Effect of Seed Priming Treatments on Germination, Growth and Yield of Ajwain (*Trachyspermum ammi* L.)

ABSTRACT

Aim: To discern the most effective seed priming treatment among several priming treatments, which provide early and maximum germination, prosperous growth, and prodigious yield.

Study Design: Nine treatments with one control treatment in Randomized Block Design (RBD) with three replications.

Place and Duration of Study: Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S), during the rabi season of 2022.

Methodology: The ajwain seeds were primed with treatments comprised of, Gibberellic acid at 100 ppm and 200 ppm, Monopotassium phosphate (KH_2PO_4) at 2% and 3%,moringa leaf extract at 5% and 7.5%, tulsi leaf extract at 5% and 7.5%, hydro-priming (soaking in water), control (without soaking), for 24 hours before sowing.After that, primed seeds shade-dried for 4-5 hours. Then, the seeds were sown in the field.

Results: The outcomes unveiled fascinating insights. Notably, treating the seeds with 7.5% moringa leaf extract (T_6) revealed remarkable results, exhibiting the swiftest germination at 11.67 days, a staggering initial plant stand of 99.38%, and an impressive germination percentage of 93.33%. Meanwhile, the utilization of 200 ppm GA_3 led to a maximum plant height of 89.70 cm. Furthermore, the application of 7.5% moringa leaf extract (T_6) observed the minimum days to 50% flowering at 92.98 days and days to harvesting at 156.17 days and boasting the maximum primary branches plant^{-1} at 11.55. Among the myriad treatments, the application of 7.5% moringa leaf extract (T_6) emerged as a standout, showcasing unparalleled results witha maximum number of umbels and umbellets at 200.72 and 18.03, respectively. A prodigious yield of 10.49g plant^{-1}, 2.67 kg plot^{-1} and 11.86q ha^{-1}.

Conclusions: These findings underscore the potency of specific seed priming treatments, particularly, the 7.5% moringa leaf extract (T_6) and 200 ppm Gibberellic acid(T_2), in fostering robust ajwain seed germination, growth, accelerated plant development, and prodigious yield.

Keywords:*Ajwain, Seed priming, Moringa leaf extract, Tulsi leaf extract, Germination,Growth, yield.*

1. INTRODUCTION

Ajwain, scientifically termed*Trachyspermum ammi* L., stands as an annual herbaceous specimen within the esteemed medicinal cohort of the Apiaceae family. Flourishing predominantly in arid and semi-arid terrains characterized by saline-rich soil compositions, this botanical entity finds its cultivation prevalent across diverse locales such as Iran, Pakistan, Afghanistan, India, and select regions of Europe. Cultivation methodologies exhibit seasonal nuances, with planting typically undertaken between October and November in India.While, the saline tract area of Vidarbha adjusts its sowing to the latter half of August, culminating in a harvest during December-Januarywith residual moisture and the rest of the Ajwain growing area concentrating with October- November sowing, with irrigation facility.

The geographical expanse of Ajwain's cultivation in India extends over Gujarat, Rajasthan, Madhya Pradesh, Uttar Pradesh, Maharashtra, Bihar, and West Bengal, encompassing an approximate land area of 37,810 hectares and yielding around 27,920 tons of produce by the year 2020 [1]. This botanical's fruit harbours stimulant, antispasmodic, and carminative attributes, historically revered for its remedial efficacy against an array of ailments encompassing flatulence, dyspepsia, diarrhoea, abdominal pains, piles, bronchial afflictions, lack of appetite, galactagogue, asthma, and amenorrhea [14].

The optimum developmental milieu for ajwain dictates specific climatic requisites, necessitating temperatures ranging between 15 to 27^{0}C and a relative humidity spanning 60 to 70% during its growth phase. Notably, the phase of seed formation demands a relatively warmer climate. Remarkably, ajwain displays a moderate resistance to drought, enabling its cultivation in both *Kharif* and rainy seasons. Its nutritional matrix showcases pivotal vitamins like riboflavin, thiamine, nicotinic acid, and carotene, coupled with essential minerals encompassing calcium, phosphorus, iron, potassium, and salt. The quintessential essential oil harboured within ajwain, predominantly constituting 35- 60% of its composition, is thymol. This oil not only exudes a redolent fragrance, but also stands as a potent bearer of antiseptic properties.

Seed germination and seedling establishment are critical stages in plant life, and the successful establishment of a plant depends on the rapid and uniform germination of seed under adverse environmental conditions. In Ajwain,the rate of deterioration of seed quality parameters israpid during storage, resulting in poor germination, vigour, and establishment of crops. Seed priming is an excellent technique which improves germination and better crop stand. Thus, Seed priming has shown its promise in enabling the seeds to overcome various biotic and abiotic stresses. Therefore, it is a crucial pre-sowing procedure for improving germination and uniform emergence of a crop in normal and less-than-ideal circumstances. By getting the seeds to a point when metabolic processes have already been started and giving them a head start over unprimed seeds, pre-sowing priming is known to boost the performance of the seeds. The primed seeds can continue where they left off in the remaining stages of germination (radical protrusion) after receiving more imbibition. It has been established that seeds produced from such crops have higher seed quality than the crops which has been raised from non-primed seeds.

2.MATERIAL AND METHODS

The present investigation was carried out during the rabi season of2022-2023, in the research field of the Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment consisted of ten treatments and was replicated three times using a Randomized Block Design (RBD).

2.1 Treatment details

Treatments included, T_1 (GA_3 @100 ppm), T_2 (GA_3 @200 ppm), T_3 (KH_2PO_4 @ 2%), T_4 (KH_2PO_4 @ 3%),), T_5 (Moringa leaf extract @5%), T_6 (Moringa leaf extract @ 7.5%), T_7 (Tulsi leaf extract @ 5%), T_8 (Tulsi leaf extract @ 7.5%), T_9 (Soaking in water / Hydropriming), T_{10} (Absolute Control/ Without soaking). The seeds were primed for 24 hours before sowing. Then, the seeds were

shade-dried for 4-5 hours, to reduce the excess moisture level. After priming, immediately seeds were sown in the field. In each plot, the seeds were sown in the middle of every ridge with 70 hills and each hill has approximately 25-30 seeds, as a characteristic of the Apiaceae family.

2.2 Procedure for preparation of the priming treatments

Initially, a stock solution of 1000ppm was prepared by dissolving 1g of GA_3 in 5ml of ethanol, and which was subsequently added to 995ml of distilled water. Following this, GA_3 solutions of 100ppm and 200ppm were prepared by dissolving 10ml and 20ml of GA_3 in 90ml and 80ml of water, respectively. KH_2PO_4 solutions of 2% and 3% were prepared by dissolving 2g and 3g of KH_2PO_4 in 100ml of water and the seeds were soaked for 24 hours.Moringa leaf extract and tulsi leaf extract were prepared according to [7]. Fresh moringa leaves and tulsi leaves were washed thoroughly in tap water and crushed into fine paste by using a mortar and pestle, each 5g and 7.5g of the sample were ground by a blender with 100ml of water separately. The ground mixture is filtered through a fine cotton cloth, which constitutes 5% and 7.5% of moringa leaf extract and tulsi leaf extract, respectively. Seeds were soaked for 24 hours before sowing.

3.RESULTS AND DISCUSSION

3.1Germination parameters

Table 1 illustrates the impact of various seed priming treatments on key germination parameters, such as initial plant stand (%), days required for germination, and germination percentage (%). The data unequivocally demonstrates that, employing diverse priming methods significantly enhanced seed germination attributes when compared to the control treatment, T_{10}. Particularly, seeds primed with moringa leaf extract at 7.5% (T_6) exhibited the maximum initial plant stand (99.38%), which was at par with KH_2PO_4 at 3% (T_4) and GA_3 at 200 ppm (T_2), which registered 98.56% and 98.08% initial plant stand, respectively. Conversely, ajwain seeds without soaking (absolute control) T_{10}, displayed the minimum initial plant stand, significantly only at 80.67%, compared to other priming treatments.This might be due to the fact that, a higher concentration of calcium and other mineral contents in moringa (*Moringa oleifera*) leaves might be responsible for promoting the initial plant stand rate. Moreover, a higher zeatin concentration in *Moringa oleifera* leaves (5-200 Hg g of fresh weight) and enhanced mobilizations of metabolites/ inorganic solutes to germinating plumule, which results in enhanced growth. The findings align with previous studies by [4,13].

Remarkably, organic priming treatments notably reduced the days required for germination. Seeds primed with 7.5% moringa leaf extract (T_6) sprouted in the minimum duration (11.67 days), akin to KH_2PO_4 at 3% (T_4) with 12.67 days and moringa leaf extract at 5% (T_5) with 13.33 days. In contrast, T_{10} seeds took 18.33 days for germination, significantly maximum than other treatments.This could be because, calcium in moringa leaf extract promotes quicker germination and functions as an enzyme co-factor during germination. The activity of several phosphatases and kinase enzymes involved in signal translation is modulated by calcium, which also helps in reducing the days to germinate.Similar results were found by [4,13].

Furthermore, seeds primed with 7.5% moringa leaf extract (T_6) demonstrated the maximum germination rate at 93.33%, akin to KH_2PO_4 at 3% (T_4) with 91.00% and moringa leaf extract at 5% (T_5) with 88.33%. Conversely, the control treatment (T_{10}) substantially minimum germination percentage to 79.00% compared to other priming methods. This could be due to, the role of phytohormones, amino acids, and mineral elements present in moringa leaf extract, which positively influenced germination parameters. Furthermore, priming treatment promotes the mobilization of seed reserve from endosperm to embryo, resulting in better performance of germination. These outcomes concur with findings from studies conducted by [2,4,13,7].

3.2 Growth parameters

Table 1 depicts the influence of various seed priming treatments on the growth parameters of ajwain. There were noteworthy differences observed among these treatments. Specifically, seeds treated with GA_3 at 200ppm (T_2) resulted in plants with a maximum height of 89.70cm, statistically comparable to treatments involving GA_3 at 100ppm, moringa leaf extract at 7.5% (T_6), and KH_2PO_4 at 3% (T_4), which produced plant height of 87.17cm, 85.70cm, and 84.83cm, respectively. In Contrast, the control treatment (T_{10}) without soaking exhibited a minimum plant height of 69.27cm. This might be a consequence of GA_3's increase in cell division and stem elongation. The phytohormone gibberellin is in charge of controlling plant height. By making the cell wall more flexible, GA_3 treatments are also successful in promoting vegetative development. These findings align with studies by [10,6,3,9].

Regarding the number of primary branches plant^{-1}, statistically significant differences were evident. Seeds treated with 7.5% moringa leaf extract showed the maximum number of primary branchesplant^{-1} at 11.95, followed by those treated with 3% KH_2PO_4 at 10.70. Conversely, the control treatment (T_{10}) exhibited the minimum number of branches plant^{-1} at 7.17. This might be because, moringa (*Moringa Oleifera*) leaves have larger concentrations of calcium, zeatin concentration (5-200 Hg g of fresh weight) and other minerals, which might encourage the growth of more branches. Furthermore, this could also be the result of higher or enhanced mobilizations of metabolites/inorganic solutes to germinating plumule, which leads to enhanced growth of primary branches. These results correspond with findings by [11].

The treatment involving moringa leaf extract at 7.5% (T_6) remarkably led to the minimum duration of 92.98 days to achieve 50 percent blooming and significantly reduced the harvesting duration to 156.17 days, which was akin to KH_2PO_4 at 3% (T_4) which recorded 95.36 days and 158.51days. And also akin tomoringa leaf extract at 5% (T_5) required 96.90 days and 160.57 days for 50 percent blooming and harvesting, respectively. In contrast, the control treatment (T_{10}) took amaximumdurationof 105.32 days to achieve this stage. This might be due to, moringa leaf extract-primed seeds providing an energizing start, early crop establishment led to early 50%flowering and harvesting. These outcomes coincide with studies by [4,5,13].

3.3 Yield parameters

In examining the outcomes depicted in Table 1, notable variations in yield parameters resulting from diverse seed priming treatments compared to the control treatment (T_{10}) were evident. Specifically, Treatment (T_6) utilizing moringa leaf extract at 7.5% exhibited statistical significance over

all other treatments, yielding 200.72 umbels plant^{-1}. Following closely was Treatment (T_4) involving KH_2PO_4 at 3% with a count of 187.23 umbels plant^{-1}. Conversely, the control treatment (T_{10}) without soaking displayed a notableminimum of umbels plant^{-1} at 162.63. This might be due to, the moringa extract is rich in zeatin-like cytokinin that induces cytokinin bio-synthesis improvement and the number of photosynthetic active leaves and number of umbels. These results align with findings by [11].

Furthermore, Treatment (T_6) with moringa leaf extract at 7.5% generated 18.03 umbellets umbel^{-1}, comparable to KH_2PO_4 at 3% (T_4) and GA_3 at 200ppm (T_2) that yielded 17.27 and 17.13 umbellets umbel^{-1}, respectively. In contrast, the control treatment (T_{10}) exhibited a minimum count of 13.36 umbellets umbel^{-1}. This might be due to improved vegetative growth coupled with increased photosynthesis on one hand and greater mobilization of photosynthates towards reproductive sites increased the number of umbellets per umbel on the other. These results corroborate the findings of [11].

Additionally, Treatment (T_6) employing moringa leaf extract at 7.5% significantly increased yield plant^{-1}, plot^{-1}, and hectare^{-1}. Seedsemployed with moringa leaf extract at 7.5% treatment produced the maximum yield plant^{-1} at 10.49grams, 2.67kilograms plot^{-1}, and 11.86 quintal hectare^{-1}, paralleled by Treatment (T_4) using KH_2PO_4 at 3%, generating 9.87g plant^{-1}, 2.62kg plot^{-1}, and 11.61q ha^{-1}. Similarly, also with GA_3 at 200ppm (T_2) yielded 9.74g plant^{-1}, 2.59kg plot^{-1}, and 11.47q ha^{-1}. In contrast, the control treatment (T_{10}) yielded the minimum at 5.30g plant^{-1}, 1.74kg plot^{-1}, and 7.71q ha^{-1}. This might be due to, the greater partitioning of photoassimilates to developing grains. Moringa leaf extract's noteworthy benefits might be linked to its impact on growth parameters, which raised photosynthesis and sink capacity by utilizing photoassimilates from leaves, and translocation to produce high-quality and abundant fruit. Furthermore, zeatin-like cytokinin, which increases cytokinin biosynthesis and the number of photosynthetic active leaves, is abundant in moringa extract. It also impacted on the yield.These findings are supported by research conducted by [8,11,12].

Table 1. Effect of seed priming treatments on germination, growth and yield parameters of Ajwain plant

Tre.	Treatment details	Initial plant stand (%)	Days to germination	Germination percentage (%)	Plant height (cm)	Number of primary branches	Days to 50% flowering	Days to harvesting	Umbels plant^{-1}	Umbellets umbel^{-1}	Yield plant^{-1} (g)	Yield Plot^{-1} (kg)	Yield ha^{-1} (q)
T_1	GA_3 at 100ppm	96.30	16.33	82.33	87.17	8.07	99.89	165.18	170.87	14.78	6.53	1.88	8.33
T_2	GA_3at 200ppm	98.08	14.33	87.67	89.70	10.63	97.90	162.33	182.29	17.13	9.74	2.59	11.47
T_3	KH_2PO_4 at 2%	95.42	14.67	84.33	77.01	8.48	99.08	166.10	172.35	14.90	7.23	2.03	9.01
T_4	KH_2PO_4 at 3%	98.56	12.67	91.00	84.83	10.70	95.36	158.51	187.23	17.27	9.87	2.62	11.61
T_5	Moringa leaf extract at 5%	95.08	13.33	88.33	80.60	9.56	96.90	160.57	180.91	15.73	8.30	2.32	10.30
T_6	Moringa leaf extract at 7.5%	99.38	11.67	93.33	85.70	11.95	92.98	156.17	200.72	18.03	10.49	2.67	11.86
T_7	Tulsi leaf extract at 5%	92.15	15.67	83.67	73.37	8.15	100.32	166.21	168.67	15.00	6.93	1.92	8.52
T_8	Tulsi leaf extract at 7.5%	88.94	15.00	86.33	77.10	8.75	98.70	163.91	175.65	15.85	7.43	2.09	9.27
T_9	Hydropriming (Soaking in water)	85.51	15.67	85.00	76.36	7.99	100.99	167.25	166.68	14.60	6.23	1.86	8.25
T_{10}	Absolute control (Withoutsoaking)	80.67	18.33	79.00	69.27	7.17	105.32	171.93	162.63	13.36	5.30	1.74	7.71
	SE (m)±	**1.03**	**0.78**	**1.60**	**2.22**	**0.26**	**1.33**	**1.09**	**1.20**	**0.31**	**0.25**	**0.03**	**0.15**
	CD at 5%	**3.08**	**2.32**	**4.77**	**6.62**	**0.79**	**3.97**	**4.45**	**3.58**	**0.92**	**0.76**	**0.10**	**0.47**

4.CONCLUSION

The investigation results indicate that, all treatments exhibited a broader range of variability in germination, growth,and yield parameters compared to the control treatment. Specifically, treating seeds with a 7.5% concentration of moringa leaf extract resulted in significant enhancements in germination metrics such as initial plant stand (%), germination percentage (%), and minimum days required for germination.

Concerning growth factors, priming seeds with GA_3 at 200ppm led to a significant increase in plant height (cm). Additionally, using moringa leaf extract at 7.5% resulted in the maximum number of primary branches plant^{-1}, the minimum days to 50 percent blooming, and days to harvesting. Specifically, it also exhibited substantial amplifications in yield parameters such as the number of umbels plant^{-1}, umbellets umbel^{-1}, yield plant^{-1}(g), yield plot^{-1}(kg), and yield hectare^{-1}(q). Overall, it's evident that employing a 7.5% concentration of moringa leaf extract facilitates early and extensive germination and prodigious yield. While GA_3 at 200ppm promotes plant height. These results are, however, based on one year of experimentation. Hence further studies using different priming treatments with different concentrations will be helpful for the confirmation of the results.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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%	: Per cent
@	: At the rate
^{0}c	: Degree celcius
C.D.	: Critical difference
cm	: Centimeter
et al.,	: Et alia (and others)
g	: Grams
GA_3	: Gibberellic acid
ha	: Hectare
kg	: Kilograms
ml	: Milliliter
No.	: Number
Plant^{-1}	: Per plant
Plot^{-1}	: Per plot
ppm	: Parts per million
q	: Quintal
Tre	: Treatments
Umbel plant^{-1}	: Umbels per plant

Umbellets umbel^{-1} : Umbellets per umbels

ABBREVIATIONS