

Plant Bioregulators to Check Uneven Ripening of Coloured Grapes

Uneven ripening in coloured grape cultivars is one of the significant constraints in commercial grape cultivation, especially under semi-arid subtropical conditions. As evident from recent studies, plant bioregulators (ABA and ethylene) could produce uniformly coloured berries in India and may be a viable alternative to overcome the problem of uneven ripening of coloured grape varieties. Furthermore, since ethylene (Ethrel) is more affordable than abscisic acid, the study advocates using it to enhance the colour of grape berries in commercial viticulture.

GRAPE (*Vitis vinifera* L.) is a member of the Vitaceae family and originated in the temperate region between the Black and Caspian Seas. The European grapes (*Vitis vinifera* L.) and American grapes (*Vitis labrusca* and *V. rotundifolia*) are the two-important species of cultivated grapevines worldwide, along with a few French hybrids. With the world scenario of grape consumption pattern, the grape has been preferred mostly for wine preparation, whereas a limited quantity of grapes is used for table purposes, raisins, and juice delicacies. However, an opposite trend of grapes consumption is prevalent in India, used primarily for table purposes, followed by raisin making. Despite the earlier introduction in India, the commercial cultivation of grapes started in the late 1960s with a meagre 800 ha area, which now occupies around 1,55,000 ha area with an annual production of 3.358 million MT and productivity of 22.39 MT ha⁻¹ in 2020-21 (MoA&FW, 2022). India is also credited with the highest productivity of grapes in the world.

Commercial viticulture has been practiced in India for almost the last six decades and it is now regarded as one of the most profitable horticulture ventures. Though most of the commercial viticulture (85% area) takes place in the tropical region (Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu), sub-tropical viticulture is practiced in the states of Punjab, Haryana, western Uttar Pradesh, and a small portion of Delhi, which can produce grapes during June. However, uneven ripening of grape berries is a significant constraint in these semi-arid subtropical regions of North India. To overcome this problem, the application of plant bioregulators can serve as a viable alternative in the short term.

Plant Bioregulators

Plant bioregulators are synthetic compounds that regulate plant growth and development through their exogenous application. Plant bioregulators can regulate several growth and developmental stages in plants, and the

invention of their roles has been considered an important landmark in horticultural research. In commercial grape production, plant bioregulators play a significant role in many aspects, such as berry thinning and development, production of seedless berries, development of uniformly coloured berries, etc. Plant bioregulators such as abscisic acid (ABA), ethylene, pro-hexadione calcium, and benzothiadiazole are showing promising results in enhancing the grape berry colour.

Abscisic acid and ethylene play a key role in fruit development and ripening in grape. Both are recognized as important hormones triggering ripening and colour development in ripening grape berries. Ethylene is a gaseous compound that has wide-ranging functions in fruit crops. Firstly, ethylene is involved in most development steps of the plant life cycle, including seed germination, flowering, fruit ripening, abscission, and senescence. Many coloured grape varieties such as Crimson Seedless, Kyoho, Cabernet Sauvignon, and Merlot respond well to the exogenous treatment with ethylene and abscisic acid resulting in enhanced berry colour and more uniform ripening. In addition to the improvement in berry colour, these plant bioregulators also enhance other grape berry quality characteristics such as berry size, total soluble solids, berry phenolics and flavonoids, ascorbic acid content, and antioxidant activity. Thus, incorporating these bioregulators in viticulture to improve berry colour may also lead to the production of grape berries with increased bioactive compounds, thereby fetching more market prices.

Among the other new generation plant bioregulators, the pre-harvest treatments with benzothiadiazole (BTH) have doubled the anthocyanins concentration in some coloured grape cultivars such as 'Merlot' and also shown that treatments with benzothiadiazole can trigger the systemic acquired resistance in plants which in turn promotes disease resistance. Prohexadione-calcium (Pro-Ca), a gibberellin biosynthesis blocker, has also been



(a)



(b)

Uneven ripening of grape berries in (a) Flame Seedless and (b) Beauty Seedless varieties

helpful in grapes after its earlier success in commercial apple cultivation. Exogenous application of pro-hexadione calcium enhances the concentration of berry skin anthocyanins, better colour, and sensory characteristics.

Uneven Ripening of Grapes

Uneven ripening in coloured grape cultivars is one of the major constraints in commercial grape cultivation, especially under semi-arid subtropical conditions. Anthocyanins are the major colouring compounds attributing to the berry colour. Besides, several physiological, chemical, and environmental factors, including light, temperature, and amount of plant bioregulators/plant hormones influence the colour development in grape berries. Many red and black coloured grapevine cultivars have lower pigmentation than needed for optimum market appeal and requirements of the processing industry due to deviation from ideal light, temperature, soil moisture, and nutrition conditions. Among these, the temperature is the primary factor contributing to the non-uniform berry ripening under semi-arid subtropical North Indian conditions.

Use of plant bioregulators in tackling uneven ripening in grape

Several attempts have been made to overcome this problem, such as the regulation of crops by using cultural practices like girdling, ringing, thinning, and exogenous treatments with plant bioregulators. These approaches have shown some encouraging results in the improvement of grape quality. The grape variety 'Flame Seedless' has been recommended for commercial cultivation in North Indian states such as Punjab, Haryana, Uttar Pradesh, and other neighbouring states. Beauty Seedless is another cultivar that has the potential to be grown commercially in these North Indian conditions. Berries of the Flame Seedless cultivar are light red coloured, while in the Beauty Seedless cultivar, they are dark-red coloured. Both these cultivars ripen during the first week of June to the third week of June in these regions. However, as stated earlier, berry ripening is uneven within the cluster, resulting in unattractive, uneven-coloured, sour-green, and inferior-quality berries in North Indian viticulture.

Being a gaseous hormone, ethylene is available in the market as an aqueous solution of Ethrel® (Ethepon 39 SL) (39% w/w). When Ethrel solution is sprayed on the grape berries, it penetrates the berry skin and is translocated and progressively decomposed to ethylene, which positively influences the berry ripening and colour development. Recently, the study found that the application of plant bioregulators such as abscisic acid (400 ppm) and ethylene (400 ppm) at the veraison stage (berry starts ripening stage) improved the colour of the grape berries in Beauty Seedless and Flame Seedless varieties under North Indian semi-arid subtropical conditions. Furthermore, since ethylene (Ethrel) is more affordable than abscisic acid, we advocate using it to enhance the colour of grape berries in commercial viticulture. To prepare a spray solution of ethylene (400 ppm), 1 ml of Ethrel is dissolved in 1 litre of water by mixing it uniformly; thus, the prepared solution must be sprayed immediately.

Moreover, the ethylene application also enhanced the berry quality characteristics such as total soluble solids (TSS), berry phenolics and flavonoids, ascorbic acid content, and antioxidant activity in both Flame Seedless as well as Beauty Seedless varieties. However, a slight reduction in berry firmness may be observed after the treatment with ethylene since ethylene is a stress hormone. On the other hand, a better compromise between berry colour and firmness can be achieved by using an optimized dose of ethylene. Other reports are also available on the successful use of abscisic acid and ethylene to improve coloured grape cultivars, such as Crimson Seedless, Rubi, Flame Seedless, etc., under the semi-arid subtropical regimes.

SUMMARY

The availability of grapes in the month of June can only be possible through semi-arid subtropical viticulture in North India. However, the uneven development of berry colour in these regions is a major constraint in commercial viticulture, resulting in poor market prices. Plant bioregulators significantly improve the grape berry colour in the semi-arid subtropics of India and



(a) Control



(b) ABA 400 PPM



(c) Ethylene 400 PPM



(d) Control



(e) ABA 400 PPM



(f) Ethylene 400 PPM

Comparison of grape bunches treated with plant bioregulators at the veraison stage (berry starts ripening stage);
Flame Seedless (a, b, c) and Beauty Seedless (d, e, f)

other parts of the world. A better compromise between grape berry colour and quality characteristics can be achieved by employing plant bioregulators in subtropical viticulture.

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