*Original Research Article*

# CORIANDER SEED QUALITY AND VIGOUR ASSESSMENT AS AFFECTED BY BIOREGULATORS AND VARIED IRRIGATION REGIMES BASED ON CLIMATOLOGICAL APPROACH



## Abstract

The evaluation of seed quality parameters in coriander (*Coriandrum sativum* L.) under different irrigation regimes based on climatological approach and varied compositions of stress mitigating chemicals was carried out in the Laboratory of Seed Technology Research Unit, Department of Plant Breeding and Genetics, College of Agriculture, JNKVV Jabalpur (M.P.). The investigation consisted of four Irrigation regimes *ie* IW/CPE 0.6, 0.8, 1.0 and 1.2 and stress mitigating chemicals (Salicylic acid, thiourea and $KNO_3$) with different concentrations. The experiment was laid out in Completely Randomized Design with three replicates during *Rabi* season (2020-21 and 2021-22). The findings revealed significant influence on Germination percent, Test weight, radicle length, plumule length, seedling height, seed moisture content, total solids, seed vigour index I & II of coriander was observed. Marked influence of applied irrigation regime was exhibited by the seed lot collected from plots with IW/CPE ratio 0.8. The maximum standard germination of 82.89% was recorded in seeds from the plants which were grown in sufficient moisture content comprising of IW/CPE 1.2. Exogenous application of salicylic acid improved the seed germination parameters. The highest concentration was most effective in each treatment. Salicylic acid @ 150 ppm expressed better results. The results depicted higher test weight with 17.80g, higher plumule length of 15.75cm, radical length of 5.61 cm, seedling height of 21.36 cm, maximum magnitude 1841.64 and 28.33 of seed vigour index I & II respectively for Jawahar Dhaniya-10 was registered when the seeds harvested from plots with treatment combination of IW/CPE 0.8 along with foliar spray of salicylic acid @ 150ppm (I2C2). Higher content of 89.57% total solids was expressed under interaction of IW/CPE 0.6 with exogenous application of thiourea @ 500ppm (I1C3). Hence it can be concluded that treatment combination of IW/CPE 0.8 along with foliar spray of salicylic acid @ 150ppm (I2C2) ascertained better seed germination and quality attributes.

***Keywords***: Coriander, IW/CPE ratio, Salicylic acid, Thiourea, Germination parameters and Vigour Index.



**Introduction**

Seed spices are annual herbs which are natures gift to mankind as there dried seeds and fruits are used as spices. They add flavour to the food, can be used as preservative and possess medicinal properties (Anonymous, 2015). Coriander (*Coriandrum sativum* L.), a member of umbelliferae family, is cultivated for its high commercial value of stems, leaves and seeds and considered as natural source of essential oils, *i.e.*, petroselinic acid, geraniol, limonene and linalool, used in pharmaceutical and food industries (Hassan and Ali, 2013). Dhaniya seed retains aromatic odour and taste of coriander fruits owing to the essential oil content. In conjugation with the essential oil, the seed also comprises of 16.1% fatty oil, 14.1% protein, 21.6% carbohydrate, 32.6% fibers, 11.2% moisture and 4.4% mineral matters and coriander leaves are rich source of vitamin A and Vitamin C (Singh *et al.,* 2017). Worldwide appreciation is received by *cilantro* as it is a basic ingredient in varied traditional foods, particularly curry powder because of its strong and typical aroma (Mahendra and Bisht, 2011 and Sahib *et al.*, 2013).

Despite its significance, coriander productivity in India remains low, which may be ascribed to many reasons, of which, availability of quality seed is one of the determining factor. Quality seed is an essential unit for releasing higher yield per unit area. A crucial element in achieving the seed quality of any crop is the management of irrigation and fertilisers. The quality seed not only enables the farmers to take economic decisions regarding cost of seed but it provides them an understanding about the quality of seed to plant, uniformity of plant stand and consequently higher net returns. To meet the goal of agricultural production, it is crucial that genetically pure and robust seed is available at planting time. It is reported that the use of quality seeds can raise the productivity of crop by 15-20% (Ambika, 2014 and Singh and Malik 2021).

Production of higher quality seed is of utmost importance as the seed spices have higher commercial value. The seed quality can be estimated by seed size, weight, density, germination percentage, moisture content, vigour index, seedling length and dry weight. Seed size and test weight are important seed quality attributes that affects the seed germination, establishment and performance of the crop (Adebisi *et al*., 2011). The vigorous seeds are very beneficial with properties like rapid seedling emergence and higher plant stand (Deswal, 2017). Several germination tests have been carried out to correlate well with field emergence. The assessment of seed physiological potential is usually performed through germination and vigour tests. The vigour tests are regarded as important for revealing relatively narrow variations in the different deterioration stages of the seeds of a seed lot (Baalbaki *et al*., 2009). Physiological quality of seeds as determined by an emergence test is not enough to predict storage potential of seeds (Suman *et al*., 2018).

Water deficit during early reproductive growth stage can reduce the duration of seed-filling period that will have an effect on seed oil content and can influence the oil composition in seed (Yeganehpoor *et al*., 2017). Optimum utilization of water by the mother plant during seed production is predominant as it influences seed yield and quality of spice crops. The majority of research on the water requirements of various crops has concentrated on optimizing yield of commodity products and has only rarely taken seed yield or quality characteristics into account. The impact of water stress on seed yield confides on the crop and varies depending on the intensity, duration, and timing of the water deficit. Water stress before and during flowering has generally been found to reduce the number of seeds produced per plant, which has an effect on seed yield. Seed is the most vital input of agriculture and without high quality seeds, other inputs remain worthless. The seed quality depends upon the climate variables prevailing during the entire crop growth period. Rabi crop production is more risky due to shortened crop growth periods and increased terminal heat and water stress (Maity and Pramanik 2013). The two critical stages of water requirement in coriander are flower initiation and seed development. It is imperative to mitigate the impact of climate change on Coriander since Irrigation scheduling is a systematic method through which the farmer can decide when to irrigate and how much water to apply. In climatological approaches, irrigation is scheduled on IW/CPE ratio (Sharma *et al.* 2022). In this approach, known amount of irrigation water is applied when cumulative pan evaporation reaches predetermined level. Irrigation is a very important factor affecting the growth and yield of coriander and also affects the composition of volatile oils. Therefore, available water has to be used very precisely to enhance yield without affecting the seed quality.

Exogenous application of stress mitigating chemicals such as salicylic acid, thiourea and $KNO_3$ offer unique opportunities of scaling plants to any size and alter physiological processes in the plant to increase seed yield and quality in various crops. Bioregulators act as an effective tool to enhance growth, productivity, seed quality to combat with various abiotic stresses and play a vital role in uptake of nutrients, maintain membrane stability, water relations, stomatal regulation, photosynthesis, growth and inhibition of ethylene biosynthesis (Sharma *et al*., 2022). Salicylic acid participates in the regulation of various physiological processes, seed germination, flowering and heat production in thermo-genic plant (Yeganehpoor *et al.,* 2021). Therefore considering significance of coriander, the present investigation was carried out to access the influence of stress mitigating chemicals and irrigation scheduling based on climatological approach on seed germination traits and quality. This research paper focuses on studying the seed quality and vigour of coriander since there are a few documented researches.

## Materials and Methods

The experiment conducted at Vegetable Research Centre, Department of Horticulture, JNKVV, Jabalpur, Madhya Pradesh, India during *Rabi* season for two years 2021 and 2022. The investigation was laid out in split plot design in the field consisted of four Irrigation regimes *ie* IW/CPE 0.6, 0.8, 1.0 and 1.2 as the main plot and stress mitigating chemicals (Salicylic acid, thiourea and $KNO_3$) as sub-plots with different concentrations. All the agronomic practices were carried out as per the recommendations for a successful raising of coriander crop. Crop was harvested plot-wise after it reached full maturity. Harvested seeds were dried in shade under open field conditions for 3 to 4 days followed by threshing and winnowing to obtain a better seed lot. Thereafter, the collection of seed samples was done from properly dried and clean seeds. The quality of coriander seeds harvested from various plots was evaluated using Completely Randomized Design with three replications at the Laboratory of Seed Technology Research Unit, Department of Plant Breeding and Genetics, College of Agriculture, JNKVV Jabalpur (M.P.). Observations were recorded on standard germination, seedling length, seedling dry weight, seedling vigour index-I, seedling vigour index-II, seed density and electrical conductivity.

The data was analysed statistically at 5 % level of significance ($p = 0.05$) as per the methods suggested by Panse and Sukhatme (1978). The aggregate of two years data has been illustrated here through tables and ANOVA using SAS software and Duncan's mean range test to compare the treatment means at the level of 0.05 probabilities. The seed quality parameters tested for the experiment are as follows:

Seeds of all five randomly selected plants from each plot were mixed and randomly 1000 seeds were taken out from the lot and weighed using electronic balance. The average value was recorded as test weight in grams.

Germination percent was determined through three replication of 100 seeds from respective treatments were used for germination by using between paper methods (BP) at 25 ± 20 °C in seed germinator for 8 days at 90% relative humidity. The seeds were categorized as normal seedlings, abnormal seedlings, hard seed, and dead seed. The germination percentage was recorded based on normal seedlings only. Germination percentage was worked out according to standard procedure (AOAC, 1995) using the following formula:

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds kept for germination}} \times 100$$

The seedlings root length, shoot length and height were measured after the final count in standard germination test. Ten normal seedlings were selected randomly from each replicate. The seedlings root length (cm) was measured from the point of attachment to the tip of the root (ISTA, 1999). The shoot length was measured from point of the attachment of the cotyledon to the tip of the seedling. The seedling length was measured from tip of shoot to root tip and the mean length will be calculated and expressed as seedling length in centimeters. Ten normal seedlings used for root and shoot length were selected randomly were weighed to determine the fresh weight. The seedling were kept in paper bag and dried in hot air oven at $60^0$C for 48 hours. Then the seedlings were removed and allowed to cool in a desiccator for 30 minutes and thereafter, the weight of dried sample was recorded and expressed in grams (ISTA, 1999).

Moisture content of coriander seeds was determined by using a laboratory oven method (AOAC, 1995)

$$\text{Moisture content \%} = \frac{\text{Initial weight (g) - Final weight (g)}}{\text{Initial weight (g)}} \times 100$$

Total solids of seed was obtained using an accurate measurement through moisture content and determined using the formula:

$$\text{Total Solids} = 100 - \text{Moisture content (\%)}$$

Seed Vigour index I was computed by adopting the following formula as suggested by Abdul Baki and Anderson (1973) and expressed in number.

$$\text{Seed Vigour I} = \text{Germination (\%)} \times \text{Seedling length (cm.)}$$

Seed Vigour Index II was calculated using formula given by Abdul-Baki and Anderson (1973) by multiplying the standard germination with mean seed used.

$$\text{Seed vigour II} = \text{Germination (\%)} \times \text{Mean seedling dry weight (g)}$$

**Results and Discussion**

A close inspection of analysis of variance embossed Table 4 and 5 revealed that test weight (g) and germination attributes viz. seed germination percentage, seed moisture content, total solids, seedling height, seedling dry weight, seed vigour Index I & II was significant for irrigation scheduling and varied compositions of stress mitigating chemicals.

**Influence of Irrigation Regimes**

Test weight indicates the degree of development of the seed and is regarded as a crucial indicator of seed quality. It determines the density of the grain and contributes to yield and quality of the seeds. Marked influence of applied irrigation regime exhibited for test weight of coriander seeds. The array of data appertaining to test weight of coriander seeds have been tabulated in Table 1. Coriander crop sown under IW/CPE 0.8 produced bolder seeds. The scrutiny of the data for mean value of two years expressed that the magnitude increment in test weight under IW/CPE 0.8 higher test weight of 16.76g. It is validated from the present findings that more test weight might be due to enhanced physiological activities like photosynthesis and translocation of nutrients and photosynthates. The results also support the findings of Singh (2014) and Natesh *et al*. (2005) in coriander, Talab *et al.* (2014), Krishnaveni *et al*. (2016) and Shivran and Jat (2013). Soltani *et al*. (2002) and Pereira *et al.* (2008) reported similar results, stating that seed germination and development is higher for seeds with higher seed size, weight and density. Pramila *et al.* 2013 also explained that seed lots with higher test weight paralleled superior quality in terms of higher germination and seedling vigour.

Germination referred to as emergence and development of the seedling into a young plant from seed embryo Standard germination test used to assess the emergence capacity of seed lots and its ability to germinate under favourable conditions (ISTA, 2003). The data compiled during the experiment contemplated significant variations. Variation of germination percentage is portrayed in Table 1. The maximum standard germination of 82.89% was recorded in seeds from the plants which were grown in sufficient moisture content comprising of IW/CPE 1.2 whereas minimum germination of 79.24% was recorded with IW/CPE 0.6 where the crop grown with two irrigations only. Lower seed germination percentage can be attributed to immature embryos and lower food reserves. Seeds with fully mature embryos and high amounts of food reserves are potentially the most germinative and vigorous ones (Deswal *et al.,* 2017). Thakur and Thakur (2018) reported a percent decrease in germination percentage at 75% water deficit. This is in agreement with the results of Balla *et al*., 2013 in onion.

The findings on seedling length (cm) and seedling dry weight (g) revealed that significant variations were apparent. The set of the observations embodied in Table 1 revealed that the seeds harvested from the plots comprising of IW/CPE 0.8 possessed higher plumule length of 15.39 cm, radical length of 5.20 cm and seedling height of 20.60 cm. This may be because plants in frequently irrigated treatments retained higher leaf water potential, better stomatal conductance, and thus higher transpiration to keep the plant canopy temperature low. This resulted in higher carbohydrate production because the stomata were opened for a longer period of time, and the carbohydrates were then transported to the sink. The coriander seeds thus had superior quality traits (Singh *et al.*, 2017).

**Table 1. Seed Germination attributes as influenced by combined application of different irrigation scheduling based on IW:CPE ratio and stress mitigating chemicals in coriander crop (Pooled data).**

| Treatments | Seed Germination Parameters | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Seed Germination (%)** | **Seed Moisture Content (%)** | **Total Solids (%)** | **Plumule Length (cm)** | **Radical Length (cm)** | **Seedling Height (cm)** | **Seedling Dry Weight (g)** | **Seed Vigour Index-I** | **Seed Vigour Index-II** | **Test Weight (g)** |
| **Main Plot: IW/CPE RATIO** | | | | | | | | | | |
| **IW/CPE 0.6** | $79.24^{d}$ | $10.81^{d}$ | $89.19^{a}$ | $9.81^{d}$ | $3.99^{d}$ | $13.81^{d}$ | $0.300^{d}$ | $1095.01^{d}$ | $23.77^{d}$ | $14.86^{d}$ |
| **IW/CPE 0.8** | $81.81^{c}$ | $11.53^{c}$ | $88.47^{b}$ | $15.39^{a}$ | $5.21^{a}$ | $20.60^{a}$ | $0.311^{a}$ | $1686.07^{a}$ | $25.39^{c}$ | $16.76^{a}$ |
| **IW/CPE 1.0** | $82.87^{b}$ | $12.12^{b}$ | $87.88^{c}$ | $13.75^{b}$ | $4.74^{b}$ | $18.49^{b}$ | $0.308^{c}$ | $1533.88^{b}$ | $25.51^{b}$ | $15.62^{c}$ |
| **IW/CPE 1.2** | $82.89^{a}$ | $12.82^{a}$ | $87.18^{d}$ | $11.72^{c}$ | $4.14^{c}$ | $15.86^{c}$ | $0.309^{b}$ | $1314.66^{c}$ | $25.62^{a}$ | $15.87^{b}$ |
| S.Em± | 0.135 | 0.124 | 0.112 | 0.1876 | 0.0462 | 0.2319 | 0.0065 | 16.42 | 0.380 | 0.194 |
| C.D. (at 5%) | 0.315 | 0.432 | 0.311 | 0.6491 | 0.1599 | 0.8026 | 0.0225 | 57.85 | 1.079 | 0.673 |
| **Sub Plot: Stress Mitigating Chemicals** | | | | | | | | | | |
| **C0 No Spray** | $78.88^{g}$ | $11.53^{g}$ | $88.47^{a}$ | $12.45^{f}$ | $4.07^{e}$ | $16.77^{f}$ | $0.297^{f}$ | $1302.88^{g}$ | $23.47^{g}$ | $14.68^{g}$ |
| **C1 SA (75 ppm)** | $82.55^{c}$ | $12.15^{b}$ | $87.85^{d}$ | $12.62^{bc}$ | $4.79^{ab}$ | $17.42^{b}$ | 0.305c | $1440.37^{c}$ | $25.15^{c}$ | $15.67^{e}$ |
| **C2 SA (150 ppm)** | $84.89^{a}$ | $12.42^{a}$ | $87.58^{e}$ | $13.22^{a}$ | $5.07^{a}$ | $18.30^{a}$ | $0.325^{a}$ | $1557.91^{a}$ | $27.61^{a}$ | $16.60^{a}$ |
| **C3 Thiourea (500 ppm)** | $81.15^{d}$ | $11.54^{f}$ | $88.46^{a}$ | $12.69^{b}$ | $4.59^{c}$ | $17.05^{d}$ | $0.300^{d}$ | $1385.56^{d}$ | $24.36^{e}$ | $15.93^{c}$ |
| **C4 Thiourea (1000 ppm)** | $83.14^{b}$ | $11.77^{c}$ | $88.23^{c}$ | $12.59^{cd}$ | $4.76^{ab}$ | $17.36^{c}$ | $0.311^{b}$ | $1444.39^{b}$ | $25.83^{b}$ | $16.18^{b}$ |
| **C5 $KNO_3$ (50 mM)** | $80.45^{f}$ | $11.59^{e}$ | $88.41^{ab}$ | $12.49^{de}$ | $4.01^{f}$ | $16.51^{g}$ | $0.298^{e}$ | $1351.44^{f}$ | $23.98^{f}$ | $15.57^{f}$ |
| **C 6 $KNO_3$ (100 mM)** | $80.84^{e}$ | $11.72^{d}$ | $88.28^{c}$ | $12.58^{cd}$ | $4.33^{d}$ | $16.91^{e}$ | $0.311^{c}$ | $1369.27^{e}$ | $25.10^{d}$ | $15.86^{d}$ |
| **S.Em±** | 0.145 | 0.131 | 0.145 | 0.2890 | 0.0862 | 0.3453 | 0.0063 | 16.42 | 0.503 | 0.260 |
| C.D. (at 5%) | 0.444 | 0.373 | 0.412 | 0.8221 | 0.2452 | 0.9818 | 0.0044 | 56.83 | 1.428 | 0.740 |

Different characters in the table indicate that there are significant differences by Duncan's mean range test at p=0.0.

The findings indicated in Table 1 expressed that irrigation regime having IW/CPE ratio had a significant effect on seedling dry weight. The results exhibited that more dry weight of 0.311g was recorded under IW/CPE 0.8. Seed Vigour Index I exhibited higher magnitude (1686.07) for those harvested from plots possessing IW/CPE 0.8 whereas a higher value for Vigour Index II (25.62) was noted under IW/CPE 1.2.The lowest magnitude of 1095.01 and 23.77 was exhibited for seed lot collected from plots with IW/CPE 0.6 for vigour index I & II respectively. The findings contemplate with those of Singh *et al.,* (2017), Suman *et al.,* 2018, Singh and Malik (2021) in coriander, Deswal *et al.,* (2017) in Fennel are in propinquity to the present findings.

Seed moisture content values were statistically influenced by the different irrigation regimes (Table 2). IW/CPE 1.2 gave higher magnitude of 12.82% for this trait whereas IW/CPE 0.6 registered lower magnitude of 10.81% moisture in seeds in the pooled average. The results of this study confides with the findings of Thakur and Thakur (2018) who observed that the seed moisture content in seeds harvested from water stressed plants below unstressed ones. The introspection of results revealed that maximum total solids of 89.19% was present in coriander seeds when the seeds were harvested from plots containing IW/CPE 0.6 and minimum 87.18% Total solids was exhibited under IW/CPE 1.2 in the pooled average.

**Influence of Stress Mitigating Chemicals**

The cluster of data enumerated through Table 1 expressed that varied compositions of bioregulators to overcome stress had a significant influence on Germination percent, Test weight, radicle length, plumule length, seedling height, seed moisture content, total solids, seed vigour index I & II of coriander. A scrutiny of the data on weight of 1000seeds enumerated in Table 1 showed that stress mitigating chemicals had a profound effect of this trait. Foliar application of salicylic acid @150ppm (C2) produced bolder seeds weighing 16.60g as test weight. Contrastingly, smaller seeds were produced under control (No spray) thus weighing 14.68g for this trait.

Germination percentage evinced a significant influence due to exogenous application of bioregulators. The maximum standard germination of 84.89% was recorded in seed lot collected from plots treated with salicylic acid (150ppm) (C2) whereas minimum germination of 78.88% was recorded with foliar spray of KNO@ 50mM. Singh and Malik (2021), Sarkar *et al.* (2020), Suman et al. (2020) in coriander, Malik and Tehlan (2013) in coriander, Ravikumar *et al.* (2019) and Mamatha *et al.* (2017) in fennel reported the similar findings of high significant variability.

The aggregate of data embodied in Table 1 so assembled expressed that maximum plumule length (15.36cm), radical length (5.20cm) and seedling length (18.30cm) was elucidated with foliar spray of Salicylic acid @ 150ppm (C2) which was statistically superior than other chemicals. The findings of this experiment are in close proximity with the observation of Singh *et al.*, (2017), Suman *et al.*, 2018, Singh and Malik (2021) in coriander, Deswal *et al.*, (2017) in Fennel.

Seedling dry weight was statistically influenced by compositions of stress mitigating chemicals such as salicylic acid, thiourea and $KNO_3$. Seedling dry weight of 0.325g was obtained with foliar application of Salicylic acid @ 150ppm (C2) whereas lowest value (0.298g) for the trait was recorded under control (C0). The increase in dry weight of coriander seedlings might owing to rapid germination, which lead to elongation of roots and resulted in enhancement of weight. The findings corroborate with those of Singh *et al.*, (2017), Suman *et al.*, (2018), Singh and Malik (2021) in coriander, Srivastava *et al.*, (2016) and Deswal *et al.*, (2017) in Fennel.

The results evinced that maximum 12.42% moisture in seeds was registered with the exogenous application of salicylic acid @ 150ppm (C2) which showed superiority and was followed by the application of thiourea @1000ppm(C4) in the average mean of two years.

Minimum 11.53% seed moisture was noted under C0 no spray (control) during mean data of two years. Yalcın and Karababa (2007) and Sharanagat and Goswami (2014) evaluated the physical properties of coriander seeds and found seed moisture content varying from 8% to 16% (w.b.) which is in range with our findings. The mean values of the results for two years revealed that higher total solid content of 88.47% was recorded under control (No spray) which was statistically at par with the application of thiourea @1000 ppm (C3) (88.46%) and lowest value (87.58%) was noted under foliar spray of salicylic acid (150ppm) (C2).

Seedling Vigour Index I and II was significantly influenced by different compositions of stress mitigating chemicals. Significant superior mean performance of seed vigour I (1557.91) and seed vigour index II (27.61) was indicated when the crop was sprayed with salicylic acid @ 150ppm (C2) whereas lowest value for seed vigour I (1302.88) and II (23.47) was noted under control (C0). The improvement in vigour index might be attributed to improved germination which was due to stimulation of enzymatic activities. This might also be due to good seedling growth caused by improved mobilization of food reserves. The results are in accordance with the findings of Dhungel *et al*. (2007) who reported significant increase in vigour index of chilli and Kumar *et al*. (2018) in coriander.

**Interaction effect of Irrigation scheduling and stress mitigating chemicals**

Concerning the interaction effect based on irrigation regimes and varied compositions of chemicals, the aggregate of the data enlisted in the Table 2 & 3 showed significant effect for radicle length, plumule length, seedling height, total solids, seed vigour index I & II and test weight (g).

The findings (Table 3) ascertained that higher (17.80g) mean value of two years for test weight of coriander seeds was expressed under the combination of IW/CPE 0.8+ SA @ 150ppm (I2C2) which was successfully preceded by combination I2C4 (17.34g). Smaller seeds were produced when the crop was grown under IW/CPE 0.6 with no spray of chemicals (I1C0) thus weighing 13.64g. Large and heavy seeds have a competitive advantage over smaller and light seeds by having higher germination rates and greater nutrient reserves for the young seedlings, which enables the seedlings to grow larger and vigorous to tap resources earlier than their small-seeded counterparts (Deswal *et al.*, 2017).

The interpretation of the result in Table 2 & 3 validated that higher plumule length of 15.75cm, radical length of 5.61 cm and seedling height of 21.36 cm for Jawahar Dhaniya-10 was registered when the seeds harvested from plots with treatment combination of IW/CPE 0.8 along with foliar spray of salicylic acid @ 150ppm. The radicle length and seedling height of treatment I2C4 was at par with I2C2 which reflected superiority.

The differences in the seed viability and vigour are a function of complex interaction of genetic constitution and environmental factors (Deswal *et al.*, 2017). The vigour assessment of coriander seeds revealed that maximum magnitude 1841.64 of seed vigour index I was reported for seed lot harvested from plots with treatment combination of IW/CPE 0.8 along with foliar spray of salicylic acid @ 150ppm (I2C2). Higher value 28.33 for seed vigour index II was noted in treatment I2C2. I3C2 was found at par with I2C1.

Higher content of 89.57% total solids was expressed under interaction of IW/CPE 0.6 with exogenous application of thiourea @ 500ppm (I1C3) which was followed by I1C0, I1C1, I1C5 and I1C6.

The results validates with the findings of Singh *et al.,* (2002) who reported pronounced effect of irrigation on quality parameters in coriander, but contradict findings were noted wherein it was observed that irrigation schedule did not influence seed quality character like germination percentage (Singh *et al.,* 2017). It was established that the seed quality of coriander was better for the combinations possessing higher length and more dry weight of seedling (Singh and Malik. 2021). These findings endorse the results of Kumar (2017), Singh *et al.* (2017) and Sarkar *et al.* (2020) who reported that seed quality improves with enhancement in seedling length, seedling fresh weight, seedling dry weight, vigour index-I, vigour index-II parameters and vice-versa. Nonetheless, a negative correlation of seed size with germination percentage, seedling root and shoot length has also been ascertained by Kaya *et al*. (2008) and Deswal *et al.* (2017).

## Conclusion

The introspection of the data for different irrigation scheduling based on IW/CPE ratio and varied compositions of stress mitigating chemicals such as salicylic acid, thiourea and $KNO_3$ elucidated that better seed germination and vigour assessment was registered when the seeds were collected from plants harvested from plots with IW/CPE 0.8. Exogenous application of salicylic acid @ 150 ppm improved the seed germination parameters. Treatment combination of IW/CPE 0.8 along with foliar spray of salicylic acid @ 150ppm (I2C2) endorsed superiority an expressed better germination traits. The reduction in seed quality attributes of coriander due to different irrigation regimes at the time of seed development gave varied results. Since, availability of resources in proper quantity during seed development plays a prominent and crucial role in producing the good quality seed which will show better performance in field.

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**Table 2. Seed Germination Attributes as influenced by combined application of different irrigation scheduling based on IW:CPE ratio and stress mitigating chemicals in coriander crop (Pooled data).**

| Treatments | | Seed Germination Attributes | | | | |
|---|---|---|---|---|---|---|
| | | **Seed Germination (%)** | **Seed Moisture Content (%)** | **Total Solids (%)** | **Plumule Length (cm)** | **Radical Length (cm)** |
| **T1** | **I1C0** | 77.29$^{a}$ | 10.60$^{a}$ | 89.40$^{ab}$ | 10.25$^{hij}$ | 3.55$^{j}$ |
| **T2** | **I1C1** | 80.55$^{a}$ | 10.72$^{a}$ | 89.28$^{ab}$ | 9.88$^{ij}$ | 4.28$^{efg}$ |
| **T3** | **I1C2** | 81.51$^{a}$ | 11.03$^{a}$ | 88.97$^{abc}$ | 9.91$^{ij}$ | 4.66$^{def}$ |
| **T4** | **I1C3** | 78.99$^{a}$ | 10.43$^{a}$ | 89.57$^{a}$ | 9.90$^{ij}$ | 4.00$^{ghij}$ |
| **T5** | **I1C4** | 80.92$^{a}$ | 11.13$^{a}$ | 88.87$^{abc}$ | 10.18$^{hij}$ | 4.10$^{fgh}$ |
| **T6** | **I1C5** | 76.62$^{a}$ | 10.76$^{a}$ | 89.24$^{ab}$ | 9.26$^{j}$ | 3.56$^{j}$ |
| **T7** | **I1C6** | 78.83$^{a}$ | 10.98$^{a}$ | 89.02$^{ab}$ | 9.27$^{j}$ | 3.84$^{hij}$ |
| **T8** | **I2C0** | 80.98$^{a}$ | 11.90$^{a}$ | 88.10$^{bcde}$ | 15.14$^{abcd}$ | 4.57$^{def}$ |
| **T9** | **I2C1** | 84.02$^{a}$ | 11.93$^{a}$ | 88.07$^{bcde}$ | 15.29$^{abcd}$ | 5.32$^{ab}$ |
| **T10** | **I2C2** | 86.20$^{a}$ | 12.04$^{a}$ | 87.96$^{cde}$ | **15.75$^{a}$** | **5.61$^{a}$** |
| **T11** | **I2C3** | 80.24$^{a}$ | 11.13$^{a}$ | 88.88$^{abc}$ | 15.18$^{abcd}$ | 5.29$^{abc}$ |
| **T12** | **I2C4** | 82.06$^{a}$ | 11.22$^{a}$ | 88.78$^{abcd}$ | 15.62$^{ab}$ | **5.53$^{a}$** |
| **T13** | **I2C5** | 78.11$^{a}$ | 11.13$^{a}$ | 88.87$^{abc}$ | 15.31$^{abc}$ | 4.72$^{cde}$ |
| **T14** | **I2C6** | 81.05$^{a}$ | 11.36$^{a}$ | 88.64$^{abcd}$ | 15.17$^{abcd}$ | 5.39$^{ab}$ |
| **T15** | **I3C0** | 81.13$^{a}$ | 11.14$^{a}$ | 88.86$^{abc}$ | 13.40$^{def}$ | 4.46$^{defg}$ |
| **T16** | **I3C1** | 82.21$^{a}$ | 12.58$^{a}$ | 87.42$^{def}$ | 13.85$^{bcde}$ | 5.22$^{abc}$ |
| **T17** | **I3C2** | 86.48$^{a}$ | 12.77$^{a}$ | 87.23$^{defg}$ | 15.21$^{abcd}$ | 5.49$^{ab}$ |
| **T18** | **I3C3** | 84.24$^{a}$ | 12.40$^{a}$ | 87.60$^{cdef}$ | 13.41$^{def}$ | 4.71$^{cde}$ |
| **T19** | **I3C4** | 85.20$^{a}$ | 12.46$^{a}$ | 87.53$^{def}$ | 13.20$^{efg}$ | 4.85$^{bcd}$ |
| **T20** | **I3C5** | 79.51$^{a}$ | 11.74$^{a}$ | 88.26$^{bcd}$ | 13.51$^{cde}$ | 4.12$^{fgh}$ |
| **T21** | **I3C6** | 81.31$^{a}$ | 11.73$^{a}$ | 88.27$^{bcd}$ | 13.58$^{cde}$ | 4.29$^{def}$ |
| **T22** | **I4C0** | 82.40$^{a}$ | 12.48$^{a}$ | 87.52$^{def}$ | 11.68$^{fghi}$ | 3.72$^{j}$ |
| **T23** | **I4C1** | 83.42$^{a}$ | 13.36$^{a}$ | 86.64$^{fg}$ | 11.46$^{ghi}$ | 4.36$^{defg}$ |
| **T24** | **I4C2** | 85.37$^{a}$ | 13.85$^{a}$ | 86.15$^{g}$ | 12.01$^{efgh}$ | 4.48$^{defg}$ |
| **T25** | **I4C3** | 81.14$^{a}$ | 12.24$^{a}$ | 87.76$^{cdef}$ | 11.33$^{ghi}$ | 4.39$^{defg}$ |
| **T26** | **I4C4** | 84.38$^{a}$ | 12.25$^{a}$ | 87.74$^{cdef}$ | 11.68$^{fghi}$ | 4.59$^{def}$ |
| **T27** | **I4C5** | 81.31$^{a}$ | 12.74$^{a}$ | 87.26$^{defg}$ | 11.53$^{ghi}$ | 3.64$^{j}$ |
| **T28** | **I4C6** | 82.18$^{a}$ | 12.83$^{a}$ | 87.13$^{efg}$ | 12.31$^{efg}$ | 3.80$^{ij}$ |
| **S.Em±** | | 3.079 | 0.291 | 0.292 | 0.578 | 0.149 |
| C.D. (at 5%) | | NS | NS | 0.823 | 1.646 | 0.490 |

Different letters within columns indicate that there are significant differences by Duncan's multiple range test at p= 0.05

**Table 3. Seed Germination Attributes as influenced by combined application of different irrigation scheduling based on IW:CPE ratio and stress mitigating chemicals in coriander crop (Pooled data).**

| Treatments | | Seed Germination Attributes | | | | |
|---|---|---|---|---|---|---|
| | | **Seedling Height (cm)** | **Seedling Dry Weight (g)** | **Seed Vigour Index-I** | **Seed Vigour Index-II** | **Test Weight (g)** |
| **T1** | **I1C0** | 13.80$^{kl}$ | 0.291$^{a}$ | 1066.57$^{mno}$ | 22.51$^{de}$ | 13.65$^{l}$ |
| **T2** | **I1C1** | 14.17$^{ijk}$ | 0.297$^{a}$ | 1141.46$^{kl}$ | 24.00$^{cde}$ | 14.41$^{kl}$ |
| **T3** | **I1C2** | 14.57$^{hij}$ | 0.317$^{a}$ | 1187.62$^{jkl}$ | 25.95$^{abc}$ | 15.52$^{def}$ |
| **T4** | **I1C3** | 13.89$^{jkl}$ | 0.294$^{a}$ | 1097.45l$^{m}$ | 23.18$^{cde}$ | 15.27$^{ghij}$ |
| **T5** | **I1C4** | 14.29$^{hij}$ | 0.303$^{a}$ | 1156.06$^{klm}$ | 24.59$^{bcd}$ | 15.40$^{efghi}$ |
| **T6** | **I1C5** | 12.82$^{l}$ | 0.290$^{a}$ | 982.45$^{o}$ | 22.28$^{e}$ | 14.80$^{ijk}$l |
| **T7** | **I1C6** | 13.11$^{l}$ | 0.304$^{a}$ | 1033.44$^{no}$ | 23.89$^{cd}$ | 14.99$^{hij}$ |
| **T8** | **I2C0** | 19.71$^{abc}$ | 0.303$^{a}$ | 1621.2$^{bcd}$ | 24.42$^{cde}$ | 15.29$^{fgh}$ |
| **T9** | **I2C1** | 20.61$^{ab}$ | 0.309$^{a}$ | 1731.89$^{abc}$ | 25.90$^{abc}$ | 16.66$^{abc}$ |
| **T10** | **I2C2** | **21.36$^{a}$** | 0.329$^{a}$ | 1841.64$^{a}$ | 28.33$^{a}$ | 17.80$^{a}$ |
| **T11** | **I2C3** | 20.48$^{ab}$ | 0.303$^{a}$ | 1643.28$^{bcd}$ | 24.38$^{cde}$ | 16.99$^{abc}$ |
| **T12** | **I2C4** | **21.15$^{a}$** | 0.315$^{a}$ | 1709.66$^{abc}$ | 25.79$^{abc}$ | 17.34$^{ab}$ |
| **T13** | **I2C5** | 20.03$^{abc}$ | 0.302$^{a}$ | 1588.1$^{cdef}$ | 23.52$^{cde}$ | 16.5$^{bcdef}$ |
| **T14** | **I2C6** | 20.53$^{abc}$ | 0.313$^{a}$ | 1666.77$^{abc}$ | 25.4$^{abc}$ | 16.73$^{abc}$ |
| **T15** | **I3C0** | 17.86$^{cde}$ | 0.300$^{a}$ | 1449.1$^{efgh}$ | 24.26$^{cde}$ | 15.19$^{ghi}$ |
| **T16** | **I3C1** | 19.07$^{bcd}$ | 0.303$^{a}$ | 1567.66$^{cde}$ | 25.13$^{abc}$ | 15.86$^{cdef}$ |
| **T17** | **I3C2** | 20.76$^{ab}$ | 0.327$^{a}$ | 1795.04$^{ab}$ | 28.21$^{a}$ | 16.85$^{abc}$ |
| **T18** | **I3C3** | 18.12$^{cde}$ | 0.303$^{a}$ | 1526.37$^{def}$ | 25.38$^{abc}$ | 15.89$^{cdef}$ |
| **T19** | **I3C4** | 18.06$^{cdef}$ | 0.310$^{a}$ | 1538.34$^{def}$ | 26.56$^{abc}$ | 16.12$^{bcd}$ |
| **T20** | **I3C5** | 17.63$^{defg}$ | 0.300$^{a}$ | 1407.59$^{fghi}$ | 23.74$^{cde}$ | 15.41$^{efg}$ |
| **T21** | **I3C6** | 17.87$^{cdefg}$ | 0.311$^{a}$ | 1453.05$^{efg}$ | 25.27$^{abc}$ | 15.77$^{cdef}$ |
| **T22** | **I4C0** | 15.40$^{hijk}$ | 0.295$^{a}$ | 1268.9$^{hij}$ | 24.72$^{bcde}$ | 14.58$^{jkl}$ |
| **T23** | **I4C1** | 15.83$^{fghi}$ | 0.307$^{a}$ | 1320.49$^{hij}$ | 25.58$^{abc}$ | 15.75$^{cde}$ |
| **T24** | **I4C2** | 16.49$^{efg}$ | 0.327$^{a}$ | 1407.36$^{fghi}$ | 27.93$^{ab}$ | 16.24$^{bcd}$ |
| **T25** | **I4C3** | 15.71$^{ghi}$ | 0.304$^{a}$ | 1275.17$^{hij}$ | 24.52$^{bcd}$ | 15.55$^{def}$ |
| **T26** | **I4C4** | 16.28$^{efg}$ | 0.313$^{a}$ | 1373.51$^{ghi}$ | 26.38$^{abc}$ | 15.85$^{cdef}$ |
| **T27** | **I4C5** | 15.17$^{hij}$ | 0.302$^{a}$ | 1233.40$^{ijk}$ | 24.36$^{cde}$ | 15.57$^{def}$ |
| **T28** | **I4C6** | 16.11$^{efg}$ | 0.320$^{a}$ | 1323.83$^{hij}$ | 25.83$^{abc}$ | 15.79$^{cdef}$ |
| **S.Em±** | | 0.69 | 0.014 | 58.20 | 1.00 | 0.62 |
| C.D. (at 5%) | | 1.96 | NS | 165.48 | 2.84 | 1.85 |

Different letters within columns indicate that there are significant differences by Duncan's multiple range test at p= 0.05

**Table 4. Analysis of variance of the effect of different irrigation regimes based on IW/CPE ratio and stress mitigating chemicals on Germination attributes**

| Source of variance | D.F | Mean Sum of Square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Seed Germination (%) | Moisture Content (%) | Total Solids (%) | Plumule Length (cm) | Radical Length (cm) | Seedling Height (cm) |
| Replication | 2 | 20.76 | 1.846 | 49.583 | 0.26 | 0.164 | 2.11 |
| Main Plot | 3 | 61.68** | 15.40*** | 15.406 | 123.861** | 6.54*** | 185.86*** |
| Error(a) | 6 | 81.37 | 0.44 | 72.626 | 0.739 | 0.045 | 1.13 |
| Sub-plot | 6 | 48.21** | 1.38** | 1.388 | 0.796** | 1.88** | 4.09* |
| Main x Sub plot | 18 | 3.45 | 0.473 | 0.473 | 0.515** | 0.108** | 0.639* |
| Error(b) | 48 | 45.99 | 0.717 | 37.697 | 1.005 | 0.089 | 1.43 |
| Total | | 39.36 | 1.251 | 29.005 | 5.287 | 0.455 | 8.11 |

**Table 5. Analysis of variance of the effect of different irrigation regimes based on IW/CPE ratio and stress mitigating chemicals on Germination attributes**

| Source of variance | D.F | Mean Sum of Square | | | |
|---|---|---|---|---|---|
| | | Seedling Dry Weight (g) | Seed Vigour Index-I | Seed Vigour Index-II | Test Weight (g) |
| Replication | 2 | 0.00008 | 5022.26 | 3.878 | 0.527 |
| Main Plot | 3 | 0.00040** | 1398923.00** | 15.98** | 12.80** |
| Error(a) | 6 | 0.00047 | 5664.848 | 0.765 | 0.795 |
| Sub-plot | 6 | 0.00110** | 82192.01*** | 22.49** | 4.26** |
| Main x Sub plot | 18 | 0 | 5290.971 | 0.341 | 0.176** |
| Error(b) | 48 | 0.00063 | 10725.27 | 3.28 | 0.813 |
| Total | | 0.0005 | 64385.59 | 4.32 | 1.349 |