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Role of Plant Growth Regulators in Vegetable Production: A Review

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A B S T R A C T

To enhance productivity and food safety Indian Agriculture become more mechanized and science based by using inputs and the plant growth regulators are among of them; plant growth regulators has quicker impact on vegetative as well as yield of the crops. As it has various advantages like less time consuming to treat the plant and environment friendly. Vegetables crops are rich sources of vitamins and minerals. Use of growth regulators in vegetable production must be specific their action and toxicologically and environmentally safe. The physiological activity of vegetable crops regulate and after the application of growth regulator finally enhance the vegetable production.

Introduction

The word plant hormones are also known as Phytohormones. These hormones helps to regulate growth of the plant and these hormones are small molecules that derived from different essential metabolic pathways. Thimann in 1948 was coined the term 'Phytohormone' as organic substance that produce naturally in plants.

The 'Plant Hormones' are natural and 'Plant Growth Regulators' are synthetic in nature. They play an important role to growth of plant (P. Hazra and M.G. Som, 2006). There are five types of plant growth regulators such as auxins, gibberellins, cytokinins, abscisic acid and ethylene. The classes are discussed in following table 1

Auxin

Charles Darwing was the first who proposed the existence of auxin in 1880. It was the first class growth regulator that was discovered. Auxins are those compounds that give positive effect on formation of bud, enlargement of cell and root initiation and they are also helpful for the formation of other growth hormones. IAA is natural occurring hormone while NAA, IBA, 2-4D etc. are synthetic in nature.

Gibberellin

Kurosava was the Japanese scientist who discovered gibberellins in 1926. It is the second growth regulator. It was extracted from the fungus '*Gibberellafujikuroi*' which is the causal organism of "foolish seedling of rice".

GA stimulate germination of seed and maturation of flower and fruit.

Cytokinins

Skoog in 1995 experimented that when pith tissues of '*Nicotianatabaccum'* were separated from the vascular tissues they grew without division of cell. There are so many different synthetic cytokinins such as 6-benzylamino purine (BAP), kinetin, 6-(benzyl-amino)-9-(2-tetrahydropyranyl)-9H-purine (PBA), 1,3-diphenylurea, thidiazuron (TDZ), etc.

Ethylene

This hormone is a gaseous plant hormone which is synthesized from methionine and it is synthesized in all organs of plant.

Abscisic acid

It is also called plant stress hormone. It act as inhibitory chemical compound that gives direct effect on growth of bud, seed and dormancy of bud. It has inhibitory effect and occurs naturally in plants. It inhibit mRNA and synthesis of protein.

Application of plant growth regulators in vegetable production

Tomato

Role of plant growth regulators are beneficial for growth parameters and yield of tomato. The different concentrations of NAA at 25, 50, 75 and 100 ppm and GA_3 20, 40, 60 and 80 ppm were sprayed on the plants of tomato and it was reported that maximum plant height i.e. 85.3 cm and 82.3 cm was observed by using NAA at 100 ppm and GA_3 at 80 ppm and yield was also increased 483.6 q/ha and 472.2 q/ha with the use of NAA at 100 ppm and GA_3 at 80 ppm (Prasad *et al.,* 2013).GA_3 @ 125 ppm gave maximum plant height, number of leaves, number of branches per plant, number of fruits, number of flowers, fruit clusters, diameter of fruit, yield per plant (kg) and per plot (kg) and yield per hectare (tonnes) were found to be maximum (Akand *et al.,* 2015). In BARI Hybrid Tomato-8, 4-CPA (4- Chlorophenoxy acetic acid) + GA_3 applied together after 75 days of transplanting and observed that the tallest plant (79.35 cm), number of flowers (38.11) and fruits and (19.04) per plant, height (87.90 cm), number of flowers (49.04) and fruits (21.9) per plant, individual fruit weight (61.16 g), and fruit yield (27.28 tha^{-1}) individual weight (58.44 g) and fruit yield (22.75 t ha^{-1}) were found to be maximum (Rahman *et al.,* 2015). The application of CCC (Cycocel) @ 500 ppm gave increased in height of plant, number of fruits per plant, fruit diameter and per plant seed yield after 45 days of transplanting of tomato seedlings as compared to NAA @ 50 ppm and GA_3@ 50 ppm (Chauhan *et al.,* 2017).

Chilli and capsicum

The treatments 2,4-D @ 2 ppm, triacontanol @ 5 ppm, NAA 40 ppm and GA_3@ 10 ppm produced 28.75%, 25.70%, 13.61% and 2.30% maximum fruit yield over control. It was recorded that maximum net profit and B: C ratio was found in case of 2 ppm 2,4-D. The use of GA_3 as foliar spray was not economical (Chaudhary *et al.*, 2006). Maximum seed yield per plant (8.30 g), seed yield per fruit (0.35 g), per plant average fresh weight of fruits (39 g) and per plant average dry weight of fruits (19.67 g) were obtained by spraying of NAA @ 40ppm as against control (Patel *et al.*, 2016). In capsicum, NAA @ 60 ppm gave maximum plant height (120.59 cm), number of branches (16.05), days to first flowering (32.51), per plant number of flowers (11.83), weight of fruit (169.66g), per plant number of fruits (9.87), per fruit number of seeds (110.78), per plant yield (1.67kg) and per plot

yield of fruit (15.07kg), yield per hectare (69.76t) were recorded (Singh *et al.,* 2017). Different concentrations of growth regulators such as NAA (25, 50 and 75 ppm), GA_3 (20, 40 and 60 ppm), 2, 4-D (5, 7.5 and 10 ppm) and ethrel (300, 400 and 500 ppm) were used in chilli and applied after 30 and 60 days after transplanting. It was recorded that NAA @ 75 ppm gave maximum yield per plant (182.31g) and yield per hectare (6.37t). On the other hand, GA_3 @ 20 and 60 ppm treated plants gave maximum plant height (60.67 cm), maximum dry weight of 20 fruit (9.39g). The plant spread in (N-S) (36.97 cm) and maximum number of seeds per fruit (60.47) were recorded in 2,4-D @ 7.5 ppm treated plants (Raj *et al.*, 2016).

Brinjal

Moniruzzaman *et al.,* (2014) used different growth regulators such as GA_3 (30, 40 and 50 ppm) and NAA (20, 40 and 60 ppm) and two varieties such as BARI Begun-5 and BARI Begun -10. It was reported that highest percentage of long and medium styled flower, leaf photosynthesis, number of fruits per plant and fruit yield (45.50 t/ha) was reported by application of NAA @ 40 ppm. The variety BARI Begun-5 took 40 days for flowering after transplanting which was earlier to 100% flowering of BARI Begun-10. Application of NAA @ 40 ppm coupled with BARI Begun-5 gave the maximum long-styled flower percent, number of fruits/plant, and the highest fruit yield (49.73 t/ha). Netam and Sharma (2014) studied that GA_3 @ 10 ppm and NAA @ 20 ppm gave maximum number of branches, number of fruits, fresh fruit weight, total soluble solid. Dhakar and Singh (2015) observes that GA_3@ 150 ppm gave heighest plant height, per plant number of leaves, length of leaf, per plant number of branches and stem diameter as compared to GA_3 @ 100 ppm and 200 ppm and minimum recorded in control.

Cauliflower

The performance of GA_3 and NAA at different levels as dipping of roots and by foliar spray on "SNOWBALL- 16" variety of Cauliflower. It was reported that foliar spray of GA_3 at 50 mg/l in cauliflower gave better results for diameter of curd (17.78 cm), length of stalk (5.22 cm), net weight of curd (3.53 kg/plant), curd yield (12.5 kg/plot) and required minimum days to 50 % marketable curd (88.80 days) was reported by Sitapara *et al.,* (2011). Highest plant height (63.10 cm), number of leaves per plant (23.66), leaf length (59.05 cm), leaf breadth (18.98 cm) at the time of harvest, diameter of curd (22.39 cm), marketable yield per hectare (29.88 t/ha) were recorded by using IAA 10ppm + GA_3 70 ppm than control. Also studied that the highest plant height (65.96 cm), number of leaves per plant (26.42), leaf length (63.64 cm), leaf breadth (20.92 cm) at the time of harvest, curd diameter (25.75 cm), marketable yield per hectare (31.03 t ha-1) were recorded from planting on 15 November and IAA 10 ppm with GA_3 70 ppm (Rahman *et al.,* 2016). Jadon *et al.,* 2009 used different doss of NAA@ 100, 120 and 140 ppm. They revealed that higher dose of NAA @ 140 ppm gave higher plant height (33.83 cm), diameter of the stem (1.65 cm), spread of the plant (45 cm) and number of leaves per plants (22.10). Yield attributing characters viz., diameter of curd (15.10 cm), weight of curd per plant (0.61 kg), weight of the head per plant (0.60 kg), length of head per plant (21.58 cm), yield (155 q/ha) and dry weight of curd per 100 g of fresh weight (10.40) were also increased than control.

Cabbage

Islam *et al.,* 2017 used different concentrations of GA_3 on cabbage. They took four different levels of GA_3 such as 0, 90, 120 and 150 ppm.

Table.1 Plant Growth Regulators and their classes

Plant growth regulators	Classes
Auxins	Indole-3-acetic acid (IAA), 1-Naphthaleneacetic acid (NAA), Indole-3-butyric acid (IBA), 2,4-Dichlorophenoxyacetic acid (2-4D), 4-Chlorophenoxyacetic acid (4-CPA).
Gibberellins	Gibberellic acid (GA_3)
Cytokinin	Kinetin, Zeatin
Ethylene	Ethereal
Abscisic acid	Dormins, Phaseic Acid

Jatindersingh (2014)

Table.2 Various Plant Growth Regulators and their Functions

Name of the plant growth regulators	Functions
Auxin	(a) Apical dominance (b) Cell division and enlargement (c) Shoot and root growth (d) Plant growth movement (e) Parthenocarpy (d) Abscission
Gibberellin	(a) Prevent genetical dwarfism (b) Regulation in bolting and flowering (c) Production of parthenocarpic fruit (d) Germination.
Cytokinins	(a) Cell and organ enlargement (b) Seed germination (c) Development of bud and shoot growth
Ethylene	(a) Ripening of fruit (b) Seedling growth and emergence (c) Abscission of leaf.
Abscisic acid	(a) Abscission (b) Dormancy (c) Inhibit seed development and germination of seed (d) Stomatal closing (e) Helps during water stress

Jatindersingh (2014) and P. Hazra and M.G. Som, (2006).

They reported that GA_3 at 120 ppm gave highest marketable yield (65.5 t/ha) while minimum yield was recorded in GA 0 ppm (41.2 t/ha). Heighest plant height, maximum number of loose leaves per plant and diameter of head was recorded by using GA_3 at 120 ppm while minimum in GA 0 ppm. On the other hand, minimum days were recorded for formation of head in GA 120 ppm and maximum days was recorded in GA 0 ppm. So, they found that GA_3 at 120 ppm was more effective. Chaurasiy *et al.*, (2014) used different concentrations of NAA (40, 80 and 120 ppm) and GA_3 (30, 60 and 90 ppm) and applied as foliar spray on plants of cabbage at 30 and 45 days after transplanting. They reported that NAA 80 ppm and GA_3 60 ppm gave heighest plant height, number of leaves per plant, plant spreading, diameter of stem, weight of plant, weight of head, and head yield as compared to all the other treatments and control.

Okra

Dhage *et al.*, 2011 revealed that IAA @ 100 ppm gave maximum plant height (107.74 cm), intermodal length (3.1 cm). However, by the application of GA_3 @ 150 ppm, minimum days are required for first flowering (39.67 days) and minimum days were required for first harvesting (44.67 days). Ravat *et al.*,

2015 recorded thatGA_3@ 50 ppm gave best seed quality characters like average pod weight (g), 100 seed weight (g). While GA_3 gave maximum plant height, number of leaves, per plant number of nodes and thiourea @500 ppm gave maximum no. of pods per plant, length of pod (cm), number of seed per pod, per plant seed yield (g) and seed yield per hectare(q).

Onion and garlic

Patel *et al.,* 2010 recorded that root dipping treatment of NAA @ 100 ppm significantly reduced physiological loss of weight, reduced loss in spoilage. Anbukkarasi *et al.,* 2013 recorded that CCC, ethylene and and fungicides play an important role in delay in sprouting and extant shelf life in onion. Bannu Priya *et al.,* 2014 reviewed the work done onpre and post-harvest treatments in onion to extend shelf life.

Cucurbits

Hidayatullah *et al.,* 2012 revealed that GA_3 @ 30 ppm increased in production of pistillate flowers, maximum no. of fruits and fruit weight as compared to control in bottle gourd. Dalai *et al.,* 2015 reported that GA_3 @ 20 ppm + NAA @ 100 ppm gave heighest wine length/plant (cm), no. of leaves/ plant. On the other hand, GA_3 @ 20 ppm + NAA @ 100 ppm gave maximum yield in cucumber. Sandra *et al.,* 2015 resulted that NAA @ 200 ppm, GA_3@ 50 ppm and etheral @ 50 ppm were very effective for enhancement in vegetative growth, fruit and seed yield and modification in sex expressions and GA_3 @ 50 ppm was effective in production of hybrid seed in bitter gourd.

Potato

Foliar application of ethrel at 250 ppm was effective in changing phenotype of plant, increased in plant height, diameter of shoot, per plant number of tubers and total yield of tuber as compared to control (Awati *et al.,* 2016). Application of GA_3 at 60 days after transplanting had increased in height of plant but number of tubers, weight and content of dry matter were not affected. Late application of GA_3 leads for induction of high percentage of sprouted tubers prior to harvest and also lead to increase physiological age of tubers (Alexios *et al.,* 2006).

Pea

Singh *et al.,* 2016 reported that GA_3 at 200 ppm gave significantly increased in height of plant, number of leaves, total number of branches, number of pods, length of pod and 100 seed weight.

From this review it has been concluded that PGRS regulate physiological process to the crop plants like rooting, flowering, growth, sprouting, ripening and use of PGRS in vegetable production found to be beneficial for yield and yield contributing characters of various vegetable crops.

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