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Impact of Plant Growth Regulators on Strawberry Plant – A Review

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ABSTRACT

Strawberry is soft, luscious, nutritious, tasty, and perishable fruit which are grown in temperate climatic conditions where the plant like a small perennial herb and also grown in a sub-tropical climate whose plant behaves as an annual belonging to the family Rosacea. Application of growth regulators has been practiced commercially to increase the production and quality of crops. Gibberellic acid has a significant role in plant heights, number of runners, number of flowers, fruit set percentage, number of fruits, fruit size, fruit weight and fruit quality. In this study we present influence of gibberellic, yield and fruit quality of strawberry, Triacontanol and NAA on growth on yield and quality, chlormequat. Gibberellins are well-known for acting as a long-day hormone in short-day plants. Gibberellin treatment increases vegetative growth but limits flower development applied gibberellic acid promoted blooming and growth. However it was observed that the highest effect on leave, runner, crown, inflorescence and flower production. Triacontanol, Activol and NAA resulted in increased vegetative growth of strawberry as compared control. Highest crown height (7.2cm) was obtained with 100 ppm Activol and highest leaf number/plant (7.2) and leaf region (49.4m2) were obtained with 50ppm tricontanol treated plants.

Key words: *Plant Growth regulators on strawberry, Gibberellin, Triacontanol and NAA on growth yield and quality, Influence of chlormequat*

Introduction

Strawberry plant

Strawberry (*Fragaria × annanassa*) is one of the mostly popular and early remunerate fruit in the world. Though strawberry is a short day plant but it haslimited vegetative growth during this short day period that caused less production with low quality (Asrey *et al*. 2004). Strawberry is pulpy, luscious, nutritious, grumpy, and perishable fruits which are grown in temperate climatic situations where the plant act as like a small perennial herb and also grown in a sub-tropical climate whose plant act as an annual belonging to the family Rosaceae (Salentijn *et al*., 2003; Srivastav *et al*., 2018; Deyton, *et al*., 1991). The civilized strawberry (*Fragaria - ananassa* Duch.) exist as monoeciousoctaploid hybrid of two largely dioecious, octaploid species, *Fragaria chiloensis* Duch. and *Fragaria virginiana* Duch (Deyton, *et al.*, 1991). Strawberry existing a non-climacteric fruit and distinguish by a high softening rate, shortpost- harvest life, and fast decompose (Bustamante *et al*., 2009). Strawberry (*Fragaria ananassa*) is a short day plant that has antioxidant, anti-inflammatory, anti- neurodegenerative and anti-cancer elements called ellagic acid, fulfilled phenolics and flavonoids and also rich in vitamins, minerals such as potassium, phosphorus, calcium, and iron (Roussos *et al*., 2009). It is a unique and one

of the over ripe fruit among temperate fruits in spring season (Behnamian and Masiha, 2005) and is a very profitable fruit crop (Bhat *et al*., 2005). Strawberry contains minerals, vitamins and also anti-cancer component called ellagic acid.

Consumption of strawberries leads to health benefits against cancer, aging, inflammation, and neurological diseases (Deyton *et al.,* 1991). Camarosa, Laguna, Seascape Chandler, Sweet Charlie, Fern, Douglas, Redgauntlet, Talisman, Cambridge Favourite, Domanil, Fanil, Gorella, Goupil, Senga gigana, Senga precosana, Surprise des Hailes are different cultivars of strawberry (Sharma and Singh, 2009; Paroussi *et al.,* 2002). Strawberry is wealthy in Vitamin A (60 IU/100 g of edible portion), vitamin C (30–120 mg/100 g of edible portion), fiber, pectin (0.55%) and has a low calorie carbohydrate content and is high in carotenoids, flavonoids, phenols, and glutathione (Sharma and Negi, 2019; Nautiyal and Shukla, 2015).

Influence of growth promoters on Strawberry plant

Application of growth regulators has been practiced commercially to increase the production and quality of crops. Gibberellic acid has a significant role in plant heights, number of runners, number of flowers, fruit set percentage, number of fruits, fruit size, fruit weight and fruit quality (Sharma and Singh, 2009) and Kasim *et al.,* 2007). This review presented on influence of gibberellic, yield and fruit quality of strawberry, triacontanol and NAA on growth on yield and quality and chlormequat.

Influence of gibberellic Acid on strawberry

Rakesh Kumra, Reena (2018) is reported that growing fruits are very active metabolically and act as strong sinks for nutrients with hormones possibly modulating the process. Among the plant growth regulators, plant growth promoter gibberellins control plant growth and fruit development in various ways and at different developmental stages. Fruit development is a complex and tightly regulated process, the development of a fruit can be separated into phases that include pre- pollination, pollination, fertilization and fruit set, post fruit set, ripening and senescence. Plant peak, number of runners, number of flowers, fruit lay percentage, number of fruits, fruit size, fruit mass, and fruit conditions are all affected by gibberellic acid (Kumra *et al*., 2018) Gibberellic acid (GA3) treatment elevated flowering in non-chilled strawberry plants, condensed the cropping season, and expand vegetative growth and fruit number (Paroussi *et al*., 2002).

Gibberellins are popular for acting as a long-dayhormone in short-day plants. Gibberellin treatment expand vegetative growth but limits flower development (Kender *et al*., 1971).

Influence on vegetative growth and runner's production

Bower and Cutting (1992) reported that GA3 ap-

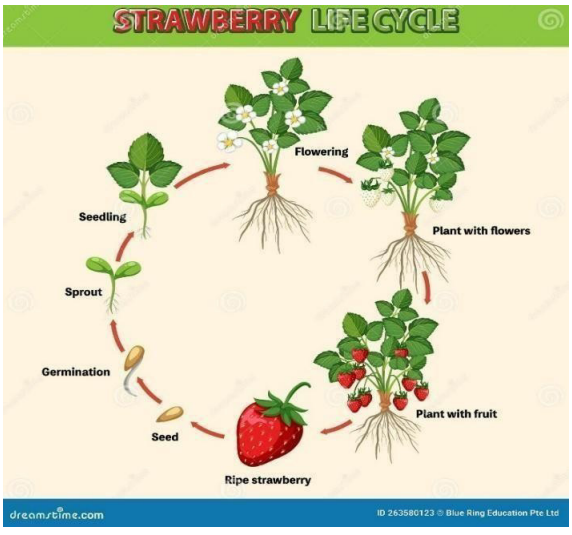

Fig. 1. strawberry Life Cycle (https://www.dreamstime.com

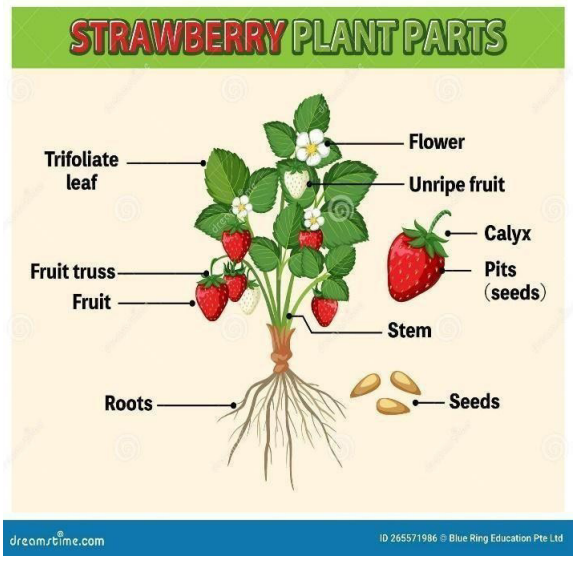

Fig. 2. Whole plant of strawberry. www.dreamstime.com/www.dreamstime.com/life-cycle-strawberry-diagram-illustration-image265571986)

plied in strawberries stimulated the growth of the vegetative shoot apex of indeterminate vegetative growth. Brian *et al*. (1958) observed that increased shoot length after GA3 treatment may be due to the increased length of certain internodes which were either in the process of elongation at the time of treatment or were differentiated soon thereafter. Nanda and Purohit (1965) explained the enhancement of growth by GA3 in relation to the mobilization of reserve starch, due to enhanced mobilization by GA3, large amounts of food material are available over a shorter period, causing a spurt in the growth processes. Guttridge and Thompson (1964) observed that gibberellins treat plants increased runner's growth and plant growth. Perez de Camacaro *et al*. (2008) reported that applied gibberellic acid promoted blooming and growth. However, it was observed that the highest effect on leave, runner, crown, inflorescence and flower production. Luangprasert (1994) applied GA for one a week during 4 leave stage in Tioga species, showed in all treatments runner production increased with no effects on leave and branch crown production.

Influence of GA3 on flowering

Paroussi *et al*. (2002) reported that application of GA3 has effect significantly on number flower on inflorescence increased. Kumar *et al.,* (2014) reported that high concentration GA3 took minimum days to initiate flowering. Stuart and Cathey (1961) observed that Gibberellins have huge impact on flowering and inflorescence production. Adams *et al*., (1975) reported that the gibberellins are known to influence both cell division and cell enlargement. Moreover, the successful fertilization of the ovule is followed by cell division and cell expansion resulting in the growth of the fruit

Effect of GA3 on yield and fruit quality of strawberry

Ingle *et al.* (2001) revealed that foliar application of GA3 @ 25 ppm increased the fruit weight, volume, TSS, ascorbic acid, peel and yield over control. Moneruzzaman *et al*., (2011) found that application of GA3 increased fruit length and diameter. Kumar *et al.,* (2012) observed that the application of GA3 in strawberry at 80 ppm improved vegetative growth, runner production, ascorbic acid and acidity. Application of 75 ppm GA3 provided maximum number of fruit in strawberry and increased the number of strawberry fruits. Davis, (2004) reported that application of gibberellic acid increased cell size and/or cell numbers. Dwivedi *et al*., (2002) the effect of photoperiods i.e. short, normal and long days, and plant growth regulators, i.e. gibberellic acid (GA3) at 50 ppm shown the maximum in leaf number and area was observed when plants of senga sengana were kept under short day condition the treated with 50 ppm GA. In 1995 maximum leaf area was recorded under short day while + 50 ppm GA. Wang (1989) were also significantly showed that increased in maximum number of leaves per plant with GA3 @ 200 ppm. Chao and Lovatt (2006) found that application of 10 ppm GA3 at 60 per cent full bloom, 75 per cent petal fall and in early July or 25ppm at 60 per cent and 90 per cent full bloom, 75 per cent petal fall and 10 days after 75 per cent petal fall reduced total yield relative to the untreated control.

Influence of chlormequat

Rakesh Kumra *et al.* (2010) said that, Plant growth retardants are commonly used in fruit crop to modify the trees vegetative growth and enhance the flowering, fruit setting and yield. It is observed that plant growth regulators exercise an indirect influence on flowering through their restricting vegetative growth. Will (1975) reported that in three year trials of strawberry plants treated in September and/or October with cycocel gave earlier and slightly higher yields. Barritt *et al*. (1975) found that CCC at 100 to 200 ppm sprayed on Gorella cultivar strawberry between 8th and 23th march enhanced first flower opening and increased fruit set. Plant growth regulators are broadly used in fruit crops harvests to promote vegetative development, blossoming, and fruit improvement.

Plant development controllers have been found to incidentally affect sprouting by lessening the vegetative turn of events (Islam and Mohammad, 2020; Kumra and Reena, 2018). The CCC has been shown in studies to effectively reduce the growth of potato stems, leaves, and runner and thicken the stem of mung bean by being control vein growth and lodging. Dwarfed plants, thickened stalks, increased chlorophyll contents and well developedroot systems are results of CCC application (Liu *et al*., 2019). As per Kumra and Reena (2018), strawberry plants treat with cycocel in September and also October yielded before and to some degree further prominent yields in three- year preliminaries. Moreover, contrasted with unrifined *Fragaria ananassa, Fragaria ananassa* obtain two shower treatments of 10 lM

TRIA showed a significant outcome on plant tallness and leaf number (Ali *et al*., 2021; Altintas, 2011; Islam and Mohammad, 2020).

Influence of auxin (NAA) and tricontanol on growth yield and quality

Triacontanol a natural component of the epicuticular waxes (Chibnall *et al.,* 1933; Crosby and Vlitos 1959) has been shown to increase the vegetative growth, chlorophyll content and dry weight of various plants when applied in field conditions (Ries, 1985). Triacontanol, Activol and NAA resulted in increased vegetative growth of strawberry as compared control. Highest crown height (7.2 cm) was obtained with 100 ppm Activol and highest leaf number/plant (7.2) and leaf zone (49.4 m^2) were obtained with 50ppm tricontanol treated plants.

NAA is a synthetic auxin that is most frequently employed in the production of high-quality strawberries in terms of total sugars, ascorbic acid content, and titrable acidity percentage (Bhople *et al*., 2020). NAA is a synthetic kind of auxin that aids in cell elongation, division, vascular tissue polarity, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, fruit setting ratio, fruit dropping avoidance, and flower sex ratio promotion (Mehraj *et al*., 2015). Naphthalene acetic acid is one of auxin's most important members, and early application of Naphthalene acetamide in early stages induces cell division in cambium cells, resulting in the production of xylem tissue in lower internodes, which provides mechanical support to plants while also preventing lodging (Thakur *et al*., 2017).

Auxins such as IBA (Indol-3- butyric acid) and NAA (Naphthyl acetic acid) are used to promote rapid and abundant rooting of cuttings from a variation of trees, vines, shrubs, annual and perennial ornamentals (Rademacher, 2015). GA treatment could only maintain emasculated flower receptacle growth for 6 days, according to Archbold and Dennis (1985), whereas growth of fruit treated with synthetic auxin Naphthalene acetic acid (NAA) could continue for up to 30 (days, albeit at a slower rate than pollinated flowers (Roberts and Hooley, 1988). The application of NAA to strawberry fruits enhances fruit size, delays ripening, and boosts anthocyanin accumulation, as well as delaying the flowering time and enhancing fruit output and quality (Indira Jadhav *et. al.,* (2016).

Auxin plays a vital function in fruit growth and ripening by transcriptionally activating Aux/IAA genes (Liu *et al*., 2011). The skin hardness and hardiness of the underlying flesh delineate the firmness of strawberry fruit, and this hardiness is linked to the formation of hard achene growth, resulting in the hardiest fruit in NAA treated plants (Rathod *et al*., 2021). Tricontanol (TRIA) is a natural plant growth regulator found in epicuticular waxes which is used to increase fruit production. TRIA is a saturated primary alcohol found in epicuticular waxes of a variation plant species, including Croton californicus, Copernica cerifera, and Jatropha curcas. It was first discovered in Alfalfa hay (Islam and Mohammad, 2017).

As stated, using GA3 and Naphthalene acetic acid alone or in combination enhances plant height, number of crowns, runners, and leaf area. Plants treat with NAA at a concentration of 19.97 mg/l produced berries with the highest total soluble solids, total sugars, and titrable acidity (Kumar and Tripathi, 2009). Because developing leaves are one of the primary sites of auxin biosynthesis, the elongating petiole tissues could directly receive sufficient amounts of auxin from young leaves, resulting in increased petiole length due to rapid cell division and cell enlargement, NAA at 19.97 mg/l and 49.94 mg/l produced significantly longer petioles than the control (Manandhar and Shrestha, 2008). Tricontanol also enhances vital plant physiological processes such as water and mineral nutrient uptake, essential oil yield, secondary metabolites, early bolting, nitrogen assimilation, proline metabolism, and glycine betaine accumulation thereby protecting plants from variety of environment stresses (Zaid *et al*., 2020). TRIA controls the activation of stress resilience components in farmed plants, which helps the plants to cope with lightning-induced alterations (Islam and Mohammad, 2020; Zaid *et al*., 2020).

Conclusion

From these results, it can be concluded that Plant growth regulators are the tools in flowering, fruiting, and ripening. The make use of PGRs is increasing day by day mainly in many agricultural fruit crops. GA3 and Triacontanol are very effect to increase vegetative growth, quality and runner's production of strawberry. Whereas growth retardant cycocel increase number of flowers, improve fruit quality and yield of strawberry. The review focuses on the affect of PGRs on growth, yield, and fruit quality of fruit crops.

Declarations

Author contribution statement

All authors listed have significantly contributed to the development and the writing of this article. There are no conflicts of interest amongst author's.

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