CHAPTER-II

REVIEW OF LITERATURE

The role of plant growth regulators in various physiological and biological processes in plants is well known, which enables a rapid phenotypic change in the plant. Plant growth regulators are known to affect seed germination, vegetative growth, flowering, seed setting, seed development, seed maturity and seed yield. Further, the physic-chemical properties of the crop are also influenced by plant growth regulators.

There is a great deal of experimental evidence in the literature showing that endogenous growth substances are involved in many processes which leads to growth and development. Plants have also been shown to respond to exogenous application of plant growth regulators. Considering their role in plants, plant growth regulators have been designated as magic chemicals which bring about an unprecedented growth and help in removing and circumventing many of the barriers imposed by genetical and environmental factors. Crop yield is a complex heritable character influenced by many morphological and physiological plant characters interacting with environment.

An attempt has been made to present the impact of plant growth regulators on plant morphological, physiological, biochemical and yield parameters. The literature on the use of growth regulators in coriander is meagre and hence the work on other closely related seed spice crops like fenugreek, cumin, fennel, dill, mustard etc., their effects on morphological, physiological, biochemical parameters and yield attributes are considered to support the present investigation.

2.1 Effect of plant growth regulators on growth, yield and yield attributes

The literature pertaining to the effect of plant growth regulators on both morphology and physiology of plants in terms of plant height, number of branches per plant, days to 50% flowering, yield and yield attributing characters recorded by several workers is reviewed in this chapter.
2.1.1 Effect of GA₃

Purbey and Sen (2005) conducted field experiment at Udaipur to study the effect of growth regulators (GA₃, NAA and brassinosteroids) on growth and yield of coriander cv. Rmt-1. They revealed that GA₃ at 100 ppm gave maximum plant height (75.39 cm) as compared to control (60.11 cm).

Verma and Sen (2006) revealed that application of gibberellic acid 50 ppm by soaking + spraying resulted in maximum number of nodes on main shoot (7.60), number of branches per plant (9.51) and number of umbels per plant (25.36).

Meena et al. (2006) conducted an experiment to study the effect of plant growth regulators (GA₃ and NAA) on growth and yield of coriander and reported that the spray of GA₃ at 25 ppm at 30 DAS gave maximum plant height (103.24 cm) as compared to control (90.95 cm).

Shah et al. (2006) to investigate the effects of foliar application of GA₃ (50 ppm) and water (control) sprayed at 40 DAS (vegetative stage) and 60 DAS (flowering stage) on yield of black cumin revealed that the spraying of GA₃ 50 ppm at vegetative stage (40 DAS) recorded more number of umbels (37.05) per plant as compared to control (27.11).

Panda et al. (2007) used GA₃ at 50, 75 and 100 ppm and Ethrel [ethephon] at 75, 100 and 125 ppm in coriander. They observed that the application of GA₃ 100 ppm significantly increased the plant height (104.26 cm) as compared to control (80.53 cm).

Srivastava and Srivastava (2007) observed that the application of GA₃ (1000 mg l⁻¹) resulted in an increase in stem elongation, leaf and internodes length and plant height in coriander.

Vasudevan et al. (2008) observed that among different chemical sprays GA₃ (100 ppm) followed by boron (0.1%) produced more number of productive branches and seed yield in coriander. Among the interaction effect, the maximum number of branches with more plant height was recorded with pinching at 30 DAS and foliar spray of GA₃ (100 ppm).

Gangaram (2011) carried out a field experiment to investigate the effect of phosphorus and plant growth regulators on growth, yield and quality of fenugreek during 2010-11. The results revealed that the 50 ppm GA₃ with 20 ppm NAA significantly increases plant height (51.96 cm) and days to 50 % flowering (42.66).
Reviews of literature

number of branches, number of pods per plant, number of seeds per pod, test weight, seed yield, straw yield and biological yield

Hassanpouraghdam et al. (2011) recorded the greatest quantity of fresh and dry weight of leaves with foliar application of GA$_3$ at 300 mg l$^{-1}$ in coriander.

Zheljazkov and Astatkie (2011) reported increased plant height with the application of GA$_3$ in coriander. Kahn and Brian (2010) reported that GA$_3$ increased canopy height at harvest in coriander.

Pariari et al. (2012) conducted an experiment to determine the effect of GA$_3$ at 50, 75 and 100 ppm and NAA at 25, 50, 75 and 100 ppm on growth of black cumin. The results showed that GA$_3$ 100 ppm increased plant height as compared to control.

Singh et al. (2012) reported that among the different PGRs applied techniques, spray of 50 ppm of GA$_3$ resulted in significant maximum plant height at harvest (118.04 cm), fresh weight of leaves per plant at harvest (27.22 g), no. of nodes on main shoot at harvest (11.89) and no. of branches per plant at harvest (14.29) more over, application of 50 ppm of GA$_3$ significantly decreased the days to 50% flowering (79.30) dry weight of leaves, number of nodes per branches, number of umbels per plant, umbellate per umbel, seeds per umbel of coriander followed by spray of 75 ppm NAA.

Shetty and Rana (2012) conducted an experiment to study the effect of gibberellic acid (GA$_3$ at 0, 50, 75 and 100 ppm) on yield of ajwain local genotype HAJ-18. They observed that the application of GA$_3$ at 100 ppm significantly increased the number of seeds (342.47) per umbel as compared to control (268.75).

Talab et al. (2014) conducted the experiments on evaluation of growth, phytochemical and morpho-physiological properties in fenugreek under application of PGRs. The treatments were consist of control (distilled water application) GA$_3$ and NAA each at 25 and 50 ppm by either a pre-plant soaking. Application of GA$_3$ @ 25 ppm recorded significantly the highest shoot dry weight, 1000-seed weight, number of seeds per pod, content of seed trigonelline, leaf area per plant and plant height, number of pods per plant, leaf and pod dry weight.

Yugandhar et al. (2016) found the maximum plant height (78.09 cm) was observed in GA$_3$ 75 ppm. However, GA$_3$ 75 ppm took minimum number of days to 50% flowering (40.33) and maturity (85.00 days).
Prajapat et al. (2015) recorded that plant height at harvest, number of branches per plant, minimum days to 50 per cent flowering, number of umbels per plant, biological yield, seed yield per plot and seed yield per hectare were favorable with the application of 100 ppm gibberellic acid at juvenile stage of plant while, number of seeds per umbellate, number of seeds per umbel and harvest index were maximum with same concentration at flowering stage of plant in fennel.

Tania et al. (2015) studied that gibberellic acid (GA₃) at 50 ppm, 75 ppm, 100 ppm and 125 ppm was sprayed on fenugreek at 40 and 60 days after sowing. GA₃ @ 100 ppm promoted growth and produced highest yield, followed by GA₃ @ 75 ppm which, was at par with GA₃ @ 100 ppm. Among the quality parameters, carbohydrate was highest with GA₃ @ 125 ppm whereas, crude protein content was highest with GA₃ @ 75 ppm. The highest oleoresin content and highest essential oil content was recorded with GA₃ @ 100 ppm.

Tariq et al. (2015) conducted an experiment to study the effect of plant growth regulators GA₃ concentrations (0, 70, 60 and 50 ppm) along with phosphorus (40 kg) give the significantly higher growth, biochemical and yield attributes of fenugreek compared to control, the combination of phosphorus and GA₃ (40 kg + 60 ppm GA₃) significantly increased seed yield (140.6%) and the content of total chlorophyll (28.5%).

Haokip et al. (2016) revealed that GA₃ @ 50 ppm performed better than all the other growth regulators for plant height, number of primary and secondary branches per plant, number of umbels per plant, number of umbellets per umbel, number of seeds per umbel, seed yield, oleoresin and essential oil and took minimum number of days to 50% flowering and maturity followed by NAA @ 75 ppm in the coriander.

Mohit et al. (2016) revealed that different concentration of GA₃ 15, 25, 35, 50, 60, 70, 80 ppm and 100 ppm sprayed on ajwain, significantly highest plant height, plant fresh weight, plant dry weight, relative water content, number of umbels, 1000 seed weight and seed yield was recorded by the treatment of GA₃ @ 100 ppm.

### 2.1.2 Effect of NAA

Studies conducted by Verma (2002) to determine the effect of plant growth regulators (IAA, NAA and GA₃ each at 10, 25 and 50 ppm) on yield of coriander cv. RCr-435. The results showed that NAA at 50 ppm recorded maximum number of seeds per umbel compared to control.
Nehara et al. (2006) conducted an experiment to study the effect of plant growth regulators (Triacontanol, NAA and Ethephon) on yield of fenugreek cv. Rmt-1. They observed that spraying of NAA at 20 ppm gave more number of pods (37.9) per plant as compared to control (34.7).

Meena et al. (2006) reported that foliar application of NAA @ 25 ppm at 30 DAS resulted in significantly higher growth and maximum number of green leaves and green leaf yield per plant in coriander grown exclusively for green leaf purpose.

Bairwa and Kaushik (2007) studied the effect of plant growth regulators (water spray, NAA at 20 ppm and Ethephon at 100 ppm) on yield of fenugreek and revealed that the spraying of NAA at 20 ppm produced maximum number of pods (32.69) per plant over control.

Menaria and Maliwal (2007) observed that the foliar application of plant growth regulator NAA at 100 ppm on yield of fennel var. GF-2 showed that plants treated with NAA at 100 ppm produced more number of umbels (27.46) per plant as compared to control (24.83).

Among different plant growth regulators (IAA, NAA and GA3 each at 10, 20 and 50 ppm) and the method of their application (pre-plant soaking, spraying 20 DAS and pre-plant soaking + spraying 20 DAS), Piyush Verma and Sen (2008) recorded significantly increased the fresh weight of leaves plant\(^{-1}\) in coriander herb by the application of NAA at 50 ppm through pre-plant soaking + spraying 20 DAS.

Sarada et al. (2008) evaluated the effect of NAA (10 and 50 ppm), Triacontanol (0.5 and 1.0 ml/lit) and water on growth of coriander and revealed that the spraying of NAA at 10 ppm significantly increased the number of secondary branches per plant (16.0) as compared to control (13.7).

Gour et al. (2009) a field experiment was conducted at Mandsaur to study the effect of plant growth regulators (GA3, NAA and Ethrel) on yield of fenugreek cv. Rmt-1. Results revealed that the spraying of NAA at 20 ppm significantly increased number of seeds (17.87) per pod as against control (15.18)

Ruchitra et al. (2009) observed that the foliar spray of naphthalene acetic acid (NAA) 20 ppm at 25 days after sowing (DAS) and 55 DAS resulted in significantly maximum plant height (74.78 cm), no. of branches/plant (7.08), fresh weight (3070.40 g/m\(^2\)) and dry weight (864.94 g/m\(^2\)) whereas, the minimum days (49.41) are required for 50% flowering in treatment of 50 ppm GA3.
Bairva et al. (2012) reported that the yield components and seed yield showed positive response to foliar application of PGRs. The productivity of fenugreek crop in terms of no. of pods/plant (86.37), pod length (12.12 cm), pod weight (4.85 mg), no. of seed/pod (18.00), seed yield (17.99 q/ha) and straw yield (47.40 q/ha) was recorded significantly maximum in 20 ppm foliar spray of NAA as compared to different concentrations of GA\textsubscript{3}.

Rohamare et al. (2013) carried out a field experiment to investigate the effect of foliar application of GA\textsubscript{3} and NAA on growth, yield and essential oil components of ajwain during 2009-11. The results revealed that foliar application of NAA @ 100 ppm significantly enhanced the yield characters i.e. no. of umbles/plant (214.22), seed yield/plant (68.34 g) and dry biomass/plant (83.16 g).

A field experiment was conducted by Shivran and Jat (2013a) to study the effect of growth regulators (Triacontanol and NAA) on growth of cumin var. RZ 223 and the results revealed that the spray of NAA at 50 ppm recorded more number of branches (5.6) per plant as compared to control (4.9).

Shivran and Jat (2013b) conducted an experiment to study the effect of bioregulators (Triacontanol at 0.5 and 1.0 ml L\textsuperscript{-1} and NAA 50 ppm) on growth of coriander cv. RCr-41. The results showed that NAA at 50 ppm produced more number of branches (6.56) compared to control (5.73).

Choudhary (2017) conducted the experiments to study the effect of nitrogen and plant growth regulators on growth and productivity of ajwain. He reported that application of thiourea @ 500 ppm and NAA @ 50 ppm spray at 40 and 60 DAS, significantly increased plant height at 105 DAS and at harvest, dry matter accumulation at 70, 105 and harvest, number of umbels per plant, number of seeds per umbel and test weight over thiourea @ 500 ppm at 40 DAS, NAA @ 50 ppm at 40 DAS and control.

Pradeep et al. (2017) studied that the foliar application of growth regulators such as NAA and GA\textsubscript{3} 50 ppm 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.

2.1.3 Effect of cycocel

Kumar et al. (2007) conducted an experiment to study the effect of cycocel on growth of coriander cv. Hisar Anand and revealed that the spray of cycocel
at 100 ppm showed reduction in plant height (122.60 cm) compared to control (122.35 cm).

Ali et al. (2011) studied the effect of licorice, fenugreek extracts and cycocel on yield of fenugreek revealed that the plants treated with cycocel at 600 ppm showed more seed yield (532.6 kg/ha) compared to control (365.6 kg/ha).

Kumar and Sundareswaran (2011) reported that cycocel (250 ppm) reduced the plant height and improved the field survival and crop stand. Cycocel also promoted the primary and secondary branching of the plants. Higher values for relative water content, chlorophyll stability and leaf proline were also obtained in this treatment. The spray has also promoted the yield attributing character like umbel number, umbellet number and seed number in coriander.

Waghamore et al. (2012) conducted an experiment to study the effect of chemicals (KCl, KH₂PO₄, GA₃ and Cycocel) and cow urine on yield of sesame var. DS-1. They observed that the application of cycocel at 500 ppm had significantly increased the seed yield (8.58 g) per plant as compared to control (5.33 g).

Haq et al. (2013) results indicated that growth and yield of black cumin were increased with the increasing of concentration of cycocel up to 100 ppm. Application of cycocel at vegetative stage was more effective than flowering stage. The maximum number of branches per plant, plant height, weight per plant, capsule per plant, 1000 seed weight, seed yield and stover yield were observed with application of cycocel 100ppm at vegetative stage.

Saxena et al. (2014) reported that significantly increased of morphological parameters in terms of fresh: dry weight, shoot weight, shoot root length and seed yield under application of cycocel, betain and ASA from 100 to 700 ppm in the coriander.

Yugandhar et al. (2016) reported that application of 75 ppm GA₃ resulted in significant maximum plant height. However, maximum number of primary branches and secondary branches per plant, number of umbels per plant, number of umbellets per umbel, and number of seeds per umbel, seed yield (9.09 g) and B: C ratio were maximum in 250 ppm cycocel.

Krishnaveni et al. (2016) observed that foliar spray of cycocel 50 ppm thrice (25, 45 and 65 DAS) resulted in best performance of the yield parameters like number of pods plant per plant, length of pod, number of seeds per pod and seed yield.
per plant. Early flower initiation and early maturity was observed with application of cycocel 75 ppm in fenugreek.

2.1.4 Effect of triaccontanol (TRIA)

Fattah et al. (1998) observed that foliar spray of 2 ppm and 4 ppm triaccontanol significantly increased plant height, leaf area index, dry weight per plant and chlorophyll content in leaves of niger as compared to control.

Sumeria (2003) observed that foliar application of triaccontanol (50 ppm) significantly increased the plant height, number branches per plant, number of siliqua per plant and seed yield characters of mustard.

Venugopal (2006) reported that the application of 100 ppm GA₃ + 2 ppm triacontanol resulted in higher fresh and dry herbage yield per hectare in coriander.

Sarada et al. (2008) conducted an experiment at RARS, Lam to study the effect of growth regulators (Triacontanol and NAA) on yield of coriander, revealed that increased seed yield per hectare (848 kg) with triacontanol at 10 ppm compared to control (692 kg).

Idrees et al. (2010) conducted field experiment at Aligarh to study the synergistic effects of gibberellic acid and triacontanol on growth, physiology, enzyme activities and essential oil content of coriander. They reported that a foliar spray of 100 ppm triaccontanol + 100 ppm GA₃ significantly promoted the values for most of the growth (shoot and root lengths, fresh and dry weights) and yield characteristics (number of umbels per plant, number of fruits per umbel, 100-seed weight and seed yield).

Singh (2010) observed that spraying of triaccontanol @ 500 ppm water, NAA and GA₃ @ 50 ppm at 1, 2 and 3 times gave significant effect on yield and yield attributing characters as compared to water spray in fenugreek. Further, maximum plant height and number of branches per plant were recorded by spraying triacontanol @ 500 ppm.

Naeem et al. (2011) suggested that foliar application of TRIA at 600 ppm concentration at 100 and 120 DAP significantly enhanced most of the growth and other physiological attributes and crop herbage yield in coriander.

Godara et al. (2013) reported that application of triacontanol significantly improved the seed yield and yield attributes in fenugreek crop compared with NAA and water sprays. Two sprays of triacontanol @ 50 ppm at 40 and 60 DAS produce maximum yield with 20% increase over control, and registered statistical superiority
over both the doses of NAA sprayed either once or twice, however it was at par with one spray of NAA at 40 DAS.

Shivran and Jat (2013b) conducted field experiment at Bikaner to study Influence of bio regulators and their time of application on growth, yield and economics of coriander (Coriandrum sativum L.). They observed that triacontanol @ 0.5 ml/lit with water spray significantly maximum plant height (78.7 cm), number of branches/plant, umbels/plant (21.78), seeds/umbel, umbellate/umbel (6.55), seed yield (1.42 t/ha), were recorded with three sprays at 40, 60 and 80 DAS closely followed by two sprays at 40 and 60 DAS over single spray at 40 DAS.

Meena et al. (2014) reported that significantly higher number of umbels per plant, umbellate per umbel, seeds per umbellate, seed, straw and biological yields were obtained with 500 ppm thiourea spray as compared to water spray and brassinolide but remained at par with 1000 ppm triacontanol.

Khan et al. (2015) the study revealed that plant growth was improved by TRIA significantly, and the increase was maximum at 100 ppm concentration in plant height, leaf area, number of leaves and herbage yield in the cumin. Chlorophyll content, protein content, NR activity and oil content increased in the plants due to TRIA treatment compared to untreated plants, and the increase was maximum at 100 ppm concentration. Effect of IAA and kinetin was similar to TRIA but maximum effect was observed at 50 ppm concentration.

Kuri et al. (2015) revealed that foliar application of 1000 ppm triacontanol significantly increased yield attributes, seed yield (1.40 t/ha), stover and biological yields, net returns and B : C ratio over control, 50 ppm NAA, 1000 ppm thiourea and 1 ppm brassinolide but remained at par with brassinolide in yield attributes and yields on pooled basis in the coriander.

Elham et al. (2016) reported that TRIA was applied to seedlings at the three-leaf stage @ 5, 10 and 20 ppm significantly increased shoot length, shoot dry weight, root length and root dry weight in the coriander.

2.1.5 Effect of vermiwash

Kumar et al. (2008) studied the effect of organic (vermiwash, goat extract and panchagavya) and inorganic (urea, DAP and KCl) foliar nutrients application on the performance of black gram during summer (2002) at Coimbatore. The results revealed that the higher values of growth and yield parameters viz. plant height, leaf area index, dry matter production, number of flower per plant, number of pods per
Reviews of literature

plant, number of filled grain per pod and grain yield were recorded in the treatment of 0.1 litres vermiwash spray followed by 1 % urea or 2% DAP spray at floral initiation and 15 days after flowering.

Gour et al. (2010) carried out an experiment at S. D. Agriculture University, Sardarkrushinagar, Gujarat. India during winter season 2009 to study growth, yield and profitability of fenugreek as influenced by varying levels of growth regulators and verminwash. Spray of vermiwash @ 1.0, 2.0 and 3.0 litres ha$^{-1}$ at preflowering stage, 1.0 litres vermiwash recorded significantly highest plant height, number of leaves, dry matter production, number of seeds per plant and seed yield per plant as compared to control (water spray).

Tharmaraj et al. (2011) conducted an experiment to study the influence of vermicompost and vermiwash on growth and yield of rice at Annamalai Nagar (TN). They found that higher number of leaves, leaf length, height of the plant and root length in the treatment of soil application of vermicompost and spray of vermiwash over control and its individual application.

Gour et al. (2012) studied the effect of plant growth regulators (NAA and Ethephon) and Vermin-wash on yield of fenugreek cv. GF-2. Among the treatments, treatment of Vermin-wash at 5 litres increased the seed yield (1218 kg) per hectare compared to control (920 kg).

Umesha et al. (2012) recorded the maximum plant height, total dry matter, fresh and dry herbage yield with the application of FYM @ 20 t ha$^{-1}$ + vermiwash @ 1.0 liters ha$^{-1}$ + neem cake @ 1.0 t ha$^{-1}$ in coriander.

Jagtap et al. (2013) conducted an experiment to study the influence of vermiwash (2 liters) and gibberellic acid (50 ppm) in fenugreek, recorded significantly higher germination percentage, vigour index and also showed enhancement in fresh and dry weights of root and shoot.

Jadav et al. (2014) conducted field experiment at Navsari to study the effect of spray of vermiwash @ 0.2 liters at 15, 30 and 45 DAS in fenugreek recorded significantly higher plant height (84.10 cm), root length (18.37 cm), number of branches per plant (6.80), total number of pods per plant (34.48), seed weight (1161.33 kg/ha) and straw weight (2833.73 kg/ha).

Pandey et al. (2014) carried out an experiment to study different level of vermi wash spray on growth and yield of fenugreek at ASPEE, Agriculture Research and Development Foundation, Malad (W), Mumbai. The experiment clearly indicated
that the growth and yield of crop obtained with treatment T₅ (vermiwash foliar thrice times spray of 0.4 and 0.8 liters ha⁻¹ at 45 and 90 DAS) had showed significantly higher plant height (86.09 cm), root length (20.67 cm), number of branches per plant (6.80), total number of pods per plant (34.48), seed yield (1261.54 kg) and straw yield (2756.86 kg) per hectar.

Alaghemand et al. (2017) studied the effect of different treatments included 7 t/ha of cow manure, vermicompost, vermiwash (obtained from 7 t/ha vermicompost); 7 t/ha of leachate vermicompost + vermiwash and no fertilizer. Use of organic fertilizers beneficially affected plant height (48 cm), pod length (12.81 cm), pod fresh (52.27 g) and dry mass (26.04 g), 1000-seed mass (1.49 g), internodes length (6.22 cm) and increase seed yield (2459.9 kg) of fenugreek.

### 2.2 Effect of plant growth regulators on nutrient content and uptake

Nehara et al. (2006) observed that foliar spray of 2 ppm tricontanol in fenugreek significantly increased the nitrogen, phosphorus and sulphur content and total uptake of nutrient in seed and straw as compared to control.

Singh (2007) noted that maximum uptake of nitrogen, phosphorus and zinc was recorded with 1000 ppm triacontanol and remained at par with 50 ppm NAA but significantly superior to control and 500 ppm NAA. However, all the PGRs (Thiourea, NAA and Triacontanol) significantly increased the nitrogen, phosphorus and zinc content in seed and straw and protein content in seeds of fenugreek over control.

Purbey and Sen (2007) at Udaipur observed that foliar spray of 20 ppm NAA at 25 DAS, full bloom and pod setting stages significantly increased the nitrogen and phosphorus content in seed and straw, total uptake of nitrogen, phosphorus and potassium in fenugreek crop compared to control and rest treatments and was at par with 10 ppm NAA spray. However, no significant effect on potassium content in seed and straw was recorded.

Idrees et al. (2010) conducted field experiment at Aligarh to study the synergistic effects of gibberellic acid and triacontanol on growth, physiology, enzyme activities and essential oil content of coriander. They reported that GA₃ @ 60 ppm significantly enhance N, P, K and Ca concentrations in seed and straw, leaf nitrogen and leaf phosphorus content except leaf potassium content.

Balai and Keshwa (2011) carried out experiment at Jobner. to study the effect of thiourea on yield and nutrient uptake of coriander (Coriandrum sativum L.)
varieties under normal and late sown conditions. They reported that foliar spray of thiourea (1000 ppm) at vegetative and flowering stages significantly increased the seed (24.6%) and straw yields (25.8%), N (25.6 and 27.3 %), P (25.7 and 27.4 k %) and K (25.2 and 26.0 %) concentrations in seed, straw and total uptake of N, P and K as compared to water sprayed control.

Gangaram (2011) reported that application 60 kg phosphorus with 20 ppm NAA significantly increases N, P and K content of seed, protein content of seed, and chlorophyll content of leaves in fenugreek.

Meena (2011) at Jodhpur found that nitrogen content in seed and straw, protein and essential oil content in seed of coriander were enhanced significantly with foliar spray of 1000 ppm tricontanol and 1 ppm brassinolide over water spray. However, highest total uptake of nitrogen was recorded in tricontanol @ 1000 ppm over rest of the treatments.

Ravimycin (2016) conducted field experiment at Environmental Biotech Lab, Annamalai University, Annamalainagar. to study the effects of vermicompost (VC) and Farmyard Manure (FYM) on the growth, biochemical and nutrient content of coriander (Coriandrum sativum L.) he found that the VC was rich in nutrients like OC, N, P, K, Ca, Mg, Fe, Zn, Cu, Mn and Br as compared to FYM. Vermicompost application increased all the nutrient content of coriander.

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jaipur district of Rajasthan during rabi season of 2016-17. The experiment consisted of four levels of nitrogen (0, 30, 60 and 90 kg/ha) and PGRs on ajwain (control, NAA @ 50 ppm, thiourea @ 500 ppm at 40 and 60 DAS). Significantly improved total uptake of nitrogen by ajwain in foliar spray of NAA @ 50 ppm spray at 40 and 60 DAS (Choudhary, 2017).

2.3 Effect of plant growth regulators on economics

Purbey (2005) studied the effect of growth regulators (GA₃, NAA and cycocel) on the economics of coriander cv. Rmt-1 and revealed that the spraying of NAA at 20 ppm recorded maximum net returns and B: C ratio (₹ 27,801 ha⁻¹ and 4.04, respectively).

Meena (2005) studied the effect of plant growth regulators (GA₃ and NAA) on the economics of coriander cv. RCr-41. He reported that the spraying of NAA at 25 ppm at 30 DAS gave maximum net returns and B: C ratio (₹ 35,385 ha⁻¹ and 3.75, respectively).
Nehara *et al.* (2006) conducted an experiment to study the effect of plant growth regulators (Triacontanol, vermiwash, NAA and Ethephon) on the economics of fenugreek cv. Rmt-1. They observed that spraying of NAA at 20 ppm gave the higher net returns and B: C ratio (₹. 20,232 ha⁻¹ and 1.77, respectively) as compared to control (₹. 17,703 ha⁻¹ and 1.64, respectively).

Sarada *et al.* (2008) conducted an experiment to study the effect of bioregulators (Triacontanol and NAA) on the economics of coriander and reported higher the B: C ratio (3.11) over control (2.46) with NAA 10 ppm.

Dutta *et al.* (2008) to study the effect of growth regulators (NAA, Triacontanol and IBA) on the economics of fenugreek and revealed that the spraying of NAA at 20 ppm gave the highest net returns and B: C ratio.

Bairwa and Kaushik (2007) carried out experiment to evaluate the effects of ethephon and NAA on the economics of coriander revealed that the plants treated with NAA at 20 ppm showed significantly higher net returns and B:C ratio (₹. 22,403 ha⁻¹ and 2.33, respectively) over control (₹. 13,557 ha⁻¹ and 0.81, respectively).

Gangaram (2011) reported that highest cost benefit ratio and net profit (₹. 32096 ha⁻¹) were obtained from 60 kg phosphorus ha⁻¹ with 20 ppm NAA.

Gour *et al.* (2010) studied the effect of growth regulators (NAA and Ethephon) and Vermin-wash on economics of fenugreek cv. GM-2 and revealed that NAA at 30 ppm gave the highest gross and net realizations and B: C ratio (₹. 40329 and 23510 ha⁻¹ and 1.39, respectively) as compared to control (₹. 30096 and 13557 ha⁻¹ and 0.81, respectively).

Singh *et al.* (2012) while studying the effect of plant growth regulators (GA₃ and NAA) on the economics of coriander cv. NRCSS ACr-1 reported maximum net returns and B: C ratio (₹. 39,158 ha⁻¹ and 4.33, respectively) with GA₃ 50 ppm compared to control (₹. 25,408 ha⁻¹ and 3.22, respectively).

Foliar application of plant growth regulators (GA₃ and NAA) on the economics of fenugreek revealed that the plants treated with NAA at 20 ppm showed maximum net returns and B: C ratio (₹. 27,752 ha⁻¹ and 4.06, respectively) over control (Meena *et al.*, 2013).

Shivran and Jat (2013b) while studying the effect of plant growth regulators with coriander, NAA at 50 ppm gave maximum net returns and B: C ratio (₹. 21,804 ha⁻¹ and 1.45, respectively) over control (₹. 14,805 ha⁻¹ and 1.00, respectively).
Foliar application of plant growth regulators (NAA and thiourea) on the economics of ajwain revealed that the plants treated with NAA at 50 ppm recorded maximum net returns and B: C ratio (₹ 48354 ha⁻¹ and 2.33, respectively) over 500 ppm thiourea (Choudhary, 2017).