EFFECT OF GIRDLING, THINNING AND GA_3 ON FRUIT GROWTH, YIELD, QUALITY AND SHELF LIFE OF GRAPES (*Vitis vinifera* L.) cv. Perlette

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THESIS

Submitted to the Faculty of Post-Graduate Studies
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In partial fulfilment of requirements for the award of degree of

MASTER OF SCIENCES IN AGRICULTURE
(POMOLOGY AND POST HARVEST TECHNOLOGY)

Certificates

CERTIFICATE-I

This is to certify that the thesis entitled **"Effect of girdling, thinning and GA_3 on fruit growth, yield, quality and shelf life of grapes (*Vitis vinifera* L.) cv. Perlette"** submitted in partial fulfilment of the requirements for the degree of Master of Science in Agriculture **(Pomology and Post Harvest Technology)** to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu is a record of *bonafide* research carried out by **Sh. Masroor Ahmad** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that such helps or information received during the course of investigation have been duly acknowledged.

18/3/03

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CERTIFICATE-II

We, the members of the Advisory Committee of **Sh. Masroor Ahmad,** candidate for the degree of Master of Science in Agriculture **(Pomology and Post Harvest Technology)** have gone through the manuscript of the thesis entitled **"Effect of girdling, thinning and GA_3 on fruit growth, yield, quality and shelf life of grapes (*Vitis vinifera* L.) cv. Perlette"** and recommend that it may be submitted by the student in partial fulfilment of the requirement for the degree.

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This is to certify that the thesis entitled **"Effect of girdling, thinning and GA_3 on fruit growth, yield, quality and shelf life of grapes (*Vitis vinifera* L.) cv. Perlette"** submitted by **Masroor Ahmad** to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu in partial fulfilment of the requirement for the degree of Master of Science in Agriculture **(Pomology and Post Harvest Technology)** was examined and approved by the Advisory Committee and External Examiner(s) on 2nd June, 2003.

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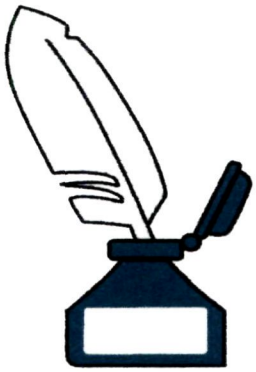

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ABSTRACT

Present investigation was carried out at research orchard of Division of Pomology and Post Harvest Technology,Udheywalla, SKUAST-Jammu during 2002 to ascertain the effect of girdling, thinning and GA_3 on fruit growth, yield, quality and shelf life of grapes cv. Perlette.

Growth pattern of berry revealed that berry takes 52 days after fruit set (DAFS) or 69 days to mature under agro-climatic conditions of Jammu region. In general berry showed a double sigmoid nature of growth curve with verasion stage at 38 DAFS.

All the treatments resulted in improved yield and quality. However, girdling + 40ppm GA_3 proved significantly most effective in increasing the berry size (1.88cm×1.80cm), berry weight (3.05g), berry volume (2.73cc), bunch size (16.85cm×14.33cm), bunch weight (495.73g) and average yield (8.87kg/vine) as compared to the control having berry size, berry weight, berry volume, bunch size, bunch weight and average yield as 1.69cm×1.66cm, 2.23g, 2.06cc, 13.83cm×9.25cm, 292.34g and 5.32kg/vine respectively. The shot berries were significantly reduced by girdling+thinning+40 ppm GA_3 (10.08%) as compared to control (13.45%).

The quality of the grapes was improved significantly by girdling + 40ppm GA_3 showing TSS (17.00%), TSS/Acid ratio (24.18), total sugars (15.04%) and reducing sugars (13.00%) as compared to control having TSS, TSS/acid ratio, total sugars and reducing sugars as 14.47%, 17.09, 14.02% and 11.86% respectively with an acidity of 0.689% with this treatment as compared to control (0.808%).

At room temperature, significant reduction in physiological loss in weight was recorded under girdling + 40ppm GA_3 treatment (9.42%) as compared to control (22.31%) on third day of storage, but after wards the berries were sunken and shattered and were unmarketable under all the treatments including control.

From this investigation it was concluded that trunk girdling + 40ppm GA_3 was effective in increasing the yield, quality and shelf life of grapes cv. Perlette under agro-climatic conditions of Jammu region.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATE(S)

LIST OF ABBREVIATIONS

°C	Degree celsius
g	gram(s)
mg	milligrams
ml	millilitre(s)
%	Percent
ppm	parts per million
cm	centimeter(s)
cc	cubic centimeter(s)
e.g.	example gratia (for example)
et al.	et alii (and others)
i.e.	idest (that is)
pp	pages
ha	Hectare
GA_3	Gibberellic acid
$d.H_2O$	distilled water
mt	million tonnes
mha	million hectare
kg	kilogram(s)
TSS	Total Soluble Solids
PLW	Physiological loss in weight
DAFS	Days after fruit set
Fig.	Figure
S.Em(±)	Standard error of means
C.D (0.05)	Critical difference at 5 percent level of significance.
G	Trunk girdling
T	Thinning by clipping
GA_3^*	Gibberellic acid (20ppm)
GA_3^{**}	Gibberellic acid (40ppm).

Chapter-1

Introduction

CHAPTER-1

INTRODUCTION

The grape (*Vitis vinifera* L.) is one of the most important and profitable fruit grown commercially throughout the world in regions of tropical, sub-tropical and temperate climates. Grape belongs to family Vitaceae and has originated in Asia minor in the regions between and to the south of Black and Caspian seas. This is the region from where the culture of the grape spread both east and west. Major grape producing countries are United States of America, Canada, Mexico, Argentina, Brazil, Australia, Egypt, Bulgaria, Germany, Russia, France and India. In India, major grape producing states are Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. Tamil Nadu in particular took a lead in viticulture followed by northern states including Jammu and Kashmir.

Grapes account for nearly half of the world production of fruit crops with approximately 57.39 million tonnes on an estimated harvestable area of 7.33 million hactare (Anonymous, 1999). In India, the estimated area under grapes is about 0.43 lakh hactare with an

annual production of 10.87 lakh tonnes (Chadha,2001). The state of Jammu and Kashmir has an area of 332 hactare with an estimated annual production of 673 tonnes (Anonymous, 2000).

Perlette is a hybrid between Scolokertek Hiralynoje 26 × Sultania Marble and was developed by Dr. H.P. Olmo at University of California, USA . This cultivar has the striking feature of translucence of the mature fruit (the French name, 'Perlette' signifying 'little pearl' clearly explain this feature). It is quite vigrous, seedless, early maturing, high yielding with well sized bunches and attractive whitish green to yellowish green berries. It is a delicious fruit crop and enrich our diet by way of valueable minerals and essential amino acids. It also contain moisture, carbohydrates, proteins, minerals, fat, fibre,calcium, phosphorus and iron having their corresponding values as per 100 grams of edible portion as 79.2g, 16.5g, 0.5g, 0.6g 0.3g, 2.9g, 20mg, 30mg and 0.52mg respectively (Gopalan *et al.*, 1991). In spite of such qualitative attributes it is also beset with serious problems like shot berries formation, lesser total soluble solids, compact cluster which prevent proper berry development and leads to rotting/uneven ripening.

Host of the research has been conducted in India and abroad for improving the grape yield and quality. Jindal *et al.* (1981) reported significant improvement in fruit quality of cultivar Gold by girdling and boric acid spray. Application of 40 ppm GA_3 along with cane ringing gave the greatest bunch weight, good berry size and quality

(Daulta, 1982). Quality was improved by the application of ethephon (1000ppm) in cv. Perlette (Dhaliwal and Sidhu, 1984). Berry weight of Ruby Seedless vines was significantly increased by cluster sprays of GA_3 and girdling and their combination (Harrell and Williams, 1987). Colapetra (1996) reported that GA_3 treatment increased berry weight particularly in seedless cultivars and retarded accumulation of soluble sugars and increased acidity. Cheema *et al.* (1997) observed that flower thinning followed by single dip in 40 ppm GA_3 and girdling gave the highest TSS and lowest juice acidity in cultivar Perlette. Dhillon and Bindra (1999) found significant increase in cluster weight with girdling after fruit set alone and in combination with 40% berry thinning. Number of shot berries were reduced with 40 ppm GA_3 in combination with brushing and clipping and the overall quality of grapes was improved with trunk girdling along with brushing of bunches and GA_3 application (Josan *et al.*, 2001).

The tradition of grape cultivation is old in the state of Jammu and Kashmir, particularly in Kashmir division, as is evident from Kalhan's Rajtarangni. However, its introduction for commercial cultivation in subtropical region of Jammu is only a few decades old because of particular agro-climatic conditions prevailing in Jammu. Perlette has been found most suitable as compared to other cultivars of grapes as it matures early before the onset of monsoon and the problem of berry rotting is avoided. However, low yield, comparatively lesser sugar content, high percentage of shot berries and compact

clusters still pose problems to commercial fruit growers of Jammu. To overcome these problems, the present investigation on the "Effect of girdling, thinning and GA_3 on fruit growth, yield, quality and shelf life of grapes (*Vitis vinifera* L.) cv.Perlette "have been undertaken with the following objectives:-

(i) To study the growth pattern of the grape berry under agro-climatic conditions of Jammu region.

(ii) To evaluate the effect of various treatments on the yield and quality of grape cv. Perlette.

(iii) To study the effect of various treatments on the post harvest life of grapes cv. Perlette.

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Chapter - 2

Review Of Literature

CHAPTER-2

REVIEW OF LITERATURE

The literature referred for planning and execution of the present investigations entitled, **Effect of girdling, thinning and GA_3 on fruit growth, yield, quality and shelf life of grapes (*Vitis vinifera* L.) cv. Perlette** has been reviewed under appropriate headings.

2.1. Growth and development pattern of berry:

Rao and Pande (1976) observed a double sigmoid growth pattern in Pusa Seedless grapes and correlated the berry growth to the higher levels of auxin during Stage I of berry developement, higher levels of inhibitors during Stage-II or lag phase and no direct evidence of relation of berry growth in Stage-III to growth substances.

Xu-Xue Feng *et al.* (1995) while studying the dynamics and characteristics of berry growth and development of grape (*Vitis vinifera* L.) cv. Muscat Hamburg reported that berry development followed a double sigmoid growth curve with 3 phases; Phase-I from 0-30 days, phase-II from 30-59 days and phase-III from 59-101 days after full bloom respectively. They also reported that the TSS

content increased rapidly in phase-III, while titratable acidity increased slowly to the end of phase-II and then decreased sharply at the beginning of ripening.

Pareek and Randhawa (1967) conducted a detailed study on the effect of auxins,gibberellins and their combinations on the mode of growth quality and maturity of the berries in Pusa Seedless and Anab-e-Shahi grape varieties. They obtain the growth curve by plotting the average commulative fresh weight of berries against time and revealed that 50 ppm GA_3 and 10ppm IAA modified the growth curve considerably by initiating the rapid growth 20 days earlier than untreated berries in Anab-e-Shahi whereas the plant growth regulators did not modify the mode of growth in Pusa Seedless. They also reported that the length and breadth of berry increased rapidly in the initial stages and then steadily upto the end. Similarly the increase in number of berries per bunch were also reported. It was also noted that total titratable acidity increased rapidly in the initial stages reaching the maximum at the time sugaring had just started in the Pusa Seedless,whileas in the Anab-e-Shahi it started earlier than the sugaring stage.After reaching a maximum there was a parallel decline in acid content with increase in TSS and sugars.

Staudt *et al.* (1986) studied the phases of berry growth in *Vitis vinifera* and reported that fresh weight of the berry showed a double sigmoid curve and three transition points have been clearly defined. The central transition point, occuring around 42 days after anthesis, may be defined as the change over from the first to the second

growth phase.

Coombe and McCarthy (2000) studied dynamics of grape berry growth and physiology of ripening. The berries of cultivars Muscat, Gordo and Blanco showed typical double sigmoid volume/time curve. They reported that the rate of increase in solutes per berry was proportional to that of berry volume and the sugar and water increment after veraision were linked and depend on the same source.

Uzun *et al.* (1997) reported that acidity increased during the first week of berry growth, and then decreased subsequently. The other parameters viz., length, width, weight and TSS gradually increased from berry set to maturity in cultivars like Uslu, Atasarisi, Alphonse, Lavelee and Ergin.

2.2. Effect on yield and yield contributing factors :

2.2.1. Effect of girdling :

Weaver and Winkler (1957) reported that girdling alone or in combination with berry thinning and growth regulators produced heavy bunches in comparison to control. Similarly, Kondrya (1967) reported that ringing alone was helpful for increasing the cluster weight but Jindal and Bakshi (1970) found no synergistic effect of girdling + GA_3 or girdling + GA_3 + thinning treatments on increasing cluster weight. Bhujbal and Wavhal (1972) observed girdling at fruit set increased bunch weight. Girdling (4-5mm wide) at the shoot base before, during or 5 or 10 days after flowering increased the bunch

weight over the control in grape cv. Black corinth. (MananKov, 1982).

Jawanda and Vij (1973) reported increase in cluster length breadth and weight with GA_3 + ringing treatments in Thompson Seedless grapes. Bhujbal and Wavhal(1972) and Dhaliwal and Sidhu (1984) also reported increased bunch length and size by girdling at fruit set. Daulta (1982) observed increased bunch weight by cane girdling alone or in combination with GA_3 (40ppm) on Delight cv. of grapes. Similar results have been reported by Dhillon and Jawanda (1969). Dhillon and Bindra (1999) reported that bunch weight showed significant increase with girdling (360g) practised after fruit set alone and in combination with 40% berry thinning (353g) than control (330g).

Sharma *et al.* (1999) studied the effect of crop load,girdling and berry thinning and water berry developement in grapes and observed that the treatments had no effect on bunch length and breadth, but bunch weight ,berry length and berry breadth, percent acidity,TSS and yield per vine were significantly improved. Similar observations were reported by Weaver and William (1952), Sarowa and Bakshi (1972) and Singh and Chundawat (1978).

Kalil *et al.* (1999) found increase in the cluster weight as a result of girdling with or without GA_3 application in cv. Maria, whereas, Roicher *et al.* (1999) while studying the response of girdling in Seedless grape varieties found that girdling did not increase the size and weight of the grapes in cultivars Sultanina.

Sharma *et al.* (1999) while studying the effect of girdling reported

significant increase in berry length (1.65cm) and berry breadth (1.40cm) by girdling at veraison stage as compared to control (1.46 and 1.31cm) respectively.

Weaver and Williams (1952) reported that girdling was done when berries were almost of maximum size, had little effect or no effect on weight of berries. Whereas, Sharples *et al.* (1955) recorded increased weight per berry by early girdling on cardinal grapes. Similarly, Jensen *et al.* (1975) found that berry weight was significantly greater in girdled vines then ungirdled vines, with no difference from width of girdling. Winkler (1953) reported maximum increase in berry weight when complete girdling was done immediately after drop of impotent flowers than incomplete girdl-ed vines in Thomson Seedless cultivar of grapes whereas the results were reverse in Ribier grapes (Jensen *et al.*, 1976). Jensen (1981) reported that width of girdling 4-8mm increased berry weight significantly than knife line girdles.

Jawanda and Vij (1973) reported that ringing and ringing+GA_3 treatment increased the berry weight, however, the results were non-significant. Weaver and Winkler (1957) observed that the berry weight increased considerably by girdling treatments or girdling in combination with thinning and growth regulators . Peacock *et al.* (1977) recorded that girdling decreased berry weight in Red Malaga cultivar of grapes. On the other hand Sarooshi (1977) reported increased berry weight by girdling in combination with GA sprays and bunch thinning and trimming. Bhujbal and Wavhal (1972) reported that cane girdling at fruit set increased the berry weight. Similarly, while studying

the effect of ringing on fruit quality of Delight cultivar it was found that ringing alone and in combination with 40ppm GA_3 (full bloom dip) improved berry weight significantly over control (Daulta, 1982) whereas, Harrell and Williams (1987) recorded increased berry weight of Ruby Seedless vines by vine or cluster sprays of GA, girdling and a combination of these treatments when compared to control.

Cheema *et al.* (1997) reported highest berry weight (3.29g) for flower thinning followed by girdling and two dips of cluster in 40 ppm GA_3. Josan *et al.* (2001) recorded maximum berry weight of 2.77g by brushing and clipping of bunches after eight laterals + dipping of bunches in 40 ppm GA_3 and girdling of an trunk as compared to control (1.81g).

Dhillon and Bindra (1999) reported that there was no effect on shot berries percentage with girdling done either at fruit set or after 10 days. Non-significant differences were noted in percentage of shot berries with berry thinning and berry thinning + girdling treatment.

Larry *et al.* (2000)observed an increase in yield with girdling while as Cheema *et al.* (1997) observed the similar results in Perlette cultivar of grapes with flower thinning + girdling + GA_3 application. Dass and Randhawa (1967) obtained higher yield through combined use of GA and ringing after full bloom stage.

2.2.2. Effect of thinning :

Sarooshi (1977) obtained more compact bunches when the

clusters were thinned to fifteen bunches per vine with respect to twenty bunches per vine, whereas, Singh and Chauhan (1980) reported reduced number of berries per cluster by cluster apex pruning. Nangia and Bakshi (1971) reported increase in bunch weight by reducing the crop load by cluster thinning in Perlette grape. Similar observations have been reported by Singh and Chundawat (1980) in Beauty Seedless grapes.

Sanghavi and Phadnis (1973); Yadav and Pandey (1974) and Singh and Chundawat (1978) reported an increase in bunch weight by berry thinning in different cultivars of grapes. Yadav and Pandey (1974) also reported an increase in bunch weight by thinning in combination with GA at berry shatter stage in Pusa Seedless grapes. Whereas, Dhillon and Bindra (1999) reported that bunch weight was reduced non-significantly with 40% berry thinning alone than control but a significant increase in cluster weight was observed with girdling practised after fruit set in combination with 40% berry thinning as compared with the control. Similarly, Cheema *et al.* (1997) while studying the effect of various treatments on fruit quality of Perlette reported that cluster weight was not significantly effected by flower thining in combination with girdling.

Mor *et al.* (1986) reported an increase in bunch weight due to cluster + berry thining in cv. Beauty Seedless also reported increase in cluster length with thinning treatment which was significantly greater over control but Josan *et al.* (2001) reported the reduction in weight and size of bunch due to brushing of bunches and clipping them after

eight laterals in cultivar Perlette.It was also observed that there was an increase in berry size with brushing of bunches along with girdling or in combination with GA_3.

Nangia and Bakshi (1971) recorded large size of berries due to cluster or bunch thinning in cultivar Perlette. Similar results were reported by Sarowa and Bakshi (1972) in cultivar Perlette, Kondrya and Bukatar (1973) in Muscat of Hamburg,where as Singh and Chundawat (1980) found uniform berry size due to cluster pruning (berry thinning) in cultivar Beauty Seedless.

An increase in berry weight by apex prunning of flower clusters and thinning of clusters in different cultivars of grapes have been observed by Singh and Chundawat in 1980 whereas, Cheema *et al.* (1997) recorded highest berry weight of 3.29g by flower thinning followed by girdling and two dips of clusters in 40ppm GA_3. While studying the effect of thinning Mor *et al.* (1986) found an increase in berry weight due to cluster + berry thining treatment in cultivar Beauty Seedless, similarly, Dhillon and Bindra (1999) also reported an increase in berry weight with 40% berry thinning.

Singh and Chauhan (1980) found a reduction in the percentage of shot berries (8.4%) with berry thinning at post bloom (berry set) stage as compared with control (22.6%) in Beauty Seedless grapes. Dhillon and Bindra (1999) recorded significant decrease in shot berries percentage due to berry thinning. Similar results were obtained by Josan *et al.* (2001) due to brushing of bunches (flower thinning) and

clipping after eight laterals + dipping of bunches in 40ppm GA_3.

2.2.3. Effect of gibberellic acid :

Khan *et al.* (1970) applied GA_3 at different concentrations (10,25,50,75 and 100 ppm) at pre-bloom and again at full bloom by dipping bunches for two minutes to Sultania grapes and found a gradual increase in bunch size corresponding to the concentration used. Similarly, Nijjar and Kanwar (1970) confirmed that 50ppm GA_3 at full bloom, provided the highest bunch length while 25ppm GA_3 did show an increasing trend but was at par with control, in cultivar Perlette. Nangia and Bakshi (1971) applied GA_3 at 50, 100 and 200 ppm at prebloom, full bloom and berry set stages (dip method) in Perlette cultivar of grape and found that prebloom application were more effective in promoting bunch elongation than full-bloom and fruit set stage.

Nilnond and Sukumalanandana (1988) studied response of GA_3 (25, 50 and 75 ppm) to Sultania, Blacksultana, Beauty Seedless, Ruby Seedless, Delight and Italia grape varieties two weeks after full bloom and revealed that GA_3 at all concentrations improved cluster size resulting in high yields. Similarly, Pandita (1995) inferred that 40ppm GA_3 under single (full bloom) cum double sprays (full bloom + berry shatter stage) on Perlette grapes resulted in the most promising bunch size (22.3×13.6 cm) and (22.7×13.4 cm) respectively as compared to control (17.6×11.2cm). Bakshi (1998) reported maximum bunch length of 23.2cm due to 60ppm GA_3 and maximum bunch breadth of 13.7cm

due to 40 ppm GA_3 .

Patil *et al.* (1980) while studying the effect of GA on bunch, berry and juice quality in Perlette grapes reported that application of GA_3 at pin head stage gave significantly better length. The maximum bunch length (21.9cm) was recorded with GA_3 (30 ppm) applied at pin head stage. The width of the bunch was not affected significantly. They also noted that the maximum bunch weight (410g) was due to 45ppm GA_3 when applied at pin had stage as against control (268g).

A bunch weight of 335.0g was recorded in Delight cultivar of grape when treated with 40ppm GA_3 + ringing (Daulta,1982) whereas, Josan *et al.*(2001) found the converse results with 40ppm GA_3.Sharma *et al.* (1973) recorded a varied response of GA_3 (25, 50 and 75ppm) at full bloom on Perlette grapes. Lower concentration (25 and 50ppm) increased bunch weight significantly while as 75 ppm proved repressive. Highest bunch weight (262.5g) was due to 50ppm GA_3 and the lowest (170g) due to 75ppm as compared to control (20g). An appreciable increase in bunch weight was also reported by Dass *et al.* (1977) in Thomspon See-dless cultivar of grapes when sprayed with 60ppm GA_3 at fruit set stage. Similar observation was reported by Mansour *et al.* (1977) due to 40ppm GA_3 in cultivar Thompson Seedless.

Josan *et al.* (2001) reported a significant reduction in number of shot berries. The minimum percentage (8.40%) of shot berries were found due to brushing of bunches and clipping after eight lateral +

dipping of bunches in 40ppm GA_3 and girdling of main trunk as compared to control (30.63%). Sharma *et al.* (1973) reported that GA_3 (25-75ppm) application increase juice content in cultivars Perlette and Selection-7. While studying the effect of GA_3 on the bunch, berry and juice quality in Perlette grapes Patil *et al.* (1980) reported maximum juice percentage (81.6%) with 45ppm GA_3 when applied at pin head stage and least in control (75.9%).

Cheema *et al.* (1997) noted that fruit yield per vine was not significantly affected by GA_3 40 ppm alone or in combination with girdling or flower thinning or both in Perlette cultivar of grape.

2.3. Effect on chemical characteristics :

2.3.1. Effect of Girdling :

Dabas *et al.* (1980) studied the effect of girdling on berry set, berry drop,panicle drying and quality of Thompson Seedless grapes and observed that Total Soluble Solids (TSS) increased due to girdling. Maximum TSS of 23.46% was due to trunk girdling (done at 45cm above ground level) followed by 22.08% due to arm girdling as compared to control (19.58%). Similarly, Reddy and Prakash (1982) reported an increase in TSS in Gulabi grape cultivar due to girdling. TSS of 20.80% was found in vine which were double girdled (4.8mm wide + knife line) followed by 19.25% due to single girdle (4.8mm wide) as compared to control (19.15%) whileas Dhillon and Bindra (1999) while studying the effect of berry thinning and girdling on fruit quality in perlette grapes reported maximum TSS (17.8%) in vines

which were girdled after fruit set followed by vines which were girdled 10 days after fruit set (17.6%) as compared to control (14.4%).

Trunk girdling done at veraison stage 45cm above the ground on the main trunk of vine with 80 bunches per vine recorded TSS of 16.16% as compared to control (15.60%) in Perlette grapes (Sharma *et al.*, 1999). Josan *et al.* (2001) studied the effect of girdling on fruit quality of grape cultivar Perlette and found that girdling of main trunk alone does not effect TSS significantly but when girdling was practised along with brushing of bunches and clipping after eight laterals, TSS was significantly increased.

Harrell and Williams (1987) while studying the effect of girdling and GA_3 on Ruby Seedless and Thompson Seedless reported that girdling significantly reduced the soluble solids concentration in Thompson seedless vines at harvest as compared to control. Whereas Cheema *et al.* (1997) reported significant increase in TSS in cultivar Perlette due to flower thinning followed by single dip in 40 ppm GA_3 + girdling as compared to control.

Dhillon and Bindra (1999) studied the effect of thining and girdling on fruit quality in grapes cultivar Perlette and found 0.55% of acid content in berries under 40% berry thining + girdling treatment (after fruits set) and 0.74% under untreated ones which showed a significant reduction in acidity for improving the quality of grapes.

Dabas *et al.* (1980) while working on Thompson Seedless cultivar of grape reported that girdling significantly increased the reducing

sugars. The maximum reducing sugar (15.59%) was found in vines which were cane girdled followed by trunk girdled vines (15.17%) as compared to control (12.44%). Dhillon and Bindra (1999) also reported significant increase in reducing sugars (17.00%) due to berry thinning + girdling after fruit set as compared to control (11.8%) in cultivar Perlette. Whereas, Josan *et al.* (2001) reported a non-significant decrease (10.45%) in reducing sugar in cultivar Perlette due to trunk girdling after fruit set as compared to control (10.55%). Similar observation was recoded by Ezzahousani (2000) in Perlette and Italian cultivars.

2.3.2. Effect of thinning :

Sharples *et al.* (1955) reported that increased total soluble solids contents tended to be associated with lesser fruit loads i.e., 24-25 clusters per vine in cardinal grapes. Higher TSS have also been reported as a result of cluster thinning in grape cultivars Muscat of Hamburg (Kondrya, 1967), Black Corinth (Singh *et al.*, 1977) and Beauty Seedless (Singh and Chundawat, 1980). Cluster + berry thinning has also been observed to increase TSS in grapes (Dhillon and Singh, 1970; Kondrya and Bukatar, 1973), whereas Sarowa and Bakshi (1972) did not observe any effect of cluster thinning on TSS in Perlette grape.

Cluster thinning reduced the acid content of juice in cultivars Perlette (Sarowa and Bakshi, 1972), Muscat of Hamberg (Kondrya, 1975), Black Corinth (Singh *et al.* 1977) and Beauty Seedless (Singh

and Chundawat, 1980). However, total acidity was not reduced by cluster thinning in de-Chaunac grapes (Looney and Wood, 1977).

Myrianthousis (1966) reported increased TSS/acid ratio by berry thinning. Similar reports were found by Singh and Chauhan (1980).

Calo and Iamini (1973) reported increased reducing sugar content when flower clusters were thinned upto 60% in Merlot variety of grapes.

2.3.3. Effect of Gibberellic acid (GA_3) :

Dhillon (1969) investigated the effects of GA_3 at 50 and 75ppm at preanthesis, pre-anthesis + full bloom and full bloom stages in Anab-e-Shahi grapes and got an increase in total soluble solids with maximum increase due to 50 ppm GA at full bloom. The increase in the TSS was also reported in cultivar Anab-e-Shahi at the full bloom stage due to GA_3 at 25ppm and 50ppm (14.72% and 15.86% respectively) as compared to 12.90% in control (Nijjar and Bhatia, 1969).

Moti (1971) reported an increase in TSS in Perlette grapes with GA at 10,20 and 40 ppm, while as Sharma *et al.* (1975) deduced no significant increase or decrease in TSS due to 25 and 50 ppm GA_3 in Perlette cultivar of grapes at full bloom and fruit set stage respectively. Whereas, Daulta (1982) observed that 40 and 60 ppm GA_3 application at full bloom stage in Delight cultivar of grapes increased TSS significantly. Pandita (1995) while studying the effect of GA_3 (5,10, 20,40ppm) at full bloom, full bloom + berryshatter and berry shatter

stages in Perlette cultivar of grapes maintained that there was an increase in TSS irrespective of treatment combination.

According to Dhillon (1969), the acid content increased with application of 50, 75 & 100 ppm GA_3 at pre anthesis, preanthesis + full bloom and full bloom stages of panicle development in cultivar Anab-e-Shahi. Similarly, Nijjar and Bhatia (1969) found that with the application of GA_3 at 25,50,75 and 100ppm at full bloom in Anab-e-Shahi grapes the acid content increased as compared to the control. Whereas, Pandita (1995) reported non-significant alteration in tartaric acid content due to the influence of GA_3 (5,10,20 and 40ppm) at full bloom (single spray), full bloom + berry shatter (double spray) and berry shatter (single spray) in Perlette grapes.

Jawanda and Vij (1973) while studying the effects of different treatments *viz.*, GA_3 at 50ppm, ringing and ringing + 50 ppm GA_3 at pre-bloom and shatter stage in Thompson Seedless grapes found that pre bloom treatments provided higher reducing sugar. A significant increase in reducing sugar content was also observed in Perlette cultivar of grapes with application of 40ppm GA_3 at full bloom (single spray), full bloom + berry shatter (double spray) and berry shatter (single spray) stage (Pandita, 1995).

2.4. Effect on Post Harvest life :

As far as the effect of girdling,thinning and GA_3 on shelf life of grapes is concerned no work has been done on this aspect but only the effect of GA_3 on the shelf life was reported. Most of the workers

used polythene bags and subjected them to refrigeration storage techniques.

Medhi and Singh (1982) in a study on the effect of gibberellic acid on shelf life of Beauty Seedless grapes dipped the clusters at berry set in solutions of 20 to 60 ppm of GA_3 for 30 seconds. Grapes treated with GA_3 at 40 ppm stored best at 0°C for 48 days, 12 days longer than non treated grapes whileas,Surinder *et al.* (1990) dipped the bunches of Perlette grapes in aqueous solutions of GA_3 at 10,25 and 50 ppm. After harvest the bunches packed in perforated polythene bags (2 bunches/bag) and stored at room temperature having 40-50% RH. The grapes treated with GA_3 at 10 or 25 ppm were found marketable for upto 4 days as compared with only 2 days in control.

Langar (2001) sprayed GA_3 at 60 ppm 15 days after full bloom on Perlette cv. of grapes and found that the treatment had just increased the shelf life by 1 day at room temperature in comparison to control (3 days).

Rao (1973) studied the changes in the concentration of carbohydrate fractions during storage of Pusa Seedless grapes and reported that the amount of reducing sugar per berry continuously decreased during storage upto 7 days from 14.5% to 14.0% upto 3 days and from 14.5% to 13.6% till 7 days. These storage observations were recorded at room temperature (30-42°C).

Palaniswamy *et al.*(1966) while studying the storage quality with

Bhokri and Bangalore Blue cultivars of grapes reported a slight increase in TSS content during the early part of storage period but the rise was unaccompanied by any improvement in the quality.

Chapter - 3

Materials & Methods

CHAPTER-3

MATERIALS AND METHODS

3.1. Location :

The present investigation entitled "Effect of girdling, thinning and GA_3 on fruit growth, yield, quality and shelf life of grapes (*Vitis vinifera* L.) cv. Perlette" was carried out at Research orchard of the Division of Pomology and Post Harvest Technology, Udheywalla , Sher-e-Kashmir University of Agricultural Sciencies and Technology Jammu during 2001-2002. The vineyard is situated at an altitude of 300 meters above mean sea level having latitude 32.43° North and longitude 74.54° East. The soil of the orchard is sandy loam in texture with assured irrigation.

3.2. Plant Material :

The study was conducted on thirty six vines of uniform vigour and age, trained to head system and subjected to uniform cultural practices and Plant Protection measures. The experiment was laid out in Randomized Block Design (RBD), replicated three times by taking single vine as a unit.

3.3 Treatments:

The vines were subjected to the following twelve treatments :

TREATMENT SYMBOL	TREATMENT	TIME OF APPLICATION
G	Girdling of main trunk	One weak before bloom
T	Thinning by clipping	After fruit set following the shatter of impotent flowers
GA_3^*	GA_3(20ppm)	At fruit set
GA_3^{**}	GA_3 (40ppm)	At fruit set
G+T	Girdling of main trunk + thinning by clipping	
$G+GA_3^*$	Girdling of main trunk + dipping of bunches in 20 ppm GA_3	
$G+GA_3^{**}$	Girdling of main trunk + dipping of bunches in 40 ppm GA_3	
$T+GA_3^*$	Thinning of bunches by clipping + dipping of bunches in 20 ppm GA_3	
$T+GA_3^{**}$	Thinning of bunches by clipping + dipping of bunches in 40 ppm GA_3	
$G+T+GA_3^*$	Girdling of main trunk + thinning of bunches by clipping + dipping of bunches in 20 ppm GA_3	
$G+T+GA_3^{**}$	Girdling of main trunk + thinning of bunches by clipping + dipping of bunches in 40 ppm GA_3	
C	Control	

Total no. of treatments = 12

Replications = 3

Design = RBD

Unit Plot Size = One vine

3.4. Method and time of application of treatments :

3.4.1. Girdling:

Girdling of main trunk was done with the help of girdling knife (double bladded girdler) about 30-35cm above the ground level. The bark of the trunk was removed about 4mm in width. The blade of the knife was pressed into the bark and moved around the trunk to form two rings. The bark between the rings was removed with the help of knife by giving a longitudinal cut. Girdling was done one week before bloom on the main trunk.

3.4.2. Thinning :

Thinning was done with the help of thinning scissor to remove the over crowded berries by cutting the branches/pedicles of the bunches. It was done after fruit set following the shatter of impotent flowers.

3.4.3. Gibberellic acid(GA_3) :

After fruit set, the individual bunches were dipped in the GA_3 solution for 15 seconds.

3.5. Preparation of GA_3 Solution :

Solution of GA_3 (20 ppm and 40 ppm) was prepared just before use. A stock solution of 100 ppm was prepared by dissolving 100 mg of the GA_3 in a little quantity of 95% methyl alcohol and volume made to 1000 ml with distilled water. From this stock solution, the

Girdled trunk of grape vine
(*Vitis vinifera* L.) cv. Perlette
{Close-up view}

Girdled trunk of grape vine
(*Vitis vinifera* L.) cv. Perlette
after healing
{Close-up view}

desired strength and quantity of solution was prepared by diluting with distilled water.

3.6. Observations :

Three randomly selected clusters were tagged and taken as an ultimate experimental unit for recording observations.

3.6.1. Growth and development pattern of berry:

The observation on growth and development of berry were recorded from 17 days after fruit set (DAFS) at weekly intervals till harvest of the fruit. For recording the observations twenty randomly selected berries were taken from all the bunches other than the selected bunches at weekly intervals and the mean value for length, breadth, weight, volume,total soluble solids and acidity of berry were calculated.

The fruit was picked at full maturity for recording the observations with respect to following parameters.

3.6.2. Yield and Yield contributing factors:

3.6.2.1. Bunch Size :

Three bunches from each replication were randomly selected and the average length and breadth of the bunches was recorded in centimeters. The length of the bunch was measured from apex to base and the breadth was measured at the point of maximum spread.

3.6.2.2. Bunch Weight :

The bunch weight in grams was determined by taking mean weight

of the selected bunches from each replication.Sixty berries from each replication (twenty berries per cluster) were taken for recording the following observations :—

3.6.2.3. Berry size :

Berry length and breadth was measured with the help of vernier calliper and the average size expressed in centimeters.

3.6.2.4. Berry weight :

The weight of selected berries was determined and average weight was expressed in grams.

3.6.2.5. Berry volume :

It was determined by water displacement method. Sixty berries from each replication were used to determine average volume of berries in cubic centimeters (cc). For recording the growth pattern ten berries were selected randomly at weekly interval for determining the berry volume.

3.6.2.6. Juice percentage :

Berries were weighed and then crushed in mixer-cum-grinder and juice extracted through muslin cloth. Juice was measured and expressed in percentage.

3.6.2.7. Yield :

The yield per vine was recorded in kilograms.

3.6.2.8. Percentage of shot berries :

The count of normal and shot berries per bunch was taken separately (the berries of the size of black pepper or smaller were considered as shot berries). The sum of the normal berries and shot berries gave the total number of berries per bunch. The percentage of shot berries was calculated, according to the procedure suggested by Nangia and Bakshi (1971) and Dhillon and Sharma (1973).

$$\text{Percentage of shot berries} = \frac{\text{Number of shot berries per bunch}}{\text{Total number of berries per buch}} \times 100$$

3.6.3. Chemical Characteristics :

3.6.3.1. Total Soluble Solids (TSS) :

Total Soluble Solids (TSS) were determined using a hand refractometer and readings were expressed as °Brix (percent) at 20°C using reference table.

3.6.3.2. Titratable acidity :

Acidity was determined by titrating a known quantity of sample (10ml juice) against standard solution of sodium hydroxide (0.1N) to a faint pink colour using phenolphthalein as an indicator. The results were expressed as tartaric acid percent (Ranganna, 1986).

3.6.3.3. TSS/acid ratio :

TSS/acid ratio was calculated by dividing TSS values with acid values.

3.6.3.4. Sugars :

Lane and Eynon (1923) method as detailed by Ranganna (1986) was followed. Results were expressed as dextrose percent. Weighed sample (25g) of fruit was throughly homogenised with distilled water in a warring blender and was taken in 250 ml volumetric flask to which 100ml distilled water was added and neutralized before clarification with 2ml led acetate (45%). Excess of lead was removed with 2.5 ml of Potassium oxalate (22%). The volume was made to 250ml and filtred. The filtrate was used to titrate 10ml of standardized Fehling's solutions (A and B) using methylene blue as indicator to a brick red precipitate for determining reducing sugars.

A measured aliquote (50ml) of the above filtrate was taken in a 250ml volumetric flask and was then hydrolized by adding 10ml of 5% HCl (1+1), kept overnight for 24hours at room temperature followed by neutralization with alkali using phenolphthalein as indicator. The volume was made to 250ml and titrated against Fehling's solution as above.

Non-reducing sugars were calcualted by multiplying the difference of total and reducing sugars with a factor of 0.95. Fehling's solution was standardized against dextrose (AR) solution of known concentration.

3.6.4. Post Harvest Studies :

The harvested fruit was kept in cardboard boxes lined with newspapers and kept at room temperature on the shelves. The

observations were taken at three days interval till fruit remained in good condition.

3.6.4.1. Physiological loss in weight (PLW) :

The initial weight and the final weight of bunches were recorded at an interval of three days till more than fifty percent of the bunches were unmarketable and the loss was calculated by the formula suggested by Srivastava and Tandon (1968), as

$$\text{Percent loss in weight} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

3.7. Statistical Analysis :

The data obtained was analysed statistically for interpretation of results (Panse and Sukhatme, 1985) using analysis of variance.

—:—

CHAPTER-4

Experimental Results

CHAPTER-4

EXPERIMENTAL RESULTS

The present investigation was conducted to study the effect of girdling, thinning and GA_3 on fruit growth and develop-ment pattern, yield, quality and shelf life of Perlette cultivar of grapes during the year 2002 in the research orchard of the Division of Pomology and Post Harvest Technology, Udheywalla, SKUAST Jammu. The treatment effect was recorded in three stages. In stage-I the growth and developement pattern of the berry was observed, in stage-II yield and quality parameters of the grapes were recorded and in stage-III, the grapes were stored at room temperature for assessing the shelf life and quality parameters. The results obtained are as under :-

4.1. GROWTH AND DEVELOPEMENT PATTERN OF BERRY :

4.1.1. Berry length :

Effect of various treatments on periodic changes in berry length with respect to control was studied from 17 days after fruit set (DAFS)

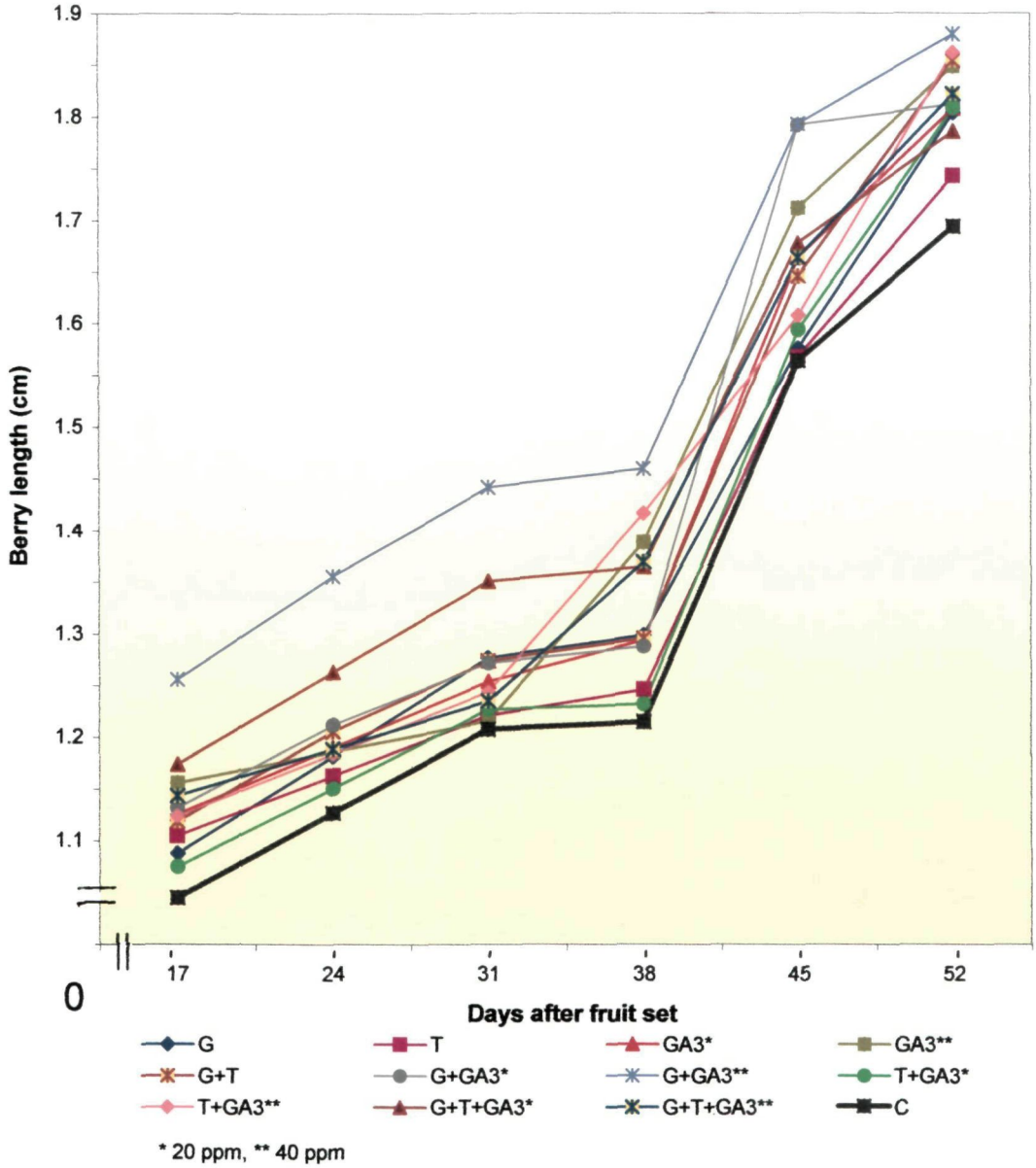


Figure 1. **Effect 0f girdling (G), thinning (T) and gibberellic acid (GA_3) on the length of berry in grapes cv.Perlette**

to harvest as shown in Fig-1 and Appendix-I.

In all the treatments it was observed that there was a slow increase in berry length from 17 DAFS upto 31 DAFS. The growth phase between 31 DAFS and 38 DAFS recorded a slow growth for most of the treatments including control where the increase in berry length was only 0.57 percent where as in treatments like girdling + thinning + 40ppm GA_3, thinning + 40ppm GA_3 and in 40ppm GA_3 recorded an increase in length as 10.93 percent, 13.90 percent and 14.14 percent respectively.

After 38 days of fruit set the increase in length was linear upto 45 DAFS in all the treatments except in case of thinning + 40ppm GA_3 where the linear increase was right from 31 DAFS till harvest. This period between 38 DAFS and 45 DAFS was recognized as linear growth period for berry length for all the treatments, however, the increase in berry length was less i.e. 22.80 percent in girdling + 40ppm GA_3 treatment as compared to girdling + 20 ppm GA_3 where a maximum increase i.e. 39.13 percent was recorded as compared to control (28.72%). The growth of berry length from 45 DAFS till harvest was again slow as compared with the earlier growth period. However, most of the treatments recognized a good amount of growth during this period except girdling + 20ppm GA_3 where the increase in berry length was very less i.e. 1.11 percent whereas, thinning + 40ppm GA_3 treatments recorded highest growth of 15.80 percent followed by girdling alone i.e, 14.46 percent when compared with the control (8.31%).

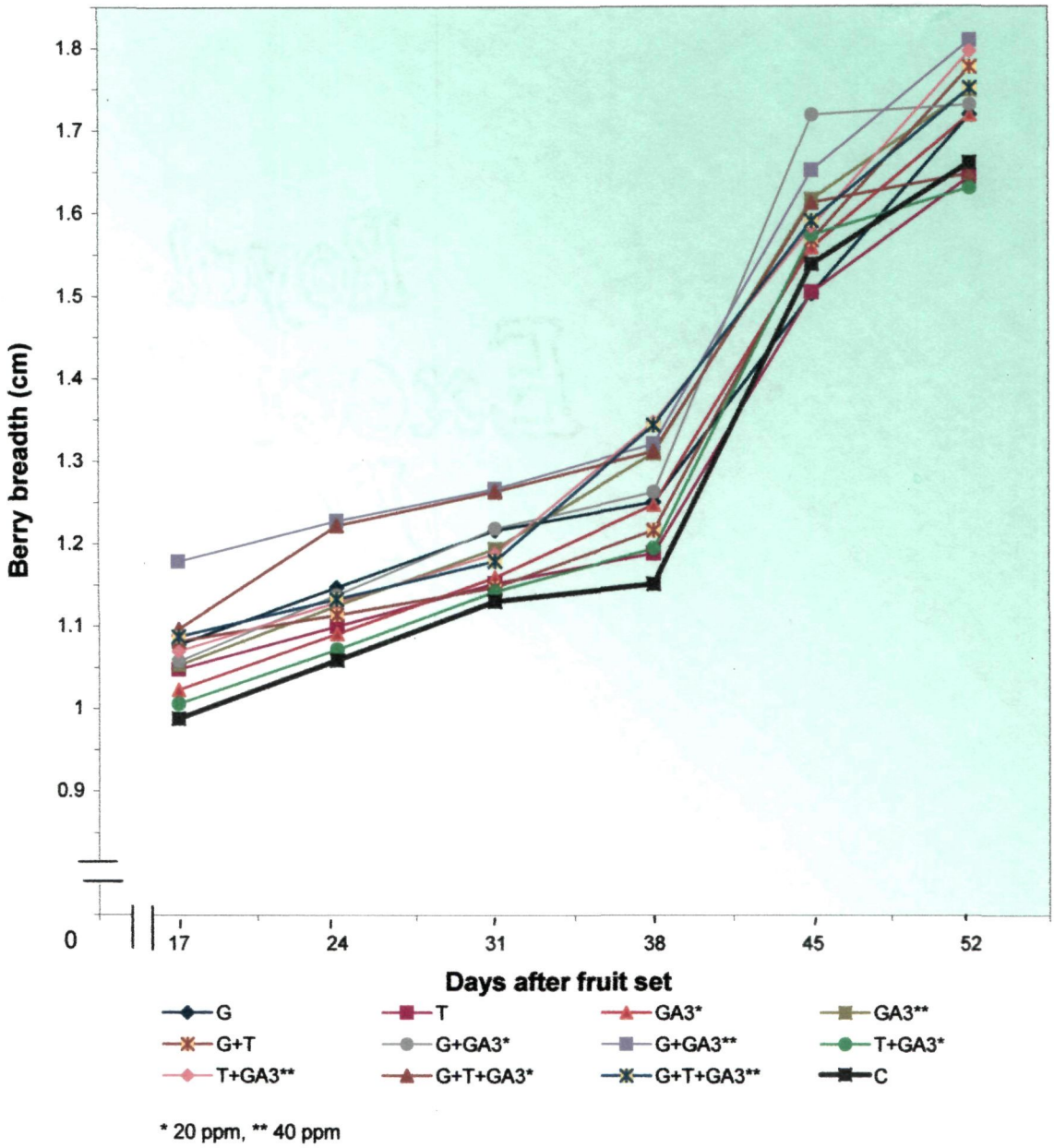


Figure 2. **Effect of girdling (G),thinning (T) and gibberellic acid (GA_3) on the breadth of berry in grapes cv.Perlette**

4.1.2. Berry breadth :

As is evident form Fig-2 and Appendix-II the increase in berry breadth was linear upto 31 DAFS almost in all the treatments except girdling + thinning + 20 ppm GA_3 where the initial increase in berry breadth from 17 DAFS to 24 DAFS was followed by a slow growth period upto 38 DAFS. During this phase i.e, between 31 DAFS and 38 DAFS the increase in breadth in treatments 40 ppm GA_3, thinning + 40 ppm GA_3, girdling + thinning + 40ppm GA_3 was 9.63%, 13.30% and 5.90% respectively as compared to control (1.85%). 20ppm GA_3 showed a linear increase in berry breadth right from 17 DAFS to 38 DAFS. However, at 45 DAFS maximum berry breadth of 1.71 cm was recorded in girdling + 20 ppm GA_3 and a minimum of 1.50cm in girdling alone when compared with control (1.53cm). After this period the berry breadth increased till harvest but at a slower rate showing a minimum increase of 2.96 percent under Thinning + 40ppm GA_3 as compared to the control (13.78%).

4.1.3. Berry weight :

The observations pertaining to berry weight in Fig-3 and Appendix-III reveals that initially, the weight increased slowly upto 24 DAFS then maintained steady state upto 31 DAFS and afterwards again resume the growth. After 38 days of fruit set a marked increase in berry weight was recorded in all the treatments. Maximum increase in berry weight between 38 DAFS and 45 DAFS was recorded under girdling + 20ppm GA_3 (103.5%) followed by thinning + 20ppm GA_3

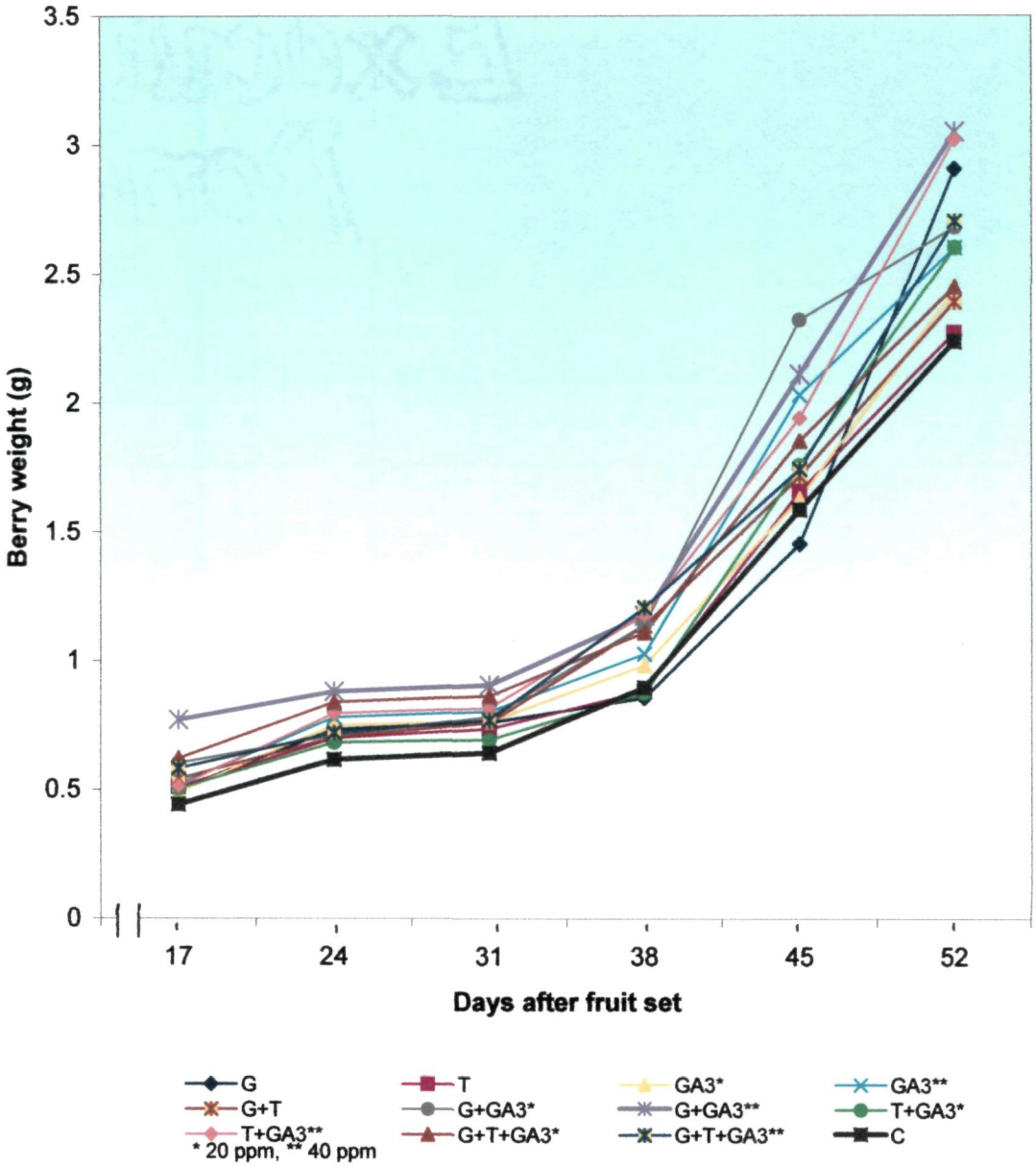


Figure 3. **Effect of girdling (G),thinning (T) and gibberellic acid (GA_3) on the weight of berry in grapes cv.Perlette**

(101.1%) and the least increase under girdling + thinning + 40ppm GA_3 (44.52%) when compared with control (76.99%). The berry weight continued to increase linearly till harvest (i.e. 52 DAFS) and at the time of harvest maximum berry weight (3.05g) was recorded in girdling + 40 ppm GA_3 followed by 3.02g in thinning + 40 ppm GA_3 treatment as compared to control (2.23g).

4.1.4. Berry Volume :

The data presented in Figure-4 and Appendix-IV depicts that initially, the berry volume increased upto 24 DAFS, then the rate of increase was very little upto 38 DAFS but after 38 days of fruit set the volume of berries continued to increase upto harvest. Maximum increase in berry volume (132.90%) between 38 DAFS and 45 DAFS was recorded in girdling + 20ppm GA_3 followed by an increase of 100.09% in girdling + 40ppm GA_3 as compared with control (76.20%). And this growth continued to increase in most of the treatments till harvest but at slower rate as compared to the earlier growth period. At the time of harvest maximum berry volume (2.73cc) was recorded in girdling + 40ppm GA_3 followed by 2.60cc in girdling + 20ppm GA_3 as compared to control (2.06cc).

4.1.5. Total soluble solids (TSS) :

From the figure-5 and appendix-V it is clearly visible that all the treatments showed increasing trend in TSS right from 17 DAFS to 38 DAFS. On 38th day after fruit set maximum TSS (8.0%) was recorded in girdling + thinning + 20ppm GA_3 and minimum (5.0%) in girdling

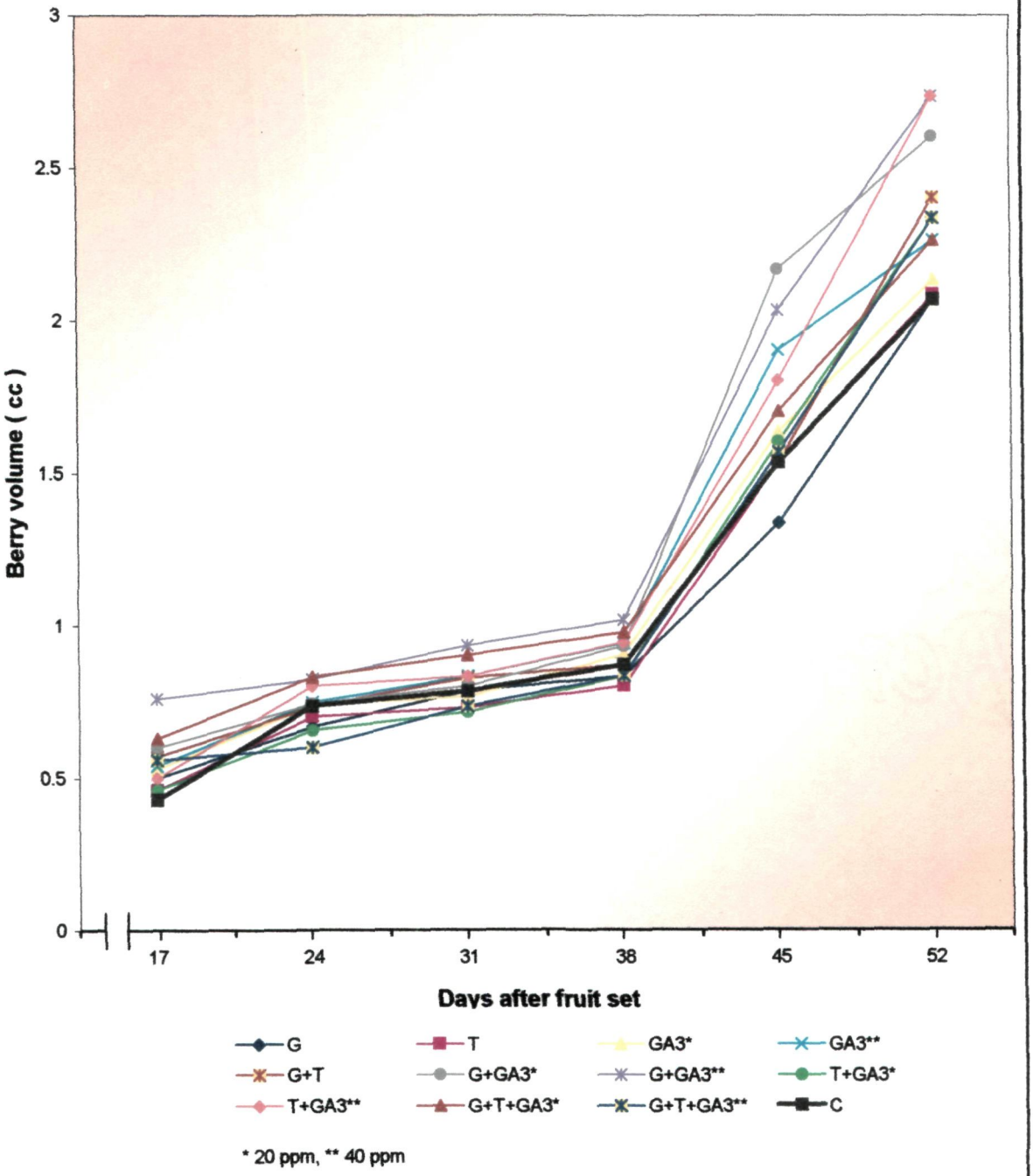


Figure 4. **Effect of girdling (G),thinning (T) and gibberellic acid (GA_3) on the volume of berry in grapes cv.Perlette**

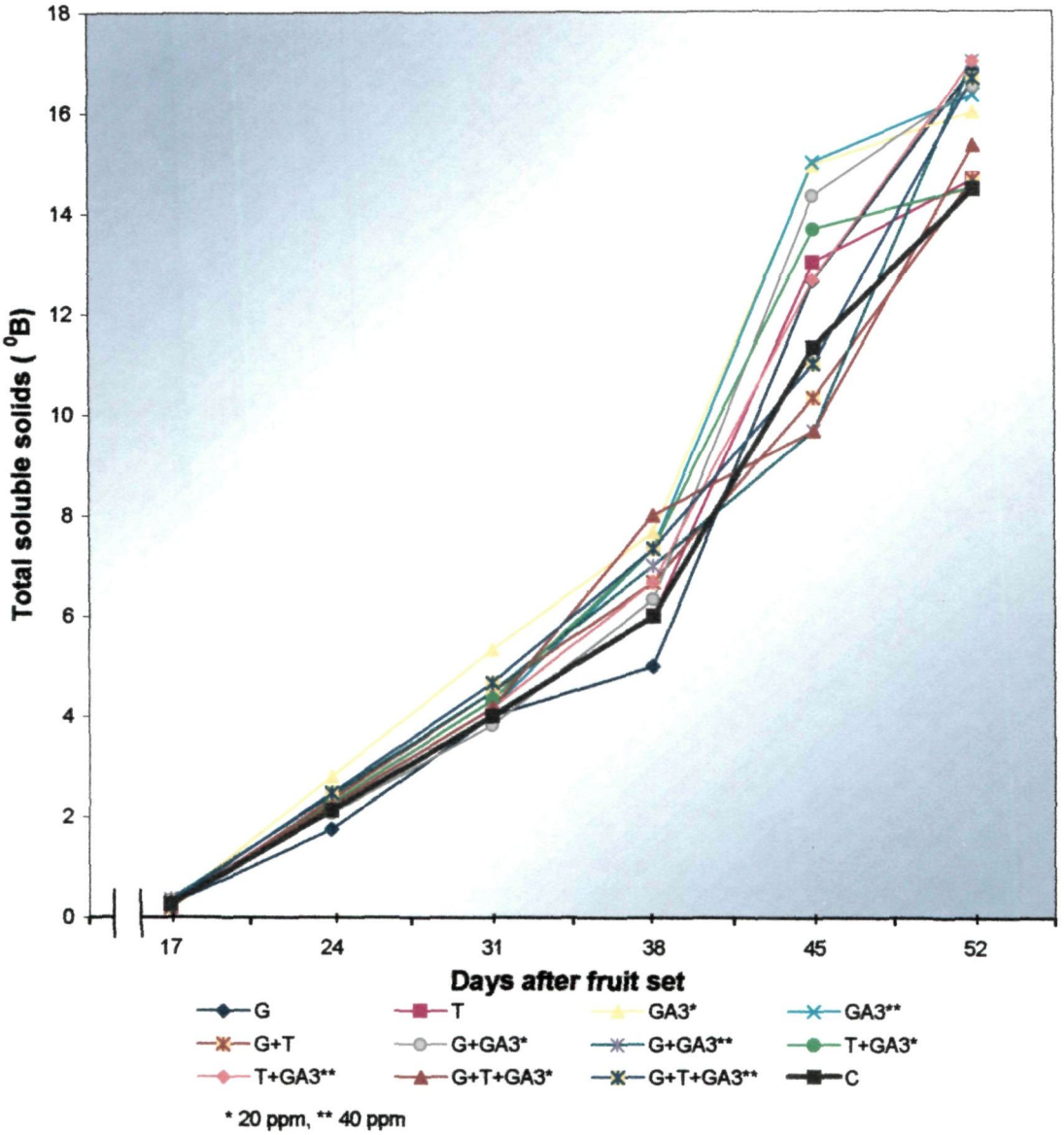


Figure 5. **Effect of girdling (G),thinning (T) and gibberellic acid (GA_3) on the total soluble solids of berry in grapes cv.Perlette**

alone. However, after 38 days of fruit set a linear increase in TSS was recorded almost in all the treatments upto 45 DAFS and between 38 to 45 DAFS a maximum increase in total soluble solids (153.0%) was recorded under girdling alone and a minimum (20.82%) under girdling + thinning + 20ppm GA_3 as compared to control (88.83%). On 45 days after fruit set maximum TSS of 15.00% was recorded in 40 ppm GA_3 followed by 14.93% in 20 ppm GA_3, 14.33% in girdling + 20ppm GA_3 as compared with the control (11.33%). Whereas minimum TSS of 9.66% was recorded under girdling + thinning + 20ppm GA_3. After 45DAFS till harvest same treatments showed an overall improvement as far as the total soluble solids are concerned and at harvest (i.e. 52 DAFS), the maximum TSS content (17.00%) was recorded in girdling + 40ppm GA_3 and also in thinning + 40 ppm GA_3 and minimum in the control (14.47%).

4.1.6. Titratable acidity :

The curves for acidity clearly showed that the total acidity increased rapidly upto 31 DAFS in all the treatments (Fig-6 and Appendix-VI). On 31 days after fruit set, maximum acid content of 3.875% was recorded in girdling + thinning + 40ppm GA_3 treatment followed by 3.642% in two treatments i.e, girdling + 40ppm GA_3 and thinning + 20ppm GA_3 and a minimum of 2.506% in 20ppm GA_3. The percent acidity dropped sharply upto 45 DAFS in all the treatments as is evident by the peak attained (Fig-6) and then become almost stablized with a little change. And at the time of harvest i.e, 52 DAFS the lowest acid content of 0.689% was recorded in girdling + 40ppm

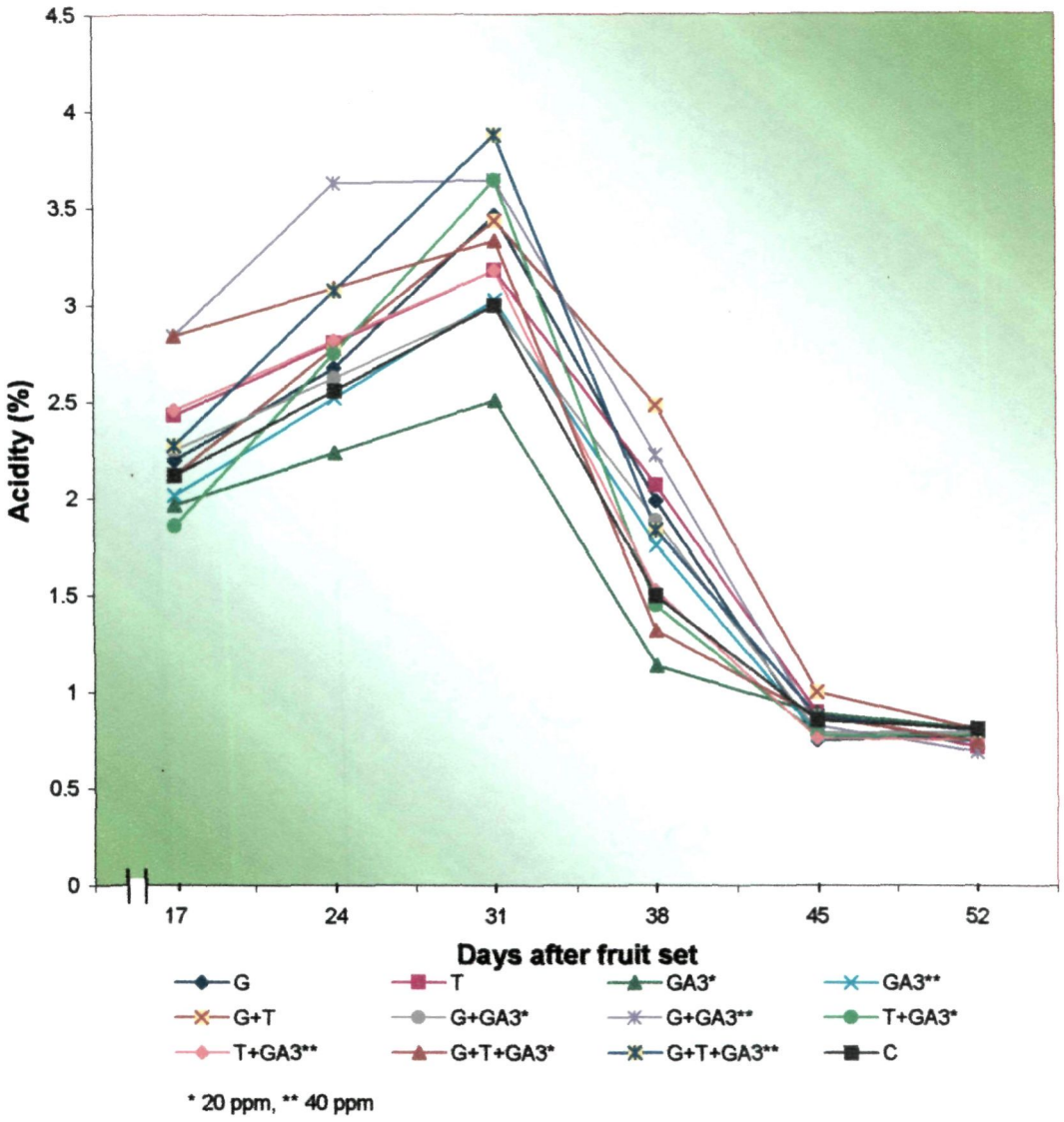


Figure 6. **Effect of girdling (G),thinning (T) and gibberellic acid (GA_3) on the titratable acidity of berry in grapes cv.Perlette**

GA_3 treatment and highest acid content of 0.808% in 20 ppm GA_3 and in girdling + thinning + 40ppm GA_3 when compared with the control (0.808%).

4.2. YIELD AND YIELD CONTRIBUTING FACTORS :

4.2.1. Bunch Length :

A perusal of the data in Table-1 indicates that most of the treatments produced longer bunches as compared to control. However, maximum bunch length of 16.85 cm was obtained with girdling + 40ppm GA_3 followed by 16.33 cm in 40 ppm GA_3 and all the treatments are statistically significant over control (13.83 cm).

The minimum bunch length of 11.41 cm and 13.18 cm was recorded in treatments trunk girdling + thinning and thinning respectively and were almost at par with the control (13.83 cm). The maximum increase in bunch length was to the tune of 21.83% in girdling + 40 ppm GA_3.

4.2.2. Bunch breadth :

The data in Table-1 revealed that most of the treatments imparted significantly higher bunch breadth over control. The maximum value of 14.33cm was recorded in trunk girdling + 40 ppm GA_3 which was followed by 13.11cm in 40 ppm GA_3, 12.98cm in 20ppm GA_3, 12.61cm in girdling, 12.33cm in thinning, 12.11cm in girdling + 20ppm GA_3, 10.65cm in girdling + thinning + 40ppm GA_3, 10.34cm in thinning + 40ppm GA_3 and 10.21cm in thinning + 20ppm GA_3.

Table 1. Effect of girdling, thinning and gibberellic acid on the bunch characters of grapes (*Vitis vinifera* L.) cv. Perlette.

Treatment	Size of bunch (cm)				Weight of bunch (g)	Percent increase over control
	Length	Percent increase over control	Breadth	Percent increase over control		
G	15·77	14.02	12·61	36·32	473·20	61·86
T	13·18	–4·69	12·33	33·29	404·49	38·36
GA_3*	14·75	6·65	12·98	40·32	384·04	31·36
GA_3**	16·33	18·07	13·11	41·72	392·65	34·31
G+T	11·41	–17·49	9·35	1·08	292·09	–0·08
G+GA_3*	14·25	3·03	12·11	30·91	393·91	34·74
G+GA_3**	16·85	21·83	14·33	54·91	495·73	69·57
T+GA_3*	16·11	16·48	10·21	10·37	380·61	30·19
T+GA_3**	15·58	12·65	10·34	11·78	370·06	265·8
G+T+GA_3*	15·70	13·52	10·65	15·13	455·70	55·88
G+T+GA_3**	15·50	12·07	9·56	3·35	405·72	38·78
Control	13·83	—	9·25	—	292·34	
S.Em(±)	**0·50**		**0·13**		**14·33**	
C.D(0·05)	**1·47**		**0·37**		**42·04**	

G= Trunk girdling, T=Thinning by clipping, *=20ppm, **=40ppm

However the treatments having values of 9.35cm in girdling + thinning and 9.56cm in girdling + thinning + 40ppm GA_3 were at par. The bunch breadth increased to a maximum tune of 54.91% in girdling + 40ppm GA_3.

4.2.3. Bunch Weight:

It is clear from the data (Table-1) that the bunch weight in all the treatments increased significantly as compared to control with highest significant increase in bunch weight (495.73g) recorded under trunk girdling + 40 ppm GA_3 followed by trunk girdling (473.20g) as compared to the control (292.34g). The other treatments like girdling + thinning + 20ppm GA_3, girdling + thinning + 40ppm GA_3 and thinning also recorded significantly superior bunch weight of 455.70g, 405.72g and 404.49g respectively. The bunch weight increase maximum to a tune of 69.57% in girdling + 40ppm GA_3.

4.2.4. Berry Length :

Increase in berry length was observed with different treatments over control and a significant variation in fruit length was observed among different treatments (Table-2). The smallest berry was produced in control (1.69cm) which was followed by 1.74cm in thinning, 1.78cm in girdling + thinning + 20ppm GA_3, 1.80cm in girdling, 1.80cm in thinning + 20ppm GA_3, 1.80cm in 20ppm GA_3, 1.81cm in girdling + 20ppm GA_3, 1.82cm in girdling + thinning + 40ppm GA_3, 1.84cm in 40ppm GA_3, 1.85cm in girdling + thinning, 1.86cm in thinning + 40ppm GA_3 and largest berry length of 1.88cm in girdling + 40ppm GA_3 and

all the above indicated values proved to be significantly higher as far as berry length is concerned. However, the treatments having values of 1.78cm in girdling + thinning + 20ppm GA_3 and 1.74cm in thinning were statistically at par with control (1.69cm). The increase in berry length was obtained to the maximum of 11.24% in girdling + 40ppm GA_3.

4.2.5. Berry breadth :

Table-2 indicates that berry breadth in most of the treatments increased significantly. Maximum berry breadth of 1.80 cm was recorded in those vines which received girdling + 40 ppm GA_3 treatment followed by 1.79cm in thinning + 40ppm GA_3 and 1.77cm in girdling + thinning treatments however, there was no significant difference in 40 ppm GA_3 (1.74cm), trunk girdling + thinning (1.77cm), trunk girdling + 20 ppm GA_3 (1.73cm), thinning + 40ppm GA_3 (1.79cm) and trunk girdling + thinning + 40 ppm GA_3 (1.75cm) treatments as compared to control having berry breadth of only 1.66cm. The percent increase in berry breadth was also observed to a maximum of 8.43% in girdling + 40ppm GA_3 over control.

4.2.6. Berry weight :

The data related to berry weight showed a significant increase in berry weight with trunk girdling, trunk girdling + 20ppm GA_3, trunk girdling + 40 ppm GA_3, thinning + 40 ppm GA_3 treatments. (Table-2).

Table 2. Effect of girdling, thinning and gibberellic acid on the berry characters of grapes (*Vitis vinifera* L.) cv. Perlette.

Treatment	Size of berry (cm)				Weight of berry (g)	Percent increase over control	Volume of berry (cc)	Percent increase over control
	Length	Percent increase over control	Breadth	Percent increase over control				
G	1·80	6·50	1·71	3·01	2·90	30·00	2·06	0
T	1·74	2·95	1·64	−1·20	2·27	1·79	2·08	0·97
GA_3*	1·80	6·50	1·71	3·01	2·43	8·96	2·13	3·39
GA_3**	1·84	8·87	1·74	4·81	2·60	16·59	2·26	9·70
G+T	1·85	9·46	1·77	6·62	2·39	7·17	2·40	16·50
G+GA_3*	1·81	7·10	1·73	4·21	2·68	20·17	2·60	26·21
G+GA_3**	1·88	11·24	1·80	8·43	3·05	36·77	2·73	32·52
T+GA_3*	1·80	6·50	1·63	−1·80	2·60	16·59	2·33	13·10
T+GA_3**	1·86	10·05	1·79	7·83	3·02	35·42	2·73	32·52
G+T+GA_3*	1·78	5·32	1·64	−1·20	2·45	9·86	2·26	9·70
G+T+GA_3**	1·82	7·69	1·75	5·42	2·70	21·07	2·33	13·10
Control	1·69	—	1·66	—	2·23	—	2·06	—
S.Em(±)	**0·02**		**0·02**		**0·15**		**0·16**	
C.D(0·05)	**0·08**		**0·07**		**0·45**		**0·47**	

G= Trunk girdling, T=Thinning by clipping, *=20ppm, **=40ppm clipping.

Maximum berry weight of 3.05g was noted under girdling + 40ppm GA_3, closely followed by berry weight of 3.02g under thinning + 40 ppm GA_3. These being at par with other treatment like 40 ppm GA_3 (2.60g), girdling + 20 ppm GA_3 (2.68g), thinning + 20 ppm GA_3 (2.60g) and girdling + thinning + 40 ppm GA_3 (2.70g) compared to control with berry weight of 2.23g.

4.2.7. Berry Volume :

It is obvious from Table-2 that all treatments except girdling recorded higher value for berry volume than the control, however, significant increase was recorded only in the girdling + 20ppm GA_3, girdling + 40ppm GA_3 and thinning + 40ppm GA_3 treatments.

Girdling + 40ppm GA_3 and thinning + 40ppm GA_3, recorded the highest value of volume i.e. 2.73cc followed by 2.60cc in girdling + 20ppm GA_3 and the lowest value of berry volume was recorded as 2.06cc in control. The maximum increase in volume was observed to be 32.52% in girdling + 40ppm GA_3.

4.2.8. Juice percentage :

A perusal of data shows that juice percentage was not significantly influenced by any of the treatments. (Table-3). However, maximum juice percentage of 55.41% and minimum percentage of 52.13% was recorded under girdling and girdling + 20ppm GA3 treatments respectively as compared to control (53.10%).

Table 3. Effect of girdling, thinning and gibberellic acid on juice percent, shot berries percent, yield and percent increase in yield of grapes (*Vitis vinifera* L.) cv. Perlette.

Treatment	Juice (%)	Shot berries per bunch (%)	Yield (kg/vine)	Percent increase in yield over control
G	55·41	13·03	8·55	60·71
T	52·87	12·26	7·30	37·21
GA_3*	51·73	12·33	6·80	27·81
GA_3**	52·52	12·13	7·25	36·27
G+T	53·68	10·90	6·32	18·79
G+GA_3*	52·13	12·89	7·17	34·77
G+GA_3**	54·77	11·27	8·87	66·72
T+GA_3*	53·90	12·61	6·80	27·81
T+GA_3**	54·46	12·19	6·66	25·18
G+T+GA_3*	54·89	10·80	8·26	55·26
G+T+GA_3**	52·71	10·08	7·29	37·03
Control	53·10	13·45	5·32	—
S.Em(±)		**0·02**	**0·08**	—
C.D(0·05)	**NS**	**0·06**	**0·23**	—

G= Trunk girdling, T=Thinning by clipping, *=20ppm, **=40ppm clipping.

4.2.9. Shot berries :

As is evident from the observations recorded in Table-3, all the treatments registered a significant reduction in percent shot berries formation and the lowest percentage of 10.08 shot berries formation was recorded in trunk girdling + thinning + 40ppm GA_3 and the highest percentage of 13.03 was recorded in girdling as compared to control (13.45%).

4.2.10. Yield :

A perusal of the data in Table-3 indicates that all the treatments resulted in the significant increase in average yield over control.

Maximum average yield per vine (8.87kg) was recorded under trunk girdling + 40 ppm GA_3 followed by 8.55 kg per vine under girdling alone as compared to control (5.32kg/vine). Treatment girdling + 40ppm GA_3 proved most effective in increasing overall yield per vine. The percentage increase in yield in girdling + 40ppm GA_3 treatment over control was 66.72% followed by 60.71% with girdling treatment and 55.26% with girdling + thinning + 20ppm GA_3. The lowest percent increase in yield was recorded due to girdling + thinning treatment (18.79%).

4.3. CHEMICAL CHARACTERISTICS:

4.3.1. Total soluble solids (TSS) :

A remarkable effect of girdling, thinning and gibberellic acid was

observed in all the treatments except in thinning, girdling + thinning and in thinning + 20ppm GA_3 as is evident from the significant increase in TSS of the berries over the control (Table-4)

Control recorded the lowest TSS value of14.47% followed by 14.50% in thinning + 20ppm GA_3, 14.66% in thinning and 14.66% in girdling + thinning in assending order,however, the difference among these treatments were non-singnificant. Similarly, no significant difference in TSS was recorded amongst 20ppm GA_3 and 40ppm GA_3, and girdling + 20ppm GA_3 and girdling + 40ppm GA_3. Amongst the different treatments maximum TSS of 17.00% was recorded in girdling +40ppm GA_3 and also in thinning + 40ppm GA_3 followed by 16.83% in girdling , 16.66% in girdling + thinning + 40ppm GA_3 and 16.00% in 20ppm GA_3. The TSS increased to a maximum of 17.48% in girdling + 40ppm GA_3 over control.

4.3.2. Titratable acidity :

The data regarding acidity (Table-4) reveals a substantial decrease in acidity with all the treatments.

Significantly lowest acid content of 0.689% was recorded in girdling + 40ppm GA_3 treatment as compared to control (0.808%). Treatments like 20 ppm GA_3, girdling + thinning, girdling + 20 ppm GA_3 and thinning + 40 ppm GA_3 with acidity of 0.808%, 0.808%, 0.790%, and 0.751% respectively were statistically at par with each other over control (0.808%). The percent decrease in acidity content was to the tune of 15.00% in girdling + 40ppm GA_3 over control.

Table 4. Effect of girdling, thinning and gibberellic acid on total soluble solids (TSS), titratable acidity and TSS/acid ratio of grapes (*Vitis vinifera* L.) cv. Perlette

Treatment	TSS (%)	Percent increase over control	Acidity (%)	Percent decrease over control	TSS/acidity ratio	Percent increase over control
G	16·83	16·30	0·733	8·75	23·12	35·28
T	14·66	1·31	0·713	11·25	19·52	14·21
GA_3*	16·00	10·57	0·808	0·0	19·97	16·85
GA_3**	16·33	12·85	0·743	7·50	22·12	29·43
G+T	14·66	1·31	0·806	0·0	18·70	9·42
G+GA_3*	16·50	14·02	0·790	1·25	20·91	22·35
G+GA_3**	17·00	17·48	0·689	15·0	24·18	41·48
T+GA_3*	14·50	0·20	0·772	3·75	18·85	10·29
T+GA_3**	17·00	17·48	0·751	6·25	23·84	39·49
G+T+GA_3*	15·33	5·94	0·743	7·50	20·78	21·59
G+T+GA_3**	16·66	15·13	0·800	0·0	20·69	21·06
Control	14·47	—	0·808	—	17·09	—
S.Em(±)	**0·17**		**0·020**		**0·81**	
C.D(0·05)	**0·51**		**0·058**		**2·39**	

G = Trunk girdling, T = Thining by chipping, * = 20ppm, ** = 40 ppm

4.3.3. Total soluble solids/acid ratio :

The data on the proportion of TSS and acid ratio recorded in table-4 showed that it varied from a minimum of 17.09 in control to the maximum of 24.18 in girdling + 40ppm GA_3. All the treatments recorded higher values of TSS/acid ratio as compared to control however, this increase was significant in all the treatments except in girdling + thinning and girdling + 20ppm GA_3.

Maximum TSS/acid ratio of 24.18 was recorded in girdling + 40ppm GA_3 followed by thinning + 40ppm GA_3 and girdling alone with corresponding values of 23.84 and 23.12 respectively. TSS/ acid ratio increased to the tune of 41.48% in girdling + 40ppm GA_3 over control.

4.3.4. Total sugars :

Amongst the various treatments girdling + 40ppm GA_3 recorded maximum total sugar content of 15.04% followed by girdling + thinning + 40ppm GA_3, girdling + thinning + 20ppm GA_3, thinning + 40ppm GA_3, girdling alone, 40ppm GA_3 and girdling +20ppm GA_3 having values of 14.82%, 14.72%, 14.68%, 14.67% 14.63% and 14.60% in decending order respectively. However all the above treatments showed significant increase in percent total sugar over control.

Treatments having values of 14.02%, 14.03%, 14.19% and 14.30% in thinning, thinning + 20ppm GA_3, 20ppm GA_3 and girdling + thinning respectively stood statistically at par with control having values of 14.02%.

Table 5. Effect of girdling, thinning and gibberellic acid on total sugars, reducing sugars and non-reducing sugars of grapes (*Vitis vinifera* L.) cv. Perlette

Treatment	Total sugars (%)	Percent increase over control	Reducing sugars (%)	Percent increase over control	Non-redcing sugars (%)	Percent increase over control
G	14·67	4·63	12·20	2·86	2·03	–5·58
T	14·02	0·0	11·80	–0·50	2·21	2·79
GA_3*	14·19	1·21	12·08	1·85	2·11	–1·86
GA_3**	14·63	4·35	11·90	0·33	2·47	14·88
G+T	14·30	1·99	12·18	2·69	2·12	–1·39
G+GA_3*	14·60	4·13	11·90	0·33	2·70	25·58
G+GA_3**	15·04	7·27	13·00	9·61	2·72	26·51
T+GA_3*	14·03	0·07	11·86	0·0	2·16	0·46
T+GA_3**	14·68	4·70	12·33	3·96	2·35	9·30
G+T+GA_3*	14·72	4·99	12·80	7·92	2·25	4·65
G+T+GA_3**	14·82	5·70	11·78	–0·67	2·04	–5·11
Control	14·02	—	11·86	—	2·15	—
S.Em(±)	**0·11**		**0·10**			
C.D(0·05)	**0·33**		**0·30**		**NS**	

G = Trunk girdling, T= Thinning by clipping, * = 20ppm, ** = 40ppm

4.3.5. Reducing sugars :

The data presented in the Table-5 shows that percent reducing sugars were improved in all the treatments however, trunk girdling + 40ppm GA_3 recorded highest reducing sugar content of 13.00% which was closely followed by trunk girdling + thinning + 20ppm GA_3 having value of 12.80% and both being significantly superior over control (11.86%).

The treatment, girdling + thinning + 40ppm GA_3 recorded reducing sugar content of 11.78% which was minimum as compared to all other treatments but was at par with the control (11.86%). The reducing sugars were increased by 9.61% in girdling + 40ppm GA_3 over control.

4.3.6. Non-reducing sugars :

The observations pertaining to non-reducing sugars are tabulated in Table-5. A perusal of data reveals that none of the treatments effected non-reducing sugars significantly. Maximum non-reducing sugar content (2.72%) was recorded due to trunk girdling + 40 ppm GA_3 and minimum of 2.03% due to girdling alone. Berries in the control recorded a non reducing sugar contant of 2.15%.

4.4.POST HARVEST STUDIES:

4.4.1. Physiological loss in weight (PLW) :

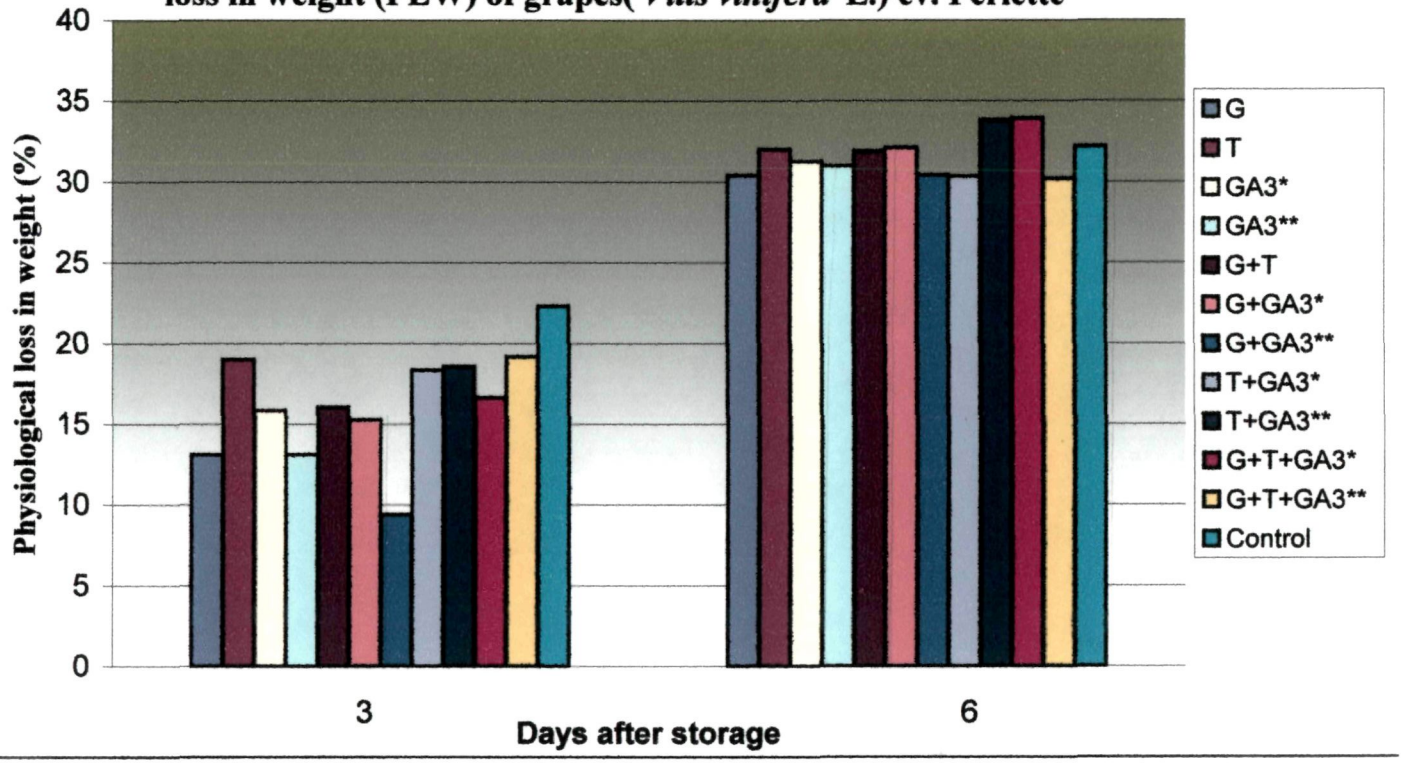
The data related to PLW during room temperature storage of grapes (*Vitis vinifera* L.) cv. Perlette is presented in Table 6.

Table 6. Effect of girdling, thinning and gibberellic acid on physiological loss in weight (PLW) of harvested grapes (*Vitis vinifera* L.) cv. Perlette at room temperature.

Treatment	Average weight (g) of bunches at harvest	PLW(%)	
		3-day	6-day
G	473·20	13·12	30·40
T	404·49	18·99	31·99
GA_3*	384·04	15·83	31·24
GA_3**	392·65	13·12	30·97
G+T	292·09	16·04	31·88
G+GA_3*	393·91	15·28	32·10
G+GA_3**	495·73	9·42	30·20
T+GA_3*	380·61	18·35	30·33
T+GA_3**	370·06	18·57	33·79
G+T+GA_3*	455·70	16·64	33·91
G+T+GA_3**	405·72	19·18	30·41
Control	292·34	22·31	32·18
S.Em(±)	**14.33**	**0·51**	
C.D(0·05)	**42.04**	**1·51**	**NS**

G= Trunk girdling, T=Thinning by clipping, *=20ppm, **=40ppm

Figure 7. **Effect of girdling, thinning and GA_3 on physiological loss in weight (PLW) of grapes(*Vitis vinifera* L.) cv. Perlette**



* 20 ppm , ** 40 ppm

A perusal of the data on third day of storage reveals that PLW was significantly less in all the treatments as compared to control . However, berries in trunk girdling + 40 ppm GA_3 treatment recorded a minimum loss of 9.42% followed by 13.12% in girdling and also in 40ppm GA_3. Maximum value of PLW (19.18%) was recorded in the treatment girdling + thinning + 40 ppm GA_3 compared to control (22.31%).

On sixth day of storage, the PLW ranged from 30.20 percent in treatment girdling + 40ppm GA_3 to 33.91 percent in girdling + thinning + 20ppm GA_3. The PLW losses in all the treatments including control were statistically at par on sixth day of storage. As berries on sixth day of storage had shattered and sunken, the biochemical aspects were analysed only upto third day of storage.

4.4.2. Total Soluble Solids (TSS) :

The data on changes in total soluble solid content of berr-ies was recorded at three days interval and the perusal of data on total soluble solids (TSS) content of fruits in table-7 reveals that there was a slight increase in TSS content of the berries during storage. Most of the treatments recorded significantly higher average values of TSS when compared with control which recorded lowest value of 14.69 percent. On third day of storage, highest TSS content of 17.47% was found in berries of those vines that had received girdling + 40ppm GA_3 treatment closely followed by thinning + 40ppm GA_3 (17.36%) and both were significantly superior to control (14.69%). The TSS content

Table 7. Effect of girdling, thinning and gibberellic acid on percent total soluble solids (TSS) of harvested grapes (*Vitis vinifera* L.) cv. Perlette at room temperature.

Treatment	TSS (%)			
	0-day	percent increase over control	3-day	Percent increase over control
G	16·83	16·30	17·33	17·97
T	14·66	1·31	15·00	2·11
GA_3*	16·00	10·57	16·34	11·23
GA_3**	16·33	12·85	16·99	15·65
G+T	14·66	1·31	15·06	2·51
G+GA_3*	16·50	14·02	16·70	13·68
G+GA_3**	17·00	17·48	17·47	18·92
T+GA_3*	14·50	0·20	14·77	0·54
T+GA_3**	17·00	17·48	17·36	18·17
G+T+GA_3*	15·33	5·94	15·46	5·24
G+T+GA_3**	16·66	15·13	17·03	15·92
Control	14·47	—	14·69	—
S.Em(±)	**0·17**		**0·25**	
C.D(0·05)	**0·51**		**0·74**	

G= Trunk girdling , T=Thinning by clipping , *=20ppm, **=40ppm

of rest of the treatments in order of preference was recorded as 17.33%, 17.03%, 16.99%, 16.70%, 16.34%, 15.46% and 15.00% for girdling, girdling + thinning + 40ppm GA_3, 40ppm GA_3, girdling + 20ppm GA_3, 20ppm GA_3, girdling + thinning + 20ppm GA_3 and in thinning respectively (Table-7). TSS increased maximum to a tune of 18.92% in girdling + 40ppm GA_3 on third day of room storage.

4.4.3. Titratable acidity :

The data pertaining to the percent titratable acidity is given in Table 8. Berries in all the treatments recorded a reduction in the acid content on third day of storage. A minimum acid content (0.610%) on third day was recorded in grapes from those vines which received trunk girdling + 40ppm GA_3 treatment followed by 0.692% in thinning + 40ppm GA_3 treated vines and both the treatments proved significantly superior over control (0.769%).

The maximum percentage of titratable acidity of 0.773 was recorded in the berries which had been treated with 20ppm GA_3 and stood at par with control (0.769%). The acidity decreased to a tune of 24.59% in girdling + 40ppm GA_3 on third day of room storage.

4.4.5. Total soluble solids/acid ratio :

In all the treatments TSS/acid ratio increased during storage at room temperature and on thrid day of shelf-life the highest TSS/acid ratio of 24.38 was recorded in berries of those vines treated with girdling + 40ppm GA_3 closely followed by thinning + 40ppm GA_3

Table 8. Effect of girdling, thinning and gibberellic acid on percent titratable acidity of harvested grapes (*Vitis vinifera* L.) cv. Perlette at room temperature.

Treatment	Acidity (%)			
	0-day	Percent decrease over control	3-day	Percent decrease over control
G	0·733	8·75	0·723	5·55
T	0·713	11·25	0·707	8·57
GA_3*	0·808	0·0	0·773	–1·29
GA_3**	0·743	7·50	0·701	8·57
G+T	0·806	0·0	0·731	4·10
G+GA_3*	0·790	1·25	0·711	7·04
G+GA_3**	0·689	15·0	0·610	24·59
T+GA_3*	0·772	3·75	0·709	8·57
T+GA_3**	0·751	6·25	0·692	10·14
G+T+GA_3*	0·743	7·50	0·734	4·10
G+T+GA_3**	0·800	0·0	0·751	1·33
Control	0·808	-	0·769	—
S.E m (±)	**0·020**		**0·004**	
C.D (0·05)	**0·058**		**0·014**	

G = Trunk girdling ,T= Thinning by clipping , * = 20 ppm ,** = 40 ppm

Table 9. Effect of girdling, thinning and gibberellic acid on total soluble solids /acid ratio of harvested grapes (*Vitis vinifera* L.) cv. Perlette at room temperature.

Treatment	TSS/acid ratio			
	0-day	Percent increase over control	3-day	Percent increase over control
G	23·12	35·28	23·95	25·00
T	19·52	14·21	21·57	12·57
GA_3*	19·97	16·85	21·02	9·70
GA_3**	22·12	29·43	23·67	23·53
G+T	18·70	9·42	19·78	3·23
G+GA_3*	20·91	22·35	22·90	19·51
G+GA_3**	24·18	41·48	24·38	27·24
T+GA_3*	18·85	10·29	21·22	10·75
T+GA_3**	23·84	39·49	24·05	25·52
G+T+GA_3*	20·78	21·59	20·98	9·49
G+T+GA_3**	20·69	21·06	21·64	12·94
Control	17·09	—	19·16	—
S.E m (±)	**0·081**		**0·41**	
C.D (0·05)	**0·39**		**1·20**	

G = Trunk girdling , T= Thinning by clipping , *=20 ppm , **=40 ppm

and girdling alone with their corresponding values of 24.05 and 23.95 respectively as compared to control (19.16). All other treatments were found to be significant as compared to control. TSS/acid ratio increased by 27.24% in girdling + 40ppm GA_3 on third day of room storage.

4.4.5. Total sugars :

The mean values of total sugars obtained by different treatments is shown in Table 10. On third day of shelf life, girdling + 40ppm GA_3 treatment had the highest sugar content of 14.98% and control showed the lowest of 13.75%. The mean percent values of rest of treatments in descending order were 14.75, 14.60, 14.57, 14.51, 14.51, 14.11, 13.95, 13.91, 13.91 and 13.85 for girdling + thinning + 40ppm GA_3, girdling, thinning + 40ppm GA_3, girdling + thinning + 20ppm GA_3, 40ppm GA_3, girdling + thinning, thinning, girdling + 20ppm GA_3, 20ppm GA_3, and thinning + 20ppm GA_3 respectively. All these treatments were found to be highly significant at 5% level of significance. Total sugarsincreased to a tune of 8.94% on third day of storage.

4.4.6. Reducing Sugars :

A perusal of the data on reducing sugar content of grapes reveals that the reducing sugar content decreases during storage period. The observations further revealed that on the day of harvesting the maximum and minimum percentage of reducing sugars was in girdling + 40ppm GA_3 and thinning treatments having values as 13.00% and

Table 10. Effect of girdling, thinning and gibberellic acid on percent total sugar of harvested grapes (*Vitis vinifera* L.) cv. Perlette at room temperature.

Treatment	Total Sugar (%)			
	0-day	Percent increase over control	3-day	Percent increase over control
G	14·67	4·63	14·60	6·18
T	14·02	0·0	13·95	1·45
GA_3*	14·19	1·21	13·91	1·16
GA_3**	14·63	4·35	14·51	5·52
G+T	14·30	1·99	14·11	2·61
G+GA_3*	14·60	4·13	13·91	1·16
G+GA_3**	15·04	7·27	14·98	8·94
T+GA_3*	14·03	0·07	13·85	0·72
T+GA_3**	14·68	4·70	14·57	5·96
G+T+GA_3*	14·72	4·99	14·51	5·52
G+T+GA_3**	14·82	5·70	14·75	7·22
Control	14·02	—	13·75	—
S.E m (±)	**0·11**		**0·03**	
C.D (0·05)	**0·33**		**0·10**	

G = Trunk girdling , T= Thinning by clipping , *=20 ppm , **=40 ppm

Table 11. Effect of girdling, thinning and gibberellic acid on percent reducing sugar of harvested grapes (*Vitis vinifera* L.) cv. Perlette at room temperature.

Treatment	Reducing sugar (%)			
	0-day	Percent increase over control	3-day	Percent increase over control
G	12·20	2·86	12·11	3·59
T	11·80	–0·06	11·69	0·0
GA_3*	12·08	1·85	11·75	0·51
GA_3**	11·90	0·33	11·76	0·59
G+T	12·18	2·69	12·03	2·90
G+GA_3*	11·90	0·33	11·16	–4·53
G+GA_3**	13·00	9·61	12·90	10·35
T+GA_3*	11·86	0·0	11·36	–2·82
T+GA_3**	12·33	3·96	12·21	4·44
G+T+GA_3*	12·80	7·92	12·60	7·78
G+T+GA_3**	12·78	7·75	12·67	8·38
Control	11·86	—	11·69	—
S.E m (±)	**0·10**		**0·04**	
C.D (0·05)	**0·30**		**0·11**	

G = Trunk girdling , T= Thinning by clipping , *=20 ppm , **=40 ppm

11.80% which decreased to 12.90% and 11.69% on third day of storage respectively. On third day at room temperature storage, significantly highest content of reducing sugar (12.90%) was recorded in berries of those vines which received pre-harvest treatment of girdling + 40ppm GA_3 followed by girdling + thinning + 40ppm GA_3 and girdling + thinning + 20ppm GA_3 with corresponding values of 12.67% and 12.60% respectively, and these treatments proved significant at 5% level of significance when compared to control (11.69%). However the maximum increases in reducing sugars was observed to be 10.35% in girdling + 40ppm GA_3.

Chapter - 5

Discussion

CHAPTER-5

DISCUSSION

The yield and quality of the grapes can be improved by manipulating its cultural practices. The use of plant bioregulators, girdling and thinning have been reported to improve yield and quality of grapes in many parts of the world. Therefore the present investigation was under taken to study the effect of girdling, thinning and gibberellic acid alone or in combination on growth and development pattern of berry, yield, quality and shelf-life of grapes and results thus obtained are discussed in this chapter under appropriate headings.

5.1. GROWTH AND DEVELOPEMENT PATTERN OF BERRY :

Berry growth refers to the increase in size (length and breadth) and its development refers to the biochemical changes occuring in it during the process of ripening. Increase in berry length and breadth is

mainly as a result of cell division or cell enlargement or both. Growth of the grape berry is characterized by a double sigmoid curve with three distinctly defined growth stages. In our study also three phases of berry growth were observed. When the initial measurements were taken 17 DAFS, (during pre lag phase) the berry size of treated vines was more than the control with girdling + 40ppm GA_3 treatment showing maximum size. From 17 DAFS onwards till 31 DAFS the berries in all the treatments including control showed a steady increase after which there was a lag phase and increase in berry size was arrested till 38 DAFS, except in thinning + 20ppm GA_3 treatment in which growth of berry continued to increase and no lag phase was observed. 38 days after fruit set there was an exponential increase (log phase) in berry size in all the treatments including control till 45 DAFS, after which the growth of berries continued but at slower rate till the harvest of the fruit. There was not much difference in the growth rate of berries of treated and untreated vines during this phase. Overall, it was observed that different treatments effected the fruit size only in initial days i.e., upto 17 DAFS after which there was not much change in the growth pattern of berries of treated and untreated vines. The effect of different treatments (girdling, thinning, GA_3) seems to be because of their influence on cell division and cell enlargement in the early phase of fruit growth i.e , immediately after fruit set. Dass and Randhawa (1977) also reported similar type of growth pattern as observed in the present study. The lag phase of the berry may be associated to the low levels of endogenous auxin like substances but

high levels of inhibitors in the berries and during this phase the embryo and endosperm grows but the ovary (berry) does not increase in size. During post-lag phase rapid growth of the pulp (mesocarp) takes place because of the termination of lag phase. Rao and Pandey (1977) correlated the termination of lag phase with higher ratio of soluble to insoluble proteins in the berries. A number of other factors may be involved in determining the size of the berries like number of leaves available on the vine and their photosynthetic rate (Pandey and Pandey, 1989).

In case of berry weight, the increase was steady upto 38 DAFS in berries of both treated and untreated vines after which their is a sudden increase in berry weight which continued nearly upto harvest with girdling + 40ppm GA_3 showing highest increase in berry weight during post-lag phase. The increase in berry weight may be due to the influx of sugars and water into the berries. Therefore, those factors that help in translocation of sugars and water to the berries help in increasing the berry weight. Further phloem plays an important role in translocation of solute and hence may determine the increase in berry weight (Coombe, 1992 and Mullins *et al.*, 1992).

The increase in TSS was linear upto 38 DAFS in berries of both treated and untreated vines after which the rise in TSS was sharp upto harvest in most of the treatments except girdling + 40ppm GA_3 and thinning + 40ppm GA_3 where the increase was at slower rate. The increase in the TSS is attributed to possible relationship between

plant hormonal regulation of berry growth and the role of plant hormones in the translocation of carbohydrates from the leaves into the berries (Alleweldt, 1977).

In the present study, the increase in acid content was observed in berries of all treated and untreated vines upto 31 DAFS after which there was a sharp decline in the acid content of the berries upto 45 DAFS and then stablized. However, minor variations were observed among the treatments. The initial increase in acid content of berries may be attributed to translocation of acids into berries after synthesis in the leaves (Stafford and Loewns, 1958) or due to its build up through synthesis in the berries (Hale, 1962). The subsequent decline in the acidity can be attributed to the conversion of acids to sugars (Kliewer, 1964) or due to their utilization in the process of respiration (Drawert and Steffen, 1965).

5.2. YIELD AND YIELD CONTRIBUTING FACTORS :

Different treatments resulted in the improvement of bunch length and breadth. However, maximum bunch length and breadth was recorded by girdling + 40ppm GA_3 as compared to control. The increased length and breadth of the bunch can be attributed to more photosynthates available by girdling of main trunk and increased cell elongation of the pedicles with GA_3 application. The improvement in the bunch length has also been reported by Jawanda and Singh (1971); Jawanda and Vij (1973) and Patil *et al.* (1980) with the help of girdling in combination with GA_3. In case of breadth, Nangia and Bakshi (1971),

Dhillon and Sharma (1973), Tanwer (1986), Sharma *et al.* (1999) and Josan *et al.*(2001) also recorded an increase in bunch breadth due to girdling.

Maximum bunch weight of 495.73g was observed with trunk girdling + 40ppm GA_3. Daulta (1982) and Dhillon and Bindra (1999) also observed increase in bunch weight with trunk girdling in combination with GA_3 application. Sharma *et al.* (1999) reported girdling + 40ppm GA_3 had an additive effect in increasing the fruit weight which he attributed to (I) Proper fruit set and minimal shot berry formation, (II) Efficient mobilization of substances even under competitive limitation and (III) Enhancement of deposition of soluble solids.

Length of the berry increased under all the treatments, however, maximum berry length (1.88cm) was observed with girdling + 40 ppm GA_3. Daulta (1982) and Sharma *et al.* (1999) also reported an increase in berry length due to girdling while Patil *et al.* (1980) and Lakshmanan *et al.* (1992) observed increase in berry length with GA_3 application. Improvement in berry length with GA_3 has been attributed by Sachs and Lang (1961) to cell elongation by increasing the cell wall plasticity, thus creating water diffusion pressure deficit and increase in water uptake there by causing cell elongation.

Girdling and GA_3 alone or in combination increased the berry breadth. However, maximum berry breadth (1.80cm) was recorded with girdling + 40ppm GA_3. Lakshmanan *et al.* (1992) also reported

that 40ppm GA_3 was more effective in increasing the berry breadth than girdling but combined effects were most prounced so confirming the present findings.

The influence of girdling, thinning and GA_3 alone or in combination indicated that maximum berry weight of 3.05g was achieved with girdling + 40ppm GA_3. Similar findings have also been reported by Harrell and William (1987). Berry as a unit of three factors length, breadth and weight has evidently become an expression of wide variety of events in which cell division and cell enlargement are the core factors and greater increase in weight occurs during the later periods of fruit growth indicating an enhanced deposition of solids. Winkler (1953) also reported an increase in weight of seedless berries due to girdling when performed after normal drop of impotent flowers. The relevance of our findings with respect to girdling and GA_3 is supported by Weaver and Williams (1952) in grapes.

Maximum berry volume was recorded in trunk girdling + 40ppm GA_3 and thinning + 40ppm GA_3 treatments as compared to control. The increased size and weight of berry due to these treatments seems to have resulted in having maximum berry volume. Patil *et al.* (1980) recorded increase in berry volume due to GA_3 at various concentrations which are close to 20ppm and 40ppm. Increase in berry volume due to GA_3 has also been observed by Ghazi *et al.* (1979) which confirms the present study.

None of the treatments was found to affect the juice percentage

significantly and it ranged between 51.73% to 55.41%. The relevance of our findings in case of juice percentage find reflection in the work of Josan *et al.* (2001) in Perlette grapes as they also could not find much variation in juice content due to trunk girdling alone and in combination with GA_3 and thinning.

Shot berry is a problem associated with most of the grape cultivars including Perlette. Growth regulators, thinning and trunk girdling either alone or in combination are found to cause a significant reduction in number of shot berries. Shot berries were minimum (10.08%) in the treatment girdling + thinning + 40ppm GA_3 while maximum being in control (13.45%). Mor *et al.* (1986) reported that cluster thinning improved berry weight and reduced the percentage of shot berries. The results of our findings are also supported by the works of Dhillon and Bindra (1999) and Josan *et al.* (2001). They correlated the decrease in the number of shot berries to heavy berry thinning which provided more leaf/fruit ratio to remaining berries resulting in production of bold berries. Where as girdling and GA_3 showed additive effects in production of bold berries by providing more photosynthates and by cell enlargement respectively.

All the treatments resulted in significant increase in average yield per vine as compared to control. However, maximum average yield (8.87kg/vine) was recorded under girdling + 40ppm GA_3 as compared to control (5.32kg/vine). The probable reason for the increase in yield may be that due to an increase in bunch size (length ×breadth) and bunch weight which accounted for the increase in the average yield/

vine. As far as the percentage increase in yield over control was concerned, it was maximum (66.72%) due to girdling + 40 ppm GA_3 probably because of the fact that the same treatment resulted in increased weight of bunches.

5.3. CHEMICAL CHARACTERISTICS :

All the treatments significantly improved TSS content, however, maximum TSS content of 17.00%, was obtained with trunk girdling + 40ppm GA_3 which was at par with thinning + 40ppm GA_3 as compared to control (14.47%). These observations are in confirmity with findings of Sanghavi and Patil (1975) ; Dobas *et al.* (1980) ; Jindal *et al.* (1982) and Josan *et al.* (2001). It seems trunk girdling makes more photosynthates like carbohydrates available to bunches thereby making them more sweeter. While thinning may provide more space for berry development making it a large sink where accumulation of soluble solids is more. Further, the combined effect of the treatments was found to be additive thus providing such results. Weaver and Williams (1952); Jawanda and Vij (1973) and Yadav and Pandey (1974) reported an increase in TSS content due to ringing alone or in combination with GA_3.

Lowest acid content (0.68%) was observed in trunk girdling + 40ppm GA_3 as compared to control (0.80%). Reduction in acid content was also recorded due to thinning by clipping alone and in combination with GA_3 and girdling. These results are in agreement with Dobas *et al.* (1980); Jindal *et al.* (1982) and Josan *et al.* (2001).

Mor *et al.* (1986) who also recorded a reduction in the acid content due to GA_3 and thinning. The decrease in acidity due to the treatments might be attributed either to the high rate of respiration during which acids gets consumed or to the conversion of acids to the sugars.

Significantly higher TSS/acid ratio as compared to control was recorded with girdling + 40ppm GA_3. Trunk girdling alone also registered significant increase in TSS/acid ratio of 23.12 over control (17.09). These observations are in confirmity with Mor *et al.* (1986);Tanwer (1986) and Dhillon and Bindra (1999). The possible reason for the increase in TSS/acid ratio is due to more availability of photosynthates to berries with girdling and GA_3.

Maximum total sugar content was recorded with girdling + 40ppm GA_3 (15.04%) followed by girdling + thinning + 40ppm GA_3 (14.82%) as compared to control (14.02%). Girdling has a great influence on quality as it influences the availability of more photosynthates to the bunches. The results are thus in consonance with the findings of Anastasite (1966) in Table grapes; Georgesca and Indreas (1972) in Black Kishmis and Jawanda and Vij (1973) in Thomson Seedless cultivar of grapes. Similarly Drawert and Steffan (1966) and Ribereau-Gayon (1966) reported that the increase in sugar content is due to the transformation of organic acids into sugars.

Highest reducing sugar content of 13.00% was recorded with girdling + 40ppm GA_3 as compared to control 11.86%. GA_3, thinning and girdling alone or in combination also improved reducing sugar

content of berries. These findings are in confirmation with the findings of Jawanda and Vij (1973); Mor *et al.* (1986) and Dhillon and Bindra (1999) however, the trend obtain was different in case of non-reducing sugars in which girdling, GA_3 or thinning treatments did not effect the non-reducing sugar content of berries significantly and can be attributed to the fact that main sugar translocated to the fruit is sucrose which gets quickly hydrolysed into glucose and fructose by enzyme invertase (Hawker, 1969).

5.4. Post Harvest Studies :

Grapes (*Vitis vinifera* L.) cv. Perlette, being non-climacteric fruit getssubjected to physiological deterioration and physiological loss in weight during storage especially at room temperature. In the present study maximum physiological loss in weight was recorded in control on third day of storage (22.31%) whereas the minimum PLW (9.42%) was recorded in berries obtained from vines treated with girdling + 40ppm GA_3. On sixth day of storage the PLW losses in treatments including control ranged from 30.20% to 33.91%. The berries were sunken and shattered and were unmarketable so post harvest studies were not extended. Eswara *et al.* (1989) also reported loss in weight of Pachadraksha grape berries at 23-35°C which was 36.78% on tenth day of storage. However in present study the shelf life could not be extended due to prevaling high room temperature i.e. 38-42°C. Neelgreevam and Mallik (1985) observed that the grape berries lost considerable water following

harvest which resulted in stem drying, browing, berry shatter, wilting and even their shrivelling. Rao *et al.* (1975) reported that the wastage during storage was much more due to physiological weight loss than berry drop and decay. As far as the present investigation is concerned, in addition to PLW, browing of the berries also caused great loss under room temperature. After three days of storage the berries developed dull appearance and were not marketable. Similar findings have been reported by Ladania (1986) which are in confirmation with the present investigation.

The probable reason for the physiological loss in weight might be that the grapes were stored under ambiant temperature which was very high (38°-42°C) and resulted in loss of water due to transpiration and hence drying and browing of stems and pedicles caused berry drop and shrivelling of the fruit. Further, as the temperature and rate of respirations have complementary effects, a rise in any one of them will influence the other because respiration in the fruit continues even after the completion of the bio-conversion but at the cost of edible substrate which accounted for the loss of weight.

Total soluble solids of the fruit increased slightly during storage and the berries tasted sweeter on third day of storage. Highest TSS content of 17.47% was recorded due to girdling + 40ppm GA_3 and lowest TSS content of 15.00% due to thinning alone as compared to control (14.69%). The increase in TSS during storage was also

reported by Suresh *et al.* (1976) and Shankariah and Roy (1991) under room conditions. The increase in TSS during storage might be due to the fact that concentration of sugar increased due to the loss of moisture so the grapes became sweeter.

A slight decrease in acidity was noticed during storage, however, minimum acidity of 0.610% was recorded on third day of storage in trunk girdling + 40ppm GA_3 as compared to control (0.769%). Suresh *et al.* (1976) and Sarkar *et al.* (1996) reported decline in acidity in grapes and Litchi respectively during storage. The reduction in the acidity might be due to the bio-conversion of acids. Reduced supply of sugars as substrate and slower rate of starch degradation might have augmented biodegradation of organic acids in the fruits, as they may be utilised in the respiratory activities of the berry. TSS/acid ratio followed the similar trend because of the fact that during storage TSS increases and acidity decreases resulting in the increase in sugar acid ratio.

Maximum total sugar content of (14.98%) was recorded in girdling + 40ppm GA_3 as compared to control (13.75%). In general, reduction in total sugars was observed on third day of storage and a similar trend has also been reported by Rao *et al.* (1976) in Pusa Seedless grapes. The reduction in the total sugar might be due to their utilization in the respiratory processes. The catabolic process reduced the level of total sugars i.e., fermentation of sugars and

respiratory activities of the fruit (Pool *et al.*, 1972).

There was a slight reduction in the contents of reducing sugars of berries during storage. Maximum reducing sugar content of 12.90% was recorded in trunk girdling + 40ppm GA_3 when compared with control (11.69%). The reduction in the reducing sugar content was also reported by Rao *et al.* (1976) in Pusa Seecdless grapes and Shankaraiah and Roy (1991) in Thompson Seedless grapes. This also coincides with the records of the present investigation. The reduction in the reducing sugar content may be due to the catabolic processes or due to respiration or by slow microbial fermentation.

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Chapter - 6

Summary & Conclusions

CHAPTER-6

SUMMARY AND CONCLUSION

A study was undertaken at research vineyard of Division of Pomology and Post Harvest Technology, Udheywalla, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu during 2002 to determine the effect of girdling, thinning, GA_3 and their combinations on berry growth, yield, quality and shelf-life of Perlette cultivar of grapes under sub-tropical conditions of Jammu region. The results thus obtained during the course of study are summarised as under :—

1. Berry growth exhibited a double sigmoid pattern reaching veraison stage 38 days after fruit set and berry takes 69 days to ripe under agro-climatic conditions of Jammu.

2. Total soluble solids of the berries increased slowly upto 38 days and thereafter showed a sharp increase upto 45 days after fruit set. Thereafter the increase in TSS was at slower rate till the time of harvest. Treatments like girdling, GA_3 and their combinations hastened the TSS accumulation in berries as compared to control.

3. The acid content of berries showed steady increase upto 31 DAFS, whereafter there was a sharp decline of acidity in all the treatments including control upto 45 DAFS. After this period the acid content of berries stablized.

4. At the time of harvest the biggest bunch size (length and breadth) was obtained from the vines treated with girdling + 40ppm GA_3.

5. Maximum berry size and berry weight was recorded with girdling + 40ppm GA_3 treatment.

6. Non-significant improvement in the juice percentage was recorded due to various treatments.

7. There was a signfiicant reduction in shot berries percentage with girdling + thinning + 40ppm GA_3 treatment as compared to control.

8. Girdling, thinning, GA_3 application or their combinations improved the yield of vines significantly however, maximum yield was observed with girdling + 40ppm GA_3.

9. Most of the treatments improved berry quality, however, highest Total Soluble Solids (TSS), TSS/acid ratio, total sugars, reducing sugars and lowest acid content was recorded in girdling + 40ppm GA_3 as compared to control.

10. The post harvest conditions of fruit were found to be better in girdling + 40ppm GA_3 treatment as compared to control on

third day under room temperature storage.

Finally, on the basis of present studies it is concluded that the grape berry takes 69days to mature under agroclimatic conditions of Jammu and exhibits a double sigmoid growth curve. In terms of yield (berry size, berry weight, bunch size and bunch weight), quality (TSS, acidity, TSS/acid ratio and sugars) and shelf life, the best results were obtained with girdling + 40ppm GA_3 treatment however, the less expensive treatment of trunk girdling alone has also shown a significant improvement in yield and quality.

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*** Original not seen**

Appendices

Appendix-I

Effect of girdling (G), thinning (T) and gibberellic acid (GA_3) on the length of berry in grapes cv. Perlette.

Treatment	Length of berry (cm)											Variance
	17 DAFS	24 DAFS	% Increase	31 DAFS	% Increase	38 DAFS	% Increase	45 DAFS	% Increase	52 DAFS	% Increase	
G	1·088	1·182	8.63	1·277	8.03	1·299	1.72	1·576	21.32	1·804	14.46	0·072
T	1·105	1·163	5.24	1·221	4.98	1·246	2.04	1·568	25.84	1·743	11.16	0·064
GA_3*	1·126	1·190	6.25	1·254	5.37	1·294	3.18	1·664	28.59	1·808	8.65	0·077
GA_3**	1·156	1·186	2.59	1·216	2.52	1·388	14.14	1·712	23.34	1·849	8.00	0·087
G+T	1·119	1·206	7.77	1·274	5.63	1·296	1.72	1·646	27.00	1·854	12.63	0·081
G+GA_3*	1·132	1·212	7.06	1·272	4.95	1·288	1.25	1·792	39.13	1·812	1.11	0·091
G+GA_3**	1·256	1·356	7.96	1·442	6.34	1·460	1.24	1·793	22.80	1·880	4.85	0·061
T+GA_3*	1·075	1·151	7.06	1·227	6.60	1·232	0.40	1·594	29.38	1·808	13.42	0·082
T+GA_3**	1·124	1·184	5.33	1·244	5.06	1·417	13.90	1·608	13.47	1·862	15.80	0·080
G+T+GA_3*	1·174	1·263	7.58	1·351	6.96	1·365	1.03	1·678	22.93	1·786	6.43	0·058
G+T+GA_3**	1·144	1·189	3.93	1·235	3.86	1·370	10.93	1·664	21.45	1·822	9.47	0·077
Control	1·045	1·127	7.84	1·208	7.18	1·215	0.57	1·564	28.72	1·694	8.31	0·066
Variance	**0·002**	**0·003**		**0·004**		**0·005**		**0·006**		**0·002**		

G= Trunk girdling. T=Thinning by clipping, *=20ppm, **=40ppm

DAFS = Days After Fruit Set

Appendix-II

Effect of girdling (G), thinning (T) and gibberellic acid (GA_3) on the breadth of berry in grapes cv. Perlette.

Treatment	Breadth of berry (cm)											Variance
	17 DAFS	24 DAFS	% Increase	31 DAFS	% Increase	38 DAFS	% Increase	45 DAFS	% Increase	52 DAFS	% Increase	
G	1·078	1·147	6.40	1·216	6.01	1.250	2·79	1·502	20.16	1·718	14.38	0·059
T	1·048	1·100	4.96	1·152	4.72	1·188	3.12	1·504	26.59	1·643	9.24	0·058
GA_3*	1·023	1·091	6.64	1·159	6.23	1·247	7.59	1·558	24.93	1·718	10.26	0·076
GA_3**	1·053	1·125	6.83	1·194	6.13	1·309	9.63	1·616	23.45	1·718	6.31	0·076
G+T	1·082	1·114	2.95	1·147	2.96	1·216	6.01	1·567	28.86	1·748	11.55	0·078
G+GA_3*	1·058	1·138	7.56	1·218	7.02	1·262	3.61	1·718	36.13	1·776	3.37	0·081
G+GA_3**	1·179	1·228	4.15	1·266	3.09	1·320	4.26	1·651	25.07	1·730	4.78	0·087
T+GA_3*	1·006	1·072	6.56	1·142	6.52	1·194	4.55	1·573	31.74	1·808	14.93	0·066
T+GA_3**	1·070	1·129	5.51	1·188	5.22	1·346	13.30	1·583	17.60	1·630	2.96	0·070
G+T+GA_3*	1·097	1·122	2.27	1·263	12.56	1·311	3.80	1·612	22.95	1·795	11.35	0·081
G+T+GA_3**	1·088	1·133	4.13	1·279	12.88	1·343	5.00	1·590	18.39	1·647	3.58	0·049
Control	0·988	1·059	7.18	1·130	6.70	1·151	1.85	1·538	33.62	1·750	13.78	0·072
Variance	**0·0024**	**0·0026**		**0·0020**		**0·0030**		**0·0036**		**0·0037**		

G= Trunk girdling. T=Thinning by clipping. *=20ppm. **=40ppm

DAFS = Days After Fruit Set

Appendix-III

Effect of girdling (G), thinning (T) and gibberellic acid (GA_3) on the weight of berry in grapes cv. Perlette.

Treatment	Weight of berry (g)											
	17 DAFS	24 DAFS	% Increase	31 DAFS	% Increase	38 DAFS	% Increase	45 DAFS	% Increase	52 DAFS	% Increase	Variance
G	0·501	0·733	46.30	0·760	3.68	0·856	12.63	1·453	69.74	2·906	100	0·798
T	0·510	0·700	37.25	0·736	5.14	0·883	19.97	1·656	87.54	2·270	37.07	0·472
GA_3*	0·491	0·750	52.74	0·763	1.73	0·983	28.83	1·630	65.81	2·430	49.07	0·527
GA_3**	0·520	0·780	50.00	0·803	2.94	1·026	27.77	2·030	97.85	2·600	28.07	0·684
G+T	0·542	0·703	29.70	0·760	8.10	1·136	49.47	1·716	51.05	2·390	39.27	0·511
G+GA_3*	0·603	0·710	17.74	0·783	10.28	1·140	45.59	2·320	103.5	2·680	15.51	0·807
G+GA_3**	0·771	0·880	14.13	0·906	2.95	1·176	29.80	2·110	79.42	3·050	44.54	0·829
T+GA_3*	0·504	0·683	35.51	0·693	1.46	0·873	21.97	1·756	101.1	2·600	48.06	0·676
T+GA_3**	0·513	0·796	55.16	0·816	2.51	1·180	44.60	1·940	64.40	3·02	55.67	0·890
G+T+GA_3*	0·621	0·840	35.26	0·863	2.73	1·110	28.62	1·853	66.93	2·450	32.21	0·505
G+T+GA_3**	0·582	0·720	23.71	0·770	6.94	1·206	56.62	1·743	44.52	2·703	55.07	0·661
Control	0.443	0.616	39.05	0.643	4.38	0.896	39.34	1.586	76.99	2.236	40.98	0.487
Variance	0.007	0.005		0.004		0.018		0.060		0.074		

G= Trunk girdling, T = Thinning by clipping, *=20ppm, **=40ppm

DAFS = Days After Fruit Set

Appendix-IV

Effect of girdling (G), thinning (T) and gibberellic acid (GA_3) on the volume of berry in grapes cv. Perlette.

Treatment	Volume of berry (cc)											
	17 DAFS	24 DAFS	% Increase	31 DAFS	% Increase	38 DAFS	% Increase	45 DAFS	% Increase	52 DAFS	% Increase	Variance
G	0·500	0·666	33.20	0·783	17.56	0·833	6.38	1·333	60.02	2·066	54 98	0·335
T	0·460	0·700	52.17	0·730	4.28	0·800	9.58	1·533	91.62	2·080	35 68	0·385
GA_3*	0·530	0·740	39.62	0·766	3.51	0·903	17.88	1·633	80.84	2·130	30 43	0·389
GA_3**	0·540	0·746	38.14	0·833	11.66	0·940	12.84	1·900	102.12	2·260	18 94	0·491
G+T	0·570	0·733	28.59	0·826	12.68	0·870	5.32	1·533	76.20	2·400	56 55	0·480
G+GA3*	0·600	0·743	23.83	0·800	7.67	0·930	16.25	2·166	132.90	2·600	20 03	0·714
G+GA_3**	0·760	0·823	8.28	0·933	13.36	1·016	8.89	2·033	100.09	2·733	34 43	0·656
T+GA_3*	0·460	0·656	42.60	0·716	9 14	0·833	16.34	1·600	92.07	2·333	45 81	0·519
T+GA_3**	0·500	0·800	60.00	0·833	4.12	0·941	12.96	1·800	91.28	2·733	51 83	0·697
G+T+GA_3*	0·630	0·830	31.74	0·900	8.43	0·976	8.44	1·700	74.18	2·260	32 94	0·394
G+T+GA_3**	0·560	0·600	7.14	0·733	22.16	0·834	13.77	1·566	87.76	2·333	48.97	0·483
Control	0·430	0·736	71.16	0·783	6.38	0·870	11.11	1·533	76.20	2·066	34.76	0·369
Variance	0·008	0·004		0·004		0·006		0·057		0·059		

G= Trunk girdling, T=Thinning by clipping, *=20ppm, **=40ppm

DAFS = Days After Fruit Set

Appendix-V

Effect of girdling (G), thinning (T) and gibberellic acid (GA_3) on the total soluble solids of berry in grapes cv. Perlette.

Treatment	Total Soluble Solids (%)											
	17 DAFS	24 DAFS	% Increase	31 DAFS	% Increase	38 DAFS	% Increase	45 DAFS	% Increase	52 DAFS	% Increase	Variance
G	0·260	1·750	573.0	4·00	128.57	5·000	25.00	12·650	153.0	16·83	33.04	42·63
T	0·260	2·116	713.0	4·00	89.57	6·000	50.00	13·000	166.66	14·66	17.76	34·66
GA_3*	0·260	2·800	976.92	5·333	90.46	7·668	43.78	14·939	94.82	16·00	7.16	33·71
GA_3**	0·300	2·233	644.33	4·166	86.56	7·333	76.02	15·000	104.55	16·33	8.86	44·98
G+T	0·200	2·350	1075.0	4·500	91.48	6·666	48.13	10·333	55.01	14·66	41.91	28·44
G+GA_3*	0·330	2·063	525.15	3·833	85.79	6·333	65.22	14·333	126.32	16·50	15.14	44·56
G+GA_3**	0·360	2·433	575.83	4·500	84.95	7·000	55.55	9·666	38.08	17·00	75.78	35·62
T+GA_3*	0·230	2·283	892.60	4·333	89.79	7·333	69.23	13·666	86.36	14·50	6.14	35·19
T+GA_3**	0·300	2·233	644.33	4·166	86.56	6·666	60.00	12·666	90.00	17·00	34.92	41·53
G+T+GA_3*	0·300	2·233	644.33	4·166	86.56	8·000	92.03	9·666	20.82	15·33	58.69	30·46
G+T+GA_3**	0·300	2·483	727.66	4·666	87.91	7·333	57.15	11·000	50.00	16·66	51.45	36·04
Control	0·260	2·133	720.38	4·000	87.52	6·000	50.00	11·333	88.83	14·47	27.71	30·25
Variance	0·001	0·064		0·165		0·713		3·112		1·069		

G = Trunk girdling. T = Thinning by clipping. * = 20ppm. **=40ppm

DAFS = Days After Fruit Set

Appendix-VI

Effect of girdling (G), thinning (T) and gibberellic acid (GA_3) on the acidity of berry in grapes cv. Perlette.

Treatment	Acidity (%)											
	17 DAFS	24 DAFS	% Increase	31 DAFS	% Increase	38 DAFS	% decrease	45 DAFS	% decrease	52 DAFS	% decrease	Variance
G	2·195	2·673	21.77	3·461	29.47	1·986	42.61	0·748	62.33	0·733	2.00	1·138
T	2·428	2·802	15.40	3·177	13.38	2·066	35.15	0·891	56.87	0·713	19.00	1·020
GA_3*	1·963	2·234	13.80	2·506	12.17	1·136	1.37	0·890	21.65	0·808	9.21	0·539
GA_3**	2·014	2·518	25.02	3·022	20.01	1·758	41.82	0·774	55.97	0·743	4.00	0·845
G+T	2·118	2·777	31.11	3·435	23.69	2·479	27.83	0·998	59.74	0·806	19.23	1·054
G+GA_3*	2·247	2·621	16.64	2·916	11.25	1·885	35.35	0·792	57.98	0·790	0.25	0·860
G+GA_3**	2·841	3·629	27.73	3·642	0.35	2·221	39.01	0·826	62.80	0·689	16.58	1·726
T+GA_3*	1·859	2·750	47.92	3·642	32.43	1·446	60.29	0·775	46.40	0·722	6.83	1·299
T+GA_3**	2·454	2·815	14.71	3·177	12.85	1·524	52.03	0·759	50.19	0·749	1.31	1·108
G+T+GA_3*	2·841	3·086	8.62	3·332	7.97	1·317	60.47	0·871	33.86	0·743	14.69	1·395
G+T+GA_3**	2·273	3·074	35.23	3·875	26.05	1·834	52.67	0·871	52.50	0·800	8.15	1·479
Control	2·188	2·557	16.86	2·996	17.16	1·498	50.00	0·851	43.19	0·808	5.05	0·816
Variance	**0·099**	**0·123**		**0·138**		**0·154**		**0·005**		**0·001**		

G= Trunk girdling. T=Thinning by clipping. *=20ppm. **=40ppm
DAFS = Days After Fruit Set

CERTIFICATE-IV

Certified that all the necessary corrections as suggested by the external examiner and the advisory committee have been duly incorporated in the thesis entitled **"Effect of girdling, thinning and GA_3 on fruit growth, yield, quality and shelf life of grapes (*Vitis vinifera* L.) cv. Perlette"** submitted by **Mr. Masroor Ahmad , Regd. No. J-01-M-13.**

13/6

Chairman

Advisory Committee

Place : Jammu,

Dated : 13-6-03

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