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RESEARCH ARTICLE

Effect of different priming agents on plant growth, fresh leaf yield, seed yield and economics of seed production in coriander

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Abstract

Coriander is an annual herb widely grown for its seeds, as a spice and for essential oil manufacturing all over the world. Moisture and temperature stresses are the major constraints to rapid and uniform crop establishment in the field. Therefore, a field research trial was conducted using coriander cv. "Solan Selection" to study the effect of different seed priming treatments on fresh crop production, seed yield and economics of seed production during 2021-22. Seeds were primed with different priming agents, namely, PEG 6000 (@ -0.75 MPa for 12 hours), GA_3 (@ 25 ppm for 18 hours), thiourea (@ 500 ppm for 18 hrs), KCl (@ 1.0% for 12 hours), KNO_3 (@ 1.0 % for 12 hrs) and hydropriming (for 12 hours) along with control. It was concluded that treatment T_1 i.e. seed priming with PEG 6000 @ -0.75 MPa for 12 hours, was found to be best among all seed priming treatments and resulted in significantly highest green leaf yield, plant height, number of branches plant^{-1}, number of umbels plant^{-1}, number of seeds umbel^{-1}, minimum days to seed maturity, highest seed yield, biological yield, 1000 seed weight and maximum B: C ratio under mid-hill conditions of Himachal Pradesh.

Keywords: Coriander, Seed priming, PEG, GA_3, Thiourea, KCl, KNO_3

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Introduction

Coriander (*Coriandrum sativum* L.) is an important spice crop belonging to the family Apiaceae (Umbelliferae). It is native to the Mediterranean region. It is also known as Cilantro or dhania. The term "cilantro" refers to the leaves of the plant which are used as a herb. The plant is widely cultivated all over the world for its seeds, as a spice and for the production of essential oils. *C. sativum* and its wild relative *C. tordylium* are the only two species that have been identified. An inflorescence is located at the terminal of each branch. The umbels of the tiny, pinkish, white flowers have short stalks and flowers are protandrous in bloom. The biology of coriander's flowering and pollination is typical of that of umbelliferous plants (Bell, 1971). The plant's major products, the fruit and the green herb, have been used traditionally for both medicinal and culinary purposes. Coriander has a wide range of medical benefits (Hegi, 1926). Manganese, iron, magnesium and dietary fibers are all prominent in coriander. The leaves also include a lot of protein and antioxidant vitamins A, C and K. India, China, Afghanistan, Indonesia, Turkey, Iran and Bulgaria are major coriander-producing countries. India is the leader with alone contribution of 80 per cent in total production.

Heydecker, in 1973, proposed the hypothesis of seed priming. Recent research suggests a connection between seed wetness and hard seediness, which significantly impacts the rapid and consistent crop stand in the field under challenging moisture and temperature conditions. According to Choudhary et al. (2008), the regulated hydration of seed prevents germination while allowing pre-germinative physiological and biochemical processes to take place. In general, seed priming involves treating seeds with various priming agents to promote germination and seedling quality as well as plant growth and flowering. Numerous enzymes involved in the mobilization of food stores are activated during seed priming (Shrinivasan et al., 2009). To acquire the best results, it is crucial to be aware of the safe upper and lower limits of priming duration before priming any crop seed. Primed seeds have a higher germination rate, better germination uniformity, faster emergence and occasionally a higher total germination percentage (Shehzad et al., 2012). It has been noted that PEG (polyethylene glycol) improves seedling vigor and germination. It is one of the most used osmoticums for seed priming (Lemmens et al., 2019). Gibberelic acid in seeds has an impact in two ways: first, it increases the embryo's capacity for growth and second, it stimulates the production of hydrolytic enzymes. During seed germination, embryonic gibberellic acid is produced, which causes the seed cover to weaken by inducing the expression of genes related to cell proliferation and expansion (Finkelstein et al., 2008). To break dormancy and increase seed germination, some compounds, including thiourea, potassium nitrate and potassium chloride, are frequently utilized (Agrawal & Dadlani, 1995). Some types of dormancy, such as the seed-coat inhibiting effect of deeply embryo-dormant seeds, have been observed to be broken by thiourea (Hartmann et al., 1997). Additionally, the use of thiourea at various plant developmental stages modifies important physiological processes and mechanisms, such as photosynthesis, nitrogen metabolism, proline metabolism, antioxidant defense systems and plant water relations (Kaya et al., 2019). Potassium nitrate is commonly utilized as a halo-priming agent to improve germination and has been recognized as a good chemical method for fostering germination in a variety of plant species (Shim et al., 2008).

Materials and Methods

This study examined the effect of different seed priming agents on growth, seed yield and economics of seed production in coriander. The experiment was carried out during the *Rabi* season 2021-2022 using cv. "Solan Selection" at Experimental Farm of the Department of Seed Science and Technology, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, HP situated at an altitude of 1250 m above mean sea level with 30˚ 50′ 45′′ North latitude and 77˚ 88′ 33′′ East longitude using Randomized Complete Block Design. It falls in the sub-humid, sub-temperate and mill-hill zone of Himachal Pradesh. The soil texture was loam to clay loam with pH 6.85-7.05 and the average maximum and minimum temperature, relative humidity and total rainfall were 23.6˚C, 6.72˚C, 53.6% and 176.7 mm, respectively, during the cropping period. Seeds were primed with different priming agents, namely, PEG 6000 (@ -0.75 MPa for 12 hours), GA_3 (@ 25 ppm for 18 hrs), thiourea (@ 500 ppm for 18 hours), KCl (@ 1.0% for 12 hours), KNO_3 (@ 1.0% for 12 hours) and hydropriming (for 12 hours) along with control. Observations on different growth and yield parameters, namely, green leaf yield (q ha^{-1}), plant height (cm), number of branches $plant^{-1}$, number of umbels $plant^{-1}$, number of seeds $umbel^{-1}$, days to seed maturity, seed yield (g $plant^{-1}$ and kg ha^{-1}), biological yield (kg ha^{-1}), harvest index (%), 1000 seed weight (g) were statistically analyzed using Windows-based computer application OPSTAT developed by Sheoran (2006) and benefit-cost ratio was worked out as per the standard procedure.

Results

Following statistical analysis, the experiment's findings on various growth and yield parameters are given here as:

Plant growth parameters and green leaf yield

Among the various seed priming treatments, T_2 (GA_3 @ 25 ppm for 18 hours) had the highest plant height (95.33 cm), but it was statistically at par with treatment T_1 (PEG 6000 @ -0.75 MPa for 12 hours), T_4 (KNO_3 @ 1.0% for 12 hours) and T_3 (Thiourea @ 500 ppm for 12 hours). In contrast, treatment T_7 had the lowest (76.81 cm) result (Table 1). The number of branches of $plant^{-1}$ varied significantly among different seed treatments. However, the seed treatment T_1 produced the maximum number of branches $plant^{-1}$ (14.00), by a substantial margin. The smallest value for this feature, however, was found in T_7 (6.73). The effect of different seed priming treatments on number of umbels $plant^{-1}$ also revealed statistical parity between PEG 6000 @ -0.75 MPa for 12 hours and GA_3 @ 25 ppm for 18 hours. However, the highest number of umbels $plant^{-1}$ (38.66) was found in treatment T_1 and the lowest (19.00) in treatment T_7 (Control). The plants grown from seeds treated with PEG 6000 @ -0.75 MPa for 12 hours (T_1) took the fewest days (165.66) to mature the seeds stage and were significantly superior to all other treatments. In contrast, the hydro-primed seeds (T_6) and control (T_7) plants required maximum days (178.33) to reach seed maturity. Similarly, data presented in Table 1 also indicated a significant effect of different seed priming treatments on green leaf yield in coriander. Among various treatments, green leaf yield (75.39 q ha^{-1}) recorded in treatment T_1 (PEG 6000 @ -0.75 MPa for 12 hours) was found to be significantly higher over all other treatments. On the other hand, the minimum green leaf yield (38.54 q ha^{-1}) was exhibited by the control.

Seed yield and yield contributing characters

The data on yield parameters (Table 2) showed that various seed treatments had a significant impact on yield-contributing traits. The treatment with GA_3 @ 25 ppm for 18 hours gave the highest seeds umbel^{-1} (86.93) and was statistically at par with priming treatments comprising PEG 6000 at -0.75 MPa for 12 hours (T_1) and thiourea 500 ppm for 18 hours (T_3). The control treatment had the lowest seeds umbel^{-1} (73.46). The seeds treated with PEG 6000 @ -0.75 MPa for 12 hours produced significantly the highest seed yield (14.33 g plant^{-1} and 1703.69 kg ha^{-1}) than other seed treatments. In contrast, the control treatment had the lowest seed yield (9.67 g plant^{-1} and 1037.03 kg ha^{-1}). A further examination of the data revealed a significant impact of various seed priming treatments on biological yield, where T_1 (PEG 6000 @ -0.75 MPa for 12 hours) had the maximum biological output (4174.49 kg ha^{-1}), which was significantly higher than the other treatments and T_7 (control) had the lowest yield (2385.19 kg ha^{-1}). A maximum 1000 seed weight (3.65 g) was also recorded in treatment T_1 (PEG 6000 @ -0.75 MPa for 12 hours), while T_7 (control) showed a minimum 1000 seed weight of 2.95 g. Further, analyzing the data demonstrated in Table 2 revealed that various seed priming treatments significantly impacted the harvest index of coriander. Among the various priming treatments, T_4 (KCl @ 1.0% for 12 hours) recorded a substantially higher harvest index (49.37%) and T_5 (KNO_3 @ 1.0% for 12 hours) had the lowest (34.41%).

Economics of seed production

The data in Table 3, pertains to the economics of various seed treatments for coriander seed production, and it revealed that the maximum net returns (Rs. 179278.5) as well as B: C ratio (2.35: 1) were obtained from treatment T_1 (PEG 6000 @ -0.75 MPa for 12 hours). Contrary to this, the lowest net returns (Rs. 86909.5) and B: C ratio (1.27:1) resulted in treatment T_7.

Discussion

Plant growth parameters and green leaf yield

Increased enzymatic activity and the generation of organic compounds in germinating seeds may have promoted early emergence and rapid cell division in the meristematic area, which may have contributed to the increase in plant height under these treatments. Additionally, the ability of plants to easily absorb more water and nutrients may be responsible for the maximum plant height in plants grown from seeds primed with GA_3. In addition, early emergence and rapid cell division in the meristematic region, a higher rate of auxin metabolism, cell wall plasticity, permeability of the cell membrane, an increase in photosynthesis, cell enlargement as well as rapid cell elongation have all been mentioned by Sadavarthe & Gupta (1963) as contributing factors to increased plant height in brinjal. The outcomes concur with those of the study conducted by Akter et al. (2007) in mustard crop. Higher branches per plant might be as a result of the start of metabolic processes that normally occur during the seed's imbibition process and subsequent drying (Hanson, 1973). Catalase, peroxidase, amylase and invertase enzymatic activity may have enhanced in the seeds primed with PEG 6000 @ -0.75 MPa for 12 hours. Similar findings were also reported by Pradhan et al. (2014), who found that PEG 6000 increased the number of tomato branches. The fact that PEG 6000 treatment also produced more branches plant^{-1}, which may be attributed to the higher number of umbels plant^{-1} in that treatment. The shorter time needed for a crop to reach maturity may be due to the quick completion of the vegetative phase, which later promotes better crop growth and earlier blooming. Early flowering eventually results in early fruit set and seed maturity. The results of the current study are comparable to those of Castillo et al. (2007) in rice crops. Osmopriming's positive impacts on seed structure, biochemistry, enzymatic activities and organic compounds in germinating seeds may have contributed to the highest

Table 1: Effect of different seed priming treatments on plant growth parameters and green leaf yield in coriander

Parameter / *Seed priming treatments*	*Plant height (cm)*	*Number of branches plant^{-1}*	*No. of umbels plant^{-1}*	*Days to seed maturity*	*Green leaf yield (q ha^{-1})*
T_1 (PEG 6000 @ -0.75 MPa for 12 hours)	93.28	14.00	38.66	165.67	75.39
T_2 (GA_3 @ 25 ppm for 18 hours)	95.33	11.47	36.76	169.33	63.70
T_3 (Thiourea @ 500 ppm for 18 hours)	87.59	11.27	25.90	170.67	64.36
T_4 (KCl @ 1.0 % for 12 hours)	90.61	9.03	24.20	175.00	65.02
T_5 (KNO_3 @ 1.0 % for 12 hours)	87.30	8.80	28.10	173.66	63.21
T_6 (Hydropriming for 12 hours)	86.03	8.43	22.86	178.33	47.57
T_7 (Control)	76.81	6.73	19.00	178.33	38.54
$CD_{0.05}$	7.76	2.31	3.84	1.48	2.93

Table 2: Effect of different seed priming treatments on seed yield and yield contributing characters in coriander

Seed priming treatments / *Parameter*	*No. of seeds umbel^{-1}*	*Seed yield plant^{-1} (g)*	*Seed yield hectare^{-1} (kg)*	*Biological yield hectare^{-1} (kg)*	*1000 seed weight (g)*	*Harvest Index (%)*
T_1 (PEG 6000 @ -0.75 MPa for 12 hours)	86.93	14.33	1,703.69	4,174.49	3.65	40.81
T_2 (GA_3 @ 25 ppm for 18 hours)	89.13	12.67	1,572.01	3,919.09	3.32	40.11
T_3 (Thiourea @ 500 ppm for 18 hours)	86.46	10.33	1,456.78	3,590.12	3.11	40.62
T_4 (KCl @ 1.0 % for 12 hours)	81.26	11.00	1,382.70	2,806.58	3.27	49.37
T_5 (KNO_3 @ 1.0 % for 12 hours)	78.33	11.00	1,242.79	3,611.73	3.15	34.41
T_6 (Hydropriming for 12 hours)	80.20	10.67	1,259.25	2,727.57	3.37	46.16
T_7 (Control)	73.46	9.67	1,037.03	2,385.19	2.95	43.48
$CD_{0.05}$	6.17	1.19	72.73	150.37	0.15	2.78

Table 3: Effect of different seed priming treatments on economics of seed production in coriander for one hectare

Seed priming treatment	*Seed Yield (kg/ha)*	*Gross return (Rs.)*	*Total Expenditure (Rs.)*	*Net return (Rs.)*	*B: C ratio*
T_1 (PEG 6000 @ -0.75 MPa for 12 hours)	1703.69	255553.50	76275	179278.5	2.35
T_2 (GA_3 @ 25 ppm for 18 hours)	1,572.01	235801.50	74745	161056.5	2.15
T_3 (Thiourea @ 500 ppm for 18 hours)	1,456.78	218517.00	70180	148336.8	2.11
T_4 (KCl @ 1.0 % for 12 hours)	1,382.70	207405.00	69674	137731.0	1.98
T_5 (KNO_3 @ 1.0 % for 12 hours)	1,242.79	186418.50	69542	116876.5	1.68
T_6 (Hydropriming for 12 hours)	1,259.25	188887.50	69345	119542.5	1.72
T_7 (Control)	1,037.03	155554.50	68645	86909.5	1.27

*Sale price of seed @ Rs. 150/- per kg

green leaf yield in (treatment T_1) by ensuring an early stand establishment and good vegetative growth. According to Chiu et al. (1995), priming also improves membrane healing in seeds and may have prompted the activity of a number of lipid peroxide-scavenging enzymes. The findings are in agreement with the findings of Pirmohammadi et al. (2022) in marshmallow.

Seed yield and yield contributing characters

A higher number of branches plant^{-1} in treatments T_1 and T_2 may have contributed to more foliage and photosynthetic area, which in turn, after pollination and fertilization, resulted in more fruits and seeds. Furthermore, an exogenous supply of GA_3 may have promoted blooming, pollination, fertilization and better umbel development as well as seed setting. With the use of GA_3 in safflower, Arslan & Cuplan (2017) also reported the highest number of seeds capsule^{-1}. The good influence on the number of branches and umbels plant^{-1}, as well as the quantity of seeds umbel^{-1} eventually led to a better yield may account for the improved yield under the mentioned treatment. Additionally, priming can improve crop production, decrease pest damage and increase drought tolerance, which all contribute to improved crop establishment (Harris et al., 1999). After seed priming, Rao & Singh (1997) also reported increased seed yield in soybeans. Accumulation of more carbohydrates due to increased photosynthetic activity may be the cause of the much higher biological yield under seed priming treatment with PEG 6000, which also recorded increased seed yield. According to Detmann et al. (2012), increased seed weight in PEG 6000 treatment might have been caused by increased accumulation of primary metabolites like sugars and proteins through increased photosynthesis and their subsequent transport to the sink, which is the seed. These results concur with those of Li et al. (2018) in purple wheat. Because the harvest index is a statistic generated from economic and biological yield, the treatment with a lower denominator percentage had a higher harvest index percentage.

Conclusion

From the present study, it was concluded that out of different seed treatments, seed priming with PEG 6000 @ -0.75 MPa for 12 hours gave the best results regarding plant growth, seed yield contributing characters and ensured the highest net return and eventually, B: C ratio in coriander under mid-hill conditions of Himachal Pradesh.

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सारांश

धनिया एक वार्षिक जड़ी बूटी है जो अपने बीजों, मसाले के रूप में और आवश्यक तेल निर्माण के लिए पूरी दुनिया में व्यापक रूप से उगाई जाती है। खेत में तेजी से और एक समान फसल तैयार होने में नमी और तापमान का तनाव प्रमुख बाधाएं हैं। इसलिए, 2021-22 के दौरान ताजा फसल उत्पादन, बीज उपज और बीज उत्पादन की अर्थव्यवस्था पर विभिन्न बीज प्राइमिंग उपचारों के प्रभाव का अध्ययन करने के लिए धनिया किस्म “सोलन चयन” का उपयोग करके एक क्षेत्र अनुसंधान परीक्षण आयोजित किया गया था। बीजों को अलग-अलग प्राइमिंग एजेंटों से प्राइम किया गया, जैसे पीईजी 6000 (@ 12 घंटे के लिए -0.75 एमपीए), जीए3 (@ 18 घंटे के लिए 25 पीपीएम), थियोरिया (@ 18 घंटे के लिए 500 पीपीएम), केसीएल (@ 12 घंटे के लिए 1.0%) , KNO3 (@12 घंटे के लिए 1.0%) और नियंत्रण के साथ हाइड्रोप्राइमिंग (12 घंटे के लिए)। यह निष्कर्ष निकाला गया कि उपचार टी 1 यानी बीज प्राइमिंग 12 घंटे के लिए पीईजी 6000 @ -0.75 एमपीए के साथ सभी बीज प्राइमिंग उपचारों में सबसे अच्छा पाया गया और इसके परिणामस्वरूप उच्चतम हरी पत्ती की उपज, पौधे की ऊंचाई, प्रति पौधे शाखाओं की संख्या, प्रति पौधे नाभि की संख्या, प्रति नाभि बीज की संख्या, बीज परिपक्वता के लिए न्यूनतम दिन, उच्चतम बीज उपज, जैविक उपज, 1000 बीज वजन और अधिकतम बी: सी अनुपात हिमाचल प्रदेश की मध्य-पहाड़ी परिस्थितियों में प्राप्त हुआ ।