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Contemporary improvements of post harvest quality in grapes

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ABSTRACT : Grape (*Vitis vinifera* L.) is considered as one of the most important leading fruit crops of temperate to tropical regions. The grape is gaining popularity for its high nutritive value, excellent in taste, multipurpose use and better economic returns. It is highly remunerative owing to high bearing capability in per unit area. In recent past application of ethrel and GA_3 has improved the physical and biochemical characters of grapes which is directly influence on the marketable quality. The combined application of micronutrients (Zn, Fe and Mn) at 0.05 per cent level was very effective in the improving quality of grapes namely uniform large size berry, perfect berries (without shot berry), characteristic color and texture. In view of cultural practice cluster thinning has been provided the highest total anthocyanin content in grapes. Pruning of grapes at two to three buds per cane has been found economically higher yield as well as improve in quality of grapes. Similarly, improvement in berry size, uniform ripening, colour development, increase in TSS, increase in TSS/Acid ratio and firmness of berries were noticed through trunk girdling. This paper reviewed mainly the advance improvements of postharvest quality in grapes through effective application of plant growth regulator, nutrient and contemporary cultural practices.

Key **W**ords : Grapes, Quality, Micronutrients, Postharvest, Growth regulator, Cultural

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Grapes is one of the most important commercially cultivated fruit crops in India especially, Northern states like Punjab, Haryana, Maharashtra and Southern states like Karnataka, Andhra Pradesh and Tamil Nadu. The total grapes production is 2483.1 metric tonnes with 3.1 per cent of the total fruit production in India during 2012 - 2013 (NHB, 2014). Maharashtra (82.6 %) is largest producer of grapes in our country. Maharashtra and Karnataka together contributes about 95.5 per cent of Indian grapes production. Grapes are widely consumed as fresh fruit in India. It is also used for producing raisins, wine, juice, juice concentrate, squash, beverages, jams and marmalades. Grapes are highly digestible and have a number of therapeutic properties. Being a non-climacteric fruit, it needs to be harvested after developing characteristic colour, flavour, aroma and size. This is because, the quality of grapes at harvest is final and zero improvement of colour, flavour, aroma and size could be noticed after harvest in all the grape varieties. At the same time, over ripening also causes deterioration in quality and it poses a problem for marketing and storage. Quality of table grapes is usually considered as a combination of appearance (average size of clusters) as uniformly large size berry, perfect berries (without shot berry) with the characteristic color and texture of the variety (Kamiloglu, 2011), flavour characteristics, sugar concentration, acidity (Jonathan, 2012). Increasing quality of grape is dependent on different practices (Kamiloglu, 2011). There are many factors effect in the quantity and quality of grape such as pruning, crop load, thinning, girdling, topping, pinching, the use of plant growth regulators and correct nutrition (Prabhu and Singaram, 2001). Generally grapes are highly perishable in nature particularly the grapes grown under north Indian conditions and therefore, cannot be marketed at a longer distance and also it cannot be stored for a longer period. This causes a glut of fruits in the market during the peak season

and the growers get low prices for the produce. The quality of grapes produced under North Indian conditions is not suitable for raisin production and grapes grown under South Indian condition are not suitable for wine making. In this review article, mainly discussed about the maturity index, quality regulation and their effect on storage capabilities are being discussed on the basis of work done by various grapes scientists in India.

Maturity indices of grapes :

The optimum stage of harvesting is a main importance in grapes. Therefore, a desired level of quality should be attained by the berries before harvesting. The maturity indices are variable factors and depend upon the varieties to varieties and species to species. The marketable quality of grapes can be influenced by many factors *viz.*, environmental conditions, cultural practices, use of growth regulator, use of chemicals etc. The maturity indices is mainly summarized by Singh *et al*. (1972) and include the characters as berry size, color, sugar acid ratio, pH of juice, juice content, total soluble solid (TSS), acidity and reducing sugar at harvest. They also showed the maturity indices of Thompson Seedless, Perlette, Beauty Seedless, Delight and Gold varieties of grapes (Table 1). These varieties are most promising cultivars of grapes grown commercially in Haryana, Punjab, Maharashtra and certain places of Tamil Nadu.

Use of growth regulator to improve the quality of grapes :

Growth regulators are the potential chemicals in manipulating the maturity of grapes. Various growth regulators have been reported to influence the quality *viz.*, gibberellic acid, ethrel, naphthalene acetic acid, cycocel, CPPU [N-(2-chloro-4-pyridyl)-N-phenyl urea] and ABA (Abssasic acid).

Ethephon (2-chloroethyl phosphonic acid) is a compound that decomposes to release the natural plant hormone ethylene. It mainly used in grapes production is to enhance fruit ripening. Andris (1986) reported that application of ethephon could advance the maturity of Thompson Seedless by about 1.0 ^{0}Brix or the equivalent of one week mature berry. He also stated the following effect under Thompson Seedless vineyard.

- Improvement in berry total soluble solids content ranging from 0.6 to 1.3 °Brix in seven out of eight trials.
- Lower the titratable acidity in four out of six trials where measured.
- No change in fresh berry weights.
- Higher percentage of A grade berries and lower percentage of substandard berry in four out of five trials.
- No measured raisin yield effects.
- No adverse effects on vine growth or cane maturity.

According to Singh and Chundawat (1978) the use of ethrel was found to certain improvement in quality of berry (Fig. 1). Application of ethrel from 250-500 ppm at various stage of maturity (*i.e.* 15 % color break stage), improved the quality of berries by early colour development, increase in total soluble content and TSS/ Acid ratio in Perlette and Beauty seedless in Turkey and Emperor grape in Delight. The enhanced ripening with the application of ethrel at 1000 ppm and improved quality was also reported by Panwar (1985). However, ethrel applied at fruit set stage (early) which leads to delayed ripening also (Weaver and Pool, 1971). Thereafter, Weaver and Montgomery (1974) were also suggested that late application did not show any response in grapes.

Gibberellic acid (GA_3 formulation) sprays are used at bloom to thin berries and increase berry size. The main goal is to improve grape maturity and raisin grades. Andris (1986) reported the following effects from treatment with GA_3 in Thompson Seedless vineyards.

- Increased fresh berry and raisin weights and it ranged between 8 and 11 per cent.
- Increased total soluble solids per berry, but only occasional increment in per cent of soluble solids concentration (°Brix).
- Higher percentage of A grade berries and medium percentage of substandard berry.
- Increased length of berries.

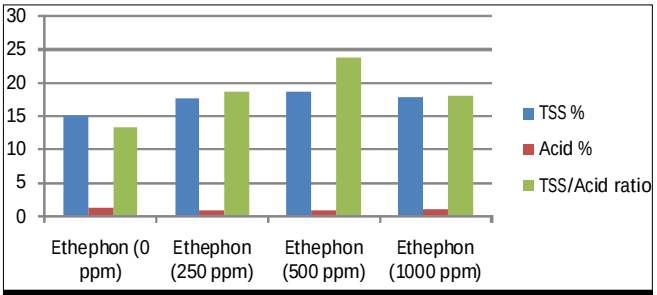

Fig. 1 : Effect of ethephon as fruit quality in Delight grapes

Table 1 : Maturity indices for different grapes cultivars

Sr. No.	Cultivar	Juice (%)	T.S.S (%)	Acid (%)	Reducing sugar (%)	T.S.S
1.	Thompson seedless	71.3	19.7	0.60	15.10	32.83
2.	Perlette	73.0	17.0	0.90	13.17	18.90
3.	Beauty seedless	74.9	19.3	1.10	16.78	17.54
4.	Delight	69.9	17.9	0.40	14.57	44.75
5.	Gold	79.9	16.6	0.26	12.14	63.84

- Measurable natural thinning of berries has been found in occasional.
- No increased cluster length at harvest in any trial.
- No experimentally documented any reductions in incidence of bunch rot.
- No effect on raisin yield. According to Elbanna and Weaver (1978) application of gibberellic acid has found to gradual increase the size, quality and firmness of the berries but the ripening was delayed considerably.

Application at 20-40 ppm at full bloom has been found quite effective in production large elongated berries (Dhawan *et al.*, 1970) (Table 2). Clark *et al*. (1993) demonstrated that spraying GA_3 at different concentrations on Seedless grape cultivars once or twice at full bloom or berry set stage has increased the cluster weight, berry weight and the yield/ vine. On the same time GA_3 delayed colour by about 20 days and total acids decreased more slowly. Normally, seedless table grapes are treated with gibberellic acid (GA_3) and found to increase in berry size and uniformity (Dokoozlian *et al*., 1994; Reynolds *et al*., 1992).

The quality of perlette grapes was also increased with the application of naphthalene acetic acid (100-150 ppm) and GA (50 ppm) (Kumar and Gupta, 1985) (Fig. 2.). Growth retardants have also been reported to influence the quality of grapes. Applications of 0.1 per cent methyl 2- (ureidoxy) propionate at berry set stage would improve early berry ripening. Use of cycocel has also been reported to improve the quality of grapes by various workers. In recent past the application of the synthetic cytokinin forchlorfenuron [N-(2-chloro-4-pyridyl)-N-phenyl urea], commonly known as CPPU, could be used to increase in berry size and may also improve fruit firmness of grapes (Peppi and Fidelibus, 2008). According to Peppi *et al.* (2006) stated that the application of ABA can increase the anthocyanin content and improve the color of 'Flame Seedless' grapes, but only drawback is softening of fruit tissue, which is undesirable (Table 3).

Use of chemicals :

The application of primary, secondary and micro nutrients also improved the marketable quality of fruits (Khera and Dhawan, 1979). Generally, grapes give more response in application of secondary (Ca, Mg, S) and micronutrients (Zn, B, Fe, Mn, Cu) in term of improved marketable quality. Application of potash (Gopalswamy and Madhavarao, 1972) and boron improved the quality of grapes. Whereas high nitrogen application was found to reduce the quality in terms of TSS and reducing sugars, but it increased the juice and

Table 2 : Effect of GA_3 on the quality of Kishmish Charni and Delight grapes

Sr. No.	Treatments	Delight		Kishmish Charni	
		T.S.S (%)	Acid (%)	T.S.S (%)	Acid (%)
1.	GA_3 30 ppm	71.3	19.7	0.60	15.10
2.	GA_3 40 ppm	73.0	17.0	0.90	13.17
3.	GA_3 50 ppm	74.9	19.3	1.10	16.78
4.	GA_3 60 ppm	69.9	17.9	0.40	14.57
5.	Control	79.9	16.6	0.26	12.14

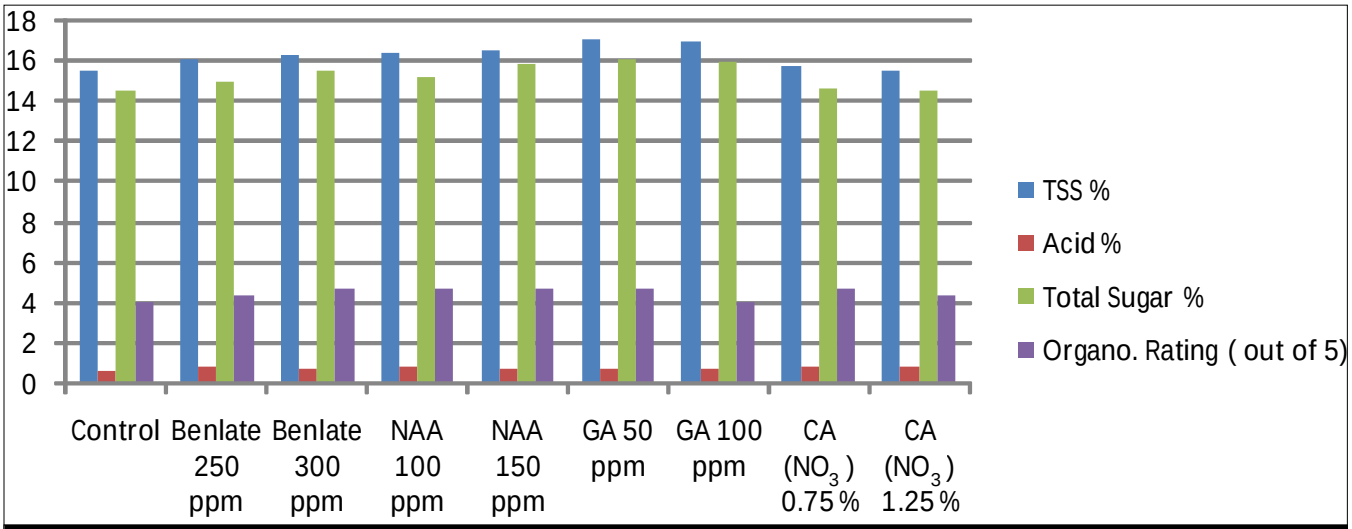

Fig. 2 : Effect of pre-harvest treatments on the quality of grapes

vitamin C content (Chadha and Singh, 1971) (Fig. 3.). Calcium content of berries has been found to be associated with the stroage behavior and quality in various cultivars of grapes. It has been found that the grape varieties containing higher calcium content were better in quality and could be stored for longer period by maintaining better quality. The spoilage of fruits was markedly lower during storage in varieties having high calcium content. Grape vine with high calcium content in leaves also contained high amount of calcium in berries. Application of calcium in the form of nitrate (0.75-1.25 %) as pre harvest spray has been found to improve the quality and storage capability of Beauty Seedless and Perlette grapes (Kumar and Gupta, 1985).

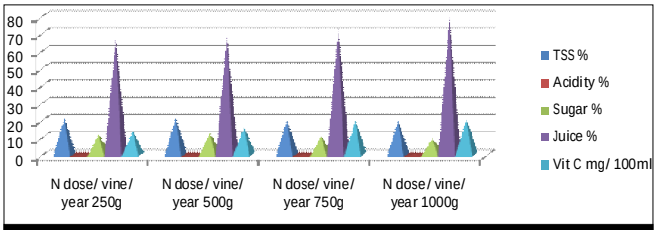

Fig. 3 : Effect of varying levels of nitrogen on fruit quality in Thompson Seedless

Zinc is one of the essential elements for plants. Zn is required for the synthesis of auxins, chlorophyll, and starch and metabolism carbohydrate. Grapevines require approximately 0.5 kg Zn/per year (Jonathan, 2012). Zinc deficiency is characterized by abnormal development of

Table 3 : Effect of CPPU and ABA on berry weight, length and diameter of Flame Seedless

Factor	Conc.	Berry weight (g)	Berry length (mm)	Berry diam. (mm)
CPPU (g. ha^{-1})	0	4.98	20.7	19.8
	5	5.19	20.6	20.1
	10	5.20	20.5	20.2
	15	5.42	21.1	20.5
	20	5.06	20.3	19.9
ABA (mg. L^{-1})	0	4.78	20.1	19.5
	200	5.32	20.8	20.4
	400	5.34	20.9	20.3
	600	5.25	20.8	20.1

Table 4 : Effect of boron and iron sprays on the quality of Thompson Seedless grapes

Sr. No.	Treatments	T.S.S (%)	Acid (%)	T.S.S/ Acid ratio
1.	Control	22.9	0.64	35.8
2.	$FeSO_4$ 0.2 (%)	23.4	0.64	36.6
3.	$FeSO_4$ 0.4 (%)	23.5	0.71	33.1
4.	H_3BO_3 0.15 (%)	24.5	0.67	36.6
5.	H_3BO_3 0.30 (%)	23.2	0.73	31.8
6.	H_3BO_3 0.15 (%) + $FeSO_4$ 0.2 (%)	24.3	0.63	38.9
7.	H_3BO_3 0.15 (%) + $FeSO_4$ 0.4 (%)	23.7	0.70	33.0
8.	H_3BO_3 0.30 (%) + $FeSO_4$ 0.2 (%)	23.1	0.70	33.0
9.	H_3BO_3 0.30 (%) + $FeSO_4$ 0.2 (%)	21.7	0.69	31.4

Table 5 : Effect of Zn, Fe and Cu sprays on the quality of Pusa Seedless

Sr. No.	Treatments	T.S.S (%)	Acid (%)	T.S.S/ Acid ratio
1.	Control	20.0	0.79	25.3
2.	$ZnSO_4$ 0.4(%) (One spray)	19.7	0.66	29.8
3.	$ZnSO_4$ 0.4(%) + $FeSO_4$ 0.4(%) (One spray)	22.4	0.63	35.5
4.	$ZnSO_4$ 0.4(%) + $CuSO_4$ 0.4(%) (One spray)	21.1	0.76	27.7
5.	Zn + Fe +Cu (One spray)	19.9	0.71	28.0
6.	$ZnSO_4$ (Two spray)	20.7	0.65	31.4
7.	Zn + Fe (Two spray)	19.8	0.71	27.9
8.	Zn + Cu (Two spray)	20.1	0.73	27.5
9.	Zn + Fe +Cu (Two spray)	20.5	0.71	28.3

internodes ('zig-zag' growth pattern of shoots), interveinal chlorosis in early summer and small rosette leaf formation. Also production of clusters with undeveloped shot berries and generally poor fruit set are all characteristics of Zn deficiency (Gowda *et al*., 2008).

Another nutrient which also has an important role in fruit quality is boron (Elbory and Mansour, 1988). Boron has an effect on cell wall structure and also has a major effect on cell elongation, root growth and transfer of sugar (Abdollahi *et al*., 2010). Boric acid (0.15 to 0.3 %) and ferrous sulphate (0.2 to 0.4 %) and in combination improved the quality of Thompson seedless grapes (Table 4). Similarly two sprays of zinc sulphate (0.4 %) alone and with one spray of ferrous sulphate (0.4 %) also improved the quality in Pusa Seedless grapes (Table 5).

Combined application of three micronutrients (Zn, Fe and Mn) in chelated form at 0.05 per cent level was very effective in improving the growth characters such as leaf area and spur thickness of Red Roomy grapevines (Abada, 2002). Similar results were noticed by Attia (1998) who mentioned that increasing leaf area, spur thickness and weight of pruning of Red Roomy grapevines were due to spraying with Zn, Fe and Cu at 0.3 per cent in sulphate form. Similarly, Salem and Elkhoreiby (1995) indicated that spraying micronutrients such as Zn, Fe and Mn were effective in improving growth of Thompson seedless grapevines. Correspondingly, Gobara (1999) showed that four sprays of Zn plus Fe in chelated form at 0.05 per cent were very effective in improving the leaf area of Flame seedless grapevines.

Suitable cultural practices to improve the quality :

There are many cultural factors improve the quality of grapes such as improve rootstock, pruning, crop load, thinning, girdling, topping and pinching etc. American vine rootstocks used in vineyards could influence the fruit quality (Howell, 1987). Similarly, "Dogridge" rootstocks are commonly used to improve the quality of grapes in vineyard of India and 'Rupestris du Lot' rootstock in Turkey (Celik *et al*., 2005). Physical appearance of grapes such as color, flavor and shape are more important for consumers (Francis, 1978). Therefore, intense studies are carried out on berry color development in grapes (Gao and Cahoon, 1998). Consumer attraction of many coloured table grape types is closely related to the anthocyanin amount on berry skin (Kliewer, 1970). Anthocyanins are responsible for many red, violet and blue colors in fruit and flowers. Anthocyanins are strong antioxidants (Romero *et al*., 2008). Kamiloglu (2011) reported that Cluster thinning practice provided the highest total anthocyanin content in the study (Table 6.).

Irrigation :

Time and frequency of irrigation also regulate the quality of grapes. More frequent irrigation could leads to deteriorate the quality of grapes by reducing total soluble solids (Nijjar and Sharma, 1973), whereas longer duration between two irrigations helped to increasing the quality. Withholding of pre harvest irrigation (10 to 15 days) has also been found to increase the quality of grapes.

Pruning and girdling :

Pruning of grapevines regulate the bearing and improve the quality of grapes. Pruning at two to three buds per cane has been found to improve the quality of beauty seedless (Gupta *et al*., 1984) and Perlette (Gupta *et al*., 1984a) grapes. The berry and bunch size, total soluble contents were increased. Besides this, there was an even ripening and color development in Beauty Seedless and reduction in shot berries development in Perlette grapes. Girdling of cane and trunk of grapevines has also been reported to improve the quality of grapes. Trunk girdling has given better results in improving the quality as compared to cane or arm girdling (Sharma and Jindal, 1981). Improvement in berry size, even ripening, colour development, increase in TSS, increase in TSS/Acid ratio and firmness of berries by trunk girdling of Beauty seedless grapes has also been reported by Gupta *et al.* (1985). Girdling at various stages of fruit development alone or in combination with ethephon has improved the quality of Thompson seedless grapes (Elbanna, 1981). Jindal *et al.* (1982) have reported that

Table 6 : Effect of some cultural practices on individual anthocyanin and total anthocyanin content of 'Horoz Karası' table grape

Treatments	Total anthocyanins (mg 100 g $^{-1}$)	Cy-3-G (mg 100 g $^{-1}$)	Dp-3-G (mg 100 g $^{-1}$)	Mv-3-G (mg 100 g $^{-1}$)	Pn-3-G (mg 100 g $^{-1}$)	Pt-3-G (mg 100 g $^{-1}$)
Control	29.73 b[(1)]	0.09 b	0.38 b	21.78 b	0.54 b	1.66 b
Cluster thinning	56.50 a	0.19 a	1.14 a	47.22 a	1.38 a	5.55 a
Boron	39.41 ab	0.12 ab	0.68 b	29.14 ab	0.66 b	3.03 b
Topping	40.83 ab	0.14 ab	0.77 ab	32.09 ab	0.87 ab	3.41 b
Cluster thinning + boron	24.46 b	0.09 b	0.35 b	16.31 b	0.39 b	1.44 b
Cluster thinning + topping	34.63 b	0.12 ab	0.66 b	25.94 b	0.56 b	2.84 b
Boron + topping	26.03 b	0.10 b	0.40 b	20.24 b	0.53 b	1.62 b
Cluster thinning + boron + topping	31.87 b	0.11 b	0.54 b	22.79 b	0.66 b	2.22 b
Significant[(2)]	17.08	0.06	0.40	17.91	0.55	2.12

[(1)] : The differences between the means marked with different letters. [(2)] :* $P \leq 0.05$

the girdling alone and in combination with boric acid (0.2 %) once or twice which helped in improving the quality of Gold cv. of grapes. Normally, summer pruning in table grape has more effects than winter pruning (Dilorenzo *et al.*, 2011). Thinning is one of the most important cultural techniques and it consists in the elimination of vegetative or reproductive organs in excess. Other cultural practices include leaf removal, fruit shoots positioning and shoot trimming also giving some response in quality of grapes.

Conclusion :

This study yielded information about influences of plant growth regulator, nutrients and some cultural practices to improve the yield, quality and anthocyanins content of commercial cultivated grape in India. Generally, application of recommended dose of plant growth regulators like GA_3, ethrel and NAA would help to improve the marketable quality of commercial grapes. The application of ethrel from 250-500 ppm at 15 per cent color break stage will improve the overall quality of grapes whereas ethrel at 1000 ppm would enhance the ripening of Perlette and Beauty seedless. The quality of Perlette grapes was increased with application of NAA (100-150 ppm) and GA_3 (50 ppm) at berry development stage. Similar improvement was also recorded by using of CPPU. In case of nutrients, the application of combined micronutrients (Zn, Fe and Mn) in chelated form at 0.05 per cent was very effective in improving the growth characters of Red Roomy grapevines. The upgraded cultural practices like using of improved rootstock, summer pruning, crop load control, effective thinning, trunk girdling, topping, pinching and timely irrigation has also improve the quality of grapes. In view of that cluster thinning practice has increased on number of berries per cluster over the control. Total anthocyanin and individual anthocyanin amounts were also significantly increased by this practice. The above analyzed improvements practice could hopes to upgrade the quality of commercially cultivated grapes grown under North Indian and South Indian conditions, which interim helps to fetch higher marketed economic benefits by the grapes grower.

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