± 0.29^{a}	6.75 ± 3.90^{a}
Hormone (IAA)						
20 mg	19.75 ± 0.25^{c}	2.59 ± 0.29^{b}	11.81 ± 0.59^{b}	20.00 ± 0.00^{cd}	2.47 ± 0.33^{cd}	12.76 ± 0.33^{b}
60 mg	20.00 ± 0.00^{cd}	3.03 ± 0.56^{c}	12.67 ± 0.35^{b}	19.75 ± 0.25^{bc}	2.00 ± 0.00^{cd}	13.19 ± 0.15^{b}
80 mg	20.25 ± 0.25^{cd}	3.34 ± 0.56^{cd}	12.38 ± 0.35^{b}	19.75 ± 0.25^{bc}	2.02 ± 0.09^{cd}	12.92 ± 0.24^{b}

Different characters in a column show significantly different values at p = 0.05 confidence level from the DMRT mean comparisons and ± means standard deviation

Table 2: Days to emergence (DTE), germination index (GI) and mean germination time (MGT) values of black sesame seeds for UB-2 and B-15-3-1 cultivars

Cultivar	UB-2			B-15-3-1		
Treatment	DTE	GI	MGT	DTE	GI	MGT
Control	19.00±0.41[ab]	3.71±1.05[a]	11.87±0.26[e]	19.50±0.29[bc]	4.17±1.18[ab]	11.35±0.50[b]
Hydropriming						
25°C	19.00±0.00[ab]	5.23±0.46[bc]	9.66±0.19[a]	18.25±0.48[a]	4.90±0.36[bc]	9.41±0.43[a]
40°C	19.50±0.29[ab]	6.49±0.46[c]	10.61±0.11[de]	19.00±0.00[bc]	5.70±0.30[bc]	11.13±0.23[b]
60°C	19.25±0.25[ab]	5.67±0.20[bc]	11.05±0.21[de]	19.25±0.25[bc]	4.78±0.42[bc]	11.39±0.17[b]
Osmopriming (KNO_3)						
0.2%	19.25±0.25[ab]	5.52±0.55[bc]	9.76±0.29[ab]	18.75±0.25[ab]	5.73±0.70[bc]	9.10±0.25[a]
0.5%	19.50±0.29[ab]	5.32±0.42[bc]	9.88±0.15[ab]	19.00±0.00[bc]	6.06±0.59[c]	9.31±0.27[a]
1%	19.50±0.29[a]	4.88±0.43[bc]	10.31±0.30[cd]	19.00±0.00[bc]	5.75±0.17[bc]	9.45±0.14[a]
Hormone (IAA)						
20 mg	20.00±0.00[b]	3.76±0.57[a]	10.82±0.22[de]	19.25±0.48[bc]	3.90±0.46[a]	10.85±0.36[b]
60 mg	19.75±0.63[ab]	4.50±0.36[ab]	10.92±0.86[de]	19.25±0.25[bc]	5.07±0.32[bc]	10.98±0.23[b]
80 mg	18.75±0.25[a]	4.44±0.23[ab]	10.91±0.09[de]	19.75±0.25[c]	4.30±0.20[bc]	10.71±0.24[b]

Different characters in a column show significantly different values at p = 0.05 confidence level from the DMRT mean comparisons and ± means standard deviation

Table 3: Days to emergence (DTE), germination index (GI) and mean germination time (MGT) values of black sesame seeds for B-15-2-1 and B-15-1-3 cultivars

Cultivar	B-15-2-1			B-15-1-3		
Treatment	DTE	GI	MGT	DTE	GI	MGT
Control	19.50±0.29[b]	4.17±0.38[a]	11.76±0.93[b]	16.50±1.55[a]	2.13±0.96[ab]	9.09±3.04[a]
Hydropriming						
25°C	18.50±0.29[a]	4.87±0.54[b]	9.76±0.29[a]	19.75±0.25[bc]	3.93±0.40[bc]	10.16±0.27[a]
40°C	19.00±0.00[b]	4.65±0.35[b]	11.58±0.25[b]	19.50±0.29[bc]	3.90±0.66[bc]	11.37±0.18[a]
60°C	20.00±0.00[b]	3.40±0.62[b]	11.78±0.46[b]	18.75±0.75[bc]	4.03±0.12[c]	11.48±0.43[a]
Osmopriming (KNO_3)						
0.2%	19.00±0.00[b]	4.50±0.33[b]	9.91±0.63[a]	18.25±0.48[bc]	4.79±0.39[c]	9.25±0.24[a]
0.5%	18.75±0.25[ab]	4.73±0.55[c]	9.26±0.19[a]	18.50±0.29[bc]	6.60±0.48[d]	9.44±0.31[a]
1%	18.75±0.25[ab]	5.04±0.59[c]	9.91±0.30[a]	18.50±0.29[bc]	7.25±0.31[d]	8.81±0.20[a]
Hormone (IAA)						
20 mg	19.50±0.50[b]	3.98±0.15[b]	11.42±0.32[b]	17.75±0.63[a]	4.80±0.22[c]	10.49±0.24[a]
60 mg	20.00±0.41[b]	3.66±0.36[b]	11.11±0.25[b]	18.25±0.63[ab]	4.41±0.42[c]	10.58±0.11[a]
80 mg	19.00±0.41[b]	3.96±0.26[b]	11.51±0.37[b]	19.50±0.29[ab]	4.02±0.63[bc]	11.27±0.15[a]

Different characters in a column show significantly different values at p = 0.05 confidence level from the DMRT mean comparisons and ± means standard deviation

Table 4: Days to emergence (DTE), germination index (GI) and mean germination time (MGT) values of okra seeds for Maneemaejo and No. 49 cultivars

Cultivar	Maneemaejo			No. 49 cultivars		
Treatment	DTE	GI	MGT	DTE	GI	MGT
Control	13.25±0.48[e]	1.41±0.24[ab]	8.88±1.19[c]	12.25±0.25[c]	2.55±0.52[c]	6.52±0.98[b]
Hydropriming						
25°C	10.50±1.19[de]	0.75±0.25[a]	3.75±1.13[ab]	12.25±0.75[c]	0.75±0.25[ab]	3.63±1.21[ab]
40°C	13.00±0.58[de]	1.76±0.31[ab]	7.74±1.27[bc]	12.25±0.29[c]	1.60±0.31[bc]	6.73±0.86[b]
60°C	13.00±0.58[de]	2.10±0.72[b]	6.79±2.50[bc]	13.00±0.00[c]	1.35±0.13[ab]	7.86±0.12[b]
Osmopriming (KNO_3)						
0.2%	11.25±0.25[de]	1.02±0.37[ab]	3.72±1.26[ab]	12.25±0.48[c]	1.00±0.00[ab]	5.75±0.14[ab]
0.5%	9.00±0.41[cd]	1.17±0.17[ab]	5.20±0.34[bc]	6.25±1.38[a]	0.63±0.38[ab]	2.88±1.66[ab]
1%	7.75±0.95[ab]	1.46±0.61[ab]	2.64±1.53[a]	7.50±1.85[ab]	0.50±0.29[ab]	2.88±1.66[ab]
Hormone (IAA)						
20 mg	8.75±0.85[cd]	0.63±0.38[a]	2.54±1.47[a]	9.25±1.70[bc]	0.25±0.25[a]	1.00±1.00[a]
60 mg	6.25±0.85[a]	0.73±0.42[a]	2.48±1.45[a]	11.00±2.68[bc]	0.58±0.58[ab]	6.52±3.78[b]
80 mg	11.25±1.18[de]	1.13±0.13[ab]	4.92±0.14[bc]	12.25±0.75[c]	1.27±0.55[ab]	4.21±1.40[ab]

Different characters in a column show significantly different values at p = 0.05 confidence level from the DMRT mean comparisons and ± means standard deviation

For the okra Maneemaejo cultivar, when seeds were soaked in KNO_3 at a concentration of 0.5% and IAA at 20 and 60 mg significantly reduced the DTE and significantly increased the GI. Seeds soaked in water at 25°C and KNO_3 at concentrations of 0.2 and 1% significantly reduced the MGT. For the No. 49 cultivar, there were significant decreases with IAA at 20 mg. In addition, seeds soaked in KNO_3 at concentrations of 0.5 and 1% significantly reduced the MGT. Seed priming did not increase the germination in the No. 49 cultivar (Table 4).

DISCUSSION

In this work, when seeds were soaked in water it resulted in increased germination index in black sesame seed UB-2 and B-15-1-3 cultivars, paniculata Phichit 4-4 cultivar and okra Maneemaejo cultivar and also reduced days to the emergence in paniculata Phichit 4-4 and Phitsanulok 5-4 cultivars and black sesame seed B-15-3-1 and B-15-2-1 cultivars. More than that it reduced the mean germination time in black sesame seed UB-2, B-15-3-1 and B-15-2-1 cultivars and okra Maneemaejo cultivar. This is because the water contributes to the stimulation of various reactions inside the seed to work better. In seeds, water absorption occurs by the imbibition process and the water level increases step by step. It activates metabolic processes, for example, at an increase in water content of 18-20%, early respiration increases including amino acid metabolism and associated enzymes. Up to a 45% increase in seed water intake stimulates respiration to the highest level. In the 45-55% water content range, ribosomes become active and transcription begins. When the water level is 60%, basic metabolic processes in the seed are activated[19].

Research has shown that water at different temperatures affects seed germination. Most seeds respond well and germination is stimulated at temperatures of 25 and 40°C. Temperature is one of the essential factors for seed germination as it affects the reaction and duration of germination, with temperature playing a role in the activity of some enzymes such as amylase, lipase, alanine, aminotransferase and ribonucleases. When the temperature is too high, the rate of protein synthesis decreases[20]. By research, a range of 15-25°C is optimal for rapeseed[21]. Temperatures in the range of 30.49-35.48°C were suitable and effective for the germination of cowpea seeds[22]. If the temperature is too high, it will affect the function of the enzyme, for example, amylase works best below 50°C. Seeds heated for 30 min at 55°C in *Crassocephalum crepidioides* and *Conyza canadensis* or 60°C in *Ageratum conyzoides* may cause seed death[23].

When the seed was soaked in Potassium Nitrate (KNO_3) it resulted in an increased germination index in paniculata Phichit 4-4 cultivar and black sesame seed UB-2, B-15-1-3 and B-15-2-1 cultivars also reduced the days to emergence in okra seed Maneemaejo and No. 49 cultivars. In addition, it reduced the mean germination time in black sesame seed UB-2, B-15-3-1 and B-15-2-1 cultivars, okra seed Maneemaejo cultivar and paniculata seed Phitsanulok 5-4 cultivar. This is due to the breakdown of substances in nutrients that are beneficial to the growth of plants. During the soaking of okra seeds in a nitrate salt, such as KNO_3, the nitrate gets into the seeds. These ions may be introduced into the seeds during soaking or seed priming. Nitrate is the most important source of nitrogen for plants where nitrogen improves plant growth and development[24]. Pea seeds primed with 0.25 mM of potassium nitrate improved the seedling germination and increased seed water uptake and seedling growth[25]. This corresponds to a study in tomato seeds, Sundar and Ahmar cultivars, where 0.75% KNO_3 increased the final emergence (%) and mean emergence time compared to the control group[26]. Moreover, tomato seed, *Tekeze*-1 cultivar, showed that KNO_3 at a 0.5% concentration responded by increasing the seed germination[27].

Seed soaked in the hormone auxin (IAA) resulted in an increased germination index in the paniculata seed Phichit 4-4 cultivar and black sesame seed B-15-1-3 cultivar, reduced days to the emergence in okra seed Maneemaejo cultivar and reduced mean germination time in okra seed Maneemaejo and No. 49 cultivars. The auxin is involved in stimulating cell division and root formation in plants. After priming seeds with IAA, the seed germination capacity was increased. According to the germination rate, index and speed in seedlings, IAA promoted the growth of germinating seedlings by increasing the amount of sugar. In addition, in the seedling stage, seedlings from IAA seed priming showed increased germination rate, germination index, seedling length and seedling weight in Chinese fir (*Cunninghamia lanceolata* (Lamb.) Hook)[28]. In addition, auxin increased the final germination percentage in wheat plants[29]. When wheat seeds were treated with auxin which increased the hypocotyl length, seedling fresh and dry weight and hypocotyl dry weight[30]. Most seeds' germination rate responds well when stimulated with low doses of hormones. However, if the amount is too high, it may inhibit the germination of seeds, including black sesame seed B-15-1-3 cultivar as the concentration of the hormones is too high.

Different species of seeds respond differently to the seed priming method. Therefore, before stimulating seed germination, it is best to test the seed and determine the most suitable method for the plant.

CONCLUSION

Depending on the type of seed, it will have a different seed priming response. For example, paniculata seeds soaked in water at 25°C had faster root germination in both cultivars. Black sesame seeds soaked in KNO_3 were able to increase the germination index in UB-2 and B-15-1-3 cultivars. Seeds soaked in water at 25°C reduced the mean germination time in UB-2, B-15-3-1 and B-15-2-1 cultivars. In okra, it was found that IAA at 20 mg reduced the mean germination time in both cultivars, but there was a clear difference, especially the in No. 49 cultivar. Therefore, during the use of seed priming in cultivation, the appropriate method should be selected to reduce the time for crop production.

SIGNIFICANCE STATEMENT

Medicinal plants are alternative medicines for patients because they have few side effects. The medicinal plants used in the research are widely used for consumption, which in some situations results in inadequate supply for the market demand. Finding ways to stimulate the germination of medicinal seeds by various methods is, therefore, useful to stimulate the seeds to germinate faster, thereby resulting in shortening the time to produce plants.

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