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Optimizing Seed Priming Duration and Copper Levels for Coriander (*Coriandrum sativum* L.) Germination and Vigour

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ABSTRACT

Background: An experiment was carried out in the STR Laboratory, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, MP, during the *Rabi* season of 2022-2023 to determine the impact of seed priming time and copper levels on seed germination and vigour characteristics of the coriander seedlings.

Method: The experiment was laid out in completely randomized design (CRD) with three replications and 12 treatment combinations of Copper levels (0, 300, 400 and 500ppm) and soaking duration (14, 16 and 18 h).

Results: The outcomes demonstrated that priming treatments had a noteworthy impact on seedling germination and vigour traits. Significantly higher germination (82%), least mean germination time (7.9 days), maximum germination index (22.83), longest radicle (17.30 cm) and plumule length (13.09 cm), maximum vigour index-I (2374.05 cm) and vigour index-II (12.29 g) and lowest mortality rate (18%) was observed when seeds were primed with Cu @ 500 ppm soaking for 16 h. Success of crop production depends on quality of seeds and it's germination percentage. Quality of seed susceptible to diverse climatic conditions resulting poor vigour and germination. Since availability of quality seed of coriander is very low, seed priming is an excellent technique which improves germination and better crop stand.

Key words: Copper levels, Coriander, Germination characteristics, Seed priming duration, Viability assessments.

INTRODUCTION

Coriander (*Coriandrum sativum* L.) is an annual green herb and seed spices having unique flavour and pleasant aroma. It is a member of the Apiaceae (Umbelliferae) family having chromosome number 2n=22. It is known by various names as *dhaniya, cilantro*, *collender, ketumbar etc*. It is native to Egypt, Turkeyand the Eastern Mediterranean region. The coriander is small bushy herb with height upto 1.40 m at flowering stage (Diederichsen, 1996). Coriander being a seed spices require a favourable climatic and soil conditions and primarily cultivated in tropical and sub-tropical regions of India during the winter season owing to its high temperature requirement at the end of growing season (Sharma *et al.,* 2022) and in shade net houses in off-season. It has a wide range of applications around the whole world. It is rich in fibre, which helps in digestion promotes the regular movements of bowel. The dried ground seeds are the major component of the curry powder. Moreover, the whole fruits are used to flavour snacks, pickles and sauces.

Seed priming is the controlled hydration process which is followed by re-drying. It enables seeds to take up water and start the internal biological processes required for germination, but prevents actual germination. In Priming, seeds are soaked in different solutions with high osmotic potential. This prevents the seeds from absorbing enough water for radicle protrusion, thus suspending the seeds in the lag phase (Taylor *et al.,* 1998). The duration of a seeds priming is extremely important because soaking for too short duration may not complete metabolic repair processes or stimulate the enzyme activities proving ineffective in enhancing seed germination or vigour (Saini *et al.,* 2017) and soaking for too long time may promote radicle emergence even after drying (Harris, 1996). Copper plays a vital role in plant growth, photosynthesis, respiration, carbon nitrogen metabolism and provides protection against oxidative stress (Shams *et al.,* 2019). It is a crucial component that also plays an important role in the metabolism of carbohydrates and lipids, DNA and RNA production and disease and pest resistance (Yerli *et al.,* 2020). Success of crop production depends on quality of

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seeds and it's germination. Quality of seed susceptible to diverse climatic conditions resulting poor vigour and germination. Since availability of quality seed of coriander is very low, seed priming is an excellent technique which improves germination and better crop stand (Taylor *et al.,*1998). Therefore, the present experiment was designed to get the best combination of Copper levels and priming duration based on germination characteristics and viability assessments.

MATERIALS AND METHODS

The experiment was conducted at Seed Technology Research (STR) Laboratory, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh during *Rabi* season of 2022- 2023 and took one year for completion of research work. The experiment was laid out in completely randomized design (CRD) with three replications and 12 treatment combinations *viz.* T_1- Cu @ 0ppm for 14 h, T_2-Cu @ 0 ppm for 16 h, T_3-Cu @ 0 ppm for 18 h, T_4-Cu @ 300 ppm for 14 h, T_5-Cu @ 300 ppm for 16 h, T_6-Cu @ 300 ppm for 18h, T_7-Cu @ 400 ppm for 14 h, T_8-Cu @ 400 ppm for 16 h, T_9-Cu @ 400 ppm for 18 h, T_{10}-Cu @ 500 ppm for 14 h, T_{11}-Cu @ 500 ppm for 16h, T_{12}-Cu @ 500 ppm for 18h. Seeds of variety Jawahar Dhaniya-1 collected from AICRP on Spices, Department of Horticulture, JNKVV, Jabalpur were selected to study the effect of seed priming duration and copper levels on germination and vigour characteristics of coriander seedlings. The solutions of 300, 400 and 500 ppm of Chela Cu EDTA were prepared and seeds were soaked in the solutions for 14 h, 16 h and 18 h. The hydroprimed seeds were used in control treatment. After completion of soaking in different durations, the seeds were washed thoroughly with distilled water followed by drying of seeds in shade for 48h to bring the seeds to original moisture content. Paper towel method was utilized to evaluate the germination and seed vigour parameters. The germinated seeds were counted daily by unrolling the paper sheet carefully till 21 days which is the final count of coriander seed. The germination percentage and vigour parameters was calculated based on the number of seeds germinated and the seeds that failed to germinate were considered dead. The various germination parameters were calculated by following formula.

Germination percentage

It was determined using following formula.

Germination percentage=

$$\frac{\text{Total no. of germinated seeds of a treatment}}{\text{Total no. of seed sown in treatment}} \times 100$$

Mean germination time (MGT)

The number of seeds that germinated was counted each day till final count *i.e.*, up to 21 days. Based on the following equation of Ellis and Roberts (1981), Mean Germination time was calculated as

$$\text{Mean germination time} = \frac{\Sigma nt}{\Sigma n}$$

Where,

$\Sigma n = n1 + n2 + n3 + n4 + n5 + \ldots\ldots + nt$

n = Number of seeds which were germinated on day t and t is the number of days

t = t^{th} day counted from the beginning of germination test.

Germination index (GI)

The number of seeds that germinated under each treatment was examined each day untill the final count. The germination Index was calculated using the formula below

Germination index (GI)=

$$\frac{\text{Total germination \%}}{\text{Time taken for 50\% germination}}$$

Radicle length (cm) and plumule length (cm) was measured using a scale 21 days after sowing.

Vigour index of seedling

Vigour index of seedling was determined by adopting the method recommended by (Abdul Baki and Anderson, 1973) and expressed as whole number for each treatment by using the below formula:

Vigour index- I (cm) was calculated by multiplying the standard germination (%) with seedling length (cm).

Vigour index- I=

$$\text{Germination (\%)} \times \text{Seedling dry weight (cm)}$$

Where, Seedling length = Radicle length + Plumule length

Vigour index- II (g) was calculated by multiplying the standard germination (%) with seedling dry weight (g).

Vigour index- I=

$$\text{Germination (\%)} \times \text{Seedling dry weight (g)}$$

RESULTS AND DISCUSSION

Seed priming improves the germination rate as well as uniformity. An enhanced and uniform seedling emergence may contribute to regulate crop establishment. Analysis of variance revealed substantial differences between seed priming duration and copper levels on all of the germination parameters examined in the laboratory studies.

Scrutiny of the data with regards to germination per cent of coriander seeds primed with different levels of copper for 14 h, 16 h and 18 h (Table 1) revealed a significant variation in the germination per cent of coriander under laboratory condition. The data manifested that the highest germination per cent (82%) was achieved by T_{11} (seeds primed with Cu 500 ppm for 16 h) which was at par with T_{12} (seed primed with Cu 500 ppm for 18 h) with 80% and T_{10} (seed primed with Cu 500 ppm for 14 h) with 76%. The germination percentage for T_1 (seed primed with Cu 0 ppm for 14 h) was the lowest (64%). The germination of primed seeds was more rapid and uniform than that of unprimed ones. Similar results were reported by Rouhi *et al.* (2018) in their study on hydro priming with distilled water for 15 h improves the germination of coriander with higher antioxidant enzyme activities, soluble sugars and total proteins of primed seeds than of non-primed. Soaking cucumber seeds for 24 h improves the germination attributes (Shakuntala *et al.,* 2020) while 48 h of seed hydro-priming was found to be effective for increasing germination and seedling growth in bitter gourd (Adhikari *et al.,* 2021). In the study by Sabongari and Aliero (2004) observed that the seeds of tomato variety Roma VF, UC82B and Xina showed maximum germination % under 24 h treatment. The study of Elkoca *et al.* (2014) reported that seed priming duration of 24 h had a negative effect on the germination of pea cv. Winner compared to 12h priming. Similar reduction in germination parameters by increasing priming duration was observed in soybean (Khalil *et al.,* 2001). Murray (1989) concluded that over priming may cause oxygen deficiency and the build-up of inhibitors resulting reductions in germination parameters. The higher dosages are hazardous, which has a negative impact on seed germination and plant growth (Adhikari *et al.,* 2012). In the present study on coriander variety Jawahar Dhaniya-1, it was observed that germination percent of coriander was improved by 82% when treated with Cu @ 500ppm. This was in correspondence with the work reported by Mehra *et al.* (2022) on same variety of coriander Jawahar Dhaniya-1. They adumbrated that seed primed with Mn 450ppm recorded maximum germination (96.81%) followed by Cu at 450 ppm with 95.81%.

The mean germination time is a measure of the time taken for the seed to germinate, focusing on the day at which most seeds have been germinated. The stimulation of metabolic activity in the embryo was probably responsible for the increase in germination percentage and rate as well as the decrease in germination time. Priming synchronizes all the cells of the germinating embryo in the G2 Phase of the cell cycle so that upon further imbibitions, cell division proceeds uniformly in all the cells ensuring uniform development of all parts of the seedlings (Varier *et al.,* 2010). Information on the mean germination time of different priming treatments is shown in Table 1. The results revealed significant variations among the treatments it decreased significantly with the increase in the soaking duration. In the present investigation the least mean germination time (7.9 days) was taken by T_{11} (seeds primed with Cu at 500 ppm for 16 h), which was at par with T_{12} (seed primed with Cu @500 ppm for 18h) with 8.0 days Mean Germination Time and T10 (seed primed with Cu 500 ppm for 14 h with (8.9 days) Mean Germination Time. Maximum (11.2 days) were spent in T_1 (seed primed with Cu 0 ppm for 14 h) in the same way Mehra *et al.* (2022) also reported least mean germination time of 6.99 days when treated with Mn @450 ppm followed by Cu @ 450 ppm with 7.51 days. The study on Arka Anamika variety of okra Lamichhane *et al.* (2021) reported maximum germination (60.12%), seed vigour (5772.68 cm) and mean germination rate (7.53 seeds per day) in seed priming with GA3 @ 200 ppm for 24 h. According to Basra *et al.* (2006), during water absorption, DNA replication, RNA activity stimulation, protein synthesisand germination-stimulating hormones like auxin and ethylene increased resulting increased germination in comparison to the control group. Earlier germination of primed seeds may be due to increase in activity of enzymes such as amylase, protease and lipase which have great role in breakdown of macromolecules for growth and development of embyo as revealed by Dell-Aquila and Tritto (1990).

The germination index data revealed in Table 1 showed significant differences between the treatments. Scrutiny of the data revealed a steady increase in Germination index with the increase in concentration of Cu as well as duration

Table 1: Effect of seed priming on germination attributes and seed vigour of coriander seedlings.

Seed priming	Germination (%)	Mean germination time (days)	Germination index (GI)	Plumule length (cm)	Radicle length (cm)	Vigour index-I (cm)	Vigour index-II (g)
T_1: Cu 0 ppm (14h)	64.00	11.20	9.82	11.86	12.42	1,606.89	6.06
T_2: Cu 0 ppm (16h)	68.00	10.40	11.58	12.24	13.56	1,676.78	6.95
T_3: Cu 0 ppm (18h)	65.33	10.70	10.70	11.88	12.64	1,700.66	7.86
T_4: Cu 300 ppm (14h)	69.33	10.40	12.04	12.45	13.70	1,773.88	7.96
T_5: Cu 300 ppm (16h)	74.00	9.50	15.13	12.40	14.00	1,784.53	7.83
T_6: Cu 300 ppm (18h)	74.00	10.20	16.11	12.40	14.25	1,897.88	9.95
T_7: Cu 400 ppm (14h)	73.33	9.30	16.50	12.68	14.62	1,864.56	9.43
T_8: Cu 400 ppm (16h)	72.00	9.10	16.03	12.64	14.23	1,809.86	8.66
T_9: Cu 400 ppm (18h)	72.00	9.10	13.57	12.63	14.08	1,872.72	9.25
T_{10}: Cu 500 ppm (14h)	76.00	8.90	17.31	12.70	14.74	1,938.33	10.12
T_{11}: Cu 500 ppm (16h)	82.00	7.90	22.83	13.09	17.30	2,374.05	12.29
T_{12}: Cu 500 ppm (18h)	80.00	8.00	17.73	13.06	14.90	2,122.12	10.45
SEm±	2.79	0.65	1.323	0.225	0.571	78.541	0.832
C.D.($p=0.05$)	8.19	1.93	3.886	0.662	1.676	230.609	2.444

of soaking. The treatment T_{11} (seed primed with Cu @ 500 ppm for 16 h) recorded the highest germination index of 22.83, followed by T_{12} (seed primed with Cu @ 500 ppm for 18h) with 17.73 GI and T_{10} (seed primed with Cu @ 500 ppm for 14 h) with 17.31 GI. T_1 (Seed primed with Cu 0 ppm for 14 h) recorded to have the lowest (9.82) germination index values.

The data on length of radicle and plumule is given in Table 1. The outcome showed that the length of the radicle and plumule was significantly increased by the varied priming concentration of Cu. The T_{11} (seeds primed with Cu @ 500 ppm for 16 h) produced the longest plumule, measuring 13.09 cm and produced radicle with a maximum length of 17.30cm which was at par with the treatments T_{12} (seed priming with Cu @ 500 ppm for 18 h) and T10 (seed primed with Cu @ 500 ppm for 14 h), which produced plumule of length 13.06 cm and 12.70 cm, respectively and radicle length of 14.90 cm and 14.74 cm, respectively . In T_1 (seed priming with Cu @ 0 ppm for 14 h), the radicle and plumule length was shortest 12.42 cm and 11.86 cm respectively. Similar result were reported by Sarkar *et al.,* 2020 with the highest root (21.4 cm) and shoot length (12.3 cm) was found when seeds were primed with 2% KH2PO4 for 20h in coriander. Akram *et al.* (2020) demonstrated that seed priming with 40 µM copper sulphate produces maximum shoot (15.21cm) and root length (11cm) of green gram while higher concentration of $CuSO_4$ (80µM) decreases the shoot and root length (3.27 cm) due to copper stress which decreased the process of cell division. Abdoli (2014) primed fennel seeds with PEG solutions and found an increase in the length of plumule, radicle and seedling, similarly increase in fresh and dry mass production of seedlings. Similar results were also reported by Mahdavi and Rahimi (2013) in their study under salt stress condition the ajowan seeds when primed with chitosan solution improved the germination and growth parameters like germination %, germination rate, seedling vigour index, hypocotyl length, radicle length and dry radicle weight. Chitosan is a polysaccharide biopolymer which stimulates growth of plants and also increases the crop yield. In priming, the osmotic pressure and the duration of maintaining the seeds in contact with the membrane are enough to allow pre-germinative metabolic processes to be occurring within the seeds up to a level limited to that instantly preceding radicle emergence (Gour *et al.,* 2019). Accumulation of more sugar which could readily support metabolic activity leading to faster seedling emergence (Sung and Chang, 1993). Increase in beta-tublin in the radicle tip has been observed during the seed priming by Bino *et al.* (1992). Microtubules (MTs) are elongated tubular structures, made of α and β-tubulin, which in plant cells play an important part in cell elongation, determination of the division site, chromosome separationand cytokinesis (Alberts *et al*., 2002 and Wasteneys and Galway, 2003).

The ability of a seed to establish seedlings quickly and uniformly is determined by an array of biochemical and molecular processes, which together make up the complex feature known as seed vigour. The data for the Vigour Index-I and Vigour Index-II was conferred in Table 1. The results showed that particular concentration of Cu had a favourable impact on the vigour index-I. Treatment T_{11} (Seed priming with Cu @ 500 ppm for 16 h) was found to demonstrate the maximum vigour index-I value, measuring 2,374.05 cm and highest vigour index-II of 12.29 g value followed by T_{12} (seed primed with Cu @ 500 ppm for 18 h) and T_{10} (seed primed with Cu @ 500 ppm for 14 h), each of which had vigour index-I values of 2,122.12 and 1,938.33 cm respectively and vigour index-II of values 10.45 g and 10.12 g respectively. T_1 (seed primed with Cu 0 ppm for 14 h) had the lowest vigour index-I and vigour index-II score 1,606.89 cm and 6.06 g respectively. This corresponds to the results reported by Sarkar *et al.* (2020), that highest seedling vigour index (3000 cm) was the result of seed primed with 2% KH2PO4 for 20h in coriander. In the study of Mehra *et al.* (2022) reported that the highest vigour index-I (1172.72 cm) and vigour index-II (5.36 g) was noticed from seed priming with Mn @450 ppm followed by Cu @450 ppm compared to control (unprimed seeds). Further more, Mahmoodi *et al.* (2011) in their research concluded that priming for 18h improves seedling vigour and field establishment of maize. Seed priming leads to enhancement in the vigour due to increase in the seed hydration status required to achieve critical and threshold water potential for germination finally leading to rapid and uniform field crop establishment and increased seed yield (Koutu *et al.,* 2019). The valuable effects of seed priming on seed germination rate are associated with the repair and build-up of nucleic acid, enhanced synthesis of RNA and proteins, repair of membranes and some age-induced damage (Bray *et al.,*1989) and enhanced respiratory activity of seeds (Benamar *et al.,* 2003).

The study revealed a substantial effect between copper levels and soaking times. From the result it can be concluded that seed priming with Cu @ 500 ppm soaking for 16 h improves the germination and vigour characteristics of the seedlings which is closely followed by Cu @ 500 ppm soaking for 18h.

CONCLUSION

The study revealed substantial effect between copper levels and soaking times. From the results it can be concluded that seed priming with Cu @500 ppm for 16 h improved the germination and vigour characteristics of the seedlings. In order to achieve a specific conclusion additional research coud be done to explore the effect of seed priming durations for extended periods.

Conflict of interest

The authors hereby declare that they have no known competing financial interests that could have appeared to influence the work reported in this paper.

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