Fruit Quality of Grape (*Vitis vinifera* L.) cv. Muscat in Response to Plant Growth Regulator Application

V. Jegadeeswari, T.N. Balamohan[1], R.M. Vijayakumar[1]
S. Mohandass[2] and S. Kuttalam[3]

Department of Fruit Crops, Horticultural College and Research Institute
Tamil Nadu Agricultural University
Coimbatore - 641 003
India

ABSTRACT. *Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore to elucidate the response of grape cv. Muscat to growth regulator application with respect to their quality in the summer and winter seasons. The quality characters such as total soluble solids (TSS), total sugars and anthocyanin content were found to be better in the treatment combination Gibberellic acid (GA)+ Brassinosteroids (BR) + Pink Pigmented Facultative Methylobacteria (PPFM). The season had profound effect on colour development while grapes harvested in the winter recorded more anthocyanin content compared to summer.*

INTRODUCTION

Grape (*Vitis vinifera* L.) is one of the earliest fruits known to mankind and is grown for its juicy and tasty berries. Grape is considered to be one of the most delicious, refreshing and nourishing fruits and a rich source of carbohydrate (15-25%) particularly rich in glucose and fructose with traces of minerals (0.2-0.6%). Over the past two decades, usage of plant growth regulators has gained considerable importance in the field of horticulture. Several chemicals have been tried for cluster thinning, hastening maturity, improving berry size and controling the vegetative growth in grape vines. Gibberellic acid (GA) came into prominence for its beneficial effect on increasing berry size of grapes. In grapes, application of GA is known to reduce the bunch compactness and improve the size and quality of berries.

Brassinosteroids (BR) are the sixth group of plant hormones with significant growth promoting activity (Clouse and Sasse, 1998). Exogenous BR levels are associated with ripening in grapes (Symons *et al.*, 2006). Brassinolides are considered as hormones with pleiotropic effects, as they influence varied developmental processes like growth, flowering and senescence. Pink Pigmented Facultative Methylobacteria (PPFM) is a microbial culture, which is a cytokinin rich source used as a growth regulator instead of synthetic cytokinin. Bacteria of the genus *Methylobacterium* are well-studied examples of facultative

---

[1] Department of Fruit Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore - 641 003, India

[2] Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore - 641 003, India

[3] Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore - 641 003, India

methylotrophs. *Methylobacterium* strains are commonly found in soils, as well as on the surfaces of leaves of a wide variety of plants (Corpe, 1985). Considering the need for optimizing the growth regulator, an attempt was made to study the bio-efficacy of growth regulators to improve fruit quality of grape cv. Muscat in summer and winter seasons.

MATERIALS AND METHODS

Field experiments were conducted at Kupanoor village of Thondamuthur Panchayat by Horticultural College and Research Institute Tamil Nadu Agricultural University, Coimbatore during 2007-2008. The investigation was laid out in a Factorial Randomized Complete Block Design (FRCBD) with three replications. Irrigated crop with three year old vines having uniform canopy size were selected for the study. Pandhal system of training was followed. In each experimental plot, vines were labeled and tagged before calyptra fall stage. The labeled vines were thoroughly sprayed with the respective treatment solutions. The treatment details are given below. After full ripening of berries, the labeled bunches were harvested separately and used for biochemical studies. As per the treatment details, growth regulators were sprayed three times, at pre flowering, flowering and fruit setting stages. Pink Pigmented Facultative Methylobacteria (PPFM) spraying was given to each bunch early in the morning (between 6.00 am and 7.00 am) as per the treatment detail. After that, the treated bunches were left for about two hours. Subsequently, GA and BR were sprayed along with teepol as per the treatment schedule.

Treatments

T_1 : Control (Water spray)
T_2 : 25 ppm Gibberellic acid (GA)
T_3 : 1 ppm Brassinosteroid (BR)
T_4 : Pink Pigmented Facultative Methylobacteria (PPFM) @10ml/l
T_5 : 25 ppm GA+ PPFM @10ml/l
T_6 : 1 ppm BR+ PPFM @10ml/l
T_7 : 25 ppm GA + 1 ppm BR
T_8 : 25 ppm GA + 1 ppm BR + PPFM @10ml/l

Biochemical analysis

The total soluble solids (TSS) were determined by using Carl-Zeiss hand refractrometer and the results expressed as Brix at 21^0C**.** The titrable acidity as per cent citric acid was estimated following the method of A.O.A.C. (1975). Total sugars were estimated by the method of Somogyi (1952) and expressed as percentage. The sugar acid ratio was calculated by dividing total sugar content with acidity. The total anthocyanin was estimated by pH differential method (Giusti and Wrolstad, 2001) and expressed as mg per 100g. The statistical analysis of the observations recorded was performed according to the method suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Total soluble solids and sugars

Total soluble solid content is an important tool used to indicate the ripeness and the quality of fruits besides the total sugars. Increase in sugars and TSS increases the quality of the produce. According to Winkler *et al*., (1974), grapes possess 85%TSS with total sugars constituting around 80 % of TSS.

The present investigation revealed that TSS and sugars had been profoundly influenced by the growth regulator treatments. Among different combinations of growth regulators used, the treatment, T_8 (GA + BR + PPFM) had registered the maximum TSS and sugar contents (Table 1). Application of GA increased the TSS by increasing the capacity of grape berries to draw more carbohydrates through increased endogenous auxin content directly or indirectly due to the quick metabolic transformation in soluble compounds (Singh *et al*., 1993). The steroidal hormone BR is involved in increasing the content of ABA (Symons *et al*., 2006). Increased endogenous ABA induces the sugar metabolic pathway. Therefore, application of BR indirectly increases the sugars in grape berries. Application of PPFM induces endogenous cytokinin in plant systems (Ivanova *et al*., 2000). Cytokinin has been shown to play a major role in the regulation of various processes associated with active growth and thus an enhanced demand for carbohydrates. Accumulation of more carbohydrates could be the reason for increased sugar content as reported by Roitsch and Ehneb (2000). In this study, cumulative effect of GA + BR + PPFM on the sugars in grape cv. Muscat was significant. This is in line with the findings of Velu (2002) in Muscat grapes, Tambe (2002) in Thompson Seedless and Bhat *et al*., (2004) in Flame Seedless grapes.

Seasonal influence on sugars and TSS of grape berries was positive (Table 1). The summer crop had registered higher sugars and TSS than the winter crop. Since there is no two way interaction, the application of growth regulators can be imposed round the year.

Acidity and sugar/acid ratio

Conversion of acids into sugars directly reduces the acid content of berries and in turn increase the sugar content of grapes (Singh and Khanduja, 1977).

Application of growth regulators significantly influenced the acidity and sugar/acid ratio. Among different combinations of growth regulators used, T_8 (GA + BR + PPFM) decreased acidity and increased sugar/acid ratio in grape berries of cultivar Muscat (Table 1). Application of GA decreased the acids by converting them into sugars (Wali *et al*., 1990). Brassinosteroids is involved in ABA mediated signaling, which converts acids into sugars (Symons *et al*., 2006), which is evidenced by lowering of acidity during harvest. Cytokinin is involved in accumulation of more carbohydrates in earlier stages of growth and development.

Table 1. Effect girdling and growth regulators on TSS (^{0} Brix), total sugars (%), sugar/acid ratio and anthocyanin (mg 100g^{-1}) content

T	TSS (^{0} Brix)		Total sugars (%)		Acidity (%)		Sugar/acid ratio		Anthocyanin (mg 100g^{-1})	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
T_1	12.6	11.1	11.6	10.8	0.610	0.621	21.4	18.2	0.367	0.376
T_2	14.2	13.4	14.7	12.7	0.363	0.485	40.3	32.2	0.546	0.557
T_3	17.2	16.8	16.8	14.6	0.385	0.435	45.7	41.2	0.540	0.551
T_4	12.9	13.1	15.9	14.2	0.533	0.527	25.6	23.4	0.507	0.505
T_5	14.2	13.6	17.6	15.9	0.505	0.506	28.1	28.5	0.541	0.551
T_6	16.1	15.1	19.4	16.5	0.483	0.506	33.4	29.9	0.537	0.545
T_7	15.7	15.2	20.1	18.1	0.420	0.414	37.6	37.0	0.548	0.552
T_8	17.6	16.6	21.0	20.2	0.360	0.360	50.4	48.1	0.552	0.557
T X S Mean	15.1	14.3	17.1	15.4	0.457	0.482	35.3	32.3	0.517	0.524

	T	S	TxS	T	S	TxS	T	S	TxS	T	S	TxS	T	S	TxS
SEd	0.57	0.28	0.81	0.51	0.25	0.73	0.02	0.01	0.02	1.23	0.61	1.74	0.01	0.009	0.026
CD (0.05)	1.1 **	0.57 *	NS	1.02 **	0.58**	NS	0.04 **	NS	NS	2.46 **	1.21 **	3.48 *	0.03 **	0.018**	NS

T - Treatment; S – Season; T x S – Interaction effect between treatment and season *significance at 0.05; ** significance at 0.01

Thus accumulated sources are converted into sugars which are reflected by minimum acidity. Decreased acidity ultimately improved the sugars which results in maximum sugar/acid ratio. The present finding is in line with the findings of Velu (2002) and Bhat *et al.*, (2004).

Season had a positive influence on sugar/acid ratio and acidity content (Table 1). Summer season had recorded lesser acidity and higher sugar/acid ratio than the winter season. This may be due to lower sunshine hours intercepted by the grape berries in winter emphasizing the necessity of solar radiation for conversion of starch into sugar. It is further observed that higher temperature also increased the rate of acid degradation and sugar accumulation (Radler, 1965).

In Treatment (T) and Season (S) interaction, the treatment combination T_8S_1 (GA + BR + PPFM in summer) registered an increased sugar/acid ratio which was due to the effective utilization of applied growth regulators by the plants in the bright sunny days.

Anthocyanin content

Grape berries contain relatively higher amounts of anthocyanin and other polyphenols which contribute largely to their appearance (Peynaud and Rebereau-Gayon, 1971). Sugar influx into the berry has been considered to be a factor influencing the rate of anthocyanin accumulation (Pirie and Mullins, 1977). The present experiment indicated that the application of growth regulators had significantly influenced the anthocyanin content in grape berries. Treatment, T_8 (GA + BR + PPFM) had profoundly influenced the anthocyanin content (Table 1).

All the environmental factors usually influence fruit development and maturation. Among them, temperature, however, contributes to uneven ripening and hampering the development of anthocyanins. Season had a profound effect on colour development, whereas winter (with mild temperature) recorded more anthocyanin than hot summers.

During maturation, high temperatures always reduce the anthocyanin content in grape berries. Maximum net assimilation rate was found between 25 and 30 ^{0}C, while the temperature above 30 ^{0}C brings the net assimilation down to half of that. Under this condition, vines are not capable of utilizing radiant energy possibly because of greater degradation of enzymes and chlorophyll pigment exceeding the rate of synthesis. The concentration of anthocyanin decreased at higher temperatures through degradation and/or inhibition of synthesis (Spayd *et al.*, 2002), resulting in decreased colour development. The detrimental effects of extreme temperature on photosynthesis may also be enhanced by induced water stress which has been shown to reduce the photosynthetic activity in grapes (Cawthon and Morris, 1981). Since the interaction effect was non-significant, the growth regulators could be imposed on the grape cultivar Muscat to increase the anthocyanin content throughout the year.

CONCLUSION

The vines which received GA + BR + PPFM had improved the quality parameters in Muscat variety of grape (*Vitis vinifera* L). Since the effects of growth regulators were independent, these treatments can be imposed on grapes throughout the year. Total soluble solids and total sugars were found to be the maximum in the treatment combination T_8 (GA + BR + PPFM) in both summer as well as winter. Considering the percentage acidity, the growth regulator treatment had a negative influence. The treatment combination T_8 (GA + BR + PPFM) registered a lower acidity content in both summer and winter seasons. The quality parameter sugar/acid ratio was found to be maximum in the treatment combination T_8 (GA + BR + PPFM) in both summer and winter.

ACKNOWLEDGEMENT

The authors are grateful to TNAU, Coimbatore, farmers of Thoandamuthur Panchayat of Coimabtore District, Tamil Nadu for providing facilities for the successful conduct of the trials.

REFERENCES

A.O.A.C. (1975). Official methods of analysis (12^{th} edition), Association of analytical chemists, Washington, D.C., U.S.A.

Bhat, Z.A., Srihari, D and Reddy, Y.N. (2004). Effect of BR's and CPPU along with BA on number of leaves, leaf area and leaf dry matter in grape cv. Flame seedless. Ann. of Agri. Bio. Res. **9**(1): 25-28

Cawthon, D.L., and Morris, J.R. (1981). Uneven ripening of Concord grapes: environmental, cultural and hormonal associations. Proc. Arkansas State Hort. Soc. 102^{th} Ann. Mtg. pp: 147-150

Clouse, S.D. and Sasse, J.M. (1998). Brasssinosteroids: Essential regulators of plant growth and development. Annu. Rev. Plant Physiol. Plant Mol. Biol. **49***:* 427-451.

Corpe, W.A. (1985). A method for detecting methylotrophic bacteria on solid surfaces. J. Microbiol. Methods **3**: 215–221.

Giusti, M.M. and Wrolstad, R.E. (2001). Characterization and measurement of anthocyanins by UV-visible spectroscopy. PP.1-13. In: Worlstad, R.E (Ed.). Current protocols in Food and Analytical chemistry.

Ivanova, E.G., Doronina, N.V, Shepeliakovskaia, A.O, Laman, A.G, Brovko, F.A. and Trotsenko, Yu.A. (2000). Facultative and obligate aerobic methylobacteria synthesize cytokinins. Mikrobiologiya. **69**: 764–769.

Panse, V.G. and P.V. Sukhatme. 198. Statistical methods for agricultural workers. ICAR, New Delhi. Pp. 134-192.

Peynaud, E. and Ribereau-Gayon, G.P. (1971). In. The biochemistry of fruits and their products, vol.2 (ed A.C. Hulme), Academic Press, London.

Pirie, A. and Mullins, M. (1977). Interrelationships of sugars, anthocyanins, total phenols and dry weight in the skin of grape berries during ripening. Am. J. Enol. Vitic. **28**(4): 204-209.

Radler, F. (1965). The effect of temperature on the ripening of Sultana grapes. Am. J. Enol. Vitic. **16**: 38-41.

Roitsch, T. and Ehneb, R. (2000). Regulation of source/ sink relations by cytokinin. Plant growth regulation. **32**: 359-367.

Singh, S., Singh, I.S. and Sungh, D.N. (1993). Physico-chemical changes during development of seedless grapes (*Vitis vinifera,* L.). Orissa J. Hort., **21**: 43-46.

Singh, S.H. and Khanduja, S.D. (1977). Physical and biochemical changes during maturation of grapes (*Vitis vinifera*.L.). Indian J. Hort., **34**: 354-357.

Somogyi, M. (1952). Notes on sugar determination. J. Bio. Chemi., **200**: 145-159.

Spayd, S.E., Tarara, J.M. Mee, D.L. and Ferguson, J.C. (2002). Separation of sunlight and temperature effects on the composition of *Vitis vinifera* cv. Merlot berries. Am. J. of Enol. and Vitic.

Symons, G.M., Davies, C. Shavrukov, Y. Dry, I. B. and Reid, J. B. (2006). Grapes on steroids. Brassinosteroids are involved in grape berry ripening. Plant Physiol. **140:** 150-158.

Tambe, T. B. (2002). Effects of Gibberellic acid in combination with brassinostroid on berry size, yield and quality of Thompson Seedless grape. J. of Maharastra, Agri. Univ. **27** (2): 151-153.

Velu, G. (2002). Studying various levels of bud load and certain thinning practices to improve yield and quality of grape cv. Muscat. M.Sc Thesis submitted to TNAU, Coimbatore.

Wali, V.K., Tiku, A.K. and Happa, R. (1990). Response of ‘Perlette’ grape to gibberellic acid. Adv. in plant Sci. **3:** 16-20.

Winkler, A.J., Cook, J.A. Kliewer, W.M. and. Lider, L.A. (1974). General Vitic. University of California Press, Berkeley.