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Role of plant growth regulators in guava (*Psidium guajava* L.) cultivation: A review

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Abstract

Guava is important fruit crop which is grown commercially in tropical and subtropical regions of the world. In India the productivity is low compare to other countries. Hence to overcome this, many technologies have been developed some importance were HDP, Meadow orcharding, crop regulation, use of improved varieties and hybrids and use of growth regulators. Among these technologies application of growth regulators plays an important role in all the stages of growth and development of cropwhich helps toimprove the final yield and quality of produce. The growth regulators are also used to improve theseed germination by breaking seed dormancy, root initiation in cuttings and air layers, to regulate proper canopy, flowering and fruit set. In this review article a detailed information on role of growth regulators in different stages of plant growth and development were given and also the research work was done in different countries on the role of various plant growth regulators in guava production have been incorporated.

Keywords: Guava, PGRs, rooting, canopy management

1. Introduction

Guava (*Psidium guajava* L.) is known as poor man's apple and commercially important fruit crop belonging to the family Myrtaceae. Though, native to tropical America, its cultivation has spread to different parts of the world because of its wider adaptability. Presently it has become one of the most common fruits of India. It is contributing 4.1% to the total fruit production in India. The crop covers about 2.60 lakh hectare area of the country with an annual production of 38.26 lakh tonnes with an average productivity of 14.75 metric tonnes per hectare (Anon, 2017) [3]. The major guava producing states are Madhya Pradesh, Uttar Pradesh, Bihar and Maharashtra. The existing guava production is not able to meet our present demand of guava fruits to the increasing population of the country. It also necessitates enhancing the production potential of guava under available resources. Besides, all available high production technologies such as use high yielding varieties, high density orcharding, the use of PGR's has been proved as a powerful tool to meet this demand by influencing fruit production directly or indirectly (Bhardwaj *et al*., 2005) [6].

2. Role of PGR's on seed germination

There are various limiting factors related to production and productivity of guava and one of them is inadequate and low quality planting materials. Seed propagation is important especially in hybridization as well as for raising rootstocks. The germination of guava seeds is uncertain due to hard seed coating over the endocarp (Singh, 1967) [43] which results in poor germination and takes long time to germinate. Application of GA_3 will improve germination as well reduces the germination period (Kalyani *et al*., 2014) [17]. GA_3 helps in early germination due to it reacts on the embryo and causes *denova* synthesis of hydrolysing enzymes particularly amylase and protease and this hydrolysed food is utilized for growth of embryo (Paleg, 1965) [28]. The Similar results were reported by Suryakanth *et al.* (2005) [45] in Guava. Looney (1998) [22] reported that some PGR's have been helpful in germination of guava seeds by increasing water uptake and exerting an effect on membrane permeability. The increased germination with GA_3 might be due to fact that either GA_3 involved in the activation of cytological enzymes with GA_3 stimulates seed germination of an amylase enzyme which convert insoluble starch into soluble sugars or might have antagonized the effect of inhibitors present in seeds. Soaking the seeds with water might have helped in leaching out the inhibitors from the seeds (Hartman and Kester, 1978) [14].

3. Role of PGR's in propagation by cuttings and stooling

Among the cuttings, hardwood, semi-hard wood and softwood stem cuttings can be used for propagation of guava.

Guava is hard to root therefore; its propagation by cuttings under ordinary conditions is not successful. It is only successful under intermittent mist conditions with the aid of rooting hormones like IBA and NAA. The maximum sprouting per cuttings (71.22%) and better survival percentage (57.22%) were noticed in softwood cutting treated with paclubutrazol at the 1000 ppm solution (Noor, *et al*., 2004) [27]. Cuttings treated with IBA at 1000 ppm will improve the rooting percent 37% (Abdul Manan *et al*., 2002) [1]. Cuttings treated with NAA and dilute coconut water produced 100% healthy roots and shoots (Agele *et al*., 2013) [2].
The use of hardwood cutting is the least expensive method for vegetative propagation (Hartman, 1969) [15]. However, guava hardwood cuttings were found hard to root (Webber, 1942, Regule, 1964; Luis *et al* 1986) [51, 23]. Moreover, the use of growth regulators to increase rooting percentage of guava stem cuttings had limited success (Sinha *et al.,* 1964; Wally, *et al.* 1981) [44, 50]. The cuttings of 10-12 cm long with 3-4 leaves, were dipped for 5 seconds in IBA, NAA or IAA, each at 1500, 2500 or 3500 ppm, respectively and planted in sand will improve the rooting. Cuttings treated with IBA 2500 ppm gave the best mean rooting percentage over 2 seasons; it was 83.3, 73.3 and 73.3% in the cultivars Baruipur, Sardar and Harijha, respectively (Mohammad *et al*., 1988) [26]. Two types of cuttings (leafy tip cuttings and hardwood cuttings) were obtained from a 5-year-old tree for rooting in a greenhouse showed, 90.11, 94.44 and 94.44% rooting with 3, 6 and 12 ppm of paclubutrazol respectively, after 6 weeks from planting compare to no rooting was observed in the control (Debanath and Maiti, 1990) [11]. Walley *et al.,* (1981) [50] treated the hardwood cuttings of guava with 50-3000 ppm IBA alone or 50-3000 ppm IBA+2 - naphthalol (2-10 ppm) and with 50-3000 ppm NAA. The highest success of 40% was obtained from the cuttings which were treated with IBA alone. Tready (1983) [49] described that rooting percentage could be increased from 0 to 30.5 percent in hardwood cuttings of guava treated with 500 ppm IBA. He further stated that IBA enhanced rooting in case of two-year old cuttings. Application of IBA at different concentration in semi hard wood cuttings of guava achieved the good percent of rooting (Khattak *et al*., 1983; Hafeezur Rahman *et al*., 1990) [18]. Lal *et al*. (2007) [21] reported that application of NAA and IBA will increase the rooting percent in stooling of guava cv. Sardar. Reddy and Majumder (1970) [36] reported that cuttings of guava were dipped in IBA at 5000 ppm for 15 seconds and then dipped in one of the several phenolic compounds at 2000 ppm for 15 seconds increased the rooting from cuttings.
Among the vegetative methods of propagation, inarching is a commercial method but it is cumbersome and costly. Stooling in guava is the easiest and cheapest method of propagation (Rathore, 1977; Chadha, 2001) [33, 8]. Different concentrations of IBA and NAA affect rooting of stooled shoots. Application of IBA 7500 ppm in lanolin pate during first week of August in cv. Sardar recorded maximum rooting percentage (96.67%) and survival of rooted stooled shoots (75%) after transplanting in the field (Lal *et al*., 2007) [21].

4. Role of PGR's in propagation by air layering

Among different growth regulators IBA, NAA play a major role ininitiation of roots in layers of various fruit species (Ray and Chaterjee, 1966; Sandhu *et al.,* 1972) [35, 38]. The combination of IBA 5000 ppm with rooting media gave a maximum percentage (84.75%) of rooted air layers (Prabkhar *et al*., 2007) [32] in cv. Lucknow-49.
Ringing and girdling interrupt the downward translocation of carbohydrates, hormones and other possible root promoting substances which helps in shoot initiation and formation from ring area of layer (Evert and Smittle, 1990; Pandey and Bisen, 2010) [12, 29]. Using these techniques on shoots prior to their removal for use as cuttings improve the rooting.

5. Role of PGR's on flowering, fruit set, fruit growth and development

Flower induction, flower intensity and crop regulation to a great extent can be manipulated by the use of plant growth regulators via blossom or fruit let thinning at early stage. Gibberellic acid spray of 200 ppm at flower bud initiation stage increased yield of guava fruit (Sharma *et al*., 1993) [39]. About 80-90 per cent flowers of guava set fruits initially of which 35-60 per cent reaches to maturity while seedless cultivar fruit retention is low. Sharma *et al*. (1993) [39] reported that GA_3 50, 100 and 200 ppm significantly increased fruit set. Profuse flowering of young guava with the spray of ethrel was also observed by many the workers (Swart and Shipper, 1982; Chandra and Govind, 1994) [46, 9].
Spraying of GA_3at 15 or 30 ppm in the month of January proved to be effective in increasing fruit retention and yield (Lal *et al*., 2013) [20]. Giberellic acid plays a major role in inducing parthenocarpic fruit as well as in fruit retention. The maximum fruit weight (181.71 g) was recorded with foliar spray of 60 ppm 2, 4-D which might be due to greater size of fruit and certain changes in metabolism of fruit which reflected in more accumulation of water and enhanced deposition of soluble solids. Exogenous application of auxin increased the sink strength of treated organs with strong movement of metabolites takes place from weaker sink to stronger sink depending upon the hormonal level (Ashuthosh *et al*., 2012) [4]. As the flowers were killed in rainy season crop, the reserved food materials and auxins force the plant to produce more flowers, more fruit set and yield (Ashuthosh *et al.,* 2012) [4].

6. Role of PGR's on canopy management

Canopy management is one of the important tools to accommodate more number of plants per unit area or to adopt different planting systems such as high density planting and Meadow orcharding and these planting systems will helps to increase the productivity. Due to absence of dwarfing rootstocks in guava the pruning and use of growth regulators play vital role in management of canopy. Guava tree respond well to canopy modification with respect to vegetative and reproductive growth and it produces fruits on current season shoots (Singh and Chanana, 2005 [40]), therefore, modification of canopy through pruning and use of certain growth regulators may be steps to enhance the production efficiency.
Paclobutrazol and ethephon may be useful in high density planting as paclobutrazol helps in making the plants dwarf by producing a retarding effect on the growth of tree through inhibition of gibberellin biosynthesis, a key plant growth promoter. Similarly, ethephon acts as a ripening hormone and it enhances the ripening process along with its growth retardation effect. Ethephon at higher concentrations (500-3000 ppm) proved to be quite effective in reducing the plant height (Mohammed *et al*., 1984) [25]. Singh and Bal (2006) [41] investigated the positive effect of PBZ application in restriction of vegetative growth of guava plants. Brar, (2010) [7] also reported that, paclobutrazol considerably restrict the overall vegetative growth of trees. Stock and scion girth was found to be increased with ethephon. The tree height and E-W

tree spread was found to increase with increasing plant density, PBZ 500 ppm markedly restrict the plant growth.

7. Role of PGR's on crop regulation and fruit thinning

Crop regulation plays major role in Guava for generating more income to the farmers. In subtropical climate, three distinct periods of flowering and fruiting are found in the guava. These three distinct periods are Ambe bahar (February to March flowering and fruit ripens in July-August), Mrig bahar (June to July flowering and fruit ripens in October to December) and Hasta bahar (October to November flowering and fruit ripens in February to April). The vegetative growth and heaviest flowering have always been obtained in summer season which caused exhausting of food reserved in turn less crop in winter. In general, production of poor quality fruits and excessive fruit fly attack in guava are typical characteristics during rainy season. Regulation of crop in guava is very important because of poor quality of fruits in rainy season. New growth starts in guava trees during spring, monsoon, and winter season. It results either on emergence of new shoots or growth in previous season shoots. During spring, maximum growth takes place. There is emergence of new shoots from the axil of the one-year-old shoots. New growth/ current season's growth gives fruiting. Due to poor quality and glut in the market, monsoon season crop fetches relatively poor returns. There is a need to regulate crop in such a way as to achieve fruit production in winter season only. The winter crop is superior in quality, free from pests and diseases and also fetches better price in market as compared to rainy season crop (Rathore and Singh, 1975) [34]. The various efforts have been made to deblossom the rainy season crop with certain chemicals, growth regulators and cultural practices in order to have a better winter crop (Teotia and Pandey, 1970; Kumar and Hoda, 1977; Singh and Singh, 1975; Chundawat *et al*., 1975; Rathore and Singh, 1975; Pandey *et al*., 1980) [47, 19, 42, 10, 34, 30]. But results reported are not similar due to various factors like cultivars, tree conditions, climate and soil types. Deblossming of rainy season crop with foliar application of NAA 800 ppm will help to increase yield of winter crop (88 kg/tree) in cv. Sardar (Tiwari and Lal, 2007) [48]. Many of the workers tried with different growth regulators combination for shedding of blossom and young fruitlets. 600 ppm NAA caused highest shedding of blossom and young fruitlets compare to 50 ppm NAA and 30 ppm 2, 4-D. meanwhile the application of NAA has been a useful to get a better winter crop (Tiwari and Lal, 2007) [48].

8. Growth regulators in enhancing shelf life of guava

Guava is a delicious and nutritious fruit and highly perishable in nature among the tropical and sub-tropical fruits, therefore cannot be stored for longer period. Certain post-harvest treatments like Giberellic acid, 2, 4-D, Malic hydrazide, Benzyl adenine application will increase or extend the shelf life of the fruit. (Patel *et al*., 1993) [31].

9. Growth regulators in improving quality parameters

Growth substances application will increase the TSS and other quality attributes in many fruit crops. In guava Babu and Shanker, (1977) [5] reported that 2, 4-D increased the TSS in Allhabad Safeda. The NAA (40-80 ppm) also helps to increase in TSS in guava. Maximum increase in T.S.S., total sugars, reducing sugar and non-reducing sugar was with foliar spray of 60 ppm 2, 4-D may be due to quick metabolic transformation of starch into soluble sugars and early ripening in response to growth substances (Ashuthosh *et al.,* 2012) [4]. The lower acidity might be due to early ripening of fruits caused by treatment, where acid might have been used during respiration or fast converted into sugars.

10. Growth regulators in micro- propagation

Studies on *in vitro* propagation of guava demonstrate that shoot tip explants from mature trees are capable of forming multiple shoots. Proliferation of shoot tip was obtained on MS basal medium containing different combinations and concentrations of auxins and cytokinins. However, highest number of shoots per explant was obtained from cultures grown on medium supplemented with 1 mg l^{-1} BAP only. About 80% shoots rooted well when medium was supplemented with IBA and NAA (0.2 mg 1^{-1} each) together. Addition of activated charcoal showed beneficial effects on rooting percentages and plantlet growth (Manoj *et al*., 2008) [24]. *In vitro* clonal propagation of guava 'Banaras local' was achieved by culturing nodal explants of mature trees on Murashige and Skoog (MS) revised medium supplemented with 4.5 μM 6-benzyladanine (BA) alone or in combination with either 0.6 μM indole-3-acetic acid (IAA), 0.5 μM indole-3-butyric acid (IBA) or 0.3 μM gibberellic acid (GA_3). Multiple shoots were induced to form by enhancement of axillary branching and BA (4.5 μM) without any auxin and gibberellin was found to give best shoot multiplication rate. (Jaiswal and Amin, 1987) [16]. A number of studies show that Invitro propagation of guava is successful only when it is supplemented with different combination of plant growth regulators.

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