

**EFFECT OF PRE-TRANSIT ROOT ZONE
COMPACTION, FOLIAGE TRIMMING AND ABSCISIC ACID
ON FIELD SURVIVAL AND GROWTH OF GRAFTED GUAVA**

Thesis

by

**KAVITA KUMARI THAKUR
(NH-2022-17-M)**

submitted to



**DR. YASHWANT SINGH PARMAR UNIVERSITY
OF HORTICULTURE AND FORESTRY, NAUNI,
SOLAN HP - 173 230 INDIA**

in

partial fulfilment of the requirements for the degree

of

**MASTER OF SCIENCE
(HORTICULTURE)
FRUIT SCIENCE**

**DEPARTMENT OF FRUIT SCIENCE
COLLEGE OF HORTICULTURE AND FORESTRY,
NERI, HAMIRPUR (H.P.) - 177 001 INDIA**

2024

Dr Shashi K. Sharma
Professor & Head
Major Advisor

Department of Fruit Science
College of Horticulture and Forestry Neri
Dr. Y.S. Parmar University of Horticulture
and Forestry (Nauni) Solan (HP)- 173230

CERTIFICATE-I

This is to certify that the thesis entitled, **“Effect of pre-transit root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava”** submitted in partial fulfillment of the requirements for the award of degree of **MASTER OF SCIENCE (HORTICULTURE) FRUIT SCIENCE** to the Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) - 173230 is a bonafide record of research work carried out by **Ms. Kavita Kumari Thakur (NH-2022-17-M)** daughter of Sh. Krishan Kumar under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been fully acknowledged.

Place: Neri, Hamirpur

Dated:

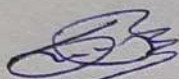
(Dr. Shashi K Sharma)

Chairman

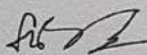
Advisory Committee

CERTIFICATE-II

This is to certify that the thesis entitled, "Effect of pre-transit root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava" submitted by Ms. Kavita Kumari Thakur (NH-2022-17-M) to the Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) in partial fulfilment of the requirements for the award of degree of **MASTER OF SCIENCE (HORTICULTURE) FRUIT SCIENCE** has been approved by the student's advisory committee after an oral examination of the same in collaboration with the external examiner.

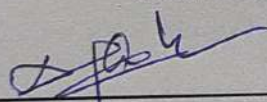


Dr. Shashi K Sharma
(Professor, Fruit Science)
Chairman, Advisory Committee

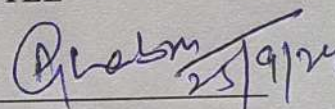

25-09-2024
(Dr. S.D. BADIYALA)

External Examiner

MEMBERS OF ADVISORY COMMITTEE



Dr. Ajay Kumar Banyal
(Associate Professor)
Department of Fruit Science


25/9/24

Dr. Arti Ghabru
(Assistant Professor)
Department of Basic Sciences
(Co-opted)



Professor and Head
Department of Fruit Science

Countersigned

Dean

**College of Horticulture and Forestry,
Neri, Hamirpur (HP)**

CERTIFICATE-III

This is to certify that all the mistakes and errors pointed by the external examiner have been incorporated in the thesis entitled, **“Effect of pre-transit root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava”**, submitted by **Ms. Kavita Kumari Thakur (NH-2022-17-M)** daughter of Sh. Krishan Kumar to the Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan H.P. - 173230 India in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE) FRUIT SCIENCE** in the discipline of **HORTICULTURAL SCIENCES**.

Dr. Shashi K Sharma
(Professor, Fruit Science)
Chairman
Advisory Committee

Professor and Head
Department of Fruit Science
College of Horticulture and Forestry
(Dr Y S Parmar University of Horticulture and Forestry)
Neri, Hamirpur (HP)

ACKNOWLEDGEMENTS

With deep reverence, I extend my heartfelt thanks to **Lord Shiva** for blessing me with robust health, courage, and unwavering determination, pivotal in achieving this academic milestone.

I express profound gratitude to my cherished grandparents, **Sh. Halku Ram** and **Smt. Dasodha Devi**, maternal grandparents, **Sh. Dila Ram** and **Smt. Chamari Devi**, and my loving parents, **Sh. Krishan Kumar Thakur** and **Smt. Promila Devi**. Their boundless love, countless sacrifices, constant support, selfless care, and enduring inspiration have been the bedrock of my success. I am extremely grateful to my brother **Lavneet** for his enduring encouragement and belief in my aspirations. Special thanks to **Balbir Singh** for his unwavering support and understanding, which provided invaluable strength throughout my pursuit of academic excellence.

I am deeply grateful to **Dr. Shashi K Sharma**, Chairman of my advisory committee and Professor and Head (Fruit Science, Neri, Hamirpur). His exceptional guidance, critical analysis, constructive criticism, and meticulous oversight throughout this journey have been beyond measure. His role transcended that of a mere guide; he was a steadfast guardian whose blessings and wisdom will guide me far into the future.

Heartfelt thanks also go to **Dr. Ajay K Banyal**, Associate Professor (Fruit Science) and **Dr. Arti Ghabru**, Assistant Professor (Basic Sciences), members of my Advisory Committee. Their continuous interest, inspiring guidance, innovative suggestions, and unwavering support were indispensable throughout my research.

I extend my sincere appreciation to **Dr. DP Sharma**, Dean (COHF, Neri, Hamirpur), for his commendable guidance and provision of essential facilities for the successful completion of this research.

I am deeply grateful to **Dr. Vikas K Sharma** (Senior Scientist, Fruit Science), **Dr. Sanjeev K Banyal** (Associate Professor, Fruit Science), **Dr. Suman** (Scientist, Fruit Science), **Mrs. Bandana** (Scientist, Department of Fruit Science), **Dr. Meenakshi Thakur**, Assistant Professor (Basic sciences) and **Dr. Pramod Verma** (Assistant Professor, Fruit Science) for their support, positivity, and motivation.

Friendship is an invaluable chain, strengthened with every passing minute. Each memory forged adds a golden link, deepening the bond with those who hold a special place in my heart. The thoughtful gestures and words of my friends have become precious treasures that I will forever cherish. Nostalgia prevails over me as I recall the amiable, ineffable, unforgettable company of my friends, **Mamta, Heena, Srishti, Parul, Manisha, Sejal, Shiwangee, Aman, Akshay, Kalpna, Gunjan** without which life would have been insipid and devoid of hue. I extend profound gratitude to my guidemates **Tarun Sir, Rohit Sir, Shiv Sir, Ritik Sir, Aparajita Ma'am, Nishchala Ma'am, Akriti, Ankita Ma'am, Eby Sir** and to **Aashima Ma'am, Ishani Ma'am, Kritika Ma'am, Sarah Ma'am, Razina Ma'am, Nivedita Ma'am, Asha Ma'am, Aditi Ma'am, Udit Sir, Devansh Sir, Himanshu Sir** for their kind and valuable support.

I am grateful to my all esteemed batch mates (**Anchal, Kashish, Ritik, Riya, Yaachika, Shubhangi, Mohini**) and juniors (**Kanika Raj, Sakshi, Simran, Ankit, Kriti, Reeve**) and **Ms. Priyanka Sharma** for their collaborative spirit throughout my academic pursuits. In addition, I extend my appreciation to **Jeevan Ji, Sanjay Ji, Suresh Sir and Babita Aunty** for their technical support during the research.

I am pleased to pay my ponderous thanks to my cousins (**Charan Singh, Som Dev, Mandeep, Chirangi, Balbir, Anup, Latu, Nandu, Sabu, Kushu, Anita di, Parvessh di, Mamta di, Shittal di, Anjali di, Lalita di, Gauri di, Shillu di, Teena di, Nishu Di, Arti di, Nancy, Anu di, Sonu di, Kalpna, Tanni, Sumedha, Tejju, Garvita**), my cute little nephew **Yash, Aayush**, and niece **Anandita, Aavya, Lavanya, Aarvi, Jagriti** who are always there for me in every moment of my life and always encouraged me to do well in my life.

I acknowledge the invaluable contributions of scientists whose work informed this thesis, and I thank all individuals whose indirect support, encouragement, and influence contributed to the completion of this thesis. Needless to say, all errors and omissions are mine.

Dated:

Place: Neri, Hamirpur

(Kavita Kumari Thakur)

CONTENTS

Chapter	Title	Page(s)
1.	INTRODUCTION	1-3
2.	REVIEW OF LITERATURE	4-16
3.	MATERIALS AND METHODS	17-30
4.	RESULTS AND DISCUSSION	31-83
5.	SUMMARY AND CONCLUSION	84-86
	LITERATURE CITED	87-103
	APPENDICES	i-xxi
	ABSTRACT	104
	BRIEF BIO-DATA OF THE STUDENT	-

ABBREVIATIONS USED

%	:	per cent
@	:	at the rate
°C	:	degree celsius
μ g	:	microgram
μ mole	:	micromole
ABA	:	abscisic acid
ANOVA	:	analysis of variance
CD	:	critical difference
cm	:	centimetre
cm ²	:	centimetre square
cm ⁻³	:	per cubic centimetre
cv.	:	cultivar
df	:	degree of freedom
dS m ⁻¹	:	decisiemens per metre
EC	:	electrical conductivity
<i>et al.</i>	:	et alia (co-worker)
etc	:	et cetera
Fig.	:	figure
FW	:	fresh weight
g cm ⁻³	:	gram per cubic centimetre
g	:	gram
ha ⁻¹	:	per hectare
i.e.	:	id est
K	:	potassium
kg	:	kilogram
kg/ha	:	kilogram per hectare
m	:	metre

m^3	:	metre cube
$\mu\text{mol m}^{-2} \text{s}^{-1}$	:	micromole per square metre and second
$\text{mol m}^{-2} \text{s}^{-1}$	:	mole per square metre and second
ml	:	millilitre
mm	:	millimetre
Pn	:	net photosynthesis
nm	:	nano metre
N	:	nitrogen
NS	:	non-significant
OC	:	organic carbon
P	:	phosphorus
pH	:	potential of hydrogen
ppm	:	parts per million
RWC	:	relative water content
S	:	significant
g_s	:	stomatal conductance
SE (d)	:	standard error of difference
SE (m)	:	standard error of mean
E	:	transpiration
<i>viz.</i>	:	videlicet

LIST OF TABLES

Table	Title	Page (s)
3.1	Physico-chemical characteristics of root zone media of the nursery plants	19
3.2	Physico-chemical properties of polybag growth medium	27
4.1	Effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts from July, 2023 to June, 2024	32
4.2	Effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of July, 2023 (before treatment)	33
4.3	Effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of August, 2023 (after treatment)	34
4.4	Effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of February, 2024	35
4.5	Effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of June, 2024	35
4.6	Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts from July, 2023 to June, 2024	36
4.7	Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of July, 2023 (before treatment)	37
4.8	Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of August, 2023 (after treatment)	38
4.9	Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of September, 2023	39
4.10	Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of December, 2023	40
4.11	Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of January, 2024	40
4.12	Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of May, 2024	41
4.13	Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month	42

	of June, 2024	
4.14	Effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts from month July, 2023 to June, 2024	43
4.15	Effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of July, 2023 (before treatment)	44
4.16	Effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of August, 2023 (after treatment)	45
4.17	Effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of October, 2023	46
4.18	Effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of June, 2024	46
4.19	Effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts from month July, 2023 to June, 2024	47
4.20	Effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts in the month of August, 2023	48
4.21	Effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts in the month of February, 2024	49
4.22	Effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts in the month of June, 2024	50
4.23	Effect of root zone compaction, foliage trimming and abscisic acid on stomatal conductance in the month of July, 2023(before treatment)	52
4.24	Effect of root zone compaction, foliage trimming and abscisic acid on stomatal conductance in the month of August, 2023 (after treatment)	53
4.25	Effect of root zone compaction, foliage trimming and abscisic acid on stomatal conductance in the month of July, 2024	53
4.26	Effect of root zone compaction, foliage trimming and abscisic acid on transpiration rate in the month of July, 2023 (before treatment)	55
4.27	Effect of root zone compaction, foliage trimming and abscisic acid on transpiration rate in the month of August, 2023 (after treatment)	56
4.28	Effect of root zone compaction, foliage trimming and abscisic acid on transpiration rate in the month of July, 2024	56

4.29	Effect of root zone compaction, foliage trimming and abscisic acid on photosynthetic activity in the month of July, 2023(before treatment)	58
4.30	Effect of root zone compaction, foliage trimming and abscisic acid on photosynthetic activity of guava grafts in the month of August, 2023	59
4.31	Effect of root zone compaction, foliage trimming and abscisic acid on photosynthetic activity in the month of July, 2024	60
4.32	Effect of root zone compaction, foliage trimming and abscisic acid on relative water content (RWC) of leaves in the month of August, 2023 (after treatment)	63
4.33	Effect of root zone compaction, foliage trimming and abscisic acid on relative water content (RWC) of leaves in the month of July, 2024	64
4.34	Effect of root zone compaction, foliage trimming and abscisic acid on per cent mortality rate of guava grafts in the month of June, 2024	66
4.35	Effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-a content of guava grafts in the month of August, 2023 (after treatment)	68
4.36	Effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-a content of guava grafts in the month of July, 2024	69
4.37	Effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-b content of guava grafts in the month of August, 2023 (after treatment)	70
4.38	Effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-b content of guava grafts in the month of July, 2024	71
4.39	Effect of root zone compaction, foliage trimming and abscisic acid on total chlorophyll content of guava grafts in the month of August, 2023 (after treatment)	73
4.40	Effect of root zone compaction, foliage trimming and abscisic acid on total chlorophyll content of guava grafts in the month of July, 2024	74
4.41	Effect of root zone compaction, foliage trimming and abscisic acid on proline content of guava grafts in the month of August, 2023 (after treatment)	76
4.42	Effect of root zone compaction, foliage trimming and abscisic acid on proline content of guava grafts in the month of July, 2024	77
4.43	Effect of root zone compaction, foliage trimming and abscisic acid on leaf soluble sugars of guava grafts in the month of August, 2023	79

4.44	Effect of root zone compaction, foliage trimming and abscisic acid on leaf soluble sugars of guava grafts in the month of July, 2024	80
4.45	CO₂ equivalence of different treatment combination of root zone compaction, foliage trimming and abscisic acid	82
4.46	Total score and ranking of different treatment combination of root zone compaction, foliage trimming and abscisic acid	83

LIST OF FIGURES

Figure	Title	Page(s)
3.1	Location map of the study site	17-18
3.2	Meteorological data of COHE, Neri from June 2023 to May 2024	18-19
3.3	Root zone compaction tool	22
4.1	Comparative account of stomatal conductance between the month of July, 2023, August, 2023 and July, 2024	54
4.2	Comparative account of transpiration rate between the month of July, 2023, August, 2023 and July, 2024	57
4.3	Comparative account of photosynthetic activity between the month of July, 2023, August, 2023 and July, 2024	60
4.4	Comparative account of leaf relative water content between the month of August, 2023 and July, 2024	64
4.5	Effect of root zone compaction, foliage trimming and abscisic acid treatments on percent mortality rate of transplanted guava grafts	66
4.6	Comparative account of Chlorophyll-a content of guava grafts between the month of August, 2023 and July, 2024	69
4.7	Comparative account of Chlorophyll-b content of guava grafts between the month of August, 2023 and July, 2024	71
4.8	Comparative account of total chlorophyll content of guava grafts between the month of August, 2023 and July, 2024	74

LIST OF PLATES

Plate	Title	Page(s)
1.	Foliage trimming of guava nursery plants	22-23

Chapter-1

INTRODUCTION

A member of the Myrtaceae family, the common guava (*Psidium guajava* L.), is known for its rich vitamin C, potassium, fibre, and antioxidants. It is native to tropical America and grows well in all tropical and subtropical regions of the world. The Portuguese introduced it to India in the 17th century. India is one of the leading producers of guava followed by China and Kenya (NHB, Indian Horticulture Database, 2021-22). It is now cultivated in about 307 thousand hectares in India (NHB, 2022) and has become the 4th important crop in terms of area and production after citrus, mango and banana. During the years 2021-2022, India produced 45.16 lakh metric tonnes of guava with Uttar Pradesh having the highest production of 9,83,590 metric tonnes, accounting about for 21.78% of total guava production (Bose and Mitra, 1990). After Uttar Pradesh, Madhya Pradesh, Bihar, Andhra Pradesh, Haryana and Punjab are the major guava-producing states of the country. Himachal Pradesh ranks 24th in production of 3160 tonnes, which is 0.07% of total production in India. In Himachal Pradesh, approximately 2.66 lakh hectares are dedicated to this crop, and further expansion is going on under the “Himachal Pradesh Subtropical Horticulture, Irrigation and Value Addition Project” with the establishment of more and more plantations under high density (Anonymous, 2022).

The concept of guava high density and meadow orcharding has been growing in popularity due to its hardy nature and ability to yield under varied growing conditions. As a result, a substantial quantity of high density of high-quality planting material is required (Padmapriya *et al.* 2021). The planting material of guava is mostly produced through grafting or layering (Singh *et al.* 2004). To obtain plants with robust root systems, the nursery is mostly raised in polyethene bags. The raising of plants in polybags produces better-quality plants, but the transportation of such plants is quite challenging due to the considerable volume, weight, root system and height of the above-grown foliage of each plant. This results in a limited capacity for goods carriers to transport these plants from the nursery site to the planting site. A utility vehicle with a

payload capacity of 1200 to 1500 kg can carry only 300 to 400 plants at a time, due to the tenderness and bulkiness of plants. Approximately 80 to 150 trips of such a vehicle are needed to transport planting material for one hectare to be planted under high density, depending on the orchard planting density, plant size, and poly bag size of the plants. Orchardists spend considerable time, energy, and money on nursery transportation. The carriage of nursery plants not only increases the orchard management cost but also adds to carbon emissions and other environmental concerns. According to recent estimates, goods transport vehicles contribute to a significant portion of vehicular emissions in India, including CO₂, NO_x, SO₂, and PM emissions (Ramachandra and Shwetmala, 2009). According to Gillespie (2022), the atmospheric CO₂ concentration has surpassed 417.2 ppm, exceeding pre-industrial levels by over 50%. Traffic flow emissions are the primary contributors, with transportation activities responsible for a significant portion of CFC, CO₂, and NO_x emissions. The total vehicular CO₂ emission worldwide was 150.43 Gt CO₂ from 1990 to 2022 and the total transport CO₂ emission of India was 4293.263 Mt CO₂ from 2000 to 2021 (IEA, 2023). If current emission levels persist, there is a chance of surpassing the global warming threshold of 1.5°C within the next nine years, which contradicts our efforts to combat climate change. Therefore, it is crucial for businesses, regardless of size, to actively engage in sustainable practices, reduce emissions, and contribute to decarbonization efforts.

The transport of nursery plants is very tedious work and, as discussed above, nursery plants are vital in contributing to fugitive emissions. According to Cambria and Pierangeli (2011), diesel fuel and fertilizer-related emissions are the main environmental burdens in the nursery production of walnut seedlings. Hence, it is imperative to put efforts into curtailing emissions, transport drudgery, and costs. In conjecture to this, it has been speculated that the considerable cost of nursery transport and level of emissions can be reduced by transporting the nursery in a compact state. When it comes to the field survival and growth of the transplanted grafts under actual orchard conditions, root zone compaction of plants may have some limitations because, if done unscientifically, root zone compaction or foliage trimming may be lethal to the plants (Pandey *et al.* 2021). Hypoxia as a result of root zone compaction significantly reduces root activity,

leading to decreased absorption and transport of nutrients and water (Ma *et al.* 2022). Hypoxia has a negative impact on plant growth, cellular metabolism, and various physiological variables, including leaf water potential, stomatal conductance, leaf relative water content, photosynthesis, and the generation/scavenging of reactive oxygen species (ROS) (Habibi *et al.* 2023). But there seems to be a certain possibility through hormonal modification of the plants. Literature suggests that elevating abscisic acid (ABA) levels in plants may prove helpful to the plant's adaptation to various abiotic stresses (Tuteja, 2007). ABA triggers the expression of numerous genes whose products are crucial for stress responses and tolerance, such as enzymes (ABA-aldehyde oxidase or ABA-aldehyde dehydrogenase) for the production of osmoprotectants (such as phaseic acid or dihydrophaseic acid), in addition to its function in controlling stomatal aperture, which is necessary to minimize water loss from leaves during drought conditions (Fujita *et al.* 2011). Furthermore, the external application of abscisic acid regulates abiotic stresses by enhancing chlorophyll content, leaf-relative water content, and proline content (Ramasamy *et al.* 2020). Additionally, it increases root diameter, improving the ability of roots to penetrate through compacted soils (Hartung *et al.* 1994).

Keeping the economic and ecological concerns of guava nursery and orchard management in view, it has been hypothesised that with compaction of the root zone and reduction in foliage of nursery plants under the influence of elevated abscisic acid levels, the volume of the guava nursery can be reduced considerably without impacting the field survival or growth of the transplanted grafts in the field. Therefore, the following objectives guided the design of the current investigations:

1. To evaluate the individual and combined effects of root zone compaction, foliage trimming, and abscisic acid treatments on field survival and growth of guava grafts.
2. To monitor changes in plant physiological and biochemical functions induced due to root zone compaction, foliage trimming, and abscisic acid treatment.

Chapter-2

REVIEW OF LITERATURE

The present investigations entitled **“Effect of pre-transit root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava”** were aimed to develop guidelines for efficient and safe transport of guava grafted plants without imparting much to the orchard management cost, environmental pollution and their field survival and performance. Though, this type of study especially on fruit plant nurseries is rare, however, the relevant literature available on various associated aspects is reviewed under the following heads:

2.1 Carbon emissions associated with nursery production and transport

2.2 Root zone compaction and plant growth

2.3 Foliage trimming and plant performance

2.4 Absciscic acid and plant stress tolerance

2.1 Carbon emissions associated with nursery production and transport

Agricultural sector is one of the major contributors of carbon (C) emissions (Warner *et al.* 2010 and Ruviaro *et al.* 2012), it has now become a focal point in the global effort to combat climate change. Agricultural practices are categorized into primary, secondary, and tertiary sources of pollution based on their C emissions (Gifford, 1984). Primary sources of C emissions are due to mobile and stationary operations involved in farming activities such as tillage, sowing, harvesting, and transport, as well as activities like pumping water and grain drying. Secondary sources of C emissions come from the manufacturing, packaging, and storage of fertilizers and pesticides, while tertiary emissions result from the acquisition of raw materials and fabrication of equipment and farm buildings. Kendall and McPherson (2012) conducted a study on the greenhouse gas inventory of a tree production system in the U.S.A., they found that five standard-sized trees emit about 4.6 kg of CO₂-equivalent (CO₂-eq). The energy usage contribution of all CO₂-eq emissions was 44%, out of which electricity and propane constituted about 78% for irrigation and greenhouse heating. Material inputs account for 36% of emissions, with plastic containers being the primary contributor. Transport emissions constituted 16% of total nursery greenhouse gas

(GHG) emissions, with bamboo stakes shipping from China (43%) and diesel fuel consumed by nursery delivery trucks (33%) being the major sources. Similarly, Warner *et al.* (2010); Russo and Zeller (2008) conducted studies on strawberries and flowers respectively, revealed that diesel fuel and fertilizer-related emissions were the main environmental burdens in nursery production, other research regarding GHG emissions was carried out on cut flower (Rose) and potted plant (Cyclamen) (Russo *et al.* 2007) and on walnut seedlings in a plant nursery (Cambria and Pierangeli, 2011). To mitigate these emissions, it is imperative to improve the efficiency of input use, minimize losses, and adopt more carbon-efficient alternatives. Furthermore, transportation is a critical component of agricultural operations and significantly contributes to global warming due to its substantial GHG emissions and air pollution. The transportation sector, as highlighted by the Inter-governmental Panel on Climate Change (2022), accounted for 15% of all human-caused and 23% of global energy-related GHG emissions in 2019. This sector emitted 8.7 Gt CO₂-eq that year, with projections indicating a potential increase of 16- 50% by 2050 (Jaramillo *et al.* 2022). Despite agriculture, forestry, and other land uses (AFOLU) contributing 13 Gt CO₂-eq in 2019, it is evident that both direct and indirect emissions from agriculture, including those associated with transportation, necessitate urgent attention to mitigate carbon emissions and curb their impact on the environment and human welfare.

2.2 Root zone Compaction and Plant Growth

Under Indian conditions also, the transit of nurseries with earth-ball contributes significantly to the C emission which otherwise can be reduced significantly by curtailing the transport volume of the nursery plants. Reduction in volume of the containerized nursery has thus been expected as one of the easiest ways to reduce the carbon emissions associated with nursery transport the reduction in the volume of earth-ball of the plant grafts/saplings can allow transport of more number of plants per goods transport truck. Compaction of the root zone implies the removal of air pockets from the soil of the root zone. However, compaction of root zone can have several pedological implications. Soil compaction increases soil bulk density and resistance to plant root penetration while reducing soil pore diameter, permeability, water flow, and air capacity (Blouin *et al.* 2008; Bejarano *et al.* 2010; Boja and Boja 2011; Lipiec *et al.*

2012). Kormanek et al. (2015) discovered that soil with unfavourable density parameters (ranging from 0.81 to 1.32 g cm⁻³) inhibits seedling root growth and may restrict their maximum penetration depth. Similarly, a reduction in the growth of *Quercus alba* seedlings in response to changes in soil bulk density from 1.0 to 1.5 g cm⁻³ (Tworkoski et al. 1983). Furthermore, Ferree et al. (2004) found that increasing soil bulk density to 1.5 g cm⁻³ reduced shoot length, leaf area, and dry weight of apple trees in containers. After 60 days of growth, there was a decrease of 13% in net photosynthesis (Pn) and 19% in transpiration (E). Also, the rise in soil bulk density led to a reduction in the concentration of quinic acid, myoinositol, and sucrose in the leaves, along with an increase in fructose and glucose levels. In certain situations, particularly on skeletal soils, high bulk density has been reported to have a beneficial impact on plant growth (Brais, 2001, Fleming et al. 2006, and Miransari et al. 2009). This positive effect is reported to be due to the improved contact between the roots and the soil, which enables better absorption of water and nutrients (Arvidsson, 1999).

Numerous investigations have highlighted that soil compaction induces varying degrees of decline in growth and yield across a wide array of plant species. The performance of the below-ground portion, namely roots, ultimately governs the growth and development of above-ground crop plants. Nonetheless, the soil conditions within the root rhizosphere predominantly regulate the performance of these roots (Trowse, 1977). Depending on the extent to which the soil has been compacted along with how much its characteristics have changed, the relationship between roots and soil compaction may be complicated. Reductions in root growth may be related to decrease nutritional bioavailability, high soil penetration resistance from compacted soil, and mechanical damage to taproots (Rosolem et al. 2002). It is commonly known that once soil penetration resistance surpasses 2 MPa pressure, root penetration is substantially impeded, and beyond this threshold, roots are essentially unable to proliferate (Taylor et al. 1966). Similarly, a study was conducted by Huang et al. (2022) on rice to investigate the mechanisms by which ethylene inhibits root elongation in compacted soil through ABA and auxin. They found that roots use ethylene to detect soil compaction, which inhibits root elongation and promotes radial expansion. Ethylene promotes ABA biosynthesis and cortical cell radial expansion. Ethylene uses auxin and ABA as downstream signals to modify rice

root cell elongation and radial expansion, causing root tips to swell and reducing their ability to penetrate compacted soil.

Several studies have indicated that soil compaction can lead to reduced water uptake, resulting in decreased stomatal conductance and higher accumulation of abscisic acid (ABA) in roots (Tardieu *et al.* 1992). Consequently, this phenomenon may trigger a decline in the root/shoot ratio, thereby impacting the rate of carbon assimilation. A deficiency in root sink activity may lead to the accumulation of carbohydrates in leaves, leading to a reduction in the carbon fixation rate (Arp, 1991). Severe soil hardness can also impede photosynthesis either through stomatal or non- stomatal inhibition. Additionally, compacted roots may encounter anaerobic conditions due to insufficient aeration and increased respiration, thereby hampering plant growth and development. The compaction of the root zone may induce hypoxia (a condition of reduced oxygen level) in the plant roots which impairs aerobic processes of the rhizosphere besides affecting water and nutrient uptake. Bai *et al.* (2010) investigated the responses of *Malus* sp. (*M. hupehensis* and *M. toringoides*) to hypoxic conditions, noting distinct differences in antioxidant responses and growth patterns. *M. toringoides* exhibited a more pronounced reduction in leaf number (50%) and root length (40%) compared to *M. hupehensis* (13% leaf reduction and 15% root reduction). Alameda and Rafael (2009) expanded this understanding by studying moderate soil compaction's effects on various woody species, finding that 41% of species (7 out of 17) showed increased relative growth rates with soil penetration resistance.

Arismendi *et al.* (2015) delved into the molecular mechanisms of hypoxia response in *Prunus* sp. rootstocks, identifying key genes associated with adaptive pathways. They found exclusive differential gene expression in each genotype, with the tolerant genotype exhibiting a moderate reduction in CO₂ assimilation compared to the sensitive genotype. The metabolic responses of *Phyllostachys praecox* to hypoxia stress, highlighting decreased root activity, elevated levels of ethanol, acetaldehyde, and lactic acid, and identifying glycerophospholipid metabolism as a significant pathway. The study conducted on *Phyllostachys praecox* cell membrane response to hypoxia stress, gave insights for productivity improvement (Ma *et al.* 2022). Finally, Habibi *et al.* (2023) provided a

comprehensive overview of hypoxia as a significant abiotic stressor in fruit trees, elucidating adaptive strategies ranging from anatomical adaptations such as adventitious root development to biochemical adjustments in respiration pathways. These studies collectively highlight the diverse mechanisms plants employ to cope with hypoxia stress, providing valuable insights into plant resilience and adaptation in dynamic environments.

In maize, soil compaction has been observed to decrease the rate of carbon assimilation, particularly during early growth stages. The primary consequence of soil compaction on assimilates partitioning predominantly affects carbon exudation, significantly favouring root carbon depletion (Tubeileh *et al.* 2003). The sensitivity of the root system architecture to the high mechanical impedance of soil can cause damage in photosynthesis, water relations, and shoot growth by soil compaction (Tubeileh *et al.* 2003). A reduction in stomatal conductance may elevate xylem sap ABA levels, which can lead to a reduction in leaf expansion of soil compaction-stressed plants (William *et al.* 1994). In summary, soil compaction can exert a considerable influence on the physiological growth of plants, particularly affecting root development and carbon assimilation.

Absciscic acid (ABA) is a pivotal factor in controlling plant responses to water stress and soil compaction (Hussain *et al.* 2000). Tardieu *et al.* (1992) conducted a study on field-grown maize (*Zea mays* L.) subjected to soil compaction and the role of ABA in controlling stomatal conductance. They found that the concentration of ABA in the root tips of maize increased significantly when seedlings were grown on compacted soil. With the increase in ABA level, the stomatal conductance decreases. However, Lachno *et al.* (1982) and Moss *et al.* (1988) failed to detect any increase in ABA concentration in impeded roots of maize. Moreover, Barley plants of the wild-type (Steptoe) and absciscic acid (ABA)-deficient mutant (Az34) genotypes were grown in compacted soil to investigate the role of ABA as a root-to-shoot signal. The results showed that when plants were grown in compacted soil (bulk density of 1.7 g cm^{-3}), their root and shoot growth, as well as leaf conductance, were reduced, relative to uncompacted control plants (1.1 g cm^{-3}). Analysis of Steptoe and Az34 xylem sap revealed that ABA concentration was greatly increased in compacted soil, which was closely correlated with reductions in leaf conductance. The study

suggested that ABA might have played a role as a root-to-shoot signal mediating effects owing to compaction stress (Mulholland *et al.* 1996).

Soil compaction has a significant impact on root system architecture which is crucial for crop growth. This study examined the role of abscisic acid (ABA) in mediating root responses to soil compaction using tomato genotype (*Solanum lycopersicum* L. cv. Ailsa Craig) with different ABA concentrations. Results showed that increased bulk density reduced root volume, surface area, depth, and lateral root number, negatively affecting root system architecture. The ABA-deficient mutant *notabilis* had lower root volume and surface area at all bulk densities. Endogenous ABA concentration has a positive influence on root system architecture when roots encounter compacted soil (Tracy *et al.* 2013).

2.3 Foliage Trimming and Plant Performance

Several studies have evaluated the effects of foliage trimming on the growth and performance of various crops. Sheikh and Hulmani (1997) observed that severe pruning of guava plants during January led to greater shoot growth and leaf area by April and August compared to mild or no pruning. Similarly, Anez (1998) further investigated the impact of pruning on guava clones Mara 6 and Mara 8, and observed varying monthly increments in shoot length (between 4 cm to 24 cm), with severe pruning resulting in the highest increase. In another study, the impact of different pruning levels on guava cv. Sardar, revealed that pruning at 30 cm produced the highest net increase in stem girth (6.8 cm), canopy volume (19.53 m³), and shoot length (8.4 cm) during the winter season (Dhaliwal and Singh 2004). Rojas (1997) experimented on *Citrus latifolia* plants and discovered that pruning either half or one-third of the branch length significantly increased canopy surface area and diameter, particularly on young and vigorous twigs. Contrarily, Yu *et al.* (2002) when exploring the impact of shoot and root pruning on Chinese fir and Masson pine bare-root seedlings noted significant consequences for root growth. For Masson pine, removing half the foliage resulted in a 53% decrease in the total number of new roots and a 56% decrease in the number of new roots greater than 1 cm, with Chinese fir also similar trends were observed. This study suggested that shoot pruning negatively impacts root development, particularly in Masson pine.

Dhaliwal *et al.* (2013) studied the effect of pruning on Kinnow (*Citrus*

reticulata) plants, discovering that specific pruning level (at a 6 feet level) resulted in the highest shoot growth (1.26 m), which was over 50% higher compared to plants with normal growth. They also observed that plants pruned at an 8-feet level had the highest increase in shoot girth (2.60 cm) from July to August. The maximum number of leaves (39.6) was found in plants pruned at 6 feet from the ground level, and the highest number of buds (57) was counted in plants pruned at the height of 6 feet from the ground level. Additionally, they reported that pruning kinnow trees at an 8-feet level resulted in the maximum mean chlorophyll-b (0.68 mg/gm) content. The beneficial effect of post-flooding pruning on avocado tree recovery is improved physiological parameters (like CO₂ assimilation, transpiration, water vapour conductance, and sap flow) and balanced shoot-to-root ratios (Sanclemente *et al.* 2014). Additionally, Yeboah *et al.* (2016) investigated the influence of root and shoot pruning on field establishment and growth of overgrown Cashew (*Anacardium occidentale* L.) seedlings, suggesting specific pruning practices can influence growth characteristics like, seedlings defoliated and root pruned before transplanting resulted in shorter plants (height ranged between 61.7 and 62.4 cm) with shorter stems (girth was between 17.7 and 17.9 mm). Conversely, when the impact of pruning was examined on guava cv. Sardar under an Ultra High-Density Orchard System, no significant difference between different pruning treatments on trunk girth and photosynthesis rate was observed (Mehta *et al.* 2012).

Several studies have evaluated the effects of pruning on the number of shoots of various fruit trees, including guava, and custard apple. Bhagawati *et al.* (2015) investigated the effects of pruning intensities on fruit plant performance in guava under the mid-hill conditions of the eastern Himalayas, finding that light pruning resulted in the highest number of shoots per pruned shoot (7.10), followed by moderate (5.86) and severe pruning (4.81). Moreover, severe pruning led to the highest cumulative length of new shoots (32.81 cm), followed by moderate (27.11 cm) and light pruning (25.12 cm). Similarly, the impact of various pruning levels on custard apple trees (*Annona squamosa* L.) cv. Dharur-6. Their study encompassed six pruning treatments (5 cm, 10 cm, 15 cm, 20 cm, 25 cm, and control) applied after harvesting the previous year's fruits, revealing that pruned trees exhibited earlier emergence of shoots compared to unpruned ones (Kadam *et al.* 2018). These studies collectively underscore the significance of pruning in

shaping fruit tree growth and performance across different environmental conditions and species. Moreover, research conducted by Islam *et al.* (2008) and Adhikari and Kandel (2015) on bakphul (*Sesbania grandiflora* L.) and Guava cv. L-49 highlighted the significance of pruning methods and timing on leaf production and fruit quality, indicating severe pruning can enhance shoot biomass and leaf development within a short period, ultimately influencing overall plant growth and productivity.

Various studies have highlighted the role of pruning in enhancing flowering and flower numbers in fruit trees. For instance, Kumar *et al.* (2005) found that light pruning in peach cultivars such as Sharbati, Flordasun and Prabhat resulted in early flowering and increased flower numbers. Similarly, the effects of plant spacing and pruning intensity on guava trees that the greatest number of flower emergence per plant (ranging from 140.75 to 146.75) was observed with a plant spacing of 2.0m x 2.0m, along with a three-fourths (3/4) shoot pruning treatment (Prabhakar, 2016). Jadav *et al.* (2009) demonstrated the impact of spacing and pruning severity on drumstick cv. PKM-1 yield, and found that wider planting distance (3×3 m) with a pruning height of 90 cm from ground level significantly affected the number of branches per plant (8.88) and increased the plant height in drumstick cv. PKM-1. The lower pruning height (90 cm) of the branch (6.13 m) resulted in significantly greater branch diameter (5.52 cm) as compared to a higher level of pruning height, i.e., 120 cm from ground level.

Several studies have evaluated the effect of pruning on the growth of nursery plants. An experiment is conducted on *Liriodendron tulipifera* seedlings to investigate the effect of shoot and root pruning. They found that shoot pruning to 10 cm and root pruning to 20 cm resulted in significantly better growth (Sterling and Lane 1975). Similarly, Song and Song (1982) concluded that lighter toppings significantly improved the growth and quality of *Populus tomentosa*. They found that for better growth and quality in field nursery, the best pruning intensity was 40 percent, which gave an increase of 77.3 percent in plant height compared to 61.4% for at full length cut, and 54.2% for the controls. Bhardwaj *et al.* (2002) found that when pruning was done at 6cm above the collar in *Celtis australis* seedlings resulted in maximum height (61.94 cm). In a similar study, different pruning levels (30cm, 40cm, 50cm and unpruned) were found to significantly

influence the growth and microclimatic characteristics but were found non-significant for the biochemical characteristics (chlorophyll content) of one-year-old mango plants. The most effective pruning method involved head back at 40 cm, followed by 50 cm and 30 cm cuts. Pruning done at 40 cm results in better shoot length, take minimum days for bud emergence and number of shoots per branch. The highest relative water content (93.63%) was found in the control and the lowest (90.13%) was found in the treatment of the head back at 40 cm (Pathania, 2020). Another study was carried out in young apple trees and found that pruning at 40 and 60 cm positively affected the feathering of treated trees (Gudarowska *et al.* 2006).

2.4 Absciscic Acid and Plant Stress Tolerance

Absciscic acid (ABA) is a phytohormone that plays a crucial role in various physiological processes in plants, particularly in response to stress. Abiotic stress resistance in plants is regulated by absciscic acid (ABA), which coordinates various functions (Finkelstein, 2013; Wani and Kumar 2015) to enable plants to cope with different stresses. Absciscic acid is a sesquiterpene that helps develop and mature seeds, synthesize proteins, produce compatible osmolytes, and as a general inhibitor of growth and metabolic activities (Srivastava, 2002). ABA regulates plant growth and development by modulating processes such as seed dormancy, germination, stomatal closure, and response to environmental stresses like drought, salinity, and cold temperatures (Swamy and Smith 1999). Long-distance transport of ABA primarily occurs in the phloem, with a lower degree of transport occurring in the xylem (Jiang and Hartung 2008). When plants experience stress, ABA levels increase, leading to stomatal closure to reduce water loss through transpiration, thus helping plants conserve water. Additionally, ABA promotes the accumulation of osmoprotectants and antioxidants, which help plants to tolerate adverse conditions. Moreover, ABA is involved in regulating gene expression related to stress responses, facilitating adaptive mechanisms that enable plants to survive and thrive in challenging environments. Overall, ABA plays a pivotal role in modulating plant responses to environmental stresses, contributing to their resilience and survival.

Plants absorb exogenously applied ABA through the leaf's waxy layer by cuticular penetration, via stomata or membrane transporters into leaf cells, and

symplastic transport between cells (Shindy *et al.* 1973; Middelberg *et al.* 2014). ABA moves systemically through the phloem to have widespread effects (Zeevaart and Boyer 1984). The initial entry into the leaf is facilitated by cuticle permeation and stomatal uptake, while controlled uptake into leaf cells is ensured by membrane transporters. Symplastic transport allows ABA to spread within leaves, coordinating physiological responses. Systemic transport via the phloem enables ABA to influence distant tissues. These mechanisms optimize ABA's absorption, distribution, and systemic action, which are crucial for plant stress responses and growth regulation. A study conducted by Friedlander *et al.* (1977) aimed to investigate the mechanism of uptake, transport, and stability of [2-14C] abscisic acid in cucumber following foliar application. These studies revealed that 4 hours after application, 70% of the ABA was taken up by the abraded leaf while only 15% penetrated the uninjured one. After 24 hours, uptake reached 90% in the first case, while, in the second case, it was not more than 40%.

Various studies have been conducted to study the effect of ABA on plant growth and development. Tuteja (2007) provided a comprehensive review of the role of ABA in integrating stress signals and coordinating stress responses in plants, emphasizing the importance of understanding ABA-dependent and ABA-independent processes with a focus on transcription factors like DREB2A/2B, AREB1, RD22BP1, MYC, and MYB, which regulate ABA-responsive gene expression for enhancing stress tolerance in crops. Moreover, Tardieu *et al.* (2010) proposed three main effects of ABA on plant growth: 1) Via its controlling effect on stomatal aperture and transpiration rate, an increased concentration of ABA tends to buffer the day-night alternations of leaf growth rate and the negative effect of evaporative demand; 2) ABA tends to improve leaf growth via an increase in the conductance to water transfer in the plant as a result of increased tissue hydraulic conductivity; and 3) ABA also has a modest non-hydraulic effect that is negative in plants subjected to water deficit, either manipulated for ABA synthesis or fed with artificial ABA, but can be positive in well-watered plants deficient in ABA, highlighting its diverse roles in plant response to water regime. Similarly, an experiment was conducted on *Ilex paraguariensis* to explore the effect of foliar application of ABA on plant growth by reducing diurnal water stress. They found that ABA treatments resulted in stomatal closure, ranging from 62% to 73%. Furthermore, these treatments

elevated the Relative Water Content (RWC) in the early evening, reaching from 82% to 92% in mature leaves and from 88% to 94% in immature ones. This resulted in enhanced leaf expansion, indicating an increase in growth. Essentially, the new leaves and shoots of the ABA-treated plants exhibited greater growth compared to those of the untreated control plants. These results demonstrate that ABA sprayed onto leaves promotes growth in *I. paraguariensis* plants by reducing diurnal water stress (Sansberro *et al.* 2004).

Several studies have evaluated the impact of exogenous abscisic acid (ABA) on regulating abiotic stress. Meng *et al.* (2008) investigated the effects of exogenous ABA and low temperature on leaf carbohydrate metabolism in cucumber cultivars, namely Guonong No.25 (a cold-tolerant cultivar) and Guonong No.41 (a cold-sensitive cultivar), it was observed that on the 3rd day after the treatment, the 150 μ M ABA-treated seedlings had 1.9, 1.7, and 1.6 times higher levels of stachyose, raffinose and glucose, respectively, compared to the untreated seedlings (0 μ M ABA). Another study carried out to investigate the role of exogenous application of ABA in regulating drought stress in apple rootstocks (*i.e.* *Malus sieversii* (Ledeb.) Roem. and *Malus hupehensis* (Pamp.) Rehd.), showing that both Leaf Relative Water Content (RWC) and leaf water potential were higher in *Malus sieversii* as compared to *Malus hupehensis* with ABA application (Zhang *et al.* 2014). Similarly, Wang *et al.* (2016) explored the impact of exogenous ABA on abiotic stress and fruit quality in grapes, and found that spraying ABA significantly reduced lipid peroxidation and electrolyte leakage while boosting the activity of superoxide dismutase and peroxidase. The concentration of proline and soluble sugars exhibits a substantial increase, reaching its peak at 30 days after veraison (DAV), and gradually decreasing by 50 DAV compared to 0 DAV. It is noteworthy that the highest concentrations of proline and soluble sugars were observed in treatments sprayed with 250 and 300 mg/L exogenous ABA throughout the entire experiment. Conversely, Mahouachi *et al.* (2012) investigated the effects of foliar glycine betaine (GB) and ABA on papaya's response to water stress. Water stress induced the accumulation of ABA, jasmonic acid (JA), and proline while reducing photosynthetic rate, stomatal conductance, leaf water status, and growth. ABA pretreatment did not significantly affect physiological responses to drought, but in combination with drought, it induced progressive JA synthesis.

Absciscic acid acts as a negative growth regulator, playing a crucial role in helping plants adapt to harsh environmental conditions such as drought, cold, pathogen infection, and salinity (Ueno, 1998; Albinsky *et al.* 1999; Mahajan and Tuteja 2005; Tao *et al.* 2011; Saeedipour 2012; Zhang *et al.* 2012). Under salinity, the accumulation of absciscic acid follows a cell signalling process that involves stress signal perception, cellular signal transduction, and regulation of gene expression encoding key enzymes in ABA biosynthesis and catabolism (Zhang *et al.* 2016). This phytohormone exhibits inhibitive functions in high concentrations under salinity, protecting plant development by inhibiting processes such as stomatal opening and plant size expansion (Mauch-Mani and Mauch 2005 ; Rai *et al.* 2011). Moreover, ABA inhibits ethylene production, a growth inhibitor under stress. In low concentrations, ABA promotes vegetative growth in several tissues, such as root growth and post-germination seedling development. In seeds, ABA modulates the biosynthesis of storage components such as lipids and proteins. The amount of active ABA is regulated by synthesis, conjugation, and hydroxylation. A homeostasis mechanism attends to several aspects of ABA metabolism, preventing excess ABA accumulation and matching ABA concentration to the type and severity of stress in exposed plants (Verslues and Bray 2006). Noaman *et al.* (2002) studied the role of absciscic acid in acclimation to salt stress. According to Parida and Das (2005), a pre-treatment with ABA can enhance tolerance to salt shock. Similarly, Bano (2010) conducted a study to analyze the variation in ABA content in xylem sap and leaves of three rice cultivars: BAS-385 (salt-sensitive), BG-402 (moderately tolerant), and NIAB-6 (tolerant) under salinity stress (1.2 dS/m NaCl). The study found that the concentration of xylem ABA significantly increased, reaching its peak in the salt-sensitive cultivar much earlier (24 hours of salt treatment) than in other cultivars. However, the ABA accumulation was delayed and the magnitude of ABA accumulation was greater in both moderately tolerant and tolerant cultivars. The xylem flux of ABA followed a similar pattern. When exposed to salt stress, the free ABA content in leaves increased in all varieties, but the magnitude of this increase was greater (about two times the basal level) in the salt-sensitive cultivar 48 hours after salt treatment. The study suggests that the basal levels of ABA and cytokinin play an important role in determining the response of a variety to salt stress.

McArtney *et al.* (2014) experimented on apple to study the effect of S-abscisic acid and (+)-8'-acetylene abscisic acid on fruit set and stomatal conductance (g_s). They observed that in 'Morganspur Delicious'/MM.111 stomatal conductance decreased to 60% within 3 hours of application of either 250 mg L⁻¹ ABA or 25 mg L⁻¹ (+)-8'-acetylene ABA as compared to control and it did not begin to recover until 4 days after application. The recovery of g_s was gradual with some inhibition still evident 19 days after application. Leaf g_s had completely recovered by 21 days after application of either ABA or (+)-8'-acetylene ABA. Ramasamy *et al.* (2020) experimented on tomato (*Solanum lycopersicum* L.) to study the effect of foliar spray of Absciscic acid (0 and 100 mM) and Selenium (0 and 50 mM) on drought mitigation. They found that ABA treatment significantly improved the relative water content ($89.57 \pm 1.24\%$, $60.48 \pm 1.37\%$) and chlorophyll levels (11.12 ± 0.51 mg/g, 07.71 ± 0.58 mg/g) of seedlings compared to control, a similar result was found in proline (18.12 ± 0.91 mg/g FW, 07.98 ± 0.40 mg/g FW). Moreover, the application of synthetic ABA (1 μ M ABA) increased root diameter, enhancing the ability of plant roots to penetrate through compacted soil (Hartung *et al.* 1994). A study by Mulholland *et al.* (1996) found that the roots of ABA-deficient mutant plants were significantly thinner than those of wild-type plants, indicating that ABA plays a critical role in determining root diameter. Additionally, ABA-deficient mutants were used to demonstrate that ABA is involved in inducing drought-stress genes (Pilet, 1998). During periods of high transpiration, ABA concentrations in root xylem and resistance to water movement from soil to roots both increase in response to soil compaction (Tardieu, 1994). Stypa (1987) also observed increased ABA content in stunted roots and shoots of maize grown in compacted soil under laboratory conditions. Moreover, de Campos *et al.* (2011) conducted a study to analyze how high levels of endogenous proline affect water relations, gas exchange, and antioxidant enzymatic activity in the leaves of transgenic 'Swingle' citrumelo rootstocks. These rootstocks were transformed with the P5CSF129A gene, which codes for the key enzyme responsible for proline synthesis, under water deficit. The study found that the presence of high levels of proline in these plants (up to 130 μ mol /g FW) led to osmotic adjustment, which was not observed in non-transformed controls.

Chapter-3

MATERIALS AND METHODS

To address the objectives of the research problem entitled “**Effect of pre-transit root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava**”, field experiments were conducted at the experimental and nursery orchard of the Department of Fruit Science, College of Horticulture and Forestry, Neri, Hamirpur, Himachal Pradesh during the year 2023 and 2024. The details of the materials used, techniques and experimental method followed during the course of the investigation are explained in this chapter under the following heads:

3.1 General description of the study area

3.1.1 Location of the experimental site

The guava nursery and experimental orchard is located at 31°41'43" North latitude and 76°27'56" East longitude, respectively. The experimental site where planting of the treated guava grafts was undertaken is situated at an altitude of 650 m above mean sea level on a West-facing sloppy terrain.

3.1.2 Weather and Climate

The experimental area is situated in the sub-tropical zone of Himachal Pradesh; it experiences hot summer during May and June followed by monsoon season from July to September. Winters are cold during December and January in this area. The average temperature of the area often rises above 40°C during summer, and may drop below 0°C in winter which is mostly accompanied with winter frost. This zone receives an average annual rainfall of 100-120 cm, the major amount of which is received during the rainy season.

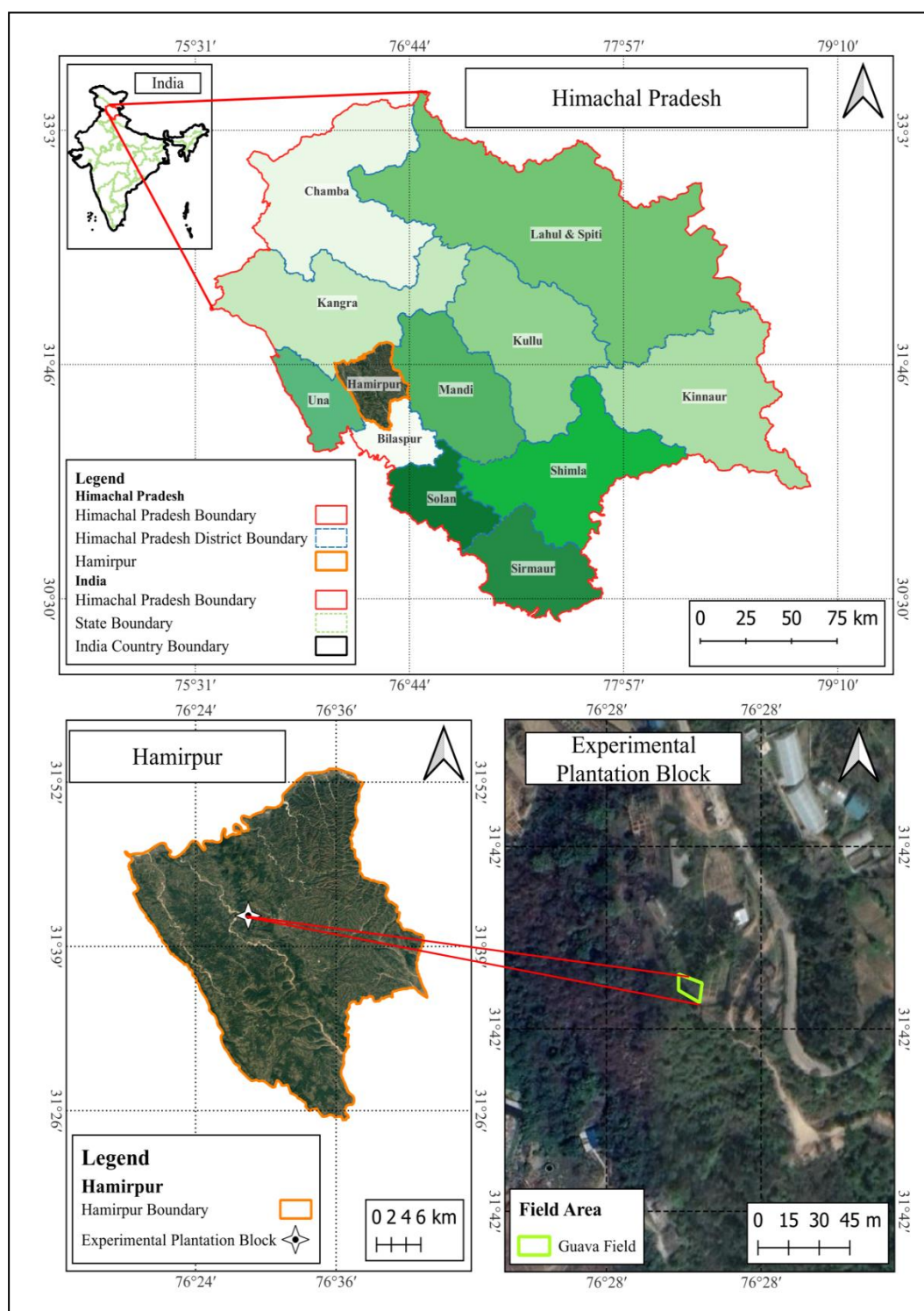
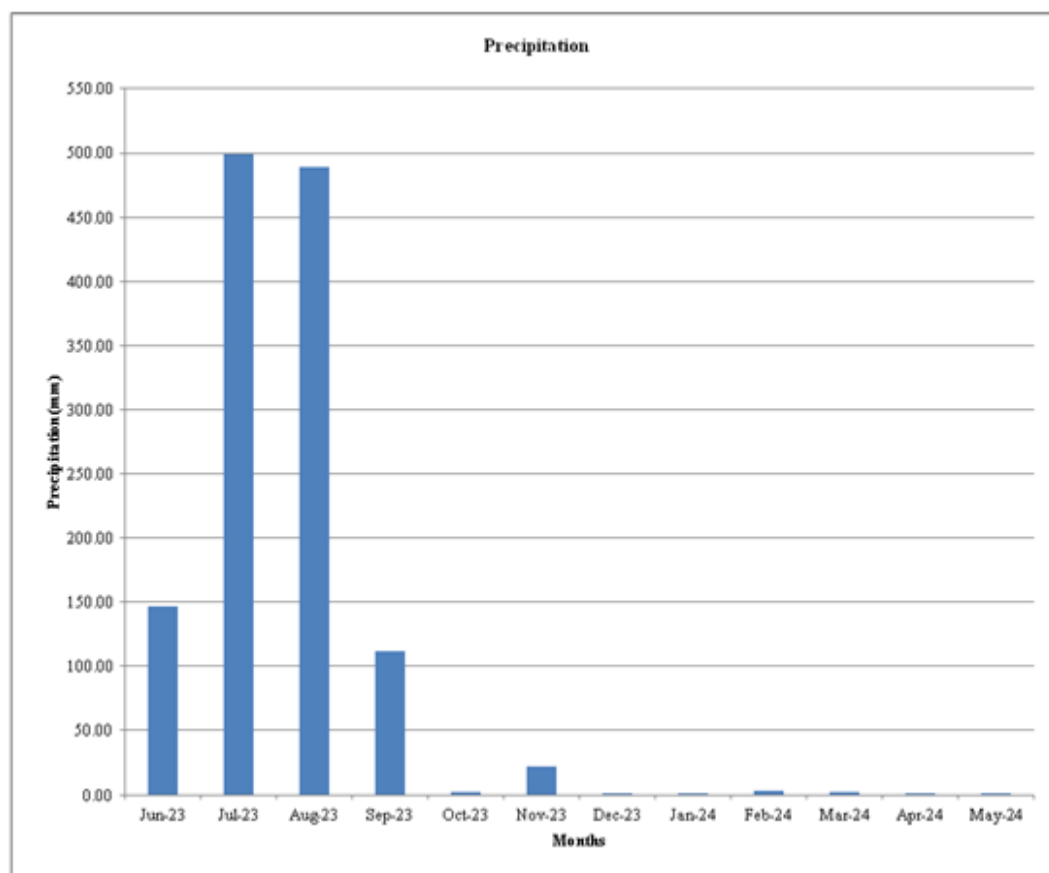
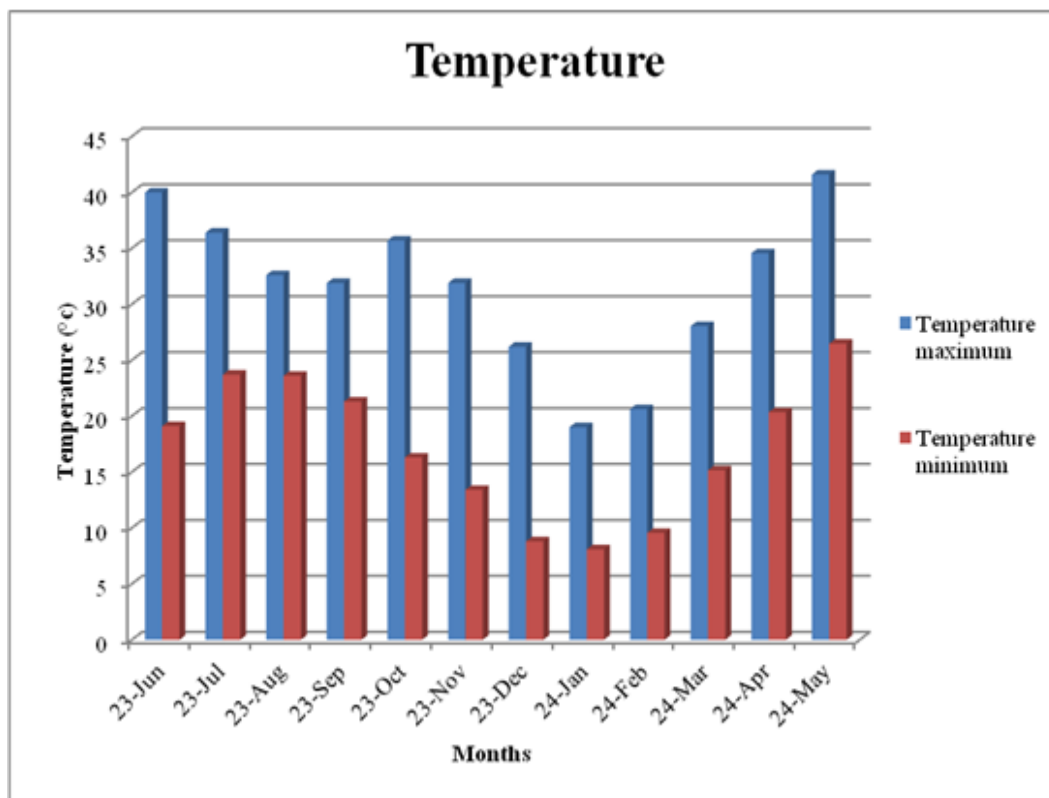


Fig 3.1 Location of Study Site



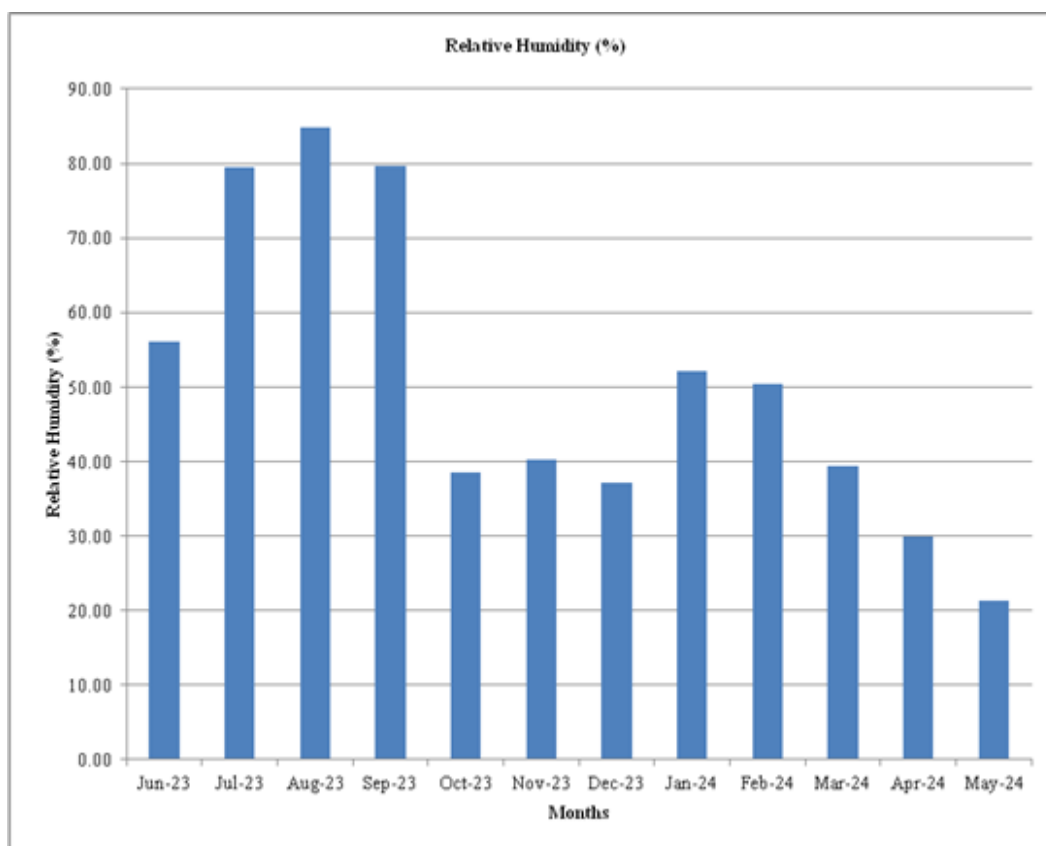


Fig 3.2 Meteorological data of COHF, Neri from June 2023 to May 2024

3.1.3 Physico-chemical properties of root zone media

Table 3.1 Physico-chemical characteristics of root zone media of the nursery plants

Sr. no.	Parametres	Observations
1.	Bulk Density (g cm^{-3})	1.46 g cm^{-3}
2.	Particle density (g cm^{-3})	2.39 g cm^{-3}
3.	Soil Porosity (%)	39.10 %
4.	Soil Organic Carbon (%)	0.76 %
5.	Soil pH	8.47
6.	Electrical conductivity (dSm^{-1})	0.14 dSm^{-1}
7.	Available Nitrogen (kg ha^{-1})	$211.85 \text{ kg ha}^{-1}$
8.	Available Phosphorus (kg ha^{-1})	7.03 kg ha^{-1}
9.	Available Potassium (kg ha^{-1})	$148.41 \text{ kg ha}^{-1}$

3.1.4 Soil

The soil type in the experimental area, where transplanting of treated grafts was done is sandy loam with a pH of 7.02, electrical conductivity (0.17 dS m^{-1}) and organic carbon (0.89 %); whereas available nitrogen, phosphorus, potassium contents of the soil were 213.15, 15.37 and 136.4 kg ha^{-1} , respectively.

3.1.5 Experimental details

The present study was carried out on the one-year-old guava grafts of cultivar ‘Lalit’ raised on seedling rootstock in polybag of size height 13 cm, diameter 11 cm. The grafts of uniform vigour and size were selected, from the nursery lot and maintained under polyhouse conditions. When these grafts attained sale-able size, these were shifted out from the polyhouse to the open nursery conditions during the first week of July. After about one month, different treatments were applied to these grafts as per following details:

Crop	Guava (<i>Psidium guajava</i> L.)
Cultivar	Lalit

Treatment details:

Treatment Factors	Treatment Level
(I) Rootzone compaction	C ₁ = 50% reduction in polybag diameter keeping its length and height constant.
	C ₂ = 25% reduction in polybag diameter keeping its length and height constant.
	C ₃ = 0% (no compaction of polybag).
(II) Foliar trimming	P ₁ = 50% reduction in foliage (height and spread).
	P ₂ = 25% reduction in foliage (height and spread).
	P ₃ = 0% (no foliage trimming).
(III) Hormonal (ABA) treatment	A ₁ = 100 ppm.
	A ₂ = 0 ppm (water spray).

Total number of treatment combinations: 18

		A					
		A₁			A₂		
		P₁	P₂	P₃	P₁	P₂	P₃
C	C₁	A ₁ P ₁ C ₁	A ₁ P ₂ C ₁	A ₁ P ₃ C ₁	A ₂ P ₁ C ₁	A ₂ P ₂ C ₁	A ₂ P ₃ C ₁
	C₂	A ₁ P ₁ C ₂	A ₁ P ₂ C ₂	A ₁ P ₃ C ₂	A ₂ P ₁ C ₂	A ₂ P ₂ C ₂	A ₂ P ₃ C ₂
	C₃	A ₁ P ₁ C ₃	A ₂ P ₂ C ₃	A ₁ P ₃ C ₃	A ₂ P ₁ C ₃	A ₂ P ₂ C ₃	A ₂ P ₃ C ₃ (Control)

Number of replications

5

Experimental Design

RBD Factorial

After application of treatments, the plants were maintained under the same nursery condition for one week and were not given any additional irrigation or any other cultural operations. After one week, these plants were transported to the field by a utility vehicle for further transplanting in the orchard. The transplanting of these experimental grafts was under taken in the field in already prepared pits of size 1×1×1 m³ filled with soil and FYM mixture (1:1 ratio). The layout of planting was terrace planting having a distance of 3 metres from terrace to terrace and 2 metres from plant to plant. The experimental plants were provided recommended doses of manures (1 kg/plant) in December and fertilizer (22g urea/plant, 50g single super phosphate/plant, 30g muriate of potash/plant) in two split doses during the month of September and February. The orchard was kept weed-free throughout the period of experimentation. The experimental plants were irrigated regularly at weekly intervals with the same of quantity of water.

3.2 Experimental methods

3.2.1 Root zone compaction:

For compaction of the root zone a special tool was designed as shown in figure below. This tool comprised of a wooden platform to which a up and down movable compression lever with a wooden compression head was attached. The height of the compression lever was adjustable according to the thickness of the

polybag. For undertaking the compression treatments, the polybag raised grafts were irrigated to saturation level. The diameter of the polybag was reduced by 25% or 50% as per the treatment details using the above mentioned compression tool. The root zone compaction operation was done in a single day during the first week of August, 2023.

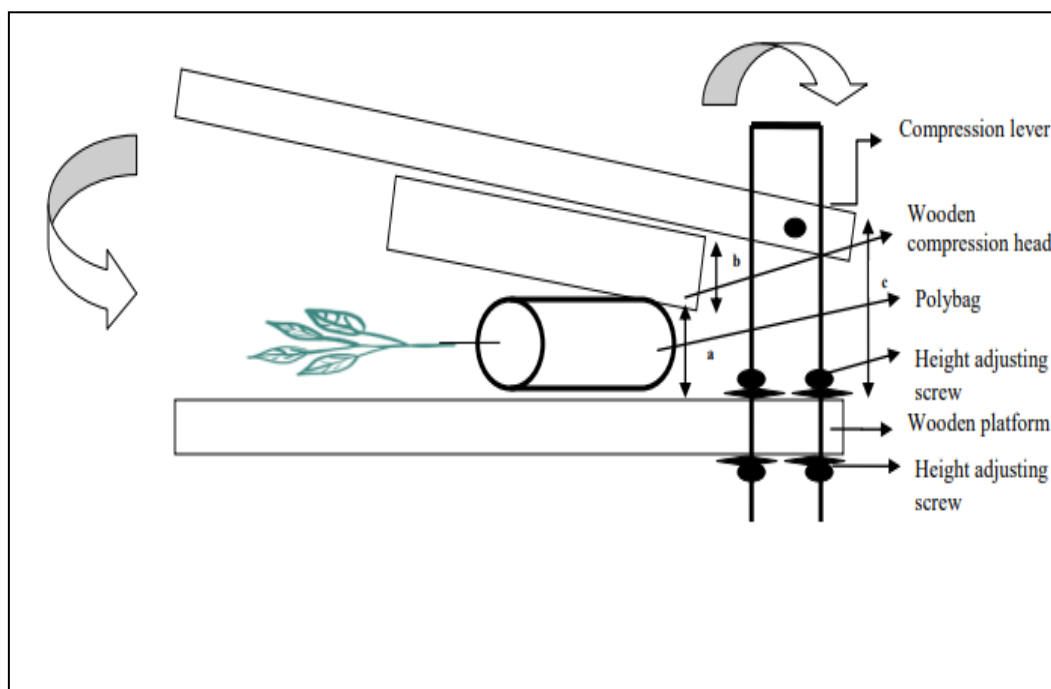


Fig 3.3 Root zone compaction tool

3.2.2 Foliage trimming:

The foliage of the ready to sale experimental guava grafts was reduced by 25% and 50% by cutting down the height and spread of the grafts to 75% and 50% of the initial physical height and spread. The foliage trimming was done during a single day during first week of August, 2023.

3.2.3 Absciscic acid treatment:

Preparation of Plant Growth Regulator Solution:

The solution of 100 ppm strength of ABA was prepared by dissolving 100 mg of abscisic acid (Analytical Grade, extra pure, Brand- Ottokemi) in a minimum quantity of absolute alcohol and then the volume was made to 1000 ml by adding the required quantity of distilled water.

Methods of Application

Foliar application of abscisic acid was done with the help of a hand sprayer during first week of August as detailed under section 3.1.4. Before spraying, 0.5ml

of wetting agent (Brand name - Stikker Plus) was added per liter. To get the best results, the spraying operation was carried out early in the morning during a clear and calm weather on the same day on which the root zone compaction and foliage trimming was done.

3.3 Observation recorded:

A. Physical and physiological parameters:

i. Number of leaves

The total number of fully-emerged leaves was counted at monthly intervals after transplanting of the treated grafts in the field.

ii.Plant height

Plant height was measured using a measuring tape from ground level to the topmost shoot tip of the plant at monthly intervals and expressed in centimetres (cm).

iii.Plant girth

The girth of each experimental plant was measured 5 cm above the ground level using digital vernier calipers at monthly intervals. The measured girth was expressed in the millimetres (mm).

iv.Stomatal conductance

Stomatal conductance of plants was recorded during the morning hours 10:00 AM to 12:00 PM, 3 days before and after the application of the treatments in July, 2023 and August, 2023 with the help of Infra-red Gas Analyzer (IRGA) (Model- LI6400, Make- LI-COR USA). It is expressed in $\text{mol m}^{-2}\text{s}^{-1}$. The stomatal conductance was also recorded in July, 2024 when the grafts were fully established.

v. Rate of transpiration

The transpiration rate of plants was recorded with the help of above said IRGA instrument described as above and expressed in $\text{m mol m}^{-2}\text{s}^{-1}$. The time of measurement was same as these were for stomatal conductance.



P₁: 50% Foliage trimming



P₂: 25% Foliage trimming



P₃: Control (0% foliage trimming)

Plate 1 Foliage trimming of guava nursery plants

vi. Photosynthetic activity

The photosynthetic activity of plants was recorded with the help of above said IRGA instrument described as above and expressed in $\mu\text{mol m}^{-2}\text{s}^{-1}$. The time of measurement was same as these were for stomatal conductance.

vii. Leaf relative water content (RWC)

For measuring the RWC, fresh leaves were weighed and then these were soaked in distilled water at 25°C for 4 hours and weighed again to record the turgid weight. Then the leaves were oven-dried at 80°C for 24 hours to determine dry weight. The RWC of the leaves was measured at the beginning of the experiment in August, 2023 and at the end of the experiment in July, 2024. The measured RWC was expressed in per cent (%) as:

$$\text{Relative Water Content (RWC)} = \frac{\text{Fresh Weight} - \text{Dry Weight}}{\text{Turgid Weight} - \text{Dry Weight}} \times 100$$

viii. Percent mortality of the transplanted grafts (%)

The percent mortality of the transplanted grafts was recorded at monthly interval and was expressed in % as:

$$\text{Mortality Rate (\%)} = \frac{\text{Number of grafts that did not survive}}{\text{Total number of transplanted grafts}} \times 100$$

ix. Relative growth rate

The relative growth rate of plants was recorded at monthly intervals and calculated by using the formula:

$$\text{Relative Growth Rate} = \frac{\ln G_2 - \ln G_1}{T_2 - T_1}$$

Where, G_1 and G_2 are the girth of the plant at time T_1 i.e. start of experiment and time T_2 i.e. one month after T_1 . The relative growth rate was expressed in $\text{mm mm}^{-1} \text{ day}^{-1}$.

B. Biochemical parameters:

i. Chlorophyll content

To estimate the chlorophyll content in the guava leaves, 5ml of leaf extract was taken and 20ml acetone (80% acetone) was added to the extract and centrifuged at 5000 rpm for 5 minutes. The supernatant of the centrifuged extract was transferred to a volumetric flask and the volume was made to 100 ml with the help of 80% acetone. The absorbance of the resultant solution was measured at 645nm, 663nm, and 653nm against the solvent as blank by using a UV-Vis

spectrophotometer. Total chlorophyll content, chlorophyll a, and chlorophyll b in the samples were estimated using the following expression:

$$\text{mg Chlorophyll a/ml extract} = 22.9(A_{663}) - 2.69(A_{645}) \times \frac{\text{Final Volume of Chlorophyll extract in 80\% acetone}}{1000 \times \text{Volume of sample}}$$

$$\text{mg Chlorophyll b/ml extract} = 22.9(A_{645}) - 4.68(A_{663}) \times \frac{\text{Final Volume of Chlorophyll extract in 80\% acetone}}{1000 \times \text{Volume of sample}}$$

$$\text{mg total Chlorophyll/ml extract} = 20.2(A_{645}) + 8.02(A_{663}) \times \frac{\text{Final Volume of Chlorophyll extract in 80\% acetone}}{1000 \times \text{Volume of sample}}$$

ii. Proline content

The proline content was estimated as per procedure described by Bates *et al.* (1973). According to this procedure to estimate the proline content in a leaf sample, 0.5 g of the sample was taken and homogenized in 5 ml of sulphosalicylic acid (3%) using a mortar and pestle. The homogenate was then filtered through Whatman No. 1 filter paper, and the aliquot was collected. Two ml of the aliquot, 2 ml of glacial acetic acid, and 2 ml of ninhydrin reagent were added to a test tube. The reaction mixture was placed in a boiling water bath at 100°C for 30 minutes until a brick-red color developed. The reaction was terminated after the test tube was placed in an ice bath and 6 ml of toluene was added to it. The solution was mixed thoroughly and chromophore-containing toluene was separated. The absorbance of the red color extract was measured at 520 nm in a UV-Vis spectrophotometer against the toluene blank. For the estimation of the proline concentration, a standard curve was prepared with the known concentrations of proline. The proline content was expressed in $\mu\text{moles per g tissue}$ and was calculated as:

$$\mu\text{moles per g tissue} = \frac{\mu\text{g proline/ml} \times \text{ml toluene}}{\text{molecular weight of proline}} \times \frac{5}{\text{g sample}}$$

iii. Soluble sugars (%)

The soluble sugars estimation was carried out as per the method described by AOAC (Association of Official Analytical Chemists) method from 1970.

Extraction:

500 mg of the ground leaf sample was taken in a 100 ml conical flask. The sugars were extracted twice with 50 ml of 80 percent ethanol followed by refluxing in a boiling water bath for 30 minutes. The contents in the flask were stirred occasionally. The combined alcoholic extract of each sample obtained was concentrated into aqueous syrup in a boiling water bath. The last traces of concentrated sugar solution were quantitatively transferred to a 100 ml volumetric

flask and the volume was raised to 98 ml with distilled water. A saturated solution of lead acetate (1 ml) was added to remove proteins and after that the volume was made up to 100 ml with distilled water. The contents were filtered through Whatman filter paper No.1 and excess lead ions were removed from the filtrate by the addition of sodium oxalate crystals followed by filtration. The clear extract thus obtained was used for the estimation of total sugars.

Estimation:

0.4 ml of the extract was taken and volume was made to 1 ml with distilled water. 1 ml of 5 percent phenol was added to each test tube. The test tubes were placed in ice cold water and 5 ml of 95.5 per cent H₂SO₄ was added swiftly. The contents were mixed well and the absorbance of the orange color developed was read at 490 nm. The total sugar content of leaves was calculated from a standard curve that was computed using the varying standard concentrations (glucose 100 µg/ml) versus absorbance at 490 nm recorded on a UV-Vis spectrophotometer. The soluble sugars estimated were expressed in per cent (%) of fresh weight.

3.4 Physiochemical properties of polybag growth medium:

The initial estimation of the physiochemical properties of the growth medium used in the poly bags in which the guava grafts were grown was done as per procedure described below.

Collection and preparation of soil samples:

Composite soil samples from the experimental poly bag were collected randomly in 1:5 proportions i.e. after 5 polybags sample was collected, randomly. The sample were placed in cloth bags, tagged, and transported to the laboratory before the application of experimental treatments. The samples were air-dried, crushed thoroughly, passed through a 2mm plastic sieve and analyzed for various soil parameters as listed below:

Table 3.2 Physico-chemical properties of polybag growth medium

Sr. No.	Parameters	Method employed	Reference
1.	Bulk Density (g cm^{-3})	The weight of oven-dried soil filled in pycnometer by gentle tapping dividing by its volume	Chopra and Kanwar (2011)
2.	Particle Density (g cm^{-3})	Pycnometer method	Gupta and Dhakshinamoorthy (1980)
3.	Soil Porosity (%)	One minus ratio of bulk density to particle density multiplied by 100	Gupta and Dhakshinamoorthy (1980)
4.	Organic Carbon (%)	Rapid titration method	Walkley and Black (1934)
5.	Soil pH	Potentiometric method	Jackson (1973)
6.	Electrical Conductivity (dS/m)	Conductimetric method	Jackson (1973)
7.	Available Nitrogen (kg ha^{-1})	Alkaline potassium permanganate method	Subbiah and Asija (1956)
8.	Available Phosphorus (kg ha^{-1})	Olsen's method	Olsen <i>et al.</i> (1954)
9.	Available Potassium (kg ha^{-1})	Neutral 1 N ammonium acetate solution method	Merwin and Peach (1951)

3.5 Carbon emission equivalence factor:

The greenhouse gases (GHG) emission equivalence of the guava grafts were estimated on the basis of emission values reported by Meng *et al.* (2019) for potted nursery production. The computed value per plant GHG/CO₂ emission equivalence for transportation by comparing the per unit nursery factor under the present trial was estimated to be around 3.055×10^{-4} litre plant⁻¹ year⁻¹. The GHG/CO₂ emission value for the untreated control was taken as the reference value and the similar value for different treatment combinations was computed on the basis of proportion of plants which could be accommodated per cubic meter volume of the carrier vehicle. The number of plants per cubic meter volume of carrier vehicle under control stood to be 128 plants per cubic meter (considering the plant dimension including polybag) then the GHG/ CO₂ equivalence of

transportation of these plants was computed. With corresponding equivalence GHG/ CO₂ equivalence of other treatment combinations was computed for different treatment combinations.

3.6 Statistical Analysis

The data collected for various parameters were tabulated and analyzed by using the MS-Excel, and OPSTAT statistical package. The analysis of variance (ANOVA) for the three factor Randomized Block Designs was done as proposed by Gomez and Gomez (1984). The ANOVA was computed as per the details given below:

ANOVA for RBD factorial

Source of variation	Degree of freedom	Sum of squares	Mean sum of square	F _{cal.}
Replication	r-1	SSR	MSSR=SSR/(r-1)	MSSR/MSSE
Treatments	17	SST	MSST=SST/17	MSST/MSSE
C	2	SSC	MSSC= SSC/2	MSSC/MSSE
P	2	SSF	MSSF= SSP/2	MSSP/MSSE
A	1	SSA	MSSA= SSA/1	MSSA/MSSE
CP	4	SSCP	MSSCF=SSCP/4	MSSCP/MSSE
CA	2	SSCA	MSSCA= SSCA/2	MSSCA/MSSE
PA	2	SSPA	MSSPA= SSPA/2	MSSPA/MSSE
CPA	4	SSCPA	MSSCPA= SSCPA/4	MSSCPA/MSSE
Error	68	ESS	MESS= ESS/(4*17)	
Total	89			

Where,

C = Root zone compaction

P = Foliar trimming

A = Hormonal (ABA) Treatment

r= replications

Critical Difference

Main Effect C,F and A	First order interaction CF, CA, FA	Second order interaction CFA
$t_{\text{error df}} \times \sqrt{\frac{2 \times MSE}{r \times 2^{n-1}}}$	$t_{\text{error df}} \times \sqrt{\frac{2 \times MSE}{r \times 2^{n-2}}}$	$t_{\text{error df}} \times \sqrt{\frac{2 \times MSE}{r \times 2^{n-3}}}$

3.7 Relative ranking of the treatment combinations

In order to arrive at the best treatment combination of pre-transit root zone compaction and foliage trimming for having efficient transport of guava grafts and their better field survival and growth after transplanting in orchard; relative ranking of the treatments was done on the basis of “Weight and Score Method” as described by Rao (2002). For relative ranking score, four parameters viz. transportation efficiency, field survival, plant growth (height and spread) and leaf number were taken into consideration. The score of individual parameter was computed as:

$$3.7.1 \text{ Transportation efficiency } (T_e) = \frac{X_a}{X_m} \times 10$$

Where,

X_a = Number of plants which were accommodated per cubic metre of carrier vehicle volume under a particular treatment combination.

X_m = Highest number of plant which were accommodated per cubic metre of carrier vehicle under different treatment combinations. For arriving at this number the plant dimension (minimum) after maximum compaction (50%) of root zone and foliage trimming (50%) were taken into consideration.

$$(X_a < X_m)$$

The multiplication factor 10 was used to scale the transportation factor on a scale of 0 to 10.

3.7.2 Field survival (S_r): Field survival of the plants was also scaled on the 10 point scale. The score for this factor was calculated as:

$$\text{Field survival } (S_r) = \frac{S_a}{S_m} \times 10$$

Where,

S_r = Field survival on a scale of 0 to 10.

S_a = Percent survival observed under a particular treatment combination.

S_m = Maximum survival (%) observed amongst all the treatment combinations.

The multiplication factor 10 was used to scale the field survival on a scale of 0 to 10.

3.7.3 Plant growth (P): Plant height and canopy spread were taken as the parameters for calculating the score of this parameter as:

$$\text{Plant growth (P)} = \frac{P_a}{P_m} \times 10$$

$$\text{Where, } P_a = \frac{(\text{Plant height} + \text{Plant spread}) \text{ under specific treatment}}{2}$$

$$P_m = \frac{(\text{Maximum plant height} + \text{Plant spread}) \text{ under specific treatment}}{2}$$

The multiplication factor 10 was used to scale the plant growth on a scale of 0 to 10.

3.7.4 Leaf number (L)

$$\text{Leaf number (L)} = \frac{\text{Leaf number under specific treatment combination at the end experiment}}{\text{Maximum leaf number recorded at the end of experiment}} \times 10$$

The multiplication factor 10 was used to scale the leaf number on a scale of 0 to 10.

3.7.5 Weight of the parameters (W): All the parameters *i.e.* Transportation efficiency, field survival, plant growth and leaf number were considered equally important, hence were award equal weight (relative importance) equivalent to 2.5.

3.7.6 Total score and ranking: Total score of a treatment combination was calculated as:

Score (S) = Sum of T_e + S_r + P + L values at a particular treatment combination.

Weight (W) = 2.5 (as defined in upper paragraph)

Total score (T_s) = $S \times W$

Chapter-4

RESULTS AND DISCUSSION

The present explorations on **“Effect of pre-transit root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava”** were conducted at the experimental orchard of the Department of Fruit Science, College of Horticulture and Forestry, Neri, Hamirpur (H.P.) during the year 2023-2024. The investigations were carried out to see the effect of root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava in sub-tropical areas of Himachal Pradesh. The results thus obtained are presented, interpreted and backed with suitable citations under following headings:

- 4.1 Effect of root zone compaction, foliage trimming and abscisic acid on plant physical and physiological characteristics.
 - 4.2 Effect of root zone compaction, foliage trimming and abscisic acid treatment on biochemical characteristics of grafted guava plants.
 - 4.3 CO₂ equivalence of different treatment combination of root zone compaction, foliage trimming and abscisic acid.
 - 4.4 Total score and ranking of different treatment combination of root zone compaction, foliage trimming and abscisic acid
- 4.1 Effect of root zone compaction, foliage trimming and abscisic acid on plant physical and physiological characteristics.**

Under this heading, data for the physical and physiological characteristics of guava grafts were recorded and analysed. The results for these parameters are presented and discussed below:

4.1.1 Number of leaves

An analysis of the data presented in Table 4.1 reveals that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had a significant impact on the number of leaves of guava grafts from July, 2023 to June, 2024.

Table 4.1 Effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts from July, 2023 to June, 2024

Number of leaves												
Treatments	2023						2024					
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
A ₁ P ₁ C ₁	19.20	5.80	36.40	53.00	63.40	73.40	79.00	93.40	97.20	104.00	113.80	117.50
A ₁ P ₁ C ₂	24.40	5.60	39.00	55.00	66.80	75.20	79.40	96.60	133.00	165.60	176.80	168.50
A ₁ P ₁ C ₃	23.00	6.20	41.80	56.20	67.60	79.60	88.00	99.60	136.00	162.00	180.80	205.50
A ₂ P ₁ C ₁	23.40	5.20	31.00	46.80	56.60	63.20	68.60	92.40	127.20	172.00	200.80	222.50
A ₂ P ₁ C ₂	20.00	5.80	35.60	50.00	61.00	70.00	75.80	95.20	110.80	128.80	151.20	153.25
A ₂ P ₁ C ₃	18.80	6.00	39.60	50.20	63.20	71.00	76.40	96.20	147.00	151.20	158.40	164.50
A ₁ P ₂ C ₁	24.60	10.60	45.80	66.60	78.80	83.40	93.40	100.60	155.20	184.00	213.20	248.50
A ₁ P ₂ C ₂	28.00	11.40	46.20	67.60	79.80	91.60	96.00	106.00	157.60	176.80	191.20	220.00
A ₁ P ₂ C ₃	22.40	10.20	47.80	68.40	80.20	93.40	100.00	118.80	120.00	121.20	127.20	140.50
A ₂ P ₂ C ₁	20.00	10.60	43.40	57.00	73.80	79.80	89.20	100.60	104.00	121.20	130.40	131.00
A ₂ P ₂ C ₂	19.60	10.80	44.60	64.80	75.00	80.20	90.20	102.20	104.00	118.40	122.00	140.00
A ₂ P ₂ C ₃	25.00	11.80	45.60	66.60	75.40	81.40	91.60	107.80	130.80	150.00	171.60	207.50
A ₁ P ₃ C ₁	22.20	24.20	57.40	76.80	91.60	102.80	111.60	123.00	130.40	172.40	180.80	207.00
A ₁ P ₃ C ₂	24.80	26.80	59.80	79.00	92.00	104.40	114.20	125.00	136.40	146.80	166.80	207.00
A ₁ P ₃ C ₃	22.60	24.60	63.20	79.60	94.60	106.00	120.80	129.60	132.60	140.00	146.80	169.50
A ₂ P ₃ C ₁	24.00	26.00	48.00	70.60	79.40	94.20	103.20	109.60	128.80	140.00	146.00	162.00
A ₂ P ₃ C ₂	22.80	24.80	51.80	73.40	82.60	95.80	103.80	110.80	114.80	121.60	122.60	132.00
A ₂ P ₃ C ₃	29.80	32.20	65.00	80.60	96.00	107.20	118.20	128.00	135.60	151.60	161.60	175.50
C.D.												
Factor(A)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Factor(P)	NS	2.32	6.72	10.63	10.99	14.13	14.33	12.72	NS	NS	NS	NS
Factor(C)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction A X P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction A X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction P X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction A X P X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

It is inferred from the data presented in the Table 4.2 that the root zone compaction (C), foliage trimming (P) and abscisic acid (A) had no significant influence on the number of leaves of guava grafts in the month of July, 2023.

Table 4.2 Effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of July, 2023 (before treatment)

Number of leaves												
		A								P		
		A ₁			Mean	A ₂			Mean	Mean		
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃
C	C ₁	19.20	24.60	22.20	22.00	23.40	20.00	24.00	22.47	21.30	22.30	23.10
	C ₂	24.40	28.00	24.80	25.73	20.00	19.60	22.80	20.80	22.20	23.80	23.80
	C ₃	23.00	22.40	22.60	22.67	18.80	25.00	29.80	24.53	20.90	23.70	26.20
Mean		22.20	25.00	23.20	23.47	20.73	21.53	25.53	22.60	21.47	23.27	24.37
Factors		C.D.				SE(d)				SE(m)		
Factor(A)		NS				1.49				1.06		
Factor(P)		NS				1.83				1.29		
Factor(C)		NS				1.83				1.29		
Interaction A X P		NS				2.59				1.83		
Interaction A X C		NS				2.59				1.83		
Interaction P X C		NS				3.17				2.24		
Interaction A X P X C		NS				4.48				3.17		

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data detailed in Table 4.3 presents the effect of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on the number of leaves of guava grafts in the month of August, 2023. Highest number of leaves (26.43) were found in P₃ (0% of foliage trimming) whereas, the lowest number of leaves (5.77) were found in P₁ (50% of foliage trimming).

The examination of data presented here further revealed that factor A and C were found to have non-significant effect on number of leaves. Moreover, interactions between A × P, A × C, P × C and A × P × C were also found to have non-significant effect.

Table 4.3 Effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of August, 2023 (after treatment)

Number of leaves															
		A								P			Mean		
		A ₁			Mean	A ₂			Mean	Mean					
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃			
C	C ₁	5.80	10.60	24.20	13.53	5.20	10.60	26.00	13.93	5.50	10.60	25.10	13.73		
	C ₂	5.60	11.40	26.80	14.60	5.80	10.80	24.80	13.80	5.70	11.10	25.80	14.20		
	C ₃	6.20	10.20	24.60	13.67	6.00	11.80	32.20	16.67	6.10	11.00	28.40	15.17		
Mean		5.87	10.73	25.20	13.93	5.67	11.07	27.67	14.80	5.77	10.90	26.43			
Factors		C.D.				SE(d)				SE(m)					
Factor(A)				NS				0.95				0.67			
Factor(P)				2.32				1.16				0.82			
Factor(C)				NS				1.16				0.82			
Interaction A X P				NS				1.65				1.16			
Interaction A X C				NS				1.65				1.16			
Interaction P X C				NS				2.02				1.43			
Interaction A X P X C				NS				2.85				2.02			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data presented in Table 4.4 demonstrates the impact of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on the number of leaves of guava grafts in the month of February, 2024. Highest number of leaves (121) were found in P₃ (0% of foliage trimming) whereas, the lowest number of leaves (95.57) were found in P₁ (50% of foliage trimming) which was statistically at par with P₂ (106). The examination of data presented here further revealed that factor A and C were found to have non-significant effect on number of leaves. Moreover, interactions between A × P, A × C, P × C and A × P × C were also found to have non-significant effect.

An analysis of the data presented in Table 4.5 reveals that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had no significant impact on the number of leaves of guava grafts in the month of June, 2024.

Table 4.4 Effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of February, 2024

Number of leaves													
		A								P			Mean
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	93.40	100.60	123.00	105.67	92.40	100.60	109.60	100.87	92.90	100.60	116.30	103.27
	C ₂	96.60	106.00	125.00	109.20	95.20	102.20	110.80	102.73	95.90	104.10	117.90	105.97
	C ₃	99.60	118.80	129.60	116.00	96.20	107.80	128.00	110.67	97.90	113.30	128.80	113.33
Mean		96.53	108.47	125.87	110.29	94.60	103.53	116.13	104.76	95.57	106.00	121.00	
Factors				C.D.				SE(d)		SE(m)			
Factor(A)				NS				5.20		3.68			
Factor(P)				12.72				6.37		4.51			
Factor(C)				NS				6.37		4.51			
Interaction A X P				NS				9.01		6.37			
Interaction A X C				NS				9.01		6.37			
Interaction P X C				NS				11.04		7.80			
Interaction A X P X C				NS				15.61		11.04			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Table 4.5 Effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of June, 2024

Number of leaves													
		A								P			Mean
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	117.50	248.50	207.00	191.00	222.50	131.00	162.00	171.83	170.00	189.75	184.50	181.42
	C ₂	168.50	220.00	207.00	198.50	153.25	140.00	132.00	141.75	160.88	180.00	169.50	170.13
	C ₃	205.50	140.50	169.50	171.83	164.50	207.50	175.50	182.50	185.00	174.00	172.50	177.17
Mean		163.83	203.00	194.50	187.11	180.08	159.50	156.50	165.36	171.96	181.25	175.50	
Factors		C.D.			SE(d)			SE(m)					
Factor(A)			NS			18.86			13.33				
Factor(P)			NS			23.10			16.33				
Factor(C)			NS			23.10			16.33				
Interaction A X P			NS			32.66			23.10				
Interaction A X C			NS			32.66			23.10				
Interaction P X C			NS			40.00			28.29				
Interaction A X P X C			NS			56.57			40.00				

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

4.1.2 Plant height (cm)

A perusal of data given in Table 4.6 revealed that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had a significant effect on the plant height of guava grafts from July, 2023 to June, 2024.

Table 4.6 Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts from July, 2023 to June, 2024

Plant Height (cm)												
Treatments	2023						2024					
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
A ₁ P ₁ C ₁	76.00	38.40	54.40	61.80	68.60	70.60	72.40	73.40	77.40	83.60	91.20	101.75
A ₁ P ₁ C ₂	75.00	39.00	54.20	60.60	70.60	74.40	76.60	78.00	81.60	89.40	98.20	106.75
A ₁ P ₁ C ₃	75.60	40.60	55.80	64.00	72.80	76.00	80.20	82.20	86.80	96.40	105.60	117.75
A ₂ P ₁ C ₁	74.00	36.80	45.00	56.80	62.20	67.80	68.40	75.00	80.20	87.40	95.80	109.00
A ₂ P ₁ C ₂	66.40	34.40	45.00	57.40	59.80	64.60	65.80	71.80	77.20	85.60	92.00	102.25
A ₂ P ₁ C ₃	65.60	37.20	50.80	58.00	64.40	71.80	73.20	75.80	78.00	85.00	93.20	96.00
A ₁ P ₂ C ₁	69.80	53.40	63.40	70.00	76.80	81.20	84.40	86.40	90.00	95.20	104.80	126.00
A ₁ P ₂ C ₂	67.60	51.00	61.40	69.20	76.20	79.80	82.20	83.80	88.20	93.80	101.00	123.25
A ₁ P ₂ C ₃	67.60	52.40	60.20	64.60	67.80	69.60	71.80	73.60	77.40	84.00	91.80	103.75
A ₂ P ₂ C ₁	62.80	52.20	56.60	63.00	69.80	73.60	74.60	79.60	83.20	92.40	108.60	124.25
A ₂ P ₂ C ₂	65.40	50.20	55.80	61.40	66.00	71.40	73.40	78.80	82.20	87.40	92.80	98.25
A ₂ P ₂ C ₃	77.60	58.20	65.00	69.60	75.00	78.00	80.00	84.80	91.00	96.20	107.80	116.75
A ₁ P ₃ C ₁	66.20	68.80	73.20	76.00	79.00	82.00	88.20	91.00	93.80	101.80	109.80	114.25
A ₁ P ₃ C ₂	64.20	65.80	68.80	71.60	73.80	78.40	83.00	84.80	90.20	99.60	111.00	120.25
A ₁ P ₃ C ₃	65.40	68.00	71.40	73.80	75.40	78.00	83.40	84.80	86.60	90.60	96.00	101.75
A ₂ P ₃ C ₁	70.60	72.60	75.80	78.60	80.60	83.40	84.60	91.00	95.00	98.20	101.60	107.25
A ₂ P ₃ C ₂	68.60	70.80	73.40	77.20	82.60	85.00	85.80	90.20	92.40	99.60	106.40	113.75
A ₂ P ₃ C ₃	67.80	74.20	81.60	89.20	92.20	93.80	94.20	101.60	104.20	107.60	111.60	119.25
C.D.												
Factor(A)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Factor(P)	NS	4.17	4.17	4.63	4.90	5.24	5.24	5.27	5.51	6.19	NS	NS
Factor(C)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction A X P	NS	NS	5.89	6.54	6.93	7.41	NS	NS	NS	NS	NS	NS
Interaction A X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction P X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction A X P X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

An analysis of the data presented in Table 4.7 reveals that root zone compaction (C), foliage trimming (P), and absciscic acid (A) had no significant impact on plant height of guava grafts in the month of July, 2023.

Table 4.7 Effect of root zone compaction, foliage trimming and absciscic acid on plant height of guava grafts in the month of July, 2023 (before treatment)

Plant Height (cm)												
		A								P		
		A ₁			Mean	A ₂			Mean	Mean		
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃
C	C ₁	76.00	69.80	66.20	70.67	74.00	62.80	70.60	69.13	75.00	66.30	68.40
	C ₂	75.00	67.60	64.20	68.93	66.40	65.40	68.60	66.80	70.70	66.50	66.40
	C ₃	75.60	67.60	65.40	69.53	65.60	77.60	67.80	70.33	70.60	72.60	66.60
Mean		75.53	68.33	65.27	69.71	68.67	68.60	69.00	68.76	72.10	68.47	67.13
Factors		C.D.				SE(d)				SE(m)		
Factor(A)		NS				2.29				1.62		
Factor(P)		NS				2.80				1.98		
Factor(C)		NS				2.80				1.98		
Interaction A X P		NS				3.96				2.80		
Interaction A X C		NS				3.96				2.80		
Interaction P X C		NS				4.85				3.43		
Interaction A X P X C		NS				6.86				4.85		

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data detailed in Table 4.8 presents the effect of root zone compaction (C), foliage trimming (P) and absciscic acid (A) on plant height of guava grafts in the month of August, 2023 (after treatment). Highest plant height (70.03 cm) were found in P₃ (0% of foliage trimming) whereas, the lowest plant height (37.73 cm) were found in P₁ (50% of foliage trimming).

The examination of data presented here further revealed that factor A and C were found to have non-significant effect on number of leaves. Moreover, interactions between A × P, A × C, P × C and A × P × C were also found to have non-significant effect.

Table 4.8 Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of August, 2023 (after treatment)

Plant Height (cm)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	38.40	53.40	68.80	53.53	36.80	52.20	72.60	53.87	37.60	52.80	70.70	53.70
	C ₂	39.00	51.00	65.80	51.93	34.40	50.20	70.80	51.80	36.70	50.60	68.30	51.87
	C ₃	40.60	52.40	68.00	53.67	37.20	58.20	74.20	56.53	38.90	55.30	71.10	55.10
Mean		39.33	52.27	67.53	53.04	36.13	53.53	72.53	54.07	37.73	52.90	70.03	
Factors				C.D.				SE(d)		SE(m)			
Factor(A)				NS				1.71		1.21			
Factor(P)				4.17				2.09		1.48			
Factor(C)				NS				2.09		1.48			
Interaction A X P				NS				2.95		2.09			
Interaction A X C				NS				2.95		2.09			
Interaction P X C				NS				3.62		2.56			
Interaction A X P X C				NS				5.12		3.62			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data presented in Table 4.9 demonstrates the impact of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on plant height of guava grafts in the month of September, 2023. Highest plant height (74.03 cm) were found in P₃ (0% of foliage trimming) whereas, the lowest number of leaves (50.87 cm) were found in P₁ (50% of foliage trimming).

The interaction between A × P had a significant effect on plant height of guava grafts in the month of September, 2023. Maximum plant height (76.93 cm) was recorded in A₂P₃ which was statistically at par with A₁P₃ (71.13 cm), while the minimum plant height (46.93 cm) was observed in A₂P₁.

The examination of data presented here further revealed that factor A, P and C were found to have non-significant effect on number of leaves. Moreover, interactions between A × C, P × C and A × P × C were also found to have non-significant effect.

Table 4.9 Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of September, 2023

Plant Height (cm)												
		A								P		
		A ₁			Mean	A ₂			Mean	Mean		
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃
C	C ₁	54.40	63.40	73.20	63.67	45.00	56.60	75.80	59.13	49.70	60.00	74.50
	C ₂	54.20	61.40	68.80	61.47	45.00	55.80	73.40	58.07	49.60	58.60	71.10
	C ₃	55.80	60.20	71.40	62.47	50.80	65.00	81.60	65.80	53.30	62.60	76.50
Mean		54.80	61.67	71.13	62.53	46.93	59.13	76.93	61.00	50.87	60.40	74.03
Factors		C.D.				SE(d)				SE(m)		
Factor(A)		NS				1.71				1.21		
Factor(P)		4.17				2.09				1.48		
Factor(C)		NS				2.09				1.48		
Interaction A X P		5.89				2.95				2.09		
Interaction A X C		NS				2.95				2.09		
Interaction P X C		NS				3.62				2.56		
Interaction A X P X C		NS				5.11				3.62		

A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data presented in Table 4.10 demonstrates the impact of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on plant height of guava grafts in the month of December, 2023. Highest plant height (83.43 cm) were found in P₃ (0% of foliage trimming) whereas, the lowest number of leaves (70.87 cm) were found in P₁ (50% of foliage trimming). The interaction between A × P had a significant effect on plant height of guava grafts. Maximum plant height (87.40 cm) was recorded in A₂P₃, while the minimum plant height (68.07 cm) was observed in A₂P₁ which was statistically at par with A₁P₁ (73.67 cm) and A₂P₂ (74.33 cm). The examination of data presented here further revealed that factor A, P and C were found to have non-significant effect on number of leaves. Moreover, interactions between A × C, P × C and A × P × C were also found to have non-significant effect. The data detailed in Table 4.11 presents the effect of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on plant height of guava grafts in the month of January, 2024. Highest plant height (86.53 cm) were found in P₃ (0% of foliage trimming) whereas, the lowest number of leaves (72.77 cm) were found in P₁ (50% of foliage trimming). The examination of data presented here further revealed that factor A and C were found to have non-

significant effect on number of leaves. Moreover, interactions between $A \times P$, $A \times C$, $P \times C$ and $A \times P \times C$ were also found to have non-significant effect.

Table 4.10 Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of December, 2023

Plant Height (cm)												
		A								P		
		A ₁			Mean	A ₂			Mean	Mean		
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃
C	C ₁	70.60	81.20	82.00	77.93	67.80	73.60	83.40	74.93	69.20	77.40	82.70
	C ₂	74.40	79.80	78.40	77.53	64.60	71.40	85.00	73.67	69.50	75.60	81.70
	C ₃	76.00	69.60	78.00	74.53	71.80	78.00	93.80	81.20	73.90	73.80	85.90
Mean		73.67	76.87	79.47	76.67	68.07	74.33	87.40	76.60	70.87	75.60	83.43
Factors		C.D.				SE(d)				SE(m)		
Factor(A)		NS				2.14				1.52		
Factor(P)		5.24				2.62				1.86		
Factor(C)		NS				2.62				1.86		
Interaction A X P		7.41				3.71				2.62		
Interaction A X C		NS				3.71				2.62		
Interaction P X C		NS				4.54				3.21		
Interaction A X P X C		NS				6.43				4.54		

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Table 4.11 Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of January, 2024

Plant Height (cm)												
		A								P		
		A ₁			Mean	A ₂			Mean	Mean		
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃
C	C ₁	72.40	84.40	88.20	81.67	68.40	74.60	84.60	75.87	70.40	79.50	86.40
	C ₂	76.60	82.20	83.00	80.60	65.80	73.40	85.80	75.00	71.20	77.80	84.40
	C ₃	80.20	71.80	83.40	78.47	73.20	80.00	94.20	82.47	76.70	75.90	88.80
Mean		76.40	79.47	84.87	80.24	69.13	76.00	88.20	77.78	72.77	77.73	86.53
Factors		C.D.				SE(d)				SE(m)		
Factor(A)		NS				2.14				1.52		
Factor(P)		5.24				2.63				1.86		
Factor(C)		NS				2.63				1.86		
Interaction A X P		NS				3.71				2.63		
Interaction A X C		NS				3.71				2.63		
Interaction P X C		NS				4.55				3.22		
Interaction A X P X C		NS				6.43				4.55		

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

An analysis of the data presented in Table 4.12 reveals that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had no significant impact on plant height of guava grafts in the month of May, 2024.

Table 4.12 Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of May, 2024

Plant Height (cm)														
		A								P				
		A ₁			Mean	A ₂			Mean	Mean				Mean
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		
C	C ₁	91.20	104.80	109.80	101.93	95.80	108.60	101.60	102.00	93.50	106.70	105.70	101.97	
	C ₂	98.20	101.00	111.00	103.40	92.00	92.80	106.40	97.07	95.10	96.90	108.70	100.23	
	C ₃	105.60	91.80	96.00	97.80	93.20	107.80	111.60	104.20	99.40	99.80	103.80	101.00	
Mean		98.33	99.20	105.60	101.04	93.67	103.07	106.53	101.09	96.00	101.13	106.07		
Factors		C.D.				SE(d)				SE(m)				
Factor(A)				NS			3.50			2.48				
Factor(P)				NS			4.29			3.03				
Factor(C)				NS			4.29			3.03				
Interaction A X P				NS			6.06			4.29				
Interaction A X C				NS			6.06			4.29				
Interaction P X C				NS			7.43			5.25				
Interaction A X P X C				NS			10.50			7.43				

A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

A perusal of data given in Table 4.13 revealed that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had a significant effect on the plant height of guava grafts in the month of June, 2024.

Table 4.13 Effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of June, 2024

Plant Height (cm)												
		A								P		
		A ₁			Mean	A ₂			Mean	Mean		
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃
C	C ₁	101.75	126.00	114.25	114.00	109.00	124.25	107.25	113.50	105.38	125.13	110.75
	C ₂	106.75	123.25	120.25	116.75	102.25	98.25	113.75	104.75	104.50	110.75	117.00
	C ₃	117.75	103.75	101.75	107.75	96.00	116.75	119.25	110.67	106.88	110.25	110.50
Mean		108.75	117.67	112.08	112.83	102.42	113.08	113.42	109.64	105.58	115.38	112.75
Factors		C.D.				SE(d)				SE(m)		
Factor(A)		NS				3.80				2.68		
Factor(P)		NS				4.65				3.29		
Factor(C)		NS				4.65				3.29		
Interaction A X P		NS				6.57				4.65		
Interaction A X C		NS				6.57				4.65		
Interaction P X C		NS				8.05				5.69		
Interaction A X P X C		NS				11.38				8.05		

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

4.1.3 Plant girth (mm)

A perusal of the data presented in the Table 4.14 depicted that root zone compaction, foliage trimming and abscisic acid had a significant influence on the increase in plant girth of guava grafts from July, 2023 to June, 2024.

Table 4.14 Effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts from month July, 2023 to June, 2024

Plant Girth (mm)												
Treatments	2023						2024					
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
A ₁ P ₁ C ₁	8.85	9.65	9.99	10.48	11.27	11.60	12.00	12.64	13.30	13.78	14.48	14.88
A ₁ P ₁ C ₂	9.32	10.42	11.24	11.91	13.19	13.62	14.22	14.81	15.29	16.88	17.91	19.10
A ₁ P ₁ C ₃	9.39	11.00	11.53	12.58	13.56	13.92	14.54	14.94	15.30	16.27	18.05	20.54
A ₂ P ₁ C ₁	9.37	10.07	11.02	11.57	12.06	12.63	13.31	13.94	14.30	15.80	17.90	19.31
A ₂ P ₁ C ₂	9.05	10.18	10.76	11.20	11.59	12.17	12.86	13.68	14.55	15.12	16.16	17.74
A ₂ P ₁ C ₃	8.63	9.48	10.46	11.38	12.96	13.53	14.31	14.77	15.27	16.21	17.49	18.44
A ₁ P ₂ C ₁	9.41	10.13	11.05	12.25	13.72	14.26	14.99	15.36	15.95	16.58	17.49	19.24
A ₁ P ₂ C ₂	9.16	10.06	10.74	11.78	13.08	13.86	14.42	15.17	16.96	17.90	19.68	22.06
A ₁ P ₂ C ₃	8.75	9.57	10.25	11.61	12.57	12.99	13.48	13.79	14.46	15.18	16.07	16.93
A ₂ P ₂ C ₁	9.14	9.84	10.28	10.86	12.30	13.05	13.73	14.52	15.37	16.39	17.74	17.86
A ₂ P ₂ C ₂	9.02	10.03	10.37	11.41	12.65	13.17	13.60	14.18	15.07	15.72	16.20	16.91
A ₂ P ₂ C ₃	9.34	10.20	11.28	12.81	13.93	14.49	15.23	16.49	17.18	17.92	19.23	21.62
A ₁ P ₃ C ₁	9.38	10.20	10.99	12.64	13.95	14.53	15.27	16.52	17.06	17.70	18.64	18.83
A ₁ P ₃ C ₂	8.55	9.38	9.73	11.16	12.48	13.47	13.94	14.53	15.20	16.15	17.56	19.34
A ₁ P ₃ C ₃	8.98	9.97	10.54	11.55	12.25	12.76	13.34	14.05	14.64	15.01	15.77	16.63
A ₂ P ₃ C ₁	8.93	9.24	10.11	10.54	11.44	12.06	12.99	13.75	14.74	15.13	15.99	17.11
A ₂ P ₃ C ₂	9.28	9.95	10.70	12.31	12.82	13.15	13.95	14.16	14.45	15.11	15.70	16.58
A ₂ P ₃ C ₃	9.22	10.04	10.93	11.36	11.88	12.08	12.42	12.59	13.38	14.27	15.43	16.12
C.D.												
Factor(A)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Factor(P)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Factor(C)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction A X P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction A X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction P X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction A X P X C	NS	1.11	1.47	2.02	NS	NS	NS	NS	NS	NS	NS	NS

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

An analysis of the data presented in Table 4.15 reveals that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had no significant impact on plant girth of guava grafts in the month of July, 2023.

Table 4.15 Effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of July, 2023 (before treatment)

Plant girth (mm)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	8.85	9.41	9.38	9.22	9.37	9.14	8.93	9.15	9.11	9.27	9.16	9.18
	C ₂	9.32	9.16	8.55	9.01	9.05	9.02	9.28	9.11	9.18	9.09	8.91	9.06
	C ₃	9.39	8.75	8.98	9.04	8.63	9.34	9.22	9.07	9.01	9.05	9.10	9.05
Mean		9.19	9.10	8.97	9.09	9.19	9.10	8.97	9.09	9.10	9.13	9.06	
Factors				C.D.				SE(d)				SE(m)	
Factor(A)				NS				0.15				0.11	
Factor(P)				NS				0.19				0.13	
Factor(C)				NS				0.19				0.13	
Interaction A X P				NS				0.26				0.19	
Interaction A X C				NS				0.26				0.19	
Interaction P X C				NS				0.32				0.23	
Interaction A X P X C				NS				0.46				0.32	

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data detailed in Table 4.16 presents the effect of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on plant girth of guava grafts in the month of August, 2023. Highest plant girth (11.00 mm) were found in A₁P₁C₃ (100 ppm ABA, 50% of foliage trimming and 0% root zone compaction) which was statistically at par with A₁P₁C₂ (10.42 mm) whereas, the lowest plant girth (9.24 mm) were found in A₂P₃C₁ (0 ppm ABA, 0% of foliage trimming and 50% root zone compaction) which was statistically at par with A₁P₃C₂ (9.38 mm), A₂P₁C₃ (9.48 mm), A₁P₂C₃ (9.57 mm), A₁P₁C₁ (9.65 mm) and A₂P₂C₁ (9.84 mm).

The examination of data presented here further revealed that factor A, P and C were found to have non-significant effect on plant girth. Moreover,

interactions between $A \times P$, $A \times C$, $P \times C$ were also found to have non-significant effect.

Table 4.16 Effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of August, 2023 (after treatment)

Plant girth (mm)														
		A								P				
		A ₁			Mean	A ₂			Mean	Mean				Mean
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		
C	C ₁	9.65	10.13	10.20	9.99	10.07	9.84	9.24	9.72	9.86	9.98	9.72	9.86	
	C ₂	10.42	10.06	9.38	9.95	10.18	10.03	9.95	10.05	10.30	10.05	9.67	10.00	
	C ₃	11.00	9.57	9.97	10.18	9.48	10.20	10.04	9.91	10.24	9.89	10.00	10.04	
Mean		10.36	9.92	9.85	10.04	9.91	10.02	9.75	9.89	10.13	9.97	9.80		
Factors		C.D.				SE(d)				SE(m)				
Factor(A)				NS				0.19				0.13		
Factor(P)				NS				0.23				0.16		
Factor(C)				NS				0.23				0.16		
Interaction A X P				NS				0.32				0.23		
Interaction A X C				NS				0.32				0.23		
Interaction P X C				NS				0.39				0.28		
Interaction A X P X C				1.11				0.55				0.39		

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data detailed in Table 4.17 presents the effect of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on plant girth of guava grafts in the month of October, 2023. Highest plant girth (12.81 mm) were found in A₂P₂C₃ (0 ppm ABA, 0% root zone compaction and 25% of foliage trimming) which was statistically at par with A₁P₃C₁ (12.64 mm) and A₁P₁C₃ (12.58 mm), whereas, the lowest plant girth (10.48 mm) were found in A₁P₁C₁ (100 ppm ABA, 50% root zone compaction and 50% of foliage trimming) which was statistically at par with A₂P₃C₁ (10.54 mm).

The examination of data presented here further revealed that factor A, P and C were found to have non-significant effect on number of leaves. Moreover, interactions between $A \times P$, $A \times C$, $P \times C$ were also found to have non-significant effect.

Table 4.17 Effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of October, 2023

Plant girth (mm)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	10.48	12.25	12.64	11.79	11.57	10.86	10.54	10.99	11.02	11.55	11.59	11.39
	C ₂	11.91	11.78	11.16	11.61	11.20	11.41	12.31	11.64	11.55	11.60	11.74	11.63
	C ₃	12.58	11.61	11.55	11.91	11.38	12.81	11.36	11.85	11.98	12.21	11.45	11.88
Mean		11.65	11.88	11.78	11.77	11.38	11.70	11.40	11.49	11.52	11.79	11.59	
Factors				C.D.				SE(d)		SE(m)			
Factor(A)				NS				0.34		0.24			
Factor(P)				NS				0.41		0.29			
Factor(C)				NS				0.41		0.29			
Interaction A X P				NS				0.59		0.41			
Interaction A X C				NS				0.59		0.41			
Interaction P X C				NS				0.72		0.51			
Interaction A X P X C				2.02				1.01		0.72			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

An analysis of the data presented in Table 4.18 reveals that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had no significant impact on plant girth of guava grafts in the month of June, 2024.

Table 4.18 Effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of June, 2024

Plant girth (mm)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	14.88	19.24	18.83	17.65	19.31	17.86	17.11	18.09	17.09	18.55	17.97	18.87
	C ₂	19.10	22.06	19.34	20.16	17.74	16.91	16.58	17.07	18.42	19.48	17.96	18.62
	C ₃	20.54	16.93	16.63	18.03	18.44	21.62	16.12	18.73	19.49	19.28	16.38	18.38
Mean		18.17	19.41	18.26	18.62	18.49	18.80	16.60	17.96	18.33	19.10	17.43	
Factors				C.D.				SE(d)				SE(m)	
Factor(A)				NS				0.81				0.57	
Factor(P)				NS				0.99				0.70	
Factor(C)				NS				0.99				0.70	
Interaction A X P				NS				1.40				0.99	
Interaction A X C				NS				1.40				0.99	
Interaction P X C				NS				1.72				1.22	
Interaction A X P X C				NS				2.43				1.72	

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

4.1.4 Relative growth rate

An analysis of the data presented in Table 4.19 reveals that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had no significant impact on the relative growth rate of guava grafts.

Table 4.19 Effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts from month July, 2023 to June, 2024

Relative growth rate (mm mm ⁻¹ d ⁻¹)											
Treatments	2023					2024					
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
A ₁ P ₁ C ₁	0.0029	0.0012	0.0015	0.0024	0.0009	0.0011	0.0016	0.0017	0.0012	0.0016	0.0021
A ₁ P ₁ C ₂	0.0037	0.0024	0.0019	0.0031	0.0011	0.0014	0.0014	0.0011	0.0034	0.0019	0.0015
A ₁ P ₁ C ₃	0.0053	0.0015	0.0029	0.0024	0.0009	0.0014	0.0009	0.0008	0.0021	0.0033	0.0029
A ₂ P ₁ C ₁	0.0024	0.0029	0.0017	0.0014	0.0015	0.0017	0.0015	0.0008	0.0032	0.0040	0.0023
A ₂ P ₁ C ₂	0.0039	0.0018	0.0012	0.0012	0.0016	0.0019	0.0022	0.0020	0.0012	0.0022	0.0042
A ₂ P ₁ C ₃	0.0030	0.0031	0.0030	0.0044	0.0015	0.0019	0.0010	0.0011	0.0020	0.0025	0.0025
A ₁ P ₂ C ₁	0.0024	0.0030	0.0034	0.0036	0.0013	0.0017	0.0008	0.0012	0.0013	0.0017	0.0015
A ₁ P ₂ C ₂	0.0032	0.0021	0.0030	0.0034	0.0019	0.0013	0.0016	0.0036	0.0017	0.0028	0.0048
A ₁ P ₂ C ₃	0.0030	0.0022	0.0040	0.0026	0.0011	0.0011	0.0007	0.0015	0.0017	0.0019	0.0028
A ₂ P ₂ C ₁	0.0025	0.0015	0.0017	0.0043	0.0019	0.0016	0.0018	0.0019	0.0021	0.0026	0.0025
A ₂ P ₂ C ₂	0.0035	0.0011	0.0032	0.0034	0.0014	0.0011	0.0014	0.0020	0.0014	0.0010	0.0016
A ₂ P ₂ C ₃	0.0030	0.0033	0.0042	0.0027	0.0013	0.0015	0.0025	0.0012	0.0014	0.0023	0.0014
A ₁ P ₃ C ₁	0.0028	0.0024	0.0045	0.0032	0.0013	0.0016	0.0025	0.0011	0.0012	0.0018	0.0007
A ₁ P ₃ C ₂	0.0030	0.0012	0.0043	0.0034	0.0027	0.0010	0.0014	0.0015	0.0018	0.0024	0.0012
A ₁ P ₃ C ₃	0.0033	0.0017	0.0026	0.0020	0.0013	0.0015	0.0018	0.0014	0.0007	0.0016	0.0016
A ₂ P ₃ C ₁	0.0012	0.0028	0.0014	0.0027	0.0018	0.0024	0.0019	0.0023	0.0009	0.0019	0.0038
A ₂ P ₃ C ₂	0.0024	0.0024	0.0045	0.0013	0.0008	0.0021	0.0005	0.0007	0.0016	0.0013	0.0012
A ₂ P ₃ C ₃	0.0029	0.0028	0.0012	0.0014	0.0005	0.0009	0.0005	0.0021	0.0021	0.0024	0.0015
C.D.											
Factor(A)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Factor(P)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Factor(C)	0.001	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction A X P	NS	NS	NS	NS	NS	NS	0.001	NS	NS	NS	NS
Interaction A X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction P X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction A X P X C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data detailed in Table 4.20 presents the effect of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on relative growth rate of guava grafts in the month of August, 2023. Highest relative growth rate ($0.0034 \text{ mm mm}^{-1} \text{d}^{-1}$) were found in C_3 (0% root zone compaction) which was statistically at par with C_2 ($0.0033 \text{ mm mm}^{-1} \text{d}^{-1}$) whereas, the lowest relative growth rate ($0.0024 \text{ mm mm}^{-1} \text{d}^{-1}$) were found in C_1 (50% root zone compaction).

The examination of data presented here further revealed that factor A and P were found to have non-significant effect on relative growth rate. Moreover, interactions between $A \times P$, $A \times C$, $P \times C$ and $A \times P \times C$ were also found to have non-significant effect.

Table 4.20 Effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts in the month of August, 2023

Relative growth rate (mm mm ⁻¹ d ⁻¹)														
		A							P					
		A ₁			Mean	A ₂			Mean	Mean				
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂			P ₃
C	C ₁	0.0029	0.0024	0.0028	0.0027	0.0024	0.0025	0.0012	0.0020	0.0026	0.0024	0.0020	0.0024	
	C ₂	0.0037	0.0032	0.0030	0.0033	0.0039	0.0035	0.0024	0.0033	0.0038	0.0034	0.0027	0.0033	
	C ₃	0.0053	0.0030	0.0033	0.0039	0.0030	0.0030	0.0029	0.0030	0.0041	0.0030	0.0031	0.0034	
Mean		0.0039	0.0029	0.0030	0.0033	0.0031	0.0031	0.0032	0.0031	0.0035	0.0029	0.0026		
Factors				C.D.		SE(d)			SE(m)					
Factor(A)				NS		0.000			0.000					
Factor(P)				NS		0.000			0.000					
Factor(C)				0.001		0.000			0.000					
Interaction A X P				NS		0.001			0.000					
Interaction A X C				NS		0.001			0.000					
Interaction P X C				NS		0.001			0.001					
Interaction A X P X C				NS		0.001			0.001					

A ₁ = Abscisic acid at 100 ppm				P ₁ = 50 % foliage trimming				C ₁ = 50 % root zone compaction			
A ₂ = Abscisic acid at 0 ppm				P ₂ = 25 % foliage trimming				C ₂ = 25 % root zone compaction			
				P ₃ = 0 % foliage trimming				C ₃ = 0 % root zone compaction			

The data detailed in Table 4.21 presents the effect of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on relative growth rate of guava grafts in the month of August, 2023. Highest relative growth rate ($0.0019 \text{ mm mm}^{-1} \text{d}^{-1}$) were found in A_1P_3 (100 ppm ABA and 0% foliage trimming) and in A_2P_2 (0

ppm ABA and 25% foliage trimming) whereas, the lowest relative growth rate ($0.0010 \text{ mm mm}^{-1}\text{d}^{-1}$) were found in A_1P_2 (100 ppm ABA and 25% foliage trimming) and in A_2P_3 (0 ppm ABA and 0 % foliage trimming) .

The examination of data presented here further revealed that factor A, C and P were found to have non-significant effect on relative growth rate. Moreover, interactions between $A \times C$, $P \times C$ and $A \times P \times C$ were also found to have non-significant effect.

Table 4.21 Effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts in the month of February, 2024

Relative growth rate (mm mm ⁻¹ d ⁻¹)														
		A							P					
		A ₁			Mean	A ₂			Mean	Mean				
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂			P ₃
C	C ₁	0.0016	0.0008	0.0025	0.0016	0.0015	0.0018	0.0019	0.0018	0.0016	0.0013	0.0022	0.0017	
	C ₂	0.0014	0.0016	0.0014	0.0014	0.0022	0.0014	0.0005	0.0014	0.0018	0.0015	0.0009	0.0014	
	C ₃	0.0009	0.0007	0.0018	0.0011	0.0010	0.0025	0.0005	0.0014	0.0010	0.0016	0.0011	0.0012	
Mean		0.0013	0.0010	0.0019	0.0014	0.0016	0.0019	0.0010	0.0015	0.0014	0.0015	0.0014		
Factors		C.D.			SE(d)				SE(m)					
Factor(A)		NS			0				0					
Factor(P)		NS			0				0					
Factor(C)		NS			0				0					
Interaction A X P		0.001			0				0					
Interaction A X C		NS			0				0					
Interaction P X C		NS			0				0					
Interaction A X P X C		NS			0.001				0					

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

According to the data presented in Table 4.22, root zone compaction (C), foliage trimming (P), and abscisic acid (A) treatments had no significant difference on relative growth rate of guava grafts in the month of June, 2024.

Table 4.22 Effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts in the month of June, 2024

Relative growth rate (mm mm ⁻¹ d ⁻¹)														
		A								P				
		A ₁			Mean	A ₂			Mean	Mean				Mean
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		
C	C ₁	0.0021	0.0015	0.0007	0.0014	0.0023	0.0025	0.0038	0.0028	0.0022	0.0020	0.0022	0.0021	
	C ₂	0.0015	0.0048	0.0012	0.0025	0.0042	0.0016	0.0012	0.0023	0.0029	0.0032	0.0012	0.0024	
	C ₃	0.0029	0.0028	0.0016	0.0024	0.0025	0.0014	0.0015	0.0018	0.0027	0.0021	0.0015	0.0021	
Mean		0.0021	0.0030	0.0012	0.0021	0.0030	0.0018	0.0021	0.0023	0.0026	0.0024	0.0017		
Factors		C.D.			SE(d)				SE(m)					
Factor(A)		NS			0.001				0					
Factor(P)		NS			0.001				0					
Factor(C)		NS			0.001				0					
Interaction A X P		NS			0.001				0.001					
Interaction A X C		NS			0.001				0.001					
Interaction P X C		NS			0.001				0.001					
Interaction A X P X C		NS			0.002				0.001					

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Thus, from the Tables 4.1 to 4.22 it can be inferred that the treatment factors root zone compaction, foliage trimming, and abscisic acid initially had a significant effect on number of leaves, plant height and plant girth of guava grafts, while at the end of the experiment all treatment factors were found non-significant with respect to number of leaves, plant height and plant girth of guava grafts. Root zone compaction (0 % no compaction of polybags), initially results in greater guava graft height, leaf number, and girth due to less soil resistance allowing unrestricted root growth, better nutritional bioavailability and better water uptake as compared to compacted soils (Tardieu et al. 1992; Rosolem et al. 2002). Over time, however, 50% compaction yields superior growth metrics as it optimizes root structure by improving soil aeration and nutrient uptake. This balance fosters better plant height, leaf number, and girth compared to 0% and 25% compaction.

Foliage trimming (0% no foliage trimming) initially yields taller guava grafts and a higher leaf count due to uninterrupted growth. However, over time, 25% pruning enhances overall plant development, leading to improved height, increased leaf number, and greater plant girth. This level of pruning optimizes resource allocation and stress management. In contrast, 50% pruning initially hampers growth due to the substantial energy required for recovery. Additionally, increased pruning severity results in more vigorous shoot growth by modifying apical dominance and boosting nutrient availability to new shoots (Gopikrishna, 1997; Singh et al. 2001; Adhikari and Kandel, 2015). Similar findings by Dhaliwal and Singh (2004) indicate that pruning to 30 cm yields the highest net increases in stem girth (6.8 cm) and shoot length (8.4 cm).

Absciscic acid (0 ppm) initially promotes unrestricted growth, resulting in the highest plant height, leaf number, and girth. Over time, ABA (100 ppm) becomes more effective in fostering superior growth due to enhanced regulation and stress tolerance. Moreover, ABA treatments enhance leaf growth by increasing tissue hydraulic conductivity, which improves water transfer within the plant (Tardieu et al., 2010). Additionally, ABA induces stomatal closure (62-73%), elevates the relative water content in leaves (82-92% in mature and 88-94% in immature leaves), and enhances leaf expansion. These factors contribute to improved growth compared to untreated controls (Sansberro et al., 2004).

4.1.5 Stomatal conductance ($\text{mol m}^{-2} \text{s}^{-1}$)

According to the data presented in Table 4.23, root zone compaction (C), foliage trimming (P), and absciscic acid (A) treatments had no significant difference on the stomatal conductance of guava grafts in the month of July, 2023 (before treatment).

Table 4.23 Effect of root zone compaction, foliage trimming and abscisic acid on stomatal conductance in the month of July, 2023 (before treatment)

Stomatal conductance (mol m ⁻² s ⁻¹)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	0.20	0.20	0.20	0.20	0.22	0.23	0.21	0.22	0.21	0.21	0.20	0.21
	C ₂	0.18	0.20	0.20	0.20	0.21	0.20	0.21	0.21	0.19	0.20	0.21	0.20
	C ₃	0.22	0.18	0.19	0.20	0.18	0.17	0.23	0.19	0.20	0.17	0.21	0.20
Mean		0.20	0.19	0.20	0.20	0.20	0.20	0.22	0.21	0.20	0.20	0.21	
Factors				C.D.				SE(d)		SE(m)			
Factor(A)				NS				0.01		0.01			
Factor(P)				NS				0.02		0.01			
Factor(C)				NS				0.02		0.01			
Interaction A X P				NS				0.02		0.02			
Interaction A X C				NS				0.02		0.02			
Interaction P X C				NS				0.03		0.02			
Interaction A X P X C				NS				0.04		0.03			

A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data presented in Table 4.24 demonstrates the significant impact of root zone compaction (C), foliage trimming (P), and abscisic acid (A) treatments on stomatal conductance. The highest stomatal conductance, 0.12 mol m⁻²s⁻¹, was recorded with A₁ (100 ppm abscisic acid), while the lowest value 0.07 mol m⁻²s⁻¹ of stomatal conductance was observed with A₂ (0 ppm of abscisic acid).

In contrast, the treatment of foliage trimming decreases the stomatal conductance as the minimum stomatal conductance, 0.07 mol m⁻²s⁻¹, was recorded with P₁ (50% foliage trimming), whereas, 0.13 mol m⁻²s⁻¹ was recorded with P₃ (0% foliage trimming).

Similarly, the application of root zone compaction decreases the stomatal conductance as the minimum stomatal conductance, 0.05 mol m⁻²s⁻¹, was observed with C₁ (50% root zone compaction), whereas, 0.16 mol m⁻²s⁻¹ was recorded with C₃ (0% root zone compaction). The interaction effects of all treatment combinations were found to be statistically non-significant.

Table 4.24 Effect of root zone compaction, foliage trimming and abscisic acid on stomatal conductance in the month of August, 2023 (after treatment)

Stomatal conductance (mol m ⁻² s ⁻¹)														
		A								P				
		A ₁			Mean	A ₂			Mean	Mean				Mean
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		
C	C ₁	0.06	0.07	0.08	0.07	0.01	0.04	0.05	0.03	0.03	0.06	0.07	0.05	
	C ₂	0.10	0.11	0.13	0.11	0.02	0.05	0.05	0.04	0.06	0.08	0.09	0.08	
	C ₃	0.17	0.19	0.19	0.18	0.06	0.09	0.25	0.13	0.12	0.14	0.22	0.16	
Mean		0.11	0.12	0.14	0.12	0.03	0.06	0.12	0.07	0.07	0.09	0.13		
Factors		C.D.				SE(d)				SE(m)				
Factor(A)		0.03				0.02				0.01				
Factor(P)		0.04				0.02				0.01				
Factor(C)		0.04				0.02				0.01				
Interaction A X P		NS				0.03				0.02				
Interaction A X C		NS				0.03				0.02				
Interaction P X C		NS				0.03				0.02				
Interaction A X P X C		NS				0.05				0.04				

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

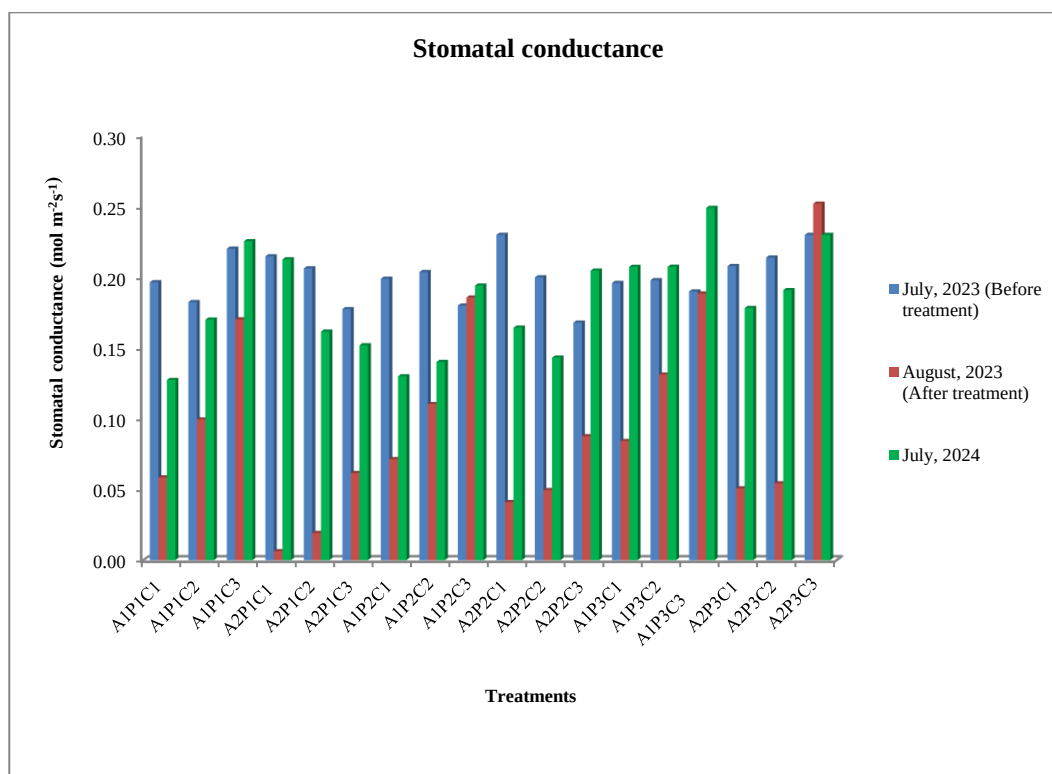
It is inferred from the data presented in the Table 4.25 that the root zone compaction (C), foliage trimming (P), and abscisic acid (A) treatments had no significant influence on the stomatal conductance of the guava plants in the month of July, 2024.

Table 4.25 Effect of root zone compaction, foliage trimming and abscisic acid on stomatal conductance in the month of July, 2024

Stomatal conductance (mol m ⁻² s ⁻¹)														
		A								P				
		A ₁			Mean	A ₂			Mean	Mean				Mean
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		
C	C ₁	0.13	0.13	0.21	0.16	0.21	0.17	0.18	0.19	0.17	0.15	0.19	0.17	
	C ₂	0.17	0.14	0.21	0.17	0.16	0.15	0.19	0.17	0.17	0.14	0.20	0.17	
	C ₃	0.23	0.20	0.25	0.22	0.15	0.21	0.23	0.20	0.19	0.20	0.24	0.21	
Mean		0.18	0.16	0.22	0.18	0.18	0.17	0.20	0.18	0.18	0.16	0.21		
Factors		C.D.				SE(d)				SE(m)				
Factor(A)		NS				0.02				0.02				
Factor(P)		NS				0.03				0.02				
Factor(C)		NS				0.03				0.02				
Interaction A X P		NS				0.04				0.03				
Interaction A X C		NS				0.04				0.03				
Interaction P X C		NS				0.05				0.03				
Interaction A X P X C		NS				0.06				0.05				

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Fig 4.1 Comparative account of stomatal conductance between the month of July, 2023, August, 2023 and July, 2024



A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

4.1.7 Transpiration rate (m mol m⁻²s⁻¹)

As evident from data given in Table 4.26, root zone compaction (C), foliage trimming (P), and absciscic acid (A) treatments had no significant difference on the transpiration rate of guava grafts in the month of July, 2023 (before treatment).

Table 4.26 Effect of root zone compaction, foliage trimming and abscisic acid on transpiration rate in the month of July, 2023 (before treatment)

Rate of transpiration (m mol m ⁻² s ⁻¹)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	4.43	4.81	4.35	4.53	3.39	4.87	4.07	4.11	3.91	4.84	4.21	4.32
	C ₂	4.46	3.62	3.29	3.79	3.83	3.35	4.95	4.04	4.14	3.48	4.12	3.92
	C ₃	3.84	4.40	4.18	4.14	3.43	3.74	5.25	4.14	3.64	4.07	4.71	4.14
Mean		4.24	4.28	3.94	4.15	3.55	3.99	4.76	4.10	3.90	4.13	4.35	
Factors				C.D.				SE(d)		SE(m)			
Factor(A)				NS				0.28		0.20			
Factor(P)				NS				0.34		0.24			
Factor(C)				NS				0.34		0.24			
Interaction A X P				NS				0.49		0.34			
Interaction A X C				NS				0.49		0.34			
Interaction P X C				NS				0.60		0.42			
Interaction A X P X C				NS				0.84		0.60			

A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data in Table 4.27 demonstrates a significant impact of root zone compaction (C), foliage trimming (P), and abscisic acid (A) on transpiration rate after treatments. The highest value of transpiration rate, $3.14 \text{ m mol m}^{-2}\text{s}^{-1}$, was recorded under the abscisic acid treatment at the rate of 100 ppm applied during August (A₁ treatment), while the lowest value of $2.04 \text{ m mol m}^{-2}\text{s}^{-1}$ was observed with no abscisic acid treatment (A₂ treatment).

The application of 50 % foliage trimming (P₁), resulted in a decreased transpiration rate of $2.23 \text{ m mol m}^{-2}\text{s}^{-1}$, compared to $3.07 \text{ m mol m}^{-2}\text{s}^{-1}$ recorded under the 0 % foliage trimming (P₃).

Likely, the application of 50% root zone compaction (C₁), resulted in a decreased transpiration rate of $1.84 \text{ m mol m}^{-2}\text{s}^{-1}$, compared to $3.48 \text{ m mol m}^{-2}\text{s}^{-1}$ recorded under the 0 % foliage trimming (C₃).

Additionally, the interaction effects of all treatment combinations were found to be statistically non-significant.

Table 4.27 Effect of root zone compaction, foliage trimming and abscisic acid on transpiration rate in the month of August, 2023 (after treatment)

Rate of transpiration (m mol m ⁻² s ⁻¹)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	2.01	2.16	2.64	2.27	1.18	1.33	1.68	1.40	1.60	1.75	2.16	1.84
	C ₂	3.01	3.18	3.74	3.31	1.31	1.50	1.99	1.60	2.16	2.34	2.87	2.46
	C ₃	3.75	3.83	3.93	3.84	2.09	2.83	4.44	3.12	2.92	3.33	4.19	3.48
Mean		2.93	3.05	3.44	3.14	1.53	1.89	2.71	2.04	2.23	2.47	3.07	
Factors		C.D.				SE(d)				SE(m)			
Factor(A)		0.39				0.20				0.14			
Factor(P)		0.48				0.24				0.17			
Factor(C)		0.48				0.24				0.17			
Interaction A X P		NS				0.34				0.24			
Interaction A X C		NS				0.34				0.24			
Interaction P X C		NS				0.41				0.29			
Interaction A X P X C		NS				0.59				0.41			

A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

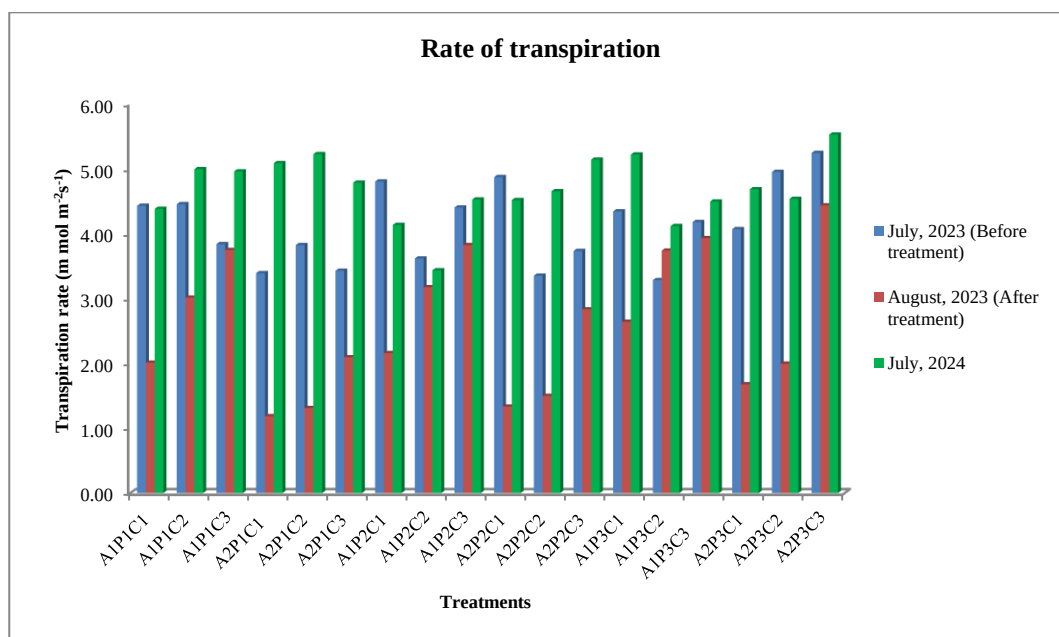
As evident from the data given in Table 4.28, root zone compaction (C), foliage trimming (P), and abscisic acid (A) treatments had no significant difference on the transpiration rate of the guava plants in the month of July, 2024.

Table 4.28 Effect of root zone compaction, foliage trimming and abscisic acid on transpiration rate in the month of July, 2024

Rate of transpiration (m mol m ⁻² s ⁻¹)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	4.38	4.13	5.22	4.58	5.09	4.52	4.69	4.77	4.74	4.33	4.95	4.67
	C ₂	5.00	3.44	4.12	4.19	5.23	4.66	4.54	4.81	5.11	4.05	4.33	4.50
	C ₃	4.96	4.53	4.50	4.66	4.79	5.15	5.53	5.15	4.87	4.84	5.01	4.91
Mean		4.78	4.03	4.61	4.48	5.04	4.77	4.92	4.91	4.91	4.40	4.77	
Factors				C.D.				SE(d)				SE(m)	
Factor(A)				NS				0.40				0.29	
Factor(P)				NS				0.49				0.35	
Factor(C)				NS				0.49				0.35	
Interaction A X P				NS				0.70				0.49	
Interaction A X C				NS				0.70				0.49	
Interaction P X C				NS				0.86				0.60	
Interaction A X P X C				NS				1.21				0.86	

A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Fig. 4.2 Comparative account of transpiration rate between the month of July, 2023, August, 2023 and July, 2024



A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

4.1.7 Photosynthetic activity ($\mu\text{mol m}^{-2} \text{s}^{-1}$)

As evident from data given in Table 4.29, root zone compaction (C), foliage trimming (P), and absciscic acid (A) treatments had no significant difference on the transpiration rate of guava grafts in the month of July, 2023 (before treatment).

Table 4.29 Effect of root zone compaction, foliage trimming and abscisic acid on photosynthetic activity in the month of July, 2023 (before treatment)

Photosynthetic activity (μmol m ⁻² s ⁻¹)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	8.32	7.01	8.33	7.89	7.93	7.12	8.08	7.71	8.12	7.07	8.21	7.80
	C ₂	7.06	7.41	7.29	7.25	7.23	7.69	7.92	7.62	7.15	7.55	7.61	7.43
	C ₃	8.20	8.13	7.23	7.85	6.79	8.81	9.12	8.24	7.49	8.47	8.17	8.05
Mean		7.86	7.52	7.62	7.66	7.32	7.88	8.37	7.86	7.59	7.70	8.00	
Factors				C.D.				SE(d)		SE(m)			
Factor(A)				NS				0.25		0.17			
Factor(P)				NS				0.30		0.21			
Factor(C)				NS				0.30		0.21			
Interaction A X P				NS				0.42		0.30			
Interaction A X C				NS				0.42		0.30			
Interaction P X C				NS				0.52		0.37			
Interaction A X P X C				NS				0.73		0.52			

A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The data detailed in Table 4.30 presents the significant impact of root zone compaction (C), foliage trimming (P), and abscisic acid (A) on photosynthetic activity. The highest photosynthetic activity ($7.03 \mu\text{mol m}^{-2} \text{s}^{-1}$) was noticed when ABA treatment (100ppm) was given, whereas the lowest ($5.02 \mu\text{mol m}^{-2} \text{s}^{-1}$) was found when hormonal treatment (0ppm) was given.

Among the different foliage trimming intensities, maximum photosynthetic activity ($6.70 \mu\text{mol m}^{-2} \text{s}^{-1}$) exhibited by P₃ (0% no reduction in foliage), while the lowest ($5.46 \mu\text{mol m}^{-2} \text{s}^{-1}$) was noticed in P₁ (50 % reduction in foliage).

The data further revealed that among different root zone compaction treatment highest photosynthetic activity ($7.50 \mu\text{mol m}^{-2} \text{s}^{-1}$) was recorded with in C₃ (0% no compaction of polybags), whereas the minimum photosynthetic activity ($4.93 \mu\text{mol m}^{-2} \text{s}^{-1}$) was found in 50% reduction in polybag diameter keeping its length and height constant (C₁).

It is also evident from the data presented here that the interactions between $A \times P$, $P \times C$, and $A \times P \times C$ had no significant effect on photosynthetic activity. However, the interaction between $A \times C$ had a significant effect on photosynthetic activity. The interaction A_1C_3 obtained the maximum photosynthetic activity ($7.79 \mu\text{mol m}^{-2} \text{s}^{-1}$) which was statistically at par with A_2C_3 ($7.22 \mu\text{mol m}^{-2} \text{s}^{-1}$), A_1C_2 ($7.14 \mu\text{mol m}^{-2} \text{s}^{-1}$), whereas the minimum photosynthetic activity ($3.68 \mu\text{mol m}^{-2} \text{s}^{-1}$) was found in A_2C_1 which was statistically at par with A_2C_2 ($4.15 \mu\text{mol m}^{-2} \text{s}^{-1}$). It signifies that root zone compaction altered the photosynthetic activity negatively and it was hampered further ABA applications.

Table 4.30 Effect of root zone compaction, foliage trimming and abscisic acid on photosynthetic activity of guava grafts in the month of August, 2023

Photosynthetic activity (μmol m ⁻² s ⁻¹)															
		A								P					
		A ₁			Mean	A ₂			Mean	Mean					
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃			
C	C ₁	5.60	6.44	6.49	6.17	3.16	3.60	4.29	3.68	4.38	5.02	5.39	4.93		
	C ₂	6.83	7.18	7.40	7.14	3.49	3.62	5.34	4.15	5.16	5.40	6.37	5.64		
	C ₃	7.47	7.92	7.98	7.79	6.24	6.70	8.72	7.22	6.86	7.31	8.35	7.50		
Mean		6.63	7.18	7.29	7.03	4.30	4.64	6.11	5.02	5.46	5.91	6.70			
Factors		C.D.				SE(d)				SE(m)					
Factor(A)				0.74				0.37				0.26			
Factor(P)				0.91				0.45				0.32			
Factor(C)				0.91				0.45				0.32			
Interaction A X P				NS				0.64				0.45			
Interaction A X C				1.28				0.64				0.45			
Interaction P X C				NS				0.79				0.56			
Interaction A X P X C				NS				1.11				0.79			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

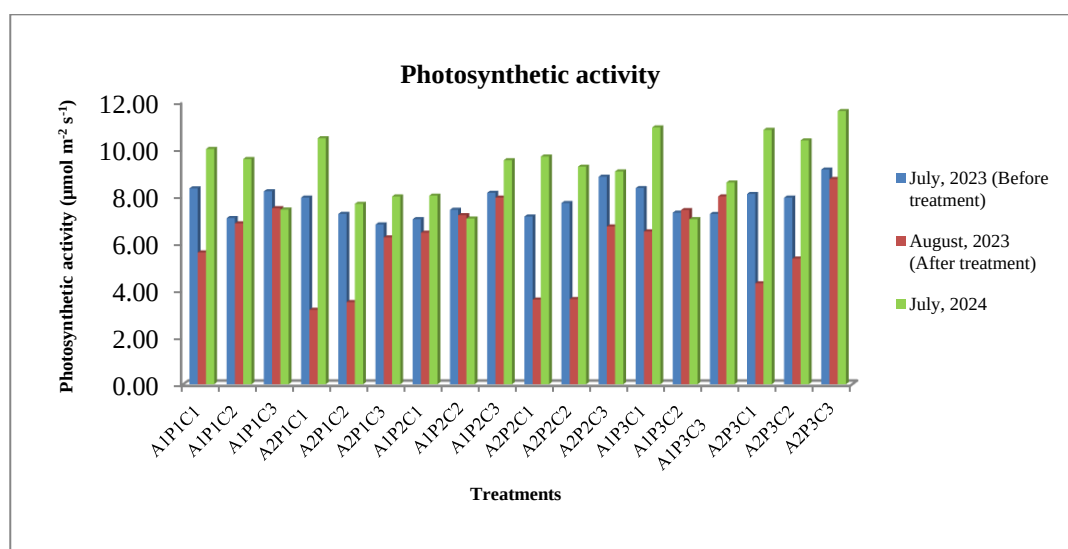
The data detailed in Table 4.31 presents the impact of root zone compaction (C), foliage trimming (P), and abscisic acid (A) treatments on photosynthetic activity in the month of July, 2024. The results indicate that there is no significant difference on the photosynthetic activity during July, 2024.

Table 4.31 Effect of root zone compaction, foliage trimming and abscisic acid on photosynthetic activity in the month of July, 2024

Photosynthetic activity (μmol m ⁻² s ⁻¹)													
		A								P			Mean
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	9.99	8.01	10.91	9.64	10.45	9.67	10.80	10.31	10.22	8.84	10.86	9.97
	C ₂	9.56	7.04	7.01	7.87	7.66	9.24	10.36	9.09	8.61	8.14	8.68	8.48
	C ₃	7.42	9.51	8.57	8.50	7.98	9.04	11.61	9.54	7.70	9.27	10.09	9.02
Mean		8.99	8.19	8.83	8.67	8.70	9.32	10.92	9.64	8.84	8.75	9.87	
Factors				C.D.				SE(d)		SE(m)			
Factor(A)				NS				0.67		0.47			
Factor(P)				NS				0.82		0.58			
Factor(C)				NS				0.82		0.58			
Interaction A X P				NS				1.15		0.82			
Interaction A X C				NS				1.15		0.82			
Interaction P X C				NS				1.41		1.00			
Interaction A X P X C				NS				2.00		1.41			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Fig. 4.3 Comparative account of photosynthetic activity between the month of July, 2023, August, 2023 and July, 2024



A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Thus, from the Table 4.24, 4.27 and 4.30 it can be inferred that the treatment factors root zone compaction, foliage trimming, and abscisic acid had a significant effect on stomatal conductance, transpiration rate, and photosynthetic activity. The impact of root zone compaction on these physiological parameters may be justified with the fact that root zone compaction reduced air and water contents of the root zone, these condition of hypoxia and reduced water uptake might have resulted in vasco constriction which induce stress and thus might have increase the ABA accumulation in the plant system and subsequent transport to leaves is the main mechanism that reduced stomatal conductance (Tardieu *et al.* 1992; Mulholland *et al.* 1996; Pezeshki 2001). Additionally, this phenomenon alters the root/shoot ratio, thereby impacting the carbon assimilation rate (Arp, 1991). The decrease in stomatal conductance leads to the reduction in excessive water loss by transpiration (Horchani *et al.* 2008). Tun and Tan, (1988); Gravatt and Kirby, 1998; Pascual *et al.* 2010; Bai *et al.* 2013; Umaru *et al.* (2021) demonstrated that the decrease in photosynthetic rate was associated with the reduction in stomatal conductance and transpiration rate, which reduces the CO₂ concentration within leaves. Moreover, reduced uptake of nitrogen from the soil horizon due to restricted root zone results in lower chlorophyll content limiting the photosynthetic potentials of a plant (Liu, 2011; Kobaissi *et al.* 2013).

Foliage trimming in nursery plants triggers stress responses, resulting in reduced stomatal conductance to conserve water, lower transpiration rates due to reduced leaf area, and decreased photosynthetic activity because of reduced leaf area and metabolic adjustments. These responses are the plant's adaptive mechanisms to manage stress and resource limitations in its environment. Similar results were reported by Saifuddin *et al.* (2010), who observed that the difference in stomatal conductance between complete and partial pruning may be attributed to the fact that complete pruning reduced the stomata frequency. Additionally, defoliation reduced the main leaf area compared to the control (Poni *et al.* 2006).

The exogenous application of abscisic acid results in the higher stomatal conductance, transpiration rate, and photosynthetic rate. This may be attributed to the fact that ABA application might have increased the concentration of antioxidants like proline, soluble sugars. Proline acts as compatible solute and plays a major role in osmotic adjustment (Teixeira and Fidalgo, 2009; Kahlaoui *et*

al. 2018) and which helps the plant to increase its stress tolerance. The findings of the present studies have been found to align with similar results reported by Crawford *et al.* (2012); McCartney *et al.* (2014); Malini *et al.* (2023).

4.1.8 Leaf relative water content (%)

The data presented in Table 4.32 shows the effect of root zone compaction (C), foliage trimming (P) and abscisic acid (A) treatment factors on leaf relative water content (RWC). All these treatment significantly affected the RWC. Highest value for leaf relative water content (77.02%) was found under ABA treatment (100ppm) was given, whereas the lowest (65.40%) was found when ABA treatment (0ppm) was given.

Among various pruning intensities maximum RWC (75.79%) was found in P₃, whereas minimum (66.88%) was found in P₁.

Data further revealed that the maximum RWC (80.10%) was found in C₃, whereas minimum (64.02%) was found in C₁. Moreover the first order interaction found significant except P × C interaction and the second order interaction found insignificant. The interaction of A₁P₃ noticed maximum leaf relative water content (79.30%) which was statistically at par with A₁P₂ (77.04%), while the minimum leaf relative water content (59.05%) was recorded in A₂P₁. The interaction between A × C had a significant effect on leaf relative water content. The maximum leaf relative water content (83.85%) was observed in A₁C₃, whereas, the minimum leaf relative water content (58.35%) was found in A₂C₁.

Table 4.32 Effect of root zone compaction, foliage trimming and abscisic acid on relative water content (RWC) of leaves in the month of August, 2023 (after treatment)

Leaf relative water content (%)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			Mean
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	67.30	69.39	72.37	69.69	52.67	59.84	62.54	58.35	59.99	64.62	67.45	64.02
	C ₂	75.18	77.38	80.01	77.53	55.57	61.69	67.23	61.49	65.38	69.53	73.62	69.51
	C ₃	81.64	84.35	85.54	83.85	68.91	73.13	87.05	76.36	75.28	78.74	86.29	80.10
Mean		74.70	77.04	79.30	77.02	59.05	64.88	72.27	65.40	66.88	70.96	75.79	
Factors				C.D.		SE(d)				SE(m)			
Factor(A)				1.63		0.82				0.58			
Factor(P)				2.00		1.00				0.71			
Factor (C)				2.00		1.00				0.71			
Interaction A X P				2.82		1.41				1.00			
Interaction A X C				2.82		1.41				1.00			
Interaction P X C				NS		1.73				1.22			
Interaction A X P X C				NS		2.45				1.73			

A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

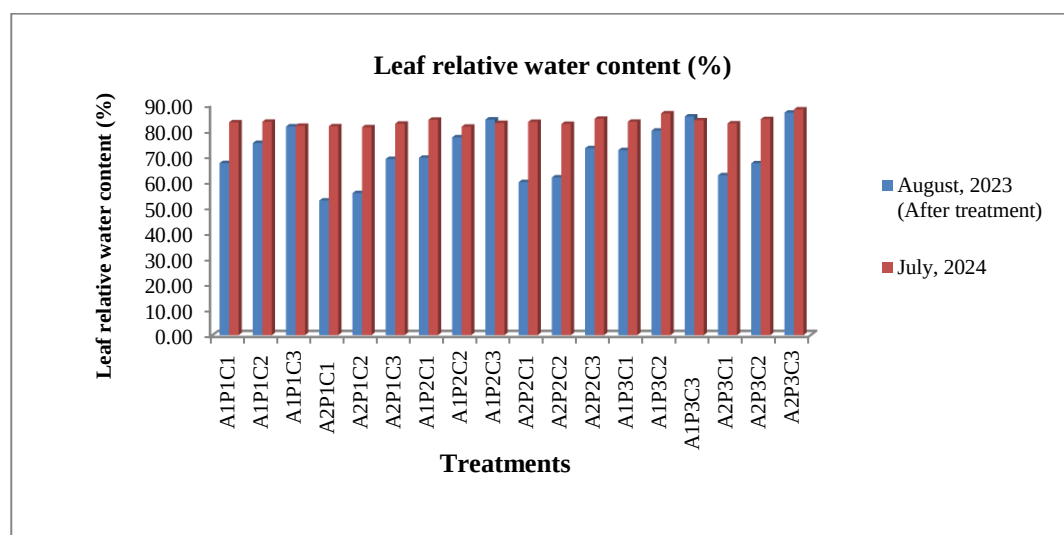
According to the data presented in Table 4.33, root zone compaction (C), foliage trimming (P) and abscisic acid (A) treatment had no significant difference on the relative leaf water content of leaves during July, 2024.

Table 4.33 Effect of root zone compaction, foliage trimming and abscisic acid on relative water content (RWC) of leaves in the month of July, 2024

Leaf relative water content (%)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	83.26	84.27	83.49	83.67	81.70	83.42	82.83	82.65	82.48	83.84	83.16	83.16
	C ₂	83.46	81.57	86.73	83.92	81.33	82.63	84.52	82.82	82.39	82.10	85.63	83.37
	C ₃	81.88	82.99	84.04	82.97	82.72	84.67	88.31	85.23	82.30	83.83	86.18	84.10
Mean		82.87	82.94	84.75	83.52	81.92	83.57	85.22	83.57	82.39	83.26	84.99	
Factors				C.D.		SE(d)				SE(m)			
Factor(A)				NS		1.18				0.84			
Factor(P)				NS		1.45				1.02			
Factor (C)				NS		1.45				1.02			
Interaction A X P				NS		2.05				1.45			
Interaction A X C				NS		2.05				1.45			
Interaction P X C				NS		2.51				1.77			
Interaction A X P X C				NS		3.55				2.51			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Fig. 4.4 Comparative account of leaf relative water content between the month of August, 2023 and July, 2024



A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

The present study has concluded that the application of root zone compaction has led to a significant decrease in the relative water content of leaves compared to the control. This decrease in the relative water content of leaves may be due to increased mechanical impedance imported by the compaction of root zone resulting in reduced water supply from root system to shoots (Masle and Passioura 1987; Grzesiak, 2009).

The role of foliage trimming may be explained by the fact that the unpruned trees had more number of old leaves (reduction in differences of leaf turgid and dry weights) as compared to the pruned tree (Singh *et al.* 2009). Our results are in line with the results of Pathania, (2020) who found the highest relative water content (93.63%) was found in control and lowest (90.13%) was found in the treatment of head back at 40 cm.

From the table it is evident that abscisic acid (A) application improves the relative leaf water content of guava grafts. Absciscic acid, a plant growth regulator induce antioxidant activity like soluble sugars, proline, which play a role in scavenging ROS, leading to a reduction in oxidative stress, resulting in improved relative water content of leaves (Agarwal *et al.* 2005). Moreover, proline and leaf sugars acts as compatible solute and helps in osmotic adjustment during stress (Ashraf and Foolad 2007; Trovato *et al.* 2008). This improvement in relative leaf water content may be attributed to the conservation of moisture in plants (Hoad *et al.* 2001). The results are consistent with those of Ramasamy *et al.* (2020) who found that foliar spray of abscisic acid significantly improved the relative water content (89.57 %) of tomato seedlings as compared to control. The application of ABA and KCl under drought conditions significantly increased the relative leaf water content of sunflower hybrids (Bukhsh *et al.* 2012).

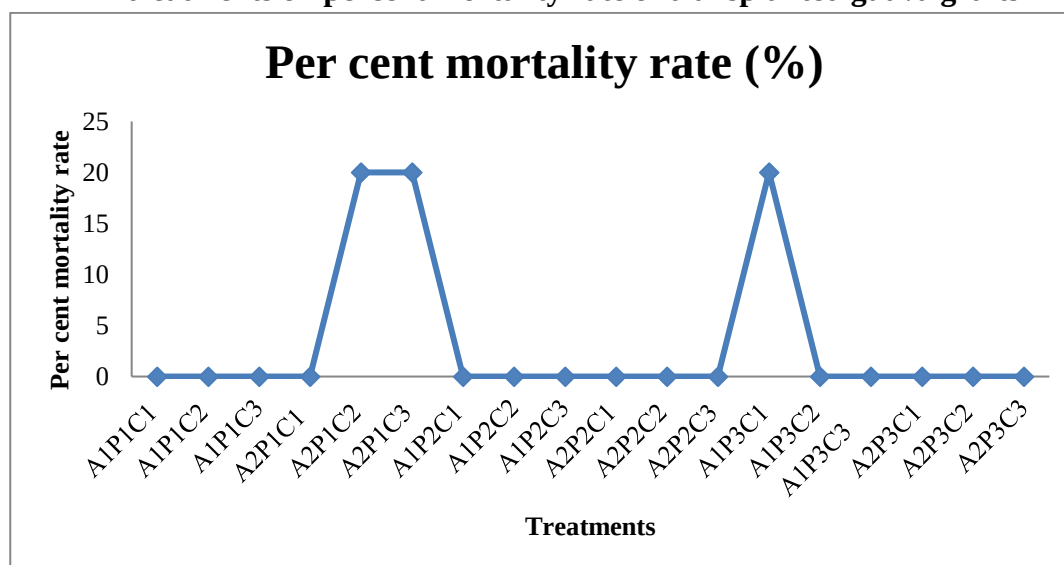
4.1.9 Percent mortality of transplanted grafts

From August, 2023 to May, 2024, all treatments showed a 0% mortality rate. However, there was a recorded mortality (20%) in A₂P₁C₂ (0 ppm ABA, 50% foliage trimming and 25% root zone compaction), A₂P₁C₃ (0 ppm ABA, 50% foliage trimming and 50% root zone compaction) and in A₁P₃C₁ (100 ppm ABA, 0% foliage trimming and 50% root zone compaction) in the month of June, 2024 as shown in the table below

Table 4.34 Effect of root zone compaction, foliage trimming and abscisic acid on per cent mortality rate of guava grafts in the month of June, 2024

Sr. no.	Treatments	Mortality rate (%)
1.	A ₁ P ₁ C ₁	0
2.	A ₁ P ₁ C ₂	0
3.	A ₁ P ₁ C ₃	0
4.	A ₂ P ₁ C ₁	0
5.	A ₂ P ₁ C ₂	20
6.	A ₂ P ₁ C ₃	20
7.	A ₁ P ₂ C ₁	0
8.	A ₁ P ₂ C ₂	0
9.	A ₁ P ₂ C ₃	0
10.	A ₂ P ₂ C ₁	0
11.	A ₂ P ₂ C ₂	0
12.	A ₂ P ₂ C ₃	0
13.	A ₁ P ₃ C ₁	20
14.	A ₁ P ₃ C ₂	0
15.	A ₁ P ₃ C ₃	0
16.	A ₂ P ₃ C ₁	0
17.	A ₂ P ₃ C ₂	0
18.	A ₂ P ₃ C ₃	0

Fig. 4.5 Effect of root zone compaction, foliage trimming and abscisic acid treatments on percent mortality rate of transplanted guava grafts



A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

4.2 Effect of root zone compaction, foliage trimming and abscisic acid intensities on biochemical characteristics of grafted guava plants.

The data pertaining to the effect of root zone compaction, foliage trimming and abscisic acid on biochemical characteristics exhibited a significant outcome which is presented in different tables below:

4.2.1 Effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll content of leaves.

4.2.1.1 Chlorophyll - a (mg/ml)

The data in Table 4.35 illustrates the impact of root zone compaction (C), foliage trimming (P) and abscisic acid treatment (A) on the leaf chlorophyll a content. The results indicate that the application of root zone compaction (C), foliage trimming (P) and abscisic acid (A) significantly influenced the chlorophyll a content. The highest chlorophyll-a content (1.57 mg/ml) was recorded under the 100 ppm abscisic acid (A₁) treatment, whereas, 1.13 mg/ml chlorophyll-a content was recorded in non-treated grafts (A₂).

The different pruning intensities also exerted a significant influence on the chlorophyll-a content. The highest chlorophyll-a content (1.91 mg/ml) was observed under untreated grafts (P₃), whereas, the 50% reduction of foliage (P₁) registered the lowest chlorophyll-a content (0.93 mg/ml).

Compaction of the root zone also influenced the chlorophyll-a content of plants. The chlorophyll-a content of the leaves decreased with the increase in compaction of the root zone. Highest chlorophyll-a content (1.54 mg/ml) was recorded under non-compacted grafts (C₃), whereas, when root zone was compacted by 50% (C₁), the chlorophyll-a content was recorded 1.19 mg/ml.

The examination of data given in Table 4.14 further revealed that the interaction effect of all treatment combinations $A \times C$ was found to be significant from the statistical perspective. The higher chlorophyll-a content (1.96 mg/ml) was recorded in the leaves of the plant which were sprayed with ABA @ 100 ppm and were not subjected to any root zone compaction (A₁C₃) which was statistically at par with the A₂C₃ (1.86 mg/ml) whereas, the plants which received root zone

compaction (A₂C₁) were found to have minimum chlorophyll-a content (0.72 mg/ml) which was statistically at par with A₂C₂ (0.74 mg/ml).

Table 4.35 Effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-a content of guava grafts in the month of August, 2023 (after treatment)

Chlorophyll-a content (mg/ml)															
		A								P					
		A ₁			Mean	A ₂			Mean	Mean				Mean	
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃			
C	C ₁	1.03	1.18	1.23	1.15	0.59	0.77	0.79	0.72	0.81	0.97	1.01	0.93		
	C ₂	1.56	1.59	1.64	1.60	0.63	0.80	1.03	0.82	1.10	1.20	1.34	1.21		
	C ₃	1.86	1.98	2.05	1.96	1.47	1.64	2.49	1.86	1.66	1.81	2.27	1.91		
Mean		1.48	1.58	1.64	1.57	0.90	1.07	1.44	1.13	1.19	1.33	1.54			
Factors				C.D.				SE(d)				SE(m)			
Factor(A)				0.14				0.07				0.05			
Factor(P)				0.17				0.09				0.06			
Factor(C)				0.17				0.09				0.06			
Interaction A X P				NS				0.12				0.09			
Interaction A X C				0.24				0.12				0.09			
Interaction P X C				NS				0.15				0.10			
Interaction A X P X C				NS				0.21				0.15			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

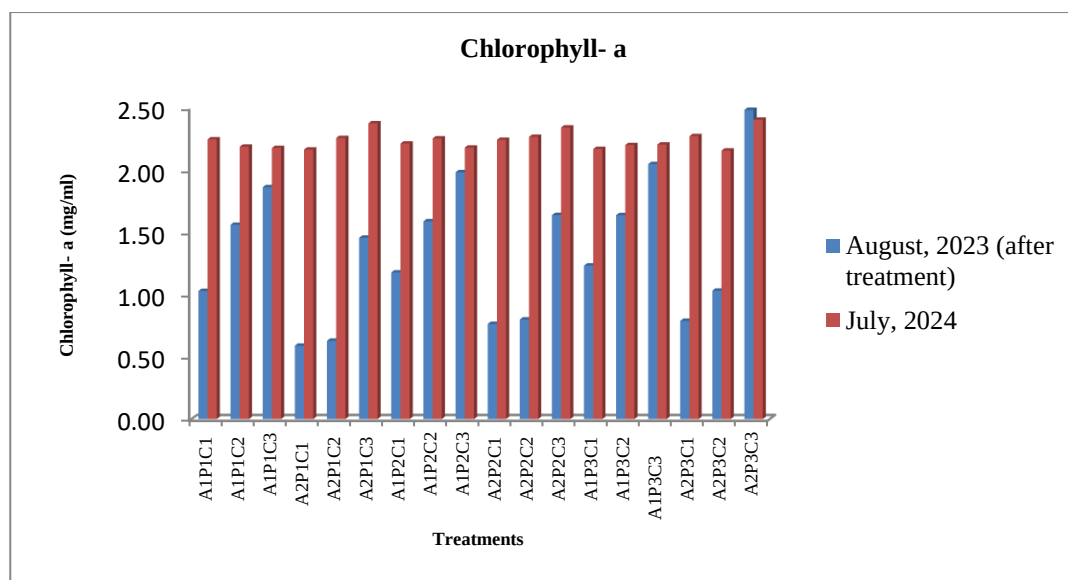
According to the data presented in Table 4.36, root zone compaction (C), foliage trimming (P) and abscisic acid (A) had no significant difference on chlorophyll-a content of guava grafts in the month of July, 2024.

Table 4.36 Effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-a content of guava grafts in the month of July, 2024

Chlorophyll-a (mg/ml)														
		A								P				
		A ₁			Mean	A ₂			Mean	Mean				Mean
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		
C	C ₁	2.25	2.22	2.17	2.21	2.17	2.25	2.28	2.23	2.21	2.23	2.22	2.22	
	C ₂	2.19	2.26	2.20	2.22	2.26	2.27	2.16	2.23	2.22	2.26	2.18	2.22	
	C ₃	2.18	2.18	2.21	2.19	2.38	2.34	2.41	2.38	2.28	2.26	2.31	2.28	
Mean		2.21	2.22	2.19	2.21	2.27	2.29	2.28	2.28	2.24	2.25	2.24		
Factors		C.D.				SE(d)				SE(m)				
Factor(A)				NS				0.04				0.03		
Factor(P)				NS				0.05				0.04		
Factor(C)				NS				0.05				0.04		
Interaction A X P				NS				0.07				0.05		
Interaction A X C				NS				0.07				0.05		
Interaction P X C				NS				0.09				0.06		
Interaction A X P X C				NS				0.13				0.09		

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Fig. 4.6 Comparative account of Chlorophyll-a content of guava grafts between the month of August, 2023 and July, 2024



A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

4.2.1.2 Chlorophyll-b (mg/ml)

The data presented in Table 4.37 demonstrates the impact of root zone compaction, foliage trimming and abscisic acid on chlorophyll b content. Upon evaluating the data, it is evident that root zone compaction, foliage trimming and abscisic acid had a significant effect on chlorophyll-b content. The maximum chlorophyll-b content (1.06 mg/ml) was recorded under the 100ppm of abscisic acid (A₁), whereas the minimum chlorophyll-b content (0.61 mg/ml) was recorded in non treated grafts (A₂).

Among the different foliage trimming treatments, highest chlorophyll-b content (1.04 mg/ml) was recorded under untreated grafts (P₃), whereas, the lowest chlorophyll - b content (0.66 mg/ml) was observed in P₁ (50% foliage trimming). Compaction of the root zone also influenced the chlorophyll-b content of plants. The chlorophyll-b content of the leaves decreased with the increase in compaction of the root zone. Highest chlorophyll-b content (1.03 mg/ml) was recorded under non-compacted grafts (C₃), whereas, when root zone was compacted by 50% (C₁), the chlorophyll-b content was recorded 0.66 mg/ml. However, the interaction effect of all treatment combinations was found to be non-significant statistically.

Table 4.37 Effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-b content of guava grafts in the month of August, 2023 (after treatment)

Chlorophyll-b content (mg/ml)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	0.76	0.96	0.98	0.90	0.27	0.37	0.60	0.42	0.52	0.67	0.79	0.66
	C ₂	0.87	1.07	1.30	1.08	0.45	0.53	0.61	0.53	0.66	0.80	0.96	0.81
	C ₃	1.11	1.17	1.31	1.20	0.48	0.85	1.35	0.89	0.79	1.01	1.33	1.04
Mean		0.92	1.07	1.20	1.06	0.40	0.58	0.86	0.61	0.66	0.83	1.03	
Factors				C.D.				SE(d)				SE(m)	
Factor(A)				0.23				0.11				0.08	
Factor(P)				0.28				0.14				0.10	
Factor(C)				0.28				0.14				0.10	
Interaction A X P				NS				0.20				0.14	
Interaction A X C				NS				0.20				0.14	
Interaction P X C				NS				0.24				0.17	
Interaction A X P X C				NS				0.34				0.24	

A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

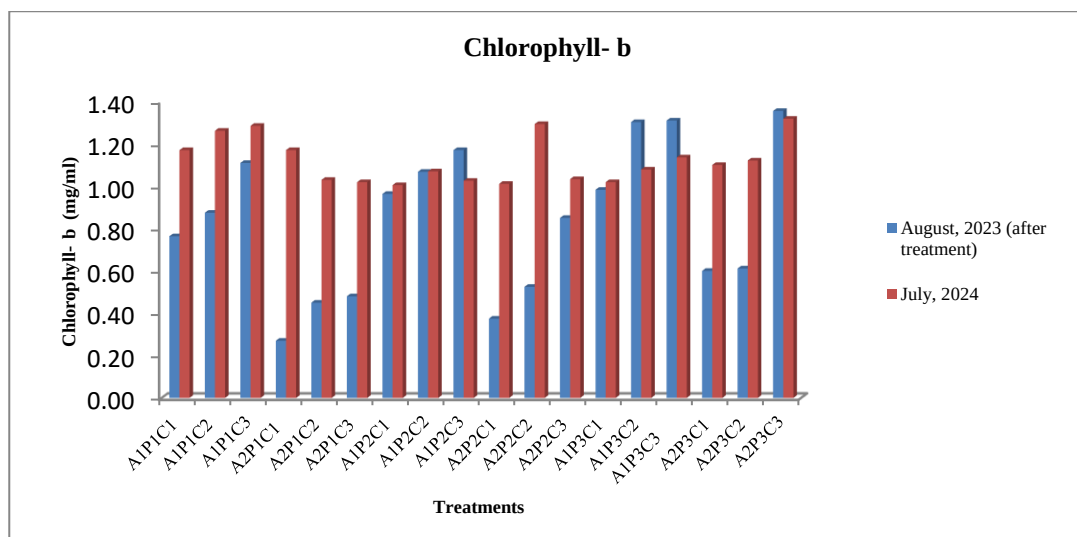
An analysis of the data presented in Table 4.38, reveals that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had no significant impact on the relative growth rate of guava grafts.

Table 4.38 Effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-b content of guava grafts in the month of July, 2024

Chlorophyll-b content (mg/ml)														
		A								P				
		A ₁			Mean	A ₂			Mean	Mean				Mean
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		
C	C ₁	1.17	1.01	1.02	1.07	1.17	1.01	1.10	1.10	1.17	1.01	1.06	1.08	
	C ₂	1.27	1.07	1.08	1.14	1.03	1.30	1.12	1.15	1.15	1.18	1.10	1.14	
	C ₃	1.29	1.03	1.14	1.15	1.02	1.04	1.32	1.12	1.15	1.03	1.23	1.14	
Mean		1.24	1.03	1.08	1.12	1.07	1.11	1.18	1.12	1.16	1.07	1.13		
Factors				C.D.				SE(d)		SE(m)				
Factor(A)				NS				0.08		0.06				
Factor(P)				NS				0.10		0.07				
Factor(C)				NS				0.10		0.07				
Interaction A X P				NS				0.13		0.10				
Interaction A X C				NS				0.13		0.10				
Interaction P X C				NS				0.17		0.12				
Interaction A X P X C				NS				0.23		0.17				

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Fig. 4.7: Comparative account of Chlorophyll-b content of guava grafts between the month of August, 2023 and July, 2024



A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

4.2.1.3 Total chlorophyll content (mg/ml)

The data presented in Table 4.39 showed the effect of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on total chlorophyll content of leaf. Root zone compaction (C), foliage trimming (P) and abscisic acid (A) showed significant effect. Highest total chlorophyll content (2.64 mg/ml) was found when 100 ppm of abscisic acid (A_1) was given whereas, the lowest total chlorophyll content (1.75 mg/ml) was found in A_2 (0ppm of abscisic acid).

A view of the data shown in Table 4.40 revealed that among different foliage trimming intensities, P_3 (0% foliage trimming) treatment registered maximum total chlorophyll content (2.58 mg/ml) and minimum total chlorophyll content (1.86 mg/ml) was obtained in P_1 (50% foliage trimming).

Data further revealed that highest total chlorophyll content (2.97 mg/ml) was found when 0 % compaction of polybags (C_3) was given, whereas lowest total chlorophyll content (1.60 mg/ml) was found in 50% reduction in polybag diameter keeping its length and height constant (C_1).

The examination of data presented here further revealed that the interactions between $A \times P$, $P \times C$ and $A \times P \times C$ were found to have non-significant effect on total chlorophyll content, whereas the interaction between $A \times C$ exhibited a significant effect on total chlorophyll content. The interaction A_1C_3 obtained highest total chlorophyll (3.18 mg/ml) which was statistically at par with the A_2C_3 (2.77 mg/ml), A_1C_2 (2.70 mg/ml), whereas the lowest total chlorophyll content (1.14 mg/ml) was recorded in A_2C_1 which was statistically at par with A_2C_2 (1.36 mg/ml).

Table 4.39 Effect of root zone compaction, foliage trimming and abscisic acid on total chlorophyll content of guava grafts in the month of August, 2023 (after treatment)

Total chlorophyll content (mg/ml)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	1.80	2.15	2.23	2.06	0.86	1.14	1.40	1.14	1.33	1.65	1.82	1.60
	C ₂	2.45	2.68	2.96	2.70	1.09	1.33	1.65	1.36	1.77	2.01	2.31	2.03
	C ₃	2.98	3.17	3.38	3.18	1.95	2.50	3.86	2.77	2.47	2.84	3.62	2.97
Mean		2.41	2.67	2.86	2.64	1.30	1.66	2.31	1.75	1.86	2.16	2.58	
Factors		C.D.				SE(d)				SE(m)			
Factor(A)				0.30			0.15			0.11			
Factor(P)				0.37			0.19			0.13			
Factor(C)				0.37			0.19			0.13			
Interaction A X P				NS			0.26			0.19			
Interaction A X C				0.52			0.26			0.19			
Interaction P X C				NS			0.32			0.23			
Interaction A X P X C				NS			0.45			0.32			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

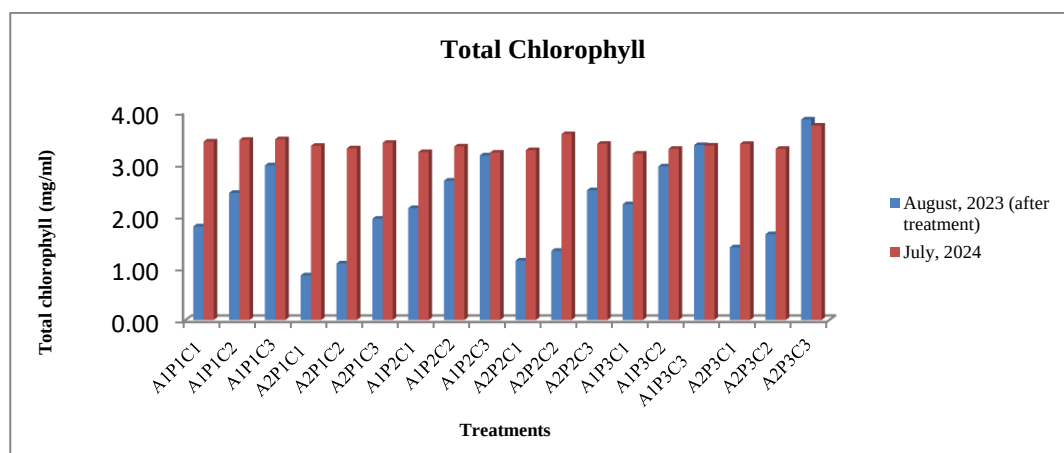
An analysis of the data presented in Table 4.40 reveals that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had no significant impact on total chlorophyll content of guava grafts in the month of July, 2024.

Table 4.40 Effect of root zone compaction, foliage trimming and abscisic acid on total chlorophyll content of guava grafts in the month of July, 2024

Total chlorophyll content (mg/ml)												
		A								P		
		A ₁			Mean	A ₂			Mean	Mean		
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃
C	C ₁	3.44	3.24	3.21	3.29	3.36	3.28	3.39	3.34	3.40	3.26	3.30
	C ₂	3.47	3.35	3.30	3.37	3.31	3.58	3.30	3.40	3.39	3.46	3.30
	C ₃	3.48	3.23	3.36	3.36	3.41	3.40	3.75	3.52	3.45	3.31	3.55
	Mean	3.46	3.27	3.29	3.34	3.36	3.42	3.48	3.42	3.41	3.34	3.39
Factors		C.D.		SE(d)		SE(m)						
Factor(A)		NS		0.07		0.05						
Factor(P)		NS		0.09		0.06						
Factor(C)		NS		0.09		0.06						
Interaction A X P		NS		0.12		0.09						
Interaction A X C		NS		0.12		0.09						
Interaction P X C		NS		0.15		0.11						
Interaction A X P X C		NS		0.21		0.15						

A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Fig. 4.8: Comparative account of total chlorophyll content of guava grafts between the month of August, 2023 and July, 2024



A ₁ = Abscisic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Abscisic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

From the result presented in Tables 4.35, 4.37 and 4.39, it has been inferred that the application of root zone compaction, foliage trimming, and abscisic acid

had a significant effect. Primarily the ABA application has been found to increase the chlorophyll pigments of guava grafts, whereas, the root zone compaction has resulted into decreased chlorophyll contents. This is significant as restricted root zone reduced the uptake of water and nitrogen from the soil horizon (Liu, 2011; Kobaissi *et al.* 2013).

The role of foliage trimming may be explained by the fact that it leads to reduce the canopy area of the plants. Moreover, defoliation reduced the amount of main leaf area as compared to control (Poni *et al.* 2006) and relative water content of leaf has a direct relation with chlorophyll content of leaves.

The influence of abscisic acid on increasing the chlorophyll contents is may be attributed to the reduction in oxidative damages to the cellular membranes due to elevated ABA levels of the plants (Ramasamy *et al.* 2020). Further, Agarwal *et al.* (2005); Silva *et al.* (2020) observed that abscisic acid increases the activity of antioxidants enzymes, which decreases the reactive oxygen species (ROS) like H₂O₂ content resulting in decreased oxidative stress. Moreover, exogenous application abscisic acid has also been found in increase the leaf relative water content (RWC) similar trend shown in Table 4.7, membrane stability as reported by Gong *et al.* 1998; Agarwal *et al.* 2005 and Barbosa *et al.* 2014.

4.2.2 Proline content (µmoles per g tissue)

The data presented in Table 4.41 reveals the impact of root zone compaction (C), foliage trimming (P) and abscisic acid (A) on proline content. The highest proline content (21.37 µmoles per g tissue) was noticed when hormonal treatment (100ppm) was given, whereas the lowest (6.61 µmoles per g tissue) was found when hormonal treatment (0ppm) was given.

Among the different foliage trimming intensities, maximum proline content (15.58 µmoles per g tissue) exhibited by P₁ (50% reduction in foliage), while the lowest (12.02 µmoles per g tissue) was noticed in P₃ (0 % reduction in foliage).

The data further revealed that among different root zone compaction treatment highest proline content (19.53 µmoles per g tissue) was found in C₁ (50% compaction of polybags), whereas the lowest proline content (9.27 µmoles per g tissue) was found in 0% reduction in polybag diameter keeping its length and

height constant (C_3). It is also evident from the data presented here that the interaction between $A \times P \times C$ had no significant effect on proline content. However, the interaction between $A \times P$, $P \times C$, and $A \times C$ had a significant effect on proline content. The interaction A_1P_1 obtained the maximum proline content (23.36 μ moles per g tissue), whereas the minimum proline content (5.08 μ moles per g tissue) was found in A_2P_3 . The interaction A_1C_1 obtained the maximum proline content (27.38 μ moles per g tissue), whereas the minimum proline content (2.31 μ moles per g tissue) was found in A_2C_3 . The interaction P_1C_1 noticed maximum proline content (21.69 μ moles per g tissue) which was statistically at par with P_2C_1 (20.08 μ moles per g tissue), while the minimum proline content (7.68 μ moles per g tissue) was recorded in P_3C_3 .

Table 4.41 Effect of root zone compaction, foliage trimming and abscisic acid on proline content of guava grafts in the month of August, 2023 (after treatment)

Proline content (μmoles per g tissue)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	30.24	27.90	24.00	27.38	13.13	12.25	9.63	11.67	21.69	20.08	16.81	19.53
	C ₂	22.72	20.63	18.12	20.49	6.78	5.70	5.03	5.84	14.75	13.17	11.58	13.17
	C ₃	17.11	16.81	14.76	16.23	3.47	2.85	0.59	2.31	10.29	9.83	7.68	9.27
Mean		23.36	21.78	18.96	21.37	7.80	6.94	5.08	6.61	15.58	14.36	12.02	
Factors				C.D.		SE(d)				SE(m)			
Factor(A)				0.44		0.22				0.16			
Factor(P)				0.54		0.27				0.19			
Factor(C)				0.54		0.27				0.19			
Interaction A X P				0.77		0.38				0.27			
Interaction A X C				0.77		0.38				0.27			
Interaction P X C				0.94		0.47				0.33			
Interaction A X P X C				NS		0.67				0.47			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

An analysis of the data presented in Table 4.42 reveals that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had no significant impact on proline content of guava grafts in the month of July, 2024.

Table 4.42 Effect of root zone compaction, foliage trimming and abscisic acid on proline content of guava grafts in the month of July, 2024

Proline content (µmoles per g tissue)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			Mean
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	0.27	0.48	0.30	0.35	0.42	0.26	0.29	0.32	0.34	0.37	0.29	0.34
	C ₂	0.23	0.29	0.40	0.31	0.35	0.24	0.48	0.35	0.29	0.26	0.44	0.33
	C ₃	0.33	0.32	0.42	0.35	0.20	0.14	0.48	0.27	0.26	0.23	0.45	0.31
	Mean	0.28	0.36	0.37	0.34	0.32	0.21	0.41	0.32	0.30	0.29	0.39	
Factors		C.D.				SE(d)				SE(m)			
Factor(A)		NS				0.07				0.05			
Factor(P)		NS				0.09				0.06			
Factor(C)		NS				0.09				0.06			
Interaction A X P		NS				0.13				0.09			
Interaction A X C		NS				0.13				0.09			
Interaction P X C		NS				0.16				0.11			
Interaction A X P X C		NS				0.22				0.16			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Proline, classified as a nonessential amino acid, fulfills a multifaceted role encompassing its functions as an osmolyte and an antioxidant. Furthermore, it exerts a protective influence on macromolecules and cellular structures (Kavikishor *et al.* 2005; Paleg *et al.* 1981; Stewart and Lee 1974). The present study has concluded that the application of root zone compaction has led to a significant increase in the proline content of leaves as compared to the control. This increase can be supported with the findings of Olivella *et al.* 2000; Arbona and Gómez-Cadenas 2008; Velasco *et al.* 2019 and Cao *et al.* 2020 supporting that the compaction of root zone has created hypoxia conditions which might have triggered the proline biosynthesis, mechanisms in the plants for preventing the reactive oxygen species (ROS) damage to the plants. This conclusion is also

supported by the study conducted by Aloni and Rosenshtein, (1982) which recorded an increase in proline content in a hypoxia-tolerant cultivar.

Zuo *et al.* (2022) concluded that the increase in proline content resulting from defoliation serves to scavenge newly generated reactive oxygen species (ROS), maintain cellular water balance, prevent membrane damage, and mitigate oxidative stress. Similar result was found by Bagchi *et al.* (2008) where proline content was increase with increase in pruning levels in guava.

Furthermore, ABA, known as a stress hormone, has been found to enhance stress tolerance of plants when applied externally. This is achieved by regulating water balance, activating antioxidant systems, maintaining membrane stability, and increasing the levels of osmotic adjustment substances such as soluble sugars, soluble proteins, and amino acids (Chen *et al.* 2018; Nawaz and Wang, 2020). Proline accumulates during stress to maintain osmotic balance in wheat and papaya (Kaur and Asthir, 2015; Mahouachi *et al.* 2012). These findings are corroborated by the research of Sun *et al.* (2023), who also reported that the exogenous application of abscisic acid increased the proline content by 32% as compared to the control.

4.2.3 Soluble sugars (%)

The data presented in Table 4.43 reveals that root zone compaction (C), foliage trimming (P) and abscisic acid (A) significantly influenced the total sugar content of guava leaves. Furthermore, the interaction effects of different treatment factors were found to be statistically significant except $A \times P$ and $P \times C$.

The highest value of soluble sugar, 4.18%, were recorded with the $A_1P_1C_1$ combination, which consists of abscisic acid at 100 ppm, 50% reduction in foliage, and 50% reduction in polybag diameter keeping its length and height constant which was statistically at par with the soluble sugar content of 4.05% observed under $A_1P_2C_1$, whereas the lowest value of soluble sugar (0.57 %) was found in $A_2P_3C_3$, which consists of abscisic acid at 0 ppm, 0 % reduction in foliage, and 0 % reduction in polybag diameter keeping its length and height constant which was statistically at par with the soluble sugar content of 0.70 % was found in $A_2P_2C_3$. It implies that all the treatment factors whether abscisic acid, foliage trimming or 50% root zone compaction led to increase in leaf soluble sugar content which

indicated that the treatment factors induced stress to the plant in response of that these plants initiated their defense mechanism and raised leaf soluble sugar levels for scavenging the stress induced reactive oxygen species (ROS).

Table 4.43 Effect of root zone compaction, foliage trimming and abscisic acid on leaf soluble sugars of guava grafts in the month of August, 2023

Soluble sugars (%)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			Mean
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	4.18	4.05	3.81	4.01	1.33	1.30	1.22	1.28	2.75	2.67	2.51	2.65
	C ₂	2.06	1.63	1.51	1.73	1.14	1.09	1.05	1.09	1.60	1.36	1.28	1.41
	C ₃	1.46	1.38	1.37	1.40	0.90	0.70	0.57	0.73	1.18	1.04	0.97	1.06
Mean		2.57	2.35	2.23	2.38	1.12	1.03	0.95	1.03	1.85	1.69	1.59	
Factors				C.D.		SE(d)				SE(m)			
Factor(A)				0.07		0.04				0.03			
Factor(P)				0.09		0.04				0.03			
Factor(C)				0.09		0.04				0.03			
Interaction A X P				NS		0.06				0.04			
Interaction A X C				0.12		0.06				0.04			
Interaction P X C				NS		0.08				0.05			
Interaction A X P X C				0.21		0.11				0.08			

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

An analysis of the data presented in Table 4.44 reveals that root zone compaction (C), foliage trimming (P), and abscisic acid (A) had no significant impact on soluble sugars of guava grafts in the month of July, 2024.

Table 4.44 Effect of root zone compaction, foliage trimming and abscisic acid on leaf soluble sugars of guava grafts in the month of July, 2024

Soluble sugars (%)													
		A								P			
		A ₁			Mean	A ₂			Mean	Mean			
		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃	
C	C ₁	0.47	0.39	0.43	0.43	0.33	0.49	0.39	0.40	0.40	0.44	0.41	0.42
	C ₂	0.44	0.43	0.35	0.41	0.39	0.42	0.45	0.42	0.42	0.42	0.40	0.41
	C ₃	0.53	0.40	0.42	0.45	0.44	0.41	0.41	0.42	0.49	0.41	0.42	0.44
Mean		0.48	0.41	0.40	0.43	0.38	0.44	0.42	0.41	0.43	0.42	0.41	
Factors		C.D.				SE(d)				SE(m)			
Factor(A)				NS				0.06				0.04	
Factor(P)				NS				0.07				0.05	
Factor(C)				NS				0.07				0.05	
Interaction A X P				NS				0.10				0.07	
Interaction A X C				NS				0.10				0.07	
Interaction P X C				NS				0.12				0.08	
Interaction A X P X C				NS				0.17				0.12	

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Recent research has demonstrated that the application of root zone compaction, foliage trimming, and abscisic acid show significant increase in soluble sugar content in leaves. The application of root zone compaction has been found to increase the concentration of ABA in roots (Tardieu *et al.* 1992) resulting in increase in soluble sugar content and proline content in leaves, which play a major part in osmotic adjustment in leaves (Hartzendorf and Rolletschek, 2001; Chen *et al.* 2018; Nawaz and Wang, 2020).

Bakhvalov *et al.* (2010) concluded that the artificial defoliation of trees causes a short-term increase in the concentration of soluble sugars in damaged leaves, likely due to the conversion of plant polysaccharides (starch, glycogen, and

cellulose) into monosaccharide (glucose and galactose) and disaccharides (sucrose and maltose).

Additionally, abscisic acid is known to enhance the accumulation of soluble sugars, proline, alcohol in leaves (Serraj and Sinclair, 2002). This accumulation helps to maintain osmotic balance and protect enzymes and membranes from the harmful effects of destabilizing ions (Farooq *et al.* 2009). Furthermore, exogenous ABA has been found to increase the accumulation of total soluble sugars in rice (Lee *et al.* 1991), and moss (Nagao *et al.* 2005) under cold stress conditions. Notably, stachyose, raffinose, and sucrose levels were significantly higher in ABA-treated seedlings (Meng *et al.* 2008). Furthermore, Nagao *et al.* 2005 concluded that increase in sugars induced by ABA is likely to be associated with reduction in the amount of starch in chloroplasts of the protonema cells.

4.3 Carbon emission equivalence factor

The data presented in Table 4.45 reveals that the estimated lowest value of CO₂ emission equivalence (1.17×10^{-4} litre plant⁻¹ year⁻¹) was found in A₁P₁C₁ (100 ppm ABA, 50 % foliage trimming and 50% root zone compaction) as well as in A₂P₁C₁ (0 ppm ABA, 50% foliage trimming and 50% root zone compaction) whereas, the highest CO₂ emission equivalence (3.05×10^{-4} litre plant⁻¹ year⁻¹) was found in A₂P₃C₃ (0 ppm ABA, 0% foliage trimming and 0% root zone compaction) as well as in A₁P₃C₃ (100 ppm ABA, 0 % foliage trimming and 0% root zone compaction).

Table 4.45 CO₂ equivalence of different treatment combination of root zone compaction, foliage trimming and abscisic acid

Sr. No.	Treatment	Number of plants/ m ³	CO ₂ equivalence/ m ³	CO ₂ equivalence/plant (litre plant ⁻¹ year ⁻¹)
1.	A ₁ P ₁ C ₁	333.33	391.04 × 10 ⁻⁴	1.17× 10 ⁻⁴
2.	A ₁ P ₁ C ₂	222.22	391.04 × 10 ⁻⁴	1.76× 10 ⁻⁴
3.	A ₁ P ₁ C ₃	208.33	391.04 × 10 ⁻⁴	1.88× 10 ⁻⁴
4.	A ₂ P ₁ C ₁	333.33	391.04 × 10 ⁻⁴	1.17× 10 ⁻⁴
5.	A ₂ P ₁ C ₂	222.22	391.04 × 10 ⁻⁴	1.76× 10 ⁻⁴
6.	A ₂ P ₁ C ₃	208.33	391.04 × 10 ⁻⁴	1.88× 10 ⁻⁴
7.	A ₁ P ₂ C ₁	256.41	391.04 × 10 ⁻⁴	1.53× 10 ⁻⁴
8.	A ₁ P ₂ C ₂	169.49	391.04 × 10 ⁻⁴	2.31× 10 ⁻⁴
9.	A ₁ P ₂ C ₃	161.29	391.04 × 10 ⁻⁴	2.42× 10 ⁻⁴
10.	A ₂ P ₂ C ₁	256.41	391.04 × 10 ⁻⁴	1.53× 10 ⁻⁴
11.	A ₂ P ₂ C ₂	169.49	391.04 × 10 ⁻⁴	2.31× 10 ⁻⁴
12.	A ₂ P ₂ C ₃	161.29	391.04 × 10 ⁻⁴	2.42× 10 ⁻⁴
13.	A ₁ P ₃ C ₁	200	391.04 × 10 ⁻⁴	1.96× 10 ⁻⁴
14.	A ₁ P ₃ C ₂	135.13	391.04 × 10 ⁻⁴	2.89× 10 ⁻⁴
15.	A ₁ P ₃ C ₃	128.20	391.04 × 10 ⁻⁴	3.05× 10 ⁻⁴
16.	A ₂ P ₃ C ₁	200	391.04 × 10 ⁻⁴	1.96× 10 ⁻⁴
17.	A ₂ P ₃ C ₂	135.13	391.04 × 10 ⁻⁴	2.89× 10 ⁻⁴
18.	A ₂ P ₃ C ₃	128.20	391.04 × 10 ⁻⁴	3.05× 10 ⁻⁴

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

4.4 Weight of the parameters (W)

The data detailed in Table 4.46 presents the total scores and rankings of various treatment combinations of root zone compaction (C), foliage trimming (P), and abscisic acid (A). Upon evaluating the rank values of all treatment combinations, it is apparent that the combination involving ABA @ 100 ppm, 25% foliage trimming, and 50% root zone compaction treatment combination was best for compaction of guava nursery for efficient transport without compromising the field survival and growth of guava grafts.

Table 4.46 Total score and ranking of different treatment combination of root zone compaction, foliage trimming and abscisic acid

Sr. No.	Treatment	Score (S) = $T_e + S_r + P + L$	Weight (W) = 2.5	Total score (T _s) = $S \times W$	Ranking
1.	A ₁ P ₂ C ₁	37.7	2.5	94.23	1
2.	A ₂ P ₁ C ₁	37.6	2.5	94.01	2
3.	A ₁ P ₁ C ₃	33.9	2.5	84.66	3
4.	A ₁ P ₂ C ₂	33.7	2.5	84.30	4
5.	A ₂ P ₂ C ₁	32.8	2.5	82.06	5
6.	A ₁ P ₁ C ₁	32.8	2.5	82.01	6
7.	A ₂ P ₂ C ₃	32.5	2.5	81.14	7
8.	A ₁ P ₃ C ₂	31.9	2.5	79.82	8
9.	A ₁ P ₁ C ₂	31.9	2.5	79.80	9
10.	A ₁ P ₃ C ₁	31.4	2.5	78.49	10
11.	A ₂ P ₃ C ₁	31.0	2.5	77.58	11
12.	A ₂ P ₃ C ₃	30.4	2.5	75.93	12
13.	A ₂ P ₁ C ₂	28.9	2.5	72.37	13
14.	A ₁ P ₃ C ₃	28.7	2.5	71.86	14
15.	A ₁ P ₂ C ₃	28.7	2.5	71.82	15
16.	A ₂ P ₂ C ₂	28.5	2.5	71.29	16
17.	A ₂ P ₁ C ₃	28.5	2.5	71.22	17
18.	A ₂ P ₃ C ₂	28.4	2.5	70.98	18

A ₁ = Absciscic acid at 100 ppm	P ₁ = 50 % foliage trimming	C ₁ = 50 % root zone compaction
A ₂ = Absciscic acid at 0 ppm	P ₂ = 25 % foliage trimming	C ₂ = 25 % root zone compaction
	P ₃ = 0 % foliage trimming	C ₃ = 0 % root zone compaction

Chapter-5

SUMMARY AND CONCLUSION

The present explorations on “**Effect of pre-transit root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava**” were conducted at the experimental orchard of the Department of Fruit Science, College of Horticulture and Forestry, Neri, Hamirpur (H.P.) during the year 2023-2024. The findings of the studies conducted are summarized as follows:

- The treatment factors root zone compaction (C), foliage trimming (P) and abscisic acid (A) produced significant effects on plants’ physical parameters. After the application of the treatments, the physical parameters were reduced due to foliage trimming but the treated plants recovered after transplanting in the field. The highest number of leaves (248.5) and plant height (126 cm) were obtained under the treatment combination of ABA @ 100 ppm, 25% foliage trimming and 50% root zone compaction. However, the plant girth (22.06 mm) was recorded better under 100 ppm of ABA, 25% foliage trimming and 25% root zone compaction. At the end of the experiment, all treatment combinations were found to have plant physical parameters similar to those observed under the control which indicated the negation of the negative effects of different treatments.
- In terms of the physiological responses in relation to the applied treatment combination, ABA at 100 ppm resulted in elevated stomatal conductance ($0.12 \text{ mol m}^{-2}\text{s}^{-1}$) and transpiration rate ($3.14 \text{ m mol m}^{-2}\text{s}^{-1}$) than untreated plants. Whereas, the other treatment factors like foliage trimming and root zone compaction reduced the stomatal conductance and transpiration rate. The highest photosynthetic activity ($7.79 \text{ } \mu\text{moles m}^{-2} \text{ s}^{-1}$) under this treatment combination (100 ppm ABA treatment combined with 0% root zone compaction) indicated improved stress tolerance of the guava grafts. Additionally, the highest leaf relative water content (83.85%) was also found in the 100 ppm ABA treatment combined with 0% root zone compaction. At the end of the experiment, *i.e.* after well establishment of

the plants under field conditions, all the treatment combinations showed statistically similar physiological responses.

- The chlorophyll content (total, a and b) after the treatment was found to be highest (3.18 mg/ml) in 100 ppm of ABA and 0% of root zone compaction. Furthermore, at the end of the experiment, all treatment combinations were found to be statistically similar in terms of chlorophyll content.
- In terms of biochemical responses, the highest proline content (27.38 μ moles per g tissue) was recorded in plants treated with 100 ppm of ABA and 50% root zone compaction. Additionally, the highest leaf soluble sugar (4.18%) was also recorded under this treatment combination *i.e.* ABA @ 100 ppm, 50% foliage trimming and 50% root zone compaction, though statistically, it was at par with 4.05% leaf sugar level which was observed under ABA @ 100 ppm, 25% foliage trimming, 50% root zone compaction.
- The estimates of carbon emission equivalence as influenced by the application of root zone compaction (C), foliage trimming (P), and abscisic acid (A) treatments revealed that under the treatment combination of 25% foliage trimming and 50% root zone compaction decrease in GHG/ CO₂ equivalence of transportation per plant was estimated (1.53×10^{-4} litre plant⁻¹year⁻¹), while it was estimated to be highest (3.05×10^{-4} litre plant⁻¹year⁻¹) under control and the lowest GHG/CO₂ emission (1.17×10^{-4} litre plant⁻¹year⁻¹) was estimated in 50% foliage trimming and 50% root zone compaction irrespective of ABA treatment.
- The calculated rank value of all the treatment combinations depicted that A₁P₂C₁ *i.e.* ABA @ 100 ppm, 25% foliage trimming and 50% root zone compaction treatment combination was best for compaction of guava nursery for efficient transport without compromising the field survival and growth of guava grafts.

CONCLUSION: With the view of reducing the drudgery and carbon emission associated with nursery transport without compromising the field survival and performance of transplanted guava grafts combinations of various treatments were tried. The impact of these treatments was evaluated for the plants' physical, biochemical, and physiological characteristics. This treatment combination of 100 ppm ABA, 25% foliage trimming, and 50% root zone compaction produced

positive results in terms of leaf number, plant height and leaf soluble sugars signifying improved stress tolerance of treated guava grafts. Therefore, it has been concluded that for efficient transport, the practice of pre-transit treatment of guava grafts with 100 ppm ABA foliar spray, 25% foliage trimming and 50% compaction of root zone can be adopted without compromising the field survival and post-transplanting growth. It will not only reduce the transportation cost of the nursery but will also help in saving the environment by reducing carbon emissions.

LITERATURE CITED

- Adhikari S and Kandel T P. 2015. Effect of time and level of pruning on vegetative growth, flowering, yield, and quality of guava. *International Journal of Fruit Science* **15**:290-301.
- Agarwal S, Sairam R K, Srivastava G C and Meena R C. 2005. Changes in antioxidant enzymes activity and oxidative stress by abscisic acid and salicylic acid in wheat genotypes. *Biologia plantarum* **49**:541-550.
- Alameda D and Rafael V. 2009. Moderate soil compaction: implications on growth and architecture in seedlings of 17 woody plant species. *Soil and Tillage Research* **103**: 325-331.
- Albinsky D, Masson J E, Bogucki A, Afsar K, Vass I, Nagy F and Paszkowski J. 1999. Plant responses to genotoxic stress are linked to an ABA/salinity signaling pathway. *The Plant Journal* **17**:73-82.
- Aloni B and Rosenshtein G. 1982. Effect of flooding on tomato cultivars: the relationship between proline accumulation and other morphological and physiological changes. *Physiologia Plantarum* **56**:513–517.
- Añez Q M E. 1998. Systematic pruning in guava (*Psidium guajava* L.). In: *Proceedings of the Interamerican Society for Tropical Horticulture*, Crane J H ed. held at Barquisimeto, Venezuela. Universidad Ezequiel Zamora (UNELLEZ), Venezuela. pp. 297-300.
- Anonymous. 2022. *Final Estimates of 2020-2021 and First Advance Estimates of 2021-2022 of Area and Production of Horticultural Crops*. Information Bureau. 1-28.
- AOAC. 1970. Official Methods of Analysis of Association of Official Analytical Chemists. 11thed. Washington D C.
- AOAC. 1980. Official methods of analysis. Association of Official Analytical Chemist. 13thed. Washington D C. 376-384p.
- Arbona V and Gómez-Cadenas A. 2008. Hormonal modulation of citrus responses to flooding. *Journal of Plant Growth Regulation* **27**:241-250.
- Arismendi M J, Almada R, Pimentel P, Bastias A, Salvatierra A, Rojas P, Hinrichsen P, Pinto M, Di Genova A, Travisany D and Maass A. 2015.

- Transcriptome sequencing of *Prunus* sp. rootstocks roots to identify candidate genes involved in the response to root hypoxia. *Tree Genetics and Genomes* **11**:1-16.
- Arp W J. 1991. Effects of source–sink relations on photosynthetic acclimation to elevated CO₂. *Plant Cell Environment* **14**:869-875.
- Arvidsson J. 1999. Nutrient uptake and growth of barley as affected by soil compaction. *Plant Soil* **208**:9-19.
- Ashraf M and Foolad M R. 2007. Roles of glycine betaine and proline in improving plant abiotic stress resistance. *Environmental and Experimental Botany* **59**:206-216.
- Ashraf M and Hafeez M. 2004. Thermotolerance of Pearl Millet and Maize at Early Growth Stages: Growth and Nutrient Relations. *Biologia Plantarum* **48**:81-86.
- Bagchi T B, Sukul P and Ghosh B. 2008. Biochemical changes during off-season flowering in guava (*Psidium guajava* L.) induced by bending and pruning. *Journal of Tropical Agriculture* **46**:64-66.
- Bai T, Li C, Li C, Liang D and Ma F. 2013. Contrasting hypoxia tolerance and adaptation in *Malus* species is linked to differences in stomatal behavior and photosynthesis. *Physiologia Plantarum* **147**:514-523.
- Bai T, Li C, Ma F, Feng F and Shu H. 2010. Responses of growth and antioxidant system to root-zone hypoxia stress in two *Malus* species. *Plant Soil* **327**:95-105.
- Bakhvalov S A, Kukushkina T A and Vysochina G I. 2010. Effect of defoliation on concentrations of allelochemicals and soluble sugars in leaves of weeping birch (*Betula pendula* Roth). *Contemporary Problems of Ecology* **3**:210-214
- Bano A. 2010. Root-to-shoot signal transduction in rice under salt stress. *Pakistan journal of botany* **42**:329–339.
- Barbosa M R, de Araujo Silva M M, Willadino L, Ulisses C and Camara T R. 2014. Plant generation and enzymatic detoxification of reactive oxygen species/Geracao e desintoxicacao enzimatica de especies reativas de oxigenio em plantas. *Ciência Rural* **44**:453-461.
- Bates L S, Waldran R P and Teare I D. 1973. Rapid determination of free proline for water stress studies. *Plant Soil* **39**:205-208.

- Bejarano M D, Villar R, Murillo A M and Quero J L. 2010. Effects of soil compaction and light on growth of *Quercus pyrenaica* Willd. (Fagaceae) seedlings. *Soil and Tillage Research* **110**:108–114.
- Bhagawati R, Bhagawati K, Choudhary V K, Rajkova D J and Sharma R. 2015. Effect of pruning Intensities on the performance of fruit plants under mid-hill condition of Eastern Himalayas: case study on Guava. *International Letters of Natural Sciences* 46.
- Bhardwaj S D, Panwar P and Yadav V. 2002. Effect of initial collar diameter, shoot and root pruning on performance of planting stock of *Celtis australis*. *Indian Forester* **128**:650-654.
- Blouin V M, Schmidt M G, Bulmer C E and Krzic M. 2008. Effects of compaction and water content on lodgepole pine seedling growth. *Forest Ecology and Management* **255**:2444-2452.
- Boja N and Boja F. 2011. Variation of soil compaction in forest nurseries. *Research Journal of Agricultural Science* **43**:23-30.
- Bose T K and Mitra S K. 1990. Guava. In: *Fruits: Tropical and Subtropical* (Bose T K, Mitra S K and Sanyal D (eds). Naya Udyog, Kolkata, India. pp 609-653.
- Bradford K J and Hsiao T C. 1982. Stomatal behavior and water relations of waterlogged tomato plants. *Plant Physiology* **70**:1508-1513.
- Brais S. 2001. Persistence of soil compaction and effects on seedling growth in northwestern Quebec. *The Soil Science Society of America Journal* **65**:1263-1271.
- Briens M and Larher F. 1982. Osmoregulation in halophytic higher plants: a comparative study of soluble carbohydrates, polyols, betaines and free proline. *Plant, Cell and Environment* **5**: 287–292.
- Bukhsh M, Ahmad R, Iqbal J, Maqbool M M, Ali A, Ishaque M and Hussain S. 2012. Nutritional and physiological significance of potassium application in maize hybrid crop production. *Pakistan Journal of Nutrition* **11**:187.
- Cambria D and Pierangeli D. 2011. A life cycle assessment case study for walnut tree (*Juglans regia* L.) seedlings production. *The International Journal of Life Cycle Assessment* **16**:859-868.
- Cao X, Wu L, Wu M, Zhu C, Jin Q and Zhang J. 2020. Absciscic acid mediated proline biosynthesis and antioxidant ability in roots of two different rice

- genotypes under hypoxic stress. *BMC plant biology* **20**:1-14.
- Chen Z, Wang Z, Yang Y, Li M and Xu B. 2018. Absciscic acid and brassinolide combined application synergistically enhances drought tolerance and photosynthesis of tall fescue under water stress. *Scientia Horticulturae* **228**:1-9.
- Chopra S L and Kanwar J S. 2011. Analytical Agricultural Chemistry. Kalyani Publishers, New Delhi, India. 500p.
- Crawford A J, McLachlan D H, Hetherington A M and Franklin K A. 2012. High Temperature Exposure Increases Plant Cooling Capacity. *Current Biology* **22**: R396-R397.
- de Campos M K F, de Carvalho K, de Souza F S, Marur C J, Pereir L F P, Bespalhok F J C and Vieira L G E. 2011. "Drought tolerance and antioxidant enzymatic activity in transgenic 'Swingle'citrumelo plants over-accumulating proline". *Environmental and Experimental Botany* **72**: 242-250.
- Dhaliwal G S and Singh G. 2004. Effect of different pruning levels on vegetative growth, flowering and fruiting in Sardar guava. *Haryana Journal of Horticultural Science* **33**:175-177.
- Dhaliwal H S, Sharma L K, Banke A K, Brar J S and Bali S K. 2013. Investigations on growth behaviour of kinnow (*Citrus reticulata*) mother plant pruned at different intensities. *Middle-East journal of scientific research* **16**:135-140.
- Else M A, Tiekstra A E, Croker S J, Davies W J and Jackson M B. 1996. Stomatal closure in flooded tomato plants involves absciscic acid and a chemically unidentified anti-transpirant in xylem sap. *Plant Physiology*. **112**: 239–247.
- Farooq M, Wahid A, Lee D J, Ito O and Siddique K H. 2009. Advances in drought resistance of rice. *Critical Reviews in Plant Sciences* **28**:199-217.
- Ferree D C, Streeter J G and Yuncong Y. 2004. Response of containergrown apple trees to soil compaction. *HortScience* **39**:40–48.
- Finkelstein R. 2013. Absciscic Acid synthesis and response. *The Arabidopsis Book* **11**:e0166-e0166.
- Fleming R L, Powers R F, Foster N W, Kranabetter J M, Scott D A, Ponder J F, Berch S, Chapman W K, Kabzems R D, Ludovici K H and Morris D M. 2006. Effects of organic matter removal, soil compaction, and vegetation control on

- 5-year seedling performance: a regional comparison of Long-Term Soil Productivity sites. *Canadian Journal of Forest Research* **36**:529-550.
- Friedlander M, Atsmon D and Galun E. 1977. Sexual differentiation in cucumber: The effects of abscisic acid and other growth regulators on various sex genotypes. *Plant and Cell Physiology* **18**:261-269.
- Fujita Y, Fujita M, Shinozaki K and Yamaguchi-Shinozaki K. 2011. ABA-mediated transcriptional regulation in response to osmotic stress in plants. *Journal of Plant Research* **124**:509-525.
- Gifford R M. 1984. Energy in Different Agricultural Systems: Renewable and Non renewable Sources. In: *Energy and Agriculture. Advanced Series in Agricultural Sciences* (Stanhill G (eds). Springer, Berlin, Heidelberg. pp. 84-112.
- Gillespie A. 2022. Global atmospheric carbon dioxide levels continue to rise. NOAA Research. <https://research.noaa.gov/2022/11/15/no-sign-of-significant-decrease-in-global-co2-emissions/> (9:00 AM, 15th July 2023)
- Gomez K A and Gomez A A. 1984. Statistical Procedures for Agricultural Research, New York: John Wiley and Sons. 690p.
- Gong M, Li Y J and Chen S Z. 1998. Absciscic acid induced thermo tolerance in maize seedlings is mediated by Ca²⁺ and associated with antioxidant systems. *Journal of Plant Physiology* **153**:488-496.
- Gopikrishna N S. 1997. Studies on the effect of pruning on vegetative growth, flowering and fruiting in Sardar guava (*Psidium guajava* L.) M.Sc. (Agri.) thesis. Department of Fruit Science, University of Agricultural Sciences, Bangalore, India. 1-81p.
- Gorai M, Ennajeh M, Khemira H and Neffati M. 2010. Combined effect of NaCl-salinity and hypoxia on growth, photosynthesis, water relations and solute accumulation in *Phragmites australis* plants. *Flora-Morphology, Distribution, Functional Ecology of Plants* **205**:462-470.
- Gravatt D A and Kirby C J. 1998. Patterns of photosynthesis and starch allocation in seedlings of four bottomland hardwood tree species subjected to flooding. *Tree Physiology*. **18**:411-417.
- Grzesiak M T. 2009. Impact of soil compaction on root architecture, leaf water status, gas exchange and growth of maize and triticales seedlings. *Plant Root* **3**:10-16.

- Gudarowska E, Szewczuk A and Deren D. 2006. The Influence of the height of pruning of apple trees in a nursery on their quality and yielding. *Scientific works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture* **25**:98-103
- Gupta R P and Dhakshinamoorthy C. 1980. Procedures for physical analysis of soils and collection of agrometeorological data, Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi, India. pp. 293
- Habibi F, Liu T, Shahid M A, Schaffer B and Sarkhosh A. 2023. Physiological, biochemical, and molecular responses of fruit trees to root zone hypoxia. *Environmental and Experimental Botany* **206**.
- Hartung W, Zhang, J and Davies W J. 1994. Does abscisic acid play a stress physiological role in maize plants growing in heavily compacted soil?. *Journal of Experimental Botany* **45**:221–226.
- Hartzendorf T and Rolletschek H. 2001. Effects of NaCl-salinity on amino acid and carbohydrate contents of *Phragmites australis*. *Aquatic Botany* **69**:195-208.
- Hasanuzzaman M, Nahar K, Alam M M, Roychowdhury R and Fujita M. 2013. Physiological, Biochemical, and Molecular Mechanisms of Heat Stress Tolerance in Plants. *International Journal of Molecular Science* **14**:9643-9684.
- Hoad S P, Russell G, Lucas M E and Bingham I J. 2001. The management of wheat, barley, and oat root systems. *Advances in Agronomy* **74**:193-246.
- Horchani F, Aloui A, Brouquisse R and Aschi-Smiti S. 2008. Physiological responses of tomato plants (*Solanum lycopersicum*) as affected by root hypoxia. *Journal of Agronomy and Crop Science* **194**:297-303.
- Horchani F, Aschi-Smiti S and Brouquisse R. 2010. Involvement of nitrate reduction in the tolerance of tomato (*Solanum lycopersicum* L.) plants to prolonged root hypoxia. *Acta Physiologiae Plantarum* **32**:1113–1123.
- Huang G, Kilic A, Karady M, Zhang J, Mehra P, Song X , Sturrock, C , Zhu Wanwan ,Qin H , Hartman S , Schneider H , Bhosale R , Dodd I , Sharp R, Huang R , Mooney S, Liang W , Bennett M , Zhang D and Pandey, B. 2022. Ethylene inhibits rice root elongation in compacted soil via ABA- and auxin-mediated mechanisms. In: *Proceedings of the National Academy of Sciences* (Sean C (eds). University of California Riverside, Riverside. pp.e2201072119.

- Hussain S, Muhammad A, Saeed A, Javaid I, Muhammad N S, Sajid M N, Sagheer A and Muhammad I. 2013. Improvement of drought tolerance in sunflower (*Helianthus annuus* L.) by foliar application of abscisic acid and potassium chloride. *Pakistan Journal of Nutrition* **12**: 345.
- Hussain A, Black C R, Taylor I B and Roberts J A. 2000. Does an antagonistic relationship between ABA and ethylene mediate shoot growth when tomato (*Lycopersicon esculentum* Mill.) plants encounter compacted soil?. *Plant, Cell and Environment* **23**:1217–1226.
- IEA-International Energy Agency. 2023. Global-co2-emissions-from-transport-by-sub-sector-in-the-net-zero-scenario-2000-2030. <https://www.iea.org/termsandconditions/> (5:00 PM, 20th February 2024).
- Islam M S, Hossain M A and Mondol M A. 2008. Effect of pruning and pollarding on shoot development in bakphul (*Sesbania grandiflora* L.). *Journal of the Bangladesh Agricultural University* **6**:285-289.
- Jackson M L. 1973. Soil Chemical Analysis. Prentice Hall Inc. Englewood Cliffs, New Jersey, USA. 498p.
- Jadav R G, Patel H C, Masu M M, Parmar A B, Sitapara H H and Patel H D. 2009. Effect of spacing and severity of pruning on yield of drumstick cv. PKM-1. *Asian Science Bulletin* **4**: 4-9.
- Jaramillo, Ribeiro K, Newman S, Dhar P, Diemuodeke S, Kajino T, Lee T, Nugroho D S, Ou S B and Strømman A H. 2022. Transport. In: *IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Shukla P R, Skea J, Slaade R, Khourdajie A I, Diemen V A, McCollum R, Pathak D, Some M, Vyas S, Fradera P R ed. held at Cambridge, UK; New York, NY, USA, 2022. Cambridge University Press.
- Jiang F and Hartung W. 2008. Long-distance signaling of abscisic acid (ABA): the factors regulating the intensity of the ABA signal. *Journal of Experimental Botany* **59**:37–43.
- Kadam S R, Dheware R M and Urade P S. 2018. Effect of different levels of pruning on quality of custard apple (*Annona squamosa* L.). *International Journal of Bio-resource and Stress Management* **9**:573-575.
- Kahlaoui B, Hachicha M, Misle E, Fidalgo F and Teixeira J. 2018. Physiological and biochemical responses to the exogenous application of proline of tomato

- plants irrigated with saline water. *Journal of the Saudi Society of Agricultural Sciences* **17**:17-23.
- Kaur G and Asthir B. 2015. Proline: A key player in plant abiotic stress tolerance. *Biologia Plantarum* **59**: 609–619.
- Kaur M, Gupta A K. and Zhawar V K. 2014. Antioxidant response and lea genes expression under exogenous ABA and water deficit stress in wheat cultivars contrasting in drought tolerance. *Journal of Plant Biochemistry and Biotechnology* **23**: 18–30.
- Kavikishor P B, Sangam S, Amrutha R N, Srilaxmi P, Naidu K R, Rao K R S S, Rao S, Reddy K J, Theriappan P and Sreenivasulu N. 2005. Regulation of proline biosynthesis, degradation, uptake and transport in higher plants: its implications in plant growth and abiotic stress tolerance. *Current Science* **88**:424-438.
- Kendall A and McPherson E G. 2012. A life cycle greenhouse gas inventory of a tree production system. *The International Journal of Life Cycle Assessment* **17**:444-452.
- Kobaissi A N, Kanso A A, Kanbar H J and Kozpard V A. 2013. Morphophysiological changes caused by soil compaction and irrigation on *Zea mays*. *Eurasian Journal of Soil Science* **2**:76-144.
- Kormanek M, Tomasz G, Jacek B and Grzegorz S. 2015. "Effects of soil bulk density on sessile oak *Quercus petraea* Liebl. seedlings." *European Journal of Forest Research* **134**:969-979.
- Kumar A, Kumar A, Pande N C and Tripathi V.K. 2005. Influence of pruning severity on the flowering and fruiting of peach. *Journal of Farm Sciences* **14**:12-13.
- Lachno D R, Harrison-Murray R S and Audus L J. 1982. The effects of mechanical impedance to root growth on the levels of ABA and IAA in root tips of *Zea mays* L. *Journal of Experimental Botany* **33**:943-51.
- Lee B M, Lee D C, Noh K A and Im J N. 1991. Study on the low temperature stress of rice seedlings as affected by abscisic acid.) *The Research Reports of the Rural Development Administration (Korea Republic)* **33**: 87-90.
- Lipiec J, Hajnos M and S´wieboda R. 2012. Estimating effects of compaction on pore size distribution of soil aggregates by mercury porosimeter. *Geoderma* **179**:20–27.

- Liu K. 2011. Corn production and plant characteristics response to N fertilization management in dry land conventional tillage system. *International Journal of Plant Production* **5**:405-416.
- Ma J, Rukh G, Ruan Z, Xie X, Ye Z and Liu D. 2022. Effects of hypoxia stress on growth, root respiration, and metabolism of *Phyllostachys praecox*. *Life* **12**:808.
- Mahajan S and Tuteja N. 2005. Cold, salinity and drought stresses: an overview. *Archives of Biochemistry and Biophysics* **444**:139–158.
- Mahouachi J, Argamasilla R and Gómez-Cadenas A. 2012. Influence of exogenous glycine betaine and abscisic acid on papaya in responses to water-deficit stress. *Journal of Plant Growth Regulation* **31**:1-10.
- Malini M K, Karwa S, Priyadarsini P, Kumar P, Nagar S, Kumar M, Kumar S, Chinnusamy V, Pandey R and Pal M. 2023. Absciscic-acid-modulated stomatal conductance governs high-temperature stress tolerance in rice accessions. *Agriculture* **13**:545.
- Masle J and Passioura J B. 1987. The effect of soil strength on the growth of young wheat plants. *Australian Journal of Plant Physiology* **14**:643-656.
- Matoh T, Matsushita N and Takahashi E. 1988. Salt tolerance of the reed plant *Phragmites communis*. *Physiologia Plantarum* **72**:8-14.
- Mauch-Mani B and Mauch F. 2005. The role of abscisic acid in plant-pathogen interactions. *Current opinion in plant biology* **8**:409–414.
- McArtney S J, Abrams S R, Woolard D D and Petracek P D. 2014. "Effects of S-abscisic acid and (+)-8'-acetylene abscisic acid on fruit set and stomatal conductance in apple." *HortScience* **49**:763-768.
- Mehta S, Singh S K, Das B, Jana B R and Mali S. 2012. Effect of pruning on guava cv. Sardar under ultra high density orcharding system. *Vegetos* **25**:192-195.
- Meng F Z, Hu L P, Wang S H, Sui X L, Wei L, Wei Y X, Sun J L and Zhang Z X. 2008. Effects of exogenous abscisic acid (ABA) on cucumber seedling leaf carbohydrate metabolism under low temperature. *Plant growth regulation* **56**:233-244.
- Meng W, He M, Li H, Hu B and Mo X. 2019. Greenhouse gas emissions from different plant production system in China. *Journal of Cleaner Production* **235**: 741-750.

- Merwin H D and Peech M. 1951. Exchangeability of soils potassium in the silt and clay fractions as influenced by the nature of the complimentary exchangeable cations. *Soil Science Society of American Proceedings* **15**:125-28.
- Middelberg M, Knoche M and Petrcek P D. 2014. Effects of pH, temperature, humidity, and rewetting on cuticular penetration of ABA. *Acta Horticulture* **1042**:143-15.
- Mielke M S, de Almeida A A F, Gomes F P, Aguilar M A G and Mangabeira P A O. 2003. Leaf gas exchange, chlorophyll fluorescence and growth responses of *Genipa americana* seedlings to soil flooding. *Environmental and Experimental Botany* **50**:221–231.
- Miransari M, Bahrami H A, Rejali F and Malakouti M J. 2009. Effects of soil compaction and arbuscular mycorrhiza on corn (*Zea mays*. L.). *Soil and Tillage Research* **103**:282–290.
- Moss G I, Hall K C and Jackson M B. 1988. Ethylene and the responses of maize (*Zea mays* L.) to physical impedance. *New Phytologist* **109**:303-11.
- Mulholland B J, Black C R, Taylor I B and Roberts J A. 1996. Effect of soil compaction on barley (*Hordeum vulgare* L.) growth: Are increased xylem sap ABA concentrations involved in maintaining leaf expansion in compacted soils?. *Journal of Experimental Botany* **47**:551–556.
- Nagao M, Minami A, Arakawa K, Fujikawa S and Takezawa D. 2005. Rapid degradation of starch in chloroplasts and concomitant accumulation of soluble sugars associated with ABA-induced freezing tolerance in the moss *Physcomitrella patens*. *Journal of plant physiology* **162**:169-180.
- Nawaz M and Wang Z. 2020. Absciscic acid and glycine betaine mediated tolerance mechanisms under drought stress and recovery in *axionopus compressus*: A new insight. *Scientific reports* **10**:6942.
- Noaman M M, Dvorak J and Dong J M. 2002. "Genes inducing salt tolerance in wheat, *Lophopyrum elongatum* and amphiploid and their responses to ABA under salt stress". *Prospects for saline agriculture* 139-144.
- Olivella C, Biel C, Vendrell M and Save R. 2000. Hormonal and physiological responses of *Gerbera jamesonii* to flooding stress. *HortScience* **35**:222–225.
- Olsen S R, Cole C V, Watanable F S and Dean L A. 1954. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. *USDA Circular*

939:1-19.

- Ou L J, Dai X Z, Zhang Z Q and Zou X X. 2011. Responses of pepper to waterlogging stress. *Photosynthetica* **49**:339–345.
- Padmapriya S, Kavino M and Vijayakumar R M. 2021. Standardization of grafting methods under different seasons of grafting in guava (*Psidium guajava* L.). *Journal of Pharmacognosy and Phytochemistry* **10**:257-260.
- Paleg L G, Douglas T J, Van Daal A and Keech D B. 1981. Proline, betaine and other organic solutes protect enzymes against heat inactivation. *Australian Journal of Plant Physiology* **8**:107–114.
- Pandey B K, Huang G, Bhosale R, Hartman S, Sturrock C J, Jose L, Martin O C, Karady M, Voesenek L A C J, Ljung K, Lynch J P, Brown K M, Whalley W R, Mooney S J, Zhang D and Bennett M J. 2021. Plant roots sense soil compaction through restricted ethylene diffusion. *Science* **371**:276-280.
- Parida A K and Das A B. 2005. Salt tolerance and salinity effects on plants: a review. *Ecotoxicology and Environmental Safety* **60**:324-349.
- Pascual I, Azcona I, Morales F, Aguirreolea J and Sanchez-D'iaz M. 2010. Photosynthetic response of pepper plants to wilt induced by *Verticillium dahliae* and soil water deficit. *Journal of Plant Physiology* **167**:701-708.
- Pathania S. 2020. Standardization of Canopy Architecture Techniques of Nursery Plant for High Density Plantation of Mango (*Mangifera indica* L.). M. Sc. Thesis. Department of Fruit Science, YSP University of Horticulture and Forestry, Solan. 60p.
- Pezeshki S R. 2001. Wetland plant responses to soil flooding. *Environmental and Experimental Botany* **46**:299–312.
- Pilet P E. 1998. Some cellular and molecular properties of abscisic acid:its particular involvement in growing plant roots. *Cellular and Molecular Life Sciences CMLS* **54**:851-865.
- Poni S, Casalini L, Bernizzoni F, Civardi S and Intrieri C. 2006. Effects of early defoliation on shoot photosynthesis, yield components, and grape composition. *American Journal of Enology and Viticulture* **57**:397-407.
- Prabhakar J. 2016. Effect of plant spacing and pruning intensity on flowering, fruiting, and yield of guava (*Psidium guajava* L.) cv. Pant Prabhat. *International Journal of Agriculture Sciences* 0975-3710.

- Rai M, Harish N S, Gupta A, Ram M P K and Jaiswal U. 2011. The role of abscisic acid in plant tissue culture: a review of recent progress. *Plant Cell, Tissue and Organ Culture (PCTOC)* **106**:179–190.
- Ramachandra T V and Shwetmala. 2009. Emissions from India's transport sector: statewise synthesis. *Atmospheric Environment* **43**:5510-5517.
- Ramasamy S, Nandagopal J G T and Balasubramanian M. 2020. Effect of Absciscic acid and Selenium foliar sprays on drought mitigation in tomato (*Solanum lycopersicum* L.). *Materials Today: Proceedings* **48**:191-195.
- Rao K P C. 2002. Agricultural Research Prioritization-Manual of Training Programme on Agricultural Research Prioritization Techniques (PME Sub Project: Micro-level Priority setting), NAARM, Hyderabad. 1-40p.
- Rojas E. 1997. "Effect of pruning and paclobutrazol on tree growth and fruit number in Tahiti lime (*Citrus latifolia* Tan/C. *volkameriana* Pasq)". In: *Proceeding of the Interamerican Society for Tropical Horticulture* held at Guatemala City, Guatemala, 1-4 September, 1997. Decanato de Agronomía, UCLA, Aptado 400, Barquisimeto, Venezuela. pp.129-135.
- Rosolem C A, Foloni J S S and Tiritan C S. 2002. Root growth and nutrient accumulation in cover crops as affected by soil compaction. *Soil and Tillage Research* **65**:109–115.
- Russo G and Zeller B D L. 2008. Environmental evaluation by means of lca regarding the ornamental nursery production in rose and sowbread greenhouse cultivation. *Acta Horticulture*. **801**:1597-1604.
- Russo G, Mugnozza G S and Zeller B D L. 2007. Environmental improvements of greenhouse flower cultivation by means of LCA methodology. *Acta Horticulture* **801**:301-308.
- Ruviaro C F, Gianezini M, Brandão F S, Winck C A and Dewes H. 2012. Life cycle assessment in Brazilian agriculture facing worldwide trends. *Journal of Cleaner Production* **28**:9-24.
- Saeedipour S. 2012. Is salinity tolerance of rice lines concerned to endogenous ABA content or to the cellular ability for ABA synthesis under stress?. *African Journal of Biotechnology* **11**:10938-10943.
- Saifuddin M, Hossain A B, Osman N, Sattar M A, Moneruzzaman K M and Jahirul M I. 2010. Pruning impacts on shoot-root-growth, biochemical and physiological changes of *Bougainvillea glabra*. *Australian journal of crop*

science **4**:530-537.

- Sanclemente M A, Schaffer B, Gil P M, Vargas A I and Davies F S. 2014. Pruning after flooding hastens recovery of flood-stressed avocado (*Persea americana* Mill.) trees. *Scientia Horticulturae* **169**:27-35.
- Sansberro P A, Mroginski L A and Bottini R. 2004. Foliar sprays with ABA promote growth of *Ilex paraguariensis* by alleviating diurnal water stress. *Plant Growth Regulation* **42**:105–111.
- Serraj R and Sinclair T R. 2002. Osmolyte accumulation: can it really help increase crop yield under drought conditions?. *Plant, Cell and Environment* **25**:333-341.
- Sheikh M K and Hulmani N C. 1997. Effect of pruning on shoot growth, leaf area and yield in guava. *Karnatka Journal of Agricultural Sciences* **10**: 93-97.
- Shindy W W, Asmundson C M, Smith O F and Kumamoto J. 1973. Absorption and distribution of high specific radioactivity 2-¹⁴C ABA in cotton seedlings. *Plant Physiology* **52**: 443-447.
- Silva F G D, Assis R N D, Mesquita R O, Marques E D S and Mota J C A. 2020. Gas exchanges and growth of maize as affected by aeration porosity and soil compaction. *Revista Ciência Agronômica* **51**:e20196834.
- Singh G, Singh A K and Rajan S. 2001. Influence of pruning date on fruit yield of guava (*Psidium guajava* L.) under subtropics. *Journal of Applied Horticulture* **3**:37-40.
- Singh M, Jaiswal U and Jaiswal V S. 2004. In Vitro regeneration and improvement in tropical fruit trees: an assessment. In: *Plant Biotechnology and Molecular Markers* (Srivastava P S, Narula A and Srivastava S (eds). Anamaya Publishers, New Delhi. pp 228-243.
- Singh N T, Vig A C and Singh R. 1985. Nitrogen response of maize under temporary flooding. *Fertility Research* **6**:111–120.
- Singh S K, Singh S K, Sharma R R and Srivastav M. 2009. Effect of pruning on morpho-physiological parameters and microclimate under high density planting of mango (*Mangifera indica*). *Indian Journal of Agricultural Sciences* **79**:632.
- Song M L and Song Z Z. 1982. Study on nursery practice with *Populus tomentosa* saplings topped at different intensities. *Forest Science and Technology* **1**:4-6.

- Srivastava L M. 2002. Absciscic Acid. In: *Plant Growth and Development: Hormones and Environment* (Srivastava LM (eds). Academic Press, Atlanta. pp. 217-231.
- Sterling K A and Lane C L. 1975. Growth and development of shoot and root pruned yellow poplar seedlings on two sites. *Tree Planters' Notes* **26**:1-2.
- Stewart G R and Lee J A. 1974. The role of proline accumulation in halophytes. *Planta* **120**:279–289.
- Stypa M L. 1987. Effects of soil bulk density on seedling physiology and growth of corn (*Zea mays* L.). Ph.D. Thesis. University of Waterloo, Canada.4028Bp.
- Subbiah B V and Asija G L. 1956. A rapid procedure for the determination of available nitrogen in soils. *Current Science* **25**:259-60.
- Sun Q, He X, Wang T, Qin H, Yuan X, Chen Y and Li Q. 2023. The Beneficial Roles of Elevated [CO₂] on Exogenous ABA-Enhanced Drought Tolerance of Cucumber Seedlings. *Horticulturae* **9**:421.
- Swamy P M and Smith B. 1999. Role of abscisic acid in plant stress tolerance. *Current Science* **76**:1220-1227.
- Taiz L, Zeiger E, Moller I M and Murphy A. 2017. *Plant Physiology and Development*. Sinauer Associates Publishers, Sunderland, Massachusetts U.S.A. 858p.
- Tao Z, Kou Y, Liu H, Li X, Xiao J and Wang S. 2011. OsWRKY45 alleles play different roles in abscisic acid signalling and salt stress tolerance but similar roles in drought and cold tolerance in rice. *Journal of Experimental Botany* **62**:4863-4874.
- Tardieu F, Parent B and Simonneau T. 2010. Control of leaf growth by abscisic acid: hydraulic or non-hydraulic processes?. *Plant, Cell and Environment* **33**:636-647.
- Tardieu F, Zhang J, Katerji N, Bethenod O, Palmer S and Davies W J. 1992. Xylem ABA controls the stomatal conductance of field grown maize subjected to soil compaction or soil drying. *Plant Cell and Environment* **15**: 193–197.
- Tardieu F.1994. Growth and functioning of roots and of root systems subjected to soil compaction. Towards a system with multiple signalling?. *Soil and Tillage Research* **30**:217-243.
- Taylor H M, Roberson G M and Parker J J Jr. 1966. Soil strength-root penetration

- relations for medium-to coarse-textured soil materials. *Soil Science* **102**:18–22.
- Teixeira J and Fidalgo F. 2009. Salt stress affects glutamine synthetase activity and mRNA accumulation on potato in an organ – dependent manner. *Plant Physiology and Biochemistry* **47**:807-813.
- Tracy S R, Black C R, Roberts J A and Mooney S J. 2013. Exploring the interacting effect of soil texture and bulk density on root system development in tomato (*Solanum lycopersicum* L.). *Environmental and Experimental Botany* **91**:38-47.
- Trouse AC. 1977. Soil physical characteristics and root growth. In: *Proceedings of the conference on the role of soil physical properties in maintaining productivity of tropical soils*. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. pp. 319–325.
- Trovato N, Mattioli R and Costantino P. 2008. Multiple roles of proline in plant stress tolerance and development. *Rendiconti Lincei* **19**: 325-346.
- Tubeileh A, Groleau-Renaud V, Plantureux S and Guckert A. 2003. Effect of soil compaction on photosynthesis and carbon partitioning within a maize-soil system. *Soil and Tillage Research* **71**:151–161.
- Tun J C and Tan S C. 1988. Soil compaction effect on photosynthesis, root rot severity and growth of white beans. *Canadian Journal of Soil Science* **68**:455-459.
- Tuteja N. 2007. Absciscic acid and abiotic stress signaling. *Plant Signaling, Behavior* **2**:135-138.
- Tworowski T J, Burger J A and Smith D W. 1983. Soil texture and bulk density affect early growth of white oak seedlings. *Tree Plant Notes* **34**:22–25.
- Ueno O. 1998. Induction of Kranz anatomy and C₄-like biochemical characteristics in a submerged amphibious plant by abscisic acid. *Plant Cell* **10**:571-583.
- Umaru M A, Adam P, Zaharah S S and Daljit S K. 2021. Impact of Soil Compaction on Soil Physical Properties and Physiological Performance of Sweet Potato (*Ipomea batatas* L.). *Malaysian Journal of Soil Science* **25**:15-27.
- Velasco N F, Ligarreto G A, Díaz H and Fonseca L P M. 2019. Photosynthetic responses and tolerance to root-zone hypoxia stress of five bean cultivars

- (*Phaseolus vulgaris* L.). *South African Journal of Botany* **123**:200-207.
- Verslues P E and Bray E A. 2006. Role of abscisic acid (ABA) and *Arabidopsis thaliana* ABA insensitive loci in low water potential-induced ABA and proline accumulation. *Journal of Experimental Botany* **57**:201–212.
- Walkley A and Black I A. 1934. Examination of the method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science* **37**:9-38.
- Wang J, Xia H, Lin L J, He H, Liang D and Lv X L. 2016. Exogenous abscisic acid increases resistances against abiotic stress and improve fruit quality of grape. *JAPS: Journal of Animal and Plant Sciences* **26**.
- Wani S H and Kumar V. 2015. Plant stress tolerance: engineering ABA: a Potent phytohormone. *Transcriptomics* **3**:1000113.
- Warner D J, Davies M, Hipps N, Osborne N, Tzilivakis Z and Lewis K A. 2010. "Greenhouse gas emissions and energy use in UK-grown short-day strawberry (*Fragaria xananassa* Duch) crops." *The Journal of Agricultural Science* **148**:667-681.
- William J D, Francois T, Trejo C L. 1994. How do chemical signals work in plants that grow in drying soil?. *Plant Physiology* **104**:309–314.
- Yeboah P A, Yeboah J, Owusu-Ansah F, Akrofi A Y and Opoku-Ameyaw K. 2016. Influence of root and shoot pruning on field establishment and growth of overgrown cashew (*Anacardium occidentale* L.) seedlings. *Journal of Horticulture and Forestry* **8**:51-57.
- Yu F A, Guo X I and Xu X I. 2002. Shoot and root pruning and exposure treatments affect root growth potential of Chinese fir and Masson pine bare-root seedlings after lifting. *New Zealand Journal of Forestry Science* **32**:299-308.
- Zeevaart J A and Boyer G L. 1984. Accumulation and transport of abscisic Acid and its metabolites in *ricinus* and *xanthium*. *Plant Physiology* **74**:934-9.
- Zhang H J, Dong H Z, Li W J and Zhang J D M. 2012. Effects of soil salinity and plant density on yield and leaf senescence of field-grown cotton. *Journal of Agronomy and Crop Science* **198**:27–37.
- Zhang H, Zhu H, Pan Y, Yu Y, Luan S and Li L. 2014. A DTX/MATEtype transporter facilitates abscisic acid efflux and modulates ABA sensitivity and drought tolerance in *Arabidopsis*. *Molecular plant* **7**:1522–1532.

- Zhang J, Liu J, Yang C, Du S and Yang W. 2016. Photosynthetic performance of soybean plants to water deficit under high and low light intensity. *South African Journal of Botany* **105**:279-287.
- Zuo H, Yin S, Wang T, Xiong X, Shi M and Guo Q. 2022. Nitrogen Application Alleviates the Adverse Effects of Defoliation Stress on *Lolium perenne* L. by Enhancing the Antioxidant System and Promoting Photosynthesis. *Agronomy* **12**: 2902.

Appendix-I

Meteorological data of COHF, Neri from June 2023 to May 2024

Months	Average Monthly Temperature (°C)		Rainfall (mm)	Relative humidity (%)
	Maximum	Minimum		
June 2023	40.00	19.10	146.80	56.10
July 2023	36.40	23.70	498.60	79.50
August 2023	32.60	23.60	489.00	84.80
September 2023	31.90	21.30	111.70	79.70
October 2023	35.70	16.30	2.50	38.50
November 2023	31.90	13.40	22.50	40.30
December 2023	26.20	8.80	0.20	37.10
January 2024	19.01	8.09	0.23	52.19
February 2024	20.63	9.57	2.66	50.40
March 2024	28.05	15.16	2.40	39.40
April 2024	34.56	20.34	0.51	29.88
May 2024	41.61	26.48	0.00	21.31

Appendix-II

ANALYSIS OF VARIANCE

Experiment: Effect of pre-transit root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of July, 2023 (before treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	4	285.29		
ABA (A)	1	16.90	16.90	0.34
Foliage trimming (P)	2	128.60	64.30	1.28
Interaction A X P	2	130.20	65.10	1.30
Root zone compaction (C)	2	30.47	15.23	0.30
Interaction A X C	2	193.40	96.70	1.93
Interaction P X C	4	45.33	11.33	0.23
Interaction A X P X C	4	190.00	47.50	0.95
Error	68	3412.71	50.19	
Total	89	4432.90		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of August, 2023 (after treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	4	68.51		
ABA (A)	1	16.90	16.90	0.83
Foliage trimming (P)	2	6947.47	3473.73	170.89
Interaction A X P	2	29.87	14.93	0.74
Root zone compaction (C)	2	32.07	16.03	0.79
Interaction A X C	2	56.60	28.30	1.39
Interaction P X C	4	31.67	7.92	0.39
Interaction A X P X C	4	67.53	16.88	0.83
Error	68	1382.29	20.33	
Total	89	8632.90		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of February, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	3164.07		
ABA (A)	1	688.90	688.90	1.13
Foliage trimming (P)	2	9807.09	4903.54	8.05
Interaction A X P	2	232.20	116.10	0.19
Root zone compaction (C)	2	1628.96	814.48	1.34
Interaction A X C	2	10.87	5.43	0.01
Interaction P X C	4	283.71	70.93	0.12
Interaction A X P X C	4	402.33	100.58	0.17
Error	68	41410.33	608.98	
Total	89	57628.46		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on leaf number of guava grafts in the month of June, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	3	23378.5		
ABA (A)	1	8515.1	8515.1	1.3
Foliage trimming (P)	2	1055.5	527.8	0.1
Interaction A X P	2	13086.8	6543.4	1.0
Root zone compaction (C)	2	1561.2	780.6	0.1
Interaction A X C	2	13695.1	6847.5	1.1
Interaction P X C	4	2831.9	708.0	0.1
Interaction A X P X C	4	55342.7	13835.7	2.2
Error	51	326438.3	6400.8	
Total	71	445905.0		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of July, 2023 (before treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	4	294.27		
ABA (A)	1	20.54	20.54	0.18
Foliage trimming (P)	2	396.47	198.23	1.68
Interaction A X P	2	438.16	219.08	1.86
Root zone compaction (C)	2	84.07	42.03	0.36
Interaction A X C	2	36.02	18.01	0.15
Interaction P X C	4	322.87	80.72	0.69
Interaction A X P X C	4	445.98	111.49	0.95
Error	68	8005.73	117.73	
Total	89	10044.10		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of August, 2023 (after treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	4	107.22		
ABA (A)	1	23.51	23.51	0.36
Foliage trimming (P)	2	15668.69	7834.34	119.79
Interaction A X P	2	252.82	126.41	1.93
Root zone compaction (C)	2	157.76	78.88	1.21
Interaction A X C	2	39.09	19.54	0.30
Interaction P X C	4	23.18	5.79	0.09
Interaction A X P X C	4	56.78	14.19	0.22
Error	68	4447.18	65.40	
Total	89	20776.22		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of September, 2023

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	48.38		
ABA (A)	1	52.90	52.90	0.81
Foliage trimming (P)	2	8134.47	4067.23	62.20
Interaction A X P	2	711.67	355.83	5.44
Root zone compaction (C)	2	292.07	146.03	2.23
Interaction A X C	2	271.27	135.63	2.07
Interaction P X C	4	28.27	7.07	0.11
Interaction A X P X C	4	40.67	10.17	0.16
Error	68	4446.42	65.39	
Total	89	14026.10		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of December, 2023

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	265.067		
ABA (A)	1	0.100	0.100	0.001
Foliage trimming (P)	2	2416.867	1208.433	11.705
Interaction A X P	2	755.267	377.633	3.658
Root zone compaction (C)	2	78.867	39.433	0.382
Interaction A X C	2	512.867	256.433	2.484
Interaction P X C	4	220.667	55.167	0.534
Interaction A X P X C	4	270.667	67.667	0.655
Error	68	7020.533	103.243	
Total	89	11540.900		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of January, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	4	291.71		
ABA (A)	1	136.90	136.90	1.32
Foliage trimming (P)	2	2916.29	1458.14	14.10
Interaction A X P	2	432.60	216.30	2.09
Root zone compaction (C)	2	109.36	54.68	0.53
Interaction A X C	2	470.60	235.30	2.28
Interaction P X C	4	287.84	71.96	0.70
Interaction A X P X C	4	359.40	89.85	0.87
Error	68	7034.29	103.45	
Total	89	12038.99		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of May, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	4	355.04		
ABA (A)	1	0.04	0.04	0.00
Foliage trimming (P)	2	1520.27	760.13	2.76
Interaction A X P	2	281.96	140.98	0.51
Root zone compaction (C)	2	45.27	22.63	0.08
Interaction A X C	2	608.02	304.01	1.10
Interaction P X C	4	769.87	192.47	0.70
Interaction A X P X C	4	1316.98	329.24	1.19
Error	68	18746.16	275.68	
Total	89	23643.60		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant height of guava grafts in the month of June, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	3	810.82		
ABA (A)	1	183.68	183.68	0.71
Foliage trimming (P)	2	1233.03	616.51	2.38
Interaction A X P	2	193.69	96.85	0.37
Root zone compaction (C)	2	256.03	128.01	0.49
Interaction A X C	2	732.86	366.43	1.41
Interaction P X C	4	1125.81	281.45	1.09
Interaction A X P X C	4	2370.64	592.66	2.29
Error	51	13218.43	259.19	
Total	71	20124.99		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of July, 2023 (before treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	1.85		
ABA (A)	1	0.01	0.01	0.03
Foliage trimming (P)	2	0.09	0.05	0.09
Interaction A X P	2	0.45	0.22	0.43
Root zone compaction (C)	2	0.31	0.15	0.29
Interaction A X C	2	0.11	0.06	0.11
Interaction P X C	4	0.46	0.12	0.22
Interaction A X P X C	4	4.80	1.20	2.30
Error	68	35.49	0.52	
Total	89	43.57		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of August, 2023 (after treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	0.86		
ABA (A)	1	0.51	0.51	0.66
Foliage trimming (P)	2	1.70	0.85	1.11
Interaction A X P	2	1.15	0.58	0.75
Root zone compaction (C)	2	0.59	0.29	0.38
Interaction A X C	2	0.69	0.35	0.45
Interaction P X C	4	1.31	0.33	0.43
Interaction A X P X C	4	8.41	2.10	2.74
Error	68	52.20	0.77	
Total	89	67.42		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of October, 2023

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	1.17		
ABA (A)	1	1.74	1.74	0.68
Foliage trimming (P)	2	1.17	0.58	0.23
Interaction A X P	2	0.13	0.07	0.03
Root zone compaction (C)	2	3.64	1.82	0.71
Interaction A X C	2	3.10	1.55	0.61
Interaction P X C	4	4.09	1.02	0.40
Interaction A X P X C	4	26.05	6.51	2.54
Error	68	174.39	2.57	
Total	89	215.49		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on plant girth of guava grafts in the month of June, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	3	72.06		
ABA (A)	1	7.65	7.65	0.65
Foliage trimming (P)	2	33.54	16.77	1.42
Interaction A X P	2	11.84	5.92	0.50
Root zone compaction (C)	2	7.00	3.50	0.30
Interaction A X C	2	53.79	26.90	2.27
Interaction P X C	4	33.27	8.32	0.70
Interaction A X P X C	4	100.93	25.23	2.13
Error	51	603.28	11.83	
Total	71	923.36		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts in the month of August, 2023

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	4	0		
ABA (A)	1	0	0	2.198
Foliage trimming (P)	2	0	0	2.272
Interaction A X P	2	0	0	0.824
Root zone compaction (C)	2	0	0	3.364
Interaction A X C	2	0	0	0.485
Interaction P X C	4	0	0	0.276
Interaction A X P X C	4	0	0	0.56
Error	68	0	0	
Total	89	0		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts in the month of February, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	4	0		
ABA (A)	1	0	0	0.149
Foliage trimming (P)	2	0	0	0.012
Interaction A X P	2	0	0	5.341
Root zone compaction (C)	2	0	0	1.279
Interaction A X C	2	0	0	0.144
Interaction P X C	4	0	0	2.158
Interaction A X P X C	4	0	0	1.414
Error	68	0	0	
Total	89	0		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on relative growth rate of guava grafts in the month of June, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	3	0		
ABA (A)	1	0	0	0.145
Foliage trimming (P)	2	0	0	0.993
Interaction A X P	2	0	0	1.508
Root zone compaction (C)	2	0	0	0.098
Interaction A X C	2	0	0	1.187
Interaction P X C	4	0	0	0.482
Interaction A X P X C	4	0	0	1.189
Error	51	0	0	
Total	71	0		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on stomatal conductance in the month of July, 2023 (before treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	0.01		
ABA (A)	1	0.00	0.00	0.50
Foliage trimming (P)	2	0.00	0.00	0.18
Interaction A X P	2	0.00	0.00	0.30
Root zone compaction (C)	2	0.00	0.00	0.34
Interaction A X C	2	0.00	0.00	0.36
Interaction P X C	4	0.01	0.00	0.48
Interaction A X P X C	4	0.01	0.00	0.56
Error	68	0.25	0.00	
Total	89	0.29		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on stomatal conductance in the month of August, 2023 (after treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	0.05		
ABA (A)	1	0.06	0.06	10.88
Foliage trimming (P)	2	0.05	0.03	4.37
Interaction A X P	2	0.02	0.01	1.45
Root zone compaction (C)	2	0.18	0.09	15.69
Interaction A X C	2	0.01	0.00	0.40
Interaction P X C	4	0.02	0.01	0.96
Interaction A X P X C	4	0.03	0.01	1.33
Error	68	0.40	0.01	
Total	89	0.82		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on stomatal conductance in the month of July, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	3	0.01		
ABA (A)	1	0.00	0.00	0.01
Foliage trimming (P)	2	0.03	0.02	1.82
Interaction A X P	2	0.00	0.00	0.28
Root zone compaction (C)	2	0.03	0.01	1.52
Interaction A X C	2	0.01	0.01	0.65
Interaction P X C	4	0.00	0.00	0.12
Interaction A X P X C	4	0.02	0.00	0.49
Error	51	0.41	0.01	
Total	71	0.51		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on transpiration rate in the month of July, 2023(before treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	4	9.34		
ABA (A)	1	0.07	0.07	0.04
Foliage trimming (P)	2	3.04	1.52	0.86
Interaction A X P	2	9.18	4.59	2.58
Root zone compaction (C)	2	2.47	1.24	0.70
Interaction A X C	2	1.73	0.86	0.49
Interaction P X C	4	10.09	2.52	1.42
Interaction A X P X C	4	4.39	1.10	0.62
Error	68	120.87	1.78	
Total	89	161.18		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on transpiration rate in the month of August, 2023 (after treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	4	3.67		
ABA (A)	1	27.09	27.09	31.64
Foliage trimming (P)	2	11.31	5.66	6.61
Interaction A X P	2	1.69	0.85	0.99
Root zone compaction (C)	2	41.33	20.67	24.14
Interaction A X C	2	4.30	2.15	2.51
Interaction P X C	4	1.40	0.35	0.41
Interaction A X P X C	4	4.49	1.12	1.31
Error	68	58.23	0.86	
Total	89	153.52		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on transpiration rate in the month of July, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	3	21.16		
ABA (A)	1	3.38	3.38	1.16
Foliage trimming (P)	2	3.24	1.62	0.56
Interaction A X P	2	0.86	0.43	0.15
Root zone compaction (C)	2	2.05	1.03	0.35
Interaction A X C	2	0.59	0.30	0.10
Interaction P X C	4	3.40	0.85	0.29
Interaction A X P X C	4	3.40	0.85	0.29
Error	51	148.97	2.92	
Total	71	187.05		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on photosynthetic activity in the month of July, 2023(before treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	12.19		
ABA (A)	1	0.83	0.83	0.62
Foliage trimming (P)	2	2.68	1.34	1.00
Interaction A X P	2	6.64	3.32	2.47
Root zone compaction (C)	2	5.68	2.84	2.11
Interaction A X C	2	1.53	0.77	0.57
Interaction P X C	4	11.66	2.92	2.17
Interaction A X P X C	4	7.88	1.97	1.46
Error	68	91.54	1.35	
Total	89	140.63		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on photosynthetic activity of guava grafts in the month of August, 2023

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	33.48		
ABA (A)	1	91.69	91.69	29.70
Foliage trimming (P)	2	23.53	11.77	3.81
Interaction A X P	2	8.17	4.09	1.32
Root zone compaction (C)	2	106.19	53.10	17.20
Interaction A X C	2	24.36	12.18	3.95
Interaction P X C	4	1.55	0.39	0.13
Interaction A X P X C	4	2.12	0.53	0.17
Error	68	209.90	3.09	
Total	89	500.99		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on photosynthetic activity in the month of July, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	3	154.57		
ABA (A)	1	17.15	17.15	2.15
Foliage trimming (P)	2	18.67	9.33	1.17
Interaction A X P	2	17.35	8.68	1.09
Root zone compaction (C)	2	27.51	13.75	1.73
Interaction A X C	2	0.93	0.47	0.06
Interaction P X C	4	23.27	5.82	0.73
Interaction A X P X C	4	29.43	7.36	0.92
Error	51	406.12	7.96	
Total	71	694.99		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on relative water content (RWC) of leaves in the month of August, 2023 (after treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	4	98.36		
ABA (A)	1	3036.58	3036.58	202.68
Foliage trimming (P)	2	1193.16	596.58	39.82
Interaction A X P	2	281.76	140.88	9.40
Root zone compaction (C)	2	4011.42	2005.71	133.87
Interaction A X C	2	274.56	137.28	9.16
Interaction P X C	4	65.03	16.26	1.09
Interaction A X P X C	4	123.67	30.92	2.06
Error	68	1018.79	14.98	
Total	89	10103.34		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on relative water content (RWC) of leaves in the month of July, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	3	294.98		
ABA (A)	1	0.12	0.12	0.01
Foliage trimming (P)	2	83.90	41.95	1.67
Interaction A X P	2	8.94	4.47	0.18
Root zone compaction (C)	2	11.72	5.86	0.23
Interaction A X C	2	44.13	22.07	0.88
Interaction P X C	4	45.73	11.43	0.46
Interaction A X P X C	4	18.63	4.66	0.19
Error	51	1282.49	25.15	
Total	71	1790.65		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-a content of guava grafts in the month of August, 2023 (after treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	4	1.154		
ABA (A)	1	4.277	4.277	39.23
Foliage trimming (P)	2	1.856	0.928	8.51
Interaction A X P	2	0.61	0.305	2.799
Root zone compaction (C)	2	15.386	7.693	70.562
Interaction A X C	2	1.717	0.859	7.875
Interaction P X C	4	0.664	0.166	1.523
Interaction A X P X C	4	0.59	0.147	1.352
Error	68	7.414	0.109	
Total	89	33.668		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-a content of guava grafts in the month of July, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	3	0.249		
ABA (A)	1	0.093	0.093	2.951
Foliage trimming (P)	2	0.004	0.002	0.06
Interaction A X P	2	0.002	0.001	0.033
Root zone compaction (C)	2	0.06	0.03	0.945
Interaction A X C	2	0.119	0.059	1.878
Interaction P X C	4	0.035	0.009	0.274
Interaction A X P X C	4	0.048	0.012	0.383
Error	51	1.61	0.032	
Total	71	2.219		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-b content of guava grafts in the month of August, 2023 (after treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	1.575		
ABA (A)	1	4.516	4.516	15.725
Foliage trimming (P)	2	2.055	1.028	3.579
Interaction A X P	2	0.135	0.068	0.235
Root zone compaction (C)	2	2.247	1.124	3.912
Interaction A X C	2	0.255	0.127	0.444
Interaction P X C	4	0.227	0.057	0.198
Interaction A X P X C	4	0.59	0.148	0.514
Error	68	19.529	0.287	
Total	89	31.129		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on chlorophyll-b content of guava grafts in the month of July, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	3	0.328		
ABA (A)	1	0	0	0.004
Foliage trimming (P)	2	0.084	0.042	0.387
Interaction A X P	2	0.274	0.137	1.263
Root zone compaction (C)	2	0.056	0.028	0.26
Interaction A X C	2	0.009	0.005	0.042
Interaction P X C	4	0.211	0.053	0.486
Interaction A X P X C	4	0.16	0.04	0.369
Error	51	5.528	0.108	
Total	71	6.65		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on total chlorophyll content of guava grafts in the month of August, 2023 (after treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	4	2.081		
ABA (A)	1	17.822	17.822	34.813
Foliage trimming (P)	2	7.943	3.972	7.758
Interaction A X P	2	1.349	0.674	1.317
Root zone compaction (C)	2	29.694	14.847	29.001
Interaction A X C	2	3.258	1.629	3.182
Interaction P X C	4	1.657	0.414	0.809
Interaction A X P X C	4	1.856	0.464	0.906
Error	68	34.813	0.512	
Total	89	100.473		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on total chlorophyll content of guava grafts in the month of July, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	3	0.281		
ABA (A)	1	0.109	0.109	1.204
Foliage trimming (P)	2	0.054	0.027	0.298
Interaction A X P	2	0.304	0.152	1.673
Root zone compaction (C)	2	0.172	0.086	0.946
Interaction A X C	2	0.065	0.032	0.357
Interaction P X C	4	0.375	0.094	1.032
Interaction A X P X C	4	0.137	0.034	0.377
Error	51	4.634	0.091	
Total	71	6.131		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on proline content of guava grafts in the month of August, 2023 (after treatment)

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculated
Replication	4	3.27		
ABA (A)	1	4902.09	4902.09	4435.59
Foliage trimming (P)	2	195.76	97.88	88.57
Interaction A X P	2	10.72	5.36	4.85
Root zone compaction (C)	2	1609.07	804.54	727.97
Interaction A X C	2	12.12	6.06	5.48
Interaction P X C	4	16.92	4.23	3.83
Interaction A X P X C	4	9.41	2.35	2.13
Error	68	75.15	1.11	
Total	89	6834.51		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on proline content of guava grafts in the month of July, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	3	0.064		
ABA (A)	1	0.008	0.008	0.082
Foliage trimming (P)	2	0.161	0.081	0.826
Interaction A X P	2	0.151	0.076	0.775
Root zone compaction (C)	2	0.007	0.003	0.034
Interaction A X C	2	0.05	0.025	0.256
Interaction P X C	4	0.225	0.056	0.575
Interaction A X P X C	4	0.083	0.021	0.213
Error	51	4.985	0.098	
Total	71	5.734		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on leaf soluble sugars of guava grafts in the month of August, 2023

Source of Variation	df	Sum of Squares	Mean Squares	F-Calculated
Replication	4	0.14		
ABA (A)	1	40.97	40.97	1432.33
Foliage trimming (P)	2	1.01	0.50	17.61
Interaction A X P	2	0.10	0.05	1.77
Root zone compaction (C)	2	41.46	20.73	724.84
Interaction A X C	2	21.45	10.73	375.00
Interaction P X C	4	0.08	0.02	0.72
Interaction A X P X C	4	0.36	0.09	3.18
Error	68	1.95	0.03	
Total	89	107.52		

Significant at 5 % level of significance

ANOVA for the effect of root zone compaction, foliage trimming and abscisic acid on leaf soluble sugars of guava grafts in the month of July, 2024

Source of Variation	df	Sum of Squares	Mean Squares	F- Calculate d
Replication	3	0.554		
ABA (A)	1	0.005	0.005	0.095
Foliage trimming (P)	2	0.007	0.003	0.062
Interaction A X P	2	0.058	0.029	0.514
Root zone compaction (C)	2	0.008	0.004	0.067
Interaction A X C	2	0.006	0.003	0.049
Interaction P X C	4	0.034	0.009	0.152
Interaction A X P X C	4	0.038	0.01	0.172
Error	51	2.859	0.056	
Total	71	3.569		

Significant at 5 % level of significance

College of Horticulture and Forestry
(Dr. Yashwant Singh Parmar University of Horticulture and Forestry)
Neri, Hamirpur (HP) 177001 India
Department of Fruit Science

Title of the thesis : **Effect of pre-transit root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava**

Name of the student : Kavita Kumari Thakur

Admission number : NH-2022-17-M

Major Advisor : Dr. Shashi Kumar Sharma

Major Field : Fruit Science

Minor/ Specialization : Plant Physiology

Degree Awarded : M.sc. (Horticulture) Fruit Science

Year of Award of Degree : 2024

Number of pages in thesis : 104+ xxi

ABSTRACT

The studies entitled “**Effect of pre-transit root zone compaction, foliage trimming and abscisic acid on field survival and growth of grafted guava**” were conducted in the experimental nursery and orchard of the Department of Fruit Science, College of Horticulture and Forestry, Neri, Hamirpur during the year 2023-24. This research aimed to monitor changes in plant physiological and biochemical functions induced due to root zone compaction, foliage trimming and abscisic acid treatment as well as to evaluate their individual and combined effects on field survival and growth of guava grafts. An experiment with three-factor treatments (root zone compaction (C), foliage trimming (P) and abscisic acid (A)) was laid out in RBD factorial layout with treatment levels of C - 0, 25, 50%; P - 0, 25, 50% and A - 0, 100 ppm. The results recorded the highest number of leaves (248.5) and plant height (126 cm) under the treatment combination of 100 ppm ABA, 25% foliage trimming, and 50% root zone compaction. After treatment, the elevated value of stomatal conductance ($0.12 \text{ mol m}^{-2} \text{ s}^{-1}$) and transpiration rate ($3.14 \text{ m mol m}^{-2} \text{ s}^{-1}$) was found under 100 ppm of ABA, whereas the highest photosynthetic activity ($7.79 \text{ } \mu\text{moles m}^{-2} \text{ s}^{-1}$), total chlorophyll content (3.19 mg/ml) and leaf relative water content (83.85%) were found under 100 ppm ABA and 0% root zone compaction. Leaf soluble sugars (4.05%) under 100 ppm of ABA, 25% foliage trimming and 50% root zone compaction and proline content (27.38 $\mu\text{moles per g tissue}$) under 100 ppm ABA and 50% root zone compaction indicated the enhanced tolerance of the plants to the induced stress caused due to different treatment factors. This has also been reflected by the restoration of physical, physiological and biochemical functions (most of these were found to be at par with control) of guava grafts under the field conditions at the end of the experiment. The CO_2 emission equivalence calculated for the plants under different treatments showed that the conjoint application of that 100 ppm ABA, 50% foliage trimming, and 50% root zone compaction treated plants were having the lowest estimates of CO_2 emission ($1.17 \times 10^{-4} \text{ litre plant}^{-1}\text{year}^{-1}$) whereas, it was $1.17 \times 10^{-4} \text{ litre plant}^{-1}\text{year}^{-1}$ for 100 ppm ABA, 25% foliage trimming and 50% root zone compaction which was quite lower than emission levels ($3.05 \times 10^{-4} \text{ litre plant}^{-1}\text{year}^{-1}$) estimated for the untreated control plants. Overall, ranking of the different treatment combinations revealed $A_1P_2C_1$ i.e. foliar spray of ABA @ 100 ppm, foliage trimming @ 25%, and root zone compaction @ 50% has proved as the best treatment for pre-transit treatment of guava grafts for having their efficient transport without compromising the field performance of guava grafts.

Signature of the Student
Name: Kavita Kumari Thakur
Date:

Signature of the Major Advisor
Name: Dr. Shashi Kumar Sharma
Date:

Head of the Department

BRIEF BIO-DATA

Name Kavita Kumari Thakur
Father's name Shri Krishan Kumar
Mother's name Smt. Promila Devi
Date of birth 29 February 2000
Permanent Address Vill. Gail P.O. Urla Teh. Padhar Distt. Mandi (H.P.) 175015

ACADEMIC QUALIFICATION					
Qualification	Month & Year	School	Board/University	Marks (%) / OGPA	Divison
10 th	March, 2015	Him Rashmi Public School, Dalah (Padhar)	H.P.B.O.S.E, Dharamshala	91.28	First
10+2	March, 2017	Ascent Public Sr. Sec. School, Padhar	H.P.B.O.S.E, Dharamshala	89.80	First
B.Sc. (Hons.) Horticulture	September, 2022	College of Horticulture UHF, Nauni	Dr. YS Parmar UHF, Nauni, Solan (H.P.)	84.40	First

Whether sponsored by some state/ Central Govt./univ./SAARC Scholarship/ Stipend/ Fellowship, any other financial assistance received during the study period

No
 Merit Scholarship

(Kavita Kumari Thakur)