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# Use of plant growth regulators for yield improvement in coriander (*Coriandrum sativum* L.)

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## Abstract

Two genotypes of coriander *viz*., ACr 1 and RCr 41 were sown during *rabi* season in three consecutive years (2009–10, 2010–11 and 2011–12) and plant growth regulators (PGRs) *viz*., abscisic acid (ABA), betaine, acetyl salicylic acid (ASA) (1, 3, 5 and 7 µM) and proline (200, 400, 600 and 800 µM) were sprayed at flowering stage. Morphological parameters in terms of fresh: dry weight, shoot: root weight, shoot root length and seed yield was significantly increased by application of proline, betain and ASA from 1 to 7 µM. Effective concentration of PGRs was influenced by climatic conditions during growth period. In genotype ACr 1, yield was maximum (6.29 and 5.92 g plant$^{-1}$) in the treatments involving betain at 1 and 5 µM while ASA at 3 and 5 µM resulted in seed yield of 4.96 and 4.97 g plant$^{-1}$, respectively. Maximum seed yield (5.41 and 5.17 g plant$^{-1}$) of genotype RCr 41 was recorded in the treatment involving proline at 200 and 400 µM, respectively. It is suggested that exogenous application of proline (200-800 µM), betain and ASA (1-5 µM) at flowering stage in both the genotypes will be useful to enhance the yield.

**Keywords:** coriander, plant growth regulators, yield

## Introduction

India is the largest producer of coriander (*Coriandrum sativum* L.) in the world and the maximum production in the country is contributed by Rajasthan state. Varieties ACr 1 and RCr 41 are suitable for normal conditions and also cover a large area of Rajasthan. It has been reported that the productivity has come to stagnate with prevailing management practices and yield performance of these genotypes have been affected by climatic factors including low temperature. The data on area, production and productivity of coriander from Spice Board, India revealed higher productivity of coriander in North-Eastern states of India where sizeable area is under cultivation. In Rajasthan, temperature starts rising by February onwards, coinciding with late flowering and grain filling stage coupled with soil moisture stress which leads to low productivity of coriander. Genetic improvement and the management of agronomic practices may be beneficial for crop adaptation to various stresses and require a long time. Therefore, it was hypothesized that the use of agrochemicals, categorized as plant growth regulators (PGRs) would help to break the yield stagnation of these two important varieties.

Exogenous application of PGRs has been reported to improve the growth and yield of various crops (Saxena & Rathore 2013). It is well documented that proline and betaine are accumulated in the regions of growth of certain plants. It has been proved that they may protect the cells (Jones & Storey 1981). Abscisic acid (ABA) is considered to be a stress hormone and functions through a set of ABA regulated genes, which in turn lead to accumulation of osmoprotectants like proline. Salicylic acid is an endogenous plant growth regulator of phenolic nature and is considered to be a potent plant hormone because of its diverse regulatory roles in the regulation of plant growth, development and responses to abiotic and biotic stresses (Senaratna *et al.* 2000; Mohammed & Tarpley 2009b). Hence, in the present investigation plant growth regulators like ABA, proline, betain and acetyl salicylic acid (ASA) were employed to analyze the effect of their application on yield performance of coriander genotypes, ACr 1 and RCr 41.

**Material and methods**

Seeds of two genotypes of coriander *viz*., ACr 1 and RCr 41 were collected from National Research Centre on Seed Spices, Ajmer and sown in a randomized block design during *rabi* season of 2009–10, 2010–11 and 2011–12. Sowing was done in the second week of November in each year. Normal agronomic practices were followed throughout the cropping period. PGRs *viz*., ABA, betaine, ASA (1, 3, 5 and 7 μM) and proline (200, 400, 600 and 800 μM) were sprayed at flowering stages (50 DAS). Morphological parameters, plant fresh weight, dry weight, shoot length and root length were recorded after third day of spray. Fresh: dry weight, shoot: root weight and shoot: root length were also calculated. Seed yield was calculated after harvesting. The pooled mean data of three years were analyzed to find out the interactive effect of treatments and year (Panse & Sukhatme 1967).

**Results and discussion**

The data on effect of PGRs on morphological parameters and seed yield of coriander genotypes ACr 1 and RCr 41 of three years (2009–10, 2010–11 and 2011–12) are presented in Tables 1 & 2, respectively. In the year 2009–10, PGRs sprayed at flowering stage showed significant effect on fresh: dry weight in both ACr 1 and RCr 41. The effect was more pronounced in RCr 41 where the ratio ranged from a minimum of 3.21 in ASA at 7 μM to a maximum of 16.31 in betain at 1 μM. All the concentration of ABA and lower concentrations of proline, betain and ASA significantly increased fresh: dry weight in RCr 41 while in ACr 1, betain 5 μM concentration resulted in a ratio of 15.30 followed by proline 200 μM (9.11) (Table 1). However, in the year 2010-11, the effect of PGRs on fresh: dry weight was not significant in all the treatments. Spray of betain at 3 μM increased the ratio significantly in both the genotypes (2.78 and 2.83 in ACr 1 and RCr 41, respectively) while proline at 200 μM and ASA at 5 μM increased the ratio as compared to control (Tables 1 & 2). In the year 2011–12, in genotype ACr 1, proline (600 μM) and betain (1 μM) showed more fresh: dry weight as compared to control, but significant increase was observed in all the treatments of ABA and ASA (5 and 7 μM). In RCr 41, ABA at 1 μM, proline at 200 μM and betain at 3 μM significantly increased the fresh: dry weight (10.14, 9.91 and 9.97, respectively).

A significant increase in shoot: root weight of RCr 41 was observed in proline and betain in 2009–10. Higher concentration of betain (5 and 7 μM) resulted in maximum ratio of 43.49 and 40.15, respectively in RCr 41, while in ACr 1 the effective concentration of betain was 3 and 5 μM where shoot: root weight was observed 25.55 and 28.23, respectively. In addition to betain, lower concentration of ASA (1 and 3 μM) also increased shoot: root weight ratio in ACr 1 (26.54 and 24.05, respectively). During 2010–11, the effect of PGRs on shoot: root weight was found concentration specific in ACr 1 where along with proline and betain, ABA at 1 μM and ASA 7 μM increased the ratio in genotype ACr 1 while in RCr 41 both proline and betain increased the ratio significantly (49.30 in proline at 600 μM and 43.60 in betain at 1 μM) as compared to control (35.83). Shoot:

**Table 1.** Effect of plant growth regulators on morphological parameters and seed yield of coriander genotype ACr 1

| Treatments | Fresh: Dry weight | | | Shoot: Root weight | | | Shoot: Root length | | | Seed yield (g plant$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009-10 | 2010-11 | 2011-12 | 2009-10 | 2010-11 | 2011-12 | 2009-10 | 2010-11 | 2011-12 | 2009-10 | 2010-11 | 2011-12 |
| ABA 1 µM | 7.05 | 1.98 | 9.63 | 20.43 | 45.39 | 27.03 | 3.62 | 6.08 | 8.42 | 4.67 | 4.21 | 2.10 |
| 3 µM | 4.49 | 1.72 | 9.51 | 15.30 | 40.47 | 30.10 | 3.70 | 5.39 | 7.31 | 4.67 | 3.97 | 1.99 |
| 5 µM | 5.40 | 1.91 | 9.30 | 10.32 | 40.80 | 26.67 | 4.43 | 6.08 | 7.73 | 3.57 | 4.01 | 1.69 |
| 7 µM | 4.89 | 2.28 | 9.58 | 13.52 | 37.61 | 39.00 | 2.76 | 5.23 | 8.15 | 4.70 | 3.05 | 1.84 |
| Proline 200 µM | 9.11 | 1.56 | 7.97 | 22.60 | 44.49 | 44.36 | 3.73 | 5.49 | 7.06 | 5.20 | 4.96 | 2.09 |
| 400 µM | 6.32 | 2.12 | 8.00 | 18.85 | 36.04 | 50.39 | 4.86 | 5.19 | 8.07 | 5.07 | 2.49 | 1.82 |
| 600 µM | 3.84 | 1.21 | 9.11 | 18.46 | 41.01 | 36.85 | 3.58 | 5.89 | 8.31 | 4.83 | 5.22 | 1.94 |
| 800 µM | 6.71 | 1.59 | 8.08 | 22.84 | 39.65 | 29.71 | 3.61 | 5.48 | 9.62 | 7.00 | 4.43 | 1.40 |
| Betain 1 µM | 7.91 | 1.71 | 8.71 | 17.94 | 51.40 | 38.95 | 3.72 | 4.98 | 10.72 | 7.87 | 8.71 | 2.28 |
| 3 µM | 4.22 | 2.78 | 6.08 | 25.55 | 39.74 | 45.46 | 5.78 | 5.48 | 10.30 | 7.40 | 2.62 | 2.11 |
| 5 µM | 15.30 | 2.00 | 8.21 | 28.23 | 58.69 | 37.61 | 3.58 | 2.85 | 9.46 | 8.07 | 7.27 | 2.43 |
| 7 µM | 7.73 | 2.30 | 7.46 | 19.72 | 28.95 | 34.70 | 2.90 | 6.31 | 8.21 | 6.70 | 2.26 | 2.12 |
| ASA 1 µM | 4.49 | 2.12 | 6.35 | 26.54 | 42.98 | 32.47 | 3.90 | 5.71 | 9.34 | 4.80 | 3.52 | 2.35 |
| 3 µM | 5.65 | 1.35 | 7.08 | 24.05 | 42.65 | 43.09 | 4.36 | 5.96 | 8.70 | 5.07 | 7.24 | 2.59 |
| 5 µM | 4.01 | 2.03 | 9.54 | 19.42 | 41.30 | 12.57 | 3.94 | 5.74 | 9.94 | 2.73 | 4.89 | 2.59 |
| 7 µM | 4.58 | 1.85 | 9.71 | 23.66 | 52.68 | 20.31 | 3.64 | 6.88 | 4.71 | 5.13 | 6.80 | 2.98 |
| Control | 4.53 | 2.41 | 8.63 | 21.20 | 38.98 | 18.23 | 3.54 | 5.53 | 5.26 | 4.45 | 2.86 | 2.45 |
| SEm (±) | 6.25 | 1.94 | 8.41 | 20.51 | 42.52 | 33.38 | 3.86 | 5.54 | 8.31 | 5.41 | 4.62 | 2.16 |
| CD (P<0.05) | 0.56 | 0.15 | 0.64 | 1.74 | 2.85 | 2.92 | 0.55 | 0.27 | 0.59 | 0.16 | 0.22 | 0.15 |

ABA=Abscisic Acid; ASA=Acetyl Salicylic Acid

**Table 2.** Effect of plant growth regulators on morphological parameters and seed yield of coriander genotype RCr 41

| Treatments | Fresh: Dry weight | | | Shoot: Root weight | | | Shoot: Root length | | | Seed yield (g $plant^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009-10 | 2010-11 | 2011-12 | 2009-10 | 2010-11 | 2011-12 | 2009-10 | 2010-11 | 2011-12 | 2009-10 | 2010-11 | 2011-12 |
| ABA 1 μM | 13.12 | 2.17 | 10.14 | 20.84 | 36.64 | 22.03 | 3.92 | 5.80 | 4.94 | 6.53 | 3.98 | 3.26 |
| 3 μM | 11.77 | 1.84 | 8.39 | 19.56 | 35.44 | 12.41 | 4.11 | 6.26 | 4.70 | 6.33 | 2.89 | 2.77 |
| 5 μM | 10.94 | 2.19 | 9.39 | 23.29 | 35.78 | 14.83 | 3.73 | 5.65 | 4.44 | 6.57 | 3.91 | 2.77 |
| 7 μM | 15.16 | 1.93 | 7.74 | 20.62 | 32.07 | 19.67 | 3.87 | 6.07 | 5.60 | 6.83 | 4.51 | 3.36 |
| Proline 200 μM | 14.46 | 1.87 | 9.91 | 27.28 | 33.04 | 14.03 | 2.58 | 6.42 | 4.74 | 8.33 | 4.60 | 3.28 |
| 400 μM | 11.81 | 1.69 | 8.46 | 33.17 | 33.50 | 24.19 | 3.22 | 6.49 | 4.45 | 6.27 | 4.92 | 4.32 |
| 600 μM | 5.36 | 2.88 | 7.29 | 7.50 | 49.30 | 16.27 | 3.17 | 6.05 | 4.64 | 7.13 | 2.01 | 1.79 |
| 800 μM | 8.53 | 2.10 | 8.59 | 36.25 | 39.15 | 15.73 | 3.38 | 6.20 | 4.50 | 7.07 | 3.42 | 2.68 |
| Betain 1 μM | 16.31 | 2.17 | 9.44 | 17.87 | 43.60 | 16.26 | 5.45 | 6.26 | 5.00 | 8.20 | 3.73 | 2.83 |
| 3 μM | 12.30 | 2.83 | 9.97 | 22.99 | 41.26 | 14.54 | 4.89 | 6.27 | 4.27 | 8.63 | 1.80 | 1.94 |
| 5 μM | 6.47 | 2.02 | 7.77 | 43.49 | 39.48 | 20.48 | 5.25 | 7.44 | 3.98 | 6.33 | 4.10 | 3.04 |
| 7 μM | 4.19 | 1.74 | 7.56 | 40.15 | 31.02 | 11.45 | 5.30 | 6.45 | 4.77 | 5.07 | 2.19 | 2.27 |
| ASA 1 μM | 11.26 | 2.23 | 8.25 | 16.85 | 40.97 | 25.12 | 5.61 | 6.17 | 4.64 | 5.07 | 3.95 | 3.15 |
| 3 μM | 14.77 | 2.43 | 7.09 | 18.71 | 34.30 | 30.23 | 4.56 | 5.62 | 4.63 | 7.20 | 4.27 | 3.31 |
| 5 μM | 4.67 | 3.12 | 9.08 | 19.09 | 36.13 | 21.71 | 5.75 | 5.61 | 4.89 | 7.20 | 2.51 | 2.45 |
| 7 μM | 3.21 | 2.35 | 7.98 | 18.44 | 32.60 | 24.34 | 4.78 | 6.06 | 4.62 | 7.20 | 4.25 | 3.38 |
| Control | 3.65 | 2.52 | 9.21 | 24.73 | 35.83 | 21.52 | 6.25 | 6.08 | 4.78 | 5.13 | 2.40 | 2.29 |
| SEm (±) | 9.88 | 2.24 | 8.60 | 24.17 | 37.06 | 19.11 | 4.46 | 6.17 | 4.68 | 6.77 | 3.50 | 2.88 |
| CD (P<0.05) | 1.26 | 0.17 | 0.52 | 1.67 | 2.64 | 2.90 | 0.52 | 0.36 | 0.36 | 0.11 | 0.24 | 0.19 |

ABA=Abscisic Acid; ASA=Acetyl Salicylic Acid

root length was also found to increase in proline and betain treatments in both the genotypes. In the year 2011–12, all the PGRs resulted in an increase in shoot: root weight significantly in genotype ACr 1with a minimum of 26.67 in ABA at 5 μM and maximum of 50.39 in proline at 400 μM. Contrary to the effect on ACr 1, genotype RCr 41 did not respond to betain and proline treatments as in the previous two years. Significant increase was observed with ASA at 1 and 3 μM treatments.

There was no effect of PGRs on shoot: root length in RCr 41 in the year 2009–10, however, in ACr 1, ABA at 5 μM, proline at 400 μM and ASA at 3 μM resulted in significant increase in shoot: root length. In 2010–11, both the genotypes showed increase in shoot: root length under ABA treatments of 1 and 5 μM which is contrary to the known ABA effect on plant height. The treatment of proline at 600 μM, betain at 7 μM, ASA at 3 and 7 μM also showed significant increase in shoot: root length in genotype ACr 1. In genotype RCr 41, except ABA at 7 μM which increased the ratio and betain at 5 μM which reduced the shoot: root length, all the other treatments were non significant.

During 2009-10, the seed yield increased significantly in both the genotypes when treated with PGRs except ASA at 5 μM in ACr 1 and betain at 7 μM and ASA at 1 μM in RCr 41. Maximum increase in seed yield in ACr 1 was 8.07 g plant$^{-1}$ in the treatment with betain at 5 μM where fresh: dry weight and shoot: root weight were also maximum. Highest seed yield (8.63 g plant$^{-1}$) of RCr 41 was recorded in the treatment with betain at 3 μM followed by proline at 200 μM (8.33 g plant$^{-1}$) and betain at 1μM (8.20 g plant$^{-1}$).

Similar results were obtained in the year 2010–11, where seed yield in ACr 1 was maximum (8.71 g plant$^{-1}$) in betain at 1 μM followed by 7.27 g plant$^{-1}$ in betain at 5 μM. Treatment of ASA also resulted in significant increase in seed yield in ACr 1 (7.24 g plant$^{-1}$ in ASA at 3 μM and 6.80 g plant$^{-1}$ in ASA at 7 μM). In RCr 41, maximum seed yield (4.92 g plant$^{-1}$) was recorded in proline at 400 μM followed by proline at 200 μM (4.60 g plant$^{-1}$). Betain at 5 μM and ASA at 1, 3 and 7 μM also increased the seed yield in RCr 41.

The data obtained during three years were pooled and analyzed for the effect of PGRs on morphological parameters and seed yield and presented in Table 3. In ACr 1, significant effect of proline and betain treatments was observed on all the parameters including seed yield plant$^{-1}$. Maximum seed yield was recorded in betain at 1 μM followed by betain at 5 μM. ASA was also effective in enhancing the yield performance of genotype ACr 1. In genotype RCr 41 seed yield was increased significantly in all the treatments except betain at 7 μM but shoot: root weight and shoot: root length were reduced as compared to control in most of the treatments except betain at 5 μM where shoot: root weight increased significantly (34.48). However, significant increase was observed in fresh: dry weight in the treatments with proline at 200 and 400 μM, lower concentration of betain and ASA (1 and 3 μM) and ABA treatments.

The climatic data of three years on temperature, rainfall and relative humidity is given in Fig. 1. The maximum temperature of October and November was higher in 2011–12 as compared to 2009–10 and 2010–11 while during February-March it was higher (28.4 and 34.6°C) in 2009–10 than 2010–11 and 2011–12 (Fig. 1 A, B & C). Seed yield of both the genotypes was more during 2009–10 in control as well as under various treatments of PGRs. Relative humidity was significantly higher in 2010–11 ranging from a minimum of 28.25% during March to 59.82% in November where considerable rainfall (134.30 mm) was received. During 2009–10, occasional showers were received during cropping season except in December. A total of 183 mm rainfall was received during the cropping season of 2010–11, while in 2011–12 no rains were received in the entire cropping season but severe frost was encountered during 11-12 and 18-20 January 2012. This frost resulted in more yield loss in genotype ACr 1 as compared to RCr 41.

Analysis of variance for the effect of cropping year, PGR treatments and interaction of climate and PGR was significant as variation in rainfall, relative humidity and mean temperature was observed during the years of experiment (Table 4 & Fig. 1). The effect of PGRs on seed

**Table 3.** Effect of plant growth regulators on morphological parameters and seed yield of coriander genotype ACr 1 and RCr 41 (Pooled data of three years)

| Treatments | Fresh Weight : Dry Weight | | Shoot Weight : Root Weight | | Shoot Length : Root Length | | Seed Yield (g plant$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | ACr 1 | RCr 41 | ACr 1 | RCr 41 | ACr 1 | RCr 41 | ACr 1 | RCr 41 |
| ABA 1 µM | 6.22 | 8.48 | 30.95 | 26.50 | 6.04 | 4.88 | 3.66 | 4.59 |
| 3 µM | 5.24 | 7.33 | 28.62 | 22.47 | 5.47 | 5.03 | 3.54 | 4.00 |
| 5 µM | 5.53 | 7.51 | 25.93 | 24.64 | 6.08 | 4.61 | 3.09 | 4.75 |
| 7 µM | 5.58 | 8.28 | 30.04 | 24.12 | 5.38 | 5.18 | 3.20 | 4.94 |
| Proline 200 µM | 6.21 | 8.75 | 37.15 | 24.78 | 5.43 | 4.58 | 4.09 | 5.41 |
| 400 µM | 5.48 | 7.32 | 35.09 | 30.29 | 6.04 | 4.72 | 3.13 | 5.17 |
| 600 µM | 4.72 | 5.18 | 32.11 | 24.36 | 5.92 | 4.62 | 4.00 | 3.64 |
| 800 µM | 5.46 | 6.40 | 30.74 | 30.38 | 6.24 | 4.69 | 4.28 | 4.39 |
| Betain 1 µM | 6.11 | 9.31 | 36.09 | 25.91 | 6.47 | 5.57 | 6.29 | 4.92 |
| 3 µM | 4.36 | 8.37 | 36.92 | 26.26 | 7.19 | 5.14 | 4.04 | 4.13 |
| 5 µM | 8.50 | 5.42 | 41.51 | 34.48 | 5.30 | 5.56 | 5.92 | 4.49 |
| 7 µM | 5.83 | 4.50 | 27.79 | 27.54 | 5.80 | 5.51 | 3.69 | 3.18 |
| ASA 1 µM | 4.32 | 7.25 | 33.99 | 27.65 | 6.32 | 5.47 | 3.56 | 4.06 |
| 3 µM | 4.69 | 8.10 | 36.60 | 27.74 | 6.34 | 4.94 | 4.96 | 4.93 |
| 5 µM | 5.19 | 5.52 | 24.43 | 25.64 | 6.54 | 5.42 | 3.41 | 4.05 |
| 7 µM | 5.38 | 4.51 | 32.22 | 25.13 | 5.08 | 5.15 | 4.97 | 4.94 |
| Control | 5.19 | 5.13 | 26.14 | 27.36 | 4.78 | 5.70 | 3.25 | 3.27 |
| SEm (±) | 0.29 | 0.47 | 1.50 | 1.45 | 0.29 | 0.25 | 0.11 | 0.13 |
| CD (P<0.05) | 0.81 | 1.31 | 4.22 | 4.08 | 0.82 | 0.69 | 0.30 | 0.37 |

ABA=Abscisic Acid; ASA=Acetyl Salicylic Acid

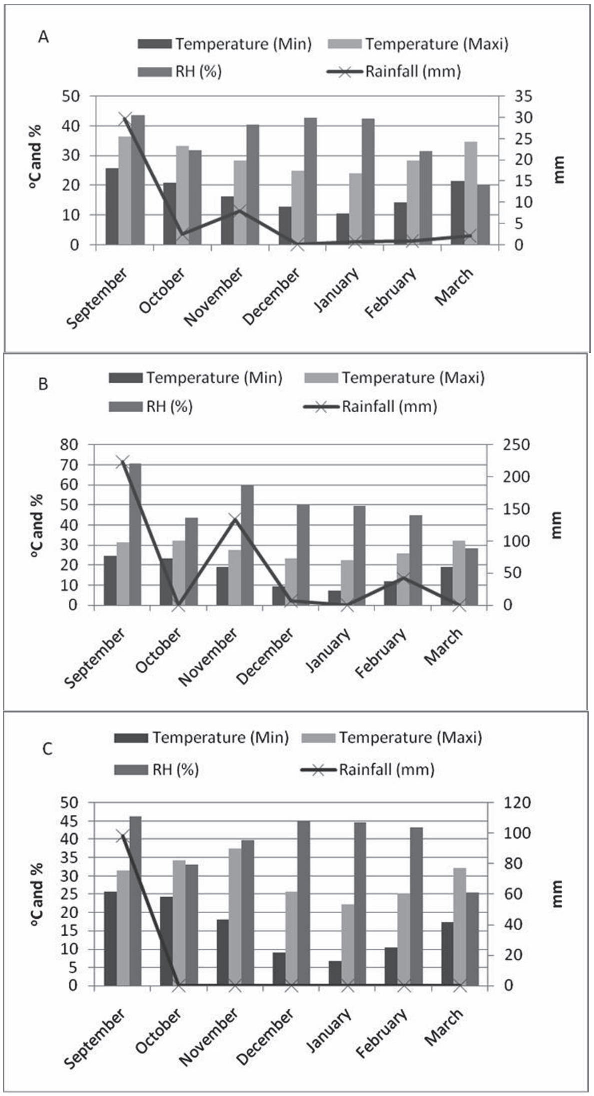


**Fig. 1.** Agro meteorological data of three cropping years
(**A**) 2009–10; (**B**) 2010–11; (**C**) 2011–12

yield was steady during three years but effective concentrations of PGRs were found different across the years. This may be due to temperature variation and rainfall during the three years. In the year 2011–12, PGRs treatment were not able to provide any protection against frost as the seed yield was drastically reduced in all treatments except ASA at 3, 5 and 7 μM, which resulted in significant increase in seed yield of genotype RCr 41. Genotype ACr 1 was less affected by frost because at the time of frost seeds attained physiological maturity as compared to RCr 41 which matured late than ACr 1. Highly significant interaction indicated

**Table 4.** Analysis of variance for different morphological parameters and seed yield of coriander genotypes ACr 1 and RCr 41

| Source of variation | Degree of freedom | Mean Sum of Square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Fresh : Dry Weight | | Shoot : Root Weight | | Shoot : Root Length | | Seed Yield (g plant$^{-1}$) | |
| | | ACr 1 | RCr 41 | ACr 1 | RCr 41 | ACr 1 | RCr 41 | ACr 1 | RCr 41 |
| Year | 2 | 553.80** | 854.67** | 6236.5** | 4373.24** | 257.3** | 44.12** | 145.97** | 222.99** |
| Rep/Year | 6 | 0.10 | 1.16 | 11.17 | 13.57 | 0.70 | 0.40 | 0.85** | 1.74** |
| Treatments | 16 | 8.29** | 22.32** | 200.50** | 74.51** | 3.34** | 1.32** | 8.20** | 3.70** |
| Treatment × Year | 32 | 9.87** | 20.25** | 160.63** | 165.69** | 4.04** | 1.48** | 4.86** | 1.91** |
| Error | 96 | 0.74 | 1.96 | 20.37 | 18.99 | 0.77 | 0.54 | 0.10 | 0.16 |

** = Significant

that PGR treatments were more effective under optimum or favourable climatic conditions.

Yield enhancement in proline, betain, ASA and even ABA treatment may be well understood by the established role of these chemical compounds in plant growth and development (Bohnert & Jensen 1996). Betaine and ASA have profound effects on crop production through their effects on crop physiology. Both are important for the regulation of plant growth, development and responses to abiotic and biotic stress tolerance (Senaratna *et al.* 2000). Increased shoot length, root length and biomass production by application of betain or ASA has been reported in maize by Farooq *et al.* (2008a & 2008b). Increase in plant height as a result of ASA application is due to increased cell enlargement, endoreduplication and/or cell division (Kang *et al.* 2007; Vanacker *et al.* 2007). Foliar application of betain or salicylic acid increased photosynthetic rates and decreased respiration rates and injury to the membranes (Farooq *et al.* 2008a; Khan *et al.* 2010; Zhou *et al.* 1999). In the present investigation, the shoot length, root length and biomass production increased by foliar application of betain and ASA. Positive effect of proline on morphological parameters and seed yield in the present investigation is also in line with its known role in improving plant abiotic stress resistance (Ashraf & Foolad 2007).

The genotypic variation due to the use of these chemicals on morphological parameters and seed yield could be explained on the basis of their maturity period as ACr1 belongs to early maturing group and RCr 41 is a late maturity genotype which may maintain more biomass in life cycle. Thus, it can be suggested that exogenous application of proline (200-800 μM), betain and ASA (1-5 μM) at flowering stage in coriander will be useful to enhance the yield to 93.53% in genotype ACr 1 and 65.44% in genotype RCr 41. Though ABA application showed significant increase in yield as compared to other three chemicals, it is not recommended for commercial use, since it is very expensive.

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