Plant Archives Vol. 18 No. 1, 2018 pp. 19-27 ***ISSN 0972-5210***

PRE-HARVEST IMPLICATIONS AND UTILITY OF PLANT BIOREGULATORS ON GRAPE: A REVIEW

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Abstract

Application of plant bioregulators have been focused by many researchers in areas of plant physiology. Several fruit development activities like chemical thinning, increasing fruit set and size, enhancing colouration and enhancing or delaying ripening of fruits have been reported to be affected by the use of various growth regulators. Among several growth regulators, gibberellic acid found to have a potentiality on enhancing the division and expansion of pericarp cells of grape berries in both seeded and seedless grape cultivars. CPPU (Forchlorfenuron) acts synergistically with natural auxins and its primary effects cause the regulation of fruit set, berry growth and development. Brassinosteroids (BR) shown to be involved in numerous plant processes like promotion of cell division, cell wall regeneration, cell expansion and cell elongation, in synergism with auxin and promotion of vascular differentiation in grape.

Key words: Grape, plant bioregulators, gibberellic acid, CPPU, brassinosteroid.

Introduction

Grape is one among the most delicious, refreshing and nourishing fruits of the world. The berries are a good source of sugars and minerals like Ca, Mg, Fe, and vitamins like B1, B2, and C. Grape has so many uses and are so unique that no fruit can challenge their superiority. It is the most widely cultivated fruit and was carried from region to region by civilized man in all the temperate climates and has been grown more recently in tropical and subtropical climates. Quality improvement is an important criterion in grape culture which can be achieved with the use of plant bioregulators. Nowadays, plant bioregulators are widely used in viticulture for promoting better fruit production and quality improvement and for many years, gibberellic acid is in use for the production of quality grape. Among the different bioregulators, GA_3, CPPU and BR play a significant role for production of export quality grapes.In the recent past, the efficiency of new chemicals like brassinosteroid and CPPU are being evaluated for the improvement of fruit quality in different grape growing regions of the world. Although various scientific outcomes have proved the potentiality of several bioregulators in grape over a period of time, their usage at the right stage with optimized concentration is essential for the improvement of yield and quality for any of the particular variety. In above point of view, the potentiality of pre-harvest applications of bioregulators for yield and quality improvement in both of seeded and seedless grapes is much essential.

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Gibberellic acid on yield parameters in grape

Gibberellic acid is widely used in vineyards, all over the world, to increase cluster weight, berry weight and size of grape cultivars which in turn increase the vine yield. It is also known to reduce the bunch compactness and tends to improve quality. The timing of GA_3 application is critical with regard to the physiological developmental stages of bunches. Their application is effective only during a short physiological stage of berry growth. GA_3 spray on bunches, after berry set phase at lower concentrations, ensures both even berry size and a top quality product that avoids the incurring of more labour expenses for operations like thinning.

El-Hodairi *et al.* (1995) observed that fruit yield of Sultanina Seedless grape in Egypt was significantly increased by GA_3 treatment particularly when 50 ppm was applied after fruit set. According to Shehata and El-Barbary (1996), fruit length and weight was increased with the treatment of GA_3 at 5 ppm + fruit thinning in 'Flame Seedless' table grapes in Egypt. However, this treatment decreased cluster weight and yield by 16.6% and 26.5%, respectively compared with spraying with GA_3 5 ppm alone. Lu *et al.* (1997) reported that the GA_3 treated berries of seeded muscadine grape cultivar Triumph weighed significantly more as compared to that of non treated vines. Those treated with GA_3 at 200 and 300 ppm weighed ~20% more berry weight than control. The effect of GA_3 in bunches and berries of grape cultivar Maria was assessed by Kalil *et al.* (1999). With the application of GA_3 (20 ppm) 14 days after flowering, there was an increase in mass, length and width of clusters including berry characters. Tomar (1999) showed that the application of GA_3 in Thompson Seedless in Himachal Pradesh at the pinhead stage gave significantly greater bunch length than application at the pea stage.

Application of GA_3 as spray to clusters twice at 10 ppm at cluster length of 5 to 7 cm and again after 5 to 7 days increased the bunch weight and berry diameter (E1-Ghany, 2001). Boskov *et al.* (2002) studied the effect of gibberellic acid (GA_3) on technological properties in Italia grape vine variety with two stages of applications, one at berry size of 7-8 mm and other at 7 days upon the initial treatment. The results revealed that two applications of GA_3 at high rates (80 ppm) induced an increase in berry weight of 9.1 g compared to control (8.1 g). It also had a significant effect on berry length and width and size uniformity within the cluster. Godara *et al.* (2002) reported that maximum increase in the bunch weight was observed with the application of 50 ppm GA_3 at full bloom followed by 50 ppm GA_3 at berry set stage. Roberto *et al.* (2002) observed that the application of gibberellic acid at 3g/100 liter in 'Rubi' grapes at 30 days after flowering recorded more weight and width of berries.

According to Gowda *et al.* (2006), the application of GA_3 (20, 25, 30 and 40 ppm) at 45, 50, 55 and 60 days after October pruning in 'Thompson Seedless' grapes significantly decreased the number of berries per bunch. Maximum berry size, diameter, weight and maximum pedicel size were noticed with 20 ppm GA_3 at pre bloom stage along with clipping of berries at pea stage (Selvaraju *et al*., 2007). Jegadeeswari (2008) studied the effect of certain growth regulators on yield and quality in grape cv. Muscat and found that grape vines treated with 25 ppm of GA_3 had recorded the maximum bunch weight, and yield per vine in grape cv. Muscat. The berry characters like berry weight and berry diameter were higher in vines treated with GA_3 at 25 ppm in grape cultivar Muscat. However, the bunches treated with GA_3 at 100 ppm had recorded the maximum berry length and minimum seed weight. Casanova *et al.* (2009) reported that application of GA_3 (80 ppm) 21 days after fruit set increased commercial berry weight by 50-90%, reaching similar size to that of 'Aledo' seeded grape, used as a comparison.

Abu-Zahra (2010) evaluated the influence of GA_3 on the fruit quality and productivity of cane pruned Thompson Seedless and reported that the bunch and berry characters were increased. Formolo *et al.* (2010) reported that double the application of GA_3 (30 ppm) at 5 mm berry diameter and 30 days after, increased cluster weight, berry length, diameter and weight significantly. In Thompson seedless grapes, application of GA_3 50 ppm resulted increased bunch length and weight, hastened berry diameter and produced larger berries in comparison to control (Abu-Zahra, 2010). Among the different concentration of GA_3 (5, 10 and 20 ppm) in two different seedless cultivars *viz.,* Thompson and Belgrade, application of GA_3 at concentration of 20 ppm increased the cluster mass, number of berries, berry length and weight in both the cultivars significantly (Dimovska *et al.,* 2011).

Rizk-Alla *et al.* (2011) found that spraying clusters with 20 ppm GA_3 + 75 ppm NAA resulted in highest cluster and berry weight, berry size, length and diameter. Mixture of GA_3 (50 ppm) and NOA (0.2%) were shown to have a significant effect on berry length irrespective of method of application in Einset Seedless grape (Kap³an, 2011). An investigation carried out by Rafaat *et al.* (2012) for three consecutive years in Thompson Seedless showed that spraying GA_3 (40 ppm) increased weight, size, length, diameter and berry index shape of berries. Positive effects with application of GA_3 (25 ppm) on cluster weight and physical characteristics of berries *i.e.,* berry weight and length were noticed when treated at full bloom stage in Perlette grapes (Meena *et al*., 2012).

Depending upon the variety, application of GA_3 at lower concentrations ranging 2.5 to 20 ppm, induces moderate cluster elongation and minimizes bunch rot in wine grapes (Grant, 2013). GA_3 significantly increased cluster weight, fruit L/D ratio, volume and fresh flesh weight in both cultivars Perlette and Yaghuti with 50 ppm GA_3 applied at berry set stage, when berries were 4 mm in size (Zahedi *et al*., 2013). Chaitakhob *et al.* (2014) reported bunch dipping with GA_3 (30 μl L^{-1}) at 50% full bloom and BA (10 μl L^{-1}) at fruit set stage (pea size) affected bunch size, width and increased the berry length/width ratio in Perlette grapes. Application of 20 ppm GA_3 at 7-10 days before blooming and 7-10 days after blooming in Flame seedless grapes increased bunch weight, length and width. It also influenced berry length, width, weight and berry shape index significantly (Dimovska *et al*., 2014).

Gibberellic acid on quality parameters in grape

Khan *et al.* (1996) reported that GA_3 treatments at 25 to 75 ppm, applied to bunch at full bloom and one month later significantly influenced TSS and reducing sugar contents and acidity of 'Kishmish Charni' grapes. The highest TSS (15.4%) and reducing sugar content (6.96%) were observed following treatment with GA_3 at 75 ppm. With increasing concentration of GA_3, percentage of acidity decreased. According to Zabadal and Dittmer (2000), the application of GA_3 at 50 ppm when berries averaged 5 mm in diameter were most effective for increasing fruit soluble solids in Vanessa Seedless grapes in USA. However, Fietosa (2002) reported that there was no significant difference in the levels of soluble solids, but acidity showed the highest values with application of GA_3 (20 ppm) and in control in grape cultivar Italia.

Highest TSS (%) and TSS: acid ratio were noticed by application of 40 ppm GA_3 at full bloom stage in combination with trunk girdling in Pusa Urvashi grape (Sasi Kumar *et al*., 2004). According to Feza Ahmad and Zargar (2005), GA_3 (50 ppm) coupled with Trunk girdling and ethephon resulted in increased TSS, TSS/ acidity ratio and decreased acidity as compared to control when applied at 50 per cent bloom in Perlette grapes. Application of GA_3 at 25 ppm had produced the highest TSS content and Sugar-acid ratio in grape cv. Muscat (Jegadeeswari, 2008). Ramteke *et al.* (2008) found that spraying GA_3 with concentration 40 and 30 ppm after berry set improved the quality of 'Sharad Seedless' grapes. Abu-Zahra (2010) evaluated the influence of GA_3 on the fruit quality and productivity of cane pruned Thompson Seedless and reported that it influenced the quality parameters of soluble solids and titrable acidity.

Among the different concentrations of GA_3 (5, 10 and 20 ppm) applied during the three different periods of the vine growing (before blooming, after blooming and before veraison) in two different seedless cultivars *viz.,* Thompson and Belgrade, higher levels of sugar and total acids were determined in the Thompson grapes with the addition of gibberellic acid at 20 ppm (Dimovska *et al.,* 2011). Rather *et al.* (2011) recorded that, Girdling + 40 ppm of GA_3 proved most effective in increasing the quality in terms of total soluble solids (TSS) (17.47 %), total sugar (8.94%), reducing sugar (10.35%), TSS: acid ratio (27.24%) and resulted in decrease in acidity (24.59%) in Perlette grapes. Spraying with 20 ppm GA_3 + 75 ppm NAA generally resulted in the lowest values of TSS percentage and TSS: acid ratio and the highest percentage of acidity in the juice as compared to control in Black Monukka grape (Rizk-Alla *et al.,* 2011).

Taleb and Naser (2012) found 50 ppm of GA_3 was effective in increasing the total soluble solids and decreasing total titratable acidity significantly in cv. Black Magic. Highest TSS (%) was recorded with 50 ppm GA_3 applied at berry set stage when berries were 4 mm in length in cultivar Perlette under Iran condition (Zahedi *et al.,* 2013). Chaitakhob *et al.* (2014) reported bunch dipping with GA_3 (30 ppm) at 50% of full bloom increased the TSS, reduced acidity and increased TSS: acidity ratio significantly in Perlette grapes. Application of 20 ppm GA_3 at 7-10 days before blooming and 7-10 days after blooming in Flame seedless grapes decreased the acidity in berries (Dimovska *et al.,* 2014).

Gibberellic acid on berry thinning in grape

Application of GA_3 on Thompson Seedless grapes at bloom stage produced a very loose cluster (Weaver and Pool, 1965). Application of 10 ppm GA_3 during flowering caused thinning in Perlette variety (Kasimatis *et al.* 1971). Tripathi (1968) observed thinning effect of GA_3 at 125 ppm applied during pre bloom and at shatter stages in Perlette grapes. Nijjar and Gill (1971) reported that 50, 75 and 100 ppm of GA_3 at full bloom stage resulted in berry thinning. Nangia and Bakhshi (1971) observed that 50 to 100 and 125 ppm GA_3 increased the length of panicles and thereby loosened the clusters in the Perlette variety.

When Pusa Seedless grape clusters were treated with 25, 50, 70 or 100 ppm GA_3 at post bloom stage, it resulted in undesirable compactness but the application at full bloom could make the bunch very loose (Dass and Randhawa, 1972). Pishbin *et al.* (1983) observed elongated clusters in Askari variety when treated with 20 to 80 ppm GA_3 at pre bloom or post bloom stages. In Perlette variety, loosened and elongated bunches were found when GA_3 was applied (50 or 100 ppm) at pre bloom stage (Dhaliwal, 1983). Gowda *et al.* (2006) indicated that the application of GA_3 at early stages of bunch development had a slight thinning effect.

CPPU on yield parameters in grape

CPPU (N-(2-Chloro-4-Pyridyl)-N-Phenylurea) is a growth regulator which has a significant physiological activity in many fruit crops, including grapes. The mode of action is similar to that of cytokinins (Dokoozlian *et al.,* 1994) and, when applied in bunches after fruit set, the CPPU increases berry size and causes delayed maturation. Diaz and Maldonado (1990) also opined that the higher concentration of CPPU treatment delayed the maturity in grape.

According to Pires (1998), depending on the variety, CPPU can determine the skin and pedicel thickness in grapes. Gao-Huanzhang and Gao (1999) reported that final berry weight of Fujiminori grape in China was highest (13.1 g) in vines sprayed with CPPU 10 ppm at 5 days after full bloom as compared to control (8.9 g).

Ezzahouani (2000) reported that post bloom applications of forchlorfenuron (5 and 10 ppm) in Perlette in Morocco increased berry weight and yield per vine compared to control. Chen and Jing (2002) reported that the treatment with forchlorfenuron to the clusters of Kyoho grape, 15 days after flowering increased the yield and berry weight and made berry glossier. Feitosa (2002) revealed that the best result was obtained with the application of CPPU (10 ppm) which resulted in an increase of 13.6% berry diameter and the berry weight by 32%.

Mellilo (2005) reported in California, the grape cultivar 'Flame Seedless' had a strong response to CPPU with regard to berry size. Application of 1 or 2 ppm of CPPU to the bunches having 3-6 and 7-10 or more leaves showed variation in berry size and bunches with 10 leaves significantly increased the berry diameter (Ramteke and Somkuwar, 2005).

Thomas and Martin (2006) studied the relative response of both seedless 'Vanessa' and 'Lakemont' and seeded 'Concord' and 'Niagara' grape cultivars with the application of CPPU at various concentrations (0, 5, 10 or 15 ppm) to clusters (4-6 mm berry diameter) and observed that CPPU at all the concentrations increased seedless berry diameter except 'Lakemont'. The cluster and berry weight increased significantly in 'Vanessa' whereas berry size increased with two seeded cultivars.

Vidhya (2008) reported that among the different growth regulator treatments imposed, 16 ppm forchlorfenuron (0.1%) had a maximum bunch weight of 240.20 g over control in grape variety Muscat. The average berries per bunch were found to be higher in the treatment with foliar spray of forchlorfenuron (0.1%) 2 ppm. The fruit characters namely berry weight, length and breadth were increased linearly with increasing trends of forchlorfenuron (0.1%).

Berry pedicel thickness was enhanced by the application of forchlorfenuron (0.1%). Among the different Forchlorfenuron levels, application of 16 ppm concentration enhanced the pedicel thickness (Vidhya, 2008).

Salunkhe *et al.* (2008) recorded maximum 100 berry weight, length and diameter of berry were observed in vines with application of CPPU at 2 ppm at 3-4 mm berry diameter stage with recommended schedule of plant growth regulators in Thompson seedless. Application of CPPU followed by ABA might increase the size of 'Flame Seedless' grapes without excessively inhibiting coloring (Peppi and Matthew, 2008).

Strydom (2013) reported that, CPPU dosages of 2, 5 and 3 ppm significantly increased berry diameter in Flame Seedless, Red Globe and Crimson Seedless respectively.

CPPU on quality parameters in grape

Application of 5 ppm of Sitofex in grape cv. King's Ruby with a load of 10 or 15 clusters per vine did not increase the TSS content in the berries (El-Hammady *et al.,* 2000). Ezzahouani (2000) revealed the soluble solids decreased while acidity increased, reflecting a late maturation of berries on CPPU treated vines. According to Das *et al.* (2001), TSS content of Pusa Seedless was not affected by the application of CPPU, dormex and GA_3.

Chen and Jing (2002) reported that, the treatment with forchlorfenuron to the clusters of Kyoho grapes, 15 days after flowering increased total soluble solids content and made the berry glossier. However, the fruit quality was not as good as at lower concentrations. In grape cv. Fujiminori, application of CPPU (10 or 20 ppm) dipping at 7 or 15 days after full bloom decreased soluble solids significantly (Sheng-Baolong *et al.,* 2004).

Peppi and Matthew (2008) revealed that forchlorfenuron, a synthetic cytokinin, applied after fruit set increased the size and firmness of table grape cultivar 'Flame Seedless', but reduced soluble solids and berry colour. Application of growth regulators did not influence the TSS content of grapes. However, 2 ppm of Forchlorfenuron had registered a maximum TSS, total and reducing sugar contents, among the different levels of growth regulators used. Moreover, spraying of the growth regulators found to have positive impact on quality parameters over dipping (Vidhya, 2008).

According to Rodrigues *et al.* (2011), the use of CPPU alone in the pea berry stage resulted in reduction of soluble solids content of the berries. There was no influence with the improvement in quality of grape cv. Italia. Rafaat *et al.* (2012) found that, 5 ppm CPPU increased TSS and reduced acidity in Thompson Seedless. CPPU (5 ppm) increased TSS in Red Globe and CPPU (3 ppm) increased total titrable acidity in Crimson Seedless (Strydom, 2013).

Brassinosteroid on yield and quality in grape

Brassinosteroid (BR) are compounds that exert a wide range of biological activities. They are essential for plant growth, reproduction and responses to various biotic and abiotic stresses. Usually, BR are steroidal hormones, which are essential for normal plant growth and development.

Watanabe *et al*. (1997) studied the potential of BR compound (TS303) as a growth regulator. They sprayed TS303 (BR) in the 12 years old vines of grape cv. Kyoho, 7 days before flowering and observed that application promoted better fruit set. Brassinosteroid (BR) are the widely distributed natural products that promote growth and possess all properties necessary for classification as a plant hormone (Clouse and Sasse, 1998). They were first isolated from the pollen of *Brassica napus*, a close relative of mustard (Grove *et al.*, 1979).

According to Zhou-Yushu *et al.* (2003), berry size of Kyoho grapes was increased with the application of homobrassinolide at 2-3 days before flowering, at full bloom and 14 days after full bloom. Symons *et al.* (2006) showed that the application of BR to grape berries evidently enhanced skin coloration and the final sugar level of the flesh, and significantly promoted ripening.

An increase in crop yield and quality has been observed when plants were treated with exogenous BR at appropriate stages of their development (Bartwal *et al.,* 2013). Harindra Champa *et al.* (2014) reported the clusters treated with 1 ppm brassinosteroid significantly increased cluster and berry weight, berry length and breadth. It also increased TSS content when vines were sprayed with brassinosteroid at 0.5 and 1.0 ppm.

Combined effect of gibberellic acid and CPPU on yield and quality in grape

In applications of GA_3 and CPPU in the cultivar Thompson Seedless, there was 28% increase in the mass of clusters compared to single applications of GA_3 (Schuck, 1994). According to Wolf *et al.* (1994) showed promising results with improvement in quality of the clusters with treatments GA_3 associated with CPPU for the cultivars Sultanina, Flame Seedless and Muscat Seedless.

Miele *et al.* (2000) evaluated the effects of CPPU (0, 3, 4, 5, 6, 8 or 12 ppm) and GA_3 (40 ppm) and found that their combinations increased berry size in grape cv. Italia. There was also a linear increase in the weight of bunches with the addition of CPPU.

Mervet *et al.* (2001) obtained best results with the application of CPPU (5 ppm) applied to berries 6 mm in diameter, in combination with GA_3 (40 ppm) in cv. Thompson Seedless. There was increase in yield per vine due to the increase of bunch weight, size in length and width of bunches but delayed maturation, reduced soluble solids and increased acidity. In Chile, Navarro *et al.* (2001) observed increased berry size, weight and production of bunches per plant, when associated with combined application of GA_3 and CPPU in grape cv. Sultanina. Tao-Jianmin *et al.* (2001) reported that the application of CPPU and GA_3 had no obvious effect on the berry soluble solid content in grape cv. Venus.

According to Feitosa (2002), the cluster of Italia grapes of export quality can be produced with combined treatments of CPPU and GA_3. However, the combined effect of CPPU and GA_3 delayed harvest by 8 days. Enlarged berries over 20 g in Fujiminori cultivar were harvested in Japan when fruits were sprayed with 25 ppm GA_3 at full bloom, followed by mixture of 500 to 100 ppm GA_3 and 10 ppm CPPU 11 days later. Treated fruits did not exhibit pale skin colour, less sweetness and less acidity (Ishikawa *et al.,* 2003). Pires *et al.* (2003) found that, applications of CPPU and GA_3 at 5 ppm to the clusters of 'Centennial Seedless' grapes increased berry weight by 59.0% and 78.7% and led to the formation of very large and excessively compact clusters with very thick pedicels. Ribeiro and Son (2003) in Porto Feliz, Brazil observed an increase in berry length and improved total soluble solids in the berries in cultivars Centennial Seedless, Flame Seedless and Thompson Seedless, when GA_3 at doses of 0, 25, 50 and 100 ppm used in combination with CPPU at 10 ppm applied at 15 days after flowering.

Dong-QuiHong *et al.* (2004) reported the highest soluble solids content was obtained after treatment with 50 ppm GA_3 + 5 ppm CPPU. According to Han and Lee (2004) the application of CPPU (10 ppm) and GA_3 (25 ppm) 10 days after bloom increased the quality parameters of seven years old Kyoho grape. In five years old Fujiminori grapevine, TSS was increased by the application of 10 ppm CPPU in combination with 25 ppm GA_3 (Wang-ShiPing *et al.,* 2004).

Natchigal *et al.* (2005) observed a synergistic effect in diameter of berries in grape cv. BRS Clara, grown in SP-Jales, when applied with a spray of GA_3 20 ppm with CPPU 4 ppm, to clusters with fruit measuring 7 mm in diameter, improved the quality but higher concentrations decreased the TSS content. Best quality Thompson Seedless grape was produced by spraying 2 ppm CPPU + 35 ppm GA_3 at 2-3 mm berry size (Ramteke and Somkuwar, 2005). Avenant and Avenant (2006) reported in grape cultivar 'Red Globe', the combination of GA_3

(20 ppm) and CPPU (5 ppm) applied at 12 mm berry size, delayed the accumulation of sugars.

In cv. Red Globe, berry size and firmness were increased by combined application of (20 ppm) GA_3 and (3 ppm) CPPU at 10 mm berry stage (Quxiley and Raath, 2010). According to Rumpai *et al.* (2010), treatment of 12.5 ppm GA_3 and 10 ppm CPPU, applied 12 days after full bloom followed by 25 ppm GA_3 25 days after full bloom increased 75% berry weight in 'Kyoho' and 56% in 'Honey Red' seedless grapes. Sung-Min Park (2010) noticed that significant increase in berry size was in Triploid grapes treated with 2.5 ppm of CPPU in combination with 100 ppm of GA_3.

Among the combinations of different concentrations of GA_3 (20 and 30 ppm) and CPPU (0.25, 0.50 and 1 ppm) used at 3-4 mm and again at 6-7 mm berry size stage in grape cultivar Red Globe, application of CPPU (1 ppm) and GA_3 (20 and 30 ppm) showed significant differences in bunch weight, berry size and acidity (Anon, 2011). Rodrigues *et al.* (2011) reported foliar spray with the mixture of GA_3 (20 ppm) and CPPU (10 ppm) in the pea berry stage promoted the increase of the length and diameter of berries without prejudice to the mass of the clusters in grape cv. Italia.

According to Ahmed Ola *et al.* (2012) combination of GA_3 at 40 ppm and CPPU at 3 ppm resulted in improved cluster weight, berry traits and TSS, but decreased acidity in cv. Thompson Seedless. Rafaat *et al.* (2012) found that spraying GA_3 at 40 ppm and CPPU at 5 ppm had significantly increased weight, size, length, diameter and berry index shape of berries of Thompson Seedless. According to Eyal Raban *et al.* (2013), three seedless table grape cultivars, 'Mystery', 'Superior', and 'Crimson Seedless' treated with gibberellin (GA_3), cytokinin (CPPU) responded to the combined treatment of GA_3 and CPPU with increased berry weight and diameter.

Combined effect of gibberellic acid and brassinosteroid on yield and quality in grape

Vivency (1995) observed, the application of 25 ppm GA_3 with 1 ppm of BR to Sonaka Seedless and Thompson Seedless bunches gave heavier bunch weight.

Velu (2001) opined that, application of 25 ppm of GA_3 with 0.5 ppm of BR at flowering and fruit set stage improved yield and quality of Muscat grapes than control. Application of GA_3 in combination with Brassinosteroid (1 ppm) was found effective for increasing the yield of Thompson Seedless grapes (Tambe, 2002).

Warusavitharana *et al*. (2008) reported that the vines treated with GA_3 at 10 ppm at pre-bloom stage, 15 ppm at initiation of flowering, 25 ppm at 3-4 mm berry diameter stage in combination with 1 ppm brassinosteroid recorded the maximum for bunch characters in three year old Thompson Seedless grapes trained under bower system.

Habibi *et al.* (2010) reported that, 50 ppm GA_3 + 1 ppm brassinosteroid increased the berry weight and diameter significantly in Bangalore Blue grapes. Padashetti *et al*. (2010) found that GA_3 (50 ppm) + BR (1 ppm) applied twice at fruit set stage increased bunch weight, berry weight and reducing sugar (%) in Arka Neelamani and TSS in Thompson seedless.

Combined effect of gibberellic acid, CPPU and brassinosteroid on yield and quality in grape

Among the growth regulators like GA_3, brassinosteroid, CPPU and BA, 2 ppm CPPU + 0.4 ppm brassinosteroid + 20 ppm BA gave the highest mean brix: acid ratio (60.23) and average brix yield (73-86 g) when fruits of Flame Seedless were dipped in growth regulators at 7 days after fruit set, whereas 3 ppm of CPPU gave the lowest mean brix: acid ratio (58.9) and average brix yield of 55.13 g (Bhat *et al.,* 2004).

According to Warusavitharana (2008), after October pruning vines and bunches at specific stage of development were treated with respective plant growth regulators like GA_3, brassinosteroid, CPPU, and benzyladenine. The results revealed that the application of GA_3 in combination with brassinosteroid and BA was found effective for cell elongation and cell division, which lead to increase berry size, yield and quality of Thompson Seedless grapes.

Bhat *et al.* (2012) evaluated the effects of GA_3, brassinosteroid and CPPU on seedless grape variety 'Tas-A-Ganesh'. He applied brassinosteroid and CPPU either alone or in combination with benzyladenine by dipping the bunches at either 7 or 15, or both 7 and 15 days after fruit set. The treatments having a combination of either higher or lower concentration of both BR (0.4 ppm) and CPPU (4 ppm) along with benzyladenine 20 ppm produced maximum bunch weight (371.13 g), berry weight (4.90 g), berry volume (4.22 cm^3), and number of berries per bunch (90.88).

Conclusion

GA_3 application has revolutionized the grape cultivation and other growth regulators like brassinolides and CPPU had also been tried with success for improving the quality. Although various research outcomes authenticated the effects of several bioregulators in grape over a period of time, their usage at the right stage with optimized concentration is essential for the improvement of yield and quality.

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