Current Journal of Applied Science and Technology

22(5): 1-10, 2017; Article no.CJAST.35163
Previously known as British Journal of Applied Science & Technology
ISSN: 2231-0843, NLM ID: 101664541

Impact of Growth Regulators on Seed Yield and Quality of Coriander (*Coriandrum sativum* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. Author PS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author VSM managed the literature searches and guided the authors during research period. Authors RCP and SK managed the analyses of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2017/35163
Editor(s):
(1) Sait Engindeniz, Department of Agricultural Economics, Faculty of Agriculture, Ege University, Turkey.
Reviewers:
(1) Nazimah Maqbool, University of Sargodha, Faisalabad, Pakistan.
(2) Rasmia Sayed Sayed Darwesh, Central Lab. For Research and Development of Date Palm, Agriculture Research Centre, Egypt.
Complete Peer review History: http://www.sciencedomain.org/review-history/20176

Original Research Article

Received 29th June 2017
Accepted 19th July 2017
Published 24th July 2017

ABSTRACT

Coriander (*Coriandrum sativum* L.) is an important seed spices crop of family Apiaceae (Umbelliferae) with cross-pollination as mode of reproduction. Coriander is an important seed spice, cultivated in almost states of India and gaining export importance. Plant growth regulators (PGRs) have emerged as magic chemical that could increase agricultural production at an unprecedented rate and help in removing or circumventing many of the barrier imposed by genetics and environment. Therefore considering significance of coriander in national economy, a field experiment was conducted at CCS Haryana Agricultural University, Hisar to study the impact of growth regulators on seed yield and quality of coriander. The research material comprised of four genotypes *viz.* DH-5, DH-36, DH-228 and DH-246 was grown with three replications in factorial RBD. Two PGRs namely NAA and GA_3 each at 50 ppm and a control (water spray) were used as treatments at the time of 50% flowering. The foliar application of growth regulators such as NAA and GA_3 at 50 percent flowering was found most effective to enhance the plant height, number of branches per plant, number of umbels per plant, number of seeds per umbel, number of seed per umbellate, seed yield and seed quality parameters such as test weight, standard germination,

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seedling length, seedling dry weight, vigor index-I & vigor index-II, dehydrogenase enzyme activity, field emergence index and seedling establishment. So, the application of NAA and GA_3 was useful in more seed setting, high seed yield and quality of all the genotype. Among all the genotypes, Hisar Anand (DH-5) was found the highest seed yielder followed by Hisar Bhoomit (DH-228), Hisar Surbhi (DH-246) and Hisar Sugandh (DH-36).

Keywords: Coriander; growth regulators; growth; seed yield and quality.

1. INTRODUCTION

Coriander (*Coriandrum sativum* L.) is an important seed spices crop of family Apiaceae (Umbelliferae) with cross-pollination as mode of reproduction. India has a unique place in world which produces 0.52 million tonnes seeds from 0.54 million hectares area. Out of the total seed spices produced in India, coriander alone contribute 51.54 per cent whereas, in respect of area coriander covers 63.68 per cent (Anonymous [1]). The growth, yield and quality of coriander could be improved by the use of plant growth regulators (PGRs), as their use has resulted in some outstanding achievements with respect to growth, yield and quality of several other crops.

Among the various plant growth regulators, the use of gibberellic acid (GA_3) and α-naphthalene acetic acid (NAA) have been found to increase the economics yield of several leafy crops. The PGRs are applied on crops to increase yield and to improved quality, thereby meeting commercial demand and quality standards. Several intrinsic and extrinsic factors effect on growth, development and secondary metabolites biosynthesis of medicinal and aromatic plants. Phytohormones and plant growth regulators (PGRs) have been defined as one of the main factors influences plants growth and their primary and secondary metabolites pool. The use of PGRs in the field of agriculture has become commercialized. Plant growth regulators (PGRs), have emerged as magic chemical that could increase agricultural production at an unprecedented rate and help in removing or circumventing many of the barrier imposed by genetics and environment (Nickel [2]).

Exogenous application of growth regulators and micronutrients also 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 (Fisher and Pyshtaeva [3], Bharud et al. [4] and El-Keltawi et al. [5]). Effectiveness of PGRs depends upon several factors viz. concentration, method and time of application etc. As such different modes (seed soaking, foliar spray, soil application, stem injection etc.) of application of PGRs alter the physiology of plant in different ways. It is well known that all the PGRs regulate the physiological functions/processes of the plant. Among different PGRs, NAA and GA_3 have been reported to boost the growth, yield and quality attributes in sunflower, dill seed, mustard, fenugreek, soybean, cumin and okra etc.

Agricultural research, till now, has been primarily concerned with increasing crops yields by use of fertilizers, pesticides, irrigation, better crop management coupled with variety development and genetic improvements. It is well known that application of growth regulators analogous to endogenous hormone not only brings changes in physio-morphological character of plants and fruits but also enhance the yield. Therefore considering significance of coriander in the national economy, the present study was conducted to access the impact of foliar application of growth regulators on seed yield and quality of coriander.

2. MATERIALS AND METHODS

Seed material comprised of four genotype namely DH-228 (Hisar Bhoomit), DH-246 Hisar Surbhi), DH-36 (Hisar Sugandh), DH-5 (Hisar Anand). Two PGRs namely NAA and GA_3 each at 50 ppm and a control (water spray) were used as treatments at the time of 50% flowering. Seed were sown during the second week (11^{th}) of October in plots of size 3.0 × 1.5 m at spacing of 50 × 20 cm. Sowing and other cultural operation were done using recommended practices. Growth parameters such as plant height, number of branches per plant, number of umbels per plant, number of seeds per umbel, number of seed per umbellate, seed yield and seed quality parameters such as test weight, standard germination, seedling length, seedling dry weight, vigor index-I & vigor index-II, dehydrogenase enzyme activity, field emergence index and seedling establishment were recorded for the study. The five plants in each plot were

randomly selected and data on particular parameters were measured at harvesting time and average was computed for growth and yield parameters.

Seed quality parameters such as test weight (1000 seed weight) and Standard germination (%) was observed using one hundred seeds of each genotype in three replicates were placed in between papers (BP) and kept at 20℃ in seed germinator. The first count was taken on 5th day and final count on 14th day and only normal seedlings were considered for percent germination according to the rules of International Seed Testing Association (ISTA [6]). Seedling length (cm) of ten randomly selected normal seedlings from three replication of standard germination test was measured to get the averaged seedling length in centimeter.

Seedling dry weight (g) was assessed after the final count in the standard germination test (14 days). The randomly selected normal seedlings from the three replication of standard germination test were taken and dried in a hot air oven for 24 hrs at 80±1℃. The dried seedlings of each replication were weighed and average seedling dry weight of each genotype was calculated.

Seedling vigor indices were calculated according to the method suggested by Baki and Anderson [7].

I. Vigor index-I (on seedling length basis):

Vigor index–I = Standard Germination (%) × Average seedling length (cm)

II. Vigor Index–II (on seedling dry weight basis):

Vigor index–II = Standard Germination (%) × Average seedling dry weight (g)

To measure the electrical conductivity, 50 normal and uninjured seeds in three replications were soaked in 75 ml deionized water in 100 ml beakers. Seeds were immersed completely in water and beakers were covered with foil. Thereafter, these samples were kept at 25℃ for 24 h. The electrical conductivity of the seed leachates was measured using a direct reading conductivity meter. The conductivity was expressed in dS cm^{-1} $seed^{-1}$. Dehydrogenase activity (OD g-1 ml-1) was observed using one gram seed of each lot replicated thrice were ground to pass through a 20 mesh draw. The 200 mg flour was soaked in 5 ml of 0.5% tetrazolium solution at 38℃ for 3-4 h. Then it was centrifuged at 10000 rpm for 3 minutes and the supernatant was poured off. The formazan was extracted with 10 ml acetone for 16 h. followed by centrifugation and absorbance of the solution was determined by Systronic spectrophotometer 169 at 480 nm. These observations were expressed as change in OD g-1 ml-1 and this procedure was performed as per Kittock and Law [8].

To determine the Field emergence index, one hundred freshly harvested seeds of each genotype as per treatment were sown in three replication during rabi season, 2013-2014 at the Seed Science and Technology Research farm, CCS Haryana Agricultural University, Hisar. The number of seedling emerged daily, counted up to stable emergence. The field emergence index was estimated as follow.

$$\frac{\text{No. of seedlings emerged}}{\text{First day of sowing}} + \ldots\ldots + \frac{\text{Number of seedlings emerged}}{\text{Day of last count}}$$

The seedling establishment was determined by counting the total number of seedlings when the emergence was completed i.e. there was no further addition in the total emergence. Statistical analysis of data collected during the study was done by applying the technique of analysis of variance (ANOVA) as suggested by Gomez and Gomez [9] and Panse and Sukhatme [10]. All the statistical analysis was carried out by using OPSTAT statistical software.

3. RESULTS AND DISCUSSION

3.1 Growth and Yield Parameters

The data pertaining to various plant growth and yield parameters (plant height, number of branches per plant, number of umbels per plant, number of seeds per umbel, number of seeds per umbellate and seed yield) are presented in Table 1 and in Fig. 1. A perusal of the data revealed that the growth

regulators significantly affect the plant height and maximum plant height (114.06 cm) was observed by the application of NAA followed by GA_3 (97.86 cm) and minimum plant height (78.38 cm) was observed by the application of control (water) among the treatments irrespective of genotypes. The overall genotypic mean resulted that DH-228 was found maximum plant height (118.41 cm) followed by DH-5 (92.03 cm) and minimum plant height (84.58 cm) was observed in DH-36. These results are same in the accordance with the finding of Verma and Sen [11] on coriander and on fenugreek by Vasudevan et al. [12].

The growth regulators significantly affect the number of branches per plant and maximum number of branches (7.53) with the foliar application of NAA at the time of fifty percent flowering followed by GA_3 (6.82) and minimum number of branches per plant (6.13) was found with control treatment at fifty percent flowering among the treatments irrespective of genotypes. The overall genotypic mean resulted that DH-5 was found maximum number of branches (7.11) followed by DH-228 (6.93) and minimum number of branches per plant (6.51) was recorded in DH-36. These results are same in the accordance with the finding of Shivran and Jat [13] and Verma and Sen [11] on coriander.

The growth regulators significantly enhanced the number of umbel per plant and maximum number of umbels (49.82) was recorded by the application of NAA followed by GA_3 (38.50) and minimum number of umbels (28.78) was recorded by the application of control (water) at the time of fifty percent flowering among the treatments irrespective of genotype. The overall genotypic mean resulted that DH-5 was found (46.07) maximum number of umbels per plant followed by DH-228 (42.36) and minimum number of umbels per plant (32.78) was recorded in DH-36. The number of seeds per umbel and umbellate also significantly affected by the application of growth regulators such as NAA, GA_3 and control (water) at fifty percent flowering. The overall genotypic mean recorded that DH-5 was found maximum number of seeds per umbel (45.83) followed by DH-228 (40.13) and minimum number of seeds per umbel (32.92) was recorded in DH-36. The application of growth regulators significantly enhanced the number of seeds per umbel and maximum number of seeds per umbel (44.99) was observed by the application of NAA at the time of fifty percent flowering followed by GA_3 (37.43) and minimum number of seeds per umbel was recorded by control (water) among the treatments irrespective of genotypes. Number of seeds per umbellate was found maximum (6.57) by the foliar application of NAA and minimum (4.98) was found in control (water) among the treatments irrespective of genotypes. Similar observation was recorded on coriander by Hnamte et al. [14], EI-Mekawey et al. [15], Verma and Sen [11] and on black cumin by Kumar et al. [16]

The perusal of data in Table 1 and in Fig. 1 revealed that seed yield also significantly affected by the foliar application of growth regulators and maximum seed yield was recorded by the application of NAA (17.47 q/ha) followed by GA_3 (14.65) and minimum seed yield was recorded by control treatment (12.94 q/ha) among the treatments irrespective of genotypes. The comparison of two growth regulators (NAA and GA_3) irrespective of genotypes (DH-228, DH-246, DH-36 and DH-5) resulted that maximum seed yield was recorded in DH-5 (18.46, 16.08 and 14.49 q/ha) followed by DH-228 (17.95, 14.34 12.28 q/ha) and minimum seed yield was observed in DH-36 (16.66, 13.85 and 12.01 q/ha). These results are same in accordance with finding of Kumar et al. [16] on black cumin, Hye et al. [17] on onion, Chaudhary et al. [18], Kumar et al. [19], Natesh et al. [20], on coriander by Verma and Sen [11], Vijaykumar and Sundareswaran [21] and Shivran and Jat [13].

3.2 Seed Quality Parameters

The quality of the seed is determined by test weight (1000 seed weight), standard germination, seedling length, seed vigor index-I, vigor index-II, seedling dry weight, dehydrogenase activity test, field emergence index and seedling establishment showed in Table 2. The maximum test weight (14.65 g) with the foliar application of NAA at the fifty percent flowering followed by GA_3 (13.73 g) and minimum test weight (12.86 g) was observed by the application of control (water) among the treatments irrespective of genotypes. The overall genotypic mean resulted that maximum test weight (15.86 g) for the genotype DH-5 and minimum test weight (8.92 g) for the genotype DH-228. The overall genotypic mean observed that maximum standard germination in Fig. 2 (90.85%) for the genotype DH-5 followed by DH-228 (90.67%) and minimum standard germination (85.48 %) was found for the genotype DH-36. The growth regulators significantly affect the standard germination and

maximum standard germination (91.06 %) by the foliar application of NAA followed by GA_3 (89.11%) and minimum standard germination (86.94%) was observed by the application of control (water) among the treatments irrespective of genotypes. These results are same in accordance with finding of Shivran and Jat [13], Verma and Sen [11] and Natesh et al. [20] on coriander.

Seedling length showed significant results by the application of growth regulators and maximum seedling length (27.60 cm) was recorded by the foliar application of NAA and followed by GA_3 (25.63 cm) and minimum seedling length (24.28 cm) was observed by the application of control (water) among the treatments irrespective of genotypes. The overall genotypic mean and maximum seedling length (28.39 cm) for the genotype DH-5 followed by DH-228 (27.12 cm) and minimum seedling length (23.77 cm) was observed for the genotype DH-36. The overall genotypic mean observed that maximum vigor index-I (2585.27) for the genotype DH-5 followed by DH-228 and minimum vigor index-I was found for the genotype DH-36. Vigor index-I showed significant results by the application of growth regulators and maximum vigor index-I (2520.74) was observed by the foliar application of NAA at fifty percent flowering followed by GA_3 (2287.28) and minimum vigor index-I (2113.54) was recorded by the application of control (water) among the treatments irrespective of genotypes. Similar observation was recorded on coriander by Vijaykumar and Sundareswaran [21], Natesh et al. [20] and Sultana et al. [22] on chilli.

Seedling dry weight showed significant results by the application of growth regulators and maximum seedling dry weight (0.35 g) was recorded by the foliar application of NAA and followed by GA_3 (0.28 g) and minimum seedling dry weight (0.18 g) was observed by the application of control (water) among the treatments irrespective of genotypes. The overall genotypic mean and maximum seedling dry weight (0.33 g) for the genotype DH-5 followed by DH-228 (0.26 g) and minimum seedling dry weight (0.23 g) was observed for the genotype DH-36. The overall genotypic mean observed that maximum vigor index-II (30.31) for the genotype DH-5 followed by DH-228 (23.68) and minimum vigor index-II (20.09) was found for the genotype DH-36. Vigor index-II showed significant results by the application of growth regulators and maximum vigor index-II (32.20) was observed by the foliar application of NAA at fifty percent flowering followed by GA_3 (25.10) and minimum vigor index-II (15.72) was recorded by the application of control (water) among the treatments irrespective of genotypes. The growth regulators significantly affect the intensity of formazan and maximum intensity of formazan (0.098) was recorded when foliar application of NAA was undertaken followed by GA_3 (0.077) and minimum (0.053) was recorded when foliar application of water was done among the treatments irrespective of genotypes. The overall genotypic mean resulted in maximum intensity of formazan (0.092) for the genotype DH-5 and minimum (0.058) for the genotype DH-36 among the genotypes. Similar observations was recorded on coriander by Verma and Sen [11], Vijaykumar and Sundareswaran [21], Natesh et al. [20], Sultana et al. [22] on chilli and by Dhoran and Gudadhe [23] on *Asparagus sprengeri* Regelin.

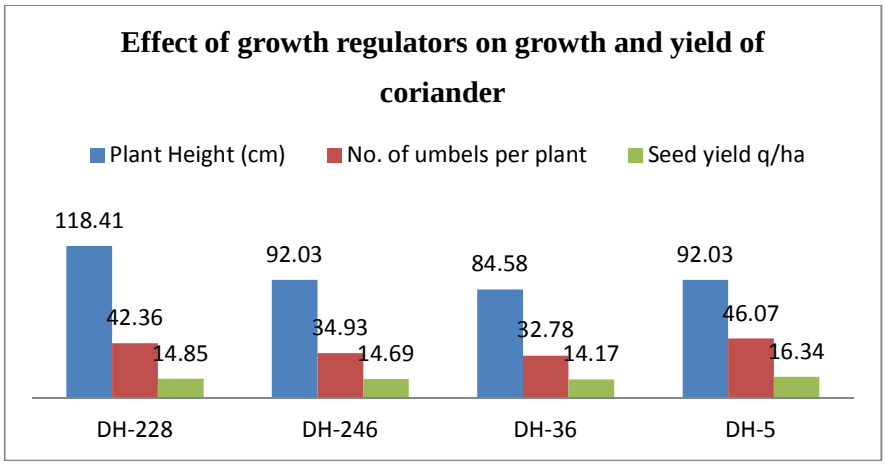

Fig. 1. Impact of growth regulators on growth and seed yield of coriander

Table 1. Impact of growth regulators on growth and yield parameters of Coriander

Genotype	Plant height at maturity (cm)				No. of branches per plant				No. of umbels per plant			
	NAA	GA_3	Water	Mean	NAA	GA_3	Water	Mean	NAA	GA_3	Water	Mean
DH-228	126.60	121.90	106.73	118.41	7.77	6.83	6.20	**6.93**	55.53	42.47	29.07	42.36
DH-246	108.53	92.73	74.83	92.03	7.40	6.63	6.20	**6.74**	48.47	32.60	23.73	34.93
DH-36	105.80	85.67	62.27	84.58	7.27	6.47	5.80	**6.51**	37.60	32.13	28.60	32.78
DH-5	115.30	91.13	69.67	92.03	7.67	7.33	6.33	**7.11**	57.67	46.80	33.73	46.07
Mean	**114.06**	**97.86**	**78.38**		**7.53**	**6.82**	**6.13**		**49.82**	**38.50**	**28.78**	
CD @ 5%	**V=3.70, G=3.19 V×G=6.39**				**V= 0.12, G=0.11, V×G=0.21**				**V=2.44, G=2.12, V×G=4.23**			
Genotype	**No. of seeds per umbel**				**No. of seeds per umbellate**				**Seed yield (q/ha)**			
	NAA	GA_3	Water	Mean	NAA	GA_3	Water	Mean	NAA	GA_3	Water	Mean
DH-228	47.40	39.43	33.57	40.13	6.20	5.73	4.80	**5.58**	17.95	14.34	12.28	14.85
DH-246	41.67	32.87	26.97	33.83	6.33	5.40	4.77	**5.50**	16.79	14.32	12.97	14.69
DH-36	39.50	32.87	26.40	32.92	6.20	5.67	4.63	**5.50**	16.66	13.85	12.01	14.17
DH-5	51.40	44.53	41.57	45.83	7.53	6.33	5.73	**6.53**	18.46	16.08	14.49	16.34
Mean	**44.99**	**37.43**	**32.13**		**6.57**	**5.78**	**4.98**		**17.47**	**14.65**	**12.94**	
CD @ 5%	**V=1.07, G=0.92, V×G=1.85**				**V=0.09, G=0.07, V×G=0.15**				**V=0.73, G=0.63, V×G=1.25**			

Table 2. Impact of growth regulators on quality parameters of coriander

Genotype	Test Weight (g)				Standard Germination (%)				Seedling Length (cm)			
	NAA	GA_3	Water	Mean	NAA	GA_3	Water	Mean	NAA	GA_3	Water	Mean
DH-228	9.39	8.98	8.40	8.92	93.22 (74.89)	90.89 (72.40)	87.89 (69.61)	**90.67 (72.30)**	27.93	26.98	26.45	27.12
DH-246	16.42	15.50	14.53	15.48	91.22 (72.75)	88.89 (70.51)	87.33 (69.12)	**89.15 (70.80)**	26.54	23.33	22.33	24.07
DH-36	15.70	14.57	13.90	14.72	87.89 (69.64)	85.67 (67.73)	82.89 (65.54)	**85.48 (67.64)**	24.99	24.02	22.31	23.77
DH-5	17.09	15.89	14.61	15.86	91.89 (73.43)	91.00 (72.52)	89.67 (71.22)	**90.85 (72.39)**	30.95	28.21	26.02	28.39
Mean	**14.65**	**13.73**	**12.86**		**91.06 (72.68)**	**89.11 (70.79)**	**86.94 (68.87)**		**27.60**	**25.63**	**24.28**	
CD @ 5%	**V=0.37, G=0.32, V×G =0.63,**				**V=0.76, G=0.66, V×G=1.33**				**V=1.67, G=1.45, V×G=2.88**			
					Figures in parentheses indicate transformed values							
Genotype	**Vigor index-I**				**Seedling Dry Weight (g)**				**Vigor index-II**			
	NAA	GA_3	Water	Mean	NAA	GA_3	Water	Mean	NAA	GA_3	Water	Mean
DH-228	2,466.62	2,314.35	2,200.32	2,327.10	0.35	0.27	0.18	**0.26**	34.08	26.00	9.78	23.28
DH-246	2,480.19	2,122.18	1,966.47	**2,189.61**	0.37	0.29	0.11	**0.25**	31.68	23.60	15.74	23.68
DH-36	2,286.73	2,142.54	1,950.99	**2,126.75**	0.30	0.25	0.16	**0.23**	26.09	21.19	12.99	20.09
DH-5	2,849.42	2,570.03	2,336.36	**2,585.27**	0.40	0.33	0.27	**0.33**	36.94	29.60	24.37	30.31
Mean	**2,520.74**	**2,287.28**	**2,113.54**		**0.35**	**0.28**	**0.18**		**32.20**	**25.10**	**15.72**	
CD @ 5%	**V=179.43, G=155.39, V×G=308.96**				**V=0.026, G=0.022, V×G=0.045**				**V=2.52, G=2.18, V×G=4.37**			
Genotype	**Seedling establishment (%)**				**Dehydrogenase enzyme activity**				**Field Emergence index**			

Genotype	Test Weight (g)				Standard Germination (%)				Seedling Length (cm)			
	NAA	**GA_3**	**Water**	**Mean**	**NAA**	**GA_3**	**Water**	**Mean**	**NAA**	**GA_3**	**Water**	**Mean**
	NAA	**GA_3**	**Water**	**Mean**	**NAA**	**GA_3**	**Water**	**Mean**	**NAA**	**GA_3**	**Water**	**Mean**
DH-228	89.56 (71.21)	84.44 (66.78)	74.45 (59.68)	82.82 (65.89)	0.102	0.078	0.047	**0.076**	5.75	5.64	5.40	5.60
DH-246	86.22 (68.19)	81.11 (64.23)	76.89 (61.25)	81.41 (64.55)	0.101	0.079	0.054	**0.078**	5.69	5.61	5.32	5.54
DH-36	86.00 (68.05)	80.00 (63.41)	74.22 (59.50)	80.07 (63.66)	0.077	0.059	0.038	**0.058**	5.64	5.52	5.35	**5.50**
DH-5	90.78 (72.30)	88.67 (70.30)	76.22 (60.82)	85.22 (67.81)	0.111	0.091	0.074	**0.092**	5.79	5.72	5.63	**5.71**
Mean	**88.14**	**83.56**	**75.45**		**0.098**	**0.077**	**0.053**		**5.72**	**5.62**	**5.43**	
C.D. @ 5%	**V=1.44, G=1.24, V×G=2.49 Figures in parentheses indicate transformed values**				**V=0.006, G=0.005, V×G=0.01**				**V=0.035, G=0.031, V×G= 0.061**			

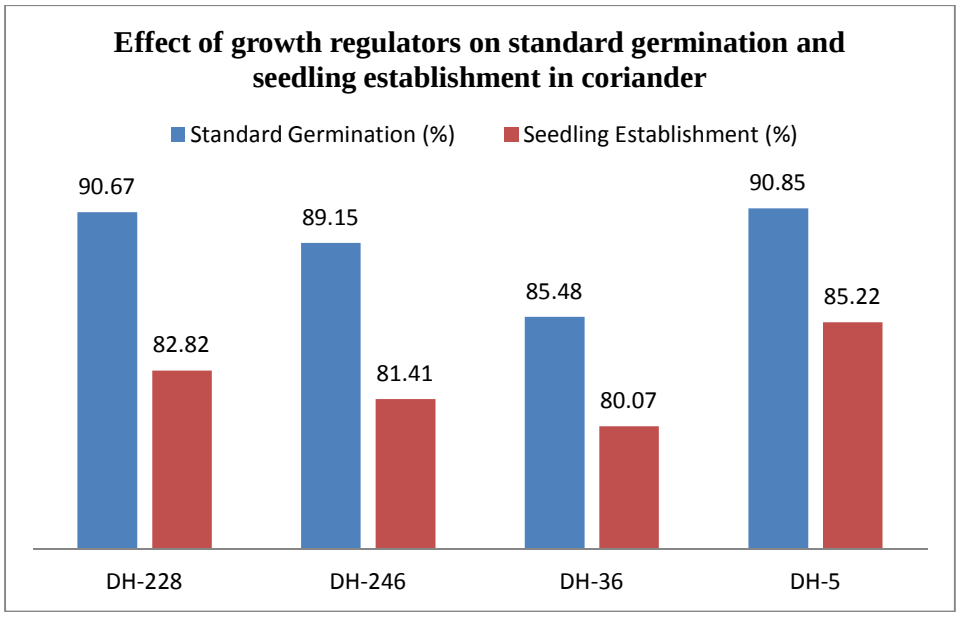

Fig. 2. Impact of growth regulators on standard germination and seedling establishment in coriander

Under field condition, the speed of emergence was calculated as emergence index. There was a significant difference among genotypes, growth regulators, and their interaction for the speed with which seedling emerged in the field as indicated in Table 2. Field emergence index showed significant results by the application of growth regulators and maximum field emergence index (5.72) was recorded by the foliar application of NAA and followed by GA_3 (5.62) and minimum field emergence index (5.43) was observed by the application of control (water) among the treatments irrespective of genotypes. The overall genotypic mean and maximum filed emergence index (5.71) for the genotype DH-5 followed by DH-228 (5.60) and minimum field emergence index (5.50) was observed for the genotype DH-36. Seedling establishment showed significant results by the application of growth regulators and maximum seedling establishment (88.14%) was recorded by the foliar application of NAA and followed by GA_3 (83.56%) and minimum seedling establishment (75.45%) was observed by the application of control (water) among the treatments irrespective of genotypes. The overall genotypic mean and maximum seedling establishment in Fig. 2 (85.22%) for the genotype DH-5 followed by DH-228 (82.82%) and minimum seedling establishment (80.67%) was observed for the genotype DH-36. These results are same in accordance with the finding of Kumar et al. [16] on black cumin, Hye et al. [17] on onion, Chaudhary et al. [18], Kumar et al. [19], Natesh et al. [20], on coriander by Verma and Sen [11], Vijaykumar and Sundareswaran [21] and Shivran and Jat [13].

4. CONCLUSIONS

On the basis of present investigation it is concluded that the foliar application of plant growth regulators (NAA & GA_3) at 50 percent flowering significantly enhanced the growth parameters, seed yield and quality of coriander crop. Among all the genotypes, irrespective of growth regulators, Hisar Anand (DH-5) was found the highest seed yielder followed by Hisar Bhoomit (DH-228), Hisar Surbhi (DH-246) and Hisar Sugandh (DH-36) with the foliar spray of NAA followed by GA_3. The foliar application of growth regulators at 50 percent flowering also influenced the seed quality of coriander seed. The best quality seed with highest value of seed quality parameters such as test weight, standard germination, seedling length, seedling dry weight, vigor index-I, vigor index-II, dehydrogenase activity test, field emergence index and seedling establishment were recorded with the foliar application of NAA followed by GA_3 and control (water). The best seed quality was harvested from NAA sprayed crop followed by GA_3 as compared to control (water).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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