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Ameliorate chemical quality through different pruning time, pruning intensity and bagging of fruit in Mrig Bahar *guava cv.* Sardar (L-49)

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Abstract
A field experiment was carried out at main experiment Station, Department of fruit Science, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, (U.P) during the year 2019 and 2020. The experiment was conducted in a Randomized block design (Factorial) with three replications. The treatment combination comprise of 3 factors *viz.* 3 pruning time, 2 pruning intensity and 2 bagging levels. The minimum cost of cultivation Rs 55754 ha^{-1} was computed under control treatment, while maximum cost of cultivation Rs 114954 ha^{-1} was obtained in treatment 20th June pruning with 60 per cent pruning intensity and bagging 20 days after fruit set. The highest gross return and net return Rs 317200 and 203811 was achieved in treatment 5th June pruning with 60 per cent pruning intensity and bagging 20 days after fruit set, respectively and the lowest gross return and net return (Rs 109500 and Rs 55754 ha^{-1}) was recorded under control treatment. The maximum cost-benefit ratio (1:1.79) was computed with treatment combination of 5th June pruning time with 60 per cent pruning intensity and bagging 20 days after fruit set. The lowest cost-benefit ratio (1:.03) was recorded in control treatment. Pruning of *guava* trees in the first week of June with 60 per cent pruning intensity of annual shoot growth and bagging 20 days after fruit set can be recommended to obtain higher yield with quality fruit and maximum return.

Keywords: C:B Ratio, yield, pruning, bagging, economics, return

Introduction
Guava (*Psidium guajava* L.) the "poor man‟s fruit" and "apple of tropics" is a popular fruit tree of tropical and sub-tropical climate and is native to the Tropical America stretching from Mexico to Peru. It belongs to the family *Myrtaceae* and has the recognition of being the most widely cultivated species of this family (Gadgil and Gadgil, 1933) [8]. *Guava* is considered as one of the exquisite, nutritionally valuable and remunerative fruit crop. *Guava* fruit is known for its „vitamin-C‟, minerals like calcium, iron and phosphorous with pleasant aroma and flavour (Ulemale and Tambe, 2015) [25]. It excels most other fruit crops in productivity, hardiness, adaptability and nutritive value. *Guava* bears on current season‟s growth and flowers appear in the axils of new leaves, therefore, it responds well to pruning. Pruning of *guava* is one of the most important practices that influence the vigor, productivity and quality of the fruits (Gadgil and Gadgil, 1933) [8]. Large trees take several years before they come into bearing and overall cost of production per unit area is further increased. Hence, there is over riding need to improve the existing planting system and to manipulate tree growth using canopy management to control tree growth patterns, tree shape and maintaining high fruit production of desired size and quality (Gorakh Singh, 2001) [22]. Jadhav *et al.*, (2002) [9] noticed that earliest emergence of vegetative bud sprout, shoot length, number of flowers per shoot and number of fruits per shoot, on severely pruned (60 cm) trees of *guava* was found to be significantly more than mild pruned (30 cm) trees and control. Rupankar Bhagawati *et al.*, (2015) [3] opined that severely pruned shoot of *Guava* have fewer number of shoots per pruned shoot. This might be due to less number of vegetative buds in severely pruned shoot. While the new shoots per shoot was lowest in shoots without pruning. Sheikh and Rao (2002) [17] found that highest fruit diameter of pomegranate was noticed in severe pruning as compared to mild pruning and control. Bikash Das (2014) [4] reported that an alteration in the rooting pattern as influenced by shoot pruning in litchi.

Shoot pruning resulted in lower biomass and carbohydrate allocation towards thicker roots.

Shaban and Haseeb (2009) [20] opined that *guava* moderate pruning gave highest significant increase in the yield for the seasons, severe pruning and pinching gave a significant intermediate effect between moderate pruning and the control. Sathya Prakash *et al.*, (2012) [16] opined that the moderately pruned *guava* trees in winter season produced fruits of largest size and of maximum weight and such fruits had highest TSS and ascorbic acid content. Smallest size and minimum weight with lowest TSS and ascorbic acid content was recorded in fruits harvested from unpruned control trees. Meland (2009) [14] stated that apple fruit weights and soluble solids contents values were highest with the lowest crop load and decreased with increasing crop load. Trees with the highest crop load had the lowest crop load in the following year. Fruit quality was generally high for all treatments.

Materials and Methods

The experiment was carried out at Main Experiment Station, Department of Fruit Science, College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh during year 2019- 20 and 2020- 21. The experiment was laid out in factorial randomized block design with thirteen treatments and three replications with one plant in each replication. The plants were planted at spacing of 6 m x 6 m. Thirteen treatment combinations were formed from 3 pruning time, 2 pruning intensity, 2 bagging time and control.

1. Total Soluble Solid (^{0}Brix)

Total Soluble Solids (TSS) was determined with a hand refractometer and the value was corrected to 20^{0}C with the help of a temperature correction chart.

2. Titratable acidity (%)

Titratable acidity was estimated by titrating a known weight of the finally blended pulp with 0.1 N NaOH using phenolphthalein as indicator. The results were expressed as percentage of citric acid using the formula (AOAC, 2002).

$$\text{Acidity (\%)} = \frac{\text{Titre value (ml)} \times \text{Normality of NaOH} \times 64 \times \text{Volume made up (ml)}}{\text{Aliquot taken (ml)} \times \text{Sample weight (g)} \times 1000} \times 100$$

3. Vitamin C content (mg/100g pulp)

Vitamin C content of the sample was determined by 2, 6-Di-chloro Phenol Indophenol dye visual titration method. This method involved three steps. The steps were as follows:

Step-1: Standardization of dye

The dye which was blue in alkaline solution and red in acid solution was reduced by ascorbic acid to colorless form. The reaction was quantitative and practically specific for ascorbic acid in solution in the pH range 1-3.5. Five ml of standard ascorbic acid solution was taken to which 5 ml of HPO_3 was added. The dye was filled in a burette. The standard ascorbic acid was titrated with the dye solution. The end point was attained by titrating till the pink color persisted for 15 sec. The dye factor was determined using the formula-

Dye factor = 0.5/Titre

Step-2: Preparation of sample

Fruit pulp was mixed thoroughly using pistel morter. In case of hard ripe fruits, 100 g fruit pulp was mixed with 100 ml water and mixed thoroughly in grinder. Juice was separated through filtration with the help of muslin cloth. 10 ml of sample was taken and volume was made up to 100ml with 3% HPO_3.

Step-3: Assay of Extract

An aliquot of 10 ml of the HPO_3 extract of the sample was taken and titrated with the standard dye to a pink end point which persisted for at least 15 sec. Titration was done rapidly and a preliminary determination of the titre was made. Then the aliquat sample was titrated using dye solution.

$$\text{Ascorbic Acid (mg/100g)} = \frac{\text{Titre value (ml)} \times \text{dye factor} \times \text{Volume made up (ml)} \times 100}{\text{Aliquot taken (ml)} \times \text{Weight of sample taken (g)}}$$

4. Reducing Sugars

An aliquot of 5 ml diluted fruit juice was taken from 100 ml as above for titration and mixed with 5 ml of each Fehling solution 'A' and 'B'. This solution was titrated against 1.0% glucose solution in boiling solution using methylene blue indicator. The appearance of light brick colour was marked as end point. A blank titration with 10 ml of fehling solution 'A' and 'B' was also run. The results were expressed as per cent of reducing sugars.

$$\text{Reducing sugars (\%)} = \frac{[\text{Blank titre value (ml)} - \text{Sample titre value (ml)}] \times 0.0025 \times \text{volume made up (ml)}}{\text{Aliquot taken (ml)} \times \text{weight of sample (g)}} \times 100$$

5. Non-reducing sugar (%)

Non-reducing sugar was estimated by traditional method as described by Kumar (2002). It was estimated by subtracting reducing sugar from the total invert sugar and multiplied with 0.95

Non-reducing sugar (%) = (Reducing Sugar – Invert Sugar) × 0.95

6. Total Invert sugar (%)

Out of 100ml sample, 5ml aliquot was taken, mixed with three drops HCl and keep for overnight. Next day 2-3 drops of phenolphthalein indicator was added and neutralized with 30% sodium hydroxide solution, containing 10ml Fehling solution 'A' and 'B'.

The mixture was titrated against 1% glucose in boiling solution using methylene blue as indicator. The appearance of brick red color was marked as the end point. The results were expressed as per cent of total invert sugars.

$$\text{Total invert sugars (\%)} = \frac{[\text{Blank titre value (ml)} - \text{Sample titre value (ml)}] \times 0.0025 \times \text{volume made up (ml)}}{\text{Aliquot taken (ml)} \times \text{weight of sample (g)}} \times 100$$

7. Total sugars (%)

The estimated values were expressed in total sugar, reducing sugar and non-reducing sugars contents of fruits and expressed as per cent reducing sugar plus per cent non-reducing sugar and expressed as per cent total sugars.

Total sugar = Reducing sugar (%) + Non reducing sugar (%)

Results and Discussion

1. Total Soluble Solid (^{0}Brix)

The pruning time 5th June gave highest total soluble solid (^{0}brix) content in *guava* fruit and the lowest total soluble solid content was estimated in treatments, pruning on 20th June during 2019 and 2020. Pruning with 60 per cent intensity gave maximum total soluble solid content. The lowest total soluble solid content was estimated in treatments, pruning at 30 per cent intensity during 2019 and 2020. The bagging treatment showed significantly, higher values with 20 days after fruit set, however the effect of treatment on control was also found significant during both the years. Dhaliwal and Kuar (2003) [6] observe the highest TSS content was recorded for pruning at 30 cm on 10 April. Brar *et al.* (2007) [5] reported the total soluble solids were higher in the fruits of pruned trees as compared to the unpruned ones. Bhagawati *et al.* (2015) [3] observe bio-chemical properties of fruits, total soluble solids and total sugar were found to increase with enhanced pruning severity and least in case of no pruning. Jayswal *et al.* (2017) [10] reported, highest TSS, Ascorbic acid, Total Sugar, Reducing Sugar and Non-Reducing Sugar in pruning at 40 cm, while the minimum was observed in unpruned plants. The results of the study revealed that among the various pruning treatments the pruning of 30 cm of apical shoots on 15th May proved to be the best in increasing the yield and yield attributes in terms of number of fruits per tree and also fruit size, weight and yield. It also improved the fruit quality by increasing TSS, sugars, ascorbic acid and pectin content of *guava* fruits (Singh *et al*. 2020) [23].

Table 1: Effect of pruning time, pruning intensity and bagging on total soluble solid (TSS ^{0} Brix)

Treatments	Total soluble solid (TSS ^{0} Brix)	
A. Pruning time	**2019**	**2020**
T_1 (Pruning on 20th May)	12.10	13.28
T_2 (Pruning on 5th June)	12.34	13.53
T_3 (Pruning on 20th June)	10.81	11.86
SE(m±)	0.205	0.263
CD (P=0.05%)	0.597	0.767
B. Pruning intensity		
P_1 (30% Pruning)	11.52	12.25
P_2 (60% Pruning)	11.99	13.53
SE(m±)	0.167	0.215
CD (P=0.05%)	NS	0.627
C. Bagging		
D_1 (Bagging at 10 DAFS)	11.28	12.37
D_2 (Bagging at 20 DAFS)	12.22	13.41
SE(m±)	0.167	0.215
CD (P=0.05%)	0.487	0.627
D. Treatment vs Control		
Treatment (T)	11.75	12.89
Control (C)	8.87	9.63
SE(m±)	0.409	0.526
CD (P=0.05%)	1.194	1.535

2. Titratable acidity (%)

The 20th June pruning and pruning with 30 per cent intensity and bagging at 10 days after fruit set gave significantly, lowest titrable Acidity in *guava* fruits during 2019. Significantly lowest values were seen with 20th June pruning, pruning with 30 per cent intensity in year 2020, the bagging at 10 days after fruit set during the year 2019. The maximum titrable acidity was observed in treatments, pruning on 05th June and the 60 per cent pruning, the bagging at 20 days after fruit set during 2019. Overall, the treatments were found significant over control during 2020. Kumar and Rattanpal (2010) [13] observed, fruit acidity was low with the pruning treatment, ½ removal of vegetative growth of plants and Bhagawati *et al.* (2015) [3] reported the acidity was found to be highest with no pruning and decreased with increase in pruning intensity. More acidity was observed in fruits from unpruned trees and a gradual decrease was observed when the intensities of pruning were increased (Kumar and Srivastava 1983) [12]. The maximum acidity was obtained with heavy pruning and minimum with light pruning treatment (Singh and Chauhan 1998) [21]. All bagging materials did not change the total titratable acidity content (Neto *et al.* 2020) [19].

Table 2: Effect of pruning time, pruning intensity and bagging on titrable Acidity (%) of *guava*

Treatments	Titrable Acidity (%)	
A. Pruning time	**2019**	**2020**
T_1 (Pruning on 20th May)	0.48	0.38
T_2 (Pruning on 5th June)	0.49	0.39
T_3 (Pruning on 20th June)	0.43	0.34
SE(m±)	0.010	0.008
CD (P=0.05%)	0.030	0.024
B. Pruning intensity		
P_1 (30% Pruning)	0.46	0.35
P_2 (60% Pruning)	0.48	0.39
SE(m±)	0.008	0.007
CD (P=0.05%)	NS	0.020
C. Bagging		
D_1 (Bagging at 10 DAFS)	0.45	0.36
D_2 (Bagging at 20 DAFS)	0.49	0.38
SE(m±)	0.008	0.007
CD (P=0.05%)	0.024	NS
D. Treatment vs Control		
Treatment (T)	0.47	0.37
Control (C)	0.52	0.43
SE(m±)	0.020	0.017
CD (P=0.05%)	NS	0.049

3. Vitamin C content (mg/100g pulp)

Increase in vitamin C content of *guava* fruit estimated for pruning time, pruning intensity during 2020 and bagging during both the years. The 5th June pruning, recorded highest Vitamin C content during both the years. The lowest Vitamin C content was estimated in treatments, pruning on 20th June during both the years. The pruning was effective only in the year 2020, with 60 per cent intensity. The bagging at 20 days after fruit set was significant during 2019 and 2020. In general higher Vitamin C content was estimated during 2020 as compare to 2019. It might be due low temperature & relative humidity in the year 2020. Meena *et al.* (2017) [14] analysis on fruit quality showed that pruning in May at 45 cm length from shoot tip also produced superior quality fruits in term of higher TSS and vitamin C. Kumar and Rattanpal (2010) [13] found that, TSS and vitamin C (mg/100 g fruit pulp) and low acidity was the best in pruning treatment by 1/2 removal of vegetative growth in *guava* fruit crop. Contrary this, pruning of 30 cm of apical shoots on 15th May proved to be the best in increasing the yield and yield attributes in terms of number of fruits per tree and also fruit size, weight and yield. It also improved the fruit quality by increasing TSS, sugars, ascorbic acid and pectin content of *guava* fruits Singh *et al.* (2020) [23].

Table 3: Effect of pruning time, pruning intensity and bagging on Vitamin C (mg/100g pulp) content of *guava* fruit

Treatments	Vitamin C (mg/100g pulp)	
A. Pruning time	**2019**	**2020**
T_1 (Pruning on 20th May)	190.18	228.11
T_2 (Pruning on 5th June)	193.87	232.54
T_3 (Pruning on 20th June)	169.87	203.75
SE(m±)	3.975	6.154
CD (P=0.05%)	11.603	17.963
B. Pruning intensity		
P_1 (30% Pruning)	180.95	210.40
P_2 (60% Pruning)	188.33	232.54
SE(m±)	3.246	5.025
CD (P=0.05%)	NS	14.667
C. Bagging		
D_1 (Bagging at 10 DAFS)	177.25	212.61
D_2 (Bagging at 20 DAFS)	192.03	230.33
SE(m±)	3.246	5.025
CD (P=0.05%)	9.474	14.667
D. Treatment vs Control		
Treatment (T)	184.64	221.47
Control (C)	147.50	140.46
SE(m±)	7.951	12.308
CD (P=0.05%)	23.206	35.926

4. Reducing Sugars

An increase in reducing sugar content (%) was observed with pruning on 5th June and pruning with 60 per cent intensity and bagging at 20 days after fruit set during both the years of experimentation. Pruning time 5th June gave highest per cent of reducing sugar in *guava* fruit during 2019 and 2020. The lowest reducing sugars were estimated in treatment, 20th June pruning during both the years. Jayswal *et al.* (2017) [10] reported the highest TSS, Ascorbic acid, Total Sugar, Reducing Sugar and Non-Reducing Sugar was recorded in pruning at 40 cm, while the minimum was observed in unpruned plants. Sawant *et al.* (2018) [18] significant increase with respect to quality parameters like maximum fruit weight, diameter of fruit, volume of fruit, TSS, ascorbic acid content and reducing sugars when *guava* plants were pruned 50 per cent of secondary branches. The pruning of 30 cm of apical shoots on 15th May proved to be the best in increasing the yield and yield attributes in terms of number of fruits per tree and also fruit size, weight and yield. It also improved the fruit quality by increasing TSS, sugars, ascorbic acid and pectin content of *guava* fruits **(**Singh *et al*. 2020) [23].

Table 4: Effect of pruning time, pruning intensity and bagging on reducing sugars (%) content of *guava* fruit

Treatments	Reducing sugar (%)	
A. Pruning time	**2019**	**2020**
T_1 (Pruning on 20th May)	4.22	4.24
T_2 (Pruning on 5th June)	4.39	4.26
T_3 (Pruning on 20th June)	3.70	3.78
SE(m±)	0.091	0.113
CD (P=0.05%)	0.266	0.330
B. Pruning intensity		
P_1 (30% Pruning)	3.91	3.96
P_2 (60% Pruning)	4.30	4.23
SE(m±)	0.074	0.092
CD (P=0.05%)	0.217	0.270
C. Bagging		
D_1 (Bagging at 10 DAFS)	3.97	3.96
D_2 (Bagging at 20 DAFS)	4.24	4.22
SE(m±)	0.074	0.092
CD (P=0.05%)	0.217	NS
D. Treatment vs Control		
Treatment (T)	4.10	4.09
Control (C)	3.32	2.96
SE(m±)	0.182	0.226
CD (P=0.05%)	0.532	0.661

5. Non-reducing sugar (%)

20th May pruning (T_1) during 2019 and 05th June pruning (T_2) during 2020, pruning with 60 per cent intensity (P_2) and bagging at 20 days after fruit set (D_2) has recorded maximum non-reducing sugar (%) in *guava* fruits. Jayswal *et al.* (2017) [10] recorded highest TSS, Ascorbic acid, Total Sugar, Reducing Sugar and Non-Reducing Sugar was recorded in pruning at 40 cm, while the minimum was observed in unpruned plants. Singh and Chauhan (1998) [21] observed highest TSS with heavy pruning which was closely followed by medium level pruning in peach variety July Elberta. The total, reducing and non-reducing sugars were also affected significantly by different pruning intensities. In *guava* among the various pruning treatments the pruning of 30 cm of apical shoots on 15th May proved to be the best in increasing the yield and yield attributes in terms of number of fruits per tree and also fruit size, weight and yield. It also improved the fruit quality by increasing TSS, sugars, ascorbic acid and pectin content of *guava* fruits **(**Singh *et al*. 2020) [23].

6. Total invert sugar and total sugars (%)

Higher amount of invert and total sugars content with pruning on 5th June (T_2), 60 per cent pruning intensity (P_2) and bagging at 20 days after fruit set (D_2) during 2019 and 2020. Basu *et al.* (2007) [2] found that pruning had a significant effect on the quality of *guava* fruits and time of pruning distinctly influenced fruit quality. TSS was found to be highest in fruits. Total sugar content was also higher. El-Souda (2005) [7] observed that in *guava* fruit TSS and total sugars were increased by pruning treatments compared to control trees without significant differences. Total sugar content of all treatments was higher than the control. Singh and Chauhan (1998) [21] observed highest TSS with heavy

pruning which was closely followed by medium level pruning in peach variety July Elberta. The total, reducing and non-reducing sugars were also affected significantly by different pruning intensities.

Table 5: Effect of pruning time, pruning intensity and bagging on Non-Reducing Sugar (%) of *guava* fruit

Treatments	Non-Reducing Sugar (%)	
A. Pruning time	**2019**	**2020**
T_1 (Pruning on 20th May)	3.37	3.34
T_2 (Pruning on 5th June)	3.35	3.45
T_3 (Pruning on 20th June)	3.08	2.98
SE(m±)	0.072	0.093
CD (P=0.05%)	0.209	0.271
B. Pruning intensity		
P_1 (30% Pruning)	3.09	3.03
P_2 (60% Pruning)	3.44	3.49
SE(m±)	0.059	0.076
CD (P=0.05%)	0.171	0.221
C. Bagging		
D_1 (Bagging at 10 DAFS)	3.11	3.09
D_2 (Bagging at 20 DAFS)	3.43	3.42
SE(m±)	0.059	0.076
CD (P=0.05%)	0.171	0.221
D. Treatment vs Control		
Treatment (T)	3.27	3.26
Control (C)	2.66	2.66
SE(m±)	0.143	0.186
CD (P=0.05%)	0.419	0.541

Table 6 (a): Effect of pruning time, pruning intensity and bagging on Total Invert sugar of *guava* fruit (%)

Treatments	Total Invert sugar (%)	
A. Pruning time	**2019**	**2020**
T_1 (Pruning on 20th May)	7.77	7.75
T_2 (Pruning on 5th June)	7.92	7.90
T_3 (Pruning on 20th June)	6.94	6.92
SE(m±)	0.165	0.166
CD (P=0.05%)	0.481	0.483
B. Pruning intensity		
P_1 (30% Pruning)	7.16	7.14
P_2 (60% Pruning)	7.92	7.90
SE(m±)	0.135	0.135
CD (P=0.05%)	0.393	0.395
C. Bagging		
D_1 (Bagging at 10 DAFS)	7.24	7.22
D_2 (Bagging at 20 DAFS)	7.84	7.82
SE(m±)	0.135	0.135
CD (P=0.05%)	0.393	0.395
D. Treatment vs Control		
Treatment (T)	7.54	7.52
Control (C)	6.12	5.75
SE(m±)	0.330	0.331
CD (P=0.05%)	0.963	0.967

Table 6 (b): Effect of pruning time, pruning intensity and bagging on total sugars (%)

Treatments	Total Sugars (%)	
A. Pruning time	**2019**	**2020**
T_1 (Pruning on 20th May)	7.59	7.57
T_2 (Pruning on 5th June)	7.74	7.72
T_3 (Pruning on 20th June)	6.78	6.76
SE(m±)	0.163	0.206
CD (P=0.05%)	0.475	0.600
B. Pruning intensity		
P_1 (30% Pruning)	7.00	6.98
P_2 (60% Pruning)	7.74	7.72
SE(m±)	0.133	0.168
CD (P=0.05%)	0.388	0.490
C. Bagging		
D_1 (Bagging at 10 DAFS)	7.08	7.06

D_2 (Bagging at 20 DAFS)	7.66	7.64
SE(m±)	0.133	0.168
CD (P=0.05%)	0.388	0.490
D. Treatment vs Control		
Treatment (T)	7.37	7.35
Control (C)	5.98	5.62
SE(m±)	0.326	0.411
CD (P=0.05%)	0.951	1.201

Conclusion

The maximum total soluble solids (TSS ^{0}Brix) of *guava* were observed with 5th June pruning time during both the years and pruning intensity 60 per cent during 2020. The bagging was effective with 20 days after fruit set during both the years. The minimum terrible acidity of *guava* fruit were observed with 20th June pruning time during both the years and 30 per cent pruning intensity during 2020 and bagging 10 days after fruit set during 2019, whereas the maximum titrable acidity were noted in pruning time 5th June, pruning intensity 60 per cent and bagging 20 days after fruit set during 2019. The maximum Vitamin C content (mg/100g pulp) of *guava* fruit were seen with 5th June pruning time during both the years and pruning intensity 60 per cent during 2020 and bagging 20 days after fruit set during both the years. The maximum reducing, invert, non-reducing and total sugars content (%) of *guava* fruit was estimated with 5th June pruning time and 60 per cent pruning intensity and bagging 20 days after fruit set during both the years.

The result obtained from the present investigation, it can be concluded that among different pruning time, the 05th June pruning was found most effective in improving chemical parameters of *guava* fruit. Chemical attributes were improved with 60 per cent pruning of annual shoot growth. T.S.S, Vitamin C and Sugars were enhanced with bagging 20 days after fruit set.

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