Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

Crop Regulation in Fruit Crops: A Review

Ashok Kumar[1], B.D.Bhuj [2], Sant Ram[3], C.P.Singh[4], Shri Dhar[5] and R.K.Yadav[6]

1. **Assoc. Professor**, Department of Horticulture, SGT University, Gurgram, Haryana, [NCR Delhi]
2. **3& 4. Professor Horticulture,** College of Agriculture, G.B.P.U.A &T- Pant Nagar, U.P., India
5. Principal Scientist, Devision of Vegetable Science, IARI, Pusa New Delhi-110012

***Corresponding Author:**
Dr Ashok Kumar, Associate Professor, Department of Horticulture,
SGT University, Gurugram, Haryana, [NCR Delhi].

Abstract

The crop regulation can be achieved by the adoption of the various practices like withholding irrigation after harvesting during the months of April-May in Northern Indian plains. This results in the shedding of flowers and the tree goes to rest. The basin of the tree is dug up, manure and irrigated in June. After about 30-35 days the tree put forth profuse flowering and fruit mature in winter.To regulate the guava crop, it is essential to reduce the fruit set during the rainy season and subsequently increase the fruit set during winter season by the use of different chemicals like NAA, ethereal and urea etc.India is second largest producer of fruits in the world after china. India is rich in fruit diversity starting from tropical, subtropical to temperate region. Some of the fruits like Guava, pomegranate, lemon, mandarin etc., if left without any treatment, give several light harvests of the variable quantities and qualities from the various flowering flushes throughout the year. Plants are forced to produce only one crop instead of two or three crops with good quality production. The main objective of crop regulation is to force the tree for rest and produce profuse blossom and fruits during any one of the two or three flushes. It can be achieved through with holing irrigation water, root exposure, root andshoot pruning, deblossming, sprayof chemical and other plant growth regulators. The selection of bahar at a location is mainly determined by prevailing production constraints like availability of the irrigation water, quality production, and occurrence and extend of the damage by the disease and pests and several market factors. Crop regulation planningis about identifying, selecting, implementing and monitoring methods to control the yield and quality of horticultural crops. To be sustainable, this must be achieved without negatively impacting people, the environment or the financial bottom line.

Key Words: Fruit Set, Fruit Quality, Crop regulation, Bahar treatment, Flowering, Yield and Quality.

1. Introduction: Crop regulation is the basis for the regular and quality crop. Crop density, ameasure of fruit crop, influences fruit growth and ultimately fruit size at harvest. It is largelydependent upon flowering and fruit set. Various methods are used to increase production withenhanced fruit quality by crop regulation. It can be achieved through manual thinning, chemicalthinning, selective harvesting, training, summer and winter pruning, prevention of pre harvestfruit drop etc. Some of the fruit crops bloom throughout the year without any resting period and produces two or three crops (bahar) in a year but yield and quality is not so good in all crop harvest. It is very essential to understand the flowering and fruiting behavior of crops and which bahar will give good crop with considering all the factors associated with a particular bahar. The acid limes bloom throughout the year but the main blooming period is February - March, with lean period from July to August. It is not uncommon to find, particularly in lime, flowers fruit lets, developing fruits and mature fruits all at a given time (Rajput and Babu, 1985). Mahalle et al., (2010) reported in Hasta bahar flowering (September and October) of Acid lime, two sprays of cycocel 1000 ppm at an interval of one month before initiation of flowering that is in August and September resulted in maximum yield in terms of number of fruits per tree and weight of fruits per tree and this treatment also improved the fruit quality in respect to juice %, TSS, acidity, ascorbic acid content and peel %. Similarly, guava bears varyingamount of fruitthroughout the year. Guava bloom thrice in a year: Ambebahar, Mrigbahar and Hasthbahar. In north India, major crop usually ripensfrom Julyto mid-October (rainy season). A small distinct crop

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

is produced from November to mid-February (winter season) whereas two flowering seasons have been reported in the climatic condition of Assam (Lal et al., 2013). Though, the quantum of production is high in rainy season (Rathore and Singh, 1974 and Singh et al., 2000), it offers poor quality due to insipid in taste (Singh et al., 1996) and infestation of pest (Rawal and Ullasa, 1988) in comparison to winter season. On the contrary, in winter season quality fruits are produced and fetch high monetary returns (Singh et al., 2000). There is a distinct difference in quality in the fruits produced in different season and winter is considered to be more favourable for quality guava production (Rathore and Singh, 1974; Pandey et al., 1980 and Singh, 1985). Though rainy season crop give higher yield, the fruit is often infested by many pests and diseases (Rawal and Ullasa, 1988) and they are rough, insipid and watery, with poor quality and less nutritive values (Syamal et al., 1980). Singh et al., (1991) studied the various cropping pattern and recommended a single winter crop in one year in order to harvest a highly economical crop of the best quality fruits. Several methods have been tried to induce new vegetative growth during rainy season so that bumper crop is obtained in subsequent winter season (Shigeura and Bullock, 1976, Singh et al., 2000). Coordination of the fruiting cycle can help in maintaining fruit supplies during most months (Lopez etal., 1982, Manica et al., 1982, Lopez and Perez, 1977and Shatat, 1993). Guava fruit harvest peaks can deviate with prevailing weather conditions and cultural practices because flowers are produced on new growth. Irrigation (Singh et al., 1997), fertilization (Shigeura and Bullock, 1976), defoliation and pruning (Singh et al., 1996, Shigeura and Bullock, 1976, Shatat, 1993) can be usedto stimulate new growth and influence fruiting in guava. Several workers have reported increased yield, fruit size and qualitative attributes of guava as a result of pruning at different periods. Cassin et al., (1969) reported that unrestricted growth gives rise to more vegetative growth than the reproductive growth, as temperature or moisture stress is essential for flowering. Regulated crops are desired to avoid the glut in the market and ensure the regular supply of fruits. Nir et al., (1972) reported that increased intensity of flowering due to stress showed that flower differentiation occurred during moisture stress and that generative buds formed did not undergo flower development till water was supplied. Goell et al., (1981) reported that moisture stress followed by alleviation was effective in initiating and promoting vegetative flushing. The flowering is delayed under longer period of stress which may be due to conditions like high and low temperature and low humidity condition. Singh and Chadha (1988) advocated that imposition of stress caused uniformity in flushing and intensity depended on amount of stress as measured by relative water content (RWC) in plant before alleviation.

Seasonal availability of major tropical & sub-tropical fruits in different month

Sr. NO.	Fruit crops	Available in month
1.	Mango	June-July
2.	Banana	Jan-Dec
3.	Citrus	Nov-Dec (Sweet orange) Dec-Jan (Mandarins) August-Nov (Lemon and lime)
4.	Grape	April-May
5.	Pomegranate	Jan-Feb
6.	Guava	Nov-Dec
7.	Papaya	Sept-Oct
8.	Custard apple	Oct-Nov
9.	Sapota	Jan-Feb

Fig 1: Sessional availability of fruits

1.1. **Why needs crop regulation**: Many crops which bloom more than one in a year do not produce good yield and quality of the fruit throughout the year. The yield and quality dependson the bahar. For example, the rainy season crop of guava is poor in quality and crop is affected by many biotic and abiotic stresses as

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

compared to winter season crop. The winter season crops (mrigbahar) which ripen from second fortnight of October to first fortnight of January are superior in quality, free from diseases and pests and fetch higher income. This requires regulation of flowering (from ambebahar to mrigbahar) to obtain most profitable crop by several methods. In different regions various methods of crop regulations are followed depending on climatic factors, cropping pattern, cultivar etc. The flowering is more in guava during summer season because of heavy new flushes that lead to more fruit production in rainy season. In this season, duration of fruit harvesting is reduced to 30 days due to high temperature and rainfall and it causes glut in the market which lead to poor price and less demand in the market. Winter season crop is superior in quality which fetches higher prices than rainy season crop. In rainy season there is a serious attack of fruit flies which deteriorates its quality and fruits become unfit for human consumption. So far getting the quality fruits in guava only winter season crop should be taken and rainy season crop should be avoided. Water availability is big issue in Maharasthra, Rajsthan and Gujrat during summer season for pomegranate grower. They always avoid taking ambebahar crop and regulating this crop in to mrigbahar with the onset of monsoon and crop is harvested during winter and some farmers prefer hasthbahar with less availability of water.

1.2. .Crop Regulation in different crops : Guava is most important commercial fruit crop grown in sub-tropical region of the Indian subcontinent. It gives an assured crop with very little care. Its cost of production is also low as compared to most of other commercial fruit crops. In guava, two distinct seasons of flowering, spring (March-April) and rains (June-July) occur from which fruits ripen during rainy and winter season respectively. In North Indian climate the rainy season crop of guava is poor in quality and nutritive value and is affected by many insect pests and diseases. The winter season fruits are superior in quality free from diseases and pests and give higher income. But it is advisable to take only one crop every year. This requires management of flowering to obtain the most desirable crop, by the methods like withholding irrigation, pruning, thinning of flowers by chemically or manually. In guava, mainly mrigbahar flowering is preferred by grower and fruits are harvested during winter season. This season crop is free from insect pest and diseases, and produces good quality fruits. Pomegranate flowers continuously when watered regularly. The plants under such conditions may continue bearing flowers and bear small crop irregularly at different period of the year, which may not be desirable commercially. To avoid this trees are given bahar treatment. In this treatment, the irrigation is withheld two months prior to the bahar followed by light earthing up in the basin. This facilitates the shedding of leaves. The trees are then medium pruned 40-45 days after withholding irrigation.

The recommended doses of fertilizers are applied immediately after pruning and irrigation is resumed. This leads to profuse flowering and fruiting. The fruits are ready for harvest 4-5 months after flowering. In tropical condition, there are three flowering seasons, viz., January-February (ambebahar) June-July (mrigbahar) and September-October (hasta bahar). The choice of flowering/fruiting is regulated taking into consideration the availability of irrigation water, market demand and pest/disease incidence in a given locality. The fruits of ambebahar are ready for harvest in the month of June to September. As the fruit development takes place during dry months, they develop an attractive colour and quality thus suitable for exports. Similarly due to dry weather, the incidences of pest and disease attack are limited. However, ambebahar can be taken only areas havingassured irrigation facilities. Themrigbahar crop is harvested in the month of December to February. Usually this bahar is favoured as the flowering and fruiting period coincides with rainy season or immediately after rains, and the crop is taken without much irrigation. As the fruits develop during the rainy season and mature during winter, the colour and sweetness of the fruit is affected. The fruits from hasta bahar are harvested during the month of March to April. They have very attractive rind with dark coloured arils. Since the availability of the fruits during this season is limited, they fetch high value. Optimum water stress cannot be developed during this period as withholding of irrigation coincides with the rainy season. This leads to poor flowering and thus affects the yield. The lemon, lime and citron are considered as continuous bloomers, particularly under tropical climate producing some flowers throughout the year, though the spring bloom is the heaviest.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

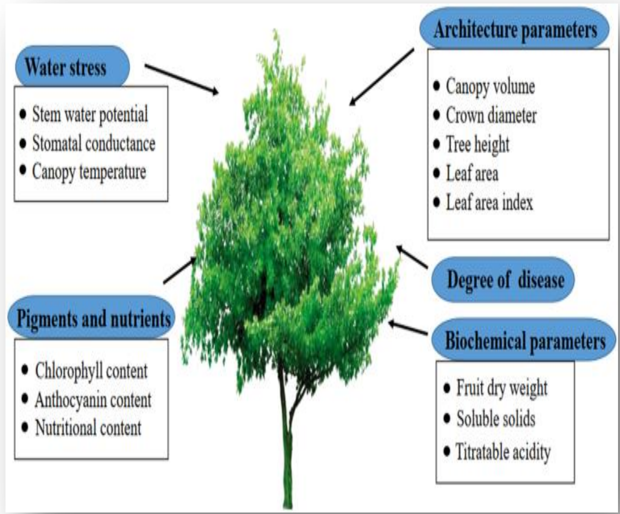

Fig 2: Five aspects and related phenotypic parameters of fruit trees.

The acid limes bloom throughout the year but the main blooming period is February - March, with lean period from July to August. Acid lime in tropical and sub-tropical conditions tends to give continuous flushes of growth, both vegetative as well as reproductive throughout the year. Acid lime trees flower thrice in a year in the months of January- February, June- July and September-October known as Ambe, Mrig and Hasta bahar, respectively. The fruits of the Ambe, Mri and Hasta bahar flowering becomes available in the month of June-July, November-December and April-May months,

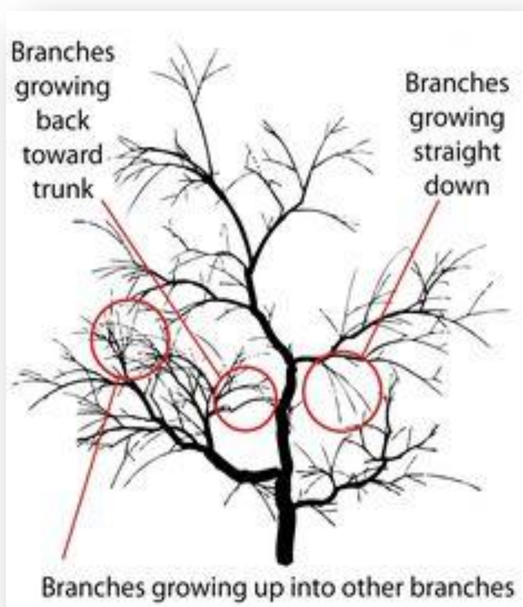

Fig 3: Pruning of Criss-cross branches

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

respectively. The flowering percentage of Ambe, Mrig and Hasthbahar occurs 47 %, 36 % and 17 %, respectively. The fruits of Hasthbahar flowering become available in the months of April-May when there is heavy demand and is sold at premium price. But Hasta bahar (summer cropping) bear only 17 % flowering and fruiting is achieved in the uncontrolled condition because of the monsoon rains preceding flower initiation. Therefore, acid lime is forced to produces hasthbahar crop. Use of Gibberellic acid (GA3) during stress period is known to reduce the intensity of flowering in the following flowering season. Cycocel (CCC) has been found very effective for imposing stress for inducing flowering. GA3 (50 ppm) increased yield and quality of Allahabad safeda guava in Assam condition (Lal and Das, 2017). Potassium nitrate (KNO3) chemical for sprouting has been found effective in acid lime. The water stress with harmones played an important role in regulation of flowering and there is relationship between severity of stress and flowering response (South Wick and Davenport, 1987; Barbera and Garimi, 1988). Webner (1943) observed that the time of flowering is reported to vary with temperature. Flowering was about a month earlier in higher temperature zone (Florida) than in cooler temperature zone (California). Motial (1964) reported that kagzi lime flowered only once a year under Saharanpur conditions. Hittalmani (1977) reported that the maximum flowering occurred only during December-January and May-July periods. Flowering potential is more related to the season than the age of the shoot. The magnitude of fruit setting and retention was however, higher in June flowering than in January. It was further revealed that, flowering was related to the season rather than to the physiological age of the shoots. C. aurantifolia bore flowers mainly on lateral shoots, whereas C. latifolia flowered mainly on terminal shoots (Hittalmaniet al., 1977). Rohidas and Chakrawar (1989) studied the ambebahar flowering under Parbhani, Maharashtra, India condition and reported that flowering started asearly as in November and continued till February with aduration of 50 to 55 days and peak between 15 to 31 January. Athani et al., (1998) noticed that the flowering was twice in Karnataka - once during December - January and again during July - August. Ghawede et al., (2002) revealed that in Akola, India, there were only two main flowering seasons, the first and the major one occurring in December - February (Ambebahar) constituting more than 50% of total number of flowers produced in the year and second one in June - July (MrigBahar)constituting about 25% of total number of flowers. Majority of the shoots which bore flowers were normal invigour as measured in terms of length of shoot and flowers were mostly on lateral shoots (> 80%) and in the apical region of shoots. In central India, mandarins bloom thrice a year. Under such circumstances, plants give irregular and small crops at indefinite intervals. To overcome this problem and to get fruitful yield in any of the three flowering seasons', flowering is regulated in such a way that we could get only crop which will be beneficial to the grower and selection of bahar depends on the climatic condition and availability of water.

1.2.1. Crop Regulation in Pomegranate: Irrigation is withheld at least two months prior to the main flowering season. Manuring andfertilization followed by light irrigation is then followed two months later after flowering. Thenthree to four days later, normal irrigation are given at recommended intervals. This will result inproducing new growth and bloom and thus ensure good crop.In Deccan, there are three flowering seasons viz,, June-July (mrig-bahar), February-March(ambe bahar) and September- October (hasta bahar). It is however desirable to take just onecrop a year depending upon market requirement for better price and availability of water. Inthe Deccan, mrig bahar is taken due to scarcity of water in hot summer months. For gettingcrop from mrig bahar, treatment with withholding of irrigation from December to March-Mayresults suppression of growth during this period. Trees will shed their leaves in March and willremain dormant till May. Shallow ploughing of land up to 10 cm depth is practiced in April. Inmid May, the manure and fertilizers are applied followed by one or two light irrigation prior tothe onset of monsoon rains. Trees will put forth new growth followed by bloom in June and willbear a good crop.In irrigated areas, Ambe bahar is also taken in the Deccan. Crop from this will mature in JuneJuly. Irrigation is stopped once rain commence during monsoons. Following monsoon period,when trees shed their leaves in October-November, shallow ploughing is done. Manures andfertilizers are applied in the months of December-January, subsequently in January, first lightirrigation is given and flowers will appear a month after irrigation. Quality of fruits and yield arebetter in Maharashtra from ambe bahar, whereas in Bangalore, fruit from mrig bahar maturingin October-November are superior in quality than ambe bahar. Regulation of hasta bahar ispractically not feasible due

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

to rainy season.Use of Chemicals/Growth Regulators: Solutions of plant growth regulators are made bydissolving their measured quantity in small amount of solvent and then diluting in water, tomake an appropriate strength/ concentration. The types of PGRs used are:- Auxin, Gibberellin,Cytokinin. Commercial formulations of PGRs are also available in liquid form and solutions ofdesired strength of these are prepared by diluting their required quantities in water.

2. Induction of water stress: In northern plains withholdingirrigation after harvesting of winter crop, results in theshedding of flowers and the tree goes to rest. The basin ofthe tree is dug up, manured and irrigated in June. After about20-25 days the tree put forth profuse flowering and fruitmature in winter. Induction of water stress by withholdingirrigation from December to June or until the beginning ofmonsoon depending upon the prevailing conditions has beenrecommended (Cheema et al., 1954; Teaotia and Pandey,1968). Water stress can be induced by practices like rootexposure and root pruning to suppress the rainy season cropso as to get a good winter crop by Cheema et al., (1954).Nutrition: To increase the quantum of winter crop thefertilizer schedule should be changed from April-May toMay-June that will induce more vegetative growth thatsubsequently increases the winter cropping. Gupta and Nijjar(1978) advocated that application of a combination ofNPK@ 40,100, 40 g respectively.Pruning: Terminal portion of the shoots up to 20 or 30 cmlength should be pruned between 20th to 30th April. Alwaysavoid severe pruning in guava. Pruning the current season'sgrowth of spring flush to avoid the rainy season crop wasadvocated by Singh (1980). Pruning current season's growthof spring flush to avoid rainy season crop has been advocatedin northern parts of the country (Tiwari and Lal, 1984). Thepruning of 25-50% shoots on 20 April, 10 May or 30 Maywas found to escape flowering in rainy season andencouraged winter season flowering of Sardar guava(Dhaliwal et al., 1984)

3. Principle of crop regulation: The basic principle of crop regulation is to manipulates the natural flowering of the guava plant in desired season that contribute to increased fruit yield, quality and profitability. This concept is based on the fact that most of the crops' flowers are borne only on new, succulent, vigorously emerging vegetative growths. These new growth flushes can be either on new emergences of lateral bud on older stems or extensions of already established terminals of various size and vigour.

3.1. Objectives of crop regulation: The main objective of crop regulation is to force the tree for rest and produce profuse blossom and fruits during any one of the two or three flushes. To regulate a uniform and good quality of fruits and to maximize the production as well as profit to the grower. To reduce cost of cultivation because uninterrupted continuous blossom would produce light crops over the whole year and require a high cost for the monitering and marketing.

3.2. The selection of bahar at a location is mainly determined by Availability of the irrigation water Quality of products : Occurrence and extend of the damage by the disease and pests Market demands Climate of the area Availability of fruit in the market Comparable yields Methods of crop regulation In order to get only appropriate season crop it is necessary to manipulate the flowering.

3.3. Methods of crop regulation: In order to get only winter season crop it is necessary to manipulate the flowering. The following practices are being adopted in order to get the remunerative fruit crop in winter season of better fruit quality in terms of size, shape, taste and aroma factors

3.4. The following practices can be adopted:

3.4.1.Pruning: Terminal portion of the guava up to 20 or 30 cm length should be pruned during April to avoid Ambe bahar and always avoid severe pruning. Pruning current season's growth of spring flush to avoid rainy season crop has been advocated in northern parts of the country. Annual pruning is used as a cheap and effective culture technique for regulating cropping pattern and increasing fruit yield and quality in guava (Bhagawati et al., 2015). The practice is popularly known as elicit treatment and is achieved by root exposure and root pruning or exposure to

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

hot sun before the onset of monsoon. In guava maximum number of fruits in winter crop was obtained from trees in which three-fourth shoot length was pruned in the month of May (Singh, 2013). In order to have a good winter harvest deblossoming of rainy season crop and root pruning have been suggested in Uttar Pradesh where root pruning is not desirable. The pruning favoured the production of more flowers in July-August flush thereby more fruits in winter season. Maximum yield (88.0 kg/tree) was recorded with one leaf pair pruning during winter season (Tiwari & Lal 2007). Moreover, (Serrano et al., 2008) reported that the light pruning increased the number of productive branches and number of fruits per branch of Guava cv. paluma. Maximum crop regulationin terms of minimum fruit yield (5.82 kg/ tree)in summer season was recorded in pruning ofthe total flowering/fruit bearing portion ofcurrent season shoots followed by headingback of current season shoots to the levels of 2basal leaves which resulted in maximum fruityield of 104.98 kg/tree and 100.91 kg/treerespectively in winter season (Singh et al.,2007). Overall yield during both the seasonswas maximal in control (110 kg/tree) howeverdue to good quality fruits obtained duringwinter season; higher income was obtainedwith the treated trees as compared to control.Overall pruning was found to have rejuvenatedimpact on aged trees due to better lightinterception leading to better photosyntheticrate and improved nutrient and water supplywith reduced canopy and better quality yields(Bhagawati et al., 2015). Singh & Bal (2006)reported that pruning help in reducing the treesize and improving the fruit quality

3.4.2. Deblossoming or Thinning: Withholding of irrigation Root exposure and root pruning Shoot Pruning Chemical/PGRs application Nutrients application Shoot bending Deblossoming or Thinning Different chemicals caused deblossoming in rainy season crop and subsequently increased the winter season crop (Singh et al., 1990 and 1991 and 1996a and Singh and Reddy, 1997). Rathore (1975) noted 96 per cent deblossoming with 100 ppm NAA in guava. While Chundawat et al., (1975) reported 24, 51 and 82 per cent deblossoming with 100, 200 and 400 ppm NAA spray, respectively. Complete deblossoming has been recorded by Pandey et al., (1980) obtained complete deblossoming with 400 ppm of NAA guava. However, Singh et al., (1991) reported complete deblossoming with 1800 ppm ethephon followed by 1 and 2 per cent potassium iodide followed by 15 to 20 per cent urea and 1800 ppm ethephon especially at higher concentrations. Whereas, Kaur (1997) found maximum abscission of flowers by the spray of 0.5 per cent potassium iodide followed by 20 per cent urea. Maximum deblossoming has been observed with 20 per cent urea spray in guava (Dwivedi et al., 1990 and Singh et al.,; 1996a).Whereas, Singh et al., (1994) and Choudhary et al., (1997) found 15 per cent urea most effective in deblossoming the rainy season guava crop. However, Singh and Singh (1994) reported complete deblossoming with double spray of 15 per cent urea in guava to regulate the crop. Similar findings were reported by Singh et al., (1993) that deblossoming can be carried out by Spray 10 per cent urea or naphthalene acetic acid (NAA) @ 600 ppm of water during the month of May, when maximum flowers have opened. Each tree requires about 10-12 liters of solution i.e. about 1000 liters per acre. For preparing NAA solution, dissolve 600 g of NAA in 1500-2000 ml alcohol, then make the volume of 1000 liters. Deblossoming can also be done manually. By deblossoming or thinning in April May flowers, the trees become work potential to produce profuse flowering in June- July and fruit harvesting in the month of November to February.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

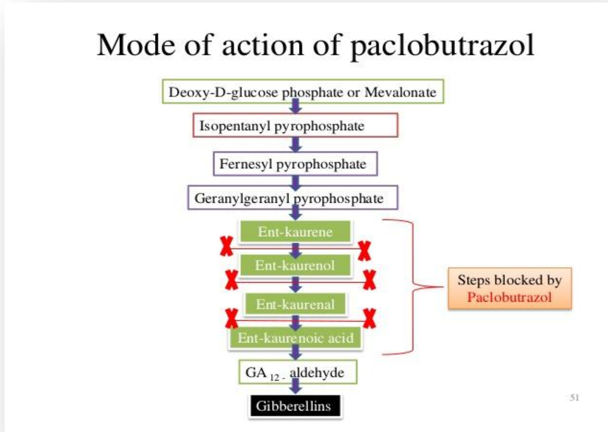

Fig4: Effect of Paclobutrazol (PBZ) on Crop Regulation

Growth regulators and certain chemicals have been found very effective in thinning of flowers and manipulating the cropping season NAA, NAD, 2, 4-D carbaryl and ethrel were found successful in reducing the rainy season and increasing the winter crop under different agroclimatic conditions (Chundawat et al., 1975). Manual deblossoming of rainy season flowers at small scale, kitchen garden and early age of the plant is very effective, but at large commercial plantation it is not in practice which is very cumbersome, laborious and uneconomic. Flower thinning by using naphthalene acetic acid (NAA), naphthalene acetamide (NAD), 2,4-dichlorophenoxy acetic acid (2,4-D),potassium iodide (KI), 2-chloroethyl phosphonic acid (ethephon), 4,6-dinitro-o-cresol (DNOC) and urea have been tried with varying degree of success. This variation may be due to cultivars, tree condition, soil type and environment. Most of the workers are in opinion that chemical thinning is economic and it increases the winter yield as well as improves fruit quality. It was, however, found that hand thinning was effective in reducing the number of fruits in rainy season crop with the subsequent increase in winter crop. The maximum reduction in number of fruits during rainy season by manual removal of flowers closely followed by pruning which subsequently produced more fruits per tree in the following winter. According to Sing et al., (1996), flower thinning from guava plants during summer, improved fruit quality and increase yield during next winter.

3.4.3.Effect of crop regulation on vegetative parameters:

3.4.3.1. Number of leaves: The maximum numbers of leaves pershoot were obtained in the severely pruned trees than inunpruned trees during the rainy season (Bajpai et al., 1973).But contrary to this, Singh et al (1990) and Singh and Reddy(1997) found no leaf by full shoot pruning in guava duringthe rainy season. However, increased numbers of leaves pershoot were recorded in guava during both rainy and winterseason crops by severe pruning (Gopikrishna, 1981 amdPrasad, 1981).

3.4.3.2. Leaf drop: The use of chemicals like NAA, ethephon, MH,KI and urea caused defoliation in guava (Singh et al., 1990and Singh and Reddy, 1997). Similarly, Kobayashi (1987)reported that ethephon concentration (600-1800 ppm)increased the defoliation from 26 to 94 per cent in guavacultivar Beaumont. Singh et al.(1989) stated that leaf droppercentage increased with the increased concentration ofNAA (200-600 ppm) when sprayed in April-May in guava.In guava spray of 1 and 2 percent potassium iodide increasedthe defoliation (Singh et al.(1990). Rajput et al.(1986) notedthat 10, 15 and 20 percent urea when sprayed in April caused71, 80 and 94 per cent defoliation, respectively. Similarresults were obtained by Dwivedi et al.(1990), Singh andSingh et al.(1994) and Singh et

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

al.(1994). While, Singh etal.(1992) obtained partial defoliation by increasing ureaconcentration (10-20 per cent) in guava during rainy season.However, Kaur (1997) reported highest defoliation withpotassium iodide at the rate of 0.5 per cent followed by 15per cent urea.

3.4.3.3. Days to emergence of new leaves: The applications of thePGR and other chemicals cause defoliation. In general, asthe concentrations of chemicals increased, the days takenfor emergence of new leaves decreased. Shigeura et al.(1975) found that 25 per cent urea spray acted as a defoliantand the new growth started after 35 days. Similarly, Menzeland Paxton (1986) reported that 25% urea spray caused theleaf initiation 4 weeks after defoliation in guava. Whereas,Rajput et al. (1986) recorded that 10 to 20 per cent ureasprays produced the new leaves between 17 to 23 days afterdefoliation. Similarly, Singh et al (1994) obtained theemergence of new leaves between 21 to 25 days after thesecond spray of 5 to 20 per cent urea. Whereas, Bariana(1998) reported that emergence of new leaves took placebetween 19 to 22 days after the second spray of urea andpotassium iodide and concluded that minimum days foremergence of new leaves were taken by potassium iodidefollowed by urea.Days to sprouting of new shoots: Different pruningtreatments influenced the shoot emergence and shootemergence was earliest in the severely pruned trees of guavathan unpruned (Dasarthy, 1951 and Bajpai et al., 1973).Similarly, Aravindakshan (1963) reported that pruning theleaders by about 4 to 5 inches, encouraged the productionof laterals earlier than in unpruned trees of guava by about12.8 days. Whereas, Sundararajan and Muthuswamy (1996)found that the initiation of laterals was advanced by 8 to 10days by pruning the previous seasons’s leaders by about 4 to5 inches from their. Similarly, the early initiation/early growthof the shoots was also noticed in severely pruned plants ofguava as reported by Gopikrishna(1981) and Sheikh andHulmani (1993).

3.4.3.4. Shoot length: Pruning increased the vegetative growth andultimately the shoot length of guava plants (Singh, 1969 andSingh 1980). Similar observations were also made bySyamlal and Rajput (1989) and Bisla et al; (1988). Similarly,Bajpai et al. (1973) recorded the maximum length in severelypruned (100 cm) trees of guava and minimum in unprunedtrees in the rainy season. Similar results were obtained byGopikrishna (1981) with severe pruning (25 cm) in guavatrees. However Sheikh and Hulmani (1997) reported thatsevere pruning (30 cm) produced the little longer shoot lengthfollowed by mild pruning (15 cm) and control in the rainyseason of guava plants.

3.4.3.5. Effect of crop regulation on floral and yield parameters: In general, guava tree flowers twice a year, i.e. in April-Mayand August-September, of which fruits ripen in rainy andwinter seasons respectively (Gupta and Nijjar, 1978).Sometimes, a third flowering occurs in October-November(Singh and Kumar, 1993), particularly in Maharashtra andTamil Nadu (Hayes, 1974). In guava floral buds appears soonafter the breal of winter stress and new growth start in theaxil of the leaves. Floral buds appear soon after first pair ofleaves mature, but there is no direct association between leafappearance and flower production (Menzel and Paxton,1986). Flowers occur either singly or in cymose of 2-3 atleaf axils of current (Braganza, 1990). The bearing twighnormally grow a few centimeters putting forth 4-5 pairs ofleaves and thereafter, either flower buds start developing ortwigs cease to grow till the next season.This is quite evidentfrom that heaviest flowering has always been obtained insummer season Because food reserved is exhausted inflowering and vegetative growth during summer, the rainyseason flowering for winter cropping is always less (Rathore,1975).

3.4.3.5.1. Number of flowers: The number of the flowers in guavadepends on the season, variety and various culturaltreatments including PGR etc. In pruned trees of guava, 70to 83 per cent of laterals flowered, while in unpruned treesonly 40 to 60 per cent of laterals flowered and the flowerinitiation and flower production is also hastened(Arvindakshan, 1963). Similarly, Sundararajan andMuthuswamy (1996) observed that tipping terminal portionof tender shoot hastened the production of flowers per shootcompared to untipped shoots in guava. Therefore, Singh(1969) and Singh (1980) suggested the annual pruning ofguava to stimulate flowering. While, Bajpai et al. (1973)and Sheikh and Hulmani (1993) reported that pruningadversely affected that flowers production in guava and themaximum number of flowers were obtained in lightly prunedtrees in comparison to unpruned trees of guava during rainyseason. Similarly, Prasad (1981) obtained maximum numberof flowers in lightly pruned (4 pairs) trees of guava duringrainy season but less in subsequently winter season. He alsofound poor flowering in

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

rainy season and maximumflowering in subsequent winter season by severe pruning.Whereas, Gopikrishna (1981) reported that severe pruningreduced the flower production in rainy and winter season.Similarly, Singh et al., (1990) and Singh and Reddy (1997)obtained no flowering in rainy season by full shoot pruning.However, one leaf pair pruning was found to be superior inthe production of flower buds during both rainy and winterseason crops of guava (Lal et al., 1996).

3.4.3.5.2. Fruit set: To manipulate the guava crop in the desired season,it is essential to reduce the fruit set during the rainy seasonand subsequently increase the fruit set during winter seasonby the use of different chemicals (Mitra et al., 1982; andChoudhary et al., 1997). Singh and Singh (1975) obtainedthe reduced fruit set during the rainy season with 1000 and2000 ppm NAA spray. Similar results were obtained byGupta and Nijjar (1982) with 600 ppm NAA. Similarly,Pandey et al (1980) recorded the significant reduced fruitset during rainy season with 600 and 800 ppm NAA and asubsequent increase in fruit set during winter season.Whereas, Agnihotri and Bhullar (1979) noted the significantreduction in fruit set by 150 ppm NAA and 400 ppm ethephonduring rainy season. However, Chundawat et al (1975)obtained 4.9 per cent fruit set buy 400 ppm NAA, 28.6 percent fruit set with 3000 ppm MH and 44.9 per cent with2000 ppm ethrel over control (47.2 per cent) during rainyseason. While, Singh and Reddy (1997) reported themaximum reduction in fruit set with 1800 ppm ethephon,800 ppm NAA and all concentration (0.5, 1.0 and 2.0 percent) of potassium iodide during the rainy season. Similarly,Dwivedi et al (1990) obtained the reduced fruit set in rainyseason with higher concentrations of urea (15 and 20 percent). Similarly, Kaur (1997) found maximum fruit set with10 and 15 per cent urea during the winter season. Similarresults were obtained by Kunda and Mitra (1997) with 10per cent urea. Man’s earliest attempt to regulate fruiting wasprobably by removing excess fruits atterset Cheema et al.,(1954). Hayes (1957). Bakhshi and Randhawa (1967) andKaul (1974) suggested withholding irrigation to reduce fruitset for rainy season crop. Root exposure and root pruningalso gave similar results. Bajpai et al.,(1973) recordedmaximum fruit set during monsoon by 30 cm shoot pruning.Full shoot pruning in summer was found effective methodof reducing fruit set in rainy season (Tiwari and Lal, 1984).It was found that hand thinning of flower buds during Mayresulted in 82 per cent fruit set in winter season per cent incontrol. Improved fruit set due to hand thinning was alsorecorded by Mitra et al., (1982) and Singh (1986).Rathore(1975) reported that NAA at 80 and 100 ppm greatlyreduced fruit set when sprayed in April to minimise the fruitset in rainy season crop, Singh and Singh (1975) tried NAA,MH and DNOC and found that NAA applied at 1000 or2000 ppm by whole plant spray resulted in 100 per centthinning of buds and flowers. Kumar and Hoda (1977)recommended NAD (50 ppm) and 2,4-D (30 ppm) forthinning rainy season crop. Agnihotri and Bhullar (1979)reported significant reduction in fruit set (74-86.6 per cent)by using NAA, carbaryl and ethephon. Pandey et al., (1980)recoeded a high flower bud abscission by spray of NAA at800 and 600 ppm and 2.4-D at 100 and 500 ppm, whichconsequently resulted in reduced fruit set during rainy season.Mitra et al., (1982) reported that NAA, NAD and 2,4-Dcaused blossom drop in guava the most promising being 50ppm NAD giving only 10.5 per cent fruit set compared to70 per cent in control 2,4-D at 30 ppm also caused markedreduction (20.5 per cent) in fruit set. Consequently in thefollowing winter, fruit set increased markedly to 80.8 and77 per cent respectively. At Ludhiana, Gupta and Nijjar(1982) found that 600 ppm NAA caused the highest sheddingof blossom and young fruitets. Singh (1986) found NAD(50 ppm) to be very effective in reducing rainy season cropwith subsequent increased fruit set in winter.

3.4.3.5.3. Fruit size: The size of fruits on the plant depends upon no.of the fruits season and genetic makeup of variety. Cheemaand Deshmukh (1927) found that pruned trees of guavaproduced larger fruits than those on unpruned trees. Similarresults have been reported by Singh (1969) and Bejpai etal., (1973).Bigger fruits were obtained by Mitra et al., (1982)by thinning flowers and young fruits. The length and diameterof fruits also increased by the use of growth substances (Mitraet al., 1982).The size of the fruits improved in both rainy andwinter season crops by the use of various thinning chemicals(Mitra et al., 1982; Singh et al., 1990 and Singh et al. 1996a).However, Singh and Reddy (1997) recorded that the fruitsize improved by all NAA, urea, ethephon and potassiumiodide treatments during both rainy and winter seasons andmaximum fruit length was found in 10 per cent urea andminimum in control. Similarly, Bariana (1988) obtained themaximum fruit size with 10 per cent urea during rainy season.Bajpai et al(1973) reported that severely pruned trees ofguava produced fewest but largest size fruits

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

during the rainyseason. Similar observations were also made by Sheikh andHulmani (1993). However, Gopikrishna (1981) found thatthere was a pronounced increase in the size of fruits of guavaby severe pruning both rainy and winter season crops.Fruit weight: In general the weight of the s fruits on theplant depends upon no. of the fruits season and geneticmakeup of variety in addition to other cultural practices .Increased fruit weight in Allahabad Safeda had been obtainedby Aravindakshan (1963). Similarly, increased fruit weighthas been recorded by Mitra et al., (1982) in Sardar by manualremoval of flowers. Application of growth substances likeNAD (30 and 50 ppm) increased weight of fruits (Mitra etal., 1982).The application of various chemicals increased thefruit weight of guava plants during both rainy and winterseason crops (Singh ,1986). Similarly, Singh et al. (1992)obtained the highest fruit weight with 600 ppm NAA whensprayed at full bloom stage. Similar results were obtainedby Kundu and Mitra (1997) with 100 ppm NAA However,Singh and Reddy (1997) reported that all treatments likeNAA, ethephon, urea and potassium iodide improved themean fruit weight of Sardar guava and the maximum fruitweight was observed with 10 pr cent urea spray during bothrainy and winter season crops. But contrary to this, Singh etal (1996b) obtained no significant difference in fruit weightwith NAA, ethephon potassium iodide and urea treatments.While, Rajput et al (1986) noted that as the concentration ofurea increased, the fruit weight also increased upto 15 percent concentration during both rainy and winter season cropsof guava and beyond 15 per cent concentration, the fruitweight was markedly reduced. Similar findings were reportedby Dwivedi et al (1990) in Sardar guava at Faizabad.Similarly, Bariana (1988) obtained heaviest fruits with 10per cent urea followed by 15 per cent urea during both rainyand winter crops of Sardar guava trees.Heavily pruned trees of guava produced heavy fruitsas compared to light pruning (Cheema and Deshmukh, 1927and Ranga Charlu, 1954). Similar findings were reported byHayes (1946) and Arvindakshan (1963). Pruning the guavavarieties Nagpur Seedless and Smooth Green by removing10 to 15 cm of the terminal protion of the past season’s shootgrowth resulted in marked increase in fruit weight duringrainy season (Sundararajan and Muthuswamy, 1966).Similarly, Bajpai et al. (1973) observed that severely prunedtrees of guava produced less number of guava fruits butlargest fruit with heaviest weight during the rainy season.Similar observations were also made by Sheikh and Hulmani(1993 and 1994) in Navalur guava cultivars at Raichur.Whereas, Gopikrishna (1981) recorded the increased fruitweight with severe pruning (25 cm) during both rainy andwinter season crops of guava.

3.4.3.5.4. Fruit number: As the concentrations of the chemicalsincrease, the number of fruits per shoot decreases in the rainyseason and there is a subsequent increase in the winter season.There was no fruiting on guava trees in the rainy season bythe spray of 125 ppm NAA at full bloom stage (April-May),as reported by Kumar and Hoda (1977). Similar results werealso reported by Singh (1986). Rajput et al (1986) recordedno fruiting in the rainy season with 10 to 20 per cent ureaspray and maximum fruits in control and in the subsequentwinter season increased number of fruits was obtained withthe increased urea concentrations (10-20 per cent). Similarly,Bariana (1988) also obtained the maximum no. of fruits incontrol followed by potassium iodide in rainy season and inwinter season highest no. of fruits were obtained by 10 percent urea in cv. Sardar.Mild pruning reduced the number of fruits in rainyseason produced more fruits in winter crop (Gopikrishna.1981: Bajpai, et al., 1973: Singh, 1986).The heavily prunedtrees of guava produced the lesser number of fruits than theunpruned ones and the lightly pruned trees produced morenumber of fruits during the rainy season (Cheema andDesmukh, 1927 and Hayes, 1946). Similarly, Bajpai et al,(1973) observed the miximum number of fruits in lightlypruned trees followed in mild and severely pruned treesduring the rainy season and suggested that heavily prunedtrees produce less number of fruits per shoot during the rainyseason in Allahabad Safeda. Similar observations were alsomade by Sheikh and Hulmani (1993).Gopikrishna (1981)and Singh (1986) advocated that mild pruning reduced thenumber of fruits in rainy season and produced more fruits inwinter season. Similarly, Prasad (1981) obtained themaximum number of fruits from lightly pruned (4 pairs) andminimum from heavily pruned trees of guava during the rainyseason but in the subsequent winter season, maximumnumber of fruits were obtained from heavily pruned treesand minimum from lightly pruned trees of guava. Whereas,Lal et al. (1996) observed that as the pruning intensityincreased the number of fruits decreased and there was nofruiting with full shoot pruning of guava during the rainyseason. Similar results were also obtained by Singh andReddy (1997) in Sardar guava.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

3.4.3.5.5. Fruit yield: The fruit yield is an ultimate factor that decidesthe success and failure of any technology in the favours ofthe fruit growers. The rainy season crop was minimizedeffectively by the use of various chemicals and a subsequentgood winter season crop was obtained (Mitra et al., 1982;Singh et al, 1993, Choudhary et al., 1997). Similarly, Guptaand Nijjar (1975) reported that the rainy season crop wasreduced effectively by 600 ppm NAA and a subsequent goodwinter crop was obtained. Whereas, Singh et al (1989) statedthat a mixture of 15 per cent urea and 400 ppm NAAproduced the highest yield during the winter season. Singhet al. (1992) obtained the highest yield of winter season cropwith 800 ppm NAA closely followed by 10 per cent ureawhen applied at full bloom stage.Similar results wereobtained by Gaur (1996) with 16 per cent urea closelyfollowed by 600 ppm NAA in Allahabad Safeda trees. Similarfindings were also reported by Dwivedi et al (1990) andSingh et al (1994) in Sardar and Allahabad Safeda guava,respectively. Singh and Singh (1994) obtained the highestwinter yield with double spray of 10 per cent analytical gradeurea in Sardar guava. However, Singh et al (1990) obtainedthe highest winter season yield with 1800 ppm ethephon(122,24 kg) followed by 15 per cent (80.42 kg) as comparedto control (20.86 kg). Whereas, Singh et al (1996a) recordedthe highest winter season yield with 600 ppm NAA followedby 1800 ppm ethephon and 20 per cent urea in Sardar guavaat Lucknow. But contrary to this Singh and Reddy (1997)reported that none of the chemicals [NAA, ethephon, KI &urea] were found promising for enhancing the fruit yield in winter seasons crop. However, the maximum winter season yield was obtained with 1800 ppm ethephon followed by 600 ppm NAA, 15 per cent urea and 0.5 per cent potassium iodide. Similarly, Singh et al (1996b) reported the lowest rainy season yield with 20 per cent urea and 1 and 2 per cent potassium iodide and a subsequent highest winter season yield was obtained with 10 per cent urea and lowest with 20 per cent urea when sprayed at full bloom stage in Allahabad Safeda guava. Khan et. al (2013) application of different defoliation and deblossoming levels in summer and winter season crops did not significantly affect the yield . However defoliation and deblossoming of the leaves adnanced the crops by 30 days. Pratibha et. al.(2013) reported that one leaf pair pruning decreased the fruit yield per tree during rainy season and subsequently increased the yield significantly during winter season. The heavily pruned trees of guava produced less yield than lightly pruned trees during the rainy season (Hayes, 1946; Naik, 1949). Similarly, Bajpai et al. (1973) obtained the highest yield in lightly pruned (30 cm) guava trees and minimum in severely pruned guava during the rainy season. Similar observations were also made by Sheikh and Hulmani (1997). Whereas, Sheikh and Hulmani 1993 obtained the higher yield in control and severe pruning reduced the yield of Navalur guava cultivars during the rainy season. However, Bajpai et al. (1977) obtained the higher yield in pruned guava than in unpruned. Pruning the current season’s growth of spring flush was advocated to avoid the rainy season crop and to get a subsequent good winter crop (Singh, 1980; Tiwari and Lal, 1984 and Singh, 1986). Similarly, Tiwari et al, (1992) reported that pruning of half current season’s crop and a subsequent good crop in winter season. Similar observations were also made by Gadgil and Gadgil (1933) and Singh et al (1993). Similarly, Gaur (1996) found that the pruning of top half of the recent season’s growth reduced the yield (6.23 kg/tree) during rainy season and increased the yield (83.54 kg/ha) during winter season in guava. Similarly, Prasad (1981) obtained the highest yield in rainy with lightly pruned (4 pairs) trees of guava and in winter with severely pruned trees. Hand thinning of flowers reduced the rainy season yield and increased winter crop but total annual yield was lower in comparison to that obtained by other treatments (Teaotia and Pandey, 1970: Pandey et al., 1980: Mitra et al., 1982: Tiwari and Lal, (1984). Singh (1969) and Singh (1986) considered thistreatment too expensive and cumbersome.

4. Quality characters:

4.1. Sugars: The sugar content of fruit from pruned andchemically treated tree is influenced in both seasons of thecropping. It has been reported by Bajpai et al., (1973) thatpruining helped in increasing the total sugar content in guava.Prasad (1981) also recorded increased total sugars contentsdue to pruning in both the seasons. Mitra et al., (1982)registered maximum total sugar by NAD (30 ppm) treatment.

4.1.1. Different chemical treatments:NAA, ethephon and urea hada significant effect on the per centage total sugar contentsduring rainy and winter season guava fruits (Singh et al.,1996b). Increased total sugars during rainy season with 30ppm NAD followed by 15 ppm 2,4-D has been observed byMitra et al. (1982). Similar results were obtained

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

by Singh(1986) with 50 ppm NAD. Similarly, Badge and Kandalkar(1983) reported that total sugar and reducing sugar improvedwith 60 or 80 ppm NAA when sprayed at full bloom stage ofguava in rainy season. But contrary results were reported byRajput et al. (1977) that total sugars and reducing sugars

are not significantly affected with 60 and 80 ppm NAA in guava during rainy season. Kundu and Mitra (1997) recorded increased sugar/acid ratio with different chemicals NAA, 2, 4-D, DNOC and urea during both rainy and winter season guava fruis. Similarly, Dwivedi et al. (1990) found increase in total sugars with urea upto 15 per cent and after that there is decrease in total sugars during both rainy and winter season guava fruits. Whereas, Ahlawat and Yamdagni (1981) obtained significant increase in sugar contents with 1 percent potassium sulphate spray in guava.

4.2. Total soluble solids (TSS): Total soluble solids are the indexof sweetness of fruit. Different thinning treatments provedsuperior in improving the TSS content of guava fruits duringrainy and winter season crops (Mitra et al.1982; Singh, 1986and Gaur, 1996). Ahlawat and Yamdagni (1981) found asignificant improvement in the TSS content with 1 per centpotassium sulphate when sprayed 7 days after fruit set inguava and six more times at weekly intervals. Similarly, Singhet al (1996a) obtained the improved TSS content withpotassium iodide when sprayed at flowering in guava duringboth rainy and winter season crops. Whereas, Kundu andMitra (1997) observed an appreciable improvement in TSScontent with different chemical treatments (NAA, 2, 4-D,DNOC and urea) as compared to control during both rainyand winter season crops of Sardar guava.All the thinning treatments used by Mitra et al.(1982) on Lucknow-49 guava influenced the TSS contentof fruits.2, 4-D at 15 ppm was found to be superior to allother treatments followed by NAD (30 ppm) during rainyseason, whereas in winter, 2,4-D (30 ppm) proved the bestfollowed by 2,4-D (15 ppm) in increasing the TSS of fruits.Similarly, Singh and Reddy (1997) obtained the maximumTSS content with 20 per cent urea and 1800 ppm ethephonfollowed by 1200 ppm ethephon during both rainy and winterseason crops. But contrary to this, Singh et al, (1996b)reported that TSS content was not significantly affected bynone of treatments (NAA, ethephon, KI and urea) whensprayed at full bloom stage during both rainy and winterseasons guava. However, Rajput et al, (1986) obtained thebest TSS content with 15 per cent urea during both rainyand winter seasons. Similar results were obtained by Dwivediet al, (1990) in Sardar guava. Whereas, Singh et al, (1992)recorded the higher TSS content with 10 per cent urea whensprayed at full bloom stage of guava during both rainy andwinter season crops. Smilar observations were also made byBariana (1998). Pruning resulted in better quality fruitsduring the rainy season (Dasarthy, 1951 and Bajpai et al.,1977) Similar results were obtained by Sheikh and Hulmani(1994) in 5 Navalur guava cultivars.

4.3. Vitamin C: The ascorbic acid content of guava fruit isinfluenced by the various crop manipulation treatments. Thework carried out by the various workers is summarized asunderMore vitamin C content in cv. Allahabad Sefedawas recorded in winter seasons (241.66 mg/100 g) by pruningtreatment than in rainy season (90.66 mg/ 100 g) (Prasad,1981). Application of 12 ppm 2, 4-D increased vitamin Ccontent (202.18 mg/100g) (Babu and Shanker, 1977). Mitraet al., (1982) also found maximum vitamin C content in thefruits treated with 125 ppm NAA in both rainy (174 6 mg/kg) and winter (253.7 mg/100g) seasons. The untreated plantshad minimum vitamin C content. Vitamin C content has beenobserved more in winter season than rainy season crop ofguava (Gupta and Nijjar, 1978). Increase in ascorbic acidcontent with 80 ppm NAA has been reported by Rajput etal. (1977) and Badge and Kandalkar (1983) in guava duringrainy season. However, Mitra et al. (1982) recordedincreased vitamin C with 125 ppm NAA in both rainy andwinter season crops of guava. Similarly, increased ascorbicacid content with NAA, 2, 4-D and urea has been recordedby Kundu and Mitra (1997) in guava during both seasons.Whereas, Singh (1985) found the increased vitamin C contentwith 4 and 6 per cent urea only in rainy season guava fruits.However, increased ascorbic acid content with15 per centurea was observed during both rainy and winter season cropsof guava (Rajput et al., 1986 and Dwivedi et al. 1990).However, Singh and Reddy (1997) recorded the maximumascorbic acid content with 1200 ppm ethephon followed by15 per cent urea in guava fruits. However, Sheikh andHulmani (1994) reported hat vitamin C content is slightlyincreased with severe pruning during the rainy season.Whereas, Prasad(1981) obtained no effect on Vitamin Ccontent with pruning during rainy season but in winter seasonincreased vitamin C content was observed in lightly prunedtrees of guava. He also recorded that there was more increasein vitamin C content in winter season (241.66) than rainyseason (90.66) with pruning treatments in Sardar guava. Incontrast, while, Singh (1986) reported that the pruning hada significant effect on vitamin C content during both rainyand winter season guava fruits.

4.4. Acidity: In general the acidity of the fruit vary with theseasons i.e. in Summer acidity is usually less as comparedto Winter but in addition to the season the crop manipulationtreatments also influence the acidity as reported by variousworkers. The acidity was slightly reduced by the spray of 40and 80 ppm NAA in guava during the rainy season (Rajputet al. 1977). Similar results were obtained by Badge andKandalkar (1983) with 60 and 80 ppm NAA and Brahmachariet al (1995) with 50 ppm NAA in the rainy season. Kunduand Mitra (1997) onbtained the appreciable improvementin sugar/Acid ration with different chemical treatments NAA,2, 4-D, DNOC and urea as compared to control in both rainyand winter season crops Bajpai et al., (1973) reported loweracidity due to pruning treatments in Allahabad Sefedacultivar.Mitra et al., (1982) reported minimum acidity in boththe seasons by the spray of 100 ppm NAA followed by 125ppm Singh (1986) also reported that NAA (100 ppm) reducedthe acidity of fruits in rainy (0. 26 %) and winter seasons 0.39 per cent.

4.5. Pectin: Pectin content in guava fruit is an importantcomponent that also influenced by various treatments ofpruning, chemical thinners, plants growth regulator, seasonof cropping and water stresses. Singh (1986) reported thatmanual removal of flowers showed the highest percentageof pectin in fruits in both the seasons. Application of 2, 4-D@ 12 ppm increased the pectin content in fruits ofcommercial cultivars (Babu and Shanker, 1977). NAD 50ppm treatment increased the pectin content significantly asreported by Singh (1986).Application of the 2, 4-D @ 12ppmincreased the pectin content during rainy season, where asSingh(1985) recorded increased pectin content with 4 and 6percent urea sprays when applied twice i.e. in January andJuly

5. Withholding of irrigation: In northern plains withholding irrigation after harvesting of winter crop of guava, results in the shedding of flowers and the tree goes to rest. The well balance manure and fertilizer along with irrigation is applied June. After about 20-25 days the tree put forth profuse flowering and fruit mature in winter. Induction of water stress by withholding irrigation from December to June or until the beginning of monsoon depending upon the prevailing conditions has been recommended (Cheema et al., 1954)

6. Root exposure and root pruning: Roots of the plant are exposed to sun by removing up to 7 -10 cm soil around 40-60 cm radius of tree trunk. The water is withheld for a month or two before flowering. As a result of water stress, leaves show wilting and fall on the ground. Before one month of commence of flowering of desired bahar, roots are again covered with a mixture of soil and FYM and irrigated immediately. Subsequent irrigations are given at suitable intervals. Consequently, plants give new vegetative growth, profuse flowering and fruiting. However, in light sandy and shallow soils, exposure of roots should not be practiced and mere withholding of water for 2-3 weeks is sufficient for wilting and debilitation of trees. It depends upon the choice of the grower as to which of the three bahars is to be taken to get maximum profit. As the availability of water is a problem in central India during April – May, the farmers prefer mrigbahar (June) so that the plants are forced to rest in April – May and no water is required during the period. Plants put forth new vegetative growth, followed by flowering (July- August) and fruiting during the coming season. Resting treatment is not feasible in North India, as mandarin plants normally rest in winter and flower once a year. Cheema et al., (1954) reported that root exposure and root pruning can be used to suppress the rainy season crop so as to get a good winter crop in guava. In certain parts of Maharashtra, root pruning is practiced to produce heavy yield. The roots are exposed and minute roots are cut away and irrigation is withheld so as to allow the leaves to shed in guava (Kumar, 2010).

6.1. Shoot pruning: Terminal portion of the guava up to 20 or 30 cm length should be pruned during April to avoid Ambebahar and always avoid severe pruning. Pruning the current season’s growth of spring flush to avoid the rainy season crop was advocated. Pruning current season’s growth of spring flush to avoid rainy season

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

crop has been advocated in northern parts of the country. The pruning of 25-50% shoots on 20 April, 10 May or 30 May was found to escape flowering in rainy season and encouraged winter season flowering of Sardar guava. Pruning the tender's shoots by about 4 to 5 inch from their tips decreased the flower drop percentage in guava trees (Arivindakshan, 1963) during rainy season. Similar observations were also made by Bajpai et al., (1977). The minimum flower drop was recorded on severely pruned trees (100 cm) and miximum flower drop was obtained on lightly pruned trees (30 cm) of guava during the rainy season (Bajpai et al., 1973).

Whereas, Tiwari et al., (1992) reported the increased flowers growth through pruning but in the following winter season flower drop percentage decreased. But contrary to this, Lal et al., (1996) found that as the pruning intensity increased the flower drop percentage decreased in the rainy season. Singh and Bal (2006) reported that pruning help in reducing the tree size and improving the fruit quality. Lal (1983) reported that pruning increases yield of guava. Pruning and hydrogen Cyanamid were found to modify the production curve of guava (Quijada et al., 1999).

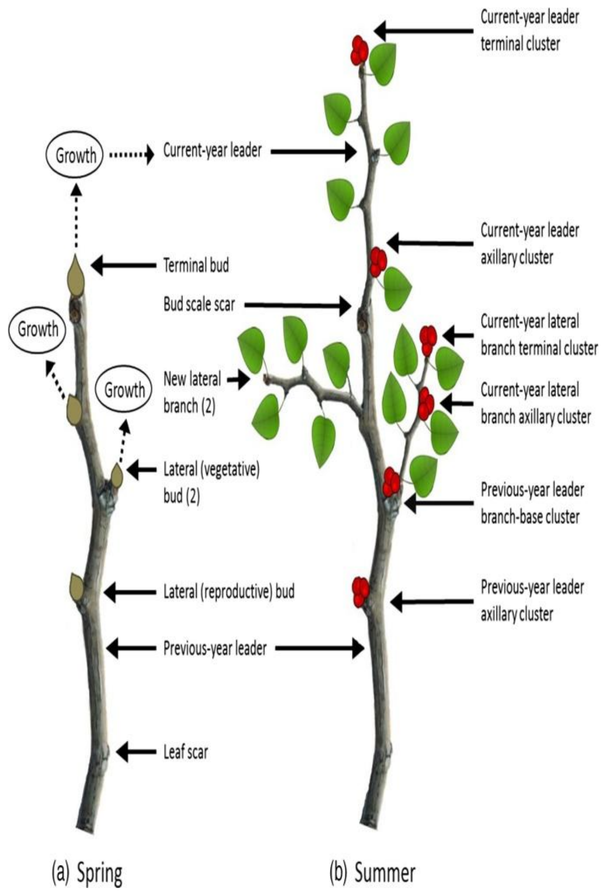

Fig5: Schematic illustration of a 'shoot' sample (b) – as defined in the present study – and possible fruiting positions recorded for the study species. In the spring (a), the previous-year leader can produce two new leaf-bearing components in the following summer (b): a new current-year leader from the terminal bud, and lateral branches [two shown in (b)] from lateral (vegetative) buds [two shown in (a)]. The current-year leader and current-year lateral branches are capable of producing fruit clusters (b) (or individual fruits if solitary) from terminal and/or axillary meristems, while the previous-year leader can produce fruit only from axillary meristems – e.g. lateral (reproductive) bud in (a). [Other lateral buds on the previous-year leader (not shown) remain dormant in the present example]. Not all sampled species produce fruit in all positions.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

[Sampling took place as soon as 'fruit set' was conspicuous (i.e. with enlarged ovaries indicative of developing fruit and seeds) and hence early enough to minimize the chance of excessive fruit removal by consumers. Upon sampling each shoot, the following were recorded.

- The length and girth (at the base) of the current- and previous-year leaders.
- The number of leaves (including any current-year leaves already lost, indicated by leaf scars) on the current-year leader and the number of leaf scars on the previous-year leader.
- The number of current-year lateral branches (i.e. emerging from the previous-year leader).
- The number of leaves and leaf scars on the current-year lateral branches.
- The total number of current-year fruit clusters per shoot, that is the number of shoot buds (meristems) that produced fruit either a single fruit (from solitary flowers) or several (2 or more) fruits (if derived from an inflorescence), and the number of fruits per cluster
- emerging from the terminal and axillary positions on the current-year leader, and/or from axillary positions (above leaf scars – including in some cases, at the base of a branch) on the previous-year leader and/or from terminal and axillary positions on each of the current-year subtending lateral branches for locations where fruit can potentially emerge from a woody shoot, depending on species). Remnants of fruits or fruit clusters produced in the same growing season (indicated by the presence of peduncles only) but missing (e.g. because of loss to consumers) were also included in the above counts.

For each shoot, five representative mature individual fruits were collected. If fruits were not mature upon shoot collection, the plant was later revisited and five fruits were collected from nearby shoot(s) on the same individual. For each individual shrub or tree from which shoots were sampled, plant height was measured (using a metre tape or a clinometer for tall trees), and main stem circumference was measured at 10% of maximum plant height. For clumped multistemmed (e.g. clonal) shrubs, the tallest stem was the stem measured.

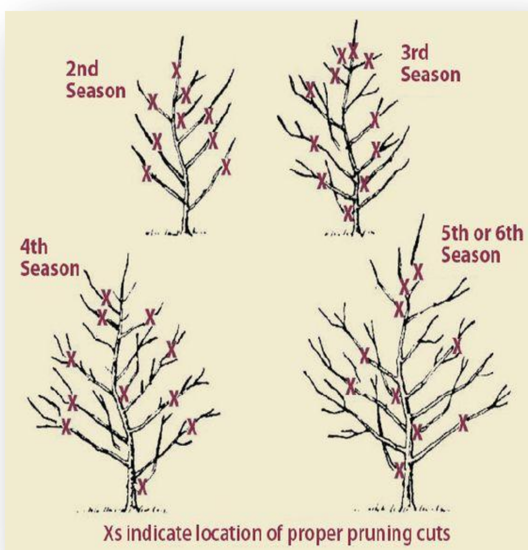

Fig6: Right methods of pruning in woody plants

Salah (2005) reported that pruning produced the highest bud emergence in guava. The time and intensity of pruning affected guava cv. Paluma tree sprout and yield (Serrano et al., 2008a).Moreover, (Serrano et al.,2008b) reported that the light pruning increased the number of productive branches and number of fruits per branch of Guava cv. paluma. Chemical/PGRs application Desai et al., (1982) from Rahuri, Maharashtra, India revealed that cycocel sprayed at 1000 ppm once on 16th August and once on 16th September to be followed by spray of

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

2, 4, 5-T at 10 ppm on 30th September resulted in 58.2 percent flowers as against 16.3 percent in control. Increase in the number of flowers and fruits with every increase in the concentration of the chemical were also evident. Babu and Rajput (1982) noted that February and June flowering was earliest with 2, 4-D at 10 or 20 ppm and latest with GA3 at 25 or 50 ppm. Duration of flowering was shortest (22 - 24 days) with GA3 at 50 ppm and longest in the controls (30 - 35 days) whereas Davenport (1983) reported that GA3 applied to Tahiti lime (Citrus latifolia Tan.) markedly inhibited flowering, producing morphologically typical vegetative growth. Babu and Rajput (1984) at Varanasi showed that Zinc alone or in combination with either of the growth regulators had a marked influence on the chlorophyll content of the leaves. GA3 alone reduced the chlorophyll contents while 2, 4-D had no effect. Tripathi and Dhakal (2005) reported that paclobutrazol applied on 17th July was the most effective in inducing early flowering at fourth week of December which was 70 days ahead of normal flowering days. The subsequent application on September, October and December also advanced flowering time by 59, 41 and 32 days respectively. The earliest (July) application of paclobutrazol was superior among the treatments under Chitwan, Nepal condition to induce and advance early flowering for off season market. Thirugnanavel et al., (2007) revealed that application of GA3 50 ppm in June + cycocel 1000 ppm in September + KN03 2% in October showed better performance in delaying flowering by nearly two months, number of flowers per shoot (7.01), initial fruit set (4.59), fruit retention (3.21 fruit per shoof) number of fruits/tree (224 fruits) and yield (11.15 kg). Mahalle et al., (2010) reported in Hasta bahar flowering (i e., September and October) of Acid lime, two sprays of cycocel l000 ppm at an interval of one month before initiation of flowering that is in August and September resulted in maximum yield in terms of number of fruits per tree and weight of fruits per tree and this treatment also improved the fruit quality in respect to juice %, TSS, acidity, ascorbic acid content, peel and pomace per centage. The onset of flowering in acid lime may be attributed to the prolonged rest period which is often associated with cool, sub-tropical winter or water stress conditions in the tropics. The cessation of root growth as a result of low temperature, water stress, weak rootstocks and confined roots were necessary for floral induction. This was later explained that based on the flower inhibitory effects of exogenously applied GA3, the citrus buds are continually induced to flower but inhibited from doing so by the presence of endogenous, root produced gibberellins. Conditions conducive to inhibition of root growth would, thus reduce the levels of gibberellins distributed to buds resulting in expression of the depressed flowering buds. This proposal was proved by many workers as above. The flowering intensity increases due to stress and flower differentiation occurs during moisture stress and the generative buds formed do not undergo flower development till water is supplied. Pre-conditioning of plant by moisture stress is a prerequisite in acid lime flower formation. Carbohydrate accumulates during stress and GA availability is reduced due to restricted root growth. On watering GA level rises which is needed for generative branches resulting in flowering. Paclobutrazol inhibits the biosynthesis of GA and internode elongation which reduces the availability of GA. Bromouracil, 2, 4 D and paclobutrazol in variable doses are effective in inducing flowering in acid lime.

6.2. Nutrition application To increase the quantum of winter crop the fertilizer schedule should be changed from April-May to May-June that will induce more vegetative growth that subsequently increases the winter cropping (Boora et al., 2016). Gupta and Nijjar (1978) advocated that application of a combination of NPK@ 40,100, 40 g, respectively. Singh and Singh, 1994 recommended that 10 % urea for better crop of Sardar guava and Allahabad safeda during winter under Lucknow and Punjab condition.

6.3. Bending of shoot: Shoot bending is one of the ways to produce (Sarker et al., 2005). In case of bending of branch wood tension of branch is increased and phloem formation decreased. As a result photosynthetic product pass slowly from the shoots of bent branch as to the other parts, maintaining increased C: N ratio and induce more flowering and fruit set. Bending forced dormant reproductive buds into growth. The upright branch produces fewer flowers and fruits than the bent branch (Ito et al., 1999). Bending induces profuse flowering and fruiting, as well as fetches greater returns (Ghosh, 2003) and regulate flowering by bending of shoots (Mitra, et al., 2008). Bending consistently increased the lipid, tryptophan, proline, polyphenol oxidase, catalase, and peroxidase levels in leaves, bark, and fruits, but decreased phenolics (Eassa et al., 2012). These changes may have resulted in greater flowering and fruiting, giving rise to higher yield (Praagh and Hauschildt 1991on apple and pear; Sarkar, et al., 2005 and Bagchi et al., 2008 on guava). Mamum et al., (2012) found that the highest number of flowers set per plant when shoot bending treatment was given during on-season (312.33) and off-season it was (111.33).

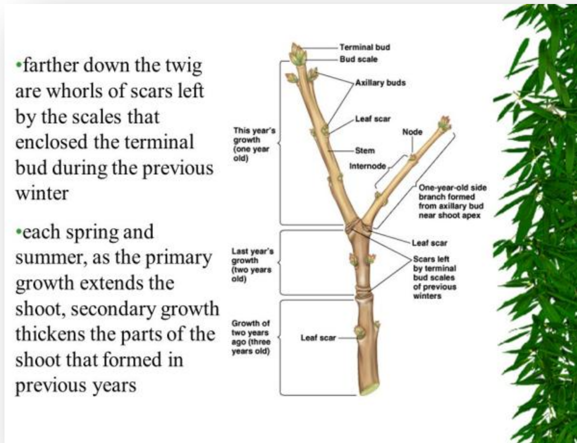

Fig7: Parts of woody twigs has prunined.

The shoot bending treatment result the highest number of fruits set per plant both on and off season (246.86) and (67.33), respectively. Shoot bending increased the fruits set per plant during off-season is also reported by Sarker and Ghosh (2006). Shoot bending increased the fruit yield per plant and quality fruit during off-season (Sarker et al., 2005). Samant et al., (2016) has also shown the positive effect of shoot bending in guava. Branch bending was done during May by retaining 10-15 pairs of leaves at apex and removing all the leaves, flowers and developing fruits manually. Branches were bent dawn by applying pressure gradually from proximal to distal end of branch. They were kept at bent position by tying the tip of branches to the wooden pegs fixed on the ground with the help of rope till flushing completes i.e. for 40-45 days. They concluded that branch bending had shown positive influence on shoot growth, flowering intensity, yield and fruit quality.

7. CONCLUSION:

The various methods involving use of differentchemicals and bending technique has beenadopted by different research workers acrossthe globe. Crop regulation in guava can beadopted successfully by employing variouscultural and chemical methods. Differentialstudies by research workers have substantiallyadvocated that application of various culturaland chemical methods was effective toregulate flowering of summer flowers and toproduce fruits in winter. The outcome ofdifferent studies reported by scientists in guavahas revealed that the fruits of winter seasonwere significantly superior in every respect,i.e., attractive size, weight and better internalbio- quality parameters than the fruits of rainyseason, which helped to fetch remunerativeprice of fruits to growers as well as affordableprice to consumers. Depending upon theavailability of manpower and chemicals, asuitable technique suited to edaphic conditionsshould be adopted to obtain higher quantitativeand qualitative outcome of fruits from guavaorchards. The suitability of crop regulationmethod must be tried first at micro-levelbefore adopting it at large scale level. Climate,water stress and plant nutrition plays animportant role as determinants in selection ofsuitable method Vis a Vis efficacy ofregulation of flowering in guava either by useof growth regulators, chemicals or byemploying shoot bending technique in guava.

8. References

1. Agnihotri, R.P. and Bhullar, J.S.(1979). Chemical deblossoming of Allahabad Safeda guava Haryana J. Hort. Sci.,8 : 203-04
2. Ahlawat, V.P. and Yamdagni, R. (1981). Effect of potassium sprays on quality of guava (Psidium guajava L.) cv. Sardar. Agric. Sci. Digest I: 213-14.
3. Aravindakshan, M. 1963. Effect of pruning on growth, flowering and fruit set in guava.Madras Agric. J. 50: 87
4. Aravindakshan, M. (1963). Effect of pruning on growth, flowering and fruit set in guava Madras Agric. J. 50: 87
5. Athani, S.I., Hulamani, N.C. and Patil, M.P. 1998. Flowering and fruit set behaviour of kagzi lime strains. Adv. Agric. Res., 9: 151-53.
6. Babu, K.N. and Shanker, G. (1977) Studies on physico-chemical constituents and fruit growth as influenced by 2,4-D on three guava cultivars Allahabad Farmer. 4: 549-553.
7. Babu, R. S.H. and Rajput, C. B. S. 1984.Effect of Zn, 2, 4-D and GA3 on the chlorophyll content of acid lime leaves. South Indian Hort., 32: 365-66.
8. Babu, R.S.H. and Rajput, C.B.S. 1982.Effect of Zinc, 2, 4-D and GA3 on flowering in Kagzilime. Punjab Hort. J., 22: 140-44.
9. Badge, T.R. and Kandalkar, D.S. (1993). Effect of growth regulators on quality of guava (Psidium guajava L.) variety Sardar. Magazine, college of Agriculture, Nagpur 54/55: 19-22. Punjabrao Krishi Vidyapeeth, Akola, India.
10. Bagchi, T.B., Sukul, P. and Ghosh, B. 2008. Biochemical changes during off-season flowering in guava induced by bending and pruning. Journal of Tropical Agriculture, 46 (1/2): 64-66.
11. Bajpai, P.N, Mohan, A., Shukla, H.S. and Dwivedi, R.M.1977. Response of guava suckers to pruning. Plant Sci., 9: 65-66.
12. Bajpai, P.N. Shukla, H.S. and Chaturvedi, A.M. (1973). Effect of pruning on growth, yield and quality of guava, Allahabad Safeda. Prog. Hort., 5: 73.
13. Bajpai, P.N. Shukla, H.S. and Chaturvedi, A.M. 1973. Effect of pruning on growth, yield and quality of guava, Allahabad Safeda. Prog. Hort., 5: 73.
14. Bajpai, P.N; Mohan, A., Shukla, H.S. and Dwivedi, R.M.(1977). Response of guava suckers to pruning. Plant Sci., 9: 65-66.
15. Bakhshi, J.C. and Randhawa, N.S. (1967). Bright prospects for guava cultivation in Punjab. Indian Hort., 11: 3.
16. Barbera, G. and Garimi, F. 1988. Sixth Intern. Citrus Congress Middle East Telavive Israel, 8 - 11 March. 88: 2.
17. Bariana, D. (1988). Deblossoming with chemicals of rainy season crop of Sardar guava. M.sc.Thesis submitted to Punjab Agric. Univ., Ludhiana.
18. Bisla, S.S; Dhiman, B.K. and Daulta , B.S. (1988). Studies on pruning and spacing in ber (Zizyphus mauritiana Lamk).Effect on vegetative growth. Haryana J. hort. Sci., 17: 177-82.
19. Boora, R.S, Dhaliwal, H.S. and Arora, N.K.2016.Crop regulation in guava-A review, Agricultural Reviews, 37 (1): 1-9
20. Braganza, M.A. (1990). Floral biology and varietal evaluation in genus Psidium. M.Sc.(Agric.) Thesis, University of Agricultural Sciences, Bangalore.
21. Brahmachari, V.S. Mandal, AK. Kumar, R. and Ray, Ruby. (1995). Effect of growth substances on fruit-set and physicochemical characteristics of Sardar guava (Psidium guajava L.). Recent Horticulture 2: 127-31.
22. Cassin, J., Bourdeaut, J., Fourgerl, A., Furon, V., Gillard, J.P., Montagut, G. and Morevilli, C. 1969. The influence of climate upon the blooming of citrus in tropical area. Proc. Int. Citrus Symp, 1: 315-23.
23. Cheema, G.S. and Deshmukh, G.B. (1927). Culture of guava and its improvement of selection in western India. Bombay Dept. Agril. Bull., 148.
24. Cheema, G.S., Bhatt, S.S. and Naik, K.C. (1954). Guava In Commercial Fruits of India. Macmillan & Co. Ltd Calcutta.
25. Cheema, G.S., Bhatt, S.S. and Naik, K.C. 1954. Guava In Commercial Fruits of India. Macmillan & Co. Ltd Calcutta.
26. Choudhary, R., Singh, U.P. and Sharma R.K. 1997.Deblossoming of rainy season crop of guava. Horticultural J., 10: 93-95.
27. Choudhary, R.; Singh, U.P. and Sharma R.K. (1997). Deblossoming of rainy season crop of guava Horticultural J. 10: 93-95.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

28. Chundawat, B.S., Gupta, O.P. and Godara, N.R. (1975). Crop regulation in Banarsi Surkha guava cultivar. Haryana J. Hort. Sci., 4: 23.
29. Chundawat, B.S., Gupta, O.P. and Godara, N.R. 1975. Crop regulation in BanarsiSurkha guava cultivar.Haryana J. Hort. Sci., 4: 23.
30. Dasarthy, T.B. (1951). The guava. Madras Agric. J., 38: 521.
31. Davenport, T.L. 1983. Daminozide and Gibberellin effects on floral induction of Citrus latifolia. Hort. Sci., 18: 947-49.
32. Desai, U. Choudhari, K. G., Rane, S. D. and Patil, Y. S. 1982.Alteration of flowering period in kagzi lime with plant growth substances. J.Maharashtra Agric. Univ., 7: 161-62.
33. Dhaliwal, G.S., Gill, H.S. and Rattanpal, H.S. (1998). Effect of time and severity of pruning on shoot growth and flowering in guava. Haryana J. Hort. Sci. 27: 223—29.
34. Dwivedi, R., Pathak, R.K. and Pandey, S.D. 1990.Effect of various concentrations of urea on crop regulation in guava (Psidium guajava L.) cultivar Sardar.Prog. Hort., 22: 134-139.
35. Dwivedi, R.; Pathak, R.K. and Pandey, S.D. (1990). Effect of various concentrations of urea on crop regulation in guava (Psidium guajava L.) cultivar Sardar. Prog. Hort., 22: 134-139.
36. Eassa, K. B.,Gowda, A. M.and El-Taweel, A. A. 2012.Effect of GA3, hand pollination and branch-bending on productivity and quality of banati guava trees grown in sandy soils. J. Plant Production, Mansoura Univ., 3 (2): 241 – 251.
37. Gadgil, D.R. and Gadgil, V.R. (1933). A survey of the marketing of fruit in Pune. Gokhale Inst., Politics Econ. Public., P3.
38. Gaur, G.S. (1996). Studies on crop regulation in guava. Recent Hort., 8: 21-23.
39. Ghawade, S.M., Panchbhai, D.M., Jadhao, B.J., Katole, S.R. and Dadmal, S.M. 2002. Flowering behaviour of kagzi lime (Citrus aurantifolia Swingle) under sub-humid tropical climate. Agric. Sci. Digest., 22: 252-54.
40. Ghosh, B. 2003.Progress report of NATP on "Off-season flower of guava". Faculty of Horticulture, BCKV, Mohonpur, Nadia, W.B., pp 3–5. Goell, A., Golgmb, Kalmar, D., Montell, A. and Sharon, S. 1981.
41. Gopikrishna, N. S. (1981).Studies on the effects of pruning on vegetative growth, flowering and fruiting of Sardar guava. Ph. D. thesis. University of Agricultural Sciences. Dharwar. Thesis Abst., (3) : 224.
42. Gupta, M. R. and Nijjar, G. S. 1978.Crop regulation in guava.Indian J. Hort., 35: 23-27. Hittalmani, S. V. 1977.
43. Gupta, M. R. and Nijjar, G. S. (1978). Crop regulation in guava. Indian J. Hort., 35: 23-27.
44. Gupta, M. R. and Nijjar, G. S. (1982). Effect of different chemicals in deblossoming of guava. Punjab hort., J., 22:161.
45. Gupta, M.R. and Singh, S. (1977). Effect of pruning on the growth, yield and fruit quality in ber. Punjab Hort. J., 17: 54-57.
46. Hayes, W.B. (1957). Fruit Growing in India. Kitabistan, Allahabad. P. 286.
47. Hirano, R. T. and Nakasone, H. Y. (1969). Pollen germination and compatibility studies of some Psidium species. I Amer Soc. Hort. Sci. 94:287-89.
48. Hittalmani, S. V., Rao, M. M. and Bojappa, K. M. 1977.Studies on the parameters of flowering in the kagzi and Tahiti limes in North Kamataka.Punjab Hort. J., 17: 97-03.
49. Ito, A., Yaegaki, H., Hayama, H., Kusaba, S., Yamaguchi, I. and Yoshioka, H. 1999. Bending shoots stimulates flowering and influences hormone levels in lateral buds of Japanese pear. Hort. Sci., 34, 1224–1228.
50. Kaul, G. L. (1974). Guava cultivation-The right way Cropping and its regulation. Indian Farmers Digest 7: 33.
51. Kaur, N. (1997). Crop regulation in Sardar guava by chemicals. M.Sc. thesis submitted to Punjab Agric Univ., Ludhiana. Kumar, N. 2010. Introduction to horticulture. Oxford & IBH publishing co.pvt. Ltd, New Delhi
52. Kaur, N. (1997). Crop regulation in Sardar guava by chemicals. M.Sc. thesis submitted to Punjab Agric Univ., Ludhiana.
53. Khan AS , Khan MR Mallik AU Saleem B Rajwan IA and Ahamad I 2011 influence of defoliation and deblossoming on vegetative and reproductive growth of guava psidium guajava cv Gola Pak J. Bot. 43:2891-96
54. Kobayashi, K.D (1987). Defoliation and vegetative growth of Psidium guajava with ethephon and gibberellic acid Acta Hort.201:145-148
55. Kumar, R. and Hoda, M. N. (1977). Crop regulation studies in Allahabad Safeda guava. Indian J. Hort., 34: 13.
56. Kundu, S. and Mitra, S.L. (1997). Regulation of cropping in guava. Indian J Hort. 54 : 139-45.

57. Lal, N. and Das, R.P. 2017. Effect of Plant Growth Regulators on Yield and Quality of Guava (Psidium guajava L.) cv. Allahabad Safeda. Int.J.Curr.Microbiol.App. Sci., 6(5): 857-863
58. Lal, S.1983. Effect of pruning on crop regulation in guava (Psidium guajava L.) cv. Lucknow-49.Prog. Hort., 7(3): 60-62 Lal. S, Tiwari, J.P and Misra, K.K. 1996.Effect of plant spacing and pruning intensity on flowering and fruiting of guava. Ann. Agric. Res., 17: 83-89.
59. Lal, N., Das, R.P. and Verma, L.R. 2013.Effect of plant growth regulators on flowering and fruit growth of guava (Psidium guajava L.) cv. Allahabad Safeda. The Asian Journal of Horticulture, 8(1): 54-56.
60. Lal. S, Tiwari, J.P and Misra, K.K. (1996). Effect of plant spacing and pruning intensity on flowering and fruiting of guava. Ann. Agric. Res., 17: 83-89.
61. Lopez, G.J. and Perez, R.P. 1977. Effect of pruning and harvesting methods on guava fields. J. Agri. Puerto Rico, 61:143-51.
62. Lopez, J.G.V., Manica, I., Koller, O.C. andRibold, I.J. 1982.Effect of six pruning periods on the yield of guava in Novo Hamburgo, Rio G randedoScl, Brazil. Proc. Trop. Reg. Am. Soc. Hort. Sci., 25:259- 62.
63. Lucknow. Singh, G., Rajan, S., Pandey, D. and Singh, A.K. 1997. Effect of soil moisture stress on water relation by plant and cropping behaviour in guava (Psidium guajava L.). Indian J. Agric. Sci., 67:303-06.
64. Mahalle, S.S., Ingle, H.V. and Sable, P.B. 2010. Influence of plant growth regulators and chemicals on yield and quality of Hasta bahar in Acid lime. Green Farm, 1: 285-87.
65. Mamun, A.A., Rahman, and Rahim, M. A. 2012. Effect of Shoot Bending and Fruit Thinning on Productivity of Guava. J. Environ. Sci. & Natural Resources, 5(2): 167 – 172.
66. Manica, I., Passos, L.P., Mundstock, E.C., Chaves, J.B. and Stringheta, P.C. 1982. Effect of four times of pruning on the production of two guava varieties in Minas Gerais, Brazil. Proc. Trop. Reg.Am. Soc. Hort. Sci., 25:259-61.
67. Menzel, C.M. and Paxton, B.F. (1986). The pattern of growth, flowering and fruiting of guava varieties in subtropical Queensland. Aust. J. Exp. Agric. 26: 123-28.
68. Mitra, S. K.,Gurung, M. R. and Pathak, P. K. 2008.Sustainable guava production in West Bengal, India. Acta Horticulturae. 2008. 773, 179-182.
69. Mitra, S.K., Sen, S. K., Maiti, S. C and Bose, T. K. (1982). Effect of growth substances on deblossoming regulation of cropping and fruit quality in guava. Horticultural J., 1: 81.
70. Moisture stress a potent factor for affecting vegetative growth and tree size on citrus. Proc. Int. Soc. Citri Cult., 2: 503-06.
71. Motial, V.S. 1964. Fruit set and fruit drop studies in some non-commercial citrus fruits. Punjab Hort. J., 4: 27- 33.
72. Naik, K. C. (1949). South Indian Fruits and their Culture. Varadachary and Co., Madras. P. 448.
73. Narayan Lal, Nisha Sahu, E.S. Marboh, A.K. Gupta and R.K. Patel, 2017.A Review on Crop Regulation in Fruit Crops,*International Journal of Current Microbiology and Applied Sciences*,**6** (7) pp. 4032-404.
74. Nir, I., Goress, R. and Leshem, B. 1972.Effect of water stress, gibberellic acid and 2-chloroethyl trimethyl ammonium chloride (CCC) on flower differentiation in Eureka lemon trees. Amer.Soc. Hort. Sci., 97: 774-78.
75. Pandey, R.M., Lal, S. and Kaul, G.L. 1980. Effect of chemicals and flower thinning on regulation of crop in guava. Indian J. Hort., 37: 234.
76. Pandey, R. M., Lal, S. and Kaul, G. L. (1980). Effect of chemicals and flower thinning on regulation of crop in guava. Indian J. Hort., 37: 234.
77. Praagh, J.P. and Hauschildt, H. 1991.Evaluation of shoot-bending, pruning and pollination for increasing fruit-set and yield on young "Cox" trees. Acta Horticulturae. 1991. 288, 244-248.
78. Prasad, Rambabu, (1981). Effect or pruning on fruiting in guava var. Allahabad Safeda. Ph. D. thesis, IARI New Delhi.
79. Pratibha,Lal S and goswami AK (2013) effect of pruning and planting system on growth,flowering, fruiting and yield of guava cv Sardar Indian J. Hort 70:496-500
80. Quijada, O, Araujo, F. andCorzo, P. 1999. Effect of pruning and hydrogen cyanamide on bud break, flowering, fruit yield and quality of guava (Psidium guajava L.) in the municipality of Mara, state of Zulia. Revista de la FacultaddeAgronomia, Universidad Del Zulia., 16(3): 276-291.
81. Rajbir Singh Boora, H.S. Dhaliwal and N.K. Arora. 2016.Crop regulation in guava-A review.*Agricultural research communication centre*, **37** (1): 1-9
82. Rajput, C. B. S. and Babu, R. S. H. 1985.Citriculture.Kalyani publishers, New Delhi. pp. 37. Rathore, D. S. 1975. Deblossoming of rainy season crop of guava by NAA. Prog. Hort., 7: 63-65.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

83. Rajput, C. B. S., Singh, S. N. and Singh, N. P. (1977). Effect of certain plant growth substances in guava Haryana J.Hort.
84. Rajput, C.B. S.; Singh, G and Mishra, J.S. (1986). Crop regulation in guava by urea sprays. Indian J. Hort., 43: 191-193.
85. Rangacharlu, V.S. (1954). Guava the apple of tropics. Andhra Agri. J., 1:105-109.
86. Rathore, D. S. (1975). Deblossoming of rainy season crop of guava by NAA. Prog. Hort., 7: 63-65.
87. Rathore, D.S. and R.N. Singh, 1974.Flowering and fruiting in three cropping pattern of guava. Indian J. Hort., 34:331-36. Rawal, R.D. and Ullasa, B.A. 1988. Management of fruit diseases of guava Psidium guajava L. Through fungicidal sprays. Indian J.Agric. Sci., 58:950-52.
88. Rohidas, S. B. and Chakrawar, V. R. 1989.Studies on floral biology of some important citrus species. II Kagzi lime (Citrus aurantifolia Swingle) Hort. J., 2: 20-25.
89. Salah, A. El-D.M. 2005. Effect of pruning on growth, flowering and fruiting of some guava cultivars. M.Sc. Thesis, Fac. Agric. Cairo Univ. Samant, D., Kishore, K. and Singh, H.S. 2016.Branch Bending for Crop Regulation in Guava under Hot and Humid Climate of Eastern India. J. Indian Soc. Coastal agric. Res., 34(1): 92-96.
90. Sarkar, A., Ghosh, B. Kundu, S. and Sukul, P. 2005. Effect of shoot pruning and bending on yield and fruit quality in guava cv. L-49. Environment and Ecology, 23S: Special 3: 621-623.
91. Sarker, A. and Ghosh, B. 2006. Studies on growth, yield and economics in guava cv. L-9 by shoot pruning and bending. J. Interacdemicia, 10(3): 327-330.
92. Serrano, L.A.L, Marinho, C.S., Gabetto, E., Silva, M. and Tardin, F.D. 2008a. Phenological and yield characteristics of “Paluma” guava tree pruned in different times and intensities, in north of Rio de Janeiro State, Brazil. Revista Ceres, 55(5): 416-424.
93. Serrano, L.A.L, Martins, M.V.V. De, I. Lima, M. Marinho, C.S. and Tardin, F.D. 2008b.Effect of pruning time and intensity on Paluma’ guava trees, in Pinheiros, ES, Brazil. Revista Brasileira de Fruticultura, 30(4): 994-1000.
94. Shatat, F.A. 1993. Pruning guava (Psidium guajava L.) effect of pruning date on yield and quality. Dirasat (Series B, Pure and applied Sci.), 19:153-59.
95. Sheikh, M.K. and Hulmani, N.C. (1993). Effect of severity of pruning on flowering and fruiting of guava cultivar Navalur. Prog. Hort., 25: 157-160.
96. Sheikh, M.K. and Hulmani, N.C. (1994). Effect of pruning on yield and chemical properties in Navalur guava selections. Karnatka J. Agric. Sci., 7 : 473-475.
97. Sheikh, M.K. and Hulmani, N.C. (1997). Effect of pruning on shoot growth, leaf area and yield in. Karnatka J. Agric. Sci.,10: 93-97.
98. Shigeura, G.T. and Bullock, R.M. 1976. Management of guava: Cycling fruit set for continuous production. Proc. Trop. Ref. Am Soc. Hort.Sci., 24:166.
99. Shigeura, G.T.; Bullock R.M. and Silva J.A. (1975). Defoliation and fruit set in guava. Hort. Sci., 10: 590.
100. Shikhamany, S.D., Iyer, C.P.A., Hariprakasha Rao, M. and Subramanian, T.R (1986). Variations in the seasonal nutrient status in relation to different yield patterns in guava cv. Allahabad Safeda. Indian J Hort. 43: 73-78.
101. Singh, G., Pandey, D., Rajan, S. and Singh, A.K. 1996a.Crop regulation in guava through different crop regulating treatments.Fruit (Paris), 51: 241-246.
102. Singh, G., Rajan, S. and Pandey, D. 1990.Standardization of Agro-techniques for guava. Annual Report, CIHNP: 11-14, Lucknow.
103. Singh, G., Rajan, S. and Pandey, D. 1991.Standardization of Agro-techniques for guava. Annual Report, CIHNP: 14-18,
104. Singh, G., Singh, A.K. andPandey, D. 2000. Effect of cropping pattern on fruiting behaviour of guava (Psidium guajava L.).Tree Am. Agric. Res, 22:175-82.
105. Singh, H., Mehrotra, N.K. and Shergill, T.S. 1994. Effect of urea spray on the crop regulation of guava cv. Allahabad Safeda.Indian J. Hort. 51:331-36.
106. Singh, U.P., Sharma, R.K. and Hoda, M.N. 1993. Regulation of cropping in guava. The Hort, J. 6: 1-6. Singh, V. 1985.Effect of foliar spray of urea on growth yield and quality of guava. Udyanika, 5:11-16.
107. Singh, A. K., Gorakh, S., Pandey, D., Rajan, S. and Singh, G. 1996. Effect of cropping pattern on quality attributes of guava (Psidium guajava) fruits. Indian J. Agric. Sci., 66 (6): 348-352.
108. Singh, Amar. (1980). Fruit Physiology and Production. Kalyani Publishers, New Delhi, Ludhiana. p. 323.
109. Singh, B., Sharma, D.P. and Kashyap, R. (1992). Effect of defoliation on survival and growth of guava (Psidiuin guajava L.) layers cv. Seedless. Adv. Plant Sci. 5: 176—79.

110. Singh, B.P., Singh, G. and Singh, A.K. (1996a). Changes in post-harvest quality of guava affected by preharvest application of crop regulators. Singapore J. of primary Industries, 24: 1-9.
111. Singh, G. and Singh, A. K. (1994). Urea induced defoliation and subsequent yield in guava. Fertilizer News, 39: 39- 41.
112. Singh, G. and Singh, A.K. (2000). Regulation of summer flowering in guava (Psidium guajava L.) and subsequent impact on yield in winter. T.J. Hort. 1. 13: 1—16.
113. Singh, G. and Singh, A.K. 1994. Urea induced defoliation and subsequent yield in guava. Fertilizer News, 39: 39- 41.
114. Singh, G., and Reddy, Y.T.N. (1997). Regulation of Cropping in guava. Indian J. Hort., 54: 44-49.
115. Singh, G., and Reddy, Y.T.N. 1997. Regulation of Cropping in guava. Indian J. Hort., 54: 44-49.
116. Singh, G., Rajan, S. and Pandey, D. (1990). Standardization of Agro-techniques for guava. Annual Report, CIHNP: 11-14, Lucknow.
117. Singh, G., Rajan, S. and Pandey, D. (1991). Standardization of Agro-techniques for guava. Annual Report, CIHNP: 14-18, Lucknow.
118. Singh, G., Rao, O.P. and Mishra, J.S. (1989). Chemical defoliation of guava with urea and NAA. Prog. Hort., 21: 49-50.
119. Singh, G.; Pandey, D.; Rajan, S. and Singh, A.K. (1996b). Crop regulation in guava through different crop regulating treatments. Fruit (Paris), 51: 241-246.
120. Singh, H. and Bal, J. S. 2006. Effect of pruning and growth regulators on physio-chemical characters of guava during rainy season planted at different spacing. Internat. J. agric. Sci., 2 (2): 533-537.
121. Singh, H. P. and Chadha, K. L. 1988.Regulation of flushing and flowering in acid lime (Citrus aurantifolia Swingle) through stress management. Prog. Hort., 20: 1-6.
122. Singh, H., Mehrotra, N.K. and Shergill, T.S. (1994). Effect of urea spray on the crop regulation of guava cv. Allahabad Safeda. Indian J. Hort. 51:331-36.
123. Singh, P. and Singh, J. (1975). Chemical deblossoming in guava to avoid rainy season crop. Science and Culture, 41: 162-163.
124. Singh, R. (1969). Fruit. National Book Trust, New Delhi p. 87.
125. Singh, R. N. (1981). Guava. In Fal Vigyan, ICAR, New Delhi. P.153.
126. Singh, R., Singh, S.N., Gupta, M.R., Dhaliwal, G.S. and Kalra, S.K. (1992). Studies on winter cropping in guava cv. Allahabad Safeda. Indian J. Hort. 49: 127—33.
127. Singh, S.; Krishnamurthi S. and Katyal, S.L. (1967). Fruit Culture in India. ICAR, New Delhi, pp: 143-152.
128. Singh, U. P. (1986). Crop regulation studies in guava. Ph. D. thesis, RAU, Pusa Bihar Agriculture College Sabour, Bihar.
129. Singh, U.P., Sharma, R.K. and Hoda, MN. (1993). Regulation of cropping in guava. The Hort, J. 6: 1-6.
130. Singh, U.R. and Kumar, R. (1993). Crop regulation in guava. In: Advances in Horticulture, Vol. 3. Chadha, K.L. and Pareek, 0.P (Eds). Malhotra Publishing House, New Delhi, pp. 1,197-1,204.
131. Singh, V. (1985). Effect of foliar spray of urea on growth yield and quality of guava. Udyanika, 5:11-16.
132. South Wick, S.M. and Davenport, T.L. 1987.Proc. of plant growth regulator. Soc. of Amer., 487-488 Syamal, M.M., Singh R.K. and Chhlonkar, V.S. 1980. Studies on growth and flowering in guava, Psidium friedrichsthalianum, 37:243-45
133. Studies on growth and fruiting in kagzi (Citrus aurantifolia Swingle) and Tahiti (Citrus latifolia Tanaka) limes.MysoreJ.Agric. Sci., 11: 113.
134. Sundararajan, S. and Muthuswamy, S. (1996). Effect of pruning on fruit size and weight in certain varieties of guava. South Indian Hort., 14: 63-64.
135. Syamlal, M.M. and Rajput, C.B.S, (1989). Effect of pruning on growth, fruiting and fruit quality of ber. Indian J hort., 46: 364-367.
136. Teaotia, S. S. and Pandey, I. C. (1970). Crop regulating studies in guava. Prog. Hort., 1: 25.
137. Teaotia, S. S., Pandey, I. C. and Awasthi, R. K. (1968). Introducing Lucknow-49 guava in your orchard. Indian Hort., 13: 21.
138. Thirugnanavel, A., Amutha, R., Rani, W. B., Indira, K., Mareeswari, P., Muthulaksmi, S., Parthiban, S. 2007. Studies on regulation of flowering in Acid lime (Citrus aurantifolia Swingle). Res. J.Agril. Biol. Sci., 3: 239-41.
139. Tiwari, R. B.; Tiwari J.P and Lal, S. 1992. Effect of shoot pruning, NAA and urea on cropping pattern of guava. Indian J. Hort., 49: 305-308.
140. Tiwari, J. P. and Lal, S (1984). Research Report. ICAR Workshop on Fruit Research, Lucknow.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 7896 - 7919
Received 25 April 2021; Accepted 08 May 2021.

141. Tiwari, R. B.; Tiwari J.P and Lal, S. (1992). Effect of shoot pruning, NAA and urea on cropping pattern of guava Indian J. Hort., 49: 305-308.
142. Tripathi, K. M. and Dhakal, D. D. 2005.Effect of paclobutrazol on off-season flower induction in acid lime (Citrus aurantifolia, Swingle) land races under Chitwan condition. J. Inst. Agric.Anim. Sci., 26: 87-92.
143. Webber, H. J. 1943.Plant characteristics and climatology. The Citrus Industry, California, 1: 41-47.