Int.J.Curr.Microbiol.App.Sci (2018) *7*(8): 2413-2419

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 7 Number 08 (2018)**
Journal homepage: http://www.ijcmas.com

Review Article https://doi.org/10.20546/ijcmas.2018.708.243

Plant Growth Regulators and Strawberry Production

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Keywords

Strawberry, PGRs, Growth, Flowering, Yield

Article Info

Accepted:
12 July 2018
Available Online:
10 August 2018

A B S T R A C T

Strawberry is an attractive, tasty, luscious and nutritious fruit grown in temperate and subtropical climate. Plant growth regulators (PGRs) play important role in strawberry production which regulate plant growth, flowering and increase the yield of crops. In recent years, the interest in strawberry production has increased rapidly because of high price value and more demand. Yield increase in strawberry crops has been obtained through improved varieties, efficient management of fertilizers and various agronomic practices. Growth regulating chemicals are also becoming important in strawberry production for the modification of their vegetative growth, flowering, and fruiting which affect total yield and fruit quality. A structured review of the effect of plant growth regulators on growth, flowering, yield and shelf life, was prepared. Effect of different PGRs, alone and their combinations were explored. Auxins and gibberellins were identified as potent PGRs for improving growth, flowering, yield and post-harvest life parameters. Areas of interest where further research is needed include evaluating the effect of different combination and time of application of PGR and difference in varietal response with the growth regulators treatment. Hence, there is further need to evaluate the effect of growth regulators on strawberry.

Introduction

Plant growth regulators used to alter the growth of a plant or plant part. Basically, there are 5 types of growth regulators viz. (A) growth promotors like auxins (indole acetic acid (IAA), indole butyric acid (IBA), naphthalene acetic acid (NAA), 2-4-dichloro phenoxy acetic acid (2, 4-D), gibberellins (Gibberellic acid or GA), cytokinins (kinetin, zeatin) and (B) growth inhibitors/retardants like abscisic acid (ABA), ethylene (Fishel, 2006; Harms and Oplinger, 1988). Generally, growth regulators application has been practiced to increase production and quality of fruit crops. Effect of PGRs has been investigated extensively in strawberry. They regulate the plant growth and increase the yield of strawberry (Dwivedi *et al.*, 1999; Kumar *et al.*, 2012a, b; Khunte *et al.*, 2014). During recent years, the interest in strawberry production has increased rapidly because of its better generic diversity, heterozygosity and broader range of its environmental adaptation of improved varieties, off-season production (Peng, *et al.*, 2015; Hancock, *et al.*, 2000;

Durner, 2018). Yield of the strawberry crop can be increased through improved varieties, efficient use of chemicals fertilizers and various agronomic practices. Besides, growth regulating chemicals are also becoming important in the strawberry for the modification of their vegetative growth, flowering, and fruiting affecting total yield and also quality (Vishal *et al.*, 2016; Palai *et al.*, 2016).

Growth parameter

PGRs have been found useful in improving growth parameters of strawberry. Palei *et al.*, (2016) reported that maximum plant spread (35.7cm), petiole length (13.2cm), number of leaves (20.8/plant) and runners (3.2/plant) was obtained in strawberry cv. Chandler with GA3 @ 100ppm. Vishal *et al.*, (2016) observed that GA3 (125ppm) gives maximum plant height (22.39cm), length of trifoliate leaves (11.64cm), number of leaves per plant (28.33), plant spread (29.70cm), breadth of trifoliate leaves (15.86cm) and runners per plant (5.87) in strawberry cv. Sujata. Rajbhar *et al.*, (2015) reported that GA3 (100 ppm) resulted higher yield in Chandler cv. of strawberry. Saima *et al.*, (2014) reported that application of GA3 75mg/l resulted maximum petiole length (25.53), leaf area (136.30cm^2), number of leaf per plant (23.00). Swamishekhar (2013) found that rate of photosynthesis was significantly affected by different concentrations of growth regulator treatments. Maximum photosynthetic rate (8.31 µmole/m^2/sec.) was registered in plants treated with CPPU 6 ppm +GA3 50 ppm treatment followed by CPPU 4 ppm + GA3 50 ppm, GA3 75 ppm and CPPU 2ppm + GA3 50 ppm treatments, while the minimum photosynthesis (3.39 µ mole/m^2/sec.) was recorded in control**.** Asadi *et al.*, (2013) assessed effect of different concentration of GA3 (25, 50, 100ppm) in strawberry cultivar Gaviota in which GA3 (50ppm) was best for proper growth and yield of strawberry. Singh and Singh (2009) reported that strawberry cultivar Sweet Charlie showed maximum total biomass (42.02gm/plant), plant height (27.33cm) and chlorophyll at 50% N standard dose and GA3 (100ppm). While, dual inoculation with 75% N and 100ppm BA gives maximum number of crowns per plant (5.87), leaves (26.92/plant) and leaf area (123.29cm^2). Perez *et al.*, (2009) observed the highest leaf number, crown number and the number of flowers in plants of the strawberry cultivar Chandler treated with 20 mg per litre of gibberellic acid. Hytonen *et al.*, (2009) concluded that GA3 is needed for runner initiation in strawberry and the inhibition of GA biosynthesis leads to the formation of crown branches. GA3 applied at a concentration of 1.0- 2.0 mg dm-1 significantly increased the number of axillary shoots (mainly crown shoots), whereas under higher (5.0- 10.0 mg dm^{-3}) doses it stimulated the development of runners as reported by Litwinczuk *et al.*, (2009). Mir *et al.*, (2004) observed that application of GA3 significantly increased the number of runners as compared to NAA and control.

Tripathi and Shukla (2006) also obtained higher plant height (20-39 cm) and number of leaves (18.09) with GA3 application at 100 ppm over the effect of NAA, GA3, CCC and BA in strawberry cultivar Chandler. Dwivedi *et al.*, (1999) evaluated the effect of Gibberellic acid (25, 50 and 100 ppm), Alar (250, 500 and 1000 ppm), Ethrel (250, 500 and 1000 ppm), Morphactin (25, 50 and 100ppm) and Cycocel (500, 1000 and 2000 ppm) on strawberry cultivars 'Senga Sengana' and 'Missionary'. GA3 (50 ppm) recorded effective plant growth regulator for improving leaf number, petiole length and number of runners in strawberry. GA3 0.08% increases 22% runner per plant and CCC 1.2% increases 10% number of runners per plant in strawberry cv. Guedes (Pankov, 1992).

Floweing, fruit set and yield parameter

PGRs play important role in flowering and fruiting of strawberry. Palei *et al.,* (2016) c carried out an experiment on strawberry Cv. Chandler with different type of PGRs GA3 (25, 50,100ppm), IAA (25, 50,100ppm) and NAA (25, 50,100ppm). Higher number of flowers per plant (24.1) and number of fruit per plant (22.5) was obtained from NAA (100ppm) over the other treatments. Rajbhar *et al.,* (2015) reported that application of GA3 100ppm + vermicompost @100q/ha resulted higher yield in strawberry cv. Chandler. Saima *et al.,* (2014) recorded that application of GA3 75mg/l resulted higher yield, flower per plant and number of berries. Asadi *et al.,* (2013) recorded more yield in strawberry cultivar Gaviota with GA3 (50ppm).

Prasad *et al.,* (2012) carried out an experiment with strawberry cultivar Douglas with different type of mulching materials and (straw mulch, black polythene mulch, transparent mulch, PGRs (GA3 (25, 50, 100ppm) and NAA (10, 20, 40ppm). Maximum yield (349.05g/plant), plant height (23.20cm), number of flowers (38.25/plant), early harvesting (81.61days), maximum cost-benefit ratio (1.62%) was observed with GA3 100ppm + black polythene mulch. Kumar *et al.,* (2012) evaluated effect different type of PGRs viz. GA3 (25, 50,75ppm), cycocel (300, 600, 900ppm) and triacotanol (1.25, 2.5, 5ppm) on strawberry cv. Sweet Charlie. Result showed that higher yield (376.69g/plant), number of fruits (23.31), and fruit yield (27.90q/ha), length: diameter ratio of fruit (1.50) was recorded with triacotanol 5ppm. Al-Madhagi *et al.,* (2012) reported increased number of fruits per plant with the application of GA3 at 50 ppm in strawberry cultivar Camarosa. Uddin *et al.,* (2012) recorded the maximum number of flowers (28.7/plant), fruits (25.9/plant) and yield (336.6 g/plant) in strawberry plant treated with GA3 75 ppm which was closely followed GA3 100 ppm and minimum (21.1, 19.6 and 248.9 g/plant, respectively) in control. Singh and Singh (2009) conducted an experiment on strawberry cultivar Sweet Charlie with different type of PGRs and bio fertilizers. Result showed that maximum total biomass (42.02gm/plant), and chlorophyll was obtained from 50% N standard dose and sprayed with GA3 100ppm. Dual inoculation with 75% N and 100ppm BA gives maximum Yield and fruit set was maximum in combination of GA3 100ppm + 50% N + azotobactor + azospirillium application.

Fruit Quality

Rajbhar *et al.,* (2015) found that GA3 100ppm + vermicompost @100q/ha resulted more TSS (10.68 ºBrix) in strawberry var. Douglas. Kumar *et al.,* (2012) recorded the maximum fruit length-diameter ratio (1.28 cm), juice content (87.35 %) and TSS (9.07 %) with GA3 (30 ppm) while maximum ascorbic acid (63.03 mg/100 g) and acidity (0.75 %) with GA3 (90 ppm). Uddin *et al.,* (2012) recorded the maximum fruit length (32.7 mm), diameter (25.0 mm), fruit weight (13.2 g) and TSS (4.7 %) in strawberry plants treated with GA3 75 ppm as compared to control (no GA3).

Kumar *et al.,* (2012a) evaluated effect different type of PGRs viz. GA3 (25, 50,75ppm), cycocel (300, 600, 900ppm) and triacotanol (1.25, 2.5, 5ppm) on strawberry cv. Sweet Charlie. Result showed higher pH value (3.69), and specific gravity (1.28%) was recorded with triacotanol 5ppm. Cycocel 900ppm gives highest vitamin C (55mg/100gm), total sugar (9.40%), TS (9.40%), TSS (9.63degree Brix), juice content (93.66%). Sharma and Singh (2009) obtained highest juice content (74.8 %) and ascorbic acid content (50.4 mg/100 g) in strawberry cultivar Chandler when plants were twice

sprayed with GA3 (75 ppm) during mid-November and mid -February. Roussos *et al.*, (2009) observed that anthocyanin content in strawberry fruit increased significantly when the plants were treated with GA3.

Shelf life of fruits

Pre and post-harvest applications of PGRs improves fruit quality, helps to delay the senescence in storage and improves the shelf life of strawberry (Singh *et al.*, 2017; Jain and Singh, 2004). Minz (2010) observed that GA3 + black polythene mulch was best to extend the shelf life of strawberry fruits for 2.48 days under ambient conditions. Jain and Singh (2004) conducted an experiment to extend the shelf life of 'Chandler' strawberry (*Fragaria* × *ananassa*) fruits with four plant growth regulators (NAA, TIBA, gibberellic acid and 2,4-D) and 2 calcium salts (calcium nitrate and CaCl2). The pre-harvest foliar spray of the crop with GA3, NAA, 2,4-D and calcium nitrate extended the shelf life and helped in developing quality ripe fruits in terms of retaining high reducing sugars, minimum cumulative physiological loss in weight and higher vitamin C retention.

Pre-harvest (14 days prior harvesting) spray with 25 ppm GA3 was the best treatment, followed by 10 ppm 2,4- D and 1% calcium nitrate, which not only extended the shelf life (up to 9 days) but also reduced the postharvest decay losses (1.55%) and minimized the cumulative physiological loss in weight (7.26%) due to moisture loss and degradative metabolism during ripening without adversely affecting the quality. The pre-harvest treatment with NAA 25 ppm favoured the higher vitamin C (49.30 mg/100 g pulp) content during storage.

The literature available revealed that plant growth regulators give an instant impact on crop growth. Latest scientific findings showed that GA3 is an effective PGR for improving growth, yield, quality and shelf life of strawberry. More research is needed to evaluate the effect of different combination and time of application of PGR on strawberry. Hence, there is need to evaluated effect of growth regulators on different varieties of strawberry.

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How to cite this article:

Saurabh K. Singh, Ashvin A. Bhople, Paresh P. Kullarkar, Nikhil Bhople and Ajay Jumale. 2018. Plant Growth Regulators and Strawberry Production. *Int.J.Curr.Microbiol.App.Sci.* 7(08): 2413-2419. doi: https://doi.org/10.20546/ijcmas.2018.708.243