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Effect of seed priming with organics and inorganics on seed quality in ajwain (*Trachyspermum ammi* L.)

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Abstract
The present investigation was undertaken to identify the best organic and inorganic seed priming treatment for improving seed quality in ajwain (*Trachyspermum ammi* L.) variety AA-01-19 under laboratory conditions. The experiment comprised fourteen treatments, *viz*., unprimed control, hydropriming, humic acid (2.5 ml L^{-1}), panchagavya (30 ml L^{-1}), vermiwash (5 %), cow urine (5 %), *Trichoderma harzianum* (4 %), single cell protein (35 ml L^{-1}), seaweed extract (10 ml L^{-1}), GA_3 (100 ppm), KCl (1.0 %), KNO_3 (0.1 %), $CaCl_2$ (2 %) and salicylic acid (100 ppm), laid out in a Completely Randomized Design with four replications. Seeds were primed at 1:2 seed to solution ratio for 8 hours. Priming treatments differed significantly for all the seed quality parameters. GA_3 @ 100 ppm recorded the highest germination (92.50%), shoot length (7.65 cm), root length (8.16 cm), seedling length (15.81 cm), seedling dry weight (9.08 mg), seedling vigour index-I (1462) and index-II (840) as against 82.50 %, 5.65 cm, 5.75 cm, 11.40 cm, 7.10 mg, 941 and 586, respectively, in the unprimed control. It was on par with panchagavya @ 30 ml L^{-1}, vermiwash @ 5 %, KNO_3 @ 0.1 %, humic acid @ 2.5 ml L^{-1} and $CaCl_2$ @ 2 % for most of the parameters. Among the organics, panchagavya @ 30 ml L^{-1} was the best, offering an eco-friendly alternative to hormonal and chemical priming for better seedling establishment in ajwain.

Keywords: Ajwain, seed priming, GA_3, panchagavya, seed quality

Introduction
Ajwain (*Trachyspermum ammi* L.), belonging to the family Apiaceae (Gersbach and Reddy, 2002) [9], is a medicinally important seed spice grown mainly for its seed and volatile oil. The principal constituent of the essential oil is thymol (35-60 %), which makes the seed valuable in culinary, medicinal and antiseptic preparations (Pruthi, 1992) [16]. During 2024-25, ajwain occupied 63.15 thousand hectares in India with a production of 65.02 thousand metric tonnes and a productivity of 1.03 metric tonnes per hectare, whereas in Karnataka the productivity was only 0.26 metric tonnes per hectare from 1.26 thousand hectares (Anon., 2025).

Poor and non-uniform germination, low seed vigour and uneven seedling establishment are the major constraints in ajwain seed production, and seed quality also deteriorates rapidly during storage. Since ajwain seeds are small and sensitive to environmental stresses during germination and early growth, a rapid and uniform crop stand is difficult to achieve and crop-specific seed enhancement protocols are lacking.

Seed priming is a controlled hydration process followed by re-drying, which allows the seed to imbibe water and initiate the metabolic events of germination without radicle protrusion (Bradford, 1986; Taylor *et al.*, 1998; Khoshvaghti *et al.*, 2013) [8, 12, 19]. Depending on the priming agent, the techniques include hydropriming, organic priming with panchagavya, vermiwash, cow urine, humic acid, seaweed extract and single cell protein, biological priming with *Trichoderma harzianum*, hormonal priming with GA_3 and salicylic acid and halo or chemical priming with KCl, KNO_3 and $CaCl_2$.

Organic formulations such as panchagavya and vermiwash have improved germination and vigour in green gram, black gram and tomato (Somasundaram *et al.*, 2003; Sundaravadivel and Kumutha, 2013; Balusamy *et al.*, 2014) [6, 17, 18], while GA_3 and KNO_3 priming have been effective in onion, bitter gourd and hot pepper (Vaganangamudi *et al.*, 1988; Kumar and Singh, 2013; Amjad *et al.*, 2007) [3, 14, 20]. Within the Apiaceae, hydropriming has improved seedling vigour in ajowan and ajwain (Ajorlou and Madadpour Inallou, 2011; Kumar *et al.*, 2024) [2, 15], GA_3 priming has improved germination speed and seedling growth in cumin and coriander (Heidari and Sadeghi, 2014; Jamshidian and Talat, 2017) [10, 11] and panchagavya has been found effective in cumin (Barad *et al.*, 2025) [7]. However, information on the comparative performance of organic, biological, hormonal and halo priming agents in ajwain is scanty. Hence, the present investigation entitled effect of seed priming with organics and inorganics on seed quality in ajwain (*Trachyspermum ammi* L.) was undertaken.

Material and Methods
A laboratory experiment was conducted in the Department of Seed Science and Technology, College of Agriculture, University of Agricultural Sciences, Raichur, during the year 2025-26. Seeds of ajwain variety AA-01-19 were obtained from the ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan. The experiment consisted of fourteen treatments with four replications in a Completely Randomized Design. The treatments were T_1: control (unprimed), T_2: hydropriming, T_3: humic acid @ 2.5 ml L^{-1}, T_4: panchagavya @ 30 ml L^{-1}, T_5: vermiwash @ 5 %, T_6: cow urine @ 5 %, T_7: *Trichoderma harzianum* @ 4 %, T_8:

single cell protein @ 35 ml L^{-1}, T_9: seaweed extract @ 10 ml L^{-1}, T_{10}: GA_3 @ 100 ppm, T_{11}: KCl @ 1.0 %, T_{12}: KNO_3 @ 0.1 %, T_{13}: $CaCl_2$ @ 2 % and T_{14}: salicylic acid @ 100 ppm.

From the earlier experiment, the seed to solution ratio of 1:2 and soaking duration of 8 h were standardized for ajwain and were adopted for all treatments. The solutions were prepared in distilled water by dissolving humic acid (2.5 ml), panchagavya (30 ml), single cell protein (35 ml) and seaweed extract (10 ml) were diluted to 1000 ml each. Vermiwash and cow urine (5 ml each) were diluted to 100 ml with distilled water to obtain 5% solutions. *Trichoderma harzianum* (4 g) was dissolved in distilled water and the volume was made up to 100 ml. GA_3 and salicylic acid (10 mg each) were dissolved separately and made up to 100 ml to obtain 100 ppm solutions. KCl (1 g), KNO_3 (0.1 g) and $CaCl_2$ (2 g) were dissolved separately in distilled water and the volume was made up to 100 ml to obtain 1%, 0.1% and 2% solutions, respectively. After soaking, the seeds were removed from the solutions, spread uniformly on blotting paper and shade dried to their original moisture level. Such seeds were used for assessing the seed quality parameters.

The germination test was conducted in four replications of 100 seeds each by the between paper method in a germination room maintained at 25 ± 2 °C temperature and 90 ± 5 per cent RH, and the normal seedlings were counted on the 14 th day to compute the germination percentage (Anon., 2024). Ten normal seedlings selected randomly from each treatment on the 14 th day were used to measure the shoot length (collar region to tip of the seedling) and root length (tip of the primary root to base of hypocotyl), and seedling length was worked out by adding both. The same seedlings were dried in a hot air oven at 70 ± 1 °C for 24 h, cooled in a desiccator for 20 min and weighed to record the seedling dry weight (mg). Seedling vigour index-I (germination % × seedling length) and index-II (germination % × seedling dry weight) were computed as per Abdul-Baki and Anderson (1973) [1].

Results and Discussion

Seed germination, shoot length, root length, seedling length, seedling dry weight and seedling vigour indices I and II differed significantly among seed priming treatments (Table 1). GA_3 @ 100 ppm (T_{10}) recorded the highest values for all parameters, while the unprimed control recorded the lowest.

Seed germination ranged from 82.50 to 92.50 per cent (Table 1). GA_3 @ 100 ppm (T_{10}) recorded the highest germination (92.50 %), a 12.1 % increase over the control (82.50 %), and was on par with panchagavya (92.00 %), vermiwash (91.75 %), KNO_3 (90.50 %), humic acid (90.25 %) and $CaCl_2$ (90.00 %). Improved germination following priming may be attributed to early metabolic activation and mobilisation of stored food reserves (Bradford, 1986; Taylor *et al*., 1998) [8, 19]. Similar responses to GA_3 in cumin and panchagavya in cumin have been reported by Heidari and Sadeghi (2014) and Barad *et al*. (2025) [7, 10], respectively.

GA_3 @ 100 ppm recorded the maximum shoot length (7.65 cm) and root length (8.16 cm), representing increases of 35.4 and 41.9 %, respectively, over the control (5.65 and 5.75 cm). It was statistically on par with panchagavya, vermiwash, KNO_3, humic acid and $CaCl_2$ for both traits. The improved seedling growth may be associated with enhanced mobilisation of seed reserves and cell elongation under GA_3, while the nutrients and growth-promoting substances in organic formulations may have contributed to the comparable response. Similar improvements with GA_3 were reported in coriander by Kumar *et al*. (2014) [13], and with panchagavya in green gram by Somasundaram *et al*. (2003) [17].

The highest seedling length (15.81 cm) was recorded with GA_3 @ 100 ppm, which was 38.7 % higher than the control (11.40 cm). Panchagavya (15.45 cm), vermiwash (15.36 cm), KNO_3 (15.27 cm), humic acid (15.20 cm) and $CaCl_2$ (15.15 cm) were statistically on par with GA_3. Seedling dry weight was also highest with GA_3 (9.08 mg), a 27.9 % increase over the control (7.10 mg) and was on par with the same group of treatments. Better seedling length and dry matter may reflect more effective reserve mobilisation and early seedling growth; comparable responses to priming have been reported in cumin and other crops (Heidari and Sadeghi, 2014; Balusamy *et al*., 2014) [6, 10].

Seedling vigour index-I was highest with GA_3 @ 100 ppm (1462), a 55.4 % increase over the control (941), and was on par with panchagavya (1421), vermiwash (1409), KNO_3 (1382) and humic acid (1372). GA_3 also recorded the highest seedling vigour index-II (840), 43.3 % above the control (586), and was on par with panchagavya (819), vermiwash (813) and KNO_3 (800). The higher vigour indices resulted from the combined improvement in germination, seedling length and dry weight. Seed priming has similarly improved seedling vigour in ajwain and other crops (Ajorlou and Madadpour Inallou, 2011; Kumar *et al*., 2024) [2, 15].

Overall, GA_3 @ 100 ppm was the most effective treatment, while panchagavya @ 30 ml L^{-1}, vermiwash @ 5 %, humic acid @ 2.5 ml L^{-1}, KNO_3 @ 0.1 % and $CaCl_2$ @ 2 % were comparable for most seed quality parameters. Among organic treatments, panchagavya performed best and offers a practical alternative for improving ajwain seed quality.

Table 1: Effect of seed priming with organics and inorganics on seed quality parameters in ajwain

Treatment	Seed germination (%)	Shoot length (cm)	Root length (cm)	Seedling length (cm)	Seedling dry weight (mg)	Seedling vigour index-I	Seedling vigour index-II
T_1: Control	82.50	5.65	5.75	11.40	7.10	941	586
T_2: Hydropriming	87.25	6.10	6.55	12.65	7.20	1104	628
T_3: Humic acid @ 2.5 ml L^{-1}	90.25	7.39	7.81	15.20	8.82	1372	796
T_4: Panchagavya @ 30 ml L^{-1}	92.00	7.51	7.94	15.45	8.90	1421	819
T_5: Vermiwash @ 5%	91.75	7.49	7.87	15.36	8.86	1409	813
T_6: Cow urine @ 5%	87.75	6.42	7.02	13.44	7.75	1179	680
T_7: *Trichoderma*	88.25	6.58	7.18	13.76	8.15	1214	719

harzianum @ 4%							
T_8: Single cell protein @ 35 ml L^{-1}	87.50	6.25	6.76	13.01	7.45	1138	652
T_9: Sea weed extract @ 10ml L^{-1}	88.25	6.48	7.10	13.58	7.82	1198	690
T_{10}: GA_3 @ 100 ppm	92.50	7.65	8.16	15.81	9.08	1462	840
T_{11}: KCl @ 1.0 %	88.00	6.45	6.98	13.43	7.72	1182	679
T_{12}: KNO_3 @ 0.1%	90.50	7.42	7.85	15.27	8.84	1382	800
T_{13}: $CaCl_2$ @ 2%	90.00	7.36	7.79	15.15	8.81	1364	793
T_{14}: Salicylic acid @ 100 ppm	87.75	6.31	6.82	13.13	7.52	1152	660
Mean	88.88	6.79	7.26	14.05	8.14	1251	725
S.Em. ±	1.10	0.11	0.16	0.22	0.10	23.93	10.74
CD @ 1 %	4.20	0.41	0.62	0.85	0.39	91.31	40.99

Conclusion

Seed priming significantly improved germination, seedling growth and vigour of ajwain over the unprimed control. GA_3 @ 100 ppm recorded the highest values for all the seed quality parameters, followed by panchagavya @ 30 ml L^{-1}, vermiwash @ 5 %, KNO_3 @ 0.1 %, humic acid @ 2.5 ml L^{-1} and $CaCl_2$ @ 2 %. Among the organics, panchagavya @ 30 ml L^{-1} was the best and was on par with GA_3, and thus can be used as a sustainable alternative to hormonal and chemical priming for better seedling establishment in ajwain.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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