EFFECT OF CROP REGULATION AND BAGGING MATERIALS ON GROWTH, FLOWERING AND QUALITY OF GUAVA (*PSIDIUM GUAJAVA* L.) CV. ALLAHABAD SAFEDA.

Thesis Submitted for the Award of the Degree of

DOCTOR OF PHILOSOPHY

in

FRUIT SCIENCE

By

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ABSTRACT

The guava (*Psidium guajava* L.) is an evergreen tropical fruit species that flourishes in diverse soil types and climates. The long-term productivity and sustainability of guava trees hinge on maintaining a harmonious balance between their vegetative and reproductive phases. Therefore, ensuring adequate nutrient supply and effective canopy management becomes crucial. This experiment aimed to explore the influence of varying pruning and the age of guava trees (cv. Allahabad Safeda) over two years. Pruning resulted in maximum average length of shoot (11.34 cm), flowers per shoot (5.65), fruit set (82.27%), yield (28.57 kg), fruit weight (127.24 gm), TSS (10.05 ^{o}Brix), total sugar (6.56%) and ascorbic acid (168.48 mg) whereas opposite trend in acidity, initiation of flowering (65.55 days) and flower bud emergence to anthesis (35.00 days) was observed. Intensifying the degree of pruning leads to the highest possible improvement in all parameters including the yield of guava trees. In both years of the study, pruning and age of plants significantly increased the amount of harvestable fruit. The pruning level of 20 cm was reported to be the most effective pruning for higher productivity and quality of guava. Further, the trees with relatively greater age (11 years old or more) can respond effectively to the pruning. Moreover, the outcome indicated that minimum total damage of 3.74% was found in C_2 (Non-woven), whereas maximum shoot length of 11.74 cm, 5.76 flowers per shoot, and 82.57 % fruit set in A_2 (Pruning 20 cm) and yield of 34.54 kg was recorded in A_2C_2 (20 cm Pruning and Non-woven bag). Fruit bagging effectively reduces total damage of 96.26% (C_2 -Non-woven bag) from pests and birds, with a marked decrease in infestation levels. Thus conclusion of study provides novel insights into sustainable guava cultivation practices, highlighting the importance of integrated approaches for improving yield and fruit quality while minimizing damage and enhancing nutritional value.

Keywords: Psidium guajava, pruning level, plant age, fruit quality, growth regulation, bagging, infestation

DECLARATION

I, hereby declare that the present work in the thesis entitled **"Effect of Crop Regulation and Bagging Materials on Growth, Flowering and Quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda"** is in fulfilment of degree of **Doctor of Philosophy (Ph.D)** outcome of research work carried out by me under the supervision of **Dr. Anis Ahmad Mirza** working as Professor, in the Horticulture, Fruit Science, School of Agriculture Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigator. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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CERTIFICATE

This is to certify that the work reported in the Ph. D. thesis entitled **"Effect of Crop Regulation and Bagging Materials on Growth, Flowering and Quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda"** submitted in fulfillment of the requirement for the award of degree of **Doctor of Philosophy (Ph.D.)** in the Fruit Science, is a research work carried out by Ankush Relhan (11916805) is bonafide record of his/her original work carried out under my supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

(Signature of Supervisor)

Dr. Anis Ahmad Mirza

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Ankush Relhan

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LIST OF ABBREVIATIONS AND SYMBOLS

%	per cent
TSS	Total Soluble Solids
PPM	Parts Per Million
Cm	Centimeter
et al	And other
g	Gram
i.e.	That is
℃	degree Celsius
+	Plus
-	Minus
×	Multiply
=	Equal
min	Minute
ml	Milliliter
M	Meter
Kg	Kilogram
NW	Non-woven
MC	Muslin Cloth
°B	°Brix
NaOH	Sodium Hydroxide
NaHCO3	Sodium Bicarbonate
HPO_3	Metaphosphoric acid
NAA	Naphthaleneacetic acid
GA3	Gibberellic acid
FYM	Farmyard manure
FRBD	Factorial Randomized Block Design
Fig	Figure

1 INTRODUCTION

Fruit crops offer a promising solution for diversifying Indian agriculture and boosting profits. By engaging in horticulture activities, farmers can increase land productivity, create employment opportunities, improve their economic conditions, and enhance nutritional security. The production of high-quality fruit crops led to increased foreign exchange earnings and attracted a new generation of entrepreneurs to the industry. In addition to its economic benefits, fruit crops also support biodiversity, maintain ecological balance, and promote sustainable agriculture. Consequently, there has been a gradual rise in the production of top-quality fruits, resulting in increased revenue from foreign exchange. The fruit crop sector attracts young entrepreneurs, and the returns are promising. Moreover, fruit crops offer opportunities to achieve biodiversity goals, maintain ecological balance, and promote sustainable agriculture.

Guava (*Psidium guajava* L.) is a important tropical crop that is often called the "apple of the tropics" related to Myrtaceae family with chromosome number of 2n = 22, which is known for its nutritional value, exquisite taste, and economic value. It was brought to the Indian subcontinent by the Portuguese in the early 17th century. Today, the leading producers of guava include India, China, Thailand, Pakistan, Mexico, Indonesia, Brazil, and Bangladesh. Guava is widely accessible, nutrient-rich, and economical, earning it the nickname "the Indian fruit (Dinesh & Vasugi., 2010).

The *Psidium* genus comprises more than 150 species; however, only a few dozen are utilized as primary carrier species. *P. guajava* and *P. cattleyanum* are the most frequently traded species globally. *P. guajava* has undergone extensive cultivation, resulting in the development of several cultivars that are distinguished by their sweetness, aroma, color, and seedlessness. On the other hand, *P. cattleyanum* produces edible fruits that are yellow or red in color, but they are primarily consumed in the regions where they are grown. The red-fruited variety of *P. cattleyanum* is also referred to as purple guava, red cattley guava, red strawberry guava, or red cherry guava. Additionally, *P. littorale*, also known as lemon guava, produces yellow fruits and is referred to as yellow cherry guava or yellow strawberry guava (Zou and Liu., 2023).

Guava bears flowers either singly or in clusters of two to three, growing on new growth from the leaf axils. It takes approximately one month for the flowers to fully develop from bud differentiation to the calyx cracking stage (Kumar *et al.*, 2022). Anther dehiscence in guava occurs between 7:00 am and 10:00 am and varies among different varieties, such as

P. guineense (7:00 am to 8:00 am), *P. cattleianum* (7:30 am to 8:30 am), Arka Kiran (7:00 am to 9:00 am), and *P. chinensis* (8:00 am to 10:00 am) (Alfia *et al.*, 2017). The wild species exhibited similar anther dehiscence timing to economically cultivated crops, facilitating the transfer of fresh viable pollen grains resulting in good seed and fruit set. In spring and autumn, anther dehiscence and the first opening of flowers occurred in the morning hours across all guava cultivars studied. The peak time for anthesis in guava cultivars is observed between 5:30 am and 6:30 am, while anther dehiscence occurs from 6:00 am to 8:00 am. These timings can differ based on the specific flowering periods and traits of each cultivar. Additionally, the stigma is receptive at the onset of flower opening and stays receptive for up to 48 hours, beginning its receptivity 24 hours prior to anthesis (Singh *et al.*, 2020).

There are many popular cultivars of guava available each with its own unique characteristics. Some of the most well-known varieties include Allahabad Safeda, Lucknow-49 (Sardar), Apple Colour, Arka Mridula, Allahabad Surkha, Anakapalli, Beaumont, Behat Coconut, Bariampur, Banglore, Banarasi, Bhavnagar, Chittidar, CISH-G-l, CISH-G-2, Dharwar, Guineese, Habsi, Kerala, Lalit, Nagpur Seedless, Nasik, Pear Shape, Portugal, Red Fleshed, Sangam, Seedless, Sindh, Smooth Green, Superior. The fruit of the Allahabad safeda variety is characterized by its large size, round shape, smooth skin, and white pulp that is soft and firm. As it ripens, it turns light yellow and develops a very sweet taste and pleasing flavor with only a few seeds. This variety is highly favored in India and has served as the ancestor to numerous Indian fruit varieties.

Allahabad Safeda is one of the most renowned variety of table-purpose fruit which is used to grow in the north Indian region. This particular tree is typically medium in height, ranging from 5.8 to 6.5 meters, and has dense foliage with vigorous branching. The fruit of this variety is round, weighs about 150 grams, and has a small number of seeds. Additionally, the fruit's white flesh is known for its excellent keeping quality (Sharma *et al.*, 2013).

Guava fruit is used to make jams, jellies, juices, and other culinary products, and it contains high levels of antioxidants and dietary fiber. Additionally, guava has a much higher vitamin C content than many other fruits, which makes it an ideal choice for treating scurvy and boosting the immune system during the COVID-19 pandemic. Guava leaf extract is recognized for its potential to alleviate diabetes symptoms, a finding supported by research from Susanto *et al.* (2019). Additionally, studies on the growth patterns of guava fruits, such as those by Saroj *et al.* (2018), have demonstrated that the growth trajectory of guava fruits typically follows a double sigmoid pattern. This pattern outlines the stages of fruit development, with the first and second rapid growth phases occurring between 30-60 days and 90-127 days after fruit set, respectively, varying according to the genotype. The initial surge in fruit growth is primarily due to an increase in cell size. However, a period of slower growth is observed between 60-90 days after fruit set, which Patel *et al.* (2014) attribute to the rapid development of seeds during this phase, slowing down the pulp growth.

Guava is an important fruit in combating nutritional deficiencies, ranking as the third highest source of Vitamin C with 299 mg per 100 grams followed by the Barbados cherry and Aonla, which contain 1000-4000 mg and 600 mg of Vitamin C per 100 grams of pulp, respectively. Guava also stands out for its fiber content, offering 6.9% fiber, which is 2 to 5 times more than most fruits and second only to figs. Additionally, guava is rich in vitamins A and C, riboflavin (B2), thiamine (B1), as well as minerals. The fruit, known for its sweet aroma, can be consumed in its entirety, including the skin, whether it is green or ripe. In some regions, guava leaves are used medicinally to treat diarrhea and in drying. The guava tree blossoms three times every year, specifically in February, June-July, and October, in southern and western India. The three corresponding bahars are known as Ambe, Mrig, and Hasthbahars. The guava tree seems to bear fruit almost constantly in this region. The "Mrigbahar" crop, which produces fruits with superior quality, taste, and vitamin-C content, is produced in the winter from November to January between these three bahars.

Guava trees in North India experience two primary flowering seasons each year. The first season starts in April and May, coinciding with the beginning of the monsoon, and the second occurs in August and September, just before the winter harvest (Mitra *et al.*, 2008). After flowering, it typically takes guava fruits about four to five months to mature, during which they shift from a dark green to a lighter yellowish-green as they ripen. To ensure the highest quality of fruit, it is advisable to pick guavas in the cooler parts of the day, such as early morning or late evening, when the fruits' physiological activities are minimized (Singh *et al.*, 2021).

Guavas are highly valued for their appealing taste and nutritional benefits. One distinctive feature of these trees is their higher proportion of shade-tolerant leaves compared to sun-exposed leaves, which tend to become less active in photosynthesis under heavy shade, reducing their productivity. The growth of the tree, the yield of the fruits, and their quality largely depend on the tree’s ability to effectively transform light into chemical energy via photosynthesis, a vital process that influences both the yield and quality of the fruits (Singh *et al.*, 2022).

Guava bear on current season growth shoots, and their flowers typically emerge in small groups known as cymes, or as solitary blooms, often appearing two or three at a time in the leaf axils. Pruning is a crucial practice that influences the tree's vigor, productivity, and fruit quality. Early pruning helps establish a sturdy framework capable of bearing a heavy crop load. Pruning on bearing trees offers several benefits, such as growth of shoots, preventing overcrowded branches, and removing diseased, crisscross, water sprouts, and root suckers. Failure to prune guava trees prolongs their vegetative growth, reduces the bearing area, and results in smaller fruits, decreased yield, and inferior quality. Hence, pruning is necessary to achieve a balance between vegetative and reproductive growth (Lian *et al.*, 2019)

Guava trees are known for their hardiness, high productivity, long lifespan, drought resistance, and low maintenance requirements, making them a highly profitable crop for fruit growers. With their wide adaptability to different growing conditions, guava cultivation has become increasingly popular among farmers seeking higher returns per unit area. In recent years, guava production has undergone a major transformation, shifting from subsistence farming to commercial production. Guava fruits are produced in the axils of young growing shoots of the current year, making guava trees highly responsive to pruning when grown under high-density plantations. Pruning plays a vital role in influencing the vitality, fruit production, and overall quality of guava trees. Research indicates that the extent of pruning can markedly affect aspects such as tree growth, flowering, fruit quality, and yield. Proper pruning techniques ensure that the tree maintains optimal health and productivity by managing its structure and enhancing light penetration, which is crucial for effective photosynthesis (Sah *et al.*, 2017).

Research indicates that shoot tips in plants become active only when they can export auxin to the main stem, although it's not confirmed if substantial auxin levels are present there initially. This leads to competition among shoot tips, both vertically and horizontally, affecting their respective growth patterns. As a result, the stronger branches, which are not always located at the upper parts of the tree, typically grow more vigorously and dominate, often due to their earlier development. The main shoot of a plant suppress the growth of shoots lower down and targeted pruning can be used to promote branching. Pruning before a plant enters a growth phase can decrease leaf production in the subsequent year, thus reducing the demand for nutrients and water. A strong root system supports rapid growth, especially in parts that have been heavily pruned. Pruning generally revitalizes plants and improves their performance, even with limited nutrients and water. It serves as a cultural practice to remove weak and diseased sections and enhance orchard aesthetics. Moreover, pruned plants usually experience fewer instances of flower and fruit dropping (Bhagawati *et al.*, 2015).

Plant growth regulators (PGRs) serve as messengers within the plant and are required in minimal quantities at low concentrations. These regulators operate at distinct sites and follow separate biosynthesis pathways. Their role is to facilitate swift alterations in physiological and biochemical characteristics, ultimately bolstering crop productivity. Gibberellic acid, for instance, has been documented as a significant influencer of vegetative growth, flowering, fruiting, and various anomalies in numerous fruit crops.

Recently, there is demand of superior quality created in market, primarily driven by the desire to secure attractive prices. To mitigate this issue and enhance both the visual and internal quality of guavas, the bagging of fruits has gained widespread adoption as a phytosanitary measure. This method involves covering individual guavas or clusters of guavas on the tree for a specified duration to achieve desired outcomes. Pre-harvest bagging has a noteworthy influence on various aspects of guavas, including size, color, taste and overall quality. The choice of bag type can impact these effects and significantly reduce the necessity for insecticides and fungicides. Additionally, pre-harvest bagging alters the micro-environment surrounding the fruit during its developmental stage, subsequently affecting the physico-chemical quality of the produce. This technique has been broadly utilized in multiple fruit crops to enhance skin color, prevent issues like splitting, mechanical damage, and sunburn on the fruit's surface (Ram *et al.*, 2013).

Fruit bagging proves to be an effective method for stimulating the synthesis of anthocyanin and other chemical parameters such as sugars, acids, and fruit coloration. Furthermore, bagging guavas with biodegradable bags has been found to enhance fruit quality. Multiple findings suggest that fruit bagging indeed has a significant effect on the growth and development of guava fruits, influencing their maturity and quality parameters.

The study's hypothesis suggests a positive impact on guava trees, enhancing both fruit yield and quality. The current research, entitled "Effect of Crop Regulation and Bagging

Materials on Growth, Flowering and Quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda." was started to address the following objectives:

- To investigate the impact of pruning and plant growth regulators on flowering behavior and quality of guava
- To evaluate the effect of different bagging materials against fruit fly on guava
- To determine the postharvest shelf life and quality of guava

2 REVIEW OF LITERATURE

Pruning fruit trees has long been a traditional horticultural practice. While it may seem straightforward when carried out in the orchard, a deeper understanding of the plant's physiology is essential. Pruning plays an important role in managing the ratio of shoots to fruits, thereby enhancing both fruit yield and quality. Numerous researchers have delved into the physiological aspects of pruning, developing standardized techniques for various fruit trees such as apple, pear, plum, cherry, apricot, phalsa, grape, fig, and guava, which are widely adopted by growers. Nevertheless, the intensity of pruning required for growth, flowering, and fruiting patterns of each fruit crop. Gibberellic acid and naphthalene acetic acid are plant growth regulators that have significant effects on guava cultivation. GA3 is primarily used to improving fruit size and quality delay fruit senescence, extending the shelf life of the fruit. NAA, on the other hand, is often used to increase fruit set percentage in fruits by reducing flower and fruit drop percentage. However, the specific effects can vary based on the concentration of the hormones used and the timing of their application, necessitating careful management to achieve the desired outcomes in guava production. The use of non-woven and muslin cloth bags for bagging guava fruits has beneficial impacts on fruit quality and protection. Bagging with these materials helps in shielding the fruits from direct sunlight, pests, and diseases, reducing the need for chemical pesticides. Non-woven bags, in particular, provide excellent air circulation and light penetration, which are essential for maintaining a low temperature around the fruit and preventing sunburn. Both types of bags help in producing cleaner fruits with fewer blemishes and improved marketability. Furthermore, bagging can also contribute to more uniform fruit sizes and earlier maturation due to the microclimate created around the fruit, enhancing overall yield quality. Surprisingly, there is no documented information regarding the optimal pruning timing, intensity, type of plant growth regulator with different concentration, and types of bagging material for guava crops. In this chapter, we aim to provide a comprehensive review of the pertinent literature in alignment with the objectives of our current study.

Wanichkul and Harach (2002) explored the impact of fruit bagging on the growth and quality of the guava cultivar 'Yen Song', comparing fruits that were bagged to those that were not. Different materials were used for bagging, including white, blue, and yellow polyethylene bags, kraft paper, aluminum foil, and polyester. The research found that the maturation period for guava fruits from flowering to ripeness lasted 15 weeks, with more pronounced growth occurring within the first 11 weeks when polyethylene bags were used.

The advantages of fruit bagging were highlighted, showing reductions in disease and insect damage, increased flesh firmness, and improved flavor. However, the study noted that bagging did not significantly affect the sensory qualities of the fruit. Different bagging materials had varying impacts on fruit quality, with blue polyethylene bags enhancing pulp thickness, the ratio of total soluble solids (TSS) to acidity, and vitamin C content, while yellow polyethylene bags increased fruit width, TSS content, and heat unit accumulation. This research emphasizes the role of specific bagging materials in affecting guava fruit development and quality.

Sarker *et al.* (2009) observed that fruit bagging with brown paper bags represented the 100% effectiveness for mango fruits against fruit flies. They also noted that the use of brown paper bags led to an increase in total soluble solids (TSS) and improved physical fruit characteristics when compared to un-bagged fruits.

Ding and Syakirah (2009) conducted research on the pre-harvest bagging of 'Harumanis' mangoes and found that using various colored paper bags did not significantly influence the mango pulp's color, carotenoid levels, weight loss, pulp firmness, soluble solid concentration (SSC), pH, titratable acidity (TA), ascorbic acid content, or the glossiness of the skin. However, distinct effects were observed when using brown and black paper bags. Bagging with these colors notably improved several attributes of the 'Harumanis' mango, including skin color, pulp firmness, color, ascorbic acid levels, and chlorophyll content, while also reducing weight loss, in comparison to other bagging treatments. This highlights the specific influence of bag color on certain qualitative aspects of mango fruits.

Dutta and Majumder (2012) explored the effects of using poly bags on mangoes during various stages of growth, specifically on days 35, 45, 55, and 65 post-fruit-set. The mangoes were harvested at 75, 85, and 90 days post-fruit-set and allowed to ripen at room temperature, within a range of 34-36℃ and 85-90% relative humidity. The study found that bagging the mangoes at different developmental stages improved their overall appearance, weight, and size, primarily because the increased humidity helped reduce water loss from the fruits. Bagging also delayed the ripening process across all harvest times. Starting the bagging process early, at 35 days post-fruit-set, significantly postponed the emergence of ripening traits compared to both later bagging and non-bagged controls, which ripened sooner. Additionally, the research noted a lower occurrence of diseases like Anthracnose and stem-end rot, caused by Colletotrichum and Diplodia spp., respectively. This decrease in disease was mainly due to less exposure of the fruits to disease-causing agents. These results indicate that bagging can be beneficial for enhancing mango quality by minimizing disease and improving fruit characteristics such as appearance, size, and weight.

Garasiya *et al.* (2013) conducted a study to investigate the effects of different plant growth regulators on the productivity of the L-49 guava variety during the winter season. The findings indicated that applying 40 ppm of NAA and a combination of 20 ppm NAA with 50 ppm GA3 significantly enhanced the fruit yield, producing an average of 439.00 and 410.05 fruits per tree, respectively. These treatments also resulted in an increase in fruit weight (153.22 and 136.13 grams), fruit volume (127.68 and 114.20 cubic centimeters), fruit diameter (5.63 and 5.36 centimeters), and overall yield (66.39 and 59.90 kilograms per tree). However, the treatment with 50 ppm of GA3 alone was associated with the lowest number of seeds per fruit. This study demonstrates the potential benefits of specific plant growth regulators in optimizing fruit production in winter season guava.

Abbasi *et al.* (2014) conducted a study to evaluate the efficacy of different covering materials, including newspaper bags, perforated polyethylene bags, muslin cloth bags, and netted cloth bags, on the bagging of guava fruit to improve fruit quality. The results indicated that fruit maturity remained consistent in both bagged and unbagged fruits, except for those bagged with newspaper bags, where fruit maturity was notably delayed. Bagged fruits showed reduced damage from fruit flies, with polyethylene bags proving most effective, followed by newspaper and muslin cloth bags. Economic analysis demonstrated that all bagging techniques were cost-effective. Perforated polyethylene bags exhibited the highest benefit-cost ratio and improved fruit quality. Moreover, fruits covered with newspaper bags exhibited the lowest weight loss, highest fruit firmness, and highest pH during storage, whereas unbagged fruits experienced the highest weight loss and lowest fruit firmness. Fruits covered with perforated polyethylene bags had the highest sugar content. Overall, among the various bagging treatments, perforated polyethylene bags emerged as the most favorable choice, especially in terms of sensory evaluation.

Bisen *et al.* (2014) conducted an experiment involving four guava plants of the Allahabad safeda cultivar. Their study focused on pre-harvest sprays with GA3 at the time of fruit set and 20 days, as well as 10 days before harvesting, in conjunction with varying concentrations of calcium nitrate. Specifically, GA3 was applied at levels of 0 ppm, 25 ppm, 50 ppm, and 100 ppm. Their observations revealed that, throughout all stages of fruit growth, the combination of medium GA3 concentration, specifically 50 ppm, led to increased fruit length and diameter. The maximum fruit diameter was notably achieved, measuring 71.00 mm, and another high diameter of 67.75 mm was recorded when 2% calcium nitrate was combined with 50 ppm GA3. These findings underscore the positive effects of these treatments on guava fruit growth, particularly in terms of fruit diameter, and suggest that the combination of 50 ppm GA3 and 2% calcium nitrate was particularly effective.

Nagaharshitha *et al.* (2014) evaluated the bagging influence on the growth and development of mango. All treatments improved fruit retention of 80 days with muslin cloth bag followed by 78.33 days in plastic bags. Physical attributes like weight, length, and diameter closely resembled the control. Most notably, bagging substantially reduced stem end rot disease incidence, offering a significant benefit.

Bhagawati *et al.* (2015) evaluated the impact of various pruning intensities to check the effect on guava growth and fruit biochemistry. They found that severely pruned trees showed the quickest bud emergence (3.98 days) and the most significant increase in new shoot length (38.21 cm). Additionally, the study observed changes in the biochemical properties of the fruits: tss and sugar content increased with the intensity of pruning, reaching highest at 10.1°Brix and 9.12% respectively, in severely pruned trees, while these measures were lowest with no pruning. Acidity was highest (0.24%) in unpruned trees and decreased to 0.19% as pruning intensity increased.

Chauhan *et al.* (2015) evaluated a study centered on mango cultivation. The research involved various treatments, including the application of calcium nitrate at concentrations of 0.5% and 1.0%, as well as GA3 at 25 ppm and 50 ppm, and NAA at 25 ppm and 50 ppm. These treatments were administered in conjunction with either mulching or water spray without mulching, which served as the control group. Notably, the sprays were conducted at different times and stages.

Haldanker *et al.* (2015) conducted research on mango at the marble stage in which they implemented bagging procedures, carried out thirty days after the fruit setting, using different types of bags. The results of their study indicated that bagging with both newspaper bags and brown paper bags resulted in improvements in fruit retention, fruit weight, fruit diameter, pulp weight, TSS, and sugar content at the ripe stage.

Phani *et al*. (2015) conducted a study to assess the quality and shelf life of guava fruits subjected to treatments of Naphthalene acetic acid (NAA) at concentrations of 100 and 200 ppm, as well as Gibberellic acid (GA3) at 150 and 300 ppm. The guava fruits were harvested at two key stages, namely the mature green stage, characterized by the maximum fruit growth and a transition in skin color from dark to light green, and the color turning stage, marked by a slight yellowing of the skin from light green. These stages were examined to determine the most appropriate stage of maturity for treatment. Throughout the storage period, there was a gradual increase in the levels of TSS and sugars in the guava fruits, peaking during the ripe stage, followed by a gradual decline towards the end of the storage period. Conversely, both titratable acidity and ascorbic acid content decreased as the storage period progressed. Organoleptic parameters, such as fruit appearance, color, flavor, taste, and overall acceptance, showed progressive improvement until the ripe stage. However, fruit texture showed a continuous decline over time. These findings suggest that guava fruits harvested at the mature green stage exhibit a longer shelf life and superior fruit quality when subjected to various treatments investigated in the study.

Sah *et al.* (2015) studied the influence of pruning on growth and flowering of guava and observed that half shoot pruning in April and July significantly increased the plant height (1.67m), plant spread (2.17m) in winter season crop. They also reported that half-shoot pruning in April significantly increases the emergence of more new shoots (328.00) and flower buds per plant (84.00) for winter season guava.

Tran *et al.* (2015) assessed the impact of various bagging materials, including white paper bags, black net screens, black bags, and white plastic bags, on three different papaya varieties. Their results revealed that utilization of black polyethylene bags led to increased fruit firmness when compared to other bagging materials.

Jakhar and Pathak (2016) reported that the pre-harvest treatment of mango fruits of the 'Amrapali' variety involving a combination of 2 % calcium chloride and 1% potassium sulfate, with bagging, proved to be enhancing fruit quality. This treatment resulted in various positive outcomes, including the highest weight of fruit, firmness, soluble solids (TSS), vitamiv C, total sugar levels, and β-carotene content. Moreover, fruits treated with 2 percent $CaCl_2$ and 1 percent K_2SO_4 in conjunction with bagging demonstrated an extended shelf life of up to 12 days, with minimal weight loss, and they exhibited the highest organoleptic quality in comparison to untreated fruits, which had a shelf life of only 6 days. These findings underscore the effectiveness of the combined pre-harvest treatment and bagging approach in enhancing the quality and extending the shelf life of 'Amrapali' mango fruits.

Jawed *et al.* (2016) conducted an investigation focusing on the effects of varying concentrations of $ZnSo_4$ (0.40%) and GA_3 (90 ppm) spray on multiple aspects of plant growth and fruit development. The findings revealed that the higher concentration of zinc sulphate and GA_3 produced favourable outcomes. Significantly, the tertiary shoot length reached 8.08 cm, with a corresponding shoot diameter increase to 4.26 mm, and an average of 7.10 leaves per shoot. Additionally, higher doses of zinc sulfate and GA3 resulted in maximum fruit set (95.55%) and fruit retention (77.48%), indicating their effectiveness in reducing fruit drop to 18.07%. Additionally, the combination of higher doses of zinc sulphate and GA_3 resulted in the maximum total soluble solids (TSS) content, measuring at 11.65. Conversely, the acidity levels were at their lowest, recorded at 0.20%, with the application of higher doses of these substances. These findings underscore the positive impact of zinc sulphate and GA_3 on plant growth, fruit development, and overall fruit quality.

Joshi *et al.* (2016) conducted an investigation focusing on litchi fruit using the pre-harvest bagging method. Their study encompassed a comprehensive evaluation of various parameters, including fruit weight, whole fruit size, soluble solids (TSS), acidity (TA) of fruits, vitamic C, sugar levels, and sensory evaluation. The research findings revealed that both brown paper bags and butter paper bags proved to be effective in extending the days to maturity, enhancing maximum fruit weight and size, elevating TSS levels to 19.50 ^{o} Brix, increasing ascorbic acid content to 21.56 mg per 100 grams, raising reducing sugar content to 11.31%, and boosting total sugar content to 13.13%. In contrast, fruits bagged with green polyethylene bags exhibited the lowest acidity at 0.51%. Consequently, brown paper bags, butter paper bags, and green polyethylene bags were identified as effective means of enhancing fruit color and preserving fruit quality at the time of harvest.

Mahesh *et al.* (2016) observed that the highest secondary (20.15) and tertiary branches (27.34) were found during the first weeks of April, August, and December with 75% of pruning, while the maximum east-west canopy spread (1.48 m) was found during the first weeks of May, September, and January with 25% pruning.

Meena *et al.* (2016) evaluated the impact of bagging on guava fruits with various polyethylenes bagging of variuos colors in comparison to unbagged fruits. Their research demonstrated that the bagging techniques significantly enhance the growth as well as quality when contrasted with unbagged counterparts. Among the diverse fruit covering materials tested, the use of yellow-colored polythene bags was identified as the most effective approach for enhancing the overall physico-chemical quality of winter season guava, specifically the 'Lalit' variety. These findings underscore the favorable influence of bagging, with yellow polythene bags emerging as the optimal choice for enhancing guava fruit quality in winter season.

Prabhakar *et al*. (2016) explored the effects of varying degrees of shoot pruning on guava's flowering and fruiting. Their research specifically looked at the winter season crop of guava. The study revealed that pruning three-fourths of the shoot notably enhanced the plant's productivity. This intensity of pruning led to a substantial increase in the number of flower buds, averaging 145.75 per plant. Additionally, this level of pruning resulted in a higher fruit set, achieving a rate of 66.85% per plant. These findings suggest that significant pruning effectively boost both the quantity and quality of guava fruit.

Ram *et al.* (2016) explored the influence of foliar applications of salicylic acid (SA) and boron along with commonly used growth regulators such as GA3, NAA, and ethephon on the growth and productivity of the guava cultivar Arka Amulya. The results indicated that using 100 ppm of salicylic acid as a foliar spray significantly improved shoot length, leaf count, and leaf area compared to the untreated group. This method demonstrated notable enhancement in these essential growth metrics. The experiment also revealed that ethephon at 100 ppm was the most effective in initiating early flowering, taking approximately 24.33 days, closely followed by 200 ppm of SA, which took about 25.33 days. In terms of fruit production, applying SA at 100 ppm led to the highest average fruits per shoot at 3.18 and achieved a fruit set percentage of 74.16%, closely matching the results from 20 ppm of NAA. In contrast, the lowest fruit set percentage was observed in the control group, at 35.57%. Additionally, specific treatments with GA3 at 50 ppm and ethephon at 100 ppm were found to increase fruit length and breadth, respectively. Notably, the highest yield per plant, which was 12.30 kg, occurred with the 100 ppm SA treatment, showing comparable outcomes to the 20 ppm NAA treatment. Furthermore, the application of 20 ppm SA resulted in the highest total soluble solids (TSS) content, while the use of 200 ppm boron produced the highest vitamin C content. Remarkably, the plants treated with 100 ppm SA also displayed the highest benefit-to-cost ratio, which was recorded at 11.18.

Rokaya *et al.* (2016) conducted experiment to investigate the impact of gibberellic acid (GA3) on the quality and preservation of mandarin oranges. The researchers applied different concentrations of GA3—10, 20, and 30 ppm—and compared these with a control group. The study evaluated several aspects of the fruit at three harvest dates: November 20, December 5, and December 20, under varying storage conditions. These aspects included fruit weight, firmness, rind color, juice yield, TSS/Acid ratio, postharvest weight loss, decay, and ascorbic acid content. The results indicated that mandarins treated with 20 ppm GA3 exhibited superior quality attributes by the end of the study period on December 20. Specifically, these fruits had an average weight of 128.6 grams, firmness of 3.54 kg/cm^2, a juice recovery rate of 57.75%, and a TSS/Acid ratio of 21.24. Moreover, using 30 ppm GA3 significantly reduced postharvest weight loss to 5.17% in ambient conditions and 6.69% in cellar conditions, compared to 9.52% and 11.76% in the untreated fruits. Additionally, the decay rate was lower in fruits treated with 30 ppm GA3, registering at 1.02% in ambient conditions and 8.21% in cellar conditions, while untreated fruits showed higher decay rates of 5.54% in ambient and 21.58% in cellar conditions.

Hiremath *et al.* 2017 investigated the impact of pruning guava shoots to a length of 20 cm on the growth characteristics of the Sardar variety. The findings indicated that this specific pruning length resulted in the shortest average plant height of 3.26 meters. Conversely, it encouraged the development of the thickest stem, measuring 15.60 cm in girth. Additionally, this pruning approach significantly influenced the plant's horizontal growth, achieving the most extensive plant spread, with a maximum east-west diameter of 7.19 meters. This suggests that moderate pruning can effectively manipulate physical growth patterns and robustness in guava plants.

Islam *et al.* (2017) examined the effects of pre-harvest bagging on 'Mallika' mangoes, focusing on fruits that were bagged at the marble stage using different materials: brown paper bags (BPB), white paper bags (WPB), muslin cloth bags (MCB), and an unbagged control group. The findings revealed that bagging, particularly with brown and white paper bags, significantly enhanced the quality of the mangoes. Improvements were noted in terms of fruit retention, weight, diameter, and nutritional value. Additionally, bagged mangoes demonstrated a longer shelf life, decreased occurrence of spongy tissue, and fewer problems with pests.

Jayswal *et al.* (2017) revealed the effect of pruning intensity, combined with different nutrient sources, affected guava fruit quality. The experiments involved different prunings levels in May, alongside nutrient application. Results indicated that pruning at 40 cm led to the highest levels of total soluble solids (TSS) at 10.96 ºB, ascorbic acid content at 241.0 mg/100g, total sugar at 8.07%, reducing sugar at 4.68%, and non-reducing sugar at 3.39%. In contrast, the lowest values for these metrics were found in unpruned plants.

Kohli *et al.* (2017) investigated the influence of different pruning heights on guava tree growth. It was found that trees pruned at 1.5 m exhibited superior growth metrics, including a tree spread of 1.13 m, canopy volume of 1.16 m^3, tree girth of 22.68 cm, trunk cross-sectional area of 40.53 cm^2, and leaf area of 90.30 cm^2. Furthermore, the greatest leaf area and chlorophyll content, at 90.30 cm^2 and 0.032 mg/g respectively, were recorded at this pruning height.

Mahadevan *et al.* (2017) conducted a study and found that pruning guava trees to a length of 30 cm significantly enhanced various quality parameters of the fruit. They observed the highest levels of total soluble solids, recorded at 10.79° Brix, which indicates a greater concentration of sugars and other dissolved solids in the juice. The ascorbic acid content was notably high, measuring 220.75 mg per 100 grams of pulp, highlighting increased vitamin C content beneficial for nutritional value. Additionally, the study noted that total sugars reached 8.64% and reducing sugars were at 8.89%, indicating a rich sugar profile favorable for taste and energy content. Furthermore, the minimum titratable acidity was 0.44%, suggesting a milder, less acidic flavor profile which could be preferable in fresh consumption or processing.

Malshe and Parulker (2017) reported their findings which showed that maximum fruit weight, with an average of 230.67 grams, was achieved through a specific bagging technique. This method also led to the highest ascorbic acid content, measuring 55.00 mg per 100 grams of fruit. Additionally, the process resulted in the highest levels of both reducing sugars at 2.28 percent and total sugars at 6.78 percent. The bagging was performed at the marble stage, and the bags were removed approximately 75 days after the initial bagging of mango fruits of the 'Alphonso' variety. These results highlight the positive impact of bagging at the marble stage, ultimately leading to improved fruit weight, ascorbic acid content, and sugar composition.

Mishra *et al.* (2017) reported that the combined application of $CaCl_2$ at 2%, K_2SO_4 at 2%, and a specific bagging technique involving blue-colored polythene material yielded significant improvements in various parameters related to rainy season guava. These enhancements included an increase in fruit weight, fruit diameter, specific gravity, fruit size, firmness of fruit, soluble solids (TSS), titratable acidity, sugars, and the overall organoleptic quality of the guava. Additionally, this approach was effective in reducing insect damage to the fruit. These findings highlight the positive impact of this combined treatment on the quality, size, and pest resistance of rainy season guava fruits.

Nikumbhe *et al.* (2017) explored the timing of pruning affects guava growth, by conducting their study across various months i.e. May, June, July, August, and September. Their findings highlighted that pruning guava trees mid-May led to the most favorable outcomes in terms of shoot regeneration. Specifically, new shoots began to appear relatively quickly, averaging 29.29 days for initiation. Moreover, these shoots reached an impressive average length of 120.21 cm, indicating vigorous growth. This suggests that the specific timing of pruning in guava cultivation significantly influence both the speed of recovery and the extent of new growth, which are critical factors for optimal fruit production and overall tree health.

Rahman *et al.* (2017) investigated the impact of different fruit bagging techniques on the yield and quality of guava, utilizing three distinct methods: bagging with white, blue and unbagged. The research found that the costs associated with these bagging methods were manageable and justified by the benefits, primarily because fruits that were not bagged and of lower quality did not attract customers. Significantly, using perforated polyethylene bags provided superior protection against ultraviolet light, significantly enhancing the guavas' quality. These findings emphasize the considerable advantages of specific bagging strategies, particularly perforated polyethylene bags, in boosting both the yield and quality of guava fruits.

Rahman *et al.* (2018) was conducted experiment to evaluate the effects of different bagging materials on the post-harvest quality of the 'Swarupkathi' guava variety. The materials tested included brown paper bags, white paper bags, white polythene bags, and black polythene bags. The research found significant impacts of these bagging treatments on various quality attributes of the fruit. Specifically, fruit bagging contributed to increases in fruit size, weight, vitamin C content, and moisture levels. Among the materials evaluated, white paper bags were particularly effective, enhancing both the physical and chemical qualities of the guava. These results affirm the benefits of fruit bagging, highlighting white paper bags as the best option for significantly improving the overall quality of guava post-harvest.

Ashour *et al.* (2018) conducted studies on Barhee date palms (Phoenix dactylifera L) to evaluate the influence of different treatments on the fruit set percentage, yield (kg), and quality of the dates. The results indicated that spraying the Barhee date palm inflorescences with a mixture of 100 ppm GA3, 100 ppm BAP, and 250 ppm boric acid significantly enhanced fruit set percentage, fruit retention percentage, weight of bunch, fruit quality and production across two seasons. These findings highlight the superior effectiveness of the combined treatment over both the control group and the individual substance applications.

Kireethi *et al.* (2018) studied an assessment to examine the impact of fruit bagging on mango fruits of the Kesar variety. Their study demonstrated that the bagging process significantly influenced various physical attributes of the fruits. Notably, fruits covered with newspaper bags demonstrated the best performance in terms of fruit retention, with a high rate of 91.11%. Furthermore, fruits that were bagged with both newspaper bags and brown paper bags exhibited the maximum fruit length, measuring 12.78 cm and 12.29 cm, respectively. These fruits also achieved the highest fruit weight which emphasize the positive impact of bagging on mango fruits, with newspaper and brown paper bags showing particularly promising results for various physical parameters.

Maurya *et al.* (2018) concluded the effects of GA3 at a concentration of 150 ppm on guava plants. Their research revealed significant outcomes, with the maximum fruit size, fruit weight, fruit volume, and specific gravity observed following this treatment. Additionally, the application of a combined spray containing 150 ppm of Gibberellic Acid (GA3) was found to significantly increase fruit yield. In summary, the application of GA3 at this particular concentration emerged as the most favorable choice for enhancing the growth and production related characteristics of guava plants.

Sahu *et al.* (2018) explored how pruning and the use of various plant growth regulators, including GA3, IAA, NAA, and 2,4-D, affect the physico-chemical properties of rejuvenated sapota plants. Their findings highlighted notable genetic differences impacting these properties. Trees pruned at primary branches showed significant increases in fruit metrics, with fruit weights averaging 138.066g, pulp weights at 120.076g, total soluble solids (TSS) at 24.686°B, ascorbic acid levels at 14.63g per 100g, and acidity at 0.146%. The study also examined the effects of different growth regulators, noting that NAA at 50 ppm produced the highest vitamin C, reaching 14.666 mg per 100g. On the other hand, applying GA3 at 20 ppm resulted in the greatest increases in fruit weight of 134.49 gm, pulp weight of 115.97 gm, TSS of 24.9 ºBrix, and also showed the minimum acidity at 0.15%. Furthermore, the GA3 at this concentration resulted in the lowest seed weight, measured at 1.116g. This research underscores the significant role of both pruning and growth regulator application in enhancing the quality and yield of sapota fruits.

Sawant *et al.* (2018) evaluated the experiment on pruning of guava and showed that maximum fruit weight (261.76g), diameter (7.97cm), volume (226.40cm$_3$), soluble sugars (12.35 °B), vitamin C (296.38 mg/100g pulp), reducing sugars (5.31%) was recorded from pruning of main trunk upto 1m along with primary branches and secondary branches upto 0.50 m.

Tendulkar *et al.* (2018) evaluated the effect of different bags on the biochemical properties and sensory parameters of mango. Their research findings revealed that pre-harvest bagging using various types of bags had a significant influence on the chemical composition of the fruits at the ripe stage compared to non-bagged fruits. However, the impact was not consistently the same across all chemical parameters. The total soluble solids (T.S.S.) and reducing sugars were notably improved by the use of plastic bags. On the other hand, opaque colored bags enhanced the ascorbic acid content of the fruits. Overall, bagging, regardless of the type of bag used, resulted in an enhancement in the sensory quality of the mango fruits when compared to non-bagged fruits of the Alphonso variety. These findings emphasize the importance of pre-harvest bagging in influencing both the chemical composition and sensory attributes of mango fruits.

Lian *et al.* (2019) focused on the influence of pruning levels on vegetative growth of the guava cultivar L-49, carried out in the month of April, May, and June. Their investigation included varying pruning intensities at 25%, 50%, and 75% of the shoot length. The study found that a moderate pruning level of 25% in mid-April was particularly beneficial, as it led to notable increases in plant height and shoot length, measuring 49.67 cm and 21.87 cm, respectively. This suggests that timing and the degree of pruning can significantly influence the vegetative growth parameters of guava trees, potentially optimizing their development and productivity.

Susanto *et al.* (2019) found that pruning by leaving 4 pairs of leaves the number of vegetative shoots (11.4) were maximum in control whereas, maximum number of generative shoots (24.2) and number of total shoots (33.8) were reported by leaving 8 pairs of leaves and unpruned plants.

Kumar *et al.* (2020) evaluated the effect of pruning time and severity on vegetative growth of guava performed in month of May, June and July with pruning intensity at 0%, 25%, 50% and 75% and showed that the maximum new shoots (5.56), flowers per tree (282.33), fruit set percentage (68.72) and retention of fruit (73.36) was observed in 50% pruning in May month whereas maximum length of new shoots (60.79cm) was recorded with 75% pruning in May.

Singh and Grover (2020) reported that nodal pruning of Sardar guava with 8th node pruning intensity increased the shoot length (11.07 cm). It was also reported that eight node pruning intensity showed the minimum duration of flowering (28 days) with vitamin C (201.84 mg/100g pulp) content of the fruits made significant increase with the increase of the severity of pruning.

Singh *et al.* (2020) studied the influence of pruning on vegetative attributes of guava performed in the month of April, May, May and June. Study oserved that pruning at 20 cm produced the maximum flowers (288.30), while 10 cm pruning produced the minimum flowers (220.53) on 30th May and May 15 was the most effective in improving fruit quality by increasing fruit size (7.8cm), weight (218.53g), TSS (11.54°B), sugars (7.76%), ascorbic acid (214.56 g/100 g pulp), and pectin (0.68%) content of guava fruits.

Ahmed and Gaber (2022) focused research on the effectiveness of various treatments on Manfaloty pomegranate trees during the 2020 and 2021 seasons, highlighted the significant advantages of white paper bagging. This approach substantially minimized fruit cracking, with cracking rates of only 2.77% in 2021 and 2.72% in 2022, and reduced sunburn to 1.45% in 2021 and 2.10% in 2022 compared to the control and other treatments. Additionally, fruits bagged with white paper achieved remarkable market acceptability scores of 95.78% in 2021 and 95.15% in 2022. The technique also improved the overall yield, increasing fruit weight, length, and diameter. These outcomes demonstrate that white paper bagging can significantly enhance both the yield and quality of Manfaloty pomegranates, making it a viable method for producing high-quality fruit under challenging conditions.

Nadeem *et al.* (2022) investigated the impact of bagging mangoes and concluded that bagging significantly influenced the fruit's quality and longevity at 12 °C with 85-90%relative humidity. Bagged fruits stored for 0 and 10 days in cold conditions successfully preserved their quality for an additional 7 and 5 days, respectively, in ambient storage, outperforming non-bagged fruits. These bagged fruits demonstrated reduced weight loss, enhanced firmness, and increased levels of tss, ascorbic acid, phenolic compounds, and antioxidant enzymes. Nevertheless, both bagged and control fruits deteriorated after 20 days under cold storage conditions. These outcomes show that bagging of fruits effectively extends the shelf-life of fruiyt for a limited period of cold storage, followed by a brief phase under ambient conditions.

Paradava *et al.* (2022) conducted the research to assess the impact of different bunch bagging materials on the quality of Grand Naine bananas. Two materials were evaluated: a non-woven material bag and a blue polyethylene sleeve. The non-woven bag notably enhanced the quality of the bananas, outperforming the blue sleeve across all tested parameters. Specifically, bananas covered with the non-woven material demonstrated superior total soluble solids (TSS) at 22.23 ^{0}Brix, the highest reducing sugar content at 12.85%, and a total sugar percentage of 21.80%. These findings underscore the significant impact of the bagging on bananas, highlighting the effectiveness of non-woven material in improving fruit attributes.

Singh and Singh (2024) studied on guava cv. Allahabad Safeda to evaluate the impact of pruning on the vegetative growth and yield. The experimental treatments included: P0, with no pruning allowing natural growth; P1, where shoots were cut back to 30cm; P2, where the pruning was to 40cm; and P3, with shoots reduced to 50cm. These varied pruning strategies aimed to investigate how altering the length of shoots after pruning impacts the growth and overall production of crop. Increasing pruning intensity in guava plants reduced shoot length, with pruned shoots at 30cm, 40cm, and 50cm showing progressively compared to unpruned controls.

Singh *et al.* (2024) evaluated the influence of pruning on the shoot length of guava. Research shows that pruning on June 5th with 60 percent intensity yields the longest new shoots. Such intensive pruning, compared to milder or delayed pruning, boosts shoot growth because it allows more photosynthates and nutrients to concentrate in fewer remaining shoots. Notably, the longest new shoots were recorded when plants were pruned to a shoot length of 45cm in May, resulting in a substantial increase in shoot length within 15 days after pruning. These findings highlight the importance of pruning on guava plants to maximize new shoot growth.

3 Materials and methods

This section provides a comprehensive account of the materials employed, as well as the methodologies and techniques implemented during the investigation. It outlines the specific tools, substances, and equipment utilized in the study, and provides a step-by-step account of the experimental processes followed to ensure accuracy of the results. The current study entitled "Effect of Crop Regulation and Bagging Materials on Growth, Flowering, and Quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda". The report outlines the treatment specifics, experimental procedures, and statistical analysis employed to assess different parameters yield throughout the study.

3.1 Experimental Site

The experiment was performed at the Guava farm of Lovely Professional University, which is located at a distance of 18 km from Jalandhar on the Jalandhar-Delhi Grand Truck Road in Phagwara, Punjab. Geographically, it is situated at North latitude of approximately 31.2222° and an East longitude of 75.7692°, whereas, the altitude of Lovely Professional University, Punjab is approximately 240 meters above mean sea level.

3.2 Experimental details

There were two experiments involved in this study. The first experimental design implemented in this study was a factorial randomized block design (Factorial RBD), featuring two factors: pruning and plant age. This configuration was replicated five times, with each replication containing one plant, spaced at intervals of 6 meters by 3 meters. The study focused on the guava crop, specifically on cv. Allahabad Safeda, conducted at the Horticultural Farm of Lovely Professional University (LPU). The first factor was Pruning, categorized into three levels: no pruning (A1), 10 cm pruning (A2), and 20 cm pruning (A3). The second factor, age of plants, was differentiated into two groups: 9-year-old plants (B1) and 11-year-old plants (B2). Overall, the experiment included a total of 30 plants. Additionally, farmyard manure (FYM) was applied at a rate of 50 kg and the nutrient ratio of N;P;K (nitrogen, phosphorus, and potassium) was maintained at 1000:2500:1500 gm as per recommendation mentioned in package and practice of Punjab Agriculture University.

Plant Growth Regulators

In this study, NAA (with 99% purity) from Loba Chemie Pvt. Ltd. and GA_3 (extra pure grade) from Loba Chemie Pvt. Ltd. were employed. Both of these chemicals are specially designated for research and development. At marble stage of fruit development, the plant growth regulators used included concentrations of 10 ppm NAA, 20 ppm NAA, 25 ppm GA_3, and 50 ppm GA_3.

Bagging Materials

For the bagging of guavas, muslin cloth bags of 40 GSM were utilized at marble stage of fruit after the application of plant growth regulators. Muslin cloth bags, crafted from lightweight and breathable cotton fabric, offer gentle protection and durability. Their breathable nature allows air circulation, making them well-suited for guavas. The fabric is strong yet soft, ensuring the fruit is supported without being damaged, while also providing protection against pests and birds. Additionally, muslin bags are reusable and washable, making them a sustainable choice.

Non-woven bags, also of 40 GSM, are made from bonded synthetic fibers, offering durability and resistance to environmental factors. These bags are designed to prevent moisture buildup and protect the fruit from pests, birds, UV rays, and rain. They are lightweight, strong, and easy to handle. Non-woven bags are customizable in size and design, fitting various guava varieties and cultivation needs. Bagging was employed after the application of plant growth regulators during the marble stage of fruit development.

3.3 Experiment-1

Crop	:	Guava
Cultivar	:	Allahabad Safeda
Experimental site	:	Horticultural Farm, LPU
Number of factors	:	2
Factor-1	:	Pruning (A)
A1	:	No
A2	:	10 cm
A3	:	20 cm
Factor-2	:	Age of plants (B)
B1	:	9 Year old
B2	:	11 Year old
Total number of replications	:	5
Total number of plants	:	30
Experimental design	:	Factorial RBD

3.4.1 Flower bud emergence to anthesis

The process of recording the flowering bud emergence to anthesis in guava involved meticulously calculating the days after when the flower buds initital emerged to when the flowers fully opened. This tracking was essential to accurately determine the total duration of the flowering period. Each day was recorded, providing a detailed timeline that reflects how long it takes for the guava flowers to transition from bud emergence to complete anthesis. This method allows for a precise measurement of the flowering cycle, crucial for understanding the reproductive timing and health of the guava plants.

3.4.2 Number of flowers per shoot

The flowers/shoot from each replication in all directions was counted. By calculating the average value of the flowers, the total flowers/branch was expressed as an average numerical value.

3.4.3 Fruit set (%)

Four shoots in the East, West, North, and South direction were selected and counted the number of flowers on each of them and the number of fruits on each labeled shoot was counted and calculated the fruit set in percentage. This methodology allowed for accurate determination of the fruit set percentage based on the flowers and fruits on the labeled shoots.

3.4.4 Yield (kg)

The yield at the time of harvesting was weighed for guava tree on an electronic weighing scale. The final yield was obtained by sum up the yield of all pickings and expressed in kg.

3.4.5 Fruit weight (g)

Each fruit selected in each treatment during harvesting was weighed by using electronic weight machine and the mean weight of guava of seven fruit taken for further analysis and expressed in gram.

3.4.6 TSS (ºBrix)

The measurement of total soluble solids in fruits, ranging from 0 to 32 °Brix, was conducted using a hand refractometer. To account for temperature variations, adjustments were made whenever the temperature deviated from the standard 20°C. Prior to use, the refractometer was thoroughly cleaned with distilled water to maintain a clear surface. Subsequently, a small amount of juice extracted from fruit, was applied to the device and mentioned in °Brix, indicating the concentration of soluble solids in the fruit juice.

3.4.7 Acidity (%)

To measure titratable acidity, 0.5 gm of guava pulp was homogenized, and the volume was made to 50 ml using water. From this, a 5 ml aliquot was taken for analysis. The sample was then titrated with a 0.1 N solution of NaOH, using 2 drop of phenolphthalein indicator, until a light pink color persisted. The titratable acidity of the sample was quantified as malic acid equivalents, following the method described by AOAC (2015). According to this method, each ml of 0.1 N NaOH corresponds to 0.0067 grams of anhydrous malic acid.

$$\text{Acidity (\%)} = \frac{\text{Normality of NaOH} \times \text{Volume made up} \times \text{Titre value} \times 64}{1000 \times \text{Aliquot taken x Weight of sample}} \text{x } 100$$

3.4.8 TSS: Acid Ratio

The TSS: acid was determined using the formula as specified by Ranganna (1986).

$$\text{TSS: Acid ratio} = \frac{\text{Total soluble solids } (^0\text{Brix})}{\text{Titratable acidity (\%)}}$$

3.4.9 Total sugar (%)

To determine total sugars in fruit pulp, 25 grams of the pulp was blended and diluted to a volume of 250 ml with distilled water. Subsequently, 2 ml of saturated lead acetate was added to the solution and allowed to sit for 10 minutes to precipitate impurities. After this, 2 ml of potassium oxalate ($K_2C_2O_4$) added to eliminate left-over lead, and the mixture was left to stand for another 10 minutes before filtering. To hydrolyze the solution, 2 ml of concentrated HCl was added to 100 ml of the filtered solution, and it was left overnight to complete sucrose inversion. The next morning, any remaining HCl was neutralized with saturated NaOH. For the titration process, 10 ml of hot Fehling's solution added, which included equal parts of Fehling’s solution A and Fehling’s solution B (5 ml each), was utilized in a conical flask, with methylene blue serving as the indicator. The reaction's conclusion was marked by the emergence of a brick-red hue. Subsequently, the overall sugar content was determined as a percentage of the juice weight, using the formula prescribed by the A.O.A.C (2015) method.

$$\text{Total sugars content} \quad = \frac{0.05 \times \text{volume made up}}{\text{Weight of sample x titre value}} * 100$$

3.4.10 Reducing sugar (%)

The reducing sugar percentage was measured by titrating a heated combination of 5 ml each of Fehling B and Fehling A solutions with a sample that was clarified and de-leaded but not hydrolyzed, using methylene blue indicator. The transition to a brick red colour was taken as the completion of the titration. The quantification of reducing sugars followed the method described in (A.O.A.C 2015), and the volume of the sample used was documented.

$$\text{Reducing sugar} \quad = \frac{0.05 \times \text{volume made up}}{\text{Weight of sample x titre value}} \text{ X } 100$$

3.4.11 Non-reducing sugar (%)

Non-reducing sugar percentage was obtained by subtracting total sugar % form reducing sugars and difference was multiplied by a 0.95 as a standard factor. The calculation was completed following the steps indicated in (A.O.A.C, 2015).

$$\text{Non} - \text{reducing sugars (\%)} = (\text{Total sugars} - \text{Reducing sugars}) \times \text{Factor}$$

3.4.12 Ascorbic acid (mg/100gm)

The concentration of ascorbic acid was measured using the procedure outlined in the AOAC (2015) guidelines.

Reagents

Indophenol dye (0.04%):

Fifty milligrams of the sodium salt of 2,6-dichlorophenol indophenol were measured and mixed with 150 ml of hot distilled water and 42 ml of sodium bicarbonate. The mixture was then cooled, and the total volume was adjusted with water to 200 ml. Finally, the solution was stored in the refrigerator.

Metaphosphoric acid (3%):

It was prepared by dissolving thirty grams of metaphosphoric acid in one liter of water

Standard ascorbic acid (0.1%):

100 mg ascorbic acid was dissolved in 100 ml of 3% MPA solution and Meta phosphoric acid (1 ml=0.1 mg ascorbic acid) was used to dilute 10 ml to 100 ml.

Standardization of dye:

Add 5 ml of HPO3 with 5 ml of standard ascorbic acid, and transfer the dye into a microburette. Determine the dye equivalence by titrating with the dye solution until a light pink color is achieved.

$$\text{Dye Equivalent} = 0.5/\text{Titre}$$

Procedure

Ascorbic acid was extracted from the pulp by macerating 10 g of material with metaphosphoric acid. The extract was filtered, and the volume was increased to 100 millilitres. A standardised dye (2, 6 dichlorophenol indophenol) was used to titrate 10 ml of the aliquot until the bright pink colour appeared at the end point. The results were expressed in milligrams per 100 gm of fruit weight.

$$\text{Ascorbic acid (mg / 100g)} = \frac{\text{Titre value x dye equivalent x dilution}}{\text{Weight of sample (g)}} \times 100$$

3.4 Experiment-2

The second experiment on cultivar 'Allahabad Safeda' cultivar of guava was conducted at the Horticultural Farm of Lovely Professional University and structured as a 2 × 4 × 3 factorial randomized block design, incorporating three main factors: pruning levels, plant growth regulators, and bagging. Specifically, two pruning levels were performed: 10 cm (A1) and 20 cm (A2); four concentrations of plant growth regulators were applied: 10 ppm NAA (B1), 20 ppm NAA (B2), 25 ppm GA_3 (B3), and 50 ppm GA_3 (B4); and three levels of bagging were employed at the marble stage of guava after the application of the PGR's; muslin cloth bags (C1), non-woven bags (C2), and no bagging (C3). The study involved three replications, with each replication consisting of two plants, totaling 144 plants. This design was intended to explore the interactions between these variables.

Crop	:	Guava
Cultivar	:	Allahabad Safeda
Experimental site	:	Horticultural Farm, LPU
Number of factors	:	3
Factor-1	:	Pruning (A)
A1	:	10 cm Pruning
A2	:	20 cm Pruning
Factor-2	:	Plant growth regulators (B)
B1	:	10 ppm NAA
B2	:	20 ppm NAA
B3	:	25 ppm GA_3
B4	:	50 ppm GA_3
Factor-3	:	Bagging (C)
C1	:	Muslin cloth
C2	:	Non-woven
C3	:	No-bagging
Experimental design	:	Factorial RBD
Total number of plants	:	144

Observations Recorded

3.6.1 Shoot Length (cm)

3.6.2 Initiation of flowering (Days)

3.6.3 Flower bud emergence to anthesis (Days)

3.6.4 Number of flowers per shoot

3.6.5 Fruit set (%)

3.6.6 Yield (Kg)

3.6.7 Fruit fly infestation (%)

3.6.8 Physical/bird damage (%)

3.6.9 Total damage (%)

3.6.10 Fruit weight (g)

3.6.11 Total soluble solids (°brix)

3.6.12 Acidity (%)

3.6.13 TSS : Acid Ratio

3.6.14 Total sugar (%)

3.6.15 Reducing sugar (%)

3.6.16 Non-reducing sugar (%)

3.6.17 Ascorbic acid (mg/100gm)

3.6.18 Shelf life (Days)

Fruit fly infestation (%)

To evaluate fruit fly damage in guava fruits, the study involved monitoring the oviposition marks made by fruit flies on the fruits to assess infestations. A sample size of 34 fruits was examined to count the oviposition punctures. Each guava fruit was inspected under adequate lighting to identify and record the presence of these marks. The percentage of fruit fly infestation across the fruits at the time of sampling was then calculated by the following formula:

$$\text{Insect damage fruit (\%)} = \frac{\text{Total fruits in sample} - \text{infested fruit fly}}{\text{Number of fruit}} \text{X100}$$

Physical/bird damage (%)

To assess the extent of physical or bird damage to guava fruits, the first step involved is to record the marks made by physical or bird damage on the fruits. To make this estimation, a minimum of 34 fruits were selected from various trees and checked for physical or bird damage. To calculate the percentage of physical or bird damage on the entire guava crop, the fruits showing signs of physical impacts or bird interactions was divided by the total number of fruits examined. This fraction was then multiplied by 100 to convert it into a percentage. This calculation provides a precise measure of the extent of damage sustained by the fruit crop.

$$\text{Physical/bird damage (\%)} = \frac{\text{Number of fruit} - \text{Damaged fruit fly}}{\text{Number of fruits}} \text{X100}$$

Total damage (%)

To determine the overall damage to guava fruits, which includes both fruit fly infestation and physical or bird damage. To calculate the total damage percentage, first determined the percentage of fruit fly damage, and then proceeded to calculate the percentage of physical or bird damage. Finally, added these two percentages together to obtain the total damage percentage.

$$\text{Total damage (\%)} = \text{Fruit fly infestation \%} + \text{Bird damage}$$

Shelf life (Days)

To determine the shelf-life of guava, select uniform samples. Regularly monitor parameters like weight loss, TSS, acidity and sugar attributes. Record data until significant quality deterioration is observed to establish the shelf life period.

3.5 Statistical analysis

The data was examined statistically using Microsoft Excel and OPSTAT software. A Factorial Randomized Block Design (FRBD) approach was employed to evaluate the mean values derived from the observations, facilitating the comparison of means and determination of the statistical significance of different treatments. This involved conducting an Analysis of Variance (ANOVA) to scrutinize the mean performances. To determine the significance of variations observed among the various treatments, the mean values recorded for each quantitative trait across all replications were analyzed using the F-test. This method helped in identifying statistically significant differences between treatment effects.

4. Results

The study entitled "Effect of Crop Regulation and Bagging Materials on Growth, Flowering and Quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda" was conducted in the Punjab sub-tropical region during 2021-2022. This research was carried out at Guava orchard of Lovely Professional University. Data pertaining to various parameters were collected and subsequently analyzed using statistical methods. The findings of this study are organized and presented under relevant sections.

Experiment 1

4.1.1 Shoot length (cm)

The intensity of pruning shows a significant and positive relationship with the shoot length of guava. The data mentioned in Table 1 and Figure 1(a) indicates the highest shoot length was documented in plants that undergo 20 cm pruning (A3 – 11.27 and 11.42 cm), followed by those with 10 cm pruning (A2 - 10.64 cm and 10.74 cm), while the minimum length of shoot was observed in non-pruned guava plants (A_1 - 9.19 cm and 9.28 cm) in the year 2021 and 2022. Moreover, the pooled data obtained was found to be 11.34 cm (A_3), 10.69 cm (A_2) and 9.24 cm (A_1) which was significant with each other.

The influence of pruning illustrates the impact on shoot length of guava as in case of 11 years old plants the maximum shoot length was (B_2 – 10.51 cm and 10.63 cm as compared to 9 year old plants (B_1 – 10.22 cm and 10.33 cm) in year 2021 and 2022. However, pooled data show a significant difference of 10.57 cm (B_2) and 10.28 cm (B_1) recorded which shows positive and significant impact of age on shoot length of guava.

Furthermore, when considering the interaction between pruning and plant age, the maximum shoot length was noted in the A_3B_2 (11.48 cm, 11.63 and 11.55 cm) and minimum shoot length was recorded in A_1B_1 (9.10 cm, 9.17 cm and 9.13 cm). However, interaction effect of pruning and plant age (A x B) was found to be non-significant in the years 2021 and 2022, as well as in the pooled data analysis as presented in Table 1 which confirms that the cumulative impact of pruning and age on shoot length is not significantly higher than the individual effect of both factors.

Shoot pruning and age both have a significant impact, resulting in the maximum length of new shoots in guava. The observation recorded on shoot length confirms a significant effect of the extent of pruning and age of guava trees. The positive impact of pruning over shoot length could be associated with greater diversion of stored nutrients towards the vegetative buds resulting in timely initiation of buds and an increase in the photosynthesis objectives. This is also associated with the mobilization of photosynthesis from the apical portion to the axillary part resulting in the forced growth of buds (Kumar *et al.* 2017). Previous studies, such as Nautiyal *et al.* (2016), have shown that severe pruning, involving the complete elimination of non fruiting shoots, significantly reduced yield. Similar studies were performed by researchers and they found that pruning promotes plant growth like length of shoot, canopy spread, collar girth, plant height, fruits per tree, fruit set percentage as well as production. The intensity of pruning influenced the growth of new shoots differently. New shoots were considerably longer in all pruning treatments compared to no pruning. The longest total new shoot length was noted in severely pruned plants, with moderately pruned plants following, and lightly pruned plants showing the least growth (Bhagawati *et al.* 2015).

4.1.2 Initiation of flowering (Days)

The commencement of the flowering process was notably impacted by two primary variables: the intensity of pruning and the age of the guava trees, as illustrated in Table 1 and Figure 1(b). The pruning intensity displayed a positive correlation with the initiation of flowering in guava. The data reveals that minimum days was taken for initiation of flowering was recorded in plants pruned 20 cm (A3 – 66.20 and 64.90 days), followed with 10 cm pruning (A2 – 68.00 and 67.70 days). In contrast, the maximum days was taken for initiation of flowering occurred in non-pruned plants (A1 – 70.90 and 70.45) in both the years 2021 and 2022. It becomes evident that the initiation of flowering was 65.55 (A3), 67.85 (A2), and 70.45 (A1), and these values were statistically significant with each other.

The influence of pruning indicates its impact on the initiation of flowering in guava. In both 11-year-old plants (68.47 and 68.13 days) and 9-year-old plants (67.67 and 67.53 days), there was no significant impact of age on the initiation of flowering in 2021 and 2022. However, in pooled analysis, it was observed that 11-year-old plants took more time for the initiation of flowers (68.30 days) compared to 9-year-old plants (67.60 days), which underscores the positive and significant influence of the age of the plants on the initiation of flowering in guava.

Additionally, when examining the interaction between pruning and plant age, the shortest duration for flowering initiation was observed in the A_3B_1 (65.80, 64.20, and 65.00

days), while the maximum days taken for the initiation of flowering was recorded in A_1B_2 (70.40, 71.20, and 70.80 days) in both years and the mean examination, respectively. Nevertheless, the interaction between pruning and age (A X B) did not yield significant results, indicating that the combined effect of pruning and age on the initiation of flowering is not significantly greater than the individual effects of each factor.

The severity of pruning has strong influence over the shifting of vegetative primordia into reproductive primordia resulting early initiation of flowers in guava plants after pruning, further, the initiation of flowers at 20 cm of pruning was earlier in comparison to pruning up to 10 cm and control (Widyastuti *et al.*, 2019). Pruning generally enhances flower production in guava trees by stimulating potentially fruit-bearing shoots, thereby increasing the number of flowers per shoot. Moreover, pruning exerts a beneficial influence on the overall well-being and vigor of the tree, optimizing the energy reserves available for the flowering process. When determining the appropriate pruning regimen, it is crucial to take into account the specific requirements and growth patterns of guava trees (Supanjani, 2019). Notably, pruning has been observed to accelerate flower initiation by approximately 10 days when compared to unpruned trees (Hiremath *et al.*, 2017).

Table 1 – Effect of Pruning and Plant Age on Shoot Length and Initiation of flowering in Guava cv. Allahabad Safeda

Factors	Shoot length(cm)			Initiation of flowering (Days)		
	2021	2022	Pooled value	2021	2022	Pooled value
Factor (A)						
A_1	9.19[c]	9.28[c]	9.24[c]	70.00[a]	70.90[a]	70.45[a]
A_2	10.64[b]	10.74[b]	10.69[b]	68.00[b]	67.70[b]	67.85[b]
A_3	11.27[a]	11.42[a]	11.34[a]	66.20[c]	64.90[c]	65.55[c]
Standard Error	0.074	0.065	0.03	0.37	0.39	0.26
Critical Difference	0.13	0.13	0.10	1.10	1.16	0.76
Factor (B)						
B_1	10.22[b]	10.33[b]	10.28[b]	67.67	67.53	67.60[b]
B_2	10.51[a]	10.63[a]	10.57[a]	68.47	68.13	68.30[a]
Standard Error	0.06	0.053	0.03	0.30	0.32	0.21
Critical Difference	0.10	0.11	0.08	NS	NS	0.62
Factor (A X B)						
A_1B_1	9.10	9.17	9.13	69.60	70.60	70.10
A_1B_2	9.29	9.39	9.34	70.40	71.20	70.80
A_2B_1	10.50	10.63	10.56	67.60	67.80	67.70
A_2B_2	10.77	10.86	10.81	68.40	67.60	68.00
A_3B_1	11.07	11.20	11.13	65.80	64.20	65.00
A_3B_2	11.48	11.63	11.55	66.60	65.60	66.10
Standard Error	0.104	0.092	0.05	0.52	0.55	0.36
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - no pruning, A2 - 10 cm pruning, A3 - 20 cm pruning). B represents the age of guava trees (B1 - 9 years old plants, B2 - 11 years old plants). Year-1 (2021), Year-2 (2022).

4.1.3 Flower bud emergence to anthesis (Days)

The intensity of pruning demonstrated a notable positive correlation with the duration from the emergence of flower buds to anthesis in guava. According to Table 1 and Figure 1(c), it was noted that the shortest period from the emergence of flower buds emergence to anthesis occurred in plants that underwent pruning at 20 cm (A3 – 34.80 and 35.50 days), followed by those with 10 cm pruning (A2 – 36.90 and 37.30 days). In contrast, the longest duration for flower bud emergence to anthesis was noted in non-pruned plants (A1 – 38.40 and 38.60 days) in the years 2021 and 2022, respectively. When considering the pooled analysis for both years, it is clear that the period from the appearance of the flower bud to full bloom was 35.00 (A3), 37.10 (A2), and 38.50 (A1), and these values exhibited statistical significance among each other.

The influence of pruning demonstrates the impact on flower bud emergence to anthesis of guava. 9-year-old plants exhibited the shortest duration for flower bud emergence to anthesis (B1 – 36.53 and 37.00 days) in comparison to 11-year-old counterparts (B2 – 36.87 and 37.07 days) during the years 2021 and 2022, respectively. Furthermore, in the pooled analysis for both years, the flower bud emergence to anthesis was recorded 36.77 (B_1) and 36.97 days (B_2), which shows a non-significant impact of the age of the plants on the flower bud emergence to anthesis in guava.

Moreover, when examining the interaction effect of pruning with the age of the plant, the minimum days was taken for emergence of flower bud to anthesis was recorded in A_3B_1 (34.40, 35.00 and 34.70 days), while the maximum number of days for flower bud emergence to anthesis was documented in A_1B_1 (38.40, 38.80 and 38.60 days) in year 2021, 2022 and pooled analysis. It was worth noting that interaction of pruning and age of plants did not demonstrate effectiveness in flower bud emergence to anthesis of flower of guava trees. However, the interaction between pruning and plant age (A X B) did not yield statistically significant results, indicating that the combined effect of pruning and age on flower bud emergence to anthesis is not significantly greater than the individual effects of each factor.

Pruning promotes the development of fresh shoots and triggers flower formation in guava trees. However, there was no significant effect of age of trees or interaction between age and pruning level on duration between bud emergence to anthesis. Pruning fosters the development of fresh vegetative shoots, thereby increasing the abundance of flower buds on guava trees. Consequently, this expedites the appearance of flower buds and the onset of anthesis. Nevertheless, the impact of pruning on flower bud emergence to anthesis varies across different levels of pruning intensity (Dhaliwal *et al.*, 1998). This amplified effect can be attributed to the greater accumulation of stored photosynthates and the earlier activation of vegetative buds in older plants as a result of pruning.

4.1.4 Number of flowers per shoot

The total flower appears per shoot were significantly increased with the level of pruning (Table 2; Figure. 1(c)). The maximum flowers (5.60 and 5.70) was noted in plants that underwent pruning at 20 cm (A3) during year 2021 and 2022 respectively which was followed by 10 cm pruning (5.00 and 5.15), whereas, minimum flowers was recorded in plants subjected to no-pruning (4.13 and 4.15) during the year 2021 and 2022 respectively. However, examining the pooled data for both years, it becomes apparent that the number of flowers was 5.65 (A3), 5.05 (A2), and 4.14 (A1), and these values exhibited statistical significance with each other.

The influence of pruning was evident in its impact on the flowers per shoot of guava. 11-year-old plants displayed the highest flowers (B2 – 5.02 and 5.12) as compared to 9-year-old plants (B1 – 4.80 and 4.88) in the years 2021 and 2022. Furthermore, in the pooled analysis for both years, the number of flowers recorded 5.07 (B2) followed by 4.84 (B1), highlighting that the age of the plants did not effects the number of flowers in guava.

Additionally, when considering the interaction effect of pruning with the age of the plant, the highest number of flowers was recorded in A_3B_2 (5.75, 5.85 and 5.80), while the lowest number of flowers was documented in A_1B_1 (4.05, 4.05 and 4.05) in year 2021, 2022 and pooled analysis. However, the interaction between pruning and plant age did not (A × B) yield statistically significant results, indicating that the combined effect of pruning intensity and age of plants on no. of flowers is not significantly greater than the individual effects of each factor.

Pruning, a critical horticultural practice, significantly influences the number of flowers per shoot in plants, primarily due to its impact on resource distribution and hormonal balance. When pruning removes parts of a plant, resources such as nutrients and water, which were initially shared among all shoots and leaves, are now concentrated in fewer branches. This leads to more resources being available for the development of the remaining shoots, potentially increasing the number of flowers. Positive impact of pruning intensity on the vegetative growth and flowering of trees increases the rate of stomatal conduction as compared to those that were not pruned (Tripathi *et al.,* 2019). Additionally, pruning affects the plant's hormonal dynamics, particularly the balance between auxins and cytokinins. Auxins, produced in the tips of shoots, generally inhibit the growth of lateral buds (apical dominance). Pruning reduces the auxin concentration in the plant, relieving this inhibition and allowing lateral buds to grow and potentially form more flowers. Moreover, pruning enhances light penetration and air circulation within the plant's canopy. Improved light exposure can stimulate the growth of flowers, and better air flow helps prevent diseases that could otherwise impede flowering. It was observed that the pruning can speed up the initiation of flowers by 10 days as compared to trees that are not pruned (Hiremath *et al.,* 2017).

Table 2 – Effect of Pruning and Plant Age on Flower bud emergence to anthesis and Number of flowers per shoot in Guava cv. Allahabad Safeda

Factors	Flower bud emergence to anthesis (Days)			Number of flowers per shoot		
	2021	2022	Pooled value	2021	2022	Pooled value
Factor (A)						
A_1	38.40^a	38.60^a	38.50^a	4.13^c	4.15^c	4.14^c
A_2	36.90^b	37.30^b	37.10^b	5.00^b	5.15^b	5.08^b
A_3	34.80^c	35.20^c	35.00^c	5.60^a	5.70^a	5.65^a
Standard Error	0.28	0.39	0.23	0.07	0.07	0.05
Critical Difference	0.83	1.16	0.69	0.21	0.20	0.15
Factor (B)						
B_1	36.53	37.00	36.77	4.80	4.88	4.84
B_2	36.87	37.07	36.97	5.02	5.12	5.07
Standard Error	0.23	0.32	0.19	0.06	0.05	0.04
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor (A X B)						
A_1B_1	38.40	38.80	38.60	4.05	4.05	4.05
A_1B_2	38.40	38.40	38.40	4.20	4.25	4.23
A_2B_1	36.80	37.20	37.00	4.90	5.05	4.98
A_2B_2	37.00	37.40	37.20	5.10	5.25	5.18
A_3B_1	34.40	35.00	34.70	5.45	5.55	5.50
A_3B_2	35.20	35.40	35.30	5.75	5.85	5.80
Standard Error	0.40	0.55	0.33	0.10	0.09	0.07
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - no pruning, A2 - 10 cm pruning, A3 - 20 cm pruning). B represents the age of guava trees (B1 - 9 years old plants, B2 - 11 years old plants). Year-1 (2021), Year-2 (2022).

4.1.5 Fruit set (%)

The onset of the flowering process was noteworthy impacted by two key factors: the intensity of pruning and age of the guava trees, as depicted in Table 3; Figure 1(e). Pruning intensity exhibited a substantial and positive association with the percentage of fruit set percentage in guava. The data reveals that maximum fruit set % was recorded in plants subjected to a 20 cm pruning (A3 – 82.11 and 82.43), closely followed by those with 10 cm pruning (A2 – 73.97% and 74.73%). Conversely, the minimum fruit set was recorded in non-pruned plants (A1 – 67.80 and 68.08) in both the years 2021 and 2022. The analysis of combined data for year 2021 and 2022 demonstrates that the fruit set was 82.27 (A3), 74.35 (A2), and 67.94 (A1), with statistically significant differences among each other in both years and combined analysis.

The influence of pruning was shows relatively significant impact on flower set of guava. 11-year-old plants (75.70% and 76.16%) and 9-year-old plants (73.56% and 74.00%) showed positive and significant age-related impact on fruit set in the years 2021 and 2022. However, the pooled analysis revealed that 11-year-old plants shows maximum fruit set % (75.93%) compared to 9-year-old plants (73.78%), underscoring the positive and significant influence of the age of the plants on fruit set % in guava.

Furthermore, when examining the interaction effect of pruning with the age of the plant, the highest fruit set percentage was recorded in A_3B_1 (82.60, 82.90 and 82.75 %), while the minimum fruit set % was recorded in A_1B_2 (66.56, 66.72 and 66.64%) in the years 2021, 2022, and the pooled analysis, respectively. However, the interaction effect of pruning and the age of the plants (A × B) found non-significant in during 2021, 2022 and in the pooled analysis.

Careful pruning, which involves the selective removal of branches and leaves, effectively opens up the tree canopy. This allows an increased influx of solar radiation and nutrients to reach the fruiting branches, resulting in a greater percentage of fruit set. However, excessive or severe pruning beyond the recommendation was reported to be harmful and might be accountable to lower fruit set percentage (Aswathy and Arumugam, 2017; Kumar, 2020). Several studies have reported that pruning guava trees leads to a higher number of flowering shoots and an increased fruit set percentage compared to unpruned trees. This effect may be attributed to accelerated growth, improved sunlight availability for photosynthesis, and alterations in the actions of growth regulators like IAA, which contribute to enhanced fruit set percentage in guava fruit (Prakash *et al.,* 2012; Singh *et al.,* 2020). The effect of pruning was more visualized in older trees in comparison to younger once. This distinction can be attributed to the higher accumulation of stored photosynthesis and the earlier activation of vegetative buds in older plants resulting from the pruning process.

4.1.6 Yield (kg/plant)

The pruning intensity had a significant and positive impact on the yield of guava. As presented in Table 3 and Figure 1(f), the numbers indicates that highest fruit yield was observed in plants subjected to a 20 cm pruning (A3 – 28.14 and 28.99 kg), closely followed by those with 10 cm pruning (A2 – 26.14 and 27.06 kg). In contrast, the minimum fruit yield was recorded in non-pruned plants (A1 – 23.53 and 23.79 kg) in the years 2021 and 2022. When considering the pooled analysis for both years, it is evident that the fruit yield was 28.57 kg (A3), 26.60 kg (A2), and 23.66 kg (A1), which was a statistically significant difference among each other.

The influence of pruning was shows relatively significant impact on yield of guava. 11-year-old plants achieved a maximum fruit yield (B_2 – 26.31 and 27.15 kg) compared to 9-year-old plants (B_1 – 25.56 and 26.08 kg) in the years 2021 and 2022. Furthermore, in the pooled analysis for both years, the fruit yield was recorded as 26.73 kg (B_2) and 25.82 kg (B_1), indicating a significant and positive influence of the age of plants on fruit yield in guava.

Moreover, when assessing the interaction effect of pruning with the age of the plant, the highest yield of fruit was recorded in A_3B_2 (28.66 kg, 29.75 kg and 29.20 kg), while the minimum fruit yield was documented in A_1B_1 (23.24 kg, 23.14 kg and 23.19 kg) in the year 2021, 2022, and combined examination of data respectively. Notably, the interaction of pruning and the age of the plants did not significantly affect the fruit yield of guava trees. In years 2021, 2022 and combined examination, the interaction (A X B) was determined to be non-significant with each other.

The enhanced response in older plants may be due to increased photosynthetic activity and earlier activation of vegetative buds following pruning. Interestingly, the interaction between pruning intensity and plant age did not show statistical significance. This suggests that while both factors independently contribute to guava yield, their combined effect does not significantly surpass the influence of each factor on its own. These findings highlight the importance of considering both pruning practices and tree age in guava cultivation strategies to maximize yield. They also offer valuable insights for future research and practical applications in the field of horticulture, particularly in optimizing yield for different ages of guava trees. Increased pruning severity led to a higher fruit weight, primarily due to the greater number and increased surface area of active leaves, resulting in enhanced photosynthate production. Consequently, this substantial increase in size and weight attributed to the increased availability of nutrients (Bhuva *et al.,* 2018; Shinde *et al.,* 2020).

Table 3 – Effect of Pruning and Plant Age on Fruit set (%) and yield (kg/plant) in Guava cv. Allahabad Safeda

Factor	Fruit set (%)			Yield (kg/plant)		
	2021	2022	Pooled value	2021	2022	Pooled value
Factor (A)						
A_1	67.80^{c}	68.08^{c}	67.94^{c}	23.53^{c}	23.79^{c}	23.66^{c}
A_2	73.97^{b}	74.73^{b}	74.35^{b}	26.14^{b}	27.06^{b}	26.60^{b}
A_3	82.11^{a}	82.43^{a}	82.27^{a}	28.14^{a}	28.99^{a}	28.57^{a}
Standard Error	0.82	0.47	0.50	0.20	0.25	0.16
Critical Difference	2.43	1.39	1.47	0.59	0.73	0.57
Factor (B)						
B_1	73.56^{b}	74.00^{b}	73.78^{b}	25.56^{b}	26.08^{b}	25.82^{b}
B_2	75.70^{a}	76.16^{a}	75.93^{a}	26.31^{a}	27.15^{a}	26.73^{a}
Standard Error	0.67	0.38	0.40	0.16	0.20	0.16
Critical Difference	1.98	1.14	1.20	0.48	0.60	0.46
Factor (A X B)						
A_1B_1	66.56	66.72	66.64	23.24	23.14	23.19
A_1B_2	69.05	69.44	69.24	23.82	24.44	24.13
A_2B_1	72.49	73.31	72.90	25.82	26.85	26.34
A_2B_2	75.45	76.15	75.80	26.46	27.26	26.86
A_3B_1	81.63	81.96	81.80	27.61	28.24	27.93
A_3B_2	82.60	82.90	82.75	28.66	29.75	29.20
Standard Error	1.16	0.66	0.67	0.28	0.35	0.27
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - no pruning, A2 - 10 cm pruning, A3 - 20 cm pruning). B represents the age of guava trees (B1 - 9 years old plants, B2 - 11 years old plants). Year-1 (2021), Year-2 (2022).

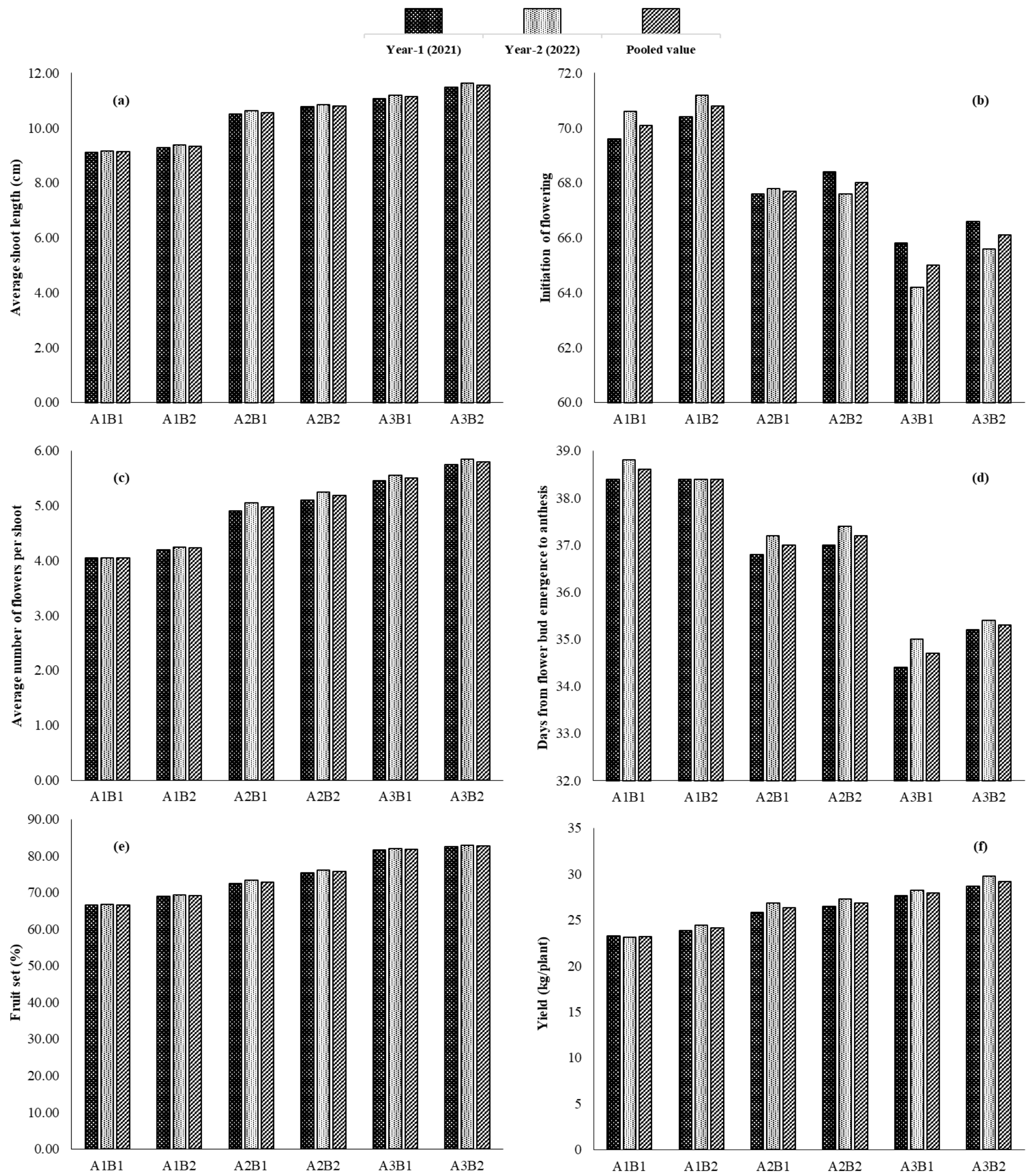

Figure 1 Shoot length, initiation of flowering, flower bud emergence to anthesis, number of flowers per shoot, fruit set %, and yield characteristics of guava trees after pruning, demonstrating the interactive effects of pruning and tree age. (*A1 - no pruning, A2 - 10 cm pruning, A3 - 20 cm pruning and B1 - 9 years old plants, B2 - 11 years old plants*).

Physico-chemical attributes of guava fruits harvested from pruned trees

4.1.7 Fruit weight (g)

The intensity of pruning demonstrated a positive and significant association with the fruit weight of guava. Presented data in Table 4; Fig. 2(a) indicating that the peak fruit weight was observed in plants underwent to 20 cm pruning (A3 – 126.63 and 127.85 g), closely followed by those subjected to 10 cm pruning (A2 – 121.93 and 122.85 g). In contrast, the lowest fruit weight was observed in non-pruned plants (A1 – 114.24 and 144.30 g) in the years 2021 and 2022. Furthermore, the combined data for both years showed fruit weights of 127.24 g (A3), 122.39 g (A2), and 114.27 g (A1), and these values were significant with each other.

The influence of pruning was shows relatively significant impact on fruit weight of guava. 11-year-old plants exhibited the highest fruit weight (B_2 – 122.40 and 122.93 g) compared to 9-year-old plants (B_1 – 119.47 and 120.40 g) in the years 2021 and 2022 respecyively. The combined data also revealed a significant difference in fruit weight, with 122.67 g (B_2) and 119.94 g (B_1), highlighting the positive and significant impact of plant age on guava fruit weight.

Furthermore, when considering the interaction effect between the pruning intensity and plant age, the highest fruit weight was observed in A_3B_2 (127.88 g, 129.21 g and 128.55 g), while the lowest fruit weight was observed in A_1B_1 (113.01 g, 113.63 g and 113.32 g). However, the interaction effect of pruning intensity and age of plant (A × B) were not statistically significant over the two years and in the aggregated data, as shown in Table 4.

Consistently, the highest weight was observed in plants underwent to more extensive pruning (20 cm). This outcome can be attributed to the reallocation of resources, reduced competition, balanced growth, and improved light penetration, all of which contribute to higher fruit yield by directing resources toward fruit production, thus facilitating optimal development and efficient photosynthesis. Previous studies have also reported similar findings of larger fruit sizes in pruned plants as compared to unpruned (Sah *et al.,* 2017; Thakre *et al.,* 2016; Kumar *et al.,* 2021; Choudhary *et al.,* 2022; Lakpathi and Rajkumar, 2018).

4.1.8 Total Soluble Solid (^{0}Brix)

The intensity of pruning displayed a significant and positive relationship with the TSS content of guava. The information in Table 4 and Figure 2(b) shows that the highest TSS content was recorded in plants underwent to 20 cm pruning intensuity (A3 – 9.96 and 10.13 °Brix), closely followed by those subjected to 10 cm pruning (A2 – 9.62 and 9.82 °Brix). In contrast, the lowest TSS content was found in non-pruned plants (A1 – 9.40 and 9.41 °Brix) in the years 2021 and 2022 respectively. Furthermore, the combined data for both years showed TSS levels of 10.05 °Brix (A3), 9.72 °Brix (A2), and 9.41 °Brix (A1), and these values were found to be statistically significantly different from each other.

The influence of pruning was shows relatively significant impact on TSS of guava. 11-year-old plants exhibited the highest TSS content (B2 – 9.68 and 9.82 °Brix) compared to 9-year-old plants (B1 – 9.64 and 9.76 °Brix) in the years 2021 and 2022, respectively. The combined data also revealed a significant difference in TSS content, with 9.75 °Brix (B2) and 9.70 °Brix (B1), highlighting the positive and significant impact of plant age on guava TSS content.

Furthermore, when considering the interaction between pruning intensity and plant age, the highest TSS content was recorded in A_3B_2 (9.98 °Brix, 10.17 °Brix, and 10.08 °Brix), while the minimum TSS content was recorded in A_1B_1 (9.38 °Brix, 9.39 °Brix, and 9.39 °Brix). However, the interaction impact of pruning intensity and plant age (A × B) was observed to be insignificant in both years and in the combined data, as described in Table 4.

The improvement in TSS (Total Soluble Solids) content in guava after pruning attributed to enhanced photosynthesis and nutrient uptake which is accountable to increased accumulation of sugars, resulting in higher TSS levels. Moreover, the pruned plants exhibited a relatively greater ratio of leaves to fruit in comparison to the unpruned plants which played a role in elevating the concentration of Total Soluble Solids (TSS) due to an enhanced synthesis of metabolites (Singh *et al.,* 2020; Aswathy and Arumugam, 2017; Singh *et al.,* 2023).

Table 4 – Effect of Pruning and Plant Age on Fruit weight (g) and TSS (^{0}Brix) of Guava cv. Allahabad Safeda

Factor	Fruit weight (g)			TSS (^{0}Brix)		
	2021	2022	Pooled value	2021	2022	Pooled value
Factor (A)						
A_1	114.24^c	114.30^c	114.27^c	9.40^c	9.41^c	9.41^c
A_2	121.93^b	122.85^b	122.39^b	9.62^b	9.82^b	9.72^b
A_3	126.63^a	127.85^a	127.24^a	9.96^a	10.13^a	10.05^a
Standard Error	0.60	0.59	0.54	0.014	0.019	0.012
Critical Difference	1.78	1.76	1.62	0.04	0.05	0.03
Factor (B)						
B_1	119.47^b	120.40^b	119.94^b	9.64^b	9.76^b	9.70^b
B_2	122.40^a	122.93^a	122.67^a	9.68^a	9.82^a	9.75^a
Standard Error	0.49	0.48	0.45	0.012	0.016	0.010
Critical Difference	1.46	1.43	1.32	0.04	0.04	0.03
Factor (A X B)						
A_1B_1	113.01	113.63	113.32	9.38	9.39	9.39
A_1B_2	115.47	114.97	115.22	9.41	9.43	9.43
A_2B_1	120.02	121.09	120.55	9.60	9.79	9.69
A_2B_2	123.83	124.62	124.23	9.65	9.85	9.75
A_3B_1	125.37	126.49	125.93	9.94	10.09	10.02
A_3B_2	127.88	129.21	128.55	9.98	10.17	10.08
Standard Error	0.85	0.84	0.77	0.020	0.027	0.017
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b, c) in the columns show significant differences (Tukey's test, $p \leq 0.05$) and demonstrate the treatment effects during the same time period. A represents pruning levels (A1 - no pruning, A2 - 10 cm pruning, A3 - 20 cm pruning). B represents the age of guava trees (B1 - 9 years old plants, B2 - 11 years old plants). Year-1 (2021), Year-2 (2022).

4.1.9 Acidity (%)

The pruning intensity demonstrated a significant and positive correlation with the Titratable Acidity (TA) content in guava. Data presented in Table 5 and Figure 2(c) indicate that the lowest acidity content was recorded in plants underwent to 20 cm pruning (A3 – 0.32 and 0.32 %), closely followed by those subjected to 10 cm pruning (A2 – 0.36 and 0.35%). In contrast, the highest acidity content was found in non-pruned plants (A1 – 0.39 and 0.39%) in the years 2021 and 2022. Furthermore, the combined data for both years showed acidity levels of 0.32% (A3), 0.36% (A2), and 0.39% (A1), and these values were statistically significant with each other.

The influence of pruning was shows relatively significant impact on acidity of guava. 11-year-old plants exhibited the lowest TA content (B2 – 0.35%) compared to 9-year-old plants (B1 – 0.36%) in the years 2021 and 2022. The age of plants were found non effective in year 2021, 2022 and combined data examination. Therefore in both years and pooled data, the A X B order interaction was found non-significant which highlighting that there was non-significant impact of plant age on guava TA content.

Furthermore, when considering the interaction between the pruning intensity and plant age, the lowest TA content was recorded in A_3B_2 (0.32), while the highest TA content was recorded in A_1B_1 (0.39%). However, the interaction between pruning intensity and plant age (A × B) was found to be insignificant in both years and in the combined data examination, as mentioned in Table 5 which highlighting that there was non-significant impact of plant age on guava TA content.

The decrease in titratable acidity with increased pruning intensity could be attributed to the greater accumulation of acid in the newly developed leaves during fruit development. This reduction in acidity, coupled with improvements in sunlight penetration, increased leaf area, and higher chlorophyll content due to pruning, significantly enhances fruit quality. Moreover, maintaining a balanced fruit load on guava trees is also pivotal for quality improvement, as suggested by previous studies (Kumar *et al*., 2022; Bhagawati *et al.,* 2015; Nasreen and Singh, 2022). In conclusion, the study underscores the significance of pruning as a vital practice for optimizing guava fruit quality, particularly in managing acidity levels. The findings provide valuable insights for horticulturists and farmers in implementing effective pruning strategies to enhance the overall quality and marketability of guava fruits.

4.1.10 TSS: Acid

The pruning intensity demonstrated a significant and positive correlation with the TSS: Acid content in guava. The data in Table 5 and Figure 2(d) indicate that highest TSS: Acid was recorded in plants underweent to 20 cm pruning (A3 – 31.70 and 32.25), closely followed by those subjected to 10 cm pruning (A2 – 27.36 and 27.93). In contrast, the minimum TSS:Acid was observed in unpruned plants (A1 – 24.32 and 24.36) in the years 2021 and 2022 respectively. Furthermore, the combined data for both years showed TSS: Acid of 31.98 (A3), 27.64 (A2), and 24.34 (A1), and these values were statistically significant with each other.

The influence of pruning was shows relatively significant impact on TSS:Acid of guava. 11-year-old plants exhibited the highest TSS: Acid (B_2 – 28.12 and 28.53) compared to 9-year-old plants (B_1 – 27.47 and 27.83) in the years 2021 and 2022, respectively. The combined data also revealed a significant difference in TSS: Acid ratio, with 28.53 (B_2) and 27.65 (B_1), highlighting the positive and significant impact of plant age on guava TSS: Acid ratio.

Furthermore, when considering the interaction between the intensity pruning and plant age, the maximum TSS:Acid was recorded in A_3B_2 (31.71, 32.29 and 31.99), while the minimum TSS: Acid was recorded in A_1B_1 (23.98, 24.00 and 23.99) in year 2021, 2022 and pooled data. However, the interaction influence of intensity of pruning and plant of age (A × B) was recorded to be insignificant in both years and in the combined data examination, as outlined in the Table 5.

The lower TSS: acid ratio in unpruned plants can be attributed to factors such as slower starch-to-sugar conversion, competition for nutrients, and limited light exposure. Pruning positively influences total sugars, likely due to better nutrient allocation to vegetative buds, promoting their timely initiation and enhancing photosynthetic efficiency. This process is further supported by the redistribution of photosynthates from the upper part of the tree to lateral branches, fostering bud growth (Mali *et al.*, 2016; Paikra and Sahu, 2021). In conclusion, pruning stands out as a pivotal agricultural practice for improving guava fruit quality, as evidenced by its significant impact on the TSS: acid ratio. This finding provides valuable insights for horticulturists aiming to enhance fruit quality through targeted pruning strategies.

Table 5 – Effect of Pruning and Plant Age on acidity and TSS: acid ratio of Guava cv. Allahabad Safeda

Factor	Acidity (%)			TSS: acid ratio		
	2021	2022	Pooled value	2021	2022	Pooled value
Factor (A)						
A_1	0.39[a]	0.39[a]	0.39[a]	24.32[c]	24.36[c]	24.34[c]
A_2	0.36[b]	0.35[b]	0.36[b]	27.36[b]	27.93[b]	27.64[b]
A_3	0.32[c]	0.32[c]	0.32[c]	31.70[a]	32.25[a]	31.98[a]
Standard Error	0.004	0.008	0.004	0.32	0.59	0.36
Critical Difference	0.01	0.02	0.01	1.87	1.94	1.91
Factor (B)						
B_1	0.36	0.36	0.36	27.47	27.83	27.65
B_2	0.35	0.35	0.35	28.12	28.53	28.32
Standard Error	0.003	0.006	0.004	0.26	0.48	0.29
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor (A X B)						
A_1B_1	0.39	0.39	0.39	23.98	24.00	23.99
A_1B_2	0.38	0.38	0.38	24.66	24.72	24.69
A_2B_1	0.36	0.36	0.36	26.73	27.28	27.01
A_2B_2	0.36	0.34	0.35	27.99	28.57	28.28
A_3B_1	0.33	0.32	0.32	31.71	32.21	31.96
A_3B_2	0.32	0.32	0.32	31.70	32.29	31.99
Standard Error	0.005	0.011	0.006	0.46	0.83	0.50
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - no pruning, A2 - 10 cm pruning, A3 - 20 cm pruning). B represents the age of guava trees (B1 - 9 years old plants, B2 - 11 years old plants). Year-1 (2021), Year-2 (2022).

4.1.11 Total Sugars (%)

The pruning intensity indicated a positive and significant association with the total sugar % in guava. Data in Table 6 and Figure 2(e) indicate that the highest sugars was recorded in plants subjected to 20 cm pruning (A3 – 6.54 and 6.57%), closely followed by those subjected to 10 cm pruning (A2 – 6.45 and 6.50%). In contrast, the lowest total sugars content was found in non-pruned plants (A1 – 6.30 and 6.31%) in the years 2021 and 2022. Furthermore, the combined data for both years showed total sugar levels of 6.56 (A3), 6.47 (A2), and 6.30 (A1), and these values showed significant differences from one another.

The influence of pruning was shows relatively significant impact on total sugar of guava. 11-year-old plants exhibited the highest total sugar content (B2 – 6.45 and 6.48%) compared to 9-year-old plants (B1 – 6.41 and 6.44%) in the years 2021 and 2022, respectively. The combined data also revealed a significant difference in total sugar content, with 6.47% (B2) and 6.43% (B1), highlighting the positive and significant impact of plant age on guava total sugar content.

Furthermore, when considering the interaction between pruning and plant age, the maximum sugar content was observed in A_3B_2 (6.56, 6.59 and 6.58%), while the lowest sugar content was observed in A_1B_1 (6.29, 6.28 and 6.28%). But the interaction effect of pruning and plant age (A × B) was determined to be insignificant across both years and in the aggregated data shown in Table 6.

The positive impact of pruning on total sugars attributed to the enhanced allocation of stored nutrients towards the vegetative buds. This allocation promotes their timely initiation and contributes to an increase in the objectives of photosynthesis. Additionally, this phenomenon is linked to the transfer of photosynthesis from the top section of the tree to the lateral branches, which stimulates bud growth. This, in turn, leads to a greater synthesis of carbohydrates and other metabolites, which are then transported to the fruit tissues. The observed phenomenon is likely due to the improved uptake of nutrients in pruned trees, leading to enhanced production of carbohydrates and metabolites, which are then transported to the fruits resulting in increased synthesis of carbohydrates and metabolites and their subsequent translocation to the fruits (Singh *et al.*, (2023). These findings align with previous studies conducted on various fruits such as custard apple and mango Dahapute *et al.* (2018) and Rani *et al.* (2019) respectively.

4.1.12 Reducing Sugars (%)

The intensity of pruning exhibited a significant and positive association with the content of reducing sugars in guava. Data depicted in Table 6 and Figure 2(f) reveals that the maximum concentration of reducing sugar was noted in plants pruned to 20 cm. (A_3 – 3.79 and 3.81%), closely followed by those subjected to 10 cm pruning (A_2 – 3.74 and 3.77%). Conversely, the minimum reducing sugar was noted in non-pruned plants (A_1 – 3.66 and 3.66%) in the years 2021 and 2022. Additionally, the combined data for both years showed reducing sugar levels of 3.80 (A_3), 3.75 (A_2), and 3.66 (A_1), and these values exhibited significant differences.

The influence of pruning was shows relatively significant impact on reducing sugar of guava. 11-year-old plants displayed the highest reducing sugar content (B2 – 3.74 and 3.76%) in comparison to 9-year-old plants (B1 – 3.72 and 3.74%) in the years 2021 and 2022, respectively. The combined data also demonstrated a significant distinction in reducing sugar content, with 3.75% (B2) and 3.73% (B1), underscoring the positive and substantial impact of plant age on guava reducing sugar content.

Furthermore, in assessing the interaction between pruning and plant age, the maximum reducing sugar content was observed in A_3B_2 (3.81, 3.82 and 3.81%), while the lowest reducing sugar was noted in A_1B_1 (3.65, 3.64 and 3.64%). Nevertheless, the interaction impact of pruning intensity and plant age (A × B) was determined to be insignificant across both years and in the aggregated data shown in Table 6.

The positive impact of pruning on reducing sugars attributed to the enhanced allocation of stored nutrients towards the vegetative buds. This allocation promotes their timely initiation and contributes to an increase in the objectives of photosynthesis. Additionally, this phenomenon is linked to the transfer of photosynthesis from the top section of the tree to the lateral branches, which stimulates bud growth. The higher levels of total sugars can be explained by an increased leaves to fruit ratio in the pruning intensity. This, in turn, leads to a greater synthesis of carbohydrates and other metabolites, which are then transported to the fruit tissues. The observed phenomenon is likely due to the improved uptake of nutrients in pruned trees, this led to a higher synthesis of carbohydrates and metabolites, which were subsequently moved to the fruits (Parsana *et al.*, (2023).

Table 6 – Effect of Pruning and Plant Age on Total Sugars % and Reducing Sugars % of Guava cv. Allahabad Safeda

Factor	Total Sugars (%)			Reducing Sugars (%)		
	2021	2022	Pooled value	2021	2022	Pooled value
Factor (A)						
A_1	6.30[c]	6.31[c]	6.30[c]	3.66[c]	3.66[c]	3.66[c]
A_2	6.45[b]	6.50[b]	6.47[b]	3.74[b]	3.77[b]	3.75[b]
A_3	6.54[a]	6.57[a]	6.56[a]	3.79[a]	3.81[a]	3.80[a]
Standard Error	0.053	0.058	0.042	0.031	0.034	0.025
Critical Difference	0.04	0.04	0.04	0.02	0.02	0.02
Factor (B)						
B_1	6.41[b]	6.44[b]	6.43[b]	3.72[b]	3.74[b]	3.73[b]
B_2	6.45[a]	6.48[a]	6.47[a]	3.74[a]	3.76[a]	3.75[a]
Standard Error	0.043	0.047	0.035	0.025	0.028	0.020
Critical Difference	0.03	0.03	0.03	0.02	0.02	0.02
Factor (A X B)						
A_1B_1	6.29	6.28	6.28	3.65	3.64	3.64
A_1B_2	6.32	6.34	6.33	3.67	3.67	3.67
A_2B_1	6.42	6.49	6.46	3.72	3.76	3.74
A_2B_2	6.47	6.51	6.49	3.75	3.77	3.76
A_3B_1	6.52	6.56	6.54	3.78	3.80	3.79
A_3B_2	6.56	6.59	6.58	3.81	3.82	3.81
Standard Error	0.075	0.082	0.060	0.043	0.048	0.035
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - no pruning, A2 - 10 cm pruning, A3 - 20 cm pruning). B represents the age of guava trees (B1 - 9 years old plants, B2 - 11 years old plants). Year-1 (2021), Year-2 (2022).

4.1.13 Non-reducing Sugars (%)

The data shown in the Table 7 and Figure 2(g) clearly indicate that pruning intensity significantly affects the non-reducing sugars of guava. The intensity of pruning played an important role in influencing the non-reducing sugar levels. The highest average maximum non-reducing sugar content (2.75 and 2.76%) was observed with a pruning intensity of 20 cm followed by followed by 10 cm pruning (A2 – 2.71 and 2.73%). Conversely, the minimum non reducing sugar was noted in non-pruned plants (A1 – 2.65 and 2.65%) in the years 2021 and 2022. Additionally, the combined data for both years showed non-reducing sugar levels of 2.75 (A3), 2.72 (A2), and 2.65 (A1), and these values exhibited significantly different with each other.

The influence of pruning was shows relatively significant impact on non-reducing sugar of guava. 11-year-old plants displayed the highest non-reducing sugar content (B2 – 2.71 and 2.72%) in comparison to 9-year-old plants (B1 – 2.69 and 2.70%) in the years 2021 and 2022, respectively. The combined data also demonstrated a significant distinction in non-reducing sugar content, with 2.72% (B2) and 2.70% (B1), underscoring the positive and substantial impact of plant age on guava non-reducing sugar content.

Furthermore, when assessing the interaction between pruning and plant age, the maximum non reducing sugar was recorded in A_3B_2 (2.76, 2.77 and 2.76%), while the minimun non reducing sugar was noted in A_1B_1 (2.64, 2.64 and 2.64%). Nevertheless, the interaction impact of pruning intensity and plant age (A × B) was determined to be insignificant during year 2021, 2022 and in the combined data examination, as outlined in Table 7.

This increase in non-reducing sugars with more intensive pruning is attributed to the enhanced photophosphorylation and dark reactions in photosynthesis, leading to greater carbohydrate production in the fruits. This process improves nutrient availability during fruit development, thus increasing non-reducing sugar levels. Furthermore, the study noted that the effect of pruning was more pronounced in older plants (11 years old) compared to younger ones (9 years old). This could be due to older plants having more stored photosynthates and earlier activation of vegetative buds, enhancing the benefits of pruning on sugar content. However, the interaction between pruning and age was not found to be significant, suggesting that their combined impact on non-reducing sugar content does not significantly exceed the influence of each factor individually (Shukla and Bisen, 2021). In conclusion, the study highlights pruning as a key factor influencing the non-reducing sugar content in guava fruits, with older trees showing a more marked response. These findings provide important insights for guava cultivation, particularly in optimizing fruit sugar content through targeted pruning practices.

4.1.14 Ascorbic Acid (mg/100 gm)

The intensity of pruning exhibited a significant and positive connection with the ascorbic acid content in guava, measured in milligrams (mg). The information in Table 7 and Figure 2(f) demonstrates that the maximum ascorbic acid was noted in plants pruned to 20 cm pruning (A_3 - 166.04 and 170.92 mg), followed by plants subjected to 10 cm pruning (A_3 - 160.40 and 165.19 mg). In contrast, the lowest ascorbic acid content was found in non-pruned plants (A1 – 150.58 mg and 150.84 mg) in the years 2021 and 2022. Additionally, the combined data for both years showed ascorbic acid levels of 168.48 mg (A3), 162.79 mg (A2), and 150.71 mg (A1), and these values exhibited significant differences with each other.

The influence of pruning was shows relatively significant impact on ascorbic acid of guava. 11-year-old plants displayed the highest ascorbic acid content (B_2 – 160.10 mg and 163.35 mg) compared to 9-year-old plants (B_1 – 157.92 mg and 161.28 mg) in the years 2021 and 2022, respectively. The combined data also demonstrated a significant variation in ascorbic acid content, with 161.73 mg (B_2) and 159.60 mg (B_1), emphasizing the positive and significant impact of plant age on guava ascorbic acid content.

Furthermore, when examining the interaction between pruning intensity and plant age, the highest ascorbic acid was observed in A_3B_2 (167.04 mg, 169.80 mg, and 169.54 mg), while the lowest ascorbic acid was noted in A_1B_1 (149.69 mg, 150.29 mg, and 149.99 mg). The combined influence of pruning and plant age (A X B) on the outcome showed no significant effects during the two-year period, as indicated in Table 7.

Pruning enhances fruit quality through mechanisms such as better sunlight penetration, which optimizes exposure for all parts of the tree. This improvement in light exposure boosts photosynthesis, leading to an increase in carbohydrate production. Additionally, maintaining a balanced fruit load and an optimal leaf-to-fruit ratio are crucial for enhancing sugar levels, tss, and vitamin C in guava fruits (Gupta and Gill, 2015; Sawant *et al.*, 2018). In conclusion, the study underscores pruning as a key agricultural practice for enhancing the ascorbic acid content in guava fruits, particularly in older trees. These findings offer valuable insights for horticultural strategies aimed at improving guava fruit quality.

Table 7 – Effect of Pruning and Plant Age on Non-reducing sugar and ascorbic acid of Guava cv. Allahabad Safeda

Factor	Non reducing Sugars (%)			Ascorbic Acid (mg/100 gm)		
	2021	2022	Pooled value	2021	2022	Pooled value
Factor (A)						
A1	2.65[c]	2.65[c]	2.65[c]	150.58[c]	150.84[c]	150.71[c]
A2	2.71[b]	2.73[b]	2.72[b]	160.40[b]	165.19[b]	162.79[b]
A3	2.75[a]	2.76[a]	2.75[a]	166.04[a]	170.92[a]	168.48[a]
Standard Error	0.023	0.024	0.018	0.64	0.054	0.058
Critical Difference	0.02	0.02	0.02	1.90	1.61	1.71
Factor (B)						
B1	2.69[b]	2.70[b]	2.70[b]	157.92[b]	161.28[b]	159.60[b]
B2	2.71[a]	2.72[a]	2.72[a]	160.10[a]	163.35[a]	161.73[a]
Standard Error	0.019	0.020	0.015	0.52	0.44	0.47
Critical Difference	0.01	0.02	0.01	1.55	1.32	1.39
Factor (A X B)						
A1B1	2.64	2.64	2.64	149.69	150.29	149.99
A1B2	2.65	2.66	2.66	151.47	151.39	151.43
A2B1	2.70	2.72	2.71	159.01	163.75	161.37
A2B2	2.72	2.73	2.72	161.79	166.63	164.21
A3B1	2.74	2.75	2.75	165.05	169.80	167.42
A3B2	2.76	2.77	2.76	167.04	172.04	169.54
Standard Error	0.032	0.034	0.025	0.90	0.77	0.81
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - no pruning, A2 - 10 cm pruning, A3 - 20 cm pruning). B represents the age of guava trees (B1 - 9 years old plants, B2 - 11 years old plants). Year-1 (2021), Year-2 (2022).

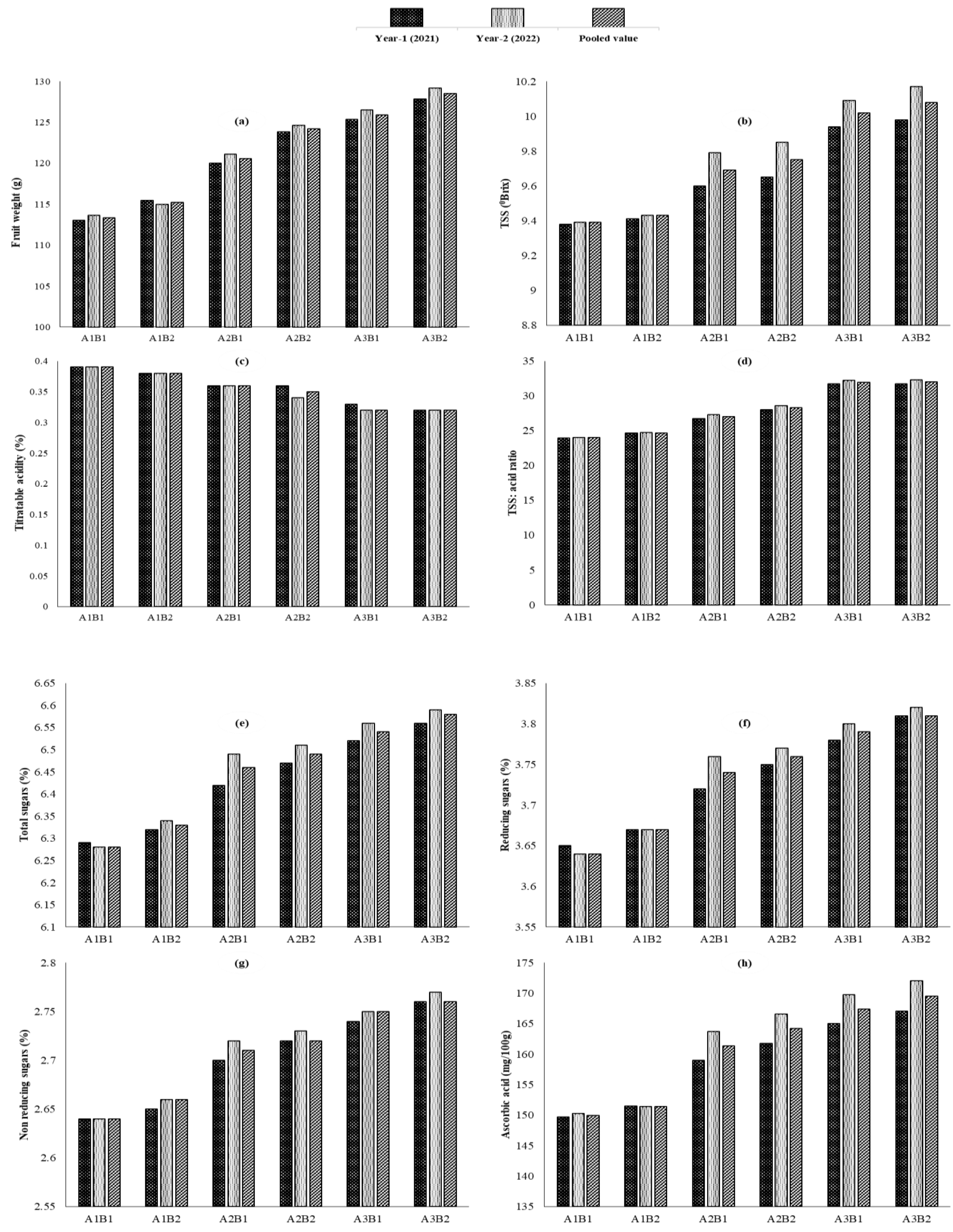

Figure 2 Physico-chemical characteristics of guava fruits after pruning, highlighting the interaction between pruning and tree age. ***(A1 - no pruning, A2 - 10 cm pruning, A3 - 20 cm pruning) represents different pruning levels, while (B1 - 9 years old plants, B2 - 11 years old plants).***

Experiment-2

4.2.1 Shoot length (cm)

The pruning intensity has a significant and positive correlation with the length of guava shoots. The information from Table 8 and Figure 3 clearly indicates that pruning intensity had a significant impact on the growth of new guava shoots, resulting in the maximum length measured in plants undergo 20 cm pruning (A2 – 11.69 cm, 11.78 cm and 11.74 cm), followed by those with 10 cm pruning (A1 – 10.77 cm, 10.83 cm and 10.80 cm) which was significant with each other in the year 2021, 2022 and combined data analysis respectively. It was possibly due to the presence of a higher level of stored photosynthates and early activation of vegetative buds in older plants following pruning.

However, plant growth regulators and bagging materials did not show a significant effect in year 2021 and 2022. First-order interactions (A×B, B×C, and C×A) along with the second-order interaction (A×B×C) were observed for both 2021 and 2022 which shows non-significant impact among the variables.

This indicates that more severe pruning leads to greater shoot elongation, potentially due to the increased availability of stored photosynthates and the early activation of vegetative buds in older plants following pruning. It is crucial to note that despite these findings, there was no significant interaction between pruning, plant growth regulators, and bagging practices. This suggests that the combined influence of these factors on shoot growth does not significantly exceed the individual effects of each practice. Pruning creates localized nutrient sinks at the vegetative buds, redirecting stored nutrients to these sites and facilitating timely shoot initiation. This redistribution is further enhanced by the movement of photosynthates from the apex of the plant to the axillary regions, promoting vigorous bud growth. The study found a clear pattern that pruning intensity positively correlated with shoot length. Intense pruning resulted in the greatest cumulative length of new shoots, followed by moderate and then light pruning (Kumar *et al.*, 2017; Lian *et al.*, 2020). In conclusion, the thesis should emphasize that pruning is a crucial horticultural practice for regulating shoot growth in guava plants. The findings suggest that more intensive pruning strategies may be beneficial for promoting vigorous shoot development, which could have important implications for guava cultivation and management practices.

4.2.2 Initiation of flowering (Days)

The initiation of the flowering process in guava trees is significantly affected by the intensity of pruning, as demonstrated in Table 8 and Figure 4. Guava plants subjected to a 20 cm pruning (A2) exhibited a notably shorter time for flower initiation, with 66.65, 65.90, and 66.28 days in year 2021, 2022, and the combined data examination, respectively. Conversely, 10 cm pruning guava plants (A1) took 68.44, 67.63 and 68.03 days in the year 2021, 2022 and pooled analysis. This difference can be attributed to the higher levels of stored photosynthates and the earlier activation of vegetative buds resulting from pruning. The severity of pruning plays a significant role in the transition from vegetative primordia to reproductive primordia, leading to the early initiation of flowers in guava plants. Hence, the initiation of flowers at a 20 cm pruning length occurred earlier compared to pruning up to 10 cm.

Furthermore, in both 2021 and 2022, first-order interactions (A × B, B × C, and C × A) or the second-order interaction (A × B × C) involving all three factors demonstrated a insignificant effect.

Pruning serves to stimulate the emergence of new growth and blossoms by redirecting the plant's energy and resources towards its development. Additionally, the newly formed shoots contain a higher concentration of growth hormones critical for initiating flowering. Pruning also improves the penetration of sunlight into the tree's interior, resulting in enhanced flowering. Pruning trees exhibited the shortest flowering duration, possibly due to increased sunlight exposure, improved nutrient availability, and enhanced air circulation, all of which fostered the initiation of flowers. In general, pruning enhances flower production in guava trees by encouraging potentially fruit-bearing shoots, thereby increasing the number of flowers per shoot. Moreover, pruning has a beneficial impact on the overall health and vitality of the tree, optimizing the energy reserves available for the flowering process. When determining the appropriate pruning regimen, it is essential to consider the specific needs and growth patterns of guava trees (Tripathi *et al.*, 2019; Singh *et al.*, 2010).

Table 8 – Effect of crop regulation and bagging material on Shoot length (cm) and initiation of flowering (days) in guava cv Allahabad Safeda

Factor	Shoot length (cm)			Initiation of flowering (Days)		
	Year I	Year II	Pooled value	Year I	Year II	Pooled value
Factor (A)						
A_1	10.77 [b]	10.83 [b]	10.80 [b]	68.44 [a]	67.63 [a]	68.03 [a]
A_2	11.69 [a]	11.78 [a]	11.74 [a]	66.65 [b]	65.90 [b]	66.28 [b]
Standard Error	0.10	0.08	0.06	0.42	0.29	0.24
Critical Difference	0.30	0.21	0.16	1.16	0.83	0.69
Factor (B)						
B_1	11.19	11.26	11.23	67.36	66.69	67.03
B_2	11.28	11.30	11.29	67.50	66.69	67.10
B_3	11.22	11.32	11.27	67.64	66.81	67.22
B_4	11.23	11.34	11.29	67.69	66.86	67.28
Standard Error	0.15	0.11	0.08	0.59	0.41	0.34
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor (C)						
C_1	11.24	11.34	11.29	67.73	66.75	67.24
C_2	11.24	11.28	11.26	67.48	66.81	67.15
C_3	11.21	11.30	11.26	67.44	66.73	67.08
Standard Error	0.13	0.09	0.07	0.51	0.35	0.30
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X B						
A1B1	10.70	10.75	10.73	68.28	67.56	67.92
A1B2	10.79	10.77	10.78	68.33	67.44	67.89
A1B3	10.74	10.84	10.80	68.61	67.83	68.22
A1B4	10.85	10.97	10.91	68.56	67.67	68.11
A2B1	11.69	11.77	11.73	66.44	65.83	66.14
A2B2	11.76	11.83	11.80	66.67	65.94	66.31
A2B3	11.69	11.81	11.75	66.67	65.78	66.22
A2B4	11.61	11.72	11.67	66.83	66.06	66.44
Mean	11.23	11.31	11.27	67.55	66.76	67.16
Standard Error	0.21	0.15	0.11	0.84	0.58	0.49
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X C						
A1C1	10.74	10.80	10.77	68.63	67.54	68.08
A1C2	10.78	10.78	10.79	68.29	67.54	67.92
A1C3	10.79	10.92	10.86	68.42	67.79	68.10

A2C1	11.74	11.88	11.81	66.83	65.96	66.40
A2C2	11.70	11.77	11.74	66.67	66.08	66.38
A2C3	11.62	11.69	11.66	66.46	65.67	66.06
Mean	11.23	11.31	11.27	67.55	66.76	67.16
Standard Error	0.18	0.13	0.09	0.73	0.50	0.42
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor B X C						
B1C1	11.19	11.31	11.25	67.92	66.67	67.29
B1C2	11.19	11.21	11.20	67.08	66.92	67.00
B1C3	11.21	11.26	11.24	67.08	66.50	66.79
B2C1	11.37	11.37	11.37	67.58	66.83	67.21
B2C2	11.24	11.31	11.27	67.50	66.67	67.08
B2C3	11.23	11.23	11.23	67.42	66.58	67.00
B3C1	11.22	11.43	11.32	67.75	66.83	67.29
B3C2	11.25	11.17	11.22	67.67	66.92	67.29
B3C3	11.18	11.38	11.28	67.50	66.67	67.08
B4C1	11.18	11.26	11.23	67.67	66.67	67.17
B4C2	11.30	11.42	11.36	67.67	66.75	67.21
B4C3	11.21	11.35	11.29	67.75	67.17	67.46
Mean	11.23	11.31	11.27	67.55	66.76	67.16
Standard Error	0.26	0.19	0.13	1.03	0.71	0.60
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, p≤0.05) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

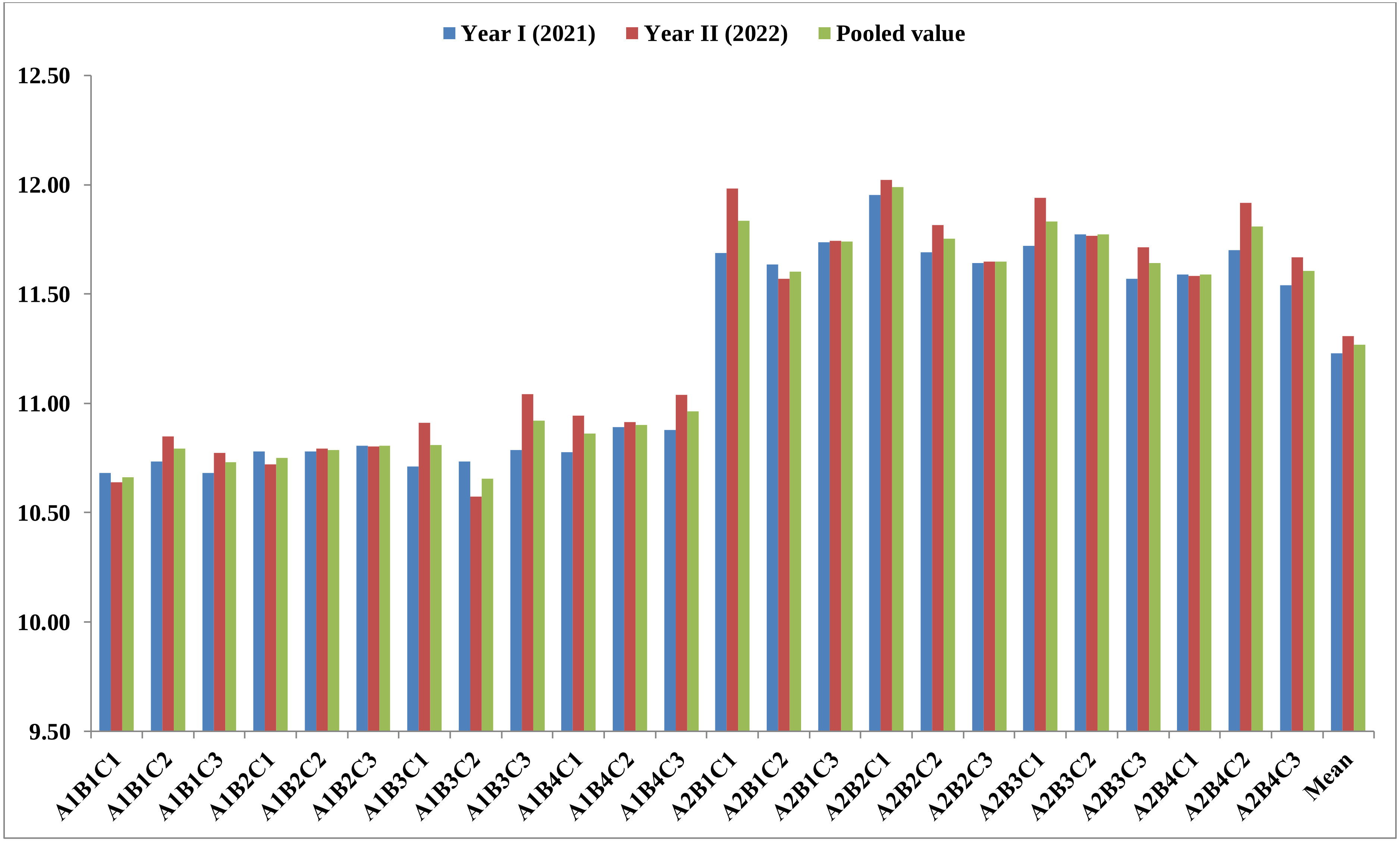

Figure 3 Effect of crop regulation and bagging material on Shoot length of guava cv Allahabad Safeda.

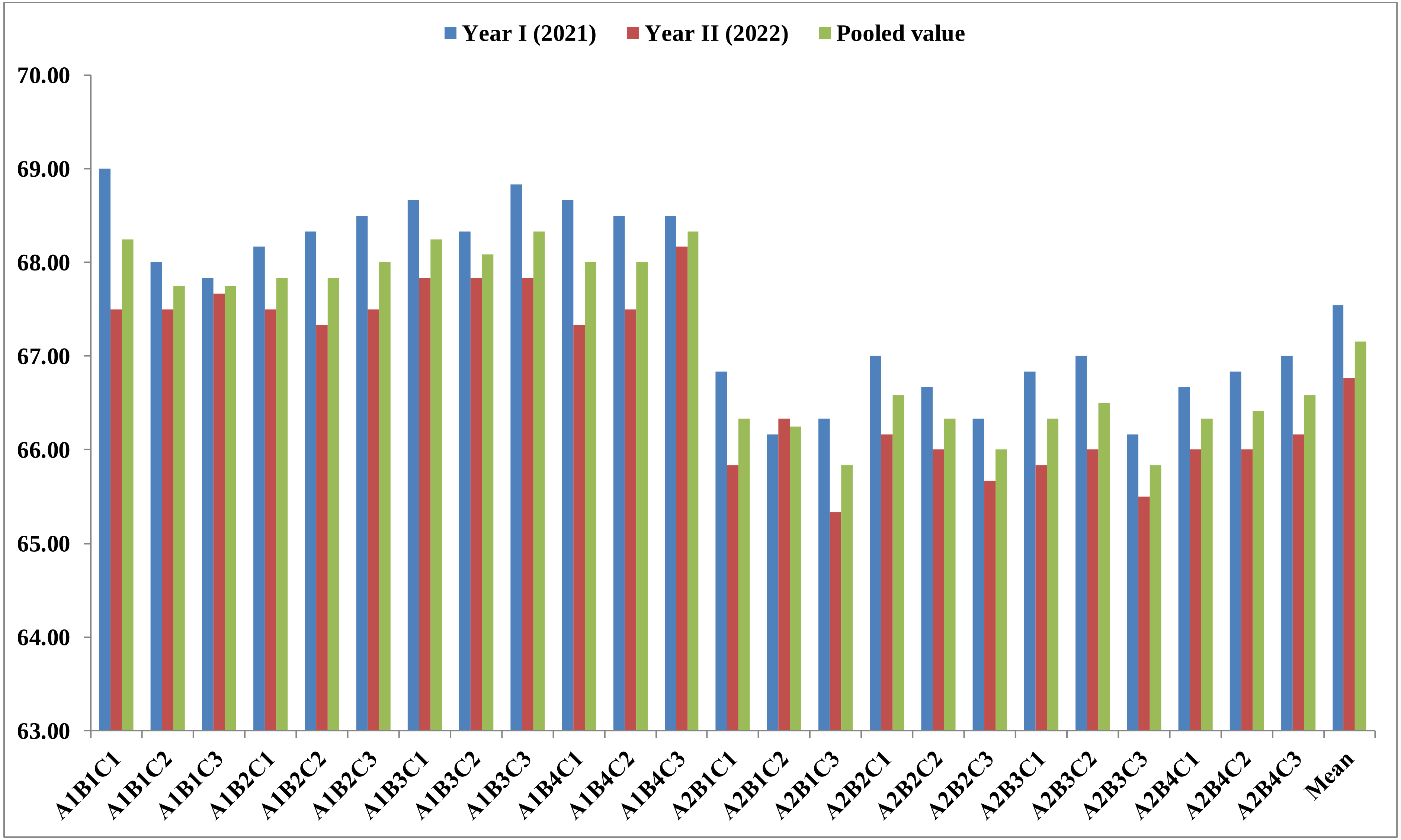

Figure 4 Effect of crop regulation and bagging material on initiation of flowering (days) of guava cv Allahabad Safeda.

4.2.3 Flower bud emergence to anthesis (Days)

The study examined the period from the appearance of flower buds to the onset of anthesis, as detailed in Table 8 and illustrated in Figure 5. The severity of pruning significantly influenced the duration from the emergence of flower buds to anthesis on the branches of guava cv. Allahabad Safeda across both 2021 and 2022. The shortest and most notably brief period from the emergence of flower buds to anthesis occurred with the 20 cm pruning intensity, lasting 35.85 and 36.24 days in 2021 and 2022, respectively, and 36.04 days in the combined data analysis. Conversely, the longest time for this transition was observed with the 10 cm pruning intensity, with durations of 37.13 and 37.46 days in 2021 and 2022, respectively, and 37.29 days in the pooled data analysis. The effects of the plant growth regulator (B) and bagging (C) were found to be insignificant in 2021 and 2022, as well as in the aggregate analysis. Neither the first-order interactions (A×B, B×C, and C×A) nor the second-order interaction (A×B×C) showed significant effects during the study years.

Pruning stimulates the growing of new vegetative shoots, leading to an increased abundance of flower buds on guava trees. This, in turn, expedites the appearance of flower buds and the onset of anthesis. It should be noted that the specific influence of pruning on the timing of flower bud emergence and anthesis varies with the intensity of the pruning. (Dhaliwal *et al.*, 1998). This enhanced effect can be attributed to the greater accumulation of stored photosynthates and the earlier activation of vegetative buds in older plants resulting from pruning.

4.2.4 Number of flowers per shoot

An examination of the information in Table 9 and shown in Figure 6 indicates that pruning significantly affects on flowers per shoot. The maximum flowers per shoot (5.71, 5.81 and 5.76) were documented in the years 2021, 2022, and the combined analysis, which pruned to 20 cm pruning. This result was statistically significant to the treatment that included 10 cm pruning. Nevertheless, the effects of plant growth regulator and bagging were deemed insignificant in the years 2021, 2022, and the combined analysis. Across both 2021 and 2022, all first-order interactions (A×B, B×C, and C×A) along with the second-order interaction (A×B×C) were determined to be statistically insignificant.

The impact of pruning intensity on the flowers per shoot in guava directly depends on the intensity of pruning. Generally, pruning results in the enhancement of flower production in guava trees. This is because pruning induces potentially fruiting shoots, which stimulates the growth of new shoots and increases the number of flowers per shoot. Pruning helps to control the size and shape of the tree, improve light penetration, and reduce competition among branches, which can promote flower production. Pruning also helps to remove old, diseased, or unproductive wood, which stimulates new growth and increases the number of flowers. Pruning also affects the overall health and vigor of the tree, which optimize the amount of energy available for flowering. This is because pruning encourages the development of vegetative growth, which increases the number of flowers produced. When deciding on the right pruning regime, it's crucial to take into account the specific requirements and growth patterns of the guava tree (Supanjani *et al.*, 2019; Singh *et al.*, 2020).

Widyastuti *et al.* (2019) found that pruning treatment had positive effects on the growth of trees. Specifically, it was shown to speed up the appearance of flowers per shoot and increase the flowers. The enhanced flowering response was linked to an increased rate of stomatal conduction, as pruned trees were found to have a higher number of stomata compared to unpruned ones. It was found that pruning speed up the time it takes for flowers to appear by as much as 10 days when compared to trees that are not pruned.

Table 9 – Effect of crop regulation and bagging material on Flower bud emergence to anthesis and number of flowers per shoot in guava cv. Allahabad Safeda

Factor	Flower bud emergence to anthesis (Days)			Number of flowers per shoot		
	Year I	Year II	Pooled value	Year I	Year II	Pooled value
Factor (A)						
A_1	37.13 [a]	37.46 [a]	37.29 [a]	5.08 [b]	5.22 [b]	5.15 [b]
A_2	35.85 [b]	36.24 [b]	36.04 [b]	5.71 [a]	5.81 [a]	5.76 [a]
Standard Error	0.10	0.08	0.06	0.42	0.29	0.24
Critical Difference	0.48	0.40	0.32	0.21	0.27	0.17
Factor (B)						
B_1	36.25	36.58	36.42	5.30	5.48	5.39
B_2	36.56	36.95	36.75	5.42	5.55	5.48
B_3	36.53	37.03	36.78	5.43	5.45	5.44
B_4	36.61	36.83	36.72	5.42	5.58	5.50
Standard Error	0.15	0.11	0.08	0.59	0.41	0.34
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor (C)						
C_1	36.29	36.88	36.58	5.38	5.47	5.42
C_2	36.48	36.85	36.67	5.41	5.51	5.46
C_3	36.69	36.81	36.75	5.39	5.57	5.48
Standard Error	0.13	0.09	0.07	0.51	0.35	0.30
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X B						
A1B1	36.77	37.17	36.97	4.95	5.18	5.06
A1B2	37.17	37.39	37.28	5.17	5.24	5.20
A1B3	37.39	37.56	37.47	5.14	5.13	5.13
A1B4	37.17	37.72	37.44	5.06	5.34	5.20
A2B1	35.72	36.00	35.86	5.66	5.78	5.72
A2B2	35.94	36.50	36.22	5.67	5.86	5.77
A2B3	35.67	36.50	36.08	5.73	5.78	5.75
A2B4	36.06	35.94	36.00	5.78	5.82	5.80
Mean	36.49	36.85	36.67	5.39	5.52	5.45
Standard Error	0.21	0.15	0.11	0.84	0.58	0.49
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X C						
A1C1	36.79	37.63	37.21	5.02	5.14	5.08

A1C2	37.21	37.50	37.35	5.13	5.22	5.17
A1C3	37.38	37.25	37.31	5.09	5.31	5.20
A2C1	35.79	36.13	35.96	5.73	5.79	5.76
A2C2	35.75	36.21	35.98	5.69	5.81	5.75
A2C3	36.00	36.38	36.19	5.70	5.84	5.77
Mean	36.49	36.85	36.67	5.39	5.52	5.45
Standard Error	0.18	0.13	0.09	0.73	0.50	0.42
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor B X C						
B1C1	36.08	36.33	36.21	5.28	5.50	5.39
B1C2	36.42	36.67	36.54	5.34	5.57	5.45
B1C3	36.25	36.75	36.50	5.30	5.38	5.34
B2C1	36.50	37.42	36.96	5.44	5.38	5.41
B2C2	36.33	36.67	36.50	5.44	5.59	5.51
B2C3	36.84	36.75	36.79	5.38	5.69	5.53
B3C1	36.08	37.09	36.58	5.42	5.44	5.43
B3C2	36.34	37.17	36.75	5.46	5.36	5.41
B3C3	37.17	36.84	37.00	5.42	5.57	5.49
B4C1	36.50	36.67	36.58	5.38	5.55	5.46
B4C2	36.84	36.92	36.88	5.40	5.55	5.47
B4C3	36.50	36.91	36.71	5.48	5.65	5.56
Mean	36.49	36.85	36.67	5.39	5.52	5.45
Standard Error	0.26	0.19	0.13	1.03	0.71	0.60
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, p≤0.05) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

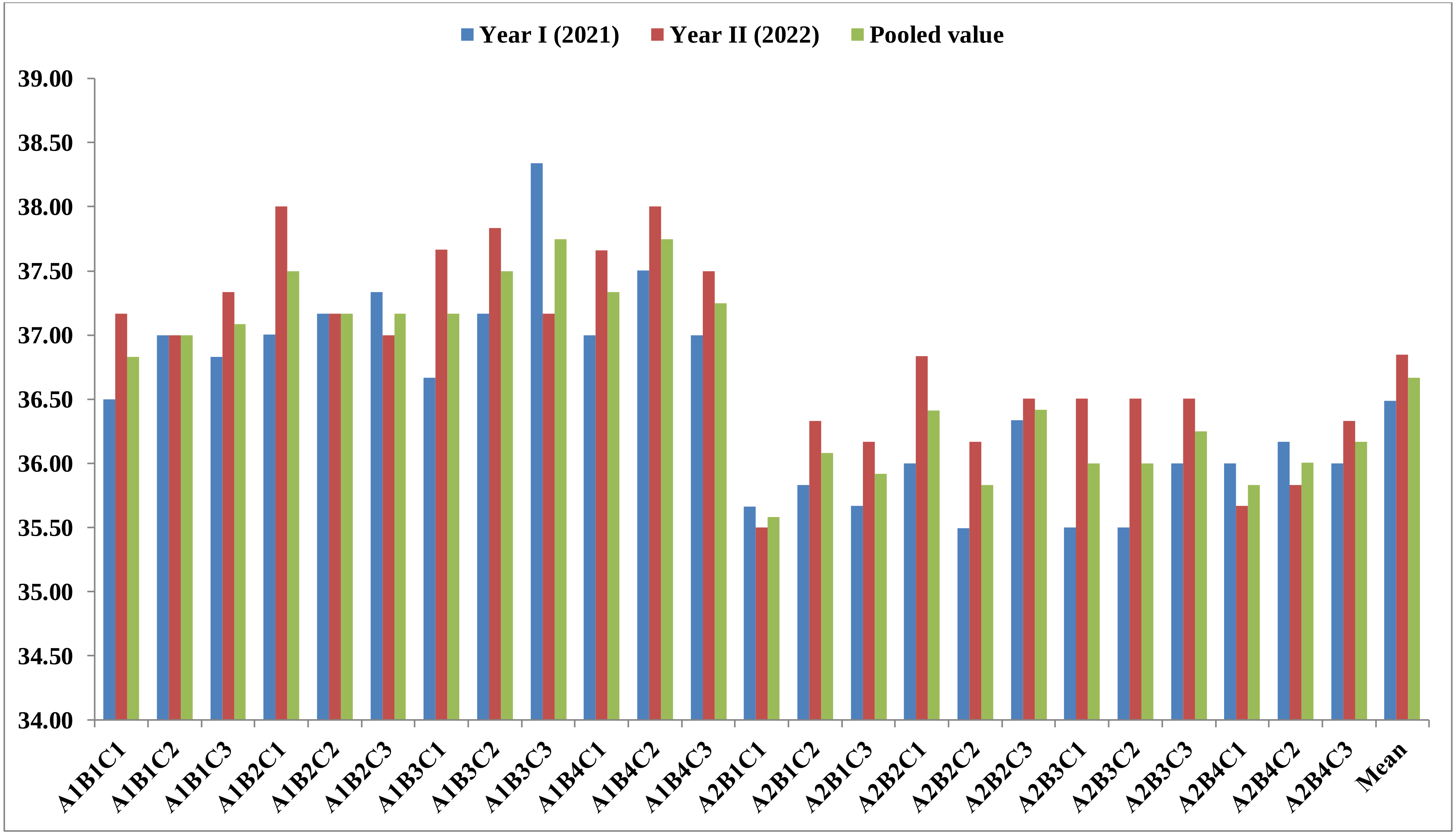

Figure 5 Effect of crop regulation and bagging material on Flower bud emergence to anthesis of guava cv. Allahabad Safeda.

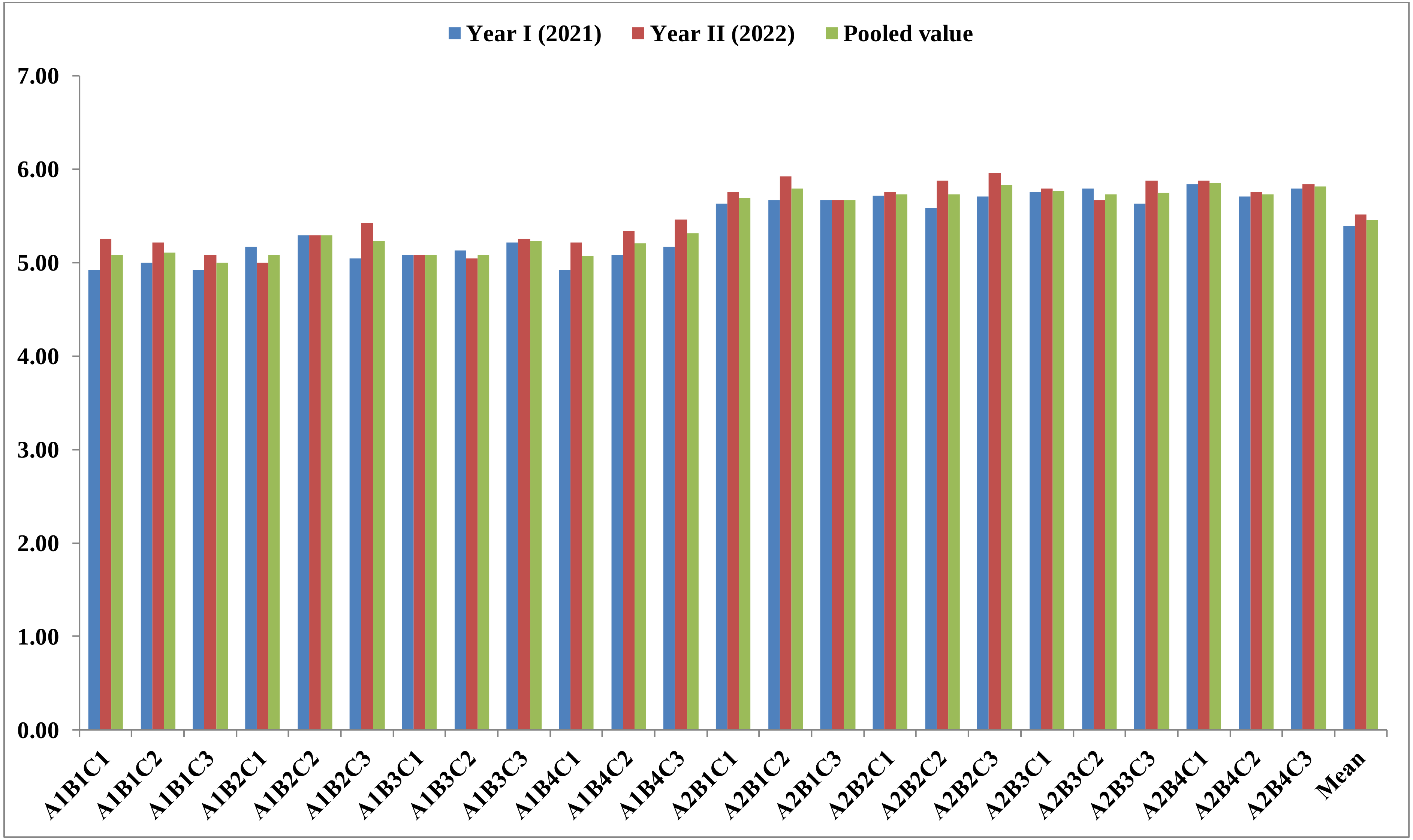

Figure 6 Effect of crop regulation and bagging material on number of flowers per shoot of guava cv. Allahabad Safeda.




4.2.5 Fruit set (%)

The mean percentage of fruit set showed a strong and positive correlation with the level of pruning. Aggregated data, displayed in Table 10 and Figure 7, confirmed that pruning markedly impacts on fruit set. Increasing the intensity of pruning shows positive impact of pruning as it increases light and nutrient availability to developing fruits. Pruning intensity 20 cm results 82.04%, 83.11% and 82.57 % fruit set in year 2021, 2022 and pooled data analysis followed by 74.94%, 75.82% and 75.38% in 10 cm pruning treatments which was significantly different with each other. Moreover, the interaction impact of pruning (A), plant growth regulator (B) and bagging (C) was determined to be statistically insignificant in both years. In both 2021 and 2022, the first-order interactions (A×B, B×C, and C×A) and the second-order interaction (A×B×C) were determined to be statistically insignificant.

Unchecked growth results in dense canopies that limit resources for individual fruits. Selective branch and leaf removal through pruning opens up the tree canopy, allowing more light and nutrients to reach fruiting branches, leading to a higher percentage of flowers setting fruit. Fruit set % was increasing with increasing the intensity of shoot pruning and heavy pruning or increasing the pruning intensity after certain pruning was harmful and results in lower fruit set percentage (Aswathy and Arumugam, 2017; Kumar *et al*., 2020 and Singh *et al*., 2021). So it's proven that pruning has a positive impact on fruit set percentage in guava by increasing the availability of light and nutrients to the developing fruit, promoting the development of new shoots and branches, and improving the overall health and productivity of the tree. Pruning guava trees in their early stages is typically advantageous for growers aiming to enhance their fruit quality and maximize yields. Regarding pruning, a study conducted shows that pruning guava trees increases the number of flowering shoots and results in higher fruit set percentages compared to unpruned trees. Pruning the shoots of plants promotes early growth and improves sunlight photosynthesis in the leaves, which alters the activity of plant growth regulators like IAA, thereby enhancing fruit set in guava (Prakash *et al*., 2012 and Singh *et al.*, 2020).

4.2.6 Yield (Kg)

The condensed information from table 10 and Figure 8 indicates that among the pruning treatment, highest guava fruit yield achieved was 32.41 kg, 34.33 kg and 33.37 kg in 20 cm pruning in year 2021, 2022 and the pooled analysis respectively. However, minimum yield was achieved 30.91, 32.44 kg and 31.68 kg in 10 cm pruning which showed significant correlations with each other in the years 2021, 2022, and the combined analysis, respectively.

The various levels of foliar application of pgr demonstrated a significant impact on yield of guava plants. GA3 application (GA3 @ 50 ppm) recorded the highest fruit yield of 32.31 kg, 34.11 kg and 33.21 kg in year 2021, 2022 and, pooled analysis respectively, followed by 31.94 kg, 33.76 kg and 32.85 kg in GA3 @ 25 ppm treatment. Whereas, minimum yield was achieved yield of 31.03 kg , 32.72 kg and 31.87 kg in 10 ppm of NAA among various application of plant growth regulators.

The data pertaining to the influence of bagging on yield (kg) is outlined in Table 10, illustrated in Figure 8 that the findings related to yield clearly reveals the significant effect of bagging of yield throughout the investigation period. The highest yield of 32.60 kg, 34.54 kg and 33.57 kg was observed in the non-woven bag treatment in year 2021, 2022 and, pooled analysis respectively, while lowest yield of 30.04 kg, 31.41 kg and 30.73 kg among bagging was noted in non-bagged treatment. Consequently, using non-woven bags leads to an increase in fruit yield compared to fruits that are not bagged.

The impact of treatments on guava fruit yield (kg) was more pronounced in 2022 than in 2021. Among the first-order interactions, the A×B interaction showed a significant effect in years, 2021 and 2022. The interaction effect of pruning and plant growth regulator resulted in the highest fruit yield of 33.05 kg, 35.16 and 34.11 kg in A_2B_4 in year 2021, 2022 and, pooled analysis respectively, which was followed by A_2B_3. The lowest fruit yield was recorded 30.20 kg, 31.59 kg and 30.90 kg in A_1B_1 treatment.

Commencing with the first-order interactions, the A×C interaction exhibited a significant correlations in the years 2021, 2022 and combined data examination. Pruning and fruit bagging practices yielded a substantial increase in fruit yield. Specifically, A_2C_2 demonstrated superior results, producing 33.40 kg, 35.67 kg, and 34.54 kg in year 2021, 2022 and, pooled analysis respectively. In comparison, A_2C_1 exhibited commendable yields of 33.12 kg, 35.34 kg, and 34.23 kg. Conversely, the least favorable outcomes were recorded in A_1C_3, where the observed values stood at 29.38 kg, 30.83 kg, and 30.11 kg in year 2021, 2022 and, combined data examination, respectively.

The significance of the interaction between the application of pgr's and the practice of fruit bagging (B×C) was evident in the study. Notably, plants treated with B4C2 exhibited the highest yields, with 33.38 kg , 35.34 kg, and 34.36 kg in the years 2021, 2022, and in the combined analysis, respectively.This was closely followed by B_4C_1, which yielded 33.07 kg, 34.88 kg, and 33.98 kg. It is noteworthy to mention that the treatment B_1C_3 resulted in the minimum observed yield of 29.64 kg, 30.98 kg and 30.31 kg.

Enhancing yield is a crucial outcome influenced by the practice of pruning in guava cultivation. Studies have indicated that pruning not only affects the yield but also positively impacts the growth, quality, and precocity of guava plants. Singh *et al*. (2001) observed in their research on Allahabad Safeda and Sardar cultivars over five years that increased yield is linked to the augmented accumulation of photosynthetic photon flux due to pruning. Meena *et al.* (2017) further emphasizes this point. Their findings suggested that a moderate pruning length was most effective in promoting robust growth, abundant flowering, and subsequently, a higher yield. Additionally, pruning appears to increase the number of stomata on guava leaves, which could be a contributing factor to these improved outcomes. Another intriguing aspect of pruning is its impact on flowering. Widyastuti *et al.* (2019) observed a significant increment in flower number, by 90%, in pruned as compared to their unpruned counterparts. This indicates that pruning can substantially enhance the reproductive capacity of guava plants. Moreover, the by-products of pruning, often considered waste, have been found to have commercial value. Cestonaro *et al*. (2021) demonstrated that pruning waste could be utilized to create nutrient-rich compost, adding an environmental and economic benefit to the practice. Finally, Srivastava *et al.* (2022) highlighted that proper pruning techniques can rejuvenate the productivity of guava plants. This underlines the importance of adopting scientifically informed pruning practices to maximize the potential of guava cultivation. Thus, pruning emerges not just as a horticultural practice but as a multifaceted tool for enhancing various aspects of guava production.

Singh *et al.* (2017) investigated the impact of different PGR's and concluded that use of Naphthaleneacetic acid (NAA) in agriculture has been noted to stimulate cell growth, primarily through vacuole expansion and the relaxation of cell walls. This process contributes to a noticeable enhancement in the size and number of fruits, ultimately leading to an overall increase in crop yield. GA_3 application in guava enhances fruit size, improves set and quality, reduces drop, extends flowering, and potentially increases stress resistance, thereby significantly boosting overall fruit yield. Brar *et al.* (2019) studied various bagging materials were used on guava fruits to evaluate their effectiveness in mitigating fruit fly damage and enhancing yield. The application of these bags, particularly non-woven ones, significantly improved the size, weight, and organoleptic quality of the fruits, leading to an overall increase in yield. Notably, fruits bagged in non-woven materials showed a dramatic reduction in fruit fly infestation, with 98-99% of them being healthy and marketable, in stark contrast to the 100% damage rate in non-bagged fruits. Among the non-woven bags, the blue and white variants were particularly effective, with yields exceeding 12 kg, and the white bags stood out in size, yield, and quality. While newspaper bags offered the highest benefit-cost ratio due to their low cost, they were less effective against fruit fly damage. The overall cost of using white non-woven bags was affordable and justified by the significantly higher quality and marketability of the bagged fruits compared to the unmarketable non-bagged.

Table 10 – Effect of crop regulation and bagging materials on on Fruit set (%) and yield (kg/plant) in guava cv. Allahabad Safeda.

Factor	Fruit set (%)			Yield (kg/plant)		
	Year I	Year II	Pooled value	Year I	Year II	Pooled value
Factor (A)						
A_1	74.94 ^{b}	75.82 ^{b}	75.38 ^{b}	30.91 ^{b}	32.44 ^{b}	31.68 ^{b}
A_2	82.04 ^{a}	83.11 ^{a}	82.57 ^{a}	32.41 ^{a}	34.33 ^{a}	33.37 ^{a}
Standard Error	0.86	0.54	0.52	0.026	0.057	0.038
Critical Difference	2.45	1.54	1.49	0.071	0.162	0.108
Factor (B)						
B_1	78.01	79.08	78.55	31.03 ^{d}	32.72 ^{d}	31.87 ^{d}
B_2	78.57	79.20	78.88	31.36 ^{c}	32.96 ^{c}	32.16 ^{c}
B_3	78.86	79.99	79.42	31.94 ^{b}	33.76 ^{b}	32.85 ^{b}
B_4	78.52	79.60	79.06	32.31 ^{a}	34.11 ^{a}	33.21 ^{a}
Standard Error	1.22	0.76	0.74	0.035	0.080	0.053
Critical Difference	Non-Significant	Non-Significant	Non-Significant	0.100	0.228	0.152
Factor (C)						
C_1	78.17	79.26	78.72	32.33 ^{b}	34.21 ^{b}	33.27 ^{b}
C_2	78.92	80.03	79.47	32.60 ^{a}	34.54 ^{a}	33.57 ^{a}
C_3	78.39	79.11	78.75	30.04 ^{c}	31.41 ^{c}	30.73 ^{c}
Standard Error	1.05	0.66	0.64	0.030	0.069	0.046
Critical Difference	Non-Significant	Non-Significant	Non-Significant	0.087	0.198	0.132
Factor A X B						
A1B1	73.94	75.12	74.53	30.20 ^{h}	31.59 ^{f}	30.90 ^{g}
A1B2	75.26	75.84	75.55	30.57 ^{g}	32.28 ^{e}	31.43 ^{f}
A1B3	75.35	76.30	75.83	31.30 ^{f}	32.83 ^{d}	32.07 ^{e}
A1B4	75.21	76.03	75.62	31.57 ^{e}	33.07 ^{d}	32.32 ^{d}
A2B1	82.08	83.04	82.56	31.85 ^{d}	33.84 ^{c}	32.85 ^{c}
A2B2	81.88	82.56	82.22	32.15 ^{c}	33.64 ^{c}	32.90 ^{c}
A2B3	82.36	83.67	83.01	32.58 ^{b}	34.69 ^{b}	33.64 ^{b}
A2B4	81.84	83.17	82.50	33.05 ^{a}	35.16 ^{a}	34.11 ^{a}
Mean	78.49	79.47	78.98	31.66	33.39	32.53
Standard Error	1.72	1.08	1.05	0.050	0.113	0.076
Critical Difference	Non-Significant	Non-Significant	Non-Significant	0.142	0.323	0.215
Factor A X C						
A1C1	74.47	75.41	74.94	31.54 ^{d}	33.08 ^{d}	32.31 ^{d}
A1C2	75.33	76.46	75.89	31.81 ^{c}	33.41 ^{c}	32.61 ^{c}
A1C3	75.02	75.61	75.31	29.38 ^{f}	30.83 ^{f}	30.11 ^{f}

A2C1	81.86	83.12	82.49	33.12^{b}	35.34^{b}	34.23^{b}
A2C2	82.51	83.60	83.05	33.40^{a}	35.67^{a}	34.54^{a}
A2C3	81.75	82.61	82.18	30.70^{e}	31.99^{e}	31.35^{e}
Mean	78.49	79.47	78.98	31.66	33.39	32.53
Standard Error	1.49	0.94	0.91	0.043	0.098	0.065
Critical Difference	Non-Significant	Non-Significant	Non-Significant	0.123	0.280	0.186
Factor B X C						
B1C1	78.24	78.98	78.61	31.61^{f}	33.38^{d}	32.50^{e}
B1C2	78.15	79.34	78.75	31.83^{e}	33.79^{c}	32.81^{d}
B1C3	77.65	78.92	78.28	29.64^{k}	30.98^{f}	30.31^{h}
B2C1	78.02	78.90	78.46	31.95^{e}	33.69^{cd}	32.82^{d}
B2C2	79.44	80.22	79.83	32.25^{d}	33.97^{c}	33.11^{c}
B2C3	78.25	78.48	78.36	29.89^{j}	31.23^{f}	30.56^{g}
B3C1	77.62	79.43	78.52	32.70^{c}	34.90^{b}	33.80^{b}
B3C2	79.79	80.81	80.30	32.97^{b}	35.07^{ab}	34.02^{b}
B3C3	79.16	79.73	79.45	30.15^{i}	31.32^{f}	30.73^{g}
B4C1	78.79	79.75	79.27	33.07^{b}	34.88^{ab}	33.98^{b}
B4C2	78.29	79.74	79.01	33.38^{a}	35.34^{a}	34.36^{a}
B4C3	78.49	79.31	78.90	30.49^{h}	32.12^{e}	31.31^{f}
Mean	78.49	79.47	78.98	31.66	33.39	32.53
Standard Error	2.11	1.32	1.28	0.086	0.139	0.093
Critical Difference	Non-Significant	Non-Significant	Non-Significant	0.174	0.396	0.264

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, p≤0.05) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

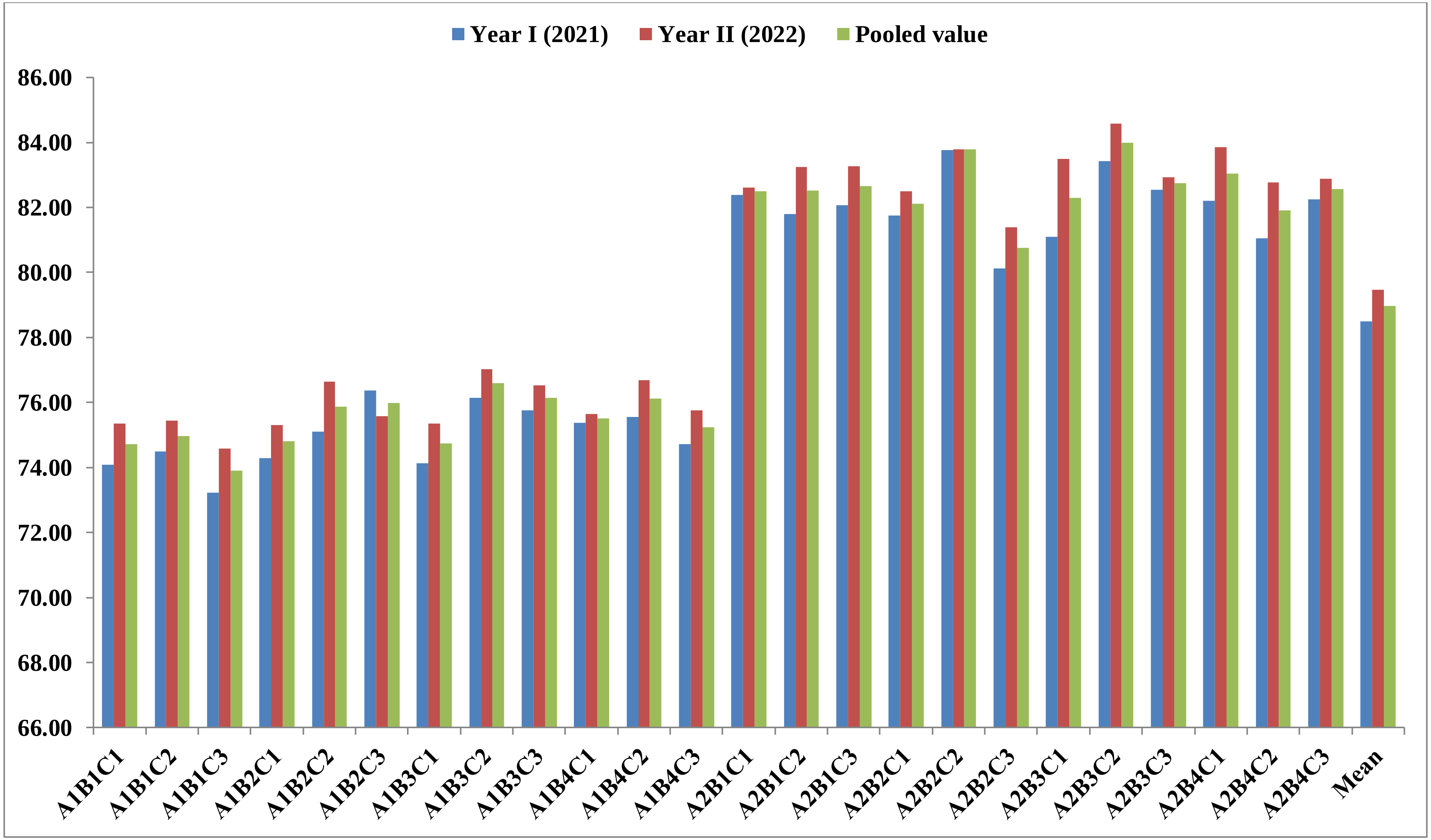

Figure 7 Effect of crop regulation and bagging materials on Fruit set (%) of guava cv. Allahabad Safeda.

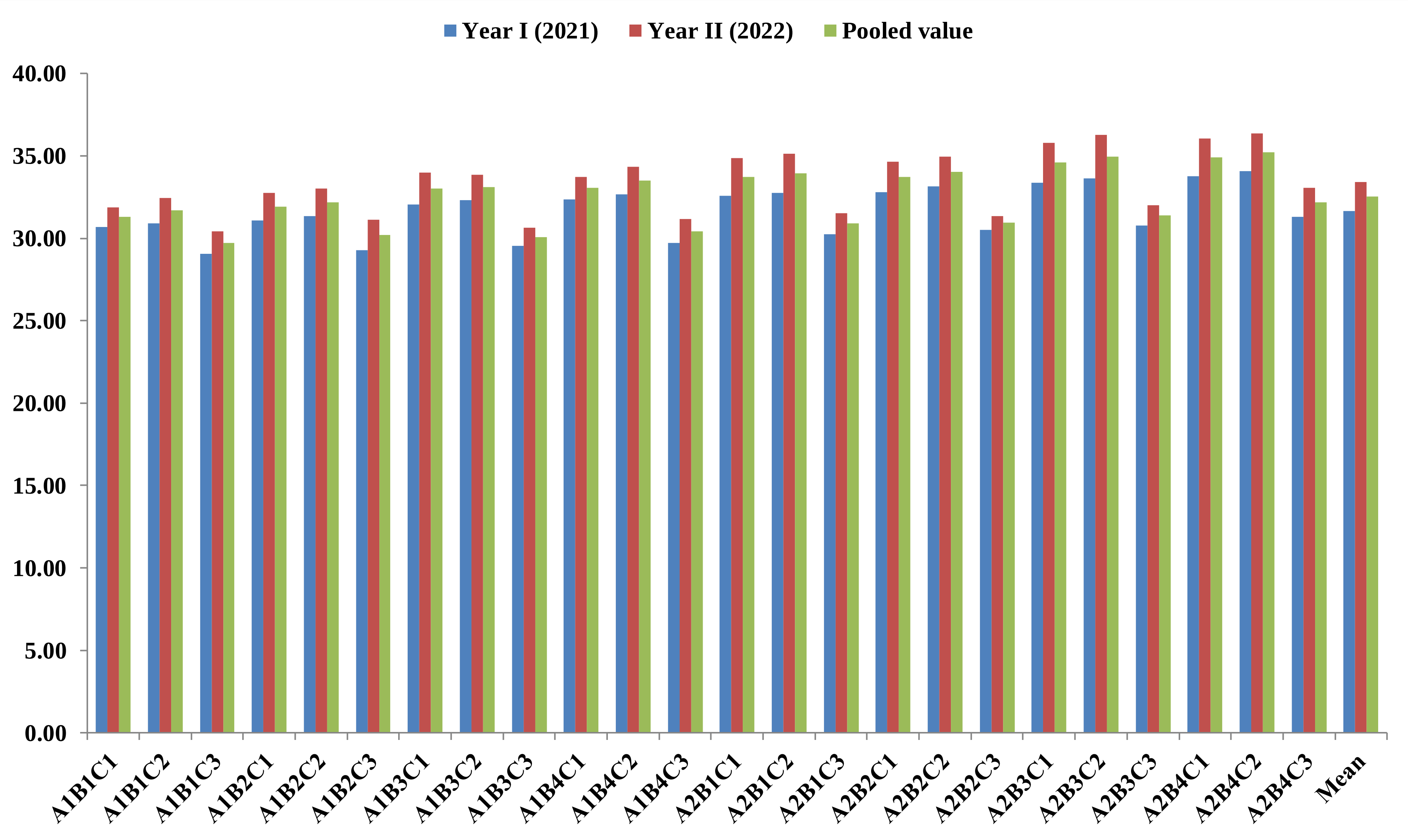

Figure 8 Effect of crop regulation and bagging materials on yield (kg/plant) of guava cv. Allahabad Safeda.

4.2.7 Fruit Fly Infestation (%)

This research primarily aimed to mitigate fruit fly infestation in guava production. The study revealed significant differences in effectiveness among various wrapping materials used, with this variability being statistically significant. Non-woven bags emerged as the most effective solution, recording the lowest fruit fly infestation rate at 2.45% (Year I), 1.90% (Year II) and 2.18% (Pooled). In contrast, 5.21% (Year I), 5.64% (Year II) and 5.42 % (Pooled) of infestation was observed in the muslin cloth bagged fruits, as detailed in Table 11 and Figure 9. The use of non-woven bags in guava cultivation has shown a significant impact on reducing fruit fly infestation. By enclosing the fruit in these bags, a physical barrier is created that effectively prevents fruit flies from accessing and laying eggs on the fruits. This method not only limits the infestation but also minimizes the use of chemical pesticides, offering an eco-friendly alternative. Studies have demonstrated that guava fruits protected with non-woven bags exhibit drastically lower rates of fruit fly damage compared to uncovered fruits. This approach is not only effective in controlling pests but also helps in maintaining quality and marketability of fruits. Furthermore, the combined effect of pruning, PGR's, and bagging did not show statistical significance over the course of the study, encompassing both 2021 and 2022. The research analyzed the first-order interactions (A×B, B×C, and C×A) and the second-order interaction (A×B×C) over these years, finding that none of these interactions had statistical significance.

Fruit flies and other pests significantly impact horticulture, affecting up to 50% of production capacity, which leads to considerable losses in fruit quality and yield. Research has shown that fruit fly infestation can cause about 40% crop loss in citrus fruits and up to 70% in mangoes. The practice of wrapping guava fruits not only reduces fruit fly attacks but also lessens the occurrence of bird damage, underscoring the value of this method in guava cultivation (Mondal *et al.*, 2015; Sharma and Nagraja, 2016).

In a similar context, bagging has proven effective for controlling insects in mangoes and guavas in Bangladesh, as evidenced by the works of Rahman *et al.* (2018) and Islam *et al.* (2020). However, its application in tomato cultivation remains less explored. This study demonstrates a marked decrease in insect incidents in bagged fruits compared to unbagged ones. Despite this, there was no significant variation in insect infestation among the different types of bagged fruits. The lowest insect infestation rate, at 2.17%, was recorded in fruits bagged in non-woven fabric. This contrast in infestation rates can be attributed to the direct exposure of non-bagged fruits to insects, whereas bagged fruits are protected by an artificial barrier that deters insect contact, as supported by Sharma *et al.* (2014).

4.2.8 Physical or Bird damage (%)

This study focused on addressing physical or bird damage in guava production. It was found that significant variations in the effectiveness of different fruit wrapping materials, with these differences being statistically significant. Non-woven bags were identified as the most effective in reducing damage, showing the lowest rates at 1.65% (Year I), 2.08% (Year II), and 1.87% (Pooled). Conversely, muslin cloth bags resulted in higher damage rates of 3.80% (Year I), 4.10% (Year II), and 3.95% (Pooled), as outlined in Table 11 and Figure 10. The adoption of non-woven bags has significantly lessened physical and bird damage. These bags act as a protective barrier, effectively shielding the fruits from direct contact and external harm. This method not only decreases damage but also reduces the need for chemical interventions, making it an environmentally friendly option. Research has shown that guavas encased in non-woven bags suffer considerably less physical and bird damage compared to their exposed counterparts. This technique is beneficial for both pest control and in preserving the quality and marketability of guava fruits. Additionally, the research indicated that the combined use of pruning, plant growth regulators, and bagging did not yield statistically significant effects over the years 2021 and 2022. The study assessed the first-order interactions (A×B, B×C, and C×A) and the second-order interaction (A×B×C) over these periods, revealing no significant effect among these factors.

Pre-harvest bagging of fruits is a conventional method for protection widely used in Asia, typically applied to a variety of fruit types. This method is used effectively for pest damage in a range of fruits, including guava, mango, litchi, papaya, citrus and pomegranate (Sharma *et. al.* 2014). In recent times, the technique of fruit bagging has gained popularity in major mango-growing areas. This method is applied before harvest to shield the fruit from various issues such as diseases, pests (including fruit flies and other insects), and physical damage like scratches and bird damage. Additionally, it is used to improve the fruit's skin color and to reduce issues such as sunburn, fruit cracking, excessive agrochemical residues, and bird damage (Pina *et al.,* 2020; Siddiq *et al.,* 2017).

In a related scenario, fruit bagging on the tree proven to be an effective way for pest and disease control, as well as for enhancing the quality of the fruits. In light of this, a experiment was conducted to evaluate the impact of five bagging materials on the 'Allahabad Safeda' variety of guava during the rainy season. Over two consecutive years, fruits at the marble growth stage were covered with different bagging materials. The study found that all types of bags notably accelerated fruit maturity and enhanced various aspects such as texture, appearance, overall quality, and biochemical properties, in comparison to fruits left unbagged. Notably, the use of non-woven bags drastically reduced the fruit drop percentage and effectively controlled pest and diseases. Unbagged fruits, on the other hand, showed a high (56.6 ± 1.08%) incidence of fruit fly, bird damage (14.6 ± 0.23%) and anthracnose (6.6 ± 0.27%). Therefore, the study concludes that using PP non-woven bags for on-the-tree fruit bagging is a beneficial practice for managing major pests and diseases, as well as for improving the quality of rainy season guava crops (Sharma *et al.*, 2020).

Table 11 Effect of crop regulation and bagging materials on Fruit Fly Infestation (%) and Physical or Bird damage (%) of guava cv. Allahabad Safeda

Factor	Fruit Fly Infestation (%)			Physical or Bird damage (%)		
	Year I	Year II	Pooled value	Year I	Year II	Pooled value
Factor (A)						
A_1	35.87	36.07	35.97	1.71	2.12	1.92
A_2	35.91	35.62	35.76	1.92	2.00	1.96
Standard Error	0.23	0.18	0.14	0.22	0.18	0.12
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor (B)						
B_1	35.62	35.70	35.66	1.63	2.29	1.96
B_2	36.27	35.95	36.11	2.04	1.96	2.00
B_3	35.87	35.87	35.87	1.80	1.88	1.84
B_4	35.78	35.87	35.83	1.80	2.12	1.96
Standard Error	0.33	0.25	0.20	0.31	0.26	0.17
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor (C)						
C_1	5.21 [b]	5.64 [c]	5.42 [c]	3.80 [a]	4.10 [c]	3.95 [a]
C_2	2.45 [c]	1.90 [b]	2.18 [b]	1.65 [b]	2.08 [b]	1.87 [b]
C_3	100.00 [a]	100.00 [a]	100.00 [a]	0.00 [c]	0.00 [a]	0.00 [c]
Standard Error	0.29	0.22	0.17	0.27	0.23	0.15
Critical Difference	0.81	0.62	0.48	0.76	0.64	0.42
Factor A X B						
A1B1	35.95	35.95	35.95	1.63	2.29	1.96
A1B2	36.11	36.44	36.28	1.96	1.96	1.96
A1B3	35.78	36.11	35.95	1.63	2.12	1.88
A1B4	35.62	35.78	35.70	1.63	2.12	1.88
A2B1	35.29	35.46	35.38	1.63	2.29	1.96
A2B2	36.44	35.46	35.95	2.12	1.96	2.04
A2B3	35.95	35.62	35.78	1.96	1.63	1.80
A2B4	35.95	35.95	35.95	1.96	2.12	2.04
Mean	35.89	35.84	35.87	1.82	2.06	1.94
Standard Error	0.47	0.36	0.28	0.44	0.37	0.24
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X C						
A1C1	5.15	5.88	5.52	3.43	3.92	3.68
A1C2	2.45	2.33	2.39	1.72	2.45	2.08
A1C3	100.00	100.00	100.00	0.00	0.00	0.00

A2C1	5.27	5.39	5.33	4.17	4.29	4.23
A2C2	2.45	1.47	1.96	1.59	1.72	1.66
A2C3	100.00	100.00	100.00	0.00	0.00	0.00
Mean	35.89	35.84	35.87	1.82	2.06	1.94
Standard Error	0.40	0.31	0.24	0.38	0.32	0.21
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor B X C						
B1C1	5.15	5.15	5.15	3.68	4.41	4.05
B1C2	1.72	1.96	1.84	1.23	2.45	1.84
B1C3	100.00	100.00	100.00	0.00	0.00	0.00
B2C1	5.39	5.64	5.52	4.17	3.43	3.80
B2C2	3.43	2.21	2.82	1.96	2.45	2.21
B2C3	100.00	100.00	100.00	0.00	0.00	0.00
B3C1	5.15	5.64	5.39	3.68	4.17	3.92
B3C2	2.45	1.96	2.21	1.72	1.47	1.60
B3C3	100.00	100.00	100.00	0.00	0.00	0.00
B4C1	5.15	6.13	5.64	3.68	4.41	4.05
B4C2	2.21	1.47	1.84	1.72	1.96	1.84
B4C3	100.00	100.00	100.00	0.00	0.00	0.00
Mean	35.89	35.84	35.87	1.82	2.06	1.94
Standard Error	0.57	0.44	0.34	0.53	0.45	0.29
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

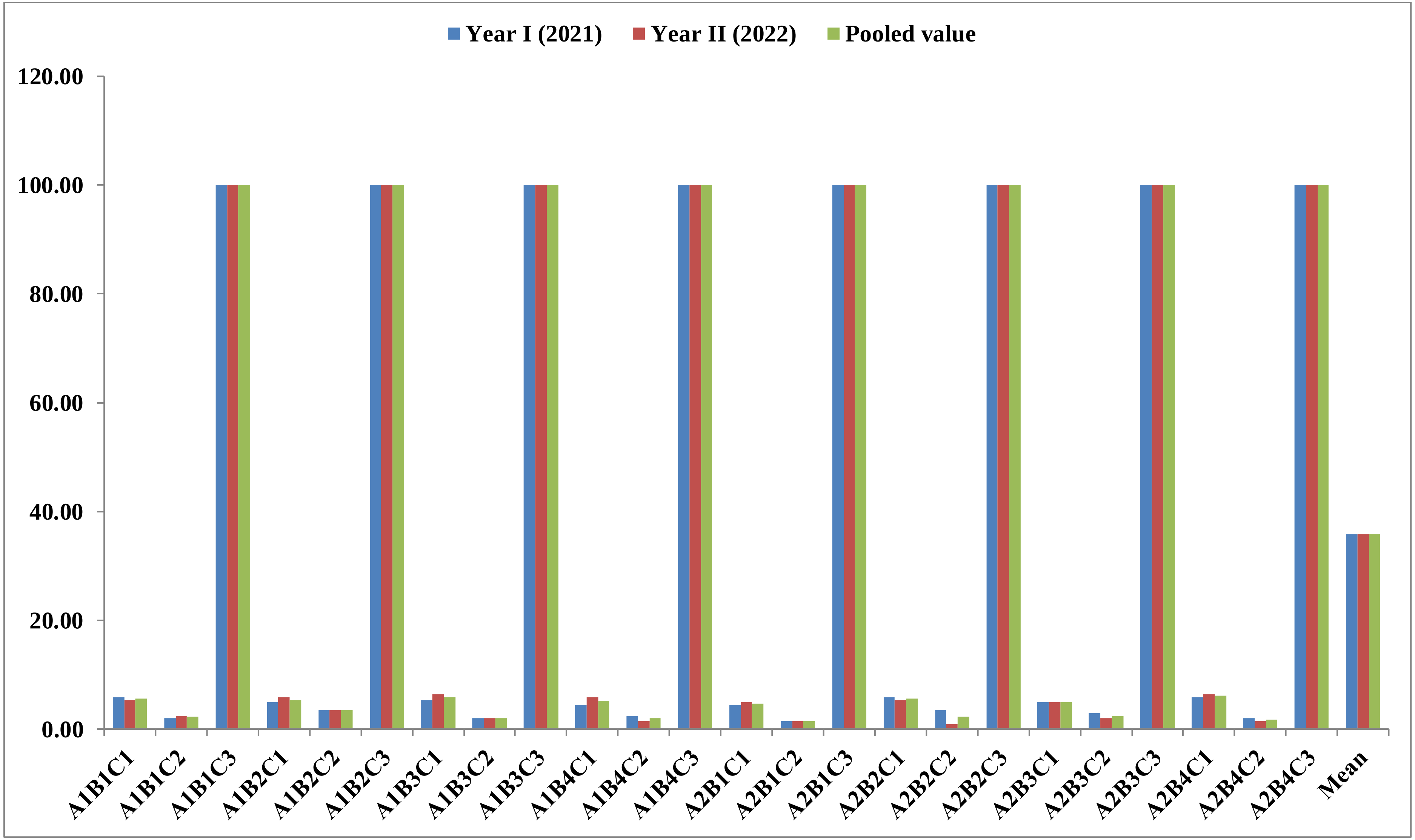

Figure 9 Effect of crop regulation and bagging materials on Fruit fly infestation (%) of guava cv. Allahabad Safeda.

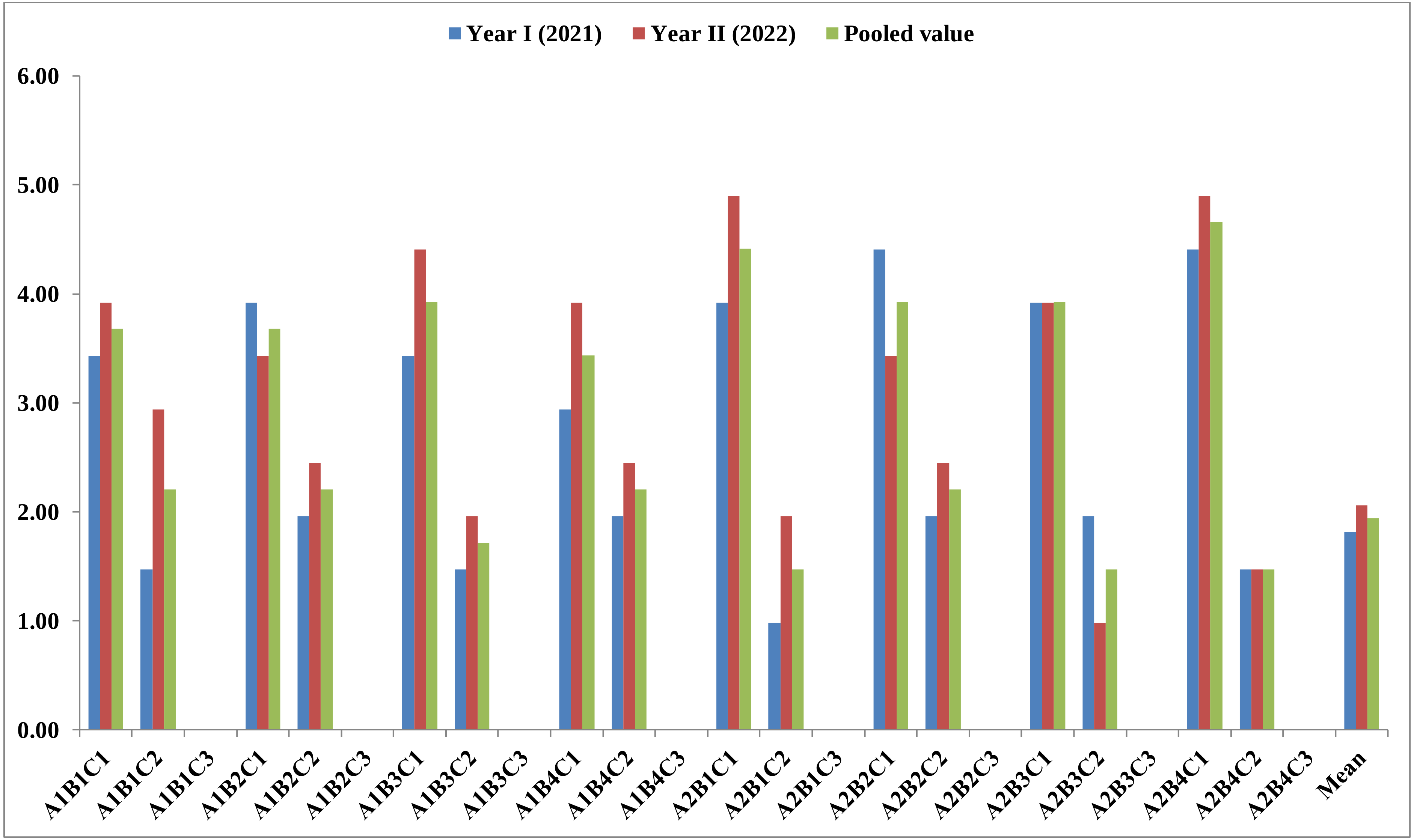

Figure 10 Effect of crop regulation and bagging materials on Physical or Bird damage (%) of guava cv. Allahabad Safeda.

4.2.9 Total damage (%)

This research was centered on total damage in guava production, with a particular focus on mitigating pest-related harm. The study assessed the effectiveness of different wrapping materials in protecting guavas from Table 12 and Figure 11. It was found that non-woven bags were the most effective in minimizing damage, as evidenced by significantly lower damage 3.31% (Year I), 4.17% (Year II), and 3.74% (Pooled). In comparison, guavas wrapped in muslin cloth bags experienced higher damage rates of 9.01% (Year I), 9.74% (Year II), and 9.37% (Pooled), as detailed in Table 12. The adoption of non-woven bags in guava cultivation has proven to be a major factor in reducing total damage. Encasing the fruit in these bags creates a physical barrier, effectively preventing pests from harming the fruits. This strategy not only reduces damage but also lessens the need for chemical pesticides, presenting an environmentally friendly option. Further, guavas protected with non-woven bags showed significantly lower damage rates than those left uncovered. This method is beneficial not just for pest control but also in preserving the quality and marketability of guavas. Furthermore, the study explored the cumulative effects of pruning intensity, PGR's, and bagging throughout 2021 and 2022 but identified no statistically significant influence from these practices. It also investigated both first-order (A×B, B×C, and C×A) and second-order (A×B×C) interactions during these years, finding that none demonstrated significant statistical impact.

Brar *et al.,* 2019 conducted a study on different bagging treatments and analyzed their effectiveness against fruit fly infestation in fruits. Non-woven bags (NWB) emerged as the most effective, completely preventing fruit fly infestation. Other materials like leno bags, butter paper bags, newspaper bags, and perforated polythene bags showed varying degrees of infestation, with leno bags recording the highest at 68%. The study highlighted that bagging significantly reduces fruit fly damage by preventing them from piercing the fruit skin to lay eggs. Non-woven bags also minimized physical or bird damage to just 1-2%, compared to 5-7% in other treatments. The control group, without any bagging, suffered 100% fruit fly damage. Ultimately, fruits bagged in NWB showed the highest marketability and healthiness, with 98-99% being free of infestation, a stark contrast to the high damage rates in unbagged fruits.

4.2.10 Fruit weight (g)

The summarized information from Table 12 and Figure 12 indicates that within the pruning treatments, the highest guava fruit weight was achieved with 20 cm pruning, recording 133.92 gm (Year I), 143.21 gm (Year II), and 138.57 gm (Pooled). In contrast, the minimum fruit weight was observed with 10 cm pruning, observed 127.73 gm (Year I), 135.34 gm (Year II), and 131.54 gm (Pooled), and these values were statistically significant with each other.

The application of various levels of foliar PGR's expressively impacts the weight of fruits. GA3 application at 50 ppm recorded the highest fruit weight of 133.53 gm (Year I), 142.27 gm (Year II), and 137.90 (Pooled), followed by GA3 at 25 ppm with 131.98 gm (Year I), 140.85 gm (Year II), and 136.41 gm (Pooled). On the other side, the lowest weight of fruit was observed with 10 ppm NAA among the different plant growth regulator applications, weighting 128.21 gm (Year I), 136.44 gm (Year II), and 132.33 gm (Pooled).

The impact of bagging on weight is outlined in Table 12 and Figure 12. The findings reveal a significant effect of bagging on fruit weight throughout the investigation period. The non-woven bag treatment resulted in the highest fruit weight of 134.73 gm (Year I), 142.74 gm (Year II), and 138.74 gm (Pooled), while the non-bagged treatment exhibited the lowest fruit weight of 124.14 gm (Year I), 132.87 gm (Year II), and 128.50 gm (Pooled). Consequently, the use of non-woven bags led to an increase in fruit weight comparison to the unbagged fruits.

The impact of treatments on guava fruit weight was more pronounced in 2022 than in 2021. Among the first-order interactions, the A×B interaction showed a significant effect in years, 2021 and 2022. The interaction between pruning and plant growth regulator resulted in the highest fruit weight of 136.59 gm (Year I), 146.64 gm (Year II), and 141.62 gm (Pooled)) in A_2B_4, followed by A_2B_3. The lowest weight was noted in A_1B_1 treatment, with 124.82 gm (Year I), 131.76 gm (Year II), and 128.29 gm (Pooled).

Examining the first-order interactions, the A×C interaction exhibited a significant effect in the years 2021, 2022, and pooled analysis. Pruning and fruit bagging practices led to a substantial increase in fruit weight. Specifically, A_2C_2 demonstrated superior results, with 138.02 gm (Year I), 147.40 gm (Year II), and 142.71 gm (Pooled), while A_2C_1 exhibited commendable yields of 136.88 gm (Year I), 146.92 gm (Year II), and 141.90 gm (Pooled). Conversely, the minimum weight of fruit was observed in A_1C_3, where the observed values stood at 130.34 gm (Year I), 137.52 gm (Year II), and 133.93 gm (Pooled) which was lowest amoung treatments.

The significance of the interaction among the application of PGR's and the practice of fruit bagging (B×C) was evident in the study. Notably, plants treated with B_4C_2 exhibited the highest yields, with 137.93 gm (Year I), 145.95 gm (Year II), and 141.94 gm (Pooled). This was closely followed by B_4C_1, which yielded 136.67 gm (Year I), 145.05 gm (Year II), and 140.86 gm (Pooled). It is noteworthy to mention that the treatment B_1C_3 resulted in the minimum observed fruit weight of 122.47 gm (Year I), 131.01 gm (Year II), and 126.74 gm (Pooled) which was lowest among treatments.

The study's findings on fruit weight indicated a significant correlation with the level of pruning. Fruits from trees pruned at 50% showed the highest average weight of 189.14 grams, while those from unpruned (control) trees had the lowest average weight of 142.99 grams (Pandey *et al.,* 2020). Furthermore, Pratap *et al.* (2023) applied treatments via spray 45 days prior to harvest. The results showed application of GA_3, NAA and application of bagging increases the fruit weight with bagging, achieved the most favorable outcomes, particularly in fruit weight. Fruits harvested from non-woven bags (NWB) demonstrated a notably higher weight compared to other methods, with the heaviest fruits weighing around 125.2g and 125.5g for blue and white non-woven bags, respectively. There was an observed increase in fruit weight by approximately 30-35% under non-woven bags treatment compared to the unbagged control group. This increase in weight is thought to be related to the protection offered by the bags against ultraviolet rays, which in turn could lead to more cell division in the fruits and ensure better distribution of photosynthates (Brar *et. al.* 2019). A similar trend was recorded with the bagging of fruits using white polythene, suggesting the same reasoning. Fruits from different colored non-woven bags demonstrated significantly better quality attributes, such as fruit weight, taste, aroma, texture, appearance, glossiness, flavour and color as compared to those from other bagging material used (Rahman *et al.,* 2017 ; Srivastava *et al.,* 2023).

Table 12 Effect of crop regulation and bagging on Total damage (%) and Fruit weight (g) of guava cv. Allahabad Safeda

Factor	Total damage (%)			Fruit weight (g)		
	Year I	Year II	Pooled value	Year I	Year II	Pooled value
Factor (A)						
A_1	37.29	38.15	37.72	127.73 [b]	135.34 [b]	131.54 [b]
A_2	37.58	37.79	37.68	133.92 [a]	143.21 [a]	138.57 [a]
Standard Error	0.38	0.32	0.22	0.10	0.25	0.17
Critical Difference	Non-Significant	Non-Significant	Non-Significant	0.29	0.71	0.47
Factor (B)						
B_1	37.09	38.15	37.62	128.21 [d]	136.44 [d]	132.33 [d]
B_2	37.91	37.83	37.87	129.59 [c]	137.54 [c]	133.57 [c]
B_3	37.34	37.83	37.58	131.98 [b]	140.85 [b]	136.41 [b]
B_4	37.42	38.07	37.75	133.53 [a]	142.27 [a]	137.90 [a]
Standard Error	0.53	0.46	0.31	0.14	0.36	0.23
Critical Difference	Non-Significant	Non-Significant	Non-Significant	0.41	1.01	0.67
Factor (C)						
C_1	9.01 [b]	9.74 [b]	9.37 [b]	133.61 [b]	142.22 [a]	137.91 [b]
C_2	3.31 [c]	4.17 [c]	3.74 [c]	134.73 [a]	142.74 [a]	138.74 [a]
C_3	100.00 [a]	100.00 [a]	100.00 [a]	124.14 [c]	132.87 [b]	128.50 [c]
Standard Error	0.46	0.40	0.27	0.12	0.31	0.20
Critical Difference	1.32	1.13	0.75	0.35	0.88	0.58
Factor A X B						
A1B1	37.42	38.40	37.91	124.82 [h]	131.76 [g]	128.29 [h]
A1B2	37.58	38.07	37.83	126.31 [g]	134.66 [f]	130.48 [g]
A1B3	37.09	38.23	37.66	129.33 [f]	137.05 [e]	133.19 [f]
A1B4	37.09	37.91	37.50	130.47 [e]	137.90 [e]	134.18 [e]
A2B1	36.76	37.91	37.34	131.61 [d]	141.12 [cd]	136.37 [d]
A2B2	38.23	37.58	37.91	132.87 [c]	140.42 [d]	136.65 [c]
A2B3	37.58	37.42	37.50	134.62 [b]	144.66 [b]	139.64 [b]
A2B4	37.74	38.24	37.99	136.59 [a]	146.64 [a]	141.62 [a]
Mean	37.44	37.97	37.70	130.83	139.28	135.05
Standard Error	0.75	0.65	0.43	0.20	0.50	0.33
Critical Difference	Non-Significant	Non-Significant	Non-Significant	0.58	1.43	0.94

Factor A X C						
A1C1	8.58	9.80	9.19	130.34 ^{d}	137.52 ^{b}	133.93 ^{b}
A1C2	3.31	4.66	3.99	131.45 ^{c}	138.08 ^{b}	134.77 ^{b}
A1C3	100.00	100.00	100.00	121.40 ^{f}	130.42 ^{d}	125.91 ^{d}
A2C1	9.43	9.68	9.56	136.88 ^{b}	146.92 ^{a}	141.90 ^{a}
A2C2	3.31	3.68	3.49	138.02 ^{a}	147.40 ^{a}	142.71 ^{a}
A2C3	100.00	100.00	100.00	126.87 ^{e}	135.31 ^{c}	131.09 ^{c}
Mean	37.44	37.97	37.70	130.83	139.28	135.05
Standard Error	0.65	0.56	0.37	0.18	0.43	0.29
Critical Difference	Non-Significant	Non-Significant	Non-Significant	0.50	1.24	0.82
Factor B X C						
B1C1	8.82	9.56	9.19	130.64 ^{f}	138.8 ^{b}	134.72 ^{d}
B1C2	2.45	4.90	3.68	131.53 ^{e}	139.52 ^{b}	135.53 ^{d}
B1C3	100.00	100.00	100.00	122.47 ^{j}	131.01 ^{d}	126.74 ^{g}
B2C1	9.56	9.07	9.31	132.01 ^{e}	140.00 ^{b}	136.00 ^{cd}
B2C2	4.17	4.41	4.29	133.25 ^{d}	140.48 ^{b}	136.86 ^{c}
B2C3	100.00	100.00	100.00	123.51 ^{i}	132.15 ^{d}	127.83 ^{g}
B3C1	8.82	9.80	9.31	135.13 ^{c}	145.03 ^{a}	140.08 ^{b}
B3C2	3.19	3.68	3.43	136.23 ^{b}	145.02 ^{a}	140.63 ^{b}
B3C3	100.00	100.00	100.00	124.57 ^{h}	132.51 ^{d}	128.54 ^{f}
B4C1	8.82	10.54	9.68	136.67 ^{b}	145.05 ^{a}	140.86 ^{ab}
B4C2	3.43	3.68	3.56	137.93 ^{a}	145.95 ^{a}	141.94 ^{a}
B4C3	100.00	100.00	100.00	126.00 ^{g}	135.81 ^{c}	130.90 ^{e}
Mean	37.44	37.97	37.70	130.83	139.28	135.05
Standard Error	0.92	0.79	0.53	0.25	0.61	0.41
Critical Difference	Non-Significant	Non-Significant	Non-Significant	0.71	1.75	1.16

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

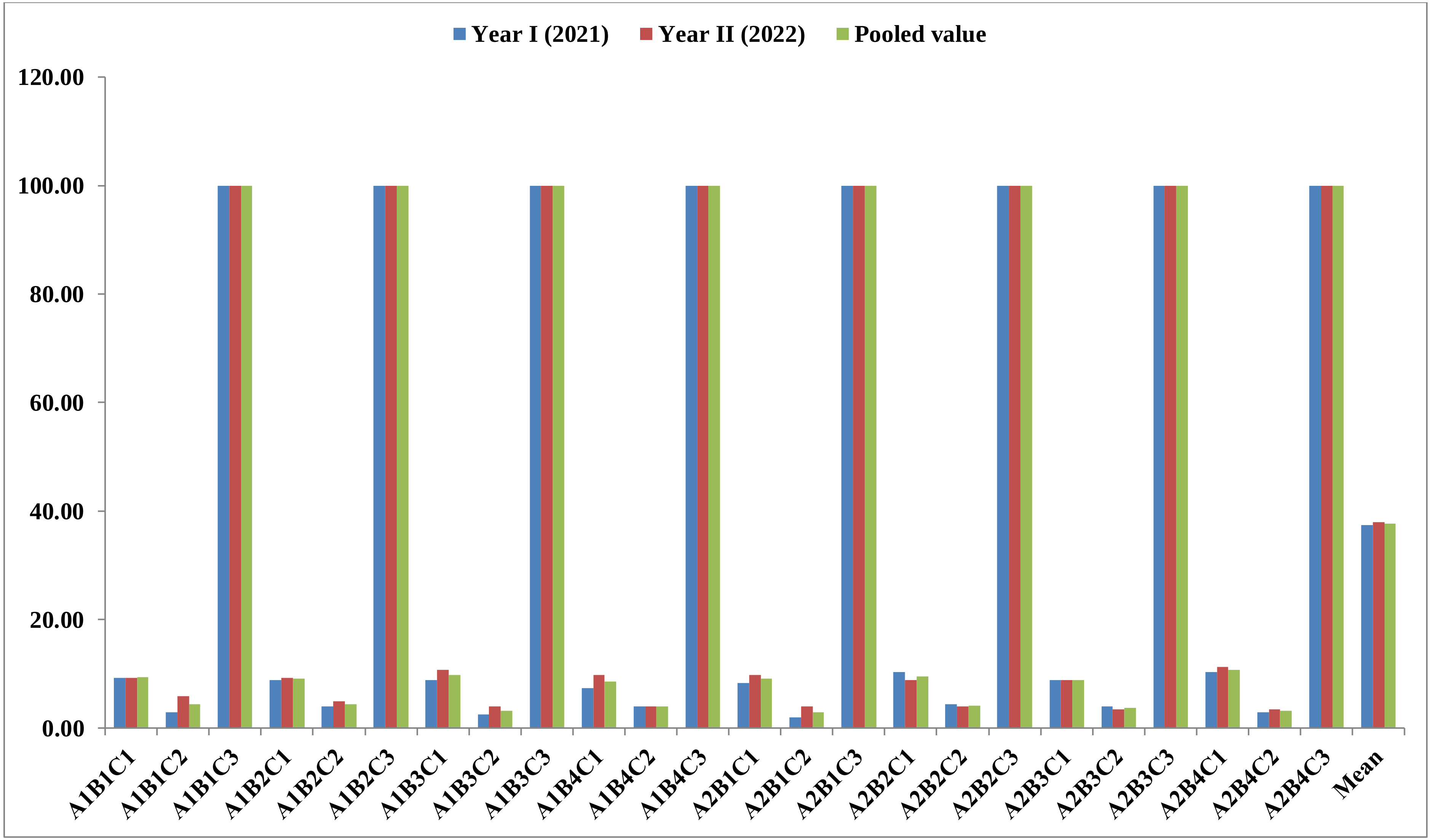

Figure 11 Effect of crop regulation and bagging on Total damage (%) of guava cv. Allahabad Safeda.

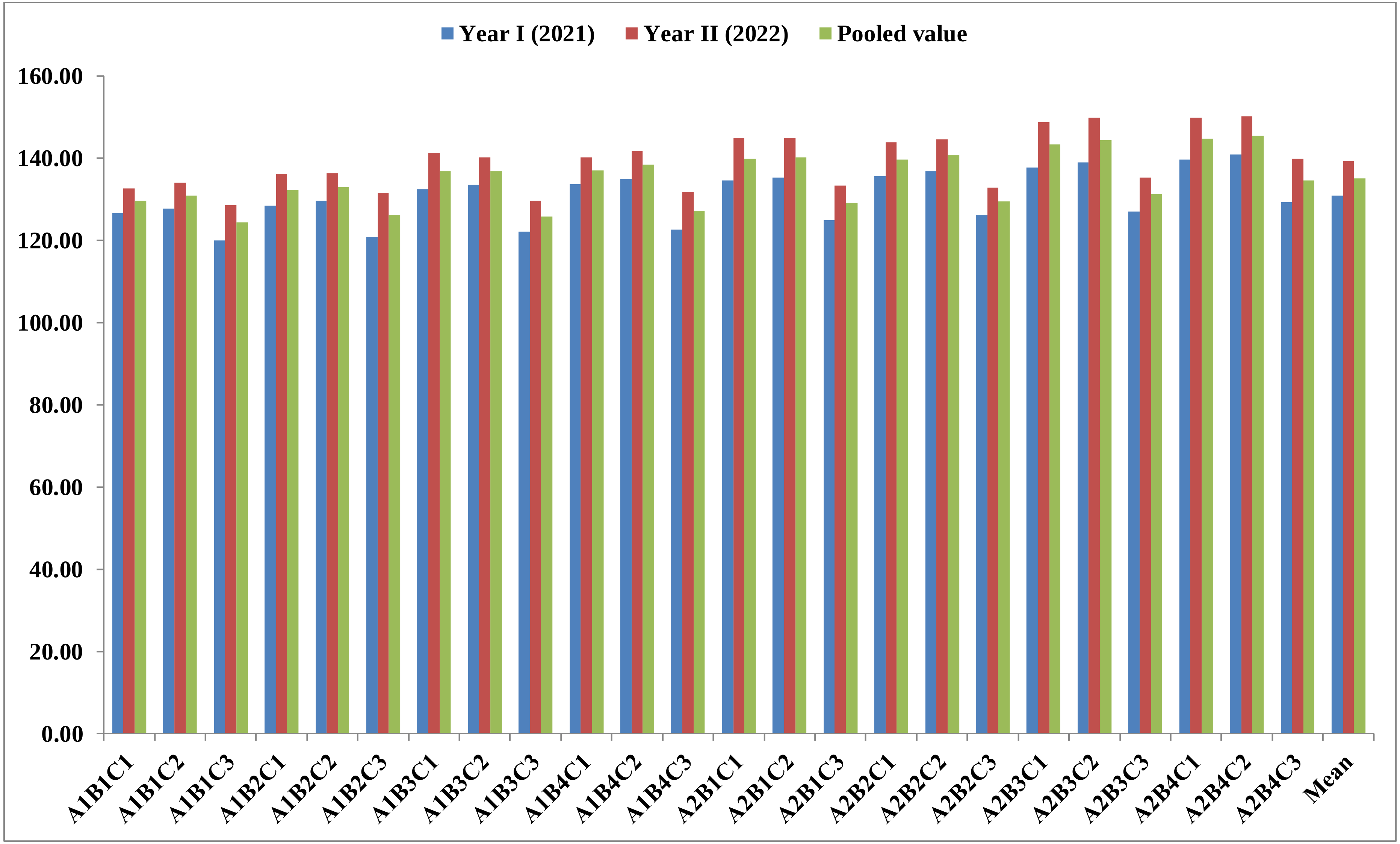

Figure 12 Effect of crop regulation and bagging on Fruit weight (g) of guava cv. Allahabad Safeda.

4.2.11 TSS (^{0}Brix)

The condensed data from Table 13 and Figure 13 indicates that the highest guava TSS was observed with 20 cm pruning, measuring 10.52 ^{0}Brix (Year I), 10.69 ^{0}Brix (Year II), and 10.61 ^{0}Brix (Pooled). In contrast, the minimum TSS was recorded with 10 cm pruning, registering 10.04 ^{0}Brix (Year I), 10.21 ^{0}Brix (Year II), and 10.12 ^{0}Brix (Pooled), and these values exhibited statistical significance.

The foliar application of various concentrations of foliar PGR's significantly impacted guava TSS. GA3 application at 50 ppm recorded the highest TSS of 10.49 ^{0}Brix (Year I), 10.66 ^{0}Brix (Year II), and 10.58 ^{0}Brix (Pooled), followed by GA3 at 25 ppm with 10.37 ^{0}Brix (Year I), 10.54 ^{0}Brix (Year II), and 10.46 ^{0}Brix (Pooled). Conversely, the lowest TSS was observed with 10 ppm NAA among the different plant growth regulator applications, measuring 10.07 ^{0}Brix (Year I), 10.24 ^{0}Brix (Year II), and 10.16 ^{0}Brix (Pooled).

The impact of fruit bagging on TSS is outlined in Table 13 demonstrate a significant effect of bagging on TSS throughout the investigation period. The non-woven bag treatment resulted in the highest TSS of 10.59 ^{0}Brix (Year I), 10.77 ^{0}Brix (Year II), and 10.68 ^{0}Brix (Pooled), while the non-bagged treatment exhibited the lowest TSS of 10.50 ^{0}Brix (Year I), 10.68 ^{0}Brix (Year II), and 10.59 ^{0}Brix (Pooled). Consequently, the use of non-woven bags led to an increment in TSS as compared to the unbagged.

Moreover, the interaction impact of pruning, plant growth regulator and bagging was determined to be statistically insignificant in both years. Over the years 2021 and 2022, the first-order interactions (A×B, B×C, and C×A) as well as the second-order interaction (A×B×C) were determined to be statistically insignificant.

A study by Bhagawati *et al.*, in 2015 observed that TSS in guava fruits increased with greater pruning intensity, with the lowest levels found in unpruned plants. Pruning improves sunlight and air penetration, boosts photosynthesis, and concentrates the tree's resources, leading to sweeter and higher-quality fruits. Furthermore, Jayswal *et al.*, in 2017 reported the highest levels of TSS, ascorbic acid, and Sugars in pruned treatments contrasting with the minimum levels found in unpruned plants. These studies collectively highlight the significant impact of pruning practices on the biochemical properties of guava fruits, particularly their TSS content. The application of GA_3 increases guava's Total Soluble Solids (TSS), enhancing fruit sweetness and size. Conversely, NAA shows a lesser impact on TSS, indicating GA_3

superior role in optimizing sugar content and overall fruit quality in guavas. GA_3, a plant growth regulator, promotes cell enlargement and division, leading to enhanced photosynthesis and nutrient allocation in guava fruits. This results in increased sugar accumulation, thus raising TSS levels. NAA, while also influencing growth, has a less pronounced effect on TSS. Bagging guava fruits significantly elevates their Total Soluble Solids (TSS) content, enhancing sweetness and quality. This method protects fruits from environmental stressors and pests, leading to better growth conditions. It also optimizes light and temperature regulation, contributing to increased sugar concentration and improved TSS (Brar *et al.,* 2019).

4.2.12 Acidity (%)

The summarized information from Table 13 and Figure 14 reveals that within the pruning treatments, the lowest guava acidity was observed with 20 cm pruning, estimated 0.30% in combined analysis. In contrast, the highest acidity was noted in 10 cm pruning, estimated 0.33%, and these values exhibited statistical significant with each other.

The impact of different concentrations of foliar application of PGR's on guava acidity was found to be non-significant. GA3 application at 50 ppm recorded the lowest acidity of 0.31% in the pooled analysis. In contrast, the highest acidity, measuring 0.32%, was observed with 10 ppm NAA, 20 ppm NAA, and 25 ppm GA3, and these values were non-significant when compared to each other.

The impact of fruit bagging on acidity is delineated in Table 13 and illustrates a noteworthy impact of bagging on acidity over the entire study duration. The non-woven bag treatment yielded the lowest acidity at 0.29%, followed by 0.30% in C_1, whereas the non-bagged treatment displayed the highest acidity at 0.36% in C_3 demonstrating statistical significance. Consequently, the adoption of non-woven bags resulted in an elevation of acidity compared to the control group.

Furthermore, the interaction impact of pruning, plant growth regulator, and bagging was determined to be statistically insignificant in both years. During the years 2021 and 2022, the first-order interactions (A×B, B×C, and C×A) and the second-order interaction (A×B×C) were all determined to have no statistically significant effects.

The reduction in titratable acidity as pruning intensity increases may be due to the accumulation of acid in new leaves as fruits develop. This decrease in acidity, together with better sunlight penetration, larger leaf areas, and increased chlorophyll content from pruning, significantly improves fruit quality. Additionally, previous research indicates that keeping a balanced fruit load on guava trees is crucial for enhancing fruit quality. Kumar and Rattanpal (2010) found that acidity was lower in guavas with half of their vegetative growth pruned. Bhagawati *et al.* (2015) reported that unpruned guava trees had the highest acidity, which decreased as pruning intensity increased. Rahman *et al.* (2018) observed that the highest acidity levels were found in control conditions, while the lowest were in fruits covered with white polythene bags. This reduction in acidity could be due to the consumption of organic acids during respiration and other biodegradable reactions.

Table 13 Effect of crop regulation and bagging on TSS (^{0}Brix) and Acidity (%) of guava fruit cv. Allahabad Safeda.

Factor	TSS (^{0}Brix)			Acidity (%)		
	Year I	Year II	Pooled value	Year I	Year II	Pooled value
Factor (A)						
A_1	10.04 ^{b}	10.21 ^{b}	10.12 ^{b}	0.33 ^{a}	0.33 ^{a}	0.33 ^{a}
A_2	10.52 ^{a}	10.69 ^{a}	10.61 ^{a}	0.30 ^{b}	0.30 ^{b}	0.30 ^{b}
Standard Error	0.04	0.04	0.03	0.003	0.003	0.003
Critical Difference	0.12	0.13	0.079	0.010	0.009	0.010
Factor (B)						
B_1	10.07 ^{b}	10.24 ^{b}	10.16 ^{c}	0.32	0.32	0.32
B_2	10.18 ^{b}	10.35 ^{b}	10.27 ^{c}	0.32	0.32	0.32
B_3	10.37 ^{a}	10.54 ^{a}	10.46 ^{b}	0.32	0.32	0.32
B_4	10.49 ^{a}	10.66 ^{a}	10.58 ^{a}	0.31	0.31	0.31
Standard Error	0.06	0.06	0.04	0.005	0.005	0.005
Critical Difference	0.16	0.18	0.11	Non-Significant	Non-Significant	Non-Significant
Factor (C)						
C_1	10.50 ^{a}	10.68 ^{a}	10.59 ^{a}	0.30 ^{b}	0.30 ^{b}	0.30 ^{b}
C_2	10.59 ^{a}	10.77 ^{a}	10.68 ^{a}	0.29 ^{b}	0.29 ^{b}	0.29 ^{b}
C_3	9.75 ^{b}	9.91 ^{b}	9.83 ^{b}	0.36 ^{a}	0.36 ^{a}	0.36 ^{a}
Standard Error	0.05	0.05	0.03	0.004	0.004	0.004
Critical Difference	0.14	0.15	0.10	0.012	0.011	0.012
Factor A X B						
A1B1	9.81	9.98	9.89	0.34	0.34	0.34
A1B2	9.92	10.09	10.01	0.33	0.33	0.33
A1B3	10.16	10.33	10.25	0.33	0.33	0.33
A1B4	10.25	10.42	10.34	0.33	0.33	0.33
A2B1	10.34	10.51	10.43	0.30	0.30	0.30
A2B2	10.44	10.61	10.53	0.30	0.30	0.30
A2B3	10.58	10.75	10.66	0.30	0.30	0.30
A2B4	10.73	10.90	10.82	0.30	0.30	0.30
Mean	10.28	10.45	10.36	0.32	0.32	0.32
Standard Error	0.08	0.09	0.06	0.007	0.007	0.007
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X C						
A1C1	10.24	10.42	10.33	0.32	0.32	0.32
A1C2	10.33	10.51	10.42	0.30	0.30	0.30
A1C3	9.54	9.69	9.62	0.37	0.37	0.37

A2C1	10.76	10.93	10.85	0.28	0.28	0.28
A2C2	10.85	11.02	10.93	0.27	0.27	0.27
A2C3	9.97	10.12	10.05	0.35	0.35	0.35
Mean	10.28	10.45	10.36	0.32	0.32	0.32
Standard Error	0.07	0.08	0.05	0.006	0.006	0.006
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor B X C						
B1C1	10.27	10.44	10.36	0.31	0.31	0.31
B1C2	10.34	10.51	10.42	0.29	0.29	0.29
B1C3	9.62	9.78	9.70	0.36	0.36	0.36
B2C1	10.37	10.55	10.46	0.30	0.30	0.30
B2C2	10.47	10.65	10.56	0.29	0.29	0.29
B2C3	9.71	9.86	9.78	0.36	0.36	0.36
B3C1	10.62	10.80	10.71	0.30	0.30	0.30
B3C2	10.71	10.88	10.79	0.29	0.29	0.29
B3C3	9.79	9.94	9.87	0.36	0.36	0.36
B4C1	10.74	10.92	10.83	0.30	0.30	0.30
B4C2	10.84	11.02	10.93	0.28	0.28	0.28
B4C3	9.90	10.06	9.98	0.36	0.36	0.36
Mean	10.28	10.45	10.36	0.32	0.32	0.32
Standard Error	0.10	0.11	0.07	0.009	0.008	0.008
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

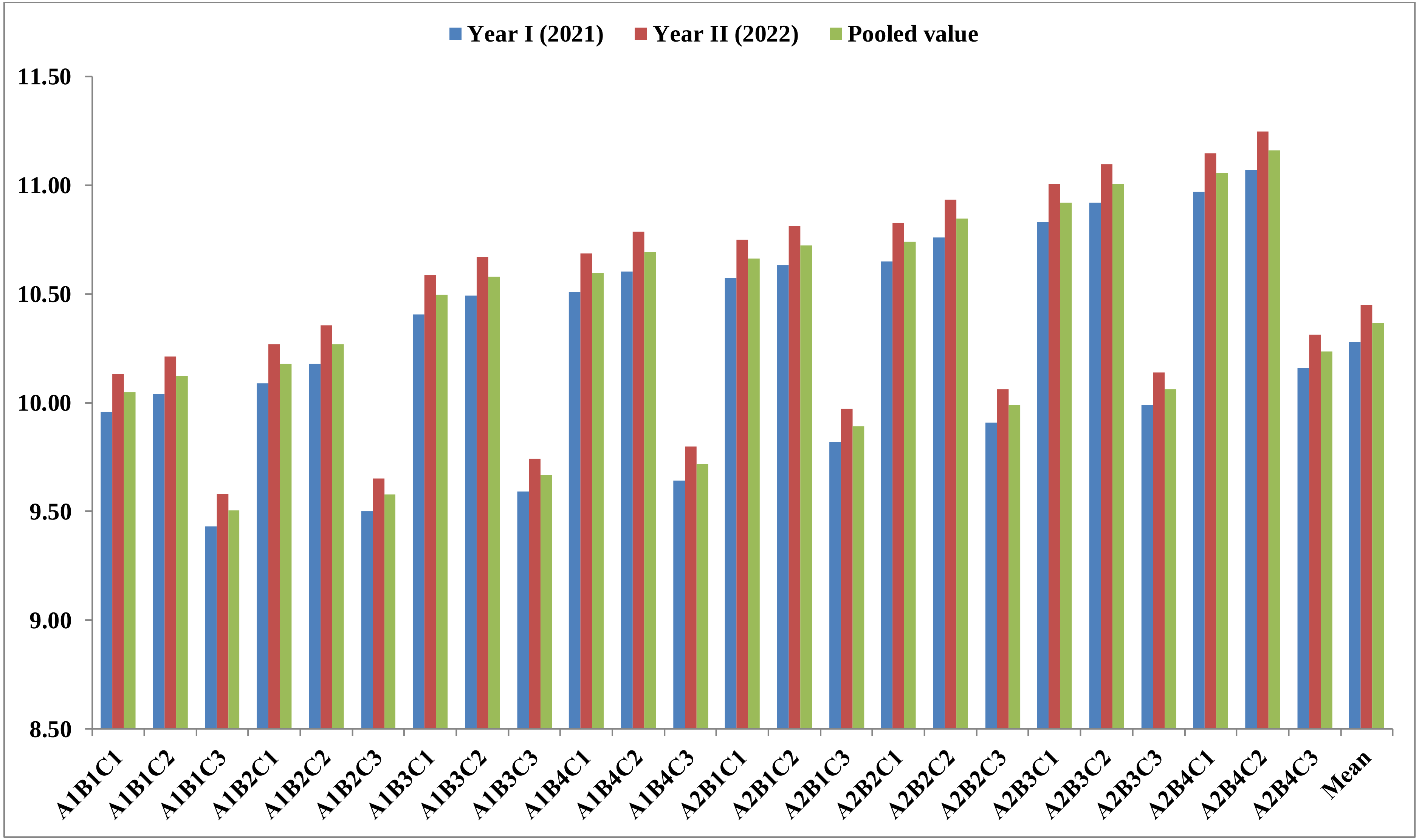

Figure 13 Effect of crop regulation and bagging on TSS (^{0}Brix) of guava fruit cv. Allahabad Safeda.

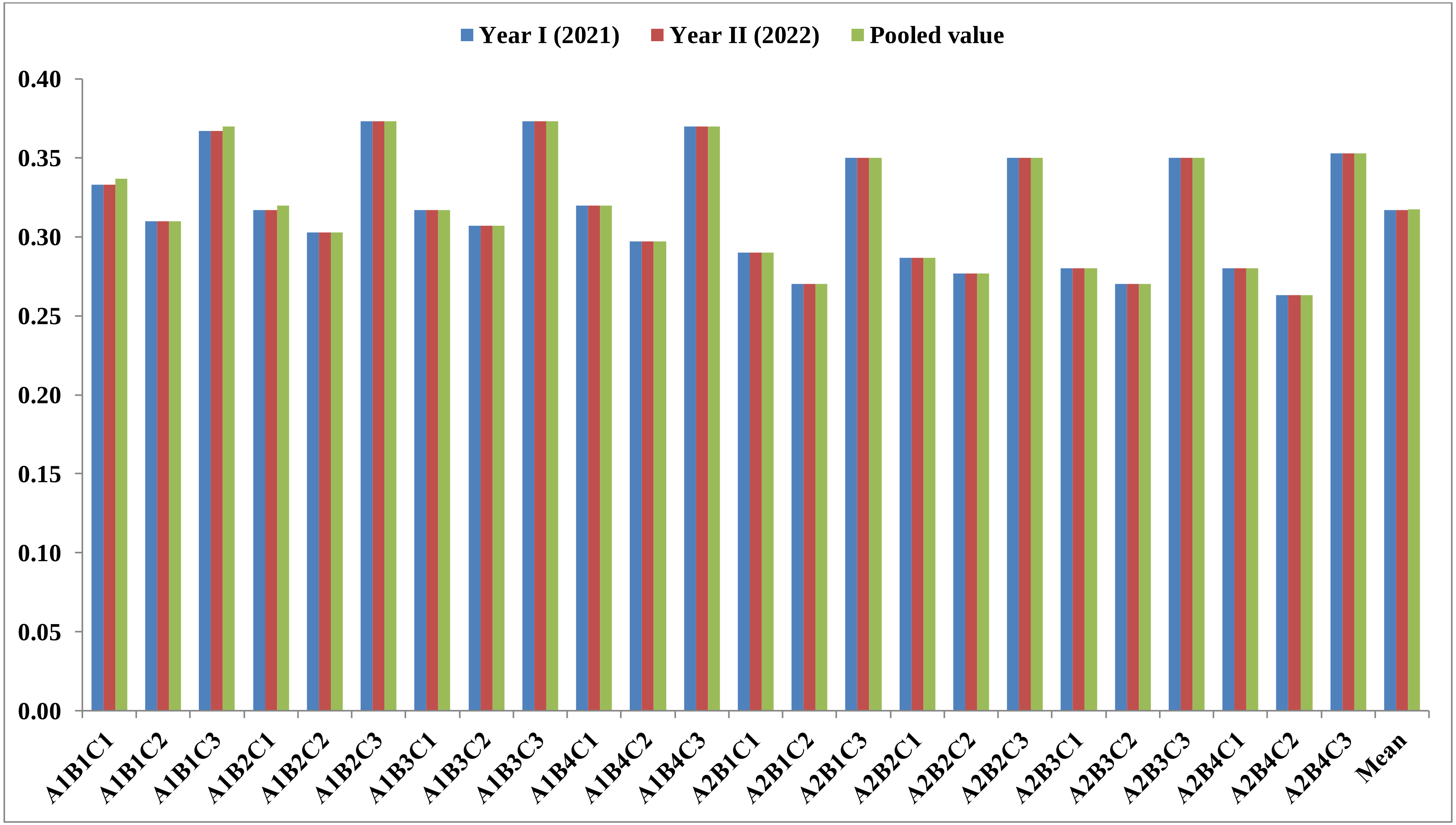

Figure 14 Effect of crop regulation and bagging on Acidity (%) of guava fruit cv. Allahabad Safeda.

4.2.13 TSS: Acid Ratio

The condensed information extracted from Table 14 and Figure 15 suggests that, the highest guava TSS: Acid levels were observed with 20 cm pruning, measuring 35.57 (Year I), 36.14 (Year II), and 35.86 (Pooled). In contrast, the lowest TSS: Acid values were noted with 10 cm pruning, recorded at 30.63 (Year I), 31.12 (Year II), and 30.87 (Pooled). Notably, these values exhibited statistical significance when compared with each other.

The impact of different concentrations plant growth regulators on guava TSS: Acid was found to be significant. GA3 application at 50 ppm yielded the highest TSS: Acid levels at 34.23 (Year I), 34.76 (Year II), and 34.49 (Pooled). Conversely, the lowest TSS: Acid levels were observed at 32.06 (Year I), 32.57 (Year II), and 32.32 (Pooled) with statistical significance evident when compared to each other.

The impact of fruit bagging on TSS: Acid is delineated in Table 14 illustrate a significant impact of bagging on TSS: Acid throughout the entire study duration. The non-woven bag treatment yielded the highest TSS: Acid at 37.17 (Year I), 37.78 (Year II), and 37.47 (Pooled), while the non-bagged treatment displayed the lowest TSS: Acid at 27.21 (Year I), 27.61 (Year II), and 27.41 (Pooled) in C_3, demonstrating statistical significance. Consequently, the adoption of non-woven bags resulted in an increase in TSS: Acid compared to the control group.

Moreover, the statistical significance of the interaction effect between pruning and bagging was established in both 2021 and 2022. Specifically, in both years, only the first-order interaction A x C was deemed significant. In this interaction, it was observed that the maximum TSS: Acid levels were recorded at 40.26 (Year I), 40.92 (Year II), and 40.59 (Pooled) in A_2C_2, while the minimum TSS: Acid ratio was noted as 25.81 (Year I), 26.20 (Year II), and 26.00 (Pooled) in A_1C_3. Furthermore, the interactions A x B and B x C were determined to be non-significant. In a similar vein, the second-order interaction A x B x C was also found to have no significant effect.

The reduced TSS: acid ratio in unpruned plants may result from slower conversion of starch to sugar, nutrient competition, and reduced light exposure. Pruning appears to enhance total sugar levels, possibly through improved nutrient distribution to vegetative buds, which supports prompt bud initiation and boosts photosynthetic efficiency. Additionally, pruning aids in the redistribution of photosynthates from the upper part of the tree to lateral branches, which promotes bud development (Paikra and Sahu, 2021). The elevated sugar-acid ratio in GA3 treated fruits is likely a result of increased sugar accumulation and a corresponding decrease in acid content within the fruits (Lal and Das, 2017). Bagging guava fruits positively affects the TSS acid ratio, primarily due to its ability to modify the microclimate around the fruit. This method protects the fruits from direct sunlight and external stressors, leading to a more controlled ripening process. As a result, bagged fruits often have higher TSS levels, which contribute to increased sweetness. At the same time, the controlled environment can slow down the accumulation of organic acids, or these acids might be utilized more effectively during respiration and other metabolic processes. Therefore, the TSS: acid ratio is generally higher in bagged guavas, indicating a sweeter and more palatable fruit, which is desirable for both fresh consumption and processing (Meena *et al.,* 2016).

4.2.14 Total sugars (%)

The summarized information from Table 14 and Figure 16 indicates a noteworthy increase in total sugar content with severity of pruning in both year 2021 and 2022 which resulted in the highest percentage of total sugar in guava fruit at 6.80% (Year I), 6.86% (Year II) and 6.83% (Pooled) in 20 cm (A_2). These values were comparable with 10 cm (A_1) pruning intensity, which yielded total sugar percentages of 6.50% (Year I), 6.58 (Year II) and 6.54% (Pooled). Significantly, there was a statistical distinction between these values upon comparison.

The impact of fruit bagging on total sugar is delineated in Table 14 illustrate a significant impact of bagging on total sugar throughout the entire study duration. The C_2 (non-woven bag) treatment yielded the highest total sugar at 6.86% (Year I), 6.93% (Year II), and 6.89% (Pooled), while the C_3 (non-bagged) treatment displayed the lowest total sugar at 6.45% (Year I), 6.53% (Year II), and 6.49% (Pooled), demonstrating statistical significance. Consequently, the adoption of non-woven bags resulted in an increase in total sugar compared to the control group.

Moreover, the non-significance effect between pruning, plant growth regulator and bagging was established in both 2021 and 2022. The interactions AxB, BxC, and AxC were identified as non-significant. Likewise, the second-order interaction AxBxC was also found insignificant.

Pruning has a positive effect on the total sugars in guava fruits primarily because it enhances the plant's photosynthetic efficiency and nutrient allocation. By selectively removing parts of the plant, pruning increases sunlight penetration and air circulation within the canopy, which boosts photosynthesis. This increase in light exposure and improved leaf health allows the tree to produce more sugars. Additionally, pruning helps to redistribute nutrients more efficiently to the fruit-bearing parts of the tree, rather than supporting non-fruiting branches. This focused distribution of resources encourages the development of sweeter fruits, as more of the plant's energy and resources are directed towards fruit production rather than maintaining excess vegetative growth. Total sugars were found to be higher in pruned plants. These observations regarding carbohydrate and sugar content align with findings reported by Bagachi *et al.,* 2008. Using fruit bagging in guava trees positively affects the total sugar content of the fruits. The non-woven fabric helps create a microenvironment that moderates temperature around the developing fruit, reducing stress and promoting more consistent and efficient metabolic processes including photosynthesis. This controlled environment also shields the fruits from direct sunlight, which can reduce excessive transpiration and allow for better moisture retention, facilitating the optimal conversion of starches into sugars. Furthermore, the protection offered by non-woven bags and muslin cloth bags from pests and physical damage allows the fruits to develop under less stress, which is conducive to higher sugar accumulation, ultimately enhancing the sweetness and overall quality of the guava fruits. Various studies supported that bagging of fruits positively impacts the total sugars of guava. (Afroz *et al.,* 2023; Abbasi *et al.,* 2014).

Table 14 Effect of crop regulation and bagging on TSS: Acid Ratio and Total Sugars % of guava fruit cv. Allahabad Safeda.

Factor	TSS : Acid Ratio			Total Sugars (%)		
	Year I	Year II	Pooled value	Year I	Year II	Pooled value
Factor (A)						
A_1	30.63 [b]	31.12 [b]	30.87 [b]	6.50 [b]	6.58 [b]	6.54 [b]
A_2	35.57 [a]	36.14 [a]	35.86 [a]	6.80 [a]	6.86 [a]	6.83 [a]
Standard Error	0.38	0.33	0.34	0.032	0.023	0.021
Critical Difference	1.07	0.93	0.96	0.091	0.076	0.069
Factor (B)						
B_1	32.06 [b]	32.57 [b]	32.32 [b]	6.63	6.66	6.65
B_2	32.61 [b]	33.15 [b]	32.88 [b]	6.65	6.70	6.68
B_3	33.50 [a]	34.05 [a]	33.77 [a]	6.66	6.74	6.70
B_4	34.23 [a]	34.76 [a]	34.49 [a]	6.68	6.77	6.73
Standard Error	0.53	0.46	0.47	0.045	0.032	0.029
Critical Difference	1.51	1.31	1.35	Non-Significant	Non-Significant	Non-Significant
Factor (C)						
C_1	34.93 [b]	35.50 [b]	35.22 [b]	6.65 [b]	6.70 [b]	6.68 [b]
C_2	37.17 [a]	37.78 [a]	37.47 [a]	6.86 [a]	6.93 [a]	6.89 [a]
C_3	27.21 [c]	27.61 [c]	27.41 [c]	6.45 [c]	6.53 [a]	6.49 [c]
Standard Error	0.46	0.40	0.41	0.039	0.028	0.025
Critical Difference	1.31	1.14	1.17	0.112	0.08	0.072
Factor A X B						
A1B1	29.45	29.90	29.67	6.48	6.52	6.50
A1B2	30.42	30.91	30.66	6.49	6.56	6.53
A1B3	31.00	31.53	31.26	6.51	6.59	6.55
A1B4	31.64	32.14	31.89	6.52	6.63	6.57
A2B1	34.68	35.25	34.96	6.77	6.80	6.79
A2B2	34.80	35.39	35.10	6.80	6.85	6.82
A2B3	36.00	36.56	36.28	6.81	6.89	6.85
A2B4	36.82	37.38	37.10	6.84	6.92	6.88
Mean	33.10	33.63	33.37	6.65	6.72	6.69
Standard Error	0.75	0.65	0.67	0.064	0.046	0.041
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X C						
A1C1	32.00 [d]	32.51 [d]	32.26 [d]	6.49	6.57	6.53
A1C2	34.08 [c]	34.64 [c]	34.36 [c]	6.72	6.80	6.76
A1C3	25.81 [f]	26.20 [f]	26.00 [f]	6.30	6.36	6.33

A2C1	37.86 [b]	38.48 [b]	38.18 [b]	6.81	6.84	6.82
A2C2	40.26 [a]	40.92 [a]	40.59 [a]	6.99	7.05	7.02
A2C3	28.60 [e]	29.03 [e]	28.82 [e]	6.61	6.71	6.66
Mean	33.10	33.63	33.37	6.65	6.72	6.69
Standard Error	0.65	0.57	0.58	0.056	NS	0.036
Critical Difference	1.85	1.61	1.65	Non-Significant	Non-Significant	Non-Significant
Factor B X C						
B1C1	33.27	33.81	33.54	6.63	6.64	6.64
B1C2	35.98	36.59	36.29	6.84	6.87	6.85
B1C3	26.94	27.33	27.13	6.42	6.48	6.45
B2C1	34.64	35.18	34.91	6.64	6.69	6.67
B2C2	36.25	36.88	36.57	6.85	6.90	6.87
B2C3	26.95	27.39	27.17	6.45	6.53	6.49
B3C1	35.83	36.43	36.13	6.65	6.72	6.68
B3C2	37.40	38.02	37.71	6.87	6.95	6.91
B3C3	27.28	27.69	27.48	6.46	6.54	6.50
B4C1	35.99	36.58	36.29	6.68	6.75	6.72
B4C2	39.04	39.64	39.34	6.88	6.98	6.93
B4C3	27.66	28.06	27.86	6.48	6.59	6.53
Mean	33.10	33.63	33.37	6.65	6.72	6.69
Standard Error	0.92	0.80	0.82	0.079	0.056	0.050
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, p≤0.05) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

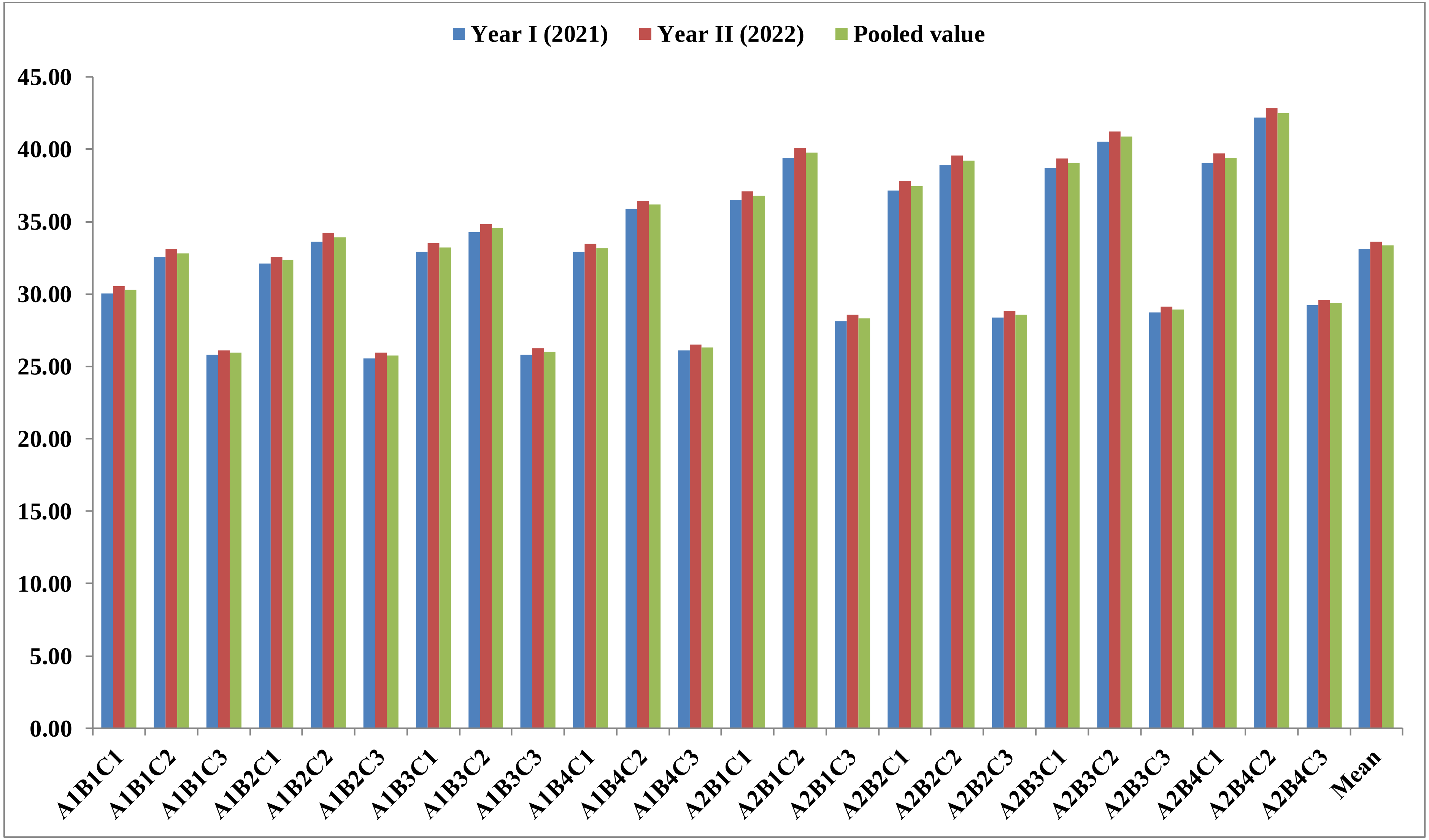

Figure 15 Effect of crop regulation and bagging on TSS: Acid Ratio of guava fruit cv. Allahabad Safeda.

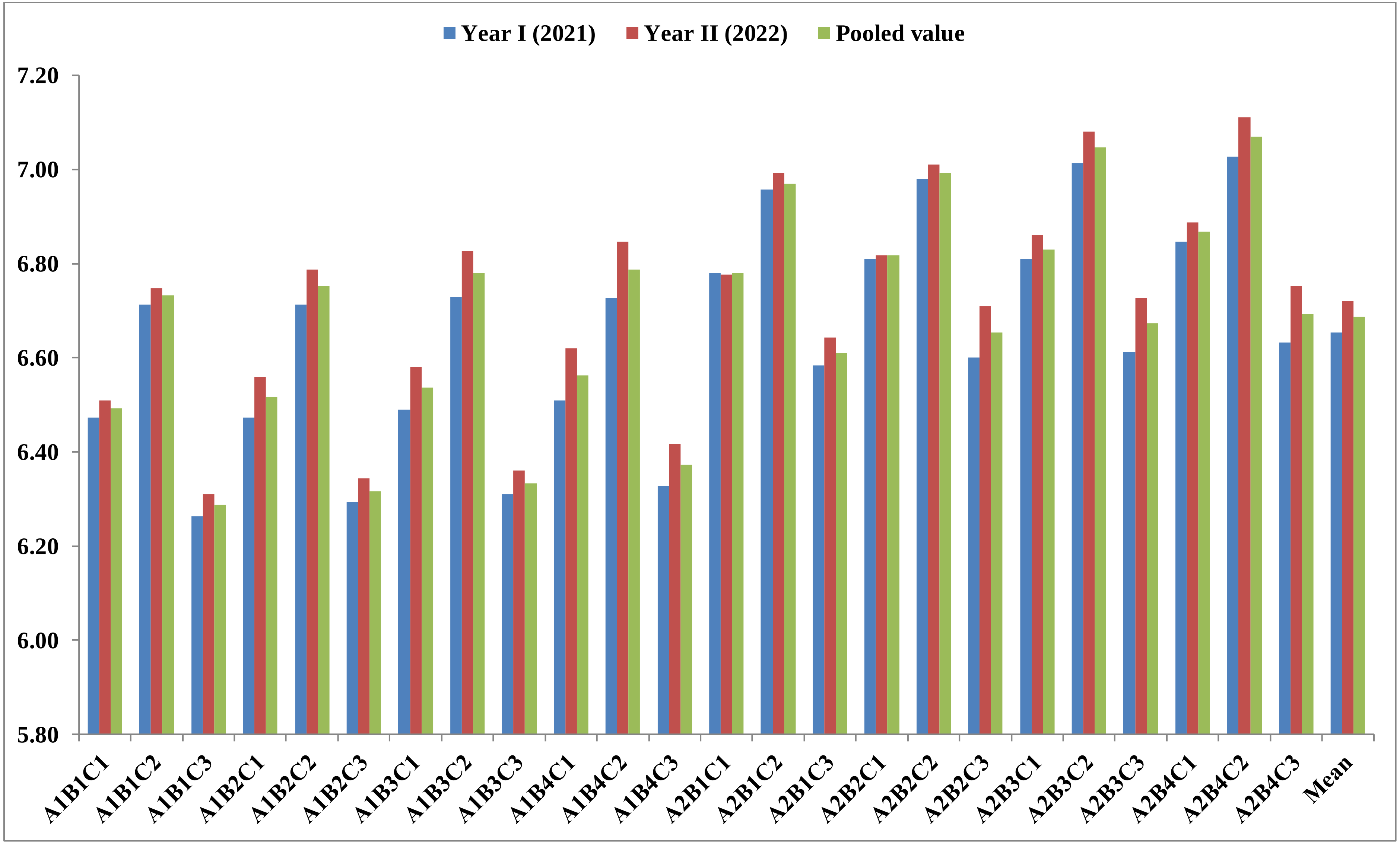

Figure 16 Effect of crop regulation and bagging on Total Sugars % of guava fruit cv. Allahabad Safeda.

4.2.15 Reducing Sugars (%)

The summarized data from Table 15 and Figure 17 indicates a substantial increase in reducing sugar with pruning intensity in both 2021 and 2022, resulting in the highest percentage of reducing sugar in guava fruit at 3.68% (Year I), 3.81% (Year II), and 3.74% (Pooled) in 20 cm (A_2). These values were comparable with 10 cm (A_1) pruning intensity, which yielded reducing sugar percentages of 3.52% (Year I), 3.63 (Year II), and 6.58% (Pooled). Importantly, there was a statistical distinction between these values upon comparison.

The impact of bagging on reducing sugar is delineated in Table 15 and results illustrate a significant impact of bagging on reducing sugar throughout the entire study duration. The C_2 (non-woven bag) treatment yielded the highest reducing sugar at 3.69% (Year I), 3.82% (Year II), and 3.76% (Pooled), while the C_3 (non-bagged) treatment displayed the lowest reducing sugar at 3.51% (Year I), 3.62% (Year II), and 3.57% (Pooled), demonstrating statistical significance. Consequently, the adoption of non-woven bags led to a rise in reducing sugar levels compared to the control group.

Moreover, the combined impact of pruning, the use of plant growth regulators, and bagging showed no significant effect in either 2021 or 2022. The first order interactions AxB, BxC and CxA were determied to be insignificant. Similarly, the second-order interaction AxBxC was also determined to be non-significant.

Pruning severity plays an essential role in concentrations of reducing sugars which direct involves in leaf-to-fruit ratio. This adjustment facilitated enhanced carbohydrate and metabolite synthesis, subsequently facilitating their translocation to the fruit tissues (Kadam *et al.,* 2018; More and Raut, 2013). This trend likely stems from the enhanced nutrient uptake in pruned trees, fostering increased carbohydrate and metabolite synthesis, and subsequent translocation to the fruits (Parsana *et al.,* 2023; Singh *et al.,* 2023). These observations align with prior studies conducted on various fruits, including custard apple and mango (Rani and Honnabyraiah, 2019). The notable association between pruning of guava trees likely arises from the elevated levels of stored photosynthates and the prompt activation of vegetative buds in older plants following pruning (Samant and Kishore, 2019). The escalation in non-reducing sugar content in guava fruits subsequent to more intense pruning may be attributed to the beneficial effects of pruning on photophosphorylation and the dark reaction of photosynthesis. When guavas are bagged, the microenvironment around the fruit changes, which influence physiological processes and biochemical pathways, including those related to sugar metabolism. Studies suggest that fruit bagging can lead to an increase in the concentration of reducing sugars in guava fruits. This increase is likely due to altered light exposure and microclimate conditions, such as humidity and temperature, which can enhance the synthesis of sugars or slow their conversion into more complex forms. As a result, bagged guavas often exhibit higher sweetness levels compared to their unbagged counterparts, making this practice beneficial for improving the taste and commercial value of the fruit (Mishra *et al.*, 2017; Sharma *et al.,* 2018).

4.2.16 Non-reducing sugars (%)

The restructured analysis from Table 15 and Figure 18 presents a noteworthy rise in non-reducing sugar correlated with the intensity of pruning for the years 2021 and 2022. The highest concentration of non-reducing sugar in guava was recorded at 3.13% (Year I), 3.06%, and 3.09% (Pooled) for the 20 cm pruning range (A_2). These values were significant to those found at the 10 cm pruning range (A_1), where the non-reducing sugar percentages were 2.98% (Year I), 2.95%, and 2.97% (Pooled). A significantly statistical difference was noted in these measurements.

The impact of fruit bagging on non-reducing sugar is outlined in Table 15 showed a significant impact of bagging on non-reducing sugar throughout the study period. The C_2 showed the highest non-reducing sugar levels at 3.17% (Year I), 3.10% (Pooled), and 3.14% (Pooled). Meanwhile, the C_3 group (without bags) had the lowest non-reducing sugar levels at 2.94% (Year I), 2.91% (Year II), and 2.93% (Pooled), which shows a statistically significant difference with each other. Thus, the use of non-woven bags led to an increase in non-reducing sugar concentration as compared to the non-bagged group.

Furthermore, there was a non-significance interaction effect between pruning, planat growth regulator and bagging was established in both 2021 and 2022. Notably, in both years, only the first-order interaction AxC, AxB and BxC, as well as the second-order interaction AxBxC, were not found to be significant.

The levels of non-reducing sugars were directly impacted by severity of pruning. The study found that the higher pruning intensity had significantly higher non-reducing sugar content in fruits. Pruning guava trees significantly influence the accumulation of non-reducing sugars in the fruits, primarily due to changes in resource allocation and overall plant health. By removing parts of the tree, pruning alters the balance between vegetative growth and fruit development, potentially enhancing the concentration of non-reducing sugars. This effect attributed to the tree diverting more of its resources towards the development of fewer fruits, thus potentially increasing their sugar content. Therefore, strategic pruning can be a vital agricultural practice for optimizing the sugars and quality guava (Singh *et al.,* 2024; Jayswas *et al.,* 2017).

Bagging of guava significantly enhances fruit quality and protection. By enclosing the fruits in bags, they are effectively shielded from direct exposure to pests. The bagging also protects guavas from physical damage like bird pecks, ensuring the fruits maintain a visually appealing exterior. However, the data also revealed an increment in non-reducing sugars in bagged fruits as compared to those that were un-bagged. Research conducted by Zhou and Guo (2005), Meena *et al.* (2016), and Watanawan *et al.* (2008) shows similar findings. Bagging can enhance non-reducing sugar levels by modifying environmental factors such as light, temperature which are crucial for fruit ripening and maturation. The use of bags, particularly thermo-resistant ones, helps limit light penetration and creates a favorable microclimate by maintaining temperature and humidity levels, whereas clear polyethylene bags can absorb light, thus raising the temperature and humidity around the fruit, potentially degrading the non-reducing sugar content.

Table 15 Effect of crop regulation and bagging on Reducing Sugar (%) and Non-reducing sugars (%) of guava cv. Allahabad Safeda

Factor	Reducing Sugars (%)			Non-reducing sugars (%)		
	Year I	Year II	Pooled value	Year I	Year II	Pooled value
Factor (A)						
A1	3.52 [b]	3.63 [b]	3.58 [b]	2.98 [b]	2.95 [b]	2.97 [b]
A2	3.68 [a]	3.81 [a]	3.74 [a]	3.13 [a]	3.06 [a]	3.09 [a]
Standard Error	0.022	0.025	0.021	0.02	0.032	0.015
Critical Difference	0.062	0.071	0.060	0.056	0.090	0.044
Factor (B)						
B1	3.62	3.71	3.67	3.01	2.96	2.98
B2	3.58	3.73	3.66	3.06	2.97	3.02
B3	3.57	3.70	3.64	3.09	3.03	3.06
B4	3.61	3.73	3.67	3.07	3.05	3.06
Standard Error	0.031	0.035	0.03	0.028	0.045	0.022
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor (C)						
C1	3.59 [b]	3.71 [b]	3.65 [b]	3.06 [b]	2.99 [a]	3.03 [b]
C2	3.69 [a]	3.82 [a]	3.76 [a]	3.17 [a]	3.10 [a]	3.14 [a]
C3	3.51 [b]	3.62 [b]	3.57 [c]	2.94 [c]	2.91 [b]	2.93 [c]
Standard Error	0.027	0.031	0.026	0.024	0.039	0.019
Critical Difference	0.076	0.087	0.073	0.069	0.111	0.054
Factor A X B						
A1B1	3.54	3.61	3.58	2.95	2.91	2.93
A1B2	3.51	3.65	3.58	2.98	2.92	2.95
A1B3	3.51	3.62	3.57	3.00	2.97	2.98
A1B4	3.53	3.63	3.58	3.00	3.00	3.00
A2B1	3.71	3.80	3.76	3.06	3.00	3.03
A2B2	3.66	3.82	3.74	3.14	3.03	3.08
A2B3	3.64	3.79	3.72	3.17	3.10	3.14
A2B4	3.69	3.82	3.76	3.14	3.10	3.12
Mean	3.60	3.72	3.66	3.06	3.00	3.03
Standard Error	0.043	0.05	0.042	0.04	0.063	0.031
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X C						
A1C1	3.52	3.64	3.58	2.97	2.93	2.95
A1C2	3.63	3.75	3.69	3.09	3.06	3.08
A1C3	3.41	3.50	3.46	2.89	2.86	2.87

A2C1	3.66	3.78	3.73	3.15	3.05	3.10
A2C2	3.75	3.90	3.83	3.25	3.15	3.20
A2C3	3.61	3.74	3.68	2.99	2.97	2.98
Mean	3.60	3.72	3.66	3.06	3.00	3.03
Standard Error	0.038	0.043	0.036	0.034	0.055	0.027
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor B X C						
B1C1	3.62	3.68	3.65	3.01	2.97	2.99
B1C2	3.73	3.85	3.79	3.11	3.02	3.07
B1C3	3.53	3.60	3.56	2.90	2.88	2.89
B2C1	3.59	3.74	3.67	3.05	2.95	3.00
B2C2	3.65	3.82	3.74	3.20	3.08	3.14
B2C3	3.51	3.65	3.58	2.94	2.88	2.91
B3C1	3.57	3.68	3.63	3.08	3.04	3.06
B3C2	3.66	3.80	3.73	3.21	3.15	3.18
B3C3	3.49	3.63	3.56	2.97	2.92	2.94
B4C1	3.59	3.74	3.67	3.09	3.01	3.05
B4C2	3.72	3.82	3.77	3.16	3.16	3.16
B4C3	3.53	3.61	3.57	2.95	2.98	2.96
Mean	3.60	3.72	3.66	3.06	3.00	3.03
Standard Error	0.053	0.061	0.052	0.048	0.078	0.038
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

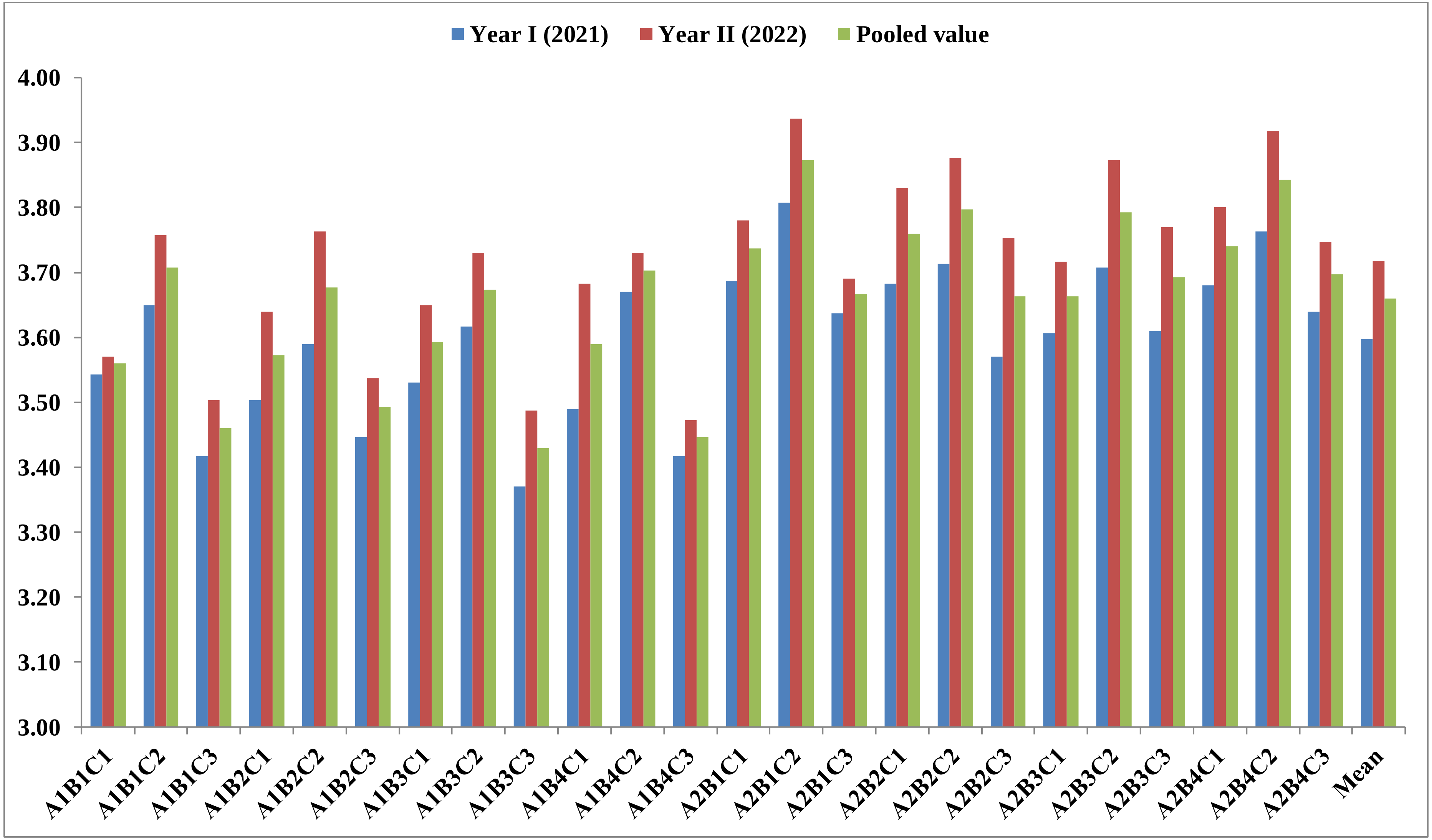

Figure 17 Effect of crop regulation and bagging on Reducing Sugar (%) of guava cv. Allahabad Safeda.

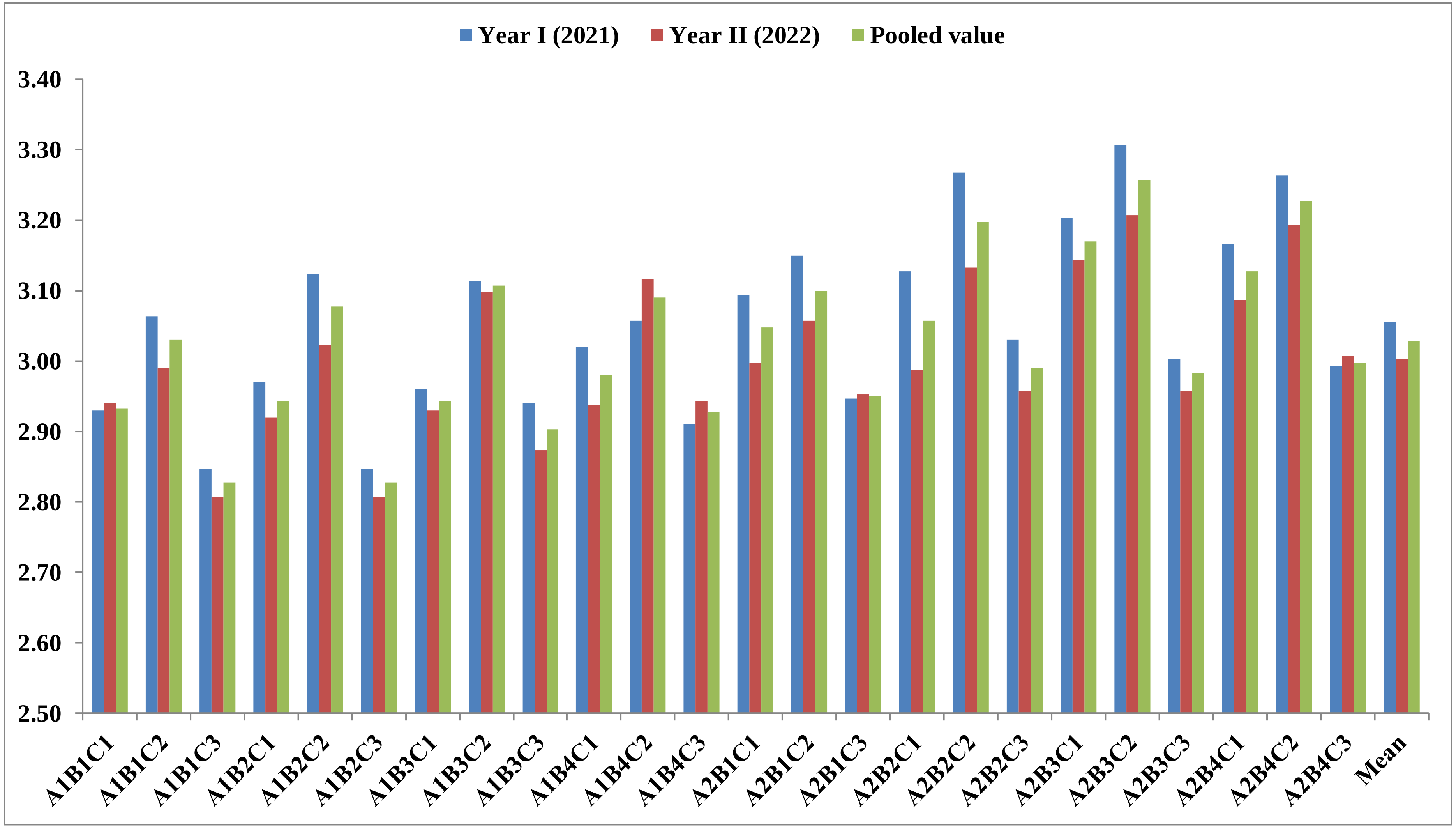

Figure 18 Effect of crop regulation and bagging on Non-reducing sugars (%) of guava cv. Allahabad Safeda.

4.2.17 Ascorbic acid (mg/100 gm)

The analysis derived from Table 16 and Figure 19 reveals a notable increase in ascorbic acid levels associated with the intensity of pruning during 2021 and 2022. The highest ascorbic acid concentration in guava was recorded at 213.45 mg (Year I), 216.86 mg (Year II), and 215.16 mg (Pooled) for the 20 cm pruning intensity (A_2). These figures were significantly different to those at the 10 cm pruning range (A_1), where ascorbic acid observed 183.77 mg (Year I), 186.71 mg, and 185.24 (Pooled) and these values were significantly different with each other.

The influence of varying plant growth regulator concentrations on guava's ascorbic acid content was found to be noteworthy. Applying GA3 at 50 ppm led to the highest ascorbic acid levels, reaching 205.38 mg (Year I), and 208.55 mg (Year II) and 206.97 mg (Pooled) in the B_4 treatment. In contrast, the B_1 treatment with the lowest ascorbic acid levels of 192.38 mg (Year I), 195.43 mg (Year II), and 193.91 mg (Pooled), demonstrating a statistically significant variation between the each other.

The study also highlighted the significant impact of fruit bagging on ascorbic acid content as outlined in Table 16. The C_2 treatment, employing non-woven bags, exhibited the highest ascorbic acid levels at 223.01 mg (Year I), 226.69 mg (Year II), and 224.85 mg (Pooled). Conversely, the C_3 (unbagged) displayed the lowest ascorbic acid levels at 163.23 mg (Year I), 165.69 mg (Year II), and 164.46 mg (Pooled), showing a statistically significant difference with each other. Therefore, using non-woven bags resulted in an increase in ascorbic acid levels compared to the unbagged group.

Furthermore, the statistical significance of the interaction effects between pruning and bagging was confirmed for both 2021 and 2022. In particular, the first-order interaction AxC was the only significant factor in both years. In this interaction, the highest ascorbic acid levels were noted at 241.56 mg (Year I), 245.50 mg (Year II), and 243.53 mg (Pooled) in the A_2C_2 treatment, while the A_1C_3 treatment showed the lowest levels at 154.87 mg (Year I), 157.18 mg (Year II), and 156.03 mg (Pooled). The interactions AxB and BxC, as well as the second-order interaction AxBxC, were not statistically significant.

The pruning intensity of guava trees has a notable impact on the ascorbic acid content, commonly known as Vitamin C, in the fruit. Research shows that guavas pruned higher pruning intensity exhibit the highest levels of Vitamin C. This suggests that more aggressive pruning strategies promote the synthesis or accumulation of ascorbic acid within the fruit tissues. In contrast, guavas from trees that undergo no pruning typically show the lowest ascorbic acid levels. This correlation indicates that managing the pruning intensity is effective agricultural practice to enhance the nutritional value of guavas, particularly their Vitamin C content. Such findings provide valuable insights for cultivators aiming to optimize fruit quality and nutritional benefits (Shashi *et al.,* 2022; Lal *et al.*, 2000; Kumar *et al.,* 2022).

The application of GA_3 found effective on the ascorbic acid content of guava fruit. Various researches indicate that treating guava trees with GA_3 at this concentration level lead to an incriment in the vitamin C of the fruit. This advises that GA_3 play a important role in stimulating the biosynthesis or accumulation of ascorbic acid within guava tissues. Consequently, guava fruits applied with GA_3 exhibit higher levels of ascorbic acid, which is beneficial for the nutritional value as well as potential health-promoting properties. Such findings highlight the potential of GA_3 as a tool for improving the ascorbic acid content of guava, offering opportunities for growers to improve fruit quality and market competitiveness (Gupta *et al.,* 2023; Kapadnis & Singh, 2022).

Bagging is a common agricultural practice, involves enclosing fruits on the plant within bags while they develop, which significantly influences their exposure to environmental factors. For guavas, bagging primarily impacts their ascorbic acid content by modifying their microclimate, especially in terms of light exposure, temperature, and humidity. When guavas are bagged, the reduction in direct sunlight alters photosynthetic activities, potentially decreasing the synthesis of ascorbic acid since sunlight can enhance the production of metabolic compounds like ascorbic acid. Additionally, bagging also modifies internal temperatures and humidity levels around the fruit, further affecting nutrient synthesis processes. Several researchers concluded the similar effect of bagging on guava where ascorbic acid found to be higher in bagged fruits as compared to those that were unbagged (Meena *et al.,* 2016; Abbasi *et al.,* 2014; Saxena *et al.*, 2021).

4.2.19 Shelf life (Days)

The summarized data from Table 16 suggested that bagging has a beneficial impact on the shelf life primarily due to the protection it offers against fruit fly infestation and physical damage which shows the significant effect of bagging on shelf on fruits. During year

2021, fruits harvested from bagged treatments demonstrated a maximum shelf life of 4.31 days (C1), followed with 4.28 days (C2). Moving to 2022, maximum shelf life of 4.45 days (C2) was observed followed by 4.37 days (C1). An aggregated or pooled data review indicated the longest shelf life was 4.37 days (C2), with a nearly matching figure of 4.36 days (C1) following it.

Additionally, none of the first order interactions (A × B, B × C, and C × A), nor the second order interaction (A × B × C) involving all three factors, exhibited a significant effect in the data from 2021, 2022, or the combined analysis.

Fruit bagging of guavas involves enclosing the fruits in bags while they are still on the tree, significantly extending their post-harvest shelf life. This method protects the guavas from fruit fly infestation, reducing the need for chemical treatments and minimizing physical and biological damage that can accelerate spoilage. By creating a controlled microclimate around the fruit, the bags help moderate temperature and humidity, which reduces the rate of respiration and delays the ripening process. This ensures the guavas remain fresher for longer periods during storage and transport, maintaining their quality and marketability (Kireeti *et al.,* 2016; Akter *et al.,* 2020).

Table 16 Effect of crop regulation and bagging on Ascorbic acid (mg/100 mg) and Shelf life of guava cv. Allahabad Safeda

Factor	Ascorbic acid (mg/100 mg)			Shelf life (Days)		
	Year I	Year II	Pooled value	Year I	Year II	Pooled value
Factor (A)						
A_1	183.77 [b]	186.71 [b]	185.24 [b]	3.90	4.06	3.98
A_2	213.45 [a]	216.86 [a]	215.16 [a]	4.04	4.10	4.07
Critical Difference	6.42	5.57	5.73	Non-Significant	Non-Significant	Non-Significant
Factor (B)						
B_1	192.38 [b]	195.43 [b]	193.91 [b]	3.89	3.98	3.94
B_2	195.66 [b]	198.90 [b]	197.28 [b]	3.94	4.03	3.99
B_3	201.00 [a]	204.28 [a]	202.64 [a]	3.95	4.13	4.04
B_4	205.38 [a]	208.55 [a]	206.97 [a]	4.10	4.18	4.14
Critical Difference	9.08	7.88	8.10	Non-Significant	Non-Significant	Non-Significant
Factor (C)						
C_1	209.58 [b]	212.99 [b]	211.29 [b]	4.31 [a]	4.37 [a]	4.34 [a]
C_2	223.01 [a]	226.69 [a]	224.85 [a]	4.28 [a]	4.45 [a]	4.37 [a]
C_3	163.23 [c]	165.69 [c]	164.46 [c]	3.32 [b]	3.42 [b]	3.37 [b]
Critical Difference	7.86	6.82	7.02	0.22	0.20	0.15
Factor A X B						
A1B1	176.70	179.39	178.05	3.91	3.94	3.93
A1B2	182.51	185.46	183.99	3.89	4.09	3.99
A1B3	186.01	189.19	187.60	3.85	4.07	3.96
A1B4	189.85	192.82	191.33	3.96	4.13	4.05
A2B1	208.06	211.47	209.77	3.87	4.02	3.94
A2B2	208.81	212.35	210.58	4.00	3.96	3.98
A2B3	215.99	219.36	217.68	4.05	4.19	4.12
A2B4	220.92	224.28	222.60	4.24	4.22	4.23
Mean	198.61	201.79	200.20	3.97	4.08	4.03
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X C						
A1C1	191.97 [d]	195.08 [d]	193.53 [d]	4.26	4.31	4.28
A1C2	204.46 [c]	207.88 [c]	206.17 [c]	4.17	4.43	4.30
A1C3	154.87 [f]	157.18 [f]	156.03 [f]	3.28	3.44	3.36
A2C1	227.18 [b]	230.90 [b]	229.04 [b]	4.36	4.43	4.40
A2C2	241.56 [a]	245.50 [a]	243.53 [a]	4.40	4.47	4.44
A2C3	171.59 [e]	174.19 [e]	172.89 [e]	3.36	3.39	3.38
Mean	198.61	201.79	200.20	3.97	4.08	4.03
Critical Difference	11.12	9.64	9.92	Non-Significant	Non-Significant	Non-Significant
Factor B X C						

B1C1	199.59	202.83	201.21	4.19	4.20	4.20
B1C2	215.91	219.51	217.71	4.22	4.39	4.31
B1C3	161.64	163.96	162.80	3.25	3.36	3.31
B2C1	207.82	211.09	209.45	4.33	4.31	4.32
B2C2	217.48	221.30	219.39	4.28	4.45	4.36
B2C3	161.69	164.33	163.01	3.22	3.33	3.28
B3C1	214.95	218.58	216.76	4.36	4.53	4.44
B3C2	224.41	228.13	226.27	4.14	4.36	4.25
B3C3	163.65	166.12	164.89	3.36	3.50	3.43
B4C1	215.96	219.48	217.72	4.36	4.45	4.40
B4C2	234.25	237.83	236.03	4.50	4.61	4.56
B4C3	165.95	168.34	167.15	3.45	3.47	3.46
Mean	198.61	201.79	200.20	3.97	4.08	4.03
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

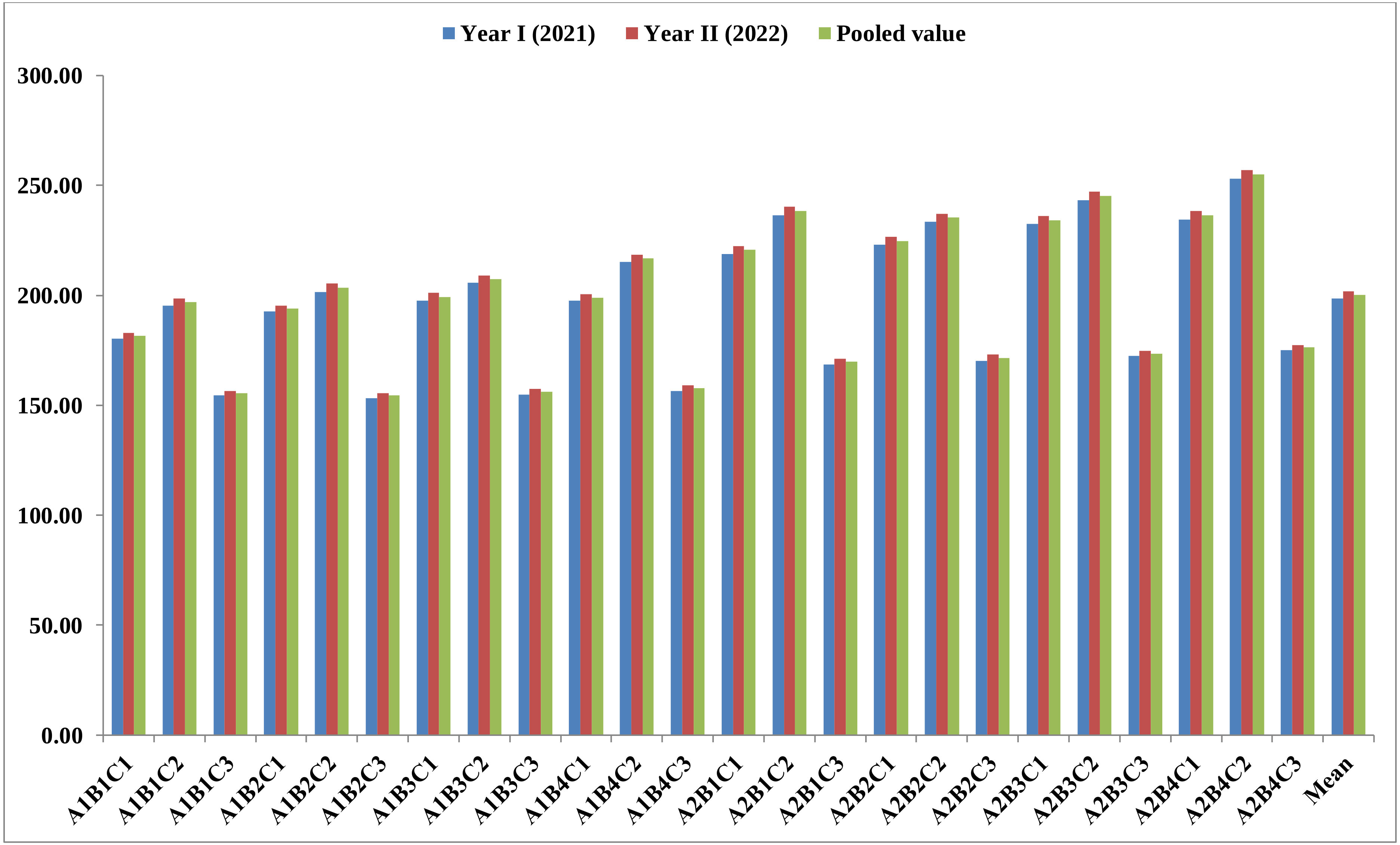

Figure 19 Effect of crop regulation and bagging on Ascorbic acid (mg/100 mg) and Shelf life of guava cv. Allahabad Safeda.

Figure 20 Effect of crop regulation and bagging on Shelf life of guava cv. Allahabad Safeda.

Physiological weight loss (%)

The relationship between all three factors and guava weight loss percent was found statistically non significant with each other. The information from Table 17, Figure 21 clearly indicates that all fruit losses their weight consistently which shows that pruning, plant growth regulators and bagging materails had no effect on weight loss percent of fruits on 2^{nd} day, 4^{th} day during the year 2021 and 2022. Furthermore, the research found that the first-order interactions (A×B, B×C, and C×A) and the second-order interaction (A×B×C) were not significant in 2021 and 2022.

The post-harvest weight loss percent in guava is primarily caused by two physiological processes: respiration and transpiration. Respiration is the natural metabolic process where the fruit converts stored sugars into energy, releasing carbon dioxide and water vapor, which contributes to weight loss. Transpiration, on the other hand, involves the loss of water vapor from the fruit's surface. Both these processes are inevitable but can be exacerbated by factors such as high ambient temperatures, low humidity, and improper handling. These factors speed up water loss and metabolic activity, leading to increased weight reduction in guavas post-harvest. Due to evaporation of water from their surfaces, the breakdown of cell walls, accelerated respiration, and increased levels of ethylene. These factors collectively contribute to the reduction in fruit weight (Wang *et al.*, 2007; Zhu *et al.*, 2008).

Table 17 Effect of crop regulation and bagging on Physiological weight loss % of guava cv. Allahabad Safeda

Factor	Physiological weight loss % (2021)			Factor		
	Day 2	Day 4	Pooled value	Day 2	Day 4	Pooled value
Factor (A)						
A_1	4.41	7.78	6.10	4.45	7.82	6.14
A_2	4.43	7.54	6.12	4.70	7.73	6.21
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor (B)						
B_1	4.43	7.78	6.10	4.60	7.55	6.08
B_2	4.41	7.72	6.07	4.73	7.74	6.23
B_3	4.42	7.51	6.22	4.56	7.98	6.27
B_4	4.44	7.65	6.04	4.42	7.83	6.13
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor (C)						
C_1	4.39	7.71	6.05	4.59	7.81	6.20
C_2	4.43	7.69	6.06	4.62	7.79	6.21
C_3	4.45	7.59	6.21	4.51	7.72	6.12
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X B						
A1B1	4.48	7.85	6.17	4.52	7.71	6.12
A1B2	4.41	7.81	6.11	4.50	7.76	6.13
A1B3	4.34	7.77	6.06	4.40	7.94	6.17
A1B4	4.42	7.70	6.06	4.39	7.87	6.13
A2B1	4.37	7.71	6.04	4.67	7.39	6.03
A2B2	4.41	7.62	6.02	4.96	7.71	6.33
A2B3	4.50	7.25	6.38	4.72	8.03	6.37
A2B4	4.46	7.59	6.02	4.45	7.79	6.12
Mean	4.42	7.66	6.11	4.57	7.78	6.18
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor A X C						
A1C1	4.38	7.72	6.05	4.31	7.89	6.10
A1C2	4.43	7.73	6.08	4.54	7.69	6.12
A1C3	4.42	7.90	6.17	4.50	7.89	6.20
A2C1	4.40	7.70	6.05	4.86	7.74	6.30
A2C2	4.42	7.66	6.04	4.71	7.90	6.30
A2C3	4.48	7.27	6.26	4.52	7.55	6.04
Mean	4.42	7.66	6.11	4.57	7.78	6.18
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant
Factor B X C						
B1C1	4.45	7.75	6.10	4.67	7.46	6.07

B1C2	4.37	7.69	6.03	4.66	7.81	6.24
B1C3	4.47	7.90	6.19	4.46	7.39	5.93
B2C1	4.37	7.77	6.07	4.71	7.81	6.26
B2C2	4.44	7.73	6.09	4.78	7.67	6.23
B2C3	4.41	7.65	6.04	4.70	7.73	6.22
B3C1	4.42	7.66	6.04	4.60	8.16	6.38
B3C2	4.48	7.71	6.10	4.58	7.80	6.19
B3C3	4.36	7.16	6.51	4.50	8.00	6.25
B4C1	4.32	7.67	5.99	4.37	7.83	6.10
B4C2	4.42	7.64	6.03	4.48	7.90	6.19
B4C3	4.58	7.63	6.11	4.40	7.76	6.08
Mean	4.42	7.66	6.11	4.57	7.78	6.18
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

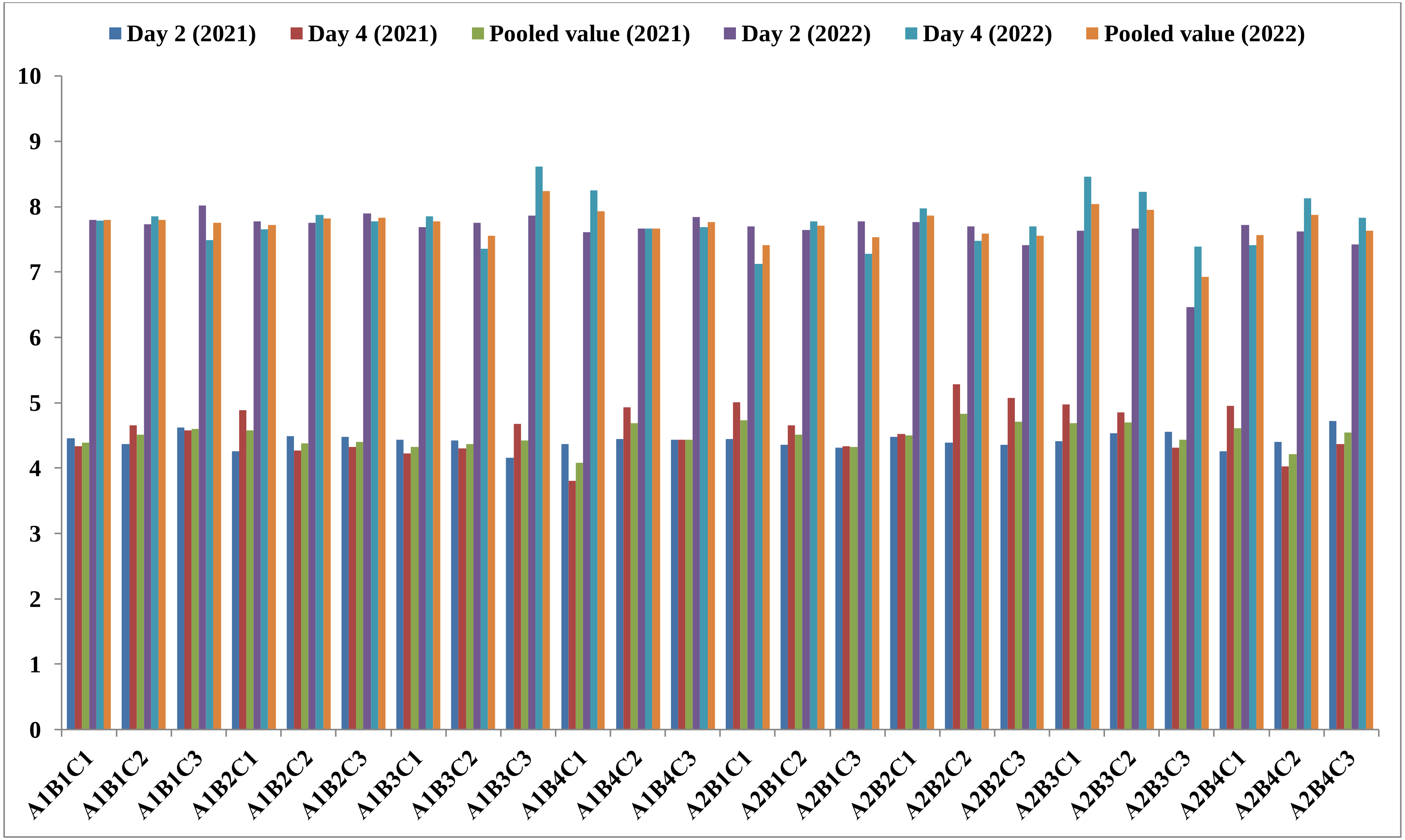

Figure 21 Effect of crop regulation and bagging on Physiological weight loss % of guava cv. Allahabad Safeda in year 2021 and 2022.

TSS (^{0}Brix)

The condensed data from Table 18 and Figure 22 indicates that the highest guava TSS was observed with 20 cm pruning (A2), measuring 10.52 ^{0}Brix on 0 day, 10.62 ^{0}Brix on 2^{nd} day, and 10.76 ^{0}Brix on 4^{th} Day in year 2021. A maximum TSS recorded during the year 2022 was 10.69 ^{0}Brix on 0 day, 10.78 ^{0}Brix 2^{nd} day, and 10.83 ^{0}Brix on 4^{th} day after harvesting. The impact of intensity of pruning on TSS of fruit was significant, as observed in various studies. Different levels of pruning intensity, ranging from light to severe, have been shown to influence the TSS concentration in guava fruits. Generally, moderate pruning tends to enhance TSS levels, likely due to improved sunlight penetration and air circulation around the fruit, which can increase sugar synthesis and accumulation (Bhagawati *et al.,* 2015; Kumar *et al.,* 2022)

The foliar application of various concentrations of foliar Pgr's significantly impacted guava TSS. GA3 application at 50 ppm (B4) recorded the highest TSS of 10.49 ^{0}Brix on 0 day, 10.59 ^{0}Brix on 2^{nd} day, and 10.73 ^{0}Brix on 4^{th} day in year 2021. A comparable trend was observed in year 2022 with consistent increasing of 10.75 °Brix on 0 day, 10.78 °Brix on 2^{nd} day, and 10.76 °Brix on 4^{th} day after harvesting. The application of gibberellic acid (GA3) on guava has a positive impact on the Total Soluble Solids (TSS) content, effectively enhancing the fruit's sweetness. GA3, a plant growth regulator, facilitates increased cell division and enlargement, which in turn promotes greater sugar accumulation within the fruit (Singh *et al.*, 1986; Lal *et al.,* 2017).

Table 18 illustrates the significant impact of fruit bagging on Total Soluble Solids (TSS), with data showing how the non-woven bag (C2) treatment influenced TSS levels during 2021. Initially, the TSS was recorded at 10.59 °Brix on 0 day, increasing to 10.69 °Brix by the 2^{nd} day, and reaching 10.83 °Brix by the 4^{th} day. Additionally, in 2022, an increasing trend in TSS was observed over the storage days of the fruit, with 10.77 °Brix on day 0, 10.85 °Brix on the 2^{nd} day, and 10.89 °Brix on the 4^{th} day. It was observed that bagging guava fruits significantly enhances their Total Soluble Solids (TSS) content by by shielding them from pests and environmental stress. This environment reduces the exposure of the fruits to pests and harsh weather. The bags help maintain a more stable microclimate around the fruit, which is crucial for the accumulation of sugars. By minimizing fluctuations in temperature and humidity and protecting against excessive sunlight, bagging ensures that the fruits develop in conditions that are ideal for sugar synthesis. Additionally, the physical barrier provided by the bags prevents direct contact with pesticides and reduces mechanical injuries, further promoting healthy and robust fruit development with enhanced sweetness. (Chaudhary *et al.*, 2014; Brar *et al.*, 2019)

Additionally, the study determined that the effects of pruning, plant growth regulator, and bagging had no statistically significant impact in either year. In 2021 and 2022, the first order interactions (A×B, B×C, and C×A) and the second order interaction (A×B×C) were all found to be statistically insignificant.

The increase in total soluble sugars in guava post-harvest is primarily due to the ongoing ripening process, which involves the conversion of starches into simpler sugars like glucose and fructose. This natural transformation is catalyzed by enzymes such as amylase, which become more active as the fruit matures. Additionally, the concentration of these sugars may appear to increase as water content decreases through transpiration and respiration. The production of ethylene, a ripening hormone, also accelerates these biochemical processes, leading to a sweeter fruit as it progresses through its post-harvest life. Various studies have shown that with the passing days, there was increase observed in Total Soluble Solids (TSS) of guava (Singh *et al.*, 2021; Supa *et al.*, 2024).

Table 18 Effect of crop regulation and bagging on TSS ^{0}Brix of guava cv. Allahabad Safeda

Factor	TSS ^{0}Brix (2021)			TSS ^{0}Brix (2022)			Mean Year 2021	Mean Year 2022
	Day 0	Day 2	Day 4	Day 0	Day 2	Day 4		
Factor (A)								
A_1	10.04 [b]	10.14 [a]	10.28 [b]	10.21 [b]	10.29 [b]	10.33 [b]	10.15	10.28
A_2	10.52 [a]	10.62 [a]	10.76 [a]	10.69 [a]	10.78 [a]	10.83 [a]	10.64	10.76
Critical Difference	0.12	0.13	0.12	0.13	0.15	0.12	-	
Factor (B)								
B_1	10.07 [b]	10.17 [b]	10.31 [b]	10.33 [b]	10.38 [b]	10.35 [b]	10.19	10.32
B_2	10.18 [b]	10.28 [b]	10.43 [b]	10.44 [b]	10.48 [b]	10.46 [b]	10.30	10.42
B_3	10.37 [a]	10.47 [a]	10.61 [a]	10.62 [a]	10.67 [a]	10.65 [a]	10.48	10.61
B_4	10.49 [a]	10.59 [a]	10.73 [a]	10.75 [a]	10.78 [a]	10.76 [a]	10.61	10.73
Critical Difference	0.16	0.19	0.17	0.21	0.16	0.13	-	
Factor (C)								
C_1	10.50 [a]	10.60 [a]	10.73 [a]	10.68 [a]	10.76 [a]	10.81 [a]	10.61	10.75
C_2	10.59 [a]	10.69 [a]	10.83 [a]	10.77 [a]	10.85 [a]	10.89 [a]	10.70	10.84
C_3	9.75 [b]	9.85 [b]	10.00 [b]	9.91 [b]	9.99 [b]	10.03 [b]	9.87	9.98
Critical Difference	0.14	0.16	0.15	0.15	0.18	0.14	-	
Factor A X B								
A1B1	9.81	9.90	10.04	9.98	10.06	10.11	9.92	10.05
A1B2	9.92	10.03	10.17	10.09	10.18	10.21	10.04	10.16
A1B3	10.16	10.27	10.40	10.33	10.42	10.46	10.28	10.40
A1B4	10.25	10.35	10.49	10.42	10.51	10.53	10.37	10.49
A2B1	10.34	10.44	10.58	10.51	10.59	10.65	10.45	10.58
A2B2	10.44	10.54	10.68	10.61	10.69	10.74	10.56	10.68
A2B3	10.58	10.68	10.82	10.75	10.83	10.88	10.69	10.82
A2B4	10.73	10.83	10.97	10.90	10.98	11.03	10.85	10.97
Mean	10.28	10.38	10.52	10.45	10.53	10.58	10.39	10.52
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant		
Factor A X C								
A1C1	10.24	10.34	10.47	10.42	10.50	10.55	10.35	10.49
A1C2	10.33	10.43	10.57	10.51	10.59	10.64	10.44	10.58
A1C3	9.54	9.64	9.79	9.69	9.78	9.80	9.66	9.76
A2C1	10.76	10.85	10.99	10.93	11.02	11.07	10.87	11.01
A2C2	10.85	10.95	11.10	11.02	11.11	11.15	10.96	11.09
A2C3	9.97	10.07	10.21	10.12	10.20	10.26	10.08	10.19
Mean	10.28	10.38	10.52	10.45	10.53	10.58	10.39	10.52
Critical Difference	Non-Signifi	Non-Signific	Non-Signifi	Non-Signifi	Non-Significa	Non-Signific	-	

	cant	ant	cant	cant	nt	ant		
Factor B X C								
B1C1	10.27	10.36	10.50	10.44	10.53	10.58	10.37	10.52
B1C2	10.34	10.44	10.58	10.51	10.60	10.65	10.45	10.59
B1C3	9.62	9.72	9.86	9.78	9.86	9.91	9.73	9.85
B2C1	10.37	10.47	10.60	10.55	10.63	10.67	10.48	10.62
B2C2	10.47	10.57	10.72	10.65	10.73	10.76	10.59	10.71
B2C3	9.71	9.81	9.96	9.86	9.94	10.00	9.82	9.93
B3C1	10.62	10.72	10.85	10.80	10.88	10.94	10.73	10.87
B3C2	10.71	10.81	10.96	10.88	10.97	11.01	10.83	10.95
B3C3	9.79	9.89	10.03	9.94	10.02	10.06	9.90	10.01
B4C1	10.74	10.84	10.98	10.92	11.00	11.04	10.85	10.99
B4C2	10.84	10.94	11.08	11.02	11.10	11.16	10.95	11.09
B4C3	9.90	10.00	10.14	10.06	10.14	10.15	10.01	10.11
Mean	10.28	10.38	10.52	10.45	10.53	10.58	10.39	10.52
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, p≤0.05) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

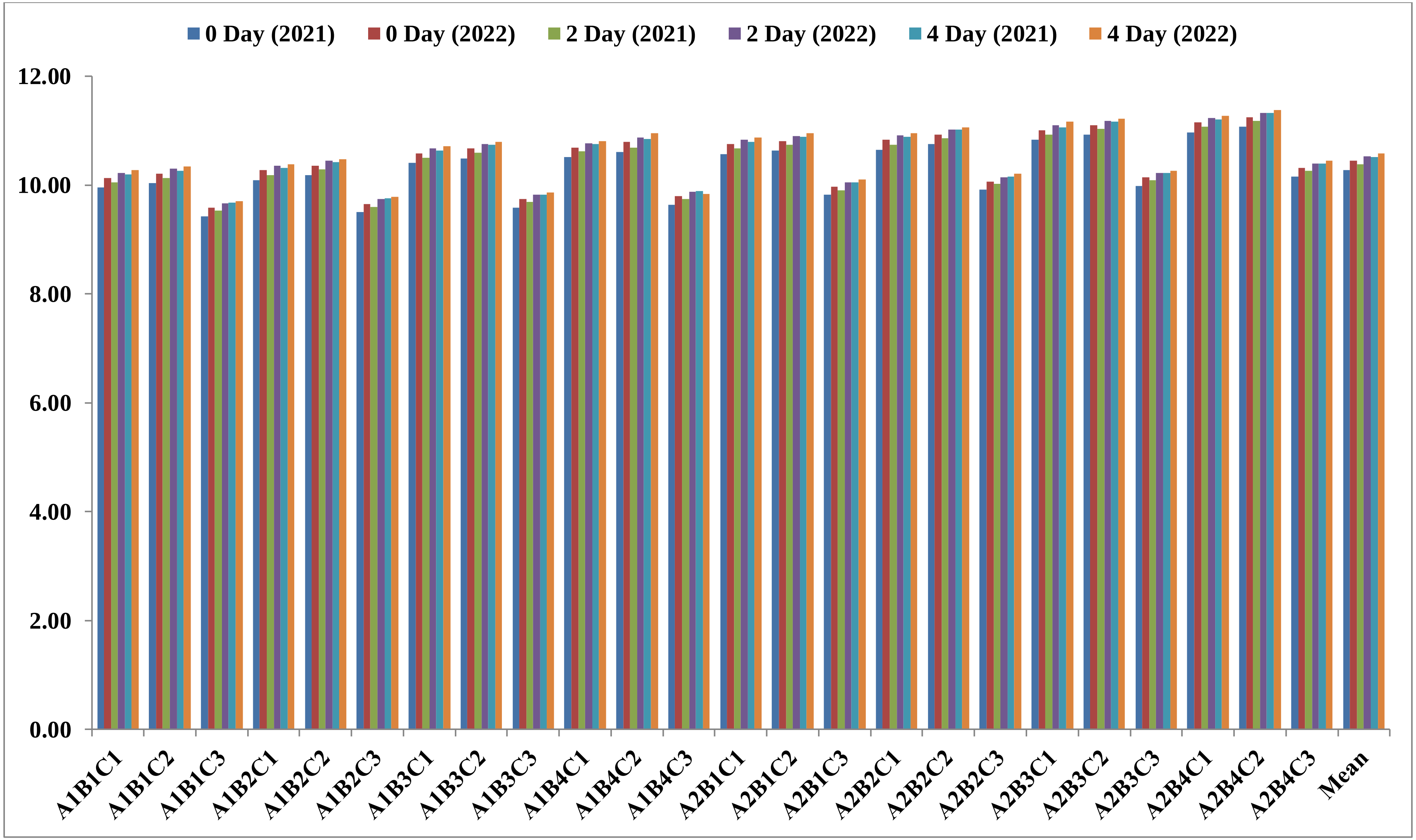

Figure 22 Effect of crop regulation and bagging on TSS ⁰Brix of guava cv. Allahabad Safeda during year 2021 and 2022.

Acidity %

The summarized data from Table 19 and Figure 23 highlights the effect of 20 cm pruning (A2) on the acidity levels of guavas over a four-day period following harvest in both 2021 and 2022. Initially, the acidity was recorded at 0.30% on the day of harvest in 2021, which then decreased to 0.29% by the 2nd day and further to 0.27% by the 4th day. A comparable trend was observed in 2022, where the initial acidity of 0.30% gradually declined to 0.29% by the 2nd day and reached 0.28% by the 4th day after harvesting. Pruning affects the decrease in fruit acidity primarily through the enhancement of photosynthesis and resource allocation. By removing excess or non-productive branches, pruning increases light penetration and circulation of air, which enhances the plant's photosynthesis efficiency. This increase in photosynthesis leads to higher sugar production within the fruit. As sugars accumulate, they can dilute or balance the concentration of organic acids, thus resulting in lower overall acidity. Additionally, pruning redirect the plant's resources towards the growth and development of the remaining fruits which further increase their sugar content relative to their acid content, which enhances fruit sweetness while reducing tartness (Jayswal *et al.,* 2017).

The influence of fruit bagging on acidity is delineated in Table 19. The results illustrate a noteworthy impact of bagging on acidity over the entire study duration. The non-woven bag treatment yielded the lowest acidity at 0.29%, 0.27% and 0.26% on 0 day, 2nd day, and 4th day respectively in year 2021. Consistent trend was observed in year 2022, where 0.29%, 0.28% and 0.27% of acidity was recorded on 0 day, 2nd day, and 4th day respectively. Bagging of fruits results in decrease` acidity primarily due to changes in the microclimate around the fruit and the modification of light exposure. The bag acts as a barrier, altering temperature and humidity levels, which accelerate the metabolic processes that convert acids into sugars, thus lowering acidity. This controlled environment facilitated by bagging optimizes the fruit's development conditions, thereby enhancing its quality by reducing its natural tartness (Kireeti *et al.*, 2016; Rahman *et al.*, 2018).

Furthermore, the interaction impact of pruning, plant growth regulator, and bagging was determined to be statistically insignificant in both years. For the years 2021 and 2022, the first-order interactions (A×B, B×C, and C×A), as well as the second order interaction A×B×C, were all determined to be statistically insignificant..

The decrease in post-harvest acidity in guava is primarily attributed to the metabolic processes that occur during the ripening and aging of the fruit. As guavas ripen, organic acid such as citric acid metabolized to provide energy for the fruit's cellular activities. This metabolic activity leads to a reduction in the concentration of these acids, which are key contributors to the fruit's tartness. Additionally, the transformation of acids into sugars and other compounds enhances the sweetness of the fruit, further reducing the perception of acidity. The natural breakdown of acids, coupled with the reduction of respiration rates and enzymatic changes, collectively results in a decrease in overall fruit acidity post-harvest. Various studies have shown that with the passing days, the acidity of guava decreases in gradually (Singh *et al.,* 2021; Supa *et al.,* 2024).

Table 19 Effect of crop regulation and bagging on Acidity % of guava cv. Allahabad Safeda

Factor	Acidity % (2021)			Acidity % (2022)			Mean Year 2021	Mean Year 2022
	Day 0	Day 2	Day 4	Day 0	Day 2	Day 4		
Factor (A)								
A_1	0.33 [a]	0.31 [a]	0.30 [a]	0.33 [a]	0.32 [a]	0.30 [a]	0.31	0.32
A_2	0.30 [b]	0.29 [b]	0.27 [b]	0.30 [b]	0.29 [b]	0.28 [b]	0.29	0.29
Critical Difference	0.010	0.014	0.013	0.009	0.015	0.016	-	
Factor (B)								
B_1	0.32	0.30	0.29	0.32	0.31	0.30	0.30	0.31
B_2	0.32	0.30	0.29	0.32	0.30	0.29	0.30	0.30
B_3	0.32	0.29	0.28	0.32	0.30	0.29	0.30	0.30
B_4	0.31	0.29	0.28	0.31	0.30	0.29	0.30	0.30
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	
Factor (C)								
C_1	0.30 [b]	0.29 [b]	0.28 [b]	0.30 [b]	0.29 [b]	0.28 [b]	0.29	0.29
C_2	0.29 [b]	0.27 [b]	0.26 [b]	0.29 [b]	0.28 [b]	0.27 [b]	0.27	0.28
C_3	0.36 [a]	0.34 [a]	0.32 [a]	0.36 [a]	0.34 [a]	0.33 [a]	0.34	0.35
Critical Difference	0.012	0.017	0.016	0.011	0.019	0.019	-	
Factor A X B								
A1B1	0.34	0.31	0.30	0.34	0.32	0.31	0.32	0.32
A1B2	0.33	0.31	0.30	0.33	0.32	0.30	0.31	0.32
A1B3	0.33	0.31	0.29	0.33	0.31	0.30	0.31	0.32
A1B4	0.33	0.31	0.29	0.33	0.31	0.30	0.31	0.31
A2B1	0.30	0.29	0.28	0.30	0.29	0.28	0.29	0.29
A2B2	0.30	0.29	0.27	0.30	0.29	0.28	0.29	0.29
A2B3	0.30	0.28	0.27	0.30	0.28	0.28	0.29	0.29
A2B4	0.30	0.28	0.27	0.30	0.28	0.27	0.28	0.29
Mean	0.32	0.30	0.28	0.32	0.30	0.29	0.30	0.30
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	
Factor A X C								
A1C1	0.32	0.30	0.29	0.32	0.30	0.29	0.31	0.30
A1C2	0.30	0.28	0.27	0.30	0.30	0.28	0.29	0.29
A1C3	0.37	0.34	0.32	0.37	0.35	0.34	0.35	0.35
A2C1	0.28	0.27	0.26	0.28	0.27	0.26	0.27	0.27
A2C2	0.27	0.26	0.24	0.27	0.26	0.25	0.26	0.26
A2C3	0.35	0.33	0.32	0.35	0.33	0.32	0.33	0.34
Mean	0.32	0.30	0.28	0.32	0.30	0.29	0.30	0.30
Critical	Non-	Non-	Non-	Non-	Non-	Non-	-	

Difference	Significant	Significant	Significant	Significant	Significant	Significant		
Factor B X C								
B1C1	0.31	0.29	0.28	0.31	0.30	0.29	0.30	0.30
B1C2	0.29	0.27	0.26	0.29	0.28	0.27	0.28	0.28
B1C3	0.36	0.34	0.32	0.36	0.35	0.34	0.34	0.35
B2C1	0.30	0.29	0.28	0.30	0.29	0.27	0.29	0.29
B2C2	0.29	0.28	0.26	0.29	0.28	0.27	0.27	0.28
B2C3	0.36	0.34	0.33	0.36	0.34	0.33	0.34	0.35
B3C1	0.30	0.28	0.27	0.30	0.28	0.27	0.28	0.28
B3C2	0.29	0.27	0.26	0.29	0.28	0.26	0.27	0.28
B3C3	0.36	0.34	0.32	0.36	0.34	0.33	0.34	0.34
B4C1	0.30	0.28	0.27	0.30	0.28	0.27	0.29	0.28
B4C2	0.28	0.26	0.25	0.28	0.27	0.26	0.26	0.27
B4C3	0.36	0.34	0.32	0.36	0.34	0.33	0.34	0.35
Mean	0.32	0.30	0.28	0.32	0.30	0.29	0.30	0.30
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, p≤0.05) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

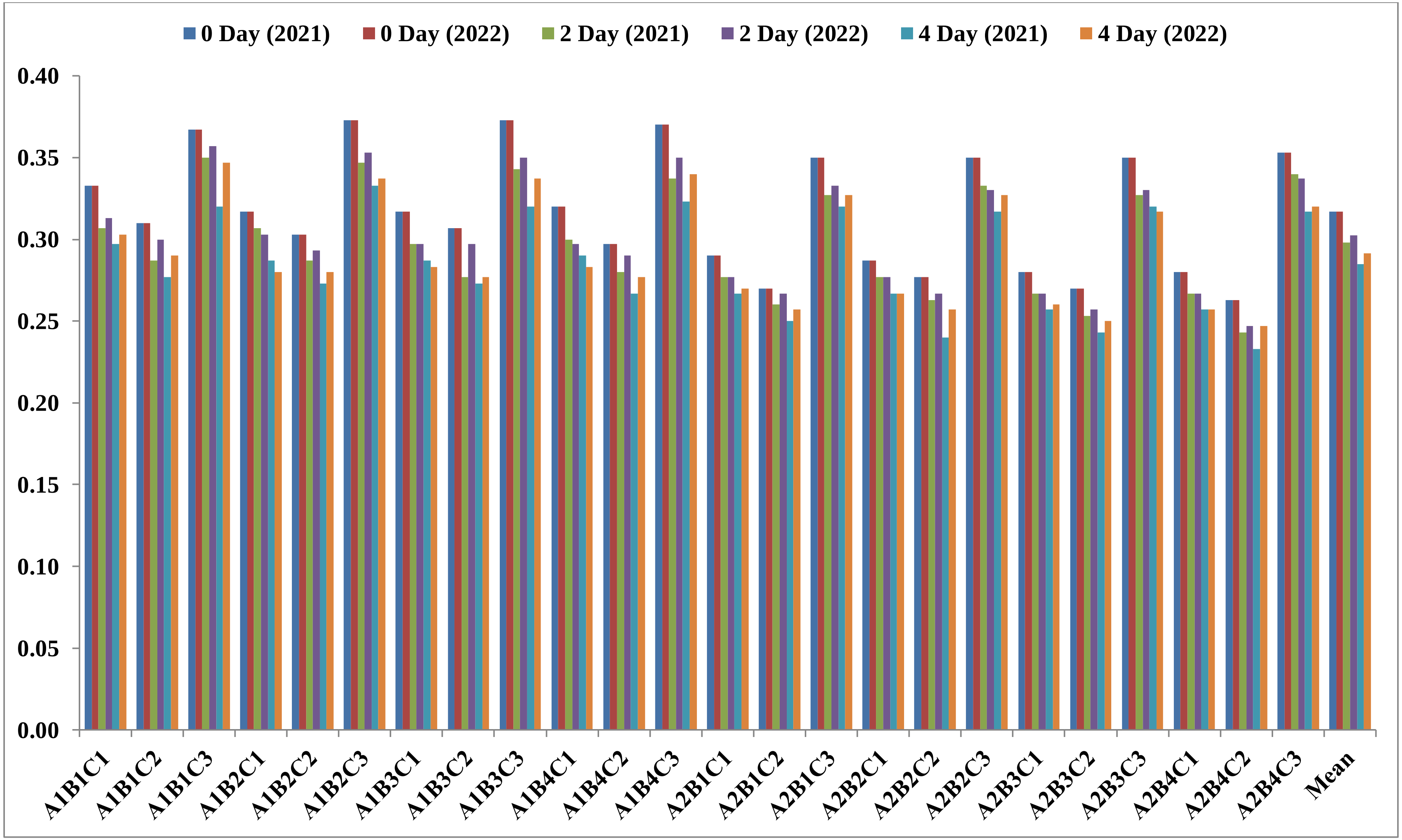

Figure 23 Effect of crop regulation and bagging on Acidity % of guava cv. Allahabad Safeda during year 2021 and 2022.

Total Sugars (%)

The summarized data from Table 20 and Figure 24 demonstrates the impact of pruning intensity on the total sugar content in guavas over a four-day period following harvest for both 2021 and 2022. Initially, the total sugar content was recorded at 6.80% on the day of harvest in 2021, which then increased to 6.91% by the 2nd day and further to 7.09% by the 4th day in 20 cm pruning (A2). A consistent pattern was observed in 2022, where the initial total sugar content of 6.86% gradually rise to 6.92% by the 2nd day and reached 7.14% by the 4th day after harvesting. A statistically significant difference was observed between these values upon comparison. Pruning beneficially impacts the sugar in guava by improving the plant's photosynthetic capabilities and nutrient distribution. By selectively removing parts of the plant, pruning enhances sunlight exposure and air flow throughout the canopy, which in turn stimulates photosynthesis. This increased light access and healthier foliage allow the tree to generate more sugars. Pruning also optimizes the redistribution of nutrients, channeling more towards the fruit-producing sections of the tree and away from non-fruit-bearing branches. This strategic allocation of resources results in the production of sweeter fruits, as the plant invests more energy and nutrients into fruit development instead of sustaining unnecessary vegetative growth. Observations indicate that pruned plants exhibit higher sugar levels in their fruits and consistent with the findings reported by Bagachi *et al.* (2008) and Porika *et al.* (2015).

Table 20 highlights the substantial influence of fruit bagging on the total sugar content in guava fruits throughout the study period. The treatment using non-woven bags (C2) demonstrated the most significant increase, starting with a total sugar content of 6.78% on day 0, rising to 6.84% by the 2nd day, and reaching 6.90% by the 4th day in 2021. A similar trend was noted in same pruning intensity during 2022, with the highest recorded sugar levels starting at 6.61% on day 0, increasing to 6.69% by the 2nd day, and peaking at 7.81% by the 4th day. Employing fruit bagging on guava trees significantly enhances the total sugar content in the fruits. Utilizing non-woven fabric bags creates a microenvironment that stabilizes temperature fluctuations around the developing fruit, which minimizes stress and optimizes metabolic functions, including photosynthesis. This regulated environment not only protects the fruits from direct exposure to sunlight, helping prevent excessive water loss through transpiration, but also improves moisture retention. Such conditions are ideal for the efficient conversion of starches into sugars. This ultimately improves the sweetness and overall quality of the guava fruits. Research has consistently shown that fruit bagging has a positive influence on the sugar of guavas (Afroz *et al.*, 2023).

Moreover, there was non-significance interaction effect between pruning, plant growth regulator and bagging was established in both 2021 and 2022. The first order interactions (AxB, CxA, and BxC) were determined to be non-significant. Likewise, the second order interaction (AxBxC) was also found to be non-significant.

The increase in total sugar percentage in guava post-harvest is predominantly due to the natural ripening processes that occur within the fruit. As guavas mature, enzymes like amylases break down complex carbohydrates, particularly starches, into simpler sugar forms such as glucose and fructose. This enzymatic activity is typically enhanced during the post-harvest phase as the fruit continues to ripen off. Additionally, loss of moisture through transpiration and respiration process results in higher concentration of sugars. Ethylene, a natural plant hormone produced in greater quantities as fruits ripen, plays a crucial role in regulating these biochemical pathways, further stimulating sugar accumulation. The cumulative effect of these factors results in a noticeable increase in the sweetness and overall sugar content of guavas during their post-harvest life, making them more palatable and desirable for consumption. The outcome aligns with the outcomes described by Bose *et al.*, 2019; Bhooriya *et al.*, 2020 Supa *et al*., 2024).

Table 20 Effect of crop regulation and bagging on Total Sugars % of guava cv. Allahabad Safeda

Factor	Total Sugars % (2021)			Total Sugars % (2022)			Mean Year 2021	Mean Year 2022
	Day 0	Day 2	Day 4	Day 0	Day 2	Day 4		
Factor (A)								
A_1	6.50 [b]	6.66 [b]	6.82 [b]	6.58 [b]	6.65 [b]	6.84 [b]	6.66	6.69
A_2	6.80 [a]	6.91 [a]	7.09 [a]	6.86 [a]	6.92 [a]	7.14 [a]	6.94	6.98
Critical Difference	0.032	0.027	0.024	0.023	0.053	0.031	-	
Factor (B)								
B_1	6.63	6.71	6.90	6.66	6.70	6.92	6.75	6.76
B_2	6.65	6.78	6.94	6.70	6.77	6.96	6.79	6.81
B_3	6.66	6.81	6.97	6.74	6.82	7.02	6.81	6.86
B_4	6.68	6.84	7.02	6.77	6.87	7.05	6.84	6.90
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	
Factor (C)								
C_1	6.65 [b]	6.77 [b]	6.96 [b]	6.70 [b]	6.76 [b]	7.03 [a]	6.79	6.83
C_2	6.86 [a]	6.98 [a]	7.14 [a]	6.93 [a]	7.00 [a]	7.11 [a]	6.99	7.01
C_3	6.45 [c]	6.60 [c]	6.77 [c]	6.53 [c]	6.61 [c]	6.82 [b]	6.61	6.66
Critical Difference	0.112	0.093	0.085	0.08	0.186	0.107	-	
Factor A X B								
A1B1	6.48	6.59	6.78	6.52	6.56	6.78	6.62	6.62
A1B2	6.49	6.64	6.80	6.56	6.63	6.82	6.65	6.67
A1B3	6.51	6.68	6.83	6.59	6.67	6.86	6.68	6.71
A1B4	6.52	6.71	6.87	6.63	6.74	6.89	6.70	6.75
A2B1	6.77	6.84	7.02	6.80	6.83	7.07	6.88	6.90
A2B2	6.80	6.91	7.08	6.85	6.90	7.11	6.93	6.95
A2B3	6.81	6.94	7.11	6.89	6.97	7.17	6.95	7.01
A2B4	6.84	6.97	7.16	6.92	7.00	7.20	6.99	7.04
Mean	6.65	6.79	6.96	6.72	6.79	6.99	6.80	6.83
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	
Factor A X C								
A1C1	6.49	6.64	6.82	6.57	6.65	6.88	6.65	6.70
A1C2	6.72	6.87	7.01	6.80	6.89	6.93	6.87	6.87
A1C3	6.30	6.46	6.63	6.36	6.42	6.70	6.46	6.49
A2C1	6.81	6.90	7.09	6.84	6.86	7.17	6.94	6.96
A2C2	6.99	7.10	7.27	7.05	7.10	7.29	7.12	7.15
A2C3	6.61	6.74	6.92	6.71	6.81	6.95	6.76	6.82
Mean	6.65	6.79	6.96	6.72	6.79	6.99	6.80	6.83
Critical	Non-	Non-	Non-	Non-	Non-	Non-	-	

Difference	Significant	Significant	Significant	Significant	Significant	Significant		
Factor B X C								
B1C1	6.63	6.71	6.88	6.64	6.66	6.96	6.74	6.75
B1C2	6.84	6.91	7.09	6.87	6.91	7.04	6.95	6.94
B1C3	6.42	6.52	6.73	6.48	6.53	6.77	6.56	6.59
B2C1	6.64	6.76	6.93	6.69	6.74	7.01	6.78	6.81
B2C2	6.85	6.96	7.12	6.90	6.96	7.08	6.98	6.98
B2C3	6.45	6.61	6.76	6.53	6.60	6.81	6.61	6.65
B3C1	6.65	6.80	6.97	6.72	6.79	7.05	6.81	6.85
B3C2	6.87	7.02	7.15	6.95	7.04	7.15	7.01	7.05
B3C3	6.46	6.63	6.79	6.54	6.63	6.84	6.62	6.67
B4C1	6.68	6.82	7.04	6.75	6.83	7.08	6.85	6.89
B4C2	6.88	7.05	7.19	6.98	7.08	7.19	7.04	7.08
B4C3	6.48	6.65	6.82	6.59	6.69	6.87	6.65	6.72
Mean	6.65	6.79	6.96	6.72	6.79	6.99	6.80	6.83
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, p≤0.05) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

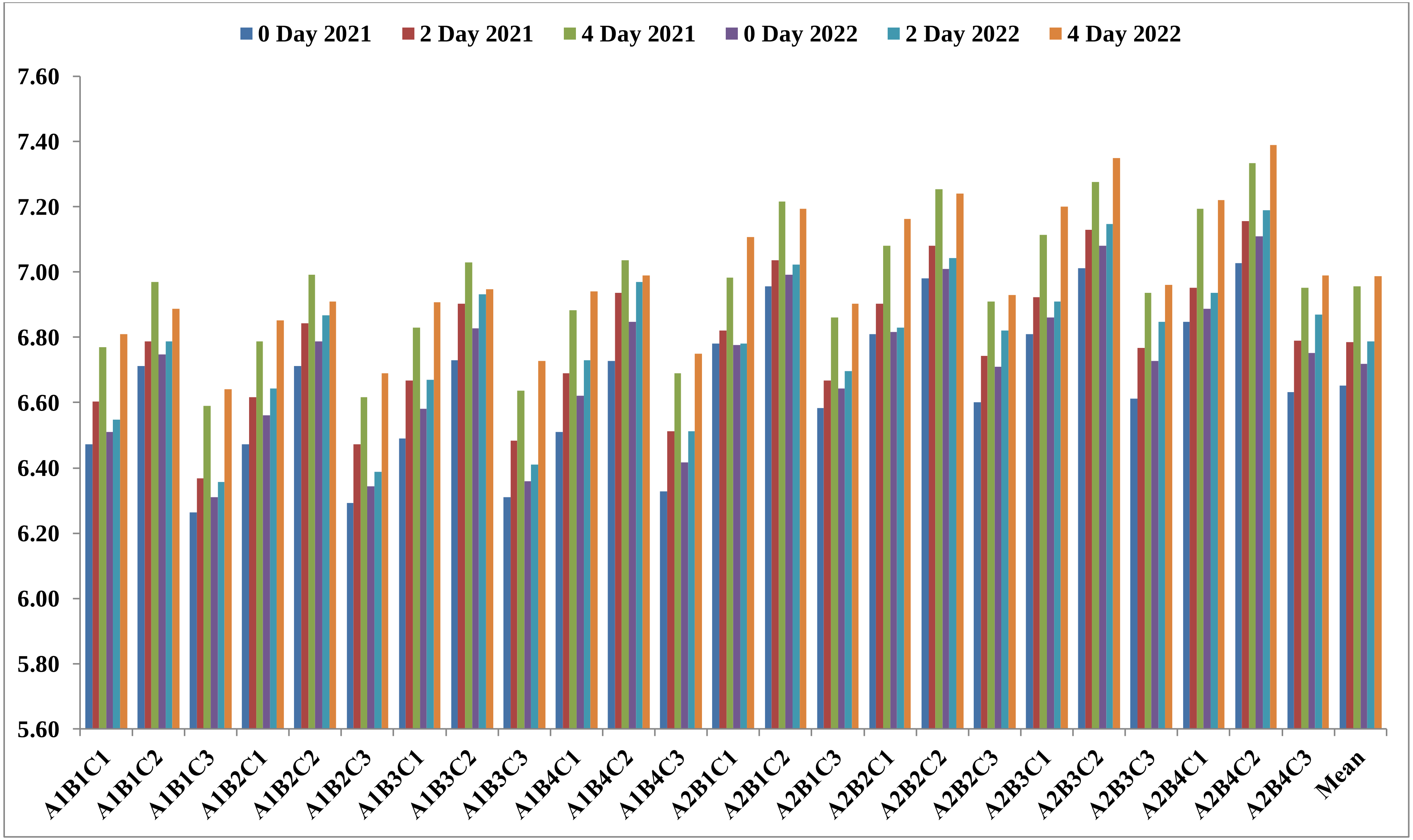

Figure 24 Effect of crop regulation and bagging on Total Sugars % of guava cv. Allahabad Safeda during year 2021 and 2022

Reducing Sugars (%)

The data summarized in Table 21 and Figure 25 shows howthe effect of pruning intensity on reducing sugar sugar content in guavas across four days post-harvest for the years 2021 and 2022. Initially, in 2021, guavas had a reducing sugar content of 3.92% on the day of harvesting, which increased to 3.99% by the second day, and reached 4.08% by the fourth day with a pruning of 20 cm (A2). A similar trend occurred in 2022, starting from 3.97%, rising to 4.00% on the second day, and peaking at 4.10% by the fourth day. These increases were statistically significant, demonstrating that pruning enhances guava sugar content by improving photosynthesis and nutrient distribution. Pruning increases sunlight exposure and airflow, which boosts photosynthesis and nutrient flow to fruit-producing parts of the tree, thereby producing sweeter produce. Same results were supported by Porika *et al.* (2015).

Additionally, Table 20 reveals the significant effects of fruit bagging on guava sugar levels. In 2021, using non-woven bags (C2), sugar content began at 3.90% and rose to 3.97% by the second day and peaking at 4.09 by the forth day. In 2022, starting at 3.95%, sugar levels increased to 3.99% by second day and peaking at 4.08 on fourth day. Fruit bagging creates a stabilized microenvironment that reduces stress and enhances metabolic functions like photosynthesis, leading to higher sugar content. This method protects fruits from direct sunlight and excessive transpiration while maintaining moisture, promoting starch-to-sugar conversion, thereby improving fruit sweetness as evidenced by recent research such as Afroz *et al.* (2023).

The study also noted insignificant interaction effects between pruning, PGR's, and bagging for both 2021 and 2022, with first and second-order interactions (AxB, CxA, BxC, and AxBxC) being non-significant.

During the post-harvest period, the increase in non-reducing sugars in guavas is primarily results in conversion of starch into simpler sugar forms. This transformation is facilitated by enzymes such as amylases, which break down starches into smaller sugar molecules. As the fruit ripens, the activity of these enzymes intensifies, enhancing the synthesis of non-reducing sugars. Additionally, the physiological changes in the fruit, including shifts in metabolic pathways and enzyme activities, promote the accumulation of non-reducing sugars, which are less reactive and contribute to the stability and sweetness of the fruit as it matures. Similar trend was observed by Bhooriya *et al*., 2020.

Table 21 Effect of crop regulation and bagging on Reducing Sugars % of guava cv. Allahabad Safeda

Factor	Reducing Sugars % (2021)			Reducing Sugars % (2022)			Mean Year 2021	Mean Year 2022
	Day 0	Day 2	Day 4	Day 0	Day 2	Day 4		
Factor (A)								
A_1	3.75 [b]	3.80 [b]	3.91 [b]	3.81 [b]	3.84 [b]	3.91 [b]	3.82	3.85
A_2	3.92 [a]	3.99 [a]	4.08 [a]	3.97 [a]	4.00 [a]	4.10 [a]	4.00	4.02
Standard Error	0.029	0.027	0.027	0.025	0.029	0.033	-	
Critical Difference	0.083	0.078	0.076	0.071	0.082	0.094		
Factor (B)								
B_1	3.79	3.84	3.94	3.84	3.87	3.95	3.85	3.89
B_2	3.81	3.88	3.98	3.87	3.90	3.99	3.89	3.92
B_3	3.85	3.91	4.01	3.91	3.95	4.02	3.93	3.96
B_4	3.88	3.95	4.06	3.94	3.97	4.06	3.96	3.99
Standard Error	0.041	0.039	0.038	0.036	0.041	0.047	-	
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant		
Factor (C)								
C_1	3.86 [a]	3.91 [a]	4.03 [a]	3.93 [a]	3.96 [a]	4.04 [a]	3.93	3.97
C_2	3.90 [a]	3.97 [a]	4.09 [a]	3.95 [a]	3.99 [a]	4.08 [a]	3.98	4.01
C_3	3.74 [b]	3.81 [b]	3.88 [b]	3.79 [b]	3.82 [b]	3.90 [b]	3.81	3.83
Standard Error	0.036	0.034	0.033	0.031	0.035	0.041	-	
Critical Difference	0.101	0.095	0.093	0.087	0.101	0.116		
Factor A X B								
A1B1	3.71	3.75	3.86	3.76	3.80	3.86	3.77	3.81
A1B2	3.73	3.79	3.91	3.79	3.83	3.89	3.81	3.84
A1B3	3.76	3.81	3.92	3.82	3.86	3.92	3.83	3.87
A1B4	3.79	3.84	3.95	3.86	3.89	3.95	3.86	3.90
A2B1	3.87	3.92	4.02	3.91	3.95	4.03	3.93	3.96
A2B2	3.89	3.97	4.06	3.94	3.97	4.09	3.97	4.00
A2B3	3.95	4.02	4.10	3.99	4.04	4.12	4.02	4.05
A2B4	3.97	4.05	4.16	4.02	4.06	4.16	4.06	4.08
Mean	3.83	3.89	4.00	3.89	3.92	4.00	3.91	3.94
Standard Error	0.058	0.055	0.053	0.050	0.058	0.066	-	
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant		
Factor A X C								

A1C1	3.77	3.81	3.94	3.86	3.89	3.94	3.84	3.90
A1C2	3.79	3.86	3.98	3.84	3.88	3.97	3.88	3.90
A1C3	3.68	3.72	3.81	3.73	3.75	3.81	3.73	3.76
A2C1	3.96	4.00	4.12	4.00	4.03	4.13	4.02	4.05
A2C2	4.01	4.07	4.19	4.06	4.10	4.19	4.09	4.12
A2C3	3.80	3.89	3.95	3.84	3.88	3.99	3.88	3.91
Mean	3.83	3.89	4.00	3.89	3.92	4.00	3.91	3.94
Standard Error	0.050	0.047	0.046	0.043	0.050	0.058		
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	
Factor B X C								
B1C1	3.82	3.85	3.98	3.88	3.92	3.98	3.88	3.92
B1C2	3.84	3.91	4.02	3.89	3.94	4.02	3.92	3.95
B1C3	3.70	3.74	3.83	3.74	3.77	3.84	3.76	3.78
B2C1	3.84	3.89	4.01	3.90	3.95	4.02	3.91	3.96
B2C2	3.88	3.95	4.09	3.93	3.96	4.06	3.97	3.98
B2C3	3.72	3.80	3.86	3.78	3.79	3.89	3.79	3.82
B3C1	3.88	3.92	4.05	3.95	3.98	4.05	3.95	3.99
B3C2	3.93	3.99	4.10	3.98	4.02	4.10	4.00	4.03
B3C3	3.75	3.83	3.89	3.79	3.84	3.92	3.82	3.85
B4C1	3.91	3.96	4.09	3.98	4.00	4.09	3.99	4.02
B4C2	3.95	4.02	4.13	4.01	4.05	4.13	4.03	4.06
B4C3	3.78	3.85	3.94	3.83	3.87	3.95	3.86	3.88
Mean	3.83	3.89	4.00	3.89	3.92	4.00	3.91	3.94
Standard Error	0.071	0.067	0.065	0.061	0.071	0.081		
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, p≤0.05) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

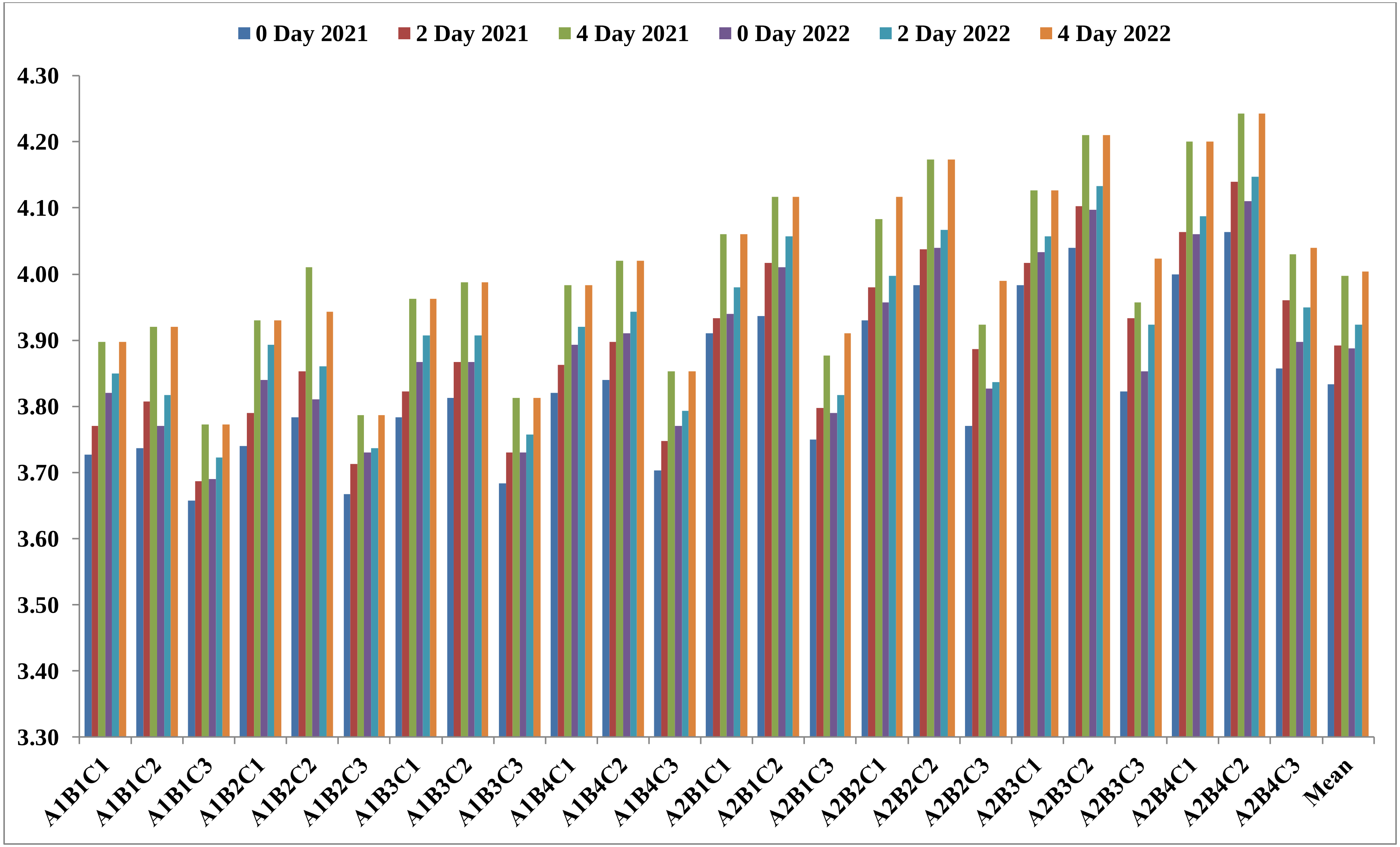

Figure 25 Effect of crop regulation and bagging on Reducing Sugars % of guava cv. Allahabad Safeda during year 2021 and 2022

Non-reducing Sugars %

The impact of pruning intensity on the non-reducing sugar content in guavas over a four-day post-harvest period for the years 2021 and 2022 is depicted in Table 22 and Figure 26. In 2021, the non-reducing sugar content initially observed 3.13% on the harvest day, 2.93% by the second day, and reached 3.01% by the fourth day for guavas pruned to 20 cm (A2). However, in 2022, where the content began at 2.90%, rose to 2.92% by the second day, and peaked at 3.04% by the fourth day. This significant difference indicate that pruning effectively boosts guava sugar content by enhancing photosynthesis and nutrient distribution, increasing sunlight exposure and airflow to the fruit-bearing parts of the tree. This link between pruning and increased sugar content is supported by research from Jayswal *et al.* (2017).

Moreover, the data from Table 20 demonstrate the positive impact of fruit bagging on guava sugar levels. In 2021, using non-woven bags (C2), the sugar content started at 3.17%, 3.02% by the second day, and 3.05% by the fourth day. An increasing sugar was observed in 2022, with initial sugar levels at 2.98%, rising to 3.04% by the second day, and reaching 3.04% by the fourth day. Fruit bagging helps to create a stable microenvironment that mitigates stress and optimizes metabolic functions such as photosynthesis, thus increasing sugar content. This method not only protects the fruits from direct sunlight and excessive water loss but also enhances moisture retention, facilitating the conversion of starches to sugars, thereby improving the fruit's sweetness as indicated by recent findings such as those by Afroz *et al.* (2023).

The analysis also showed no significant interactions between pruning, plant growth regulators, and bagging in both 2021 and 2022, including first and second-order interactions (AxB, CxA, BxC, and AxBxC).

The increase in non-reducing sugars such as sucrose in guavas during the post-harvest period primarily results from the conversion of starches to sugars. This transformation is facilitated by the enhanced activity of enzymes like amylases, which break down complex carbohydrates into simpler sugar molecules as the fruit continues to ripen off the tree. This enzymatic activity is further supported by the physiological changes in the fruit, which optimize the metabolic pathways for sugar synthesis. Moreover, as the fruit ripens and dehydrates slightly, the concentration of these sugars increases, contributing to a higher content of non-reducing sugars, which are inherently more stable and less reactive than reducing sugars. This natural biochemical process not only extends the shelf life of the fruit but also enhances its sweetness and overall appeal.

Table 22 Effect of crop regulation and bagging on Non-reducing Sugars % of guava cv. Allahabad Safeda

Factor	Non-reducing Sugars % (2021)			Non-reducing Sugars % (2022)			Mean Year 2021	Mean Year 2022
	Day 0	Day 2	Day 4	Day 0	Day 2	Day 4		
Factor (A)								
A_1	2.98 [b]	2.86 [b]	2.91 [b]	2.77 [b]	2.81 [b]	2.93 [b]	2.92	2.84
A_2	3.13 [a]	2.93 [a]	3.01 [a]	2.90 [a]	2.92 [a]	3.04 [a]	2.92	2.95
Standard Error	0.02	0.042	0.033	0.035	0.046	0.046	-	
Critical Difference	0.056	0.074	0.095	0.099	0.056	0.087		
Factor (B)								
B_1	3.01	2.88	2.96	2.83	2.83	2.98	2.95	2.88
B_2	3.06	2.90	2.96	2.84	2.87	2.97	2.97	2.89
B_3	3.09	2.90	2.96	2.83	2.87	2.99	2.98	2.90
B_4	3.07	2.90	2.96	2.83	2.90	2.99	2.97	2.91
Standard Error	0.028	0.06	0.047	0.049	0.065	0.065	-	
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant		
Factor (C)								
C_1	3.06 [b]	2.87 [a]	2.92 [b]	2.78 [b]	2.80 [b]	2.99 [a]	2.95	2.85
C_2	3.17 [a]	3.02 [a]	3.05 [a]	2.98 [a]	3.01 [a]	3.04 [a]	3.08	3.01
C_3	2.94 [c]	2.79 [b]	2.90 [b]	2.75 [b]	2.80 [b]	2.90 [b]	2.88	2.82
Standard Error	0.024	0.052	0.041	0.043	0.056	0.056	-	
Critical Difference	0.069	0.148	0.116	0.121	0.159	0.127		
Factor A X B								
A1B1	2.95	2.83	2.91	2.76	2.77	2.92	2.90	2.82
A1B2	2.98	2.86	2.89	2.77	2.80	2.93	2.91	2.83
A1B3	3.00	2.88	2.91	2.77	2.82	2.94	2.93	2.84
A1B4	3.00	2.88	2.92	2.77	2.85	2.94	2.93	2.86
A2B1	3.06	2.93	3.00	2.89	2.88	3.04	3.00	2.94
A2B2	3.14	2.94	3.02	2.91	2.93	3.02	3.03	2.95
A2B3	3.17	2.92	3.01	2.89	2.93	3.05	3.03	2.96
A2B4	3.14	2.91	3.00	2.89	2.94	3.04	3.02	2.96
Mean	3.06	2.89	2.96	2.83	2.87	2.98	2.97	2.89
Standard Error	0.04	0.085	0.067	0.069	0.092	0.091	-	
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant		
Factor A X C								

A1C1	2.97	2.83	2.87	2.71	2.76	2.93	2.89	2.80
A1C2	3.09	3.01	3.02	2.97	3.01	2.97	3.04	2.98
A1C3	2.89	2.74	2.83	2.63	2.66	2.89	2.82	2.73
A2C1	3.15	2.90	2.97	2.84	2.83	3.05	3.01	2.91
A2C2	3.25	3.03	3.08	2.98	3.00	3.11	3.12	3.03
A2C3	2.99	2.85	2.97	2.87	2.93	2.96	2.94	2.92
Mean	3.06	2.89	2.96	2.83	2.87	2.98	2.97	2.89
Standard Error	0.034	0.073	0.058	0.06	0.079	0.079	-	
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant		
Factor B X C								
B1C1	3.01	2.86	2.90	2.76	2.75	2.98	2.92	2.83
B1C2	3.11	3.00	3.08	2.98	2.97	3.02	3.06	2.99
B1C3	2.90	2.78	2.90	2.74	2.76	2.93	2.86	2.81
B2C1	3.05	2.88	2.93	2.79	2.79	2.98	2.95	2.85
B2C2	3.20	3.02	3.03	2.98	2.99	3.02	3.08	3.00
B2C3	2.94	2.81	2.91	2.75	2.81	2.92	2.88	2.83
B3C1	3.08	2.88	2.93	2.77	2.81	3.01	2.96	2.86
B3C2	3.21	3.03	3.06	2.97	3.02	3.05	3.10	3.02
B3C3	2.97	2.79	2.90	2.75	2.79	2.92	2.89	2.82
B4C1	3.09	2.86	2.95	2.78	2.83	2.99	2.97	2.87
B4C2	3.16	3.03	3.05	2.97	3.04	3.06	3.08	3.02
B4C3	2.95	2.80	2.88	2.75	2.82	2.92	2.88	2.83
Mean	3.06	2.89	2.96	2.83	2.87	2.98	2.97	2.89
Standard Error	0.048	0.104	0.082	0.085	0.112	0.112	-	
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant		

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, p≤0.05) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

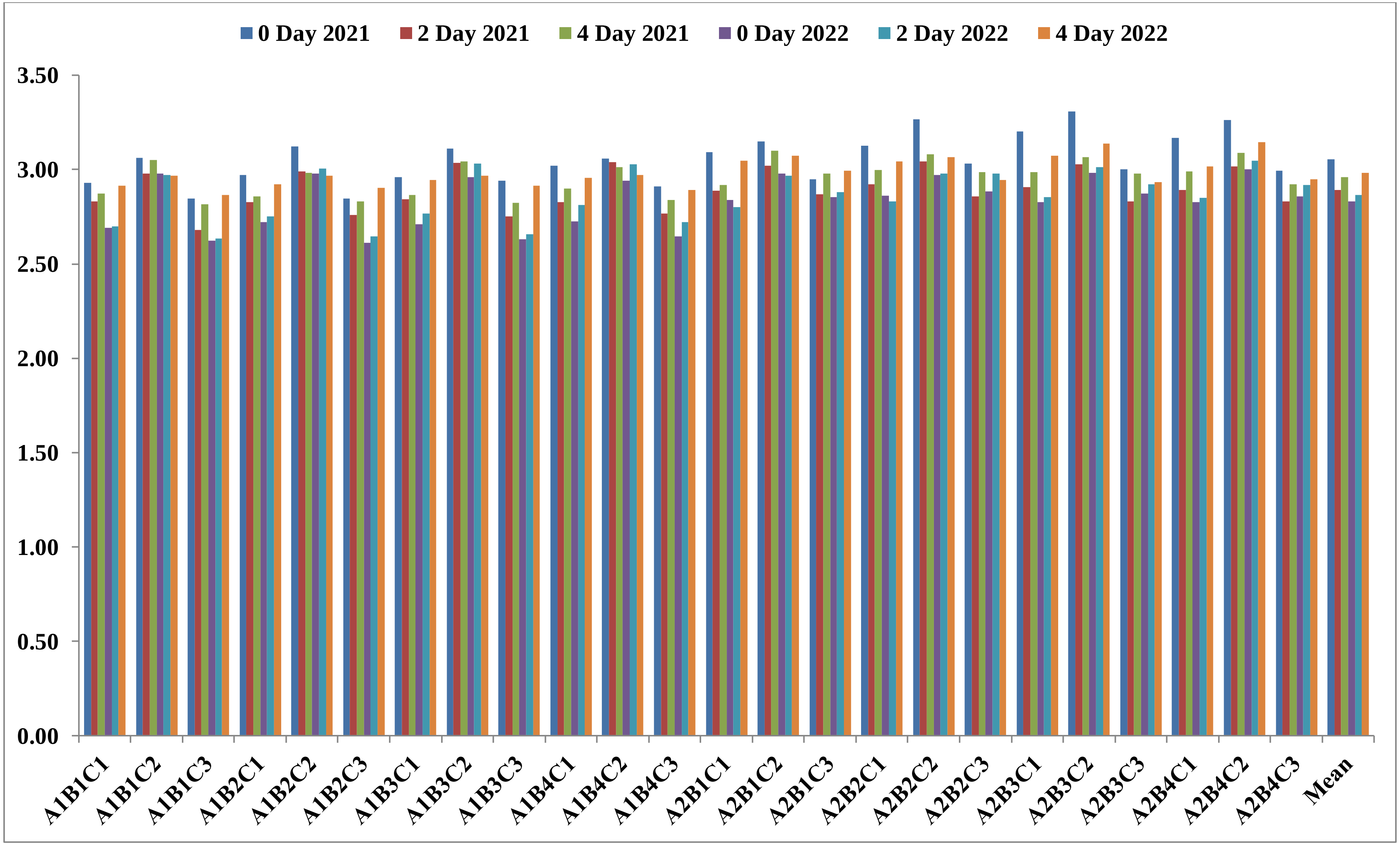

Figure 26 Effect of crop regulation and bagging on Non-reducing Sugars % of guava cv. Allahabad Safeda during year 2021 and 2022

Ascorbic acid (mg/100 gm)

The summarized information in Table 23 and Figure 27 shows a clear reduction in ascorbic acid levels in guavas over time during both 2021 and 2022 in 20 cm pruning (A2). Initially, on Day 0, the ascorbic acid content was highest at 213.45 mg, with a noticeable decrease observed in the subsequent days. By the 2^{nd} and 4^{th} days, the levels dropped to 207.70 mg and 200.33 mg, respectively, in 2021. A parallel decline was documented in 2022, starting from an initial concentration of 216.86 mg on Day 0, to 207.66 mg on the 2^{nd} day, and further down to 202.65 mg on the 4^{th} day, indicating a statistically significant variation over the period. The intensity of pruning on guava trees significantly affects their ascorbic acid levels, or Vitamin C content. Study indicates that guavas from trees with higher pruning intensities tend to have the highest Vitamin C levels as compare to unpruned trees. The decline in ascorbic acid levels in guavas after harvest is largely attributed to the natural metabolic activities that take place as the fruit ripens. Ascorbic acid is particularly vulnerable to oxidative degradation, especially under conditions of exposure to oxygen and high temperatures, which are typical after harvesting (Shashi *et al.*, 2022; Bhooriya *et al.,* 2020; Beulah *et al.*, 2021).

The influence of different concentrations of PGR's on ascorbic acid levels in guava was marked. In 2021, treating with 50 ppm of GA3 (B4) resulted in the highest ascorbic acid levels at 205.38 mg on Day 0, which then decreased to 199.83 mg by the 2^{nd} day and further to 192.72 mg by the 4^{th} day after harvesting. A consistent trend was observed in 2022, with ascorbic acid levels starting at 208.55 mg on Day 0, then dropping to 200.46 mg on the 2^{nd} day, and declining to 195.94 mg by the 4^{th} day, showing a statistically significant effect. Applying gibberellic acid (GA3) to guava trees has been shown to increase the ascorbic acid in the guava. Research suggests that GA3 enhances the biosynthesis or accumulation of ascorbic acid, improving the nutritional and health benefits of guavas.

The research also underscored the profound influence of fruit bagging on ascorbic acid concentration, as shown in Table 23. For the C2 treatment using non-woven bags, ascorbic acid levels were highest at 223.01 mg immediately after harvest (Day 0), then declined to 216.98 mg by the 2^{nd} day and further to 209.26 mg by the 4^{th} day in 2021. Similarly, in 2022, the initial ascorbic acid level was 226.69 mg on Day 0, which decreased to 216.20 mg by the 2^{nd} day and dropped to 213.93 mg by the 4^{th} day, indicating a clear and statistically significant downward trend across the days post-harvest. Bagging is a key agricultural method that involves enclosing fruits in bags as they grow, significantly changing their environmental exposure. This technique particularly impacts the ascorbic acid levels in guavas by altering the microclimate around the fruit, affecting factors like light exposure, temperature, and humidity. Reduced sunlight from bagging lower photosynthetic activity, potentially decreasing ascorbic acid synthesis since sunlight is crucial for producing metabolic compounds such as ascorbic acid. Research conucted by Meena *et al.* (2016), Abbasi *et al.* (2014), and Saxena *et al.* (2021) have noted higher ascorbic acid levels in bagged guavas compared to unbagged ones.

Moreover, the statistical analysis validated the significant interaction effects between pruning and bagging for both 2021 and 2022. Notably, the first-order interaction, AxC, emerged as the only significant factor in both years. Within this interaction, the highest levels of ascorbic acid were observed at 241.56 mg on Day 0, which then decreased to 235.07 mg by the 2nd day and further to 226.73 mg by the 4th day in 2021. In a consistent pattern for 2022, initially ascorbic acid levels recorded at 245.50 mg on Day 0, which then fell to 232.44 mg by the 2nd day and further declined to 230.40 mg by the 4th day, demonstrating a consistent and statistically significant reduction in levels over the days following the harvest. The interactions AxB and BxC, as well as the second-order interaction AxBxC, were not statistically significant.

The decrease in ascorbic acid levels in guava post-harvest is primarily due to the natural metabolic processes that occur as the fruit continues to ripen off. Ascorbic acid, also known as vitamin C, is highly susceptible to oxidative breakdown, particularly in the presence of oxygen and elevated temperatures, which are common post-harvest conditions. This enzymatic oxidation is accelerated further if the fruit is bruised or damaged. Thus, the longer the guavas are stored post-harvest, the more significant the reduction in ascorbic acid levels, affecting the nutritional quality of the fruit (Bhooriya *et al.*, 2020; Beulah *et al.*, 2021).

Table 23 Effect of crop regulation and bagging on Ascorbic acid (mg/100 gm) of guava cv. Allahabad Safeda

Factor	Ascorbic acid (mg/100 gm) (2021)			Ascorbic acid (mg/100 gm) (2022)			Mean Year 2021	Mean Year 2022
	Day 0	Day 2	Day 4	Day 0	Day 2	Day 4		
Factor (A)								
A_1	183.77 [b]	178.77 [b]	172.39 [b]	186.71 [b]	178.43 [b]	174.70 [b]	178.31	179.95
A_2	213.45 [a]	207.70 [a]	200.33 [a]	216.86 [a]	207.66 [a]	202.65 [a]	207.16	209.06
Critical Difference	6.42	6.25	6.03	5.57	2.46	2.40	-	
Factor (B)								
B_1	192.38 [a]	187.18 [b]	180.53 [b]	195.43 [b]	185.90 [d]	181.56 [d]	186.69	187.63
B_2	195.66 [b]	190.35 [b]	183.55 [b]	198.90 [b]	190.08 [c]	185.31 [c]	189.85	191.43
B_3	201.00 [a]	195.58 [a]	188.63 [a]	204.28 [a]	195.74 [b]	191.89 [b]	195.07	197.30
B_4	205.38 [a]	199.83 [a]	192.72 [a]	208.55 [a]	200.46 [a]	195.94 [a]	199.31	201.65
Critical Difference	9.08	8.84	8.52	7.88	3.49	3.39	-	
Factor (C)								
C_1	209.58 [b]	203.89 [b]	196.62 [b]	212.99 [b]	205.57 [b]	200.96 [b]	203.37	206.51
C_2	223.01 [a]	216.98 [a]	209.26 [a]	226.69 [a]	216.20 [a]	213.93 [a]	216.42	218.94
C_3	163.23 [c]	158.83 [c]	153.19 [c]	165.69 [c]	157.38 [c]	151.13 [c]	158.42	158.06
Critical Difference	7.86	7.66	7.38	6.82	3.02	2.94	-	
Factor A X B								
A1B1	176.70	171.91	165.79	179.39	171.95	168.07	171.46	173.14
A1B2	182.51	177.53	171.17	185.46	177.02	173.21	177.07	178.56
A1B3	186.01	180.95	174.50	189.19	180.54	176.29	180.49	182.00
A1B4	189.85	184.68	178.09	192.82	184.23	181.25	184.20	186.10
A2B1	208.06	202.45	195.27	211.47	199.85	195.06	201.93	202.13
A2B2	208.81	203.17	195.93	212.35	203.14	197.40	202.64	204.30
A2B3	215.99	210.22	202.77	219.36	210.94	207.49	209.66	212.60
A2B4	220.92	214.98	207.35	224.28	216.69	210.64	214.42	217.20
Mean	198.61	193.23	186.36	201.79	193.05	188.68	192.73	194.50
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	
Factor A X C								
A1C1	191.97 [d]	186.73 [d]	180.05 [d]	195.08 [d]	187.06 [d]	183.06 [d]	186.25	188.40
A1C2	204.46 [c]	198.90 [c]	191.79 [c]	207.88 [c]	199.95 [c]	197.46 [c]	198.38	201.76
A1C3	154.87 [f]	150.67 [f]	145.32 [f]	157.18 [f]	148.29 [f]	143.59 [f]	150.28	149.69
A2C1	227.18 [b]	221.06 [b]	213.20 [b]	230.90 [b]	224.07 [b]	218.87 [b]	220.48	224.61
A2C2	241.56 [a]	235.07 [a]	226.73 [a]	245.50 [a]	232.44 [a]	230.40 [a]	234.45	236.12
A2C3	171.59 [e]	166.99 [e]	161.06 [e]	174.19 [e]	166.46 [e]	158.68 [e]	166.55	166.44
Mean	198.61	193.23	186.36	201.79	193.05	188.68	192.73	194.50
Critical Difference	11.12	10.83	10.44	9.64	4.27	4.15	-	
Factor B X C								

B1C1	199.59	194.19	187.30	202.83	195.70	191.32	193.69	196.62
B1C2	215.91	210.08	202.60	219.51	208.04	205.83	209.53	211.13
B1C3	161.64	157.27	151.69	163.96	153.96	147.54	156.86	155.15
B2C1	207.82	202.17	194.94	211.09	202.14	197.79	201.64	203.67
B2C2	217.48	211.59	204.04	221.30	212.47	209.77	211.04	214.51
B2C3	161.69	157.29	151.68	164.33	155.64	148.37	156.88	156.11
B3C1	214.95	209.15	201.70	218.58	210.43	204.59	208.60	211.20
B3C2	224.41	218.35	210.59	228.13	219.04	219.44	217.78	222.20
B3C3	163.65	159.26	153.62	166.12	157.75	151.64	158.84	158.50
B4C1	215.96	210.07	202.56	219.48	214.01	210.14	209.53	214.54
B4C2	234.25	227.91	219.82	237.83	225.23	220.70	227.33	227.92
B4C3	165.95	161.50	155.77	168.34	162.15	156.99	161.08	162.49
Mean	198.61	193.23	186.36	201.79	193.05	188.68	192.73	194.50
Critical Difference	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	Non-Significant	-	

Distinct letters (a, b) within the columns indicate significant differences (Tukey's test, p≤0.05) and reflect the impact of treatment during the same time interval. A represents pruning levels (A1 - 10 cm pruning, A2 - 20 cm pruning). B represents the concentration of plant growth regulators (B1 – 10ppm NAA, B2 – 20ppm NAA, B3 – 25ppm GA3, B4 50ppm GA3). C represents the bagging material used for guava (C1 – Muslin cloth bag, C2 – Non-woven bag, C3 – No bagging) Year-1 (2021), Year-2 (2022).

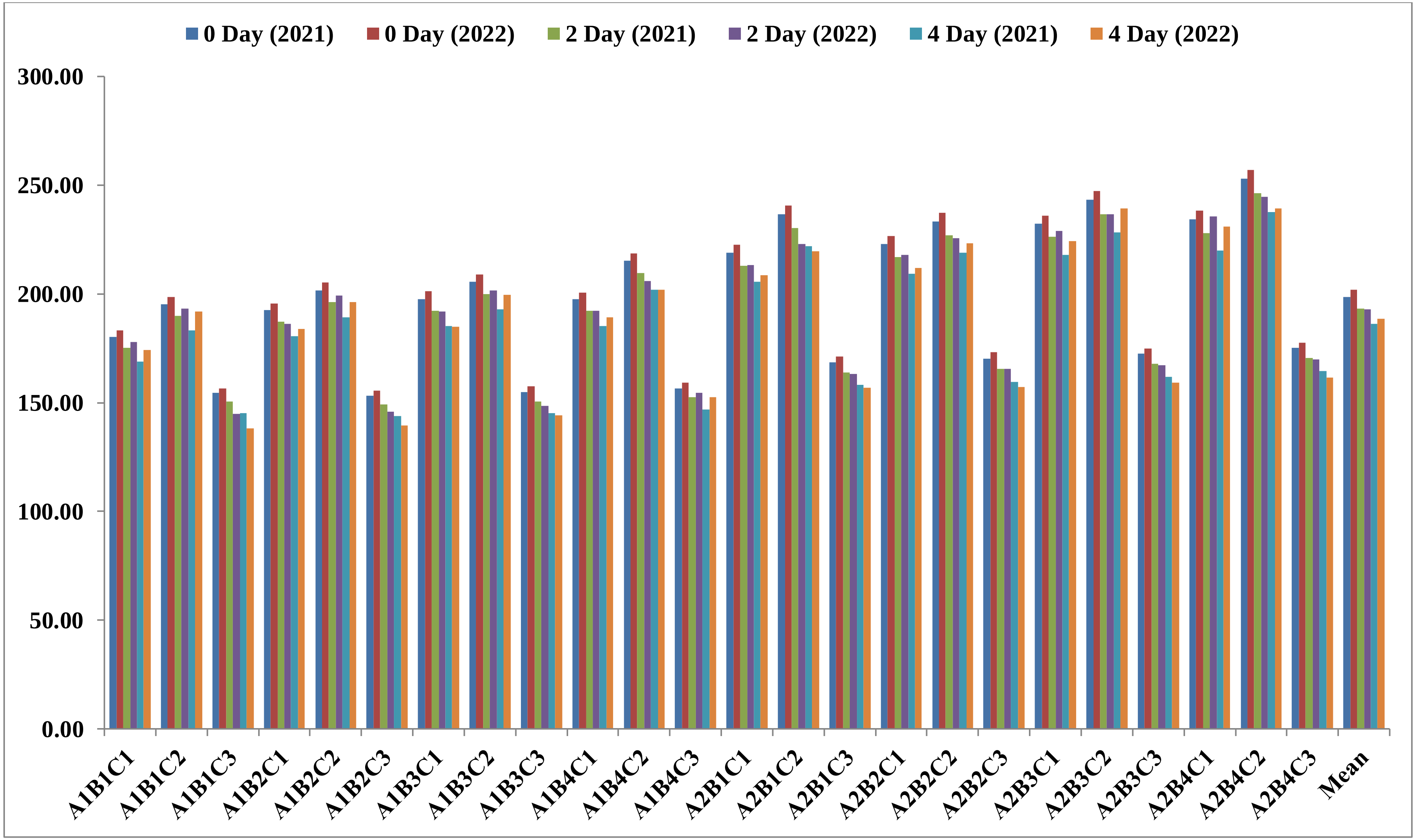

Figure 27 Effect of crop regulation and bagging on Ascorbic acid (mg/100 gm) of guava cv. Allahabad Safeda during year 2021 and 2022

SUMMARY AND CONCLUSION

The study titled "Effect of Crop Regulation and Bagging Materials on Growth, Flowering and Quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda." was conducted in 2021 and 2022 at the guava orchard of Lovely Professional University, Phagwara, Punjab. Key findings from the research are summarized and concluded as follows:

- During the first experiment, the plant shows significant effect of pruning and age of plants in various attributes such as shoot length (cm), flowers per shoot, fruit set percent, yield (kg), fruit weight (gm), Total soluble sugars (ºBrix), sugars (%) and ascorbic acid (mg/100gm) across different pruning levels and age of plants. However, only significant effect of pruning was found in various observations such as initiation of flowering, flower bud emergence to anthesis, acidity (%) and TSS: Acid ratio over both years.
- In pooled data analysis maximum length of shoot was found in 20 cm pruned plants, whereas the lowest shoot length was recorded in non-pruned plants and pruning in 11 year old found to be superior as compared to 9 year old plants.
- There were lesser days taken in initiation of flowering which shows the significant effect of pruning intensity in both years. Lesser days was taken by 20 cm pruned plants where initiation of flowering after pruning found faster as compared to other treatments. However, effect of plant age was non-significant in both years but found significant in pooled analysis in which 9 year old plants shows early initiation of flowering.
- For flower bud emergence to anthesis, minimum days were required in 20 cm pruning intensity which was significant, whereas maximum days were taken in non-pruned plants. Age of plant was non-significant for flower bud emergence to anthesis in individual year but 9 year old plants found to be significantly effective in combined data examination.
- Maximum flowers, fruit set %, Yield, fruit weight and TSS was recorded in 20 cm of pruning intensity (A3) during the both years, whereas minimum number of flowers, fruit set %, Yield, fruit weight and TSS was found in non-pruned plants. On the other hand, 11 year old plants found to be more superior as compare to 9 year old plants which was found significant with each other.
- The lowest titrable acidity and highest tss: acid ratio in guava fruit was recorded when pruning occurred 20 cm (A3) over two consecutive years. Conversely, the highest titrable acidity and lowest tss: acid ratio was observed with non-pruned plants which show significant effect with each other. Whereas, age of plant shows non-significant effect on acidity and tss: acid ratio of fruits.

- The highest levels of sugars content in guava fruit were measured in 20 cm pruning intensity (A3), whereas lowest levels of sugars content was observed in no pruned. With respect to the age of plants, 11 year older plants found to be superior in sugars content in guava fruit as compared to 9 year old which shows the significant of pruning and age of plant respectively.
- The highest ascorbic acid in guava fruit was recorded with 20 cm pruning (A3), and 11 year old plants shows higher level of ascorbic content which shows significant impact of pruning and age of plants on ascorbic acid content of guava across both years.

➢ In the second experiment, three factors were investigated: pruning, plant growth regulators (PGR), and bagging. The summary of these observations is as follows:

- The study observed that highest shoot length, shortest duration required for initiation of flowering and flower bud emergence to anthesis was found in 20 cm pruning (A2). Whereas, minimum shoot length, maximum number of days was taken for initiation of flowering and flower bud emergence to anthesis in 10 cm pruning (A1) which was shows the significant impact of pruning on shoot length, initiation of flowering and flower bud emergence to anthesis during two consecutive years.
- The maximum flowers and fruit set percentage were observed with the pruning 20 cm pruning intensity (A2). In contrast, the minimum number of flowers and fruit set % was observed with 10 cm pruning intensity (A1) over both years which shows significantly affect number of flowers and fruit set % of guava.
- The highest yield/plant and weight was observed in 20 cm pruning (A2), followed by 10 cm pruning. Whereas, highest fruit weight and fruit yield was found in 50 ppm Ga3 (B4) concentration among all concentration of Ga3 and NAA. However, in bagging materials, non-woven bagging (C2) shows superior yield and fruit weight among others which shows the significant effect of pruning, pgr and bagging over both years. This pattern indicates that first-order (A×B, B×C, and C×A) found to be statistically significant, whereas, second-order (A×B×C) interactions in these years, with none showing significant statistical relevance.
- Different bagging material had a significant impact on the fruit fly infestation, physical damage and total damage cause by insect, birds or during the time of harvesting. Among bagging materials, the lowest fruit fly infestation, physical damage and total damage occurred in non-woven bagging (C2). In contrast, the highest value for damage cause by insect was recorded in non-bagging treatment.
- The highest total soluble solid (TSS) in guava was achieved with 20 cm pruning intensity (A2). In terms of pgr application, 50 ppm of Ga3 concentration shows the superior results.

However, among bagging materials, non-woven bagging shows highest TSS which shows the significant effect of all factor on TSS of guava over both years.

- The lowest titrable acidity in guava fruits was noted with 20 cm pruning intensity over two consecutive years. However, non-woven bagging results superior as comparison to muslin cloth and unbagged fruits.
- Pruning positively influenced TSS: Acid ratio of guava fruits. The maximum TSS:Acid was recorded in 20 cm pruning intensity (A2). While minimum TSS: Acid ratio recorded in 10 cm pruning intensity (A1). However, highest TSS: Acid ratio was recorded in Ga3 50 ppm among different concentration of pgr. Highest TSS: Acid ratio was also found in non-woven bagged fruit amount different bagging. This pattern indicated that all three factors and first order interaction between C×A found to be statistical significant.
- The maximum concentrations of sugars in guava fruit were found in plants pruned at 20 cm intensity (A2). Conversely, the lowest sugar levels were observed in plants that were not pruned. Regarding the plant growth regulators, Ga3 50 ppm (B4) performed superior as compared to other concentrations exhibited higher levels of total, reducing, and non-reducing sugars. However, among bagging, non-woven bagging resulted in highest total, reducing, and non-reducing sugars in guava fruit. This pattern indicated that all three factors and first order interaction between C×A found to be statistical significant.
- The highest ascorbic acid content (mg/100g pulp) in guava fruit was recorded with 20 cm pruning (A2), Regarding the plant growth regulators, 50 ppm Ga3 application shows higher level of ascorbic content and among different bagging, non-woven bag shows highest ascorbic acid content which shows significant impact of pruning, pgr and bagging on ascorbic acid content of guava across both years. Additionally, the combined impact of pruning and bagging (interaction A × B) was found to be significant.

- Impact of crop regulation and bagging materials on post-harvest attributes of guava.
- The study found no significant influence of pruning, PGR's, and bagging on guava weight loss, which is mainly driven by respiration and transpiration processes.
- The maximum Total Soluble Solids (TSS) were recorded in C2 (non-woven bags), demonstrating a consistent increase over the storage days during both years studied, while the minimum value for acidity % was recorded in C2.
- The impact of various pruning and bagging materials on sugars were observed in guava fruits was significant. Both pruning and bagging material impact the sugar content of guava. The maximum sugar reaching was noted in A2 (20 cm pruning).
- The highest concentrations of ascorbic acid in guava fruit, reaching 243.53 mg per 100g of pulp in a pooled analysis, were recorded in the A2C2 treatment, illustrating the synergistic impact of both pruning and bagging.
- The longest shelf life was observed in fruits that were bagged, appearing healthy and unaffected by fruit flies, which contributed to their delayed spoilage compared to those that were not bagged.
- Observations of guava post-harvest were conducted on the day of harvest, 2nd and 4th days after harvest.
- There was no significant percentage of weight loss observed in guavas during the postharvest phase. The weight loss of the fruit remained consistent throughout the post-harvest analysis, resulting in a non-significant weight percentage over time.
- The highest total soluble solids (TSS ^{0}Brix) in guava which were subjected to non-woven bags during the year 2021 and 2022. However, the lowest percentage of acidity was observed in fruits that were enclosed in non-woven bags.
- Guava fruits that underwent pruning and bagging showed higher percentages of reducing, non-reducing, and total sugars. Conversely, the highest sugar content was observed in fruits bagged with non-woven materials.
- Maximum ascorbic acid content was recorded in guavas bagged with non-woven materials, but this content decreased as the number of post-harvest days increased.

In conclusion the long-term productivity and sustainability of guava trees hinge on maintaining a harmonious balance between their vegetative and reproductive phases. Therefore, ensuring adequate nutrient supply and effective canopy management becomes crucial. This study aimed to explore the impact of varying pruning techniques and the age and effect of pruning, plant growth regulator and bagging on guava cv. Allahabad Safeda over two years. Pruning resulted in highest length of shoot (11.34 cm), flowers per shoot (5.65), fruit set (82.27%), yield (28.57 kg), fruit weight (127.24 gm), TSS (10.05 ^{o}Brix), total sugar (6.56%) and ascorbic acid (168.48 mg) whereas opposite trend in acidity, initiation of flowering (65.55 days) and flower bud emergence to anthesis (35.00 days) was observed. Intensifying the degree of pruning leads to the highest possible improvement in all parameters including the yield of guava trees. In both years of the study, pruning and age of plants significantly increased the amount of harvestable fruit. The pruning level of 20 cm was recorded optimal pruning for enhanced productivity and improved fruit quality in guavas in the initial experiment. Further, the trees with relatively greater age (11 years old or more) can respond effectively to the pruning. Moreover, in experiment second, the outcome indicated that minimum total damage of 3.74% was found in C_2, whereas maximum shoot length of 11.74 cm, 5.76 flowers per shoot, and 82.57 % fruit set in A_2 and yield of 34.54 kg was recorded in A_2C_2. Fruit bagging effectively reduces total damage of 96.26% (C_2) from pests and birds, with a marked decrease in infestation levels. Thus conclusion of study provides novel insights into sustainable guava cultivation practices, highlighting the importance of integrated approaches for improving yield and fruit quality while minimizing damage and enhancing nutritional value.

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