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SYNERGISTIC EFFECTS OF SEED PRIMING AND GERMINATION MEDIA ON MORPHOLOGICAL PERFORMANCE OF DAHLIA (*Dahlia variabilis* HORT. NON WILD. DESF.)

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ABSTRACT

Dahlia [*Dahlia variabilis* hort. non (Wild.) Desf.] is half-hardy tuberous rooted winter season annual flower cultivated for cut flower production, landscaping and medicinal uses. Other than conventional methods of propagation, the seed propagation in dahlia is an economical and efficient method for producing large numbers of healthy seedlings with wide genetic variability. Thus, to standardize the seed priming technique and a suitable germinating media, this research was conducted for two years during Oct, 2022- Apr, 2023 and from Oct, 2023-April, 2024 in the Horticulture Experimental Farm, Assam Agricultural University, Jorhat with the objectives to assess the seed germination, seedling vigour, plant growth, flower and seed production of annual *Dahlia* as influenced by different seed priming treatments and germination media. A laboratory experiment was conducted by treating the seeds with five priming agents, viz. Hydropriming (P_1), $CaCl_2$ @ 1% (P_2), GA_3 @ 100ppm (P_3), Salicylic acid @ 200ppm (P_4), and Untreated Control (P_5) and sown in Whatman Filter paper. Three media compositions viz. M_1 Cocopeat + Perlite + Vermiculite (2:1:1), M_2 Cocopeat + Enriched Compost (1:1) and M_3 Cocopeat + Vermicompost (1:1) + Microbial consortia (MC) were filled up in plug trays of V-Type nursery and the seeds primed with five agents were sown for raising the seedlings. Among the different seed priming agents evaluated, GA_3 @ 100ppm was found to contribute significantly towards the observed plant parameters, followed by $CaCl_2$ @ 1%. Similarly, among the germination media combinations evaluated, Cocopeat + Vermicompost (1:1) + Microbial consortia showed better results as compared to the other media combinations. Among the treatment combinations, the interaction effect of $P_3 \times M_3$ showed the best results in the evaluated parameters as compared to the other treatment levels with respect to earliest seedling emergence (4.73 days), highest rate of germination (87.26%), stem height (5.70cm), number of leaves per seedling (5.94), leaf length (3.20cm) and leaf breadth (2.09cm), fresh weight (26.25 mg) and dry weight (2.64mg) of seedlings, highest number of healthy seedlings (80.26%) and lowest mortality rate (4.35%).

Key words : *Dahlia*, Gibberellic acid, Seed priming, Cocopeat, Vermicompost, Seed.

Introduction

The common garden dahlia [*Dahlia variabilis* hort. non (Wild.) Desf.], belonging to the Asteraceae family, is a popular winter season annual flower native to Mexico and Central America. It is a half-hardy tuberous rooted ornamental known for their prolific flowering habit, great variation in size (2.5 cm to over 40 cm in diameter), attractive shape, multitude of colours and easy cultivation.

The chromosome number of *Dahlia variabilis* L. is $2n=64$. It is extensively used for exhibition, garden display and decoration purposes (Thakur *et al.*, 2022). Also widely used for its medicinal goods, such as tuberous root for diabetic patients that helps to regulate blood glucose levels, in addition to decreasing cholesterol and triglycerides (Martínez-Damián *et al.*, 2021) and petals used in garnishing owing to gastronomic elaborations (Lara-Cortés *et al.*, 2016).

The genus name 'Dahlia' was kept in honour of Dr. Andreas Dahl a Swedish botanist, by Abbe Caunilles in 1791 (Smith, 1963). Garden dahlia (*Dahlia variabilis* L.) was domesticated in Mexico before 1575. There are at least 27 species of dahlia and it was introduced to India as early as 1857 under the auspices of the Agri Horticultural Society of India (formerly, Royal Agri-Horticultural Society of India). Presently, the Netherlands is the dominant producer with 80% global production cultivating about 400 ha annually for export (Marina, 2015; FAO, 2023) of tuberous rooted dahlias. Other countries known for cultivating dahlias in a large scale are Japan, France, South Africa, UK, Italy, Germany, and the USA. In India, its commercial cultivation is limited to the hills and plains of West Bengal, Karnataka, and Uttar Pradesh (Kumar *et al.*, 2024; Bhattacharjee, 2006), with an estimated annual production of about five million tubers for domestic markets (Kumar *et al.*, 2024). Although gladiolus, rose, and marigold dominate national production, dahlia is gradually expanding its market share and economic significance (Thakur *et al.*, 2022).

The most widely used methods for dahlia propagation are via cuttings or tuberous root division, however, the most commonly used is the commercial form by cuttings. Although, seed method is employed to obtain new varieties and are used for multiplication of border dahlias (Marina, 2015; De Hertogh and Le Nard, 1993). Dahlia is an often-cross pollinated plant. While cuttings, being a method of asexual propagation, to produce plants identical to the parent, seed-raised plants (of annual bedding dahlias) however, belong to a different market segment. Plants grown through seeds are cheaper to establish and have progeny with a wide variety of differing genotypic characteristics including flower colour and shape (Srivastava and Trivedi, 2022; Southward *et al.*, 1999). However, poor crop stand one of the major problem which arises due to either poor quality seed, inadequate seedbed preparation, untimely sowing, poor sowing technique, inadequate soil moisture, adverse soil properties and high temperatures. To overcome these abiotic factors, seed priming prior to sowing could serve an efficient low-cost way to increase germination and emergence rate in some species. Thus, standardization on seed priming of Dahlia seeds can make a positive impact on the rate of crop emergence, thereby enhancing crop development, reducing crop duration and increasing yields (Priya *et al.*, 2019).

Along with seed priming, a suitable growing media is a pre-requisite for quality seedlings production. A suitable growing media not only provides anchorage to the plant, but also serves as reservoir of water and nutrients,

allowing oxygen diffusion to the roots and gaseous exchange between the atmosphere and the roots (Raviv *et al.*, 2019; Abad *et al.*, 2014), thus responsible for the functional rooting system of the plants. Thus, the provision and standardization of media could serve as a valuable alternative to conventional use of soil providing better water holding capacity, aeration and nutrient status.

Searching for the essential variables to standardize seed priming technique and a suitable germinating media, this research was conducted for cost-efficient and quality seedlings production of annual bedding Dahlia.

Materials and Methods

This research was done for two growing years of 2022-2023 and 2023-24 at the laboratory of Department of Horticulture, Assam Agricultural University, Jorhat to study the effects of seed priming and germination media on seedling characters of annual bedding dahlia (*Dahlia variabilis*). In this experiment, annual dahlia seeds were placed for 12 hours in solutions of Hydropriming (P_1), CaCl_2 @ 1% (P_2), GA_3 @ 100ppm (P_3), Salicylic acid @ 200ppm (P_4) and Untreated Control (P_5). After completion of priming, seeds were dried at room temperature until the seeds reached the original weight before priming. The seeds were then sown in three germination media combinations-(1) Cocopeat + Perlite + Vermiculite (2:1:1) (2), Cocopeat + Enriched compost (1:1) (3) and Cocopeat + Vermicompost (1:1) + Microbial consortia. There was total of fifteen treatment combinations. The primed seeds were sown in the protrays containing the media and after that the protrays were laid out in randomized block design with factorial concept with three replications.

The parameters evaluated in the nursery included-days to seedling emergence, rate of seedling emergence at 30 DAS, seedling height, number of leaves per seedling, leaf length and leaf breadth, fresh and dry weight of seedlings, number of healthy seedlings and mortality rate.

Results and Discussion

Effect of seed priming

Seed priming is a pre-sowing seed preparation method that enables controlled seed hydration, boosts early germination and improves overall crop performance, particularly under stimulating conditions. In the study, the seeds of Dahlia primed with GA_3 (P_3) started with earlier emergence (4.73 days), followed by P_1 (Distilled water), P_2 (CaCl_2 @ 1%) and P_4 (Salicylic acid @ 200 ppm). It is commonly known that the ABA/GA balance is the primary regulator of seed dormancy and germination, and that GA_3 is the main hormone involved in the breakdown of

seed dormancy, either present endogenously or exogenously (Yamaguchi *et al.*, 2007). It promotes seed germination by increasing proteasome degradation of RGL2 (DELLA repressor that stops germination), whereas ABA-induced AB15 (a leucine zipper transcription factor) which represses seed germination (Zhao *et al.*, 2022). Physiologically, it increases α -amylase activity for breaking starch stored in seeds and activates enzymes that catalyze various developmental processes (Siega *et al.*, 2025). This was supported by the findings obtained by Dilip *et al.* (2017) in Rangpur Lime. In addition to this, the maximum rate of dahlia seedling emergence (83.69%) upon priming with GA_3 reveals the activation of certain enzymes that digested the endosperm carbohydrates rapidly and reduced the mechanical restraints of the endosperm thereby providing energy to initiate embryo growth. Similar increase in the seed germination percentage in *Dianthus caryophyllus* L. upon seeds soaked in 20 ppm GA_3 by Roychowdhury *et al.* (2012) and in *Triticum aestivum* L. (GA_3 at 150 μM) by Wang *et al.* (2016).

The GA_3 primed seedlings (P_3) were also found to have superior vegetative growth, including plant height (5.44 cm), leaf count (5.87 leaves per seedling), leaf length ((3.08 cm), and leaf breadth (1.96 cm). This increase in vegetative growth following priming with GA_3 might be due to the role of gibberellins stimulating cell elongation by altering the rheological properties of the cell wall; as a result of which, the water potential of the cell is lowered allowing for water uptake as well as translocation of reserve materials to the embryo which led to the formation of healthy seedlings, thereby increasing its cell volume (Jaryal *et al.*, 2020; Jones and Kaufman, 2008). The results were in line with the findings obtained by Balaguera-Lopez *et al.* (2008) upon seed priming of *Solanum lycopersicum* L. with 900 mg/L GA_3 and for *Cicer arietinum* L. with 10^{-6} M GA_3 that improved plant height, leaf and root fresh weight and total dry mass of the plant (Shah *et al.*, 2023). Following GA_3 , improved performance by CaCl_2 primed seeds may also be related to involvement of Ca^{2+} in membrane repairs and activation of enzymes when starch reserve mobilization and radicle protrusion are in progress (Afzal *et al.*, 2008; Farooq *et al.*, 2010). Similar findings were obtained by Bagheri *et al.* (2019) in Basil and Rehman *et al.* (2014) in *Linum usitatissimum* L.

Further, the highest fresh weight (27.04 mg) and dry weight (2.63 mg) were also observed in seedlings grown from seeds primed with GA_3 , which could be due to increased water intake and translocation of reserve materials to the embryo which led to the formation of

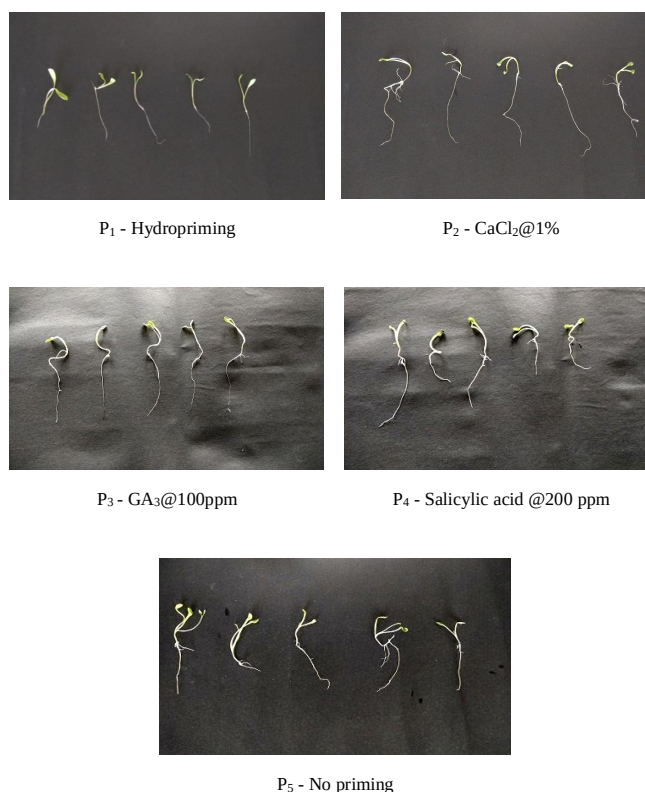


Plate 1 : Effect of Seed priming on germination.

healthy seedlings (Chauhan *et al.*, 2026). This is in conformity to the findings obtained by Chauhan *et al.* (2019) in oat, Jamil and Rha (2007) in sugarbeet and Zahedi *et al.* (2012) in sweet william. Ultimately, the use of GA_3 as priming treatment resulted in more number of healthy seedlings (79.33%) and low mortality rate (4.36%), respectively.

Effect of germination media

The germination media is a crucial factor that affects the growth performance of the plants. The seedling growth media M_3 (Cocopeat + Vermicompost (1:1) + Microbial consortia) recorded the earliest seedling emergence (4.87 days) of Dahlia, followed by M_1 (Cocopeat + Perlite + Vermiculite (2:1:1)). Faster germination rate may be attributed to higher availability of nitrogen due to presence of vermicompost, and due to enhanced metabolic activity of the seed due to application of microbial consortia. Additionally, plant growth regulators such as indole-3-acetic acid (IAA) and gibberellins produced by microbes help break seed dormancy and promote cell elongation. Similar findings were observed by Makkar *et al.* (2017) in *Linum usitatissimum* L. Microbes help in increasing nitrogen availability, phosphate solubilization and some can even solubilize potassium and zinc, improving early nutrition.

Further, along with the dense organic composition of M_3 media comprising cocopeat and vermicompost which

provides excellent porosity, effective water absorption and retention capabilities, and a stable, homogeneous structure of the media, thereby allowing maximum seedling emergence rate at 30 days after sowing *i.e.* 83.65%. Similar observations were recorded by Kumar *et al.* (2024) in *Dahlia variabilis* L. and Hazarika *et al.* (2022) in Tomato (*Solanum lycopersicum* L.).

Similarly, the highest stem height (5.23 cm) was observed in seedlings raised in M_3 germination media (Cocopeat + Vermicompost (1:1) + Microbial consortia). The influence of germination media on stem height can be ascribed to the fact that the media allowed conditions for better nutrient and water uptake resulting in better growth and development of seedlings. Vermicompost is reported to have bioactive principles which are considered to be beneficial for root growth and has been hypothesized to result in greater root initiation, increased biomass, enhanced growth and development (Oyege and Balaji, 2023; Bachman and Metzger, 2008) and balanced composition of nutrients (Zaller, 2007). Similar findings were recorded by Bharadwaj *et al.* (2019) in brinjal, Bhagat *et al.* (2013) in rough lemon and Kumar and Sharma (2014) in tomato. Additionally, microbial consortia have been found to positively influence shoot length due to production of plant growth promoting substances by the plant microbes (Sukeerthi *et al.*, 2020). This increased stem development further increased leaf production, which is enhanced by growth-promoting media (M_3) containing bacteria that increase cell division, fix more nitrogen and phosphorus, and improve nutrient availability. Similar findings were recorded by Subbaiah *et al.* (2018) in Brinjal. Moreover, increase in leaf length (2.98 cm) and leaf breadth (2.03 cm) following use of M_3 media combination (Cocopeat + Vermicompost (1:1) + Microbial consortia) may be associated with greater uptake of nutrient elements such as: P, K, Fe and Zn which is analogous to the results were obtained by Azarmi *et al.* (2008) in Tomato, Bhagat *et al.* (2013) in Rough Lemon and Subbaiah *et al.* (2018) in brinjal cv. Dommeru Local.

The seedlings raised in the media combination M_3 (Cocopeat + Vermicompost (1:1) + Microbial consortia) resulted in maximum fresh (23.97 mg) and dry weight (2.4 mg) of seedlings respectively. The germination media, firstly cocopeat can be attributed to better water holding capacity with good aeration; secondly, slow release of macro- and micronutrients from vermicompost as well as its better cation exchange capacity and nutrient retention; and thirdly plant growth-promoting rhizobacteria enhancing nutrient availability and supplying phytohormones like auxins, gibberellins and cytokinins, which stimulate root and shoot growth; ultimately resulting

in results in greater biomass accumulation (Kawade *et al.*, 2026; Regasa *et al.*, 2025; Vejan *et al.*, 2016). Such observations were also recorded by Sukeerthi *et al.* (2020) in zinnia and balsam seedlings and Subbaiah *et al.* (2012) in brinjal. However, the effect of germination media on mortality rate was found to be non-significant. Yet, the highest number of healthy seedlings (78.71%) was observed in M_3 .

Interaction effect

Among the interactions, the earliest seedling emergence (4.33 days) was observed in P_3M_3 (GA_3 + (Cocopeat + Vermicompost (1:1) + Microbial consortia), closely followed by P_2M_1 ($CaCl_2$ + Cocopeat + Perlite + Vermiculite (2:1:1)), P_2M_3 ($CaCl_2$ + (Cocopeat + Vermicompost (1:1) + Microbial consortia), P_3M_1 (GA_3 + Cocopeat + Perlite + Vermiculite (2:1:1) and P_4M_3 (Salicylic acid + Cocopeat + Vermicompost (1:1) + Microbial consortia). This could be due to the synergistic effects of both factors *i.e.* seed priming and germination media which stimulated seedling growth through improved cell division and expansion, improved biochemical properties of the protoplasm, respiration, nucleic acid metabolism etc. Similarly, P_3M_3 produced 87.26% of seedlings which was highest among other interactions, followed by the seed rate emergence in combination P_2M_3 ($CaCl_2$ + Cocopeat + Vermicompost (1:1) + Microbial consortia) respectively. These results were in conformity with Ramteke *et al.* (2016) in papaya, Maharana *et al.* (2018) in *Gmelina arborea* Roxb. and Desai *et al.* (2017) in papaya.

Further, the combination of gibberellic acid with cocopeat, vermicompost and microbial consortia (P_3M_3) supported the seedlings in achieving the maximum height (5.70 cm), leaf length and breadth (3.20 and 2.09 cm). This can be regarded as an additive effect, as GA_3 alone may stimulate elongation, but can be constrained by nutrient or water limitations, which is maintained by Cocopeat + Vermicompost (1:1) mixture providing an optimal physical and nutritional environment that enhanced GA_3 responsiveness (Siddiqui, 2022). Likewise, the hormonal stimulation, substrate physicochemical optimization and microbially mediated nutrient and hormonal cues by the microbial consortia likely converged to maximize early stem growth (Mondal *et al.*, 2020).

However, among the treatment levels, P_3M_1 resulted in higher leaf production per seedling (5.90) followed by P_3M_3 . This could be attributed to better root establishment allowing beneficial microbes to colonize the rhizosphere with adequate pore space and aeration (Khare and Arora, 2014).

Table 1 : Performance of Dahlia seedlings in different seed priming solutions, growth media and their combinations.

Treatment	Days to seedling emergence	Seedling emergence (%)	Seedling stem height (cm)	Number of leaves per seedling	Leaf length (cm)	Leaf breadth (cm)	Fresh weight of seedling (mg)	Dry weight of seedling (mg)	Mortality rate	Number of Healthy seedlings
P ₁	5.28	77.05	4.96	5.39	2.90	1.81	22.25	2.21	5.52	71.53
P ₂	5.11	80.42	5.12	5.67	3.00	1.89	23.62	2.43	5.21	75.21
P ₃	4.73	83.69	5.44	5.87	3.08	1.96	27.04	2.63	4.36	79.33
P ₄	5.22	78.74	5.06	5.51	2.84	1.88	22.09	2.25	5.175	73.57
P ₅	5.55	74.31	4.72	5.06	2.58	1.75	19.7	1.86	5.975	68.34
SEd(±)	0.29	1.21	0.08	0.11	0.06	0.05	0.59	0.06	0.41	1.30
CD(5%)	0.58	2.4	0.17	0.21	0.11	0.10	1.17	0.13	0.81	2.59
M ₁	5.03	76.78	5.04	5.5	2.83	1.81	22.69	2.24	5.33	71.45
M ₂	5.64	76.1	4.91	5.37	2.8	1.74	22.16	2.19	5.47	70.63
M ₃	4.87	83.65	5.23	5.63	2.98	2.03	23.97	2.4	4.945	78.71
SEd(±)	0.22	0.94	0.06	0.08	0.04	0.04	0.46	0.05	0.32	1.01
CD(5%)	0.45	1.86	0.13	0.17	0.09	0.07	0.91	0.1	NS	2.00
T ₁ (P ₁ M ₁)	5.17	75.09	5.01	5.34	2.90	1.67	21.9	2.14	5.94	69.15
T ₂ (P ₁ M ₂)	5.5	72.9	4.71	5.27	2.83	1.77	21.6	2.13	5.47	67.43
T ₃ (P ₁ M ₃)	5.17	81.86	5.17	5.57	2.98	1.99	23.23	2.36	5.16	76.7
T ₄ (P ₂ M ₁)	4.83	79.3	5.24	5.74	2.96	1.80	23.64	2.4	5.12	74.18
T ₅ (P ₂ M ₂)	5.67	75.93	4.9	5.48	2.90	1.79	22.81	2.31	5.24	70.69
T ₆ (P ₂ M ₃)	4.84	85.03	5.22	5.80	3.16	2.08	24.39	2.59	5.26	79.77
T ₇ (P ₃ M ₁)	4.5	81.82	5.39	5.94	3.13	1.98	25.87	2.59	4.85	76.97
T ₈ (P ₃ M ₂)	5.34	81.98	5.23	5.77	2.94	1.83	26.66	2.56	4.65	77.33
T ₉ (P ₃ M ₃)	4.33	87.26	5.7	5.90	3.20	2.09	26.25	2.64	4.35	82.91
T ₁₀ (P ₄ M ₁)	5.17	75.76	5.02	5.50	2.75	1.85	21.82	2.23	5.04	70.72
T ₁₁ (P ₄ M ₂)	5.84	76.81	4.97	5.44	2.76	1.68	21.65	2.13	5.88	70.93
T ₁₂ (P ₄ M ₃)	4.67	84.01	5.18	5.59	3.00	2.09	23.95	2.37	4.61	79.4
T ₁₃ (P ₅ M ₁)	5.5	73.11	4.55	5.00	2.57	1.77	19.2	1.84	5.91	67.2
T ₁₄ (P ₅ M ₂)	5.83	74.61	4.7	4.87	2.54	1.61	18.7	1.87	5.75	68.86
T ₁₅ (P ₅ M ₃)	5.33	77.76	4.91	5.30	2.63	1.87	21.19	1.91	5.61	72.15
SEd(±)	0.36	1.48	0.1	0.13	0.07	0.06	0.72	0.08	0.50	1.60
CD(5%)	0.71	2.94	0.2	0.26	0.14	0.12	1.44	0.16	1.00	3.17

P₁: Hydropriming, P₂: CaCl₂ @ 1%, P₃: GA₃ @ 100ppm, P₄: Salicylic acid @ 200ppm, and P₅: Untreated Control; M₁: Cocopeat + Perlite + Vermiculite (2:1:1), M₂: Cocopeat + Enriched compost (1:1); M₃: Cocopeat+Vermicompost (1:1) + Microbial consortia N.S.: Not Significant.

The interaction level, P_3M_3 resulted in the highest fresh (26.25mg) and dry weight (2.64 mg) of seedlings which was in close proximity to P_3M_1 and P_3M_2 . Also, maximum number of healthy seedlings (82.91%) was observed in the treatment level, P_3M_3 closely followed by P_2M_3 . Likewise, the lowest mortality rate (4.35%) was observed in P_3M_3 followed by P_3M_2 , P_3M_1 and P_4M_3 . The reduced mortality rate and resultant number of healthy seedlings are due to better seedling establishment and better health of the seedlings.

Conclusion

The findings of the present investigation demonstrate that seed priming with $GA_3@100ppm$ (P_3) contribute significantly superior performance, followed by $CaCl_2@1\%$. Among the germination media combinations evaluated, Cocopeat + Vermicompost (1:1) + Microbial consortia (M_3) showed better results, and therefore, the interaction effect of $P_3 \times M_3$ was the most effective treatment for promoting seedling emergence in dahlia. Thus, owing to its effectiveness, affordability, and environmentally sustainable nature, this treatment offers a practical and economically viable strategy for the production of high-quality dahlia seedlings and can be recommended as a reliable protocol for easy, low-cost propagation under nursery conditions..

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