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Crop Regulation in Guava: A Review

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ABSTRACT

Guava (*Psidum guajava* L) is one of the most promising fruit crops of India and is considered to be one of the exquisite nutritionally valuable and remunerative crops. In recent years guava is getting popularity in the international trade due to its nutritional value and processed products. It is hardy, prolific bearer and highly remunerative fruit crop. Its cultivation is done on the commercial scale. There are mainly three bahar season of the guava fruit *viz*., Ambe bahar, Mrig bahar and Hasth bahar. Continuous bearing results in reduction of yield with small size fruits. The heaviest flowering is observed in rainy season cropping, but, the fruits of this season crop are rough, insipid in taste, poor in quality, less nutritive and are heavily attacked by many insects, pests, and diseases. In order to overcome this problem and to force a full crop in any of the three seasons, as required by the grower and the traders, bahar treatment is practiced. 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. The methods to be followed for crop regulation depend on climatic factors, cropping pattern, extend of the damage by the disease and pests, market and industry demand, cultivar, etc. Crop regulation is achieved by the various techniques like water management to induce stress, pruning of shoots and roots at different levels and at different times, training of shoots and manual or chemical thinning of flowers.

Key words: Bahar treatment, Crop regulation, Deblossoming, Guava, Pruning, Water stress.

Guava, *Psidium guajava* L. which belongs to the family 'Myrtaceae' is one of the important fruit crop grown in India. It has gained considerable prominence on account of its high nutritive value, cheap and easily availability at moderate prices. Guava fruits often called poor man's apple, though the fruit is neither poor in its nutritive or commercial value. It is a good source of Vitamin-C (150-200 mg/100 g of pulp). It is a hardy, prolific bearer and highly remunerative fruit crop which grown widely in tropical and sub-tropical regions and succeeds under a wide diversity of climatic conditions. Fruit setting and fruit development are poor if the temperatures are high and humidity is low. Under tropical climate due to availability of sufficient heat and moisture, produce fruit almost continuously. However, in sub-tropical climate three distinct periods of growth and fruiting are occurred. There are Ambe bahar- February to March flowering and fruit ripens in July – August, Mrig bahar – June to July flowering and fruit ripens October to December and Hast bahar – October to November flowering and fruit ripens in February to April (Shukla *et al.* 2008). Continuous bearing results in reduction of yield with small size fruits. Hence, for commercial production it is advisable to take only one crop in the main season during which the quality of fruits is also good.

Crop regulation

In guava, flowering is more in summer season (Ambe bahar) due to the break of winter stress that leads to more fruit production in rainy season. But, in this season due to high temperature and rainfall during fruit maturation, the duration of maturation is reduced to 30 days that causes glut in the market, whereas winter season crop (Mrig bahar) is superior in quality which fetches comparatively higher price. Although, the production is surplus in rainy season (Rathore and Singh, 1974 and Singh *et al*., 2000), it offers poor quality due to insipid in taste and infestation of pest (Rawal and Ullasa, 1988) in comparison to winter season. On the contrary, in winter season quality fruits are produced with good quality and fetch high monetary returns (Singh *et al*., 2000). Guava fruit harvest peaks can deviate with prevailing weather conditions and cultural practices because flowers are produced on new growth. So, it is advisable to take only winter season crop every year. This requires crop regulation to obtain the most desirable crop, by the methods like withholding irrigation, thinning of flowers by chemically or manually, pruning, bending, root exposure, *etc*. The basic principle of crop regulation is to manipulates the natural flowering and fruiting of guava plant in desired season of the year that contribute to increased fruit yield, quality, profitability and sustainability of the environment by reducing the use of the frequency of the pesticides (Mahadevan and Kumar, 2014).

The selection of bahar at a location is mainly determined by

- Availability of the irrigation water
- Market value and demands
- Quality of fruits

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- Occurrence and extend of the damage by the insect, pest and disease
- Climate of the area
- Availability of fruit in the market
- Comparable yields

METHODS OF CROP REGULATION IN GUAVA

Several methods have been tried to induce new vegetative growth during rainy season so that bumper crop is obtained in subsequent winter season (Singh *et al.,* 2000). The work carried out by various scientists on crop manipulation is reviewed under different sub heads.

Crop regulation by shoot pruning

One of the critical characteristics of guava is that flowers are borne on newly emerging lateral shoots, irrespective of time of the year (Rathore and Singh, 1974), due to which it is suitable for pruning for various purposes. As a result, the occurrence of bloom and fruiting in the course of the year may be irregular or season depending on how the environment affects shoot growth. Pruning has its physiological effects basically due to changes in the partitioning of the reserves. It changes sink preference for allocation of photosynthates. Depending upon the time of the year, the extent and frequency of pruning, some sites of accumulation will disappear and others will be created (Thakre *et al*., 2016). Consequence, changes in seasonal fluctuations of reserves can appear as well (Clair *et al.,* 1999). In this way, pruning helps in both ways, firstly to regulate crop (Kindo, 2005) and secondly to manage high density (Kaur and Dhaliwal, 2001). Serrano *et al.,* (2008) also reported that the light pruning increased the number of productive branches and number of fruits per branch of Guava *cv*. Paluma. Pruning the current season's growth of spring flush to avoid the rainy season crop was advocated by Singh (1980) and similar experiment was also conducted by Tiwari and Lal (1984). 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 by Dhaliwal *et al*. (1998).

Maximum flower number, fruit set, fruit retention and yield (109.68 kg/ tree) with 30 cm pruning in winter crop of guava was observed by Bajpai *et al.* (1973). Whereas, Sahay and Kumar (2002) reported that pruning of half of the current shoots resulted in highest crop yield during the winter crop (36.20 kg/plant), total cost (Rs. 13 per plant) and net profit (Rs. 340.62 per plant) in guava. Similarly, Dhaliwal *et al*. (2000) studied on 5 intensities levels of pruning (control, 25, 50, 75 and 100 %) on 6 dates (From 20 February to 30 May at 20 days intervals) in guava *cv*. 'Sardar' and found that percent fruit set, fruit weight fruit retentions, TSS, ascorbic acid increased in winter crop with increasing pruning intensities and maximum fruit number was at 50 percent intensity while minimum was at 100 percent. Agnihotri *et al*., (2016) found that pruning with 75% intensity at 50% bloom stage in the month of April showed significantly superior with respect to number of newly emerged shoots and per cent increase in shoot growth after 60 days of pruning in guava. Salah (2005) observed the highest bud emergence of guava by using severe and moderate pruning.

Shoot growth was reduced in May and June pruned trees where as total yield during winter season increased significantly in May and June pruned trees in both the cultivars of guava (Allahabad Safeda and Sardar). Similar results were obtained by Singh *et al*., (2001) with pruning in February and March compared with pruning from April to June enhanced the number of shoots and flower percentage. Jadhao *et al*., (1998) revealed that pruning up to 60 cm from tip on April, 25 resulted in the most vigorous growth and highest fruit yield in winter season compared to other dates of pruning (25 March, 25 May, 25 June) and pruning intensities (30 cm of the shoot tip or no pruning) in guava *cv.* 'Sardar'. Likewise, Mishra and Pathak (1998) reported that 50 percent pruning in May produced highest yield (25.8 kg/tree) than unpruned (7.6 kg / tree) in winter crop of guava

Table 1: Nutritional Value of guava fruit in 100 g. edible portion (Kafle *et.al*., 2018).

Nutrient	Value
Energy	285 kJ (68 kcal)
Carbohydrates	14.32 g
Sugars	8.92 g
Dietary fiber	5.4 g
Fat	0.95 g
Protein	2.55 g
Vitamin A equiv.	31 µg
beta-Carotene	374 µg
Thiamine (B1)	0.067 mg
Riboflavin (B2)	0.04 mg
Niacin (B3)	1.084 mg
Pantothenic acid	0.451 mg
Vitamin B6	0.11 mg
Folate (B9)	49 µg
Vitamin C	228.3 mg
Vitamin K	2.2 µg
Iron	0.26 mg
Magnesium	22 mg
Manganese	0.15 mg
Phosphorus	40 mg
Potassium	417 mg
Sodium	2 mg
Zinc	0.23 mg
Lycopene	5204 µg

Table 2: Flowering and fruiting season in guava.

Bahar	Month		
	Water stress	Flowering	Fruiting
Ambe bahar (February)	December-January	February-March	July-August
Mrig bahar (June)	August-September	October-November	March-April
Hasta bahar(October)	3rd week of April	June-July	November-December

cv. 'Sardar'. Singh and Bal (2006) stated that pruning with (10 and 20 cm) and use of growth regulators (paclobutrazol and ethephon at 500 and 1000 ppm) on guava *cv*. Allahabad Safeda trees during rainy season show best physical characters like fruit weight at 20 cm level of pruning, whereas, fruit quality (chemical characters) were noted better at 10 cm level of pruning.

Crop regulation by water stress

In northern plains, mrig-bahar is preferred over ambe and hast-bahars, therefore, it become necessary to regulate flowering, so that Mrig-bahar can produce heavy flowering and fruits are available in winter. The practices followed for taking Mrig-bahar are: Restricting irrigation water: The trees should not be given irrigation from February to middle of May. Doing so, the tree sheds its leaves during hot season (April-May) and goes to rest. During this rest period, tree can conserve food material in its branches (Pedapati, 2015). In guava the operations of withholding water, exposing feeding roots and pruning fibrous roots to force blossom in the desired season are practiced in Mumbai and Deccan (Singh *et. al*., 2018). Stress was exerted on trees by withholding water from January to June, and the non-stressed control trees were watered at an interval of 10-15 days, depending on the evaporation. The abscission of flowers was noticed when relative water content reached 60.20% in 'Allahabad Safeda' and 53.40% in 'Sardar' guava. A trend was also noticed in the quantity of leaf proline according to the degree of water stress (Singh *et al*., 1997). In certain parts of Maharashtra, roots are exposed and minute roots are cut away and irrigation is withheld so as to allow the leaves to shed. Then, the basins are covered with the manures and soil and irrigated copiously (Kumar, 2010). Similarly, Singh (1963) recommended withholding of water for those areas of the western India where soils were lighter. However for heavier soils suggested root pruning in addition to the withholding of water during December or January. In guava the operations of withholding water, exposing feeding roots and pruning fibrous roots to force blossom in the desired season are practiced.

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 bahar 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 mrig bahar (June) so that the plants are forced to rest in April – May and no water is required during the period. 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. Radha and Mathew (2007) suggested that upper soil surrounding trunk, about 90 to 120 cm diameter is removed to expose roots. After about 3-4 weeks, exposed roots are covered with soil, followed by manuring and irrigation.

Root pruning is the practice of removing a portion of a tree's root system or severing the roots of a tree, all the way around the tree's circumference at the drip line. Root pruning is very seldom recommended or adopted in practice except at the time trees are lifted from a nursery and planted in the permanent site. Hussein (2006) utilized four pruning techniques in guava namely, removal of 20% and 40% of the total leaves, root pruning and the combination of removal of 30% of leaves plus root pruning and revealed that all pruning techniques resulted in significantly greater increases in plant height and stem diameter than the control. No clear pattern was noted regarding other growth parameters in terms of number of leaves and relative growth rate; however, root pruning resulted in greater values than the rest of the treatments. 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). Root pruning however has a harmful effect on the longevity of trees (Sharma, 2006). In certain parts of Maharashtra, root pruning is practiced to produce heavy yield. Root pruning is not recommended in Uttar Pradesh as it imposes moisture stress resulting in leaf drop and cessation of growth of crop during period of unwanted Bahar (Singh, 2013).

Bending of guava shoots for crop regulation

Shoot bending is one of the ways to produce better quality fruits in the off-season of guava (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 to the other parts, maintaining increased C: N ratio and induce more flowering and fruit set. The upright branch produces fewer flowers and fruits than the bent branch (Ito *et al*., 1999). Bending induces profuse flowering and fruiting and fetches greater returns (Ghosh and Sukul, 2003; Sarkar *et al*., 2005). Shoot bending also improved productivity of guava in different varieties at Bangladesh (Mamun *et al*., 2012). Nandi *et al.,* 2017 observed that bending in guava *cv*. Khaja in the month of October is most effective in increasing flowering shoot (32.33/ branch) and fruit yield (63.66 kg/plant) followed by bending in June. Samant *et al*., (2016) has also shown the positive effect of shoot bending in guava. Mamum *et al*., (2012) found highest number of flower set per plant when shoot bending treatment was given during on-season (312.33) and in off-season it was (111.33). Most of the growers of West Bengal prefer winter season crop and regulate flowering by bending the shoots in the month of August-September (Mitra *et al* 2008). This practice is very much dependent on training of guava branches. On the basis of calculation of expected flowering the branches of guava plants are bent down about 45-60 days before the expected date of flowering and to produce fruits in the off season. First time bending of branches of guava plant should be employed at the age of 2 years of plant. Shoot bending

increased the fruits set per plant during off-season is also reported by Sarker and Ghosh (2006). Similarly, shoot bending increased the fruit yield per plant and quality fruit during off-season (Sarker *et al*., 2005). Bending induces profuse flowering and fruiting, as well as fetches greater returns and regulates flowering (Ghosh, 2003). The shoot bending treatment result the highest number of fruits set per plant both on and off season (246.86) and (67.33), respectively.

Crop regulation by use of chemical

In order to avoid heavy crop load during rainy season use of chemicals is an important tool for crop regulation to get quantum and quality yield (Singh *et al*., 2001). Growth regulators has been found very effective in thinning of flowers and manipulating the cropping season NAA, 2,4-D carbaryl and ethrel were found successful in reducing the rainy season and increasing the winter crop under different agro-climatic 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. Crop regulation through chemical spray is an easy means of regulating the crop. Different chemicals caused deblossoming in rainy season crop and subsequently increased the winter season crop. Singh *et al.,* (2002) observed that crop regulation in guava with the help of single spray of 25% urea and double sprays of 10% urea in Sardar and Allahabad Safeda, respectively at bloom stage (April-May) has been found economically efficient for quality production. These treatments did not affect the tree adversely, the fruit quality was better as the fruiting was mainly concentrated in winter. It has also been observed that urea spray suppressed shoot growth, producing severe leaf fall followed by initiation of new shoot on which flower buds are formed for following winter season. 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 Bariana, 1988). Whereas Singh *et al.,* (1994) and Choudhary *et al.,* (1997b) found 15 per cent urea most effective in deblossoming the rainy season guava crop. Rathore (1975) reported 96 per cent deblossoming with 100 ppm NAA in guava. Whereas, Chundawat *et al.,* (1975) noted 24, 51 and 82 per cent deblossoming with 100, 200 and 400 ppm NAA spray, respectively. Complete deblossoming has been found by Pandey *et al*, (1980) with 400 ppm of NAA and Singh and Singh (1975) obtained complete deblossoming with 2000 ppm MH in guava. Singh *et al.* (2000) advocated that spraying of 10 percent urea gave significantly higher yield (100 kg tree^{-1}) in 'Allahabad Safeda' during winter season. However, two sprays of 10 percent urea and 15 percent urea at 10 days intervals during in summer season was economically feasible for crop regulation of 'Allahabad Safeda' and 'Sardar' guava, respectively. Similar observations were also made by Rajput *et al*. (1986) and found that Spray of urea (12, 15 and 20%) in guava crop resulted in no flowering and fruiting in summer season. Further, it result maximization in fruit number and fruit yield. However, fruit size was reduced in winter season crop with an increase in urea concentration.

During different cropping season, maximum length, width and weight of fruits were found in winter season followed by spring and rainy season. Spray of NAA (250 ppm) on 10 year old guava trees *cv*. Allahabad Safeda caused maximum defoliation in rainy season flowering and produced maximum yield and quality fruits during winter Dubey *et al.,* (2002). Similar findings were reported by Choudhary *et al.,* (1997a) and Das *et al.,* (2007). Kundu and Mitra (1997) noted that NAA 100 ppm and 2,4-D 100 ppm markedly increased the average size, weight of fruit as well as pulp content on 11 year old guava cv. L- 49. While, Singh *et al*., (1993) studied on 5 year old Allahabad Safeda guava and reported that among the chemicals used for crop regulation, NAA 50 and 75 ppm gave best results followed by NAA 200 and 100 ppm. Yadav *et al.,* (2001) recorded that spray of NAA 60 ppm in 15 year old guava tree *cv*. Sardar, produced maximum fruit weight, yield and ascorbic acid in the winter season crop. Kumar and Hooda (1977) reported on 15 year old guava trees cv. Allahabad Safeda that among the chemicals NAA at 50 ppm followed by 2, 4-D at 30 ppm gave better results. Correspondingly, Agnihotri *et al.,* (2013) found increased canopy spread, volume of fruit (185.38 ml), pulp thickness, pulp weight (175.57g), pulp per cent (96.6), diameter of fruit (7.34 cm), average fruit weight (181.71g) and reduced seed per cent and seed pulp ratio with foliar spray of 60 ppm 2,4-D which ultimately increased the yield per tree. Kaur and Kaur (2017) concluded from their study that 2,4-D 50 ppm was found to be the most effective treatment in enhancing the fruit yield and improving the fruit quality as compared to other treatments of NAA and urea in guava *cv.* Allahabad Safeda. Lal and Das (2017) recorded GA3 (50 ppm) with increased yield and quality of Allahabad Safeda guava in Assam condition.

Crop regulation for economic benefits

In India, there is an increasing demand from consumers and marketers for quality guava fruits. Fruits of the two most popular cultivars of guava grown in India, 'Allahabad Safeda' and 'Sardar' are intrinsically poor in quality during rainy season (Singh *et al*, 2002). On the contrary, winter season crop bears quality fruits which fetch high monetary returns (Singh *et al*., 2000). Obviously, regulation of crop will help to overcome such problems to a great extent by judicious flower thinning during summers. Understanding of crop regulation will help to optimize harvest time which reduce surplus in the market, to obtain higher price of the produce, to avoid spoilage due to excessive production at a particular time, to provide employment throughout the year and balance the trade and to reduce imports. Gurjar *et al*., (2018) obtained maximum and statistically higher yield (119.73 q/ha.), gross return (Rs 32925 per hectare) and net return (Rs 230529 per hectare) under application of 800 PPM NAA plant growth regulator. Highest cost benefit ratio (1:3.33) was also recorded under the treatment of 800 ppm of NAA which was most economic and feasible practice of crop regulation in guava fruit crop. Similarly Singh *et al*., (2000) reported significantly higher yield (100 kg/tree) in 'Allahabad Safeda' with spray of 10 % urea during winter season, while,

in 'Sardar' guava highest yield (103.98 kg/tree) was recorded with the spray of 1800 ppm ethephon during the same season which was closely followed by 20 and 15 % urea (100.25 and 96.38 kg/tree, respectively). The control trees of 'Sardar' and 'Allahabad Safeda' could give only 29.15 and 26.14 kg/tree respectively during this season. However, double spray of 15 % urea on 'Sardar' resulted into highest net future value, *i.e*., Rs 849/tree, over the entire period of experimentation, which was Rs 223 more than the control. Highest net future value in 'Allahabad Safeda', *i.e*., Rs 802/ tree, was obtained with double spray of 10 % urea over the entire period of experimentation, which was Rs 309 more than the control. Maji *et al*., (2015) found highest benefit: cost ratio (7.84:1) by summer deblossoming with spray of NAD@ 60 ppm. Thakre (2016) also noticed that one leaf pair pruning of fruited shoots only (OLPF) in guava cv. Pant Prabhat was more profitable among other treatments by recording cost: benefit ratio of 1:2.96. This treatment also recorded the highest return distributed in rainy as well as in winter season.

CONCLUSION

Guava (*Psidium guajava* L.) is one of the most popular tropical and subtropical fruit crops grown in India owing to its several health promoting properties and value-addition avenues. Here are three distinct flowering seasons *viz*., spring (Ambe Bahar), rainy (Mrig Bahar) and autumn (Hasta Bahar) with the corresponding harvesting periods during the rainy, winter and spring seasons in guava. The rainy season crop of guava is rough, insipid, poor in quality, less nutritive and is attacked by several insect pests and diseases. The winter season fruits are superior in quality, free from diseases and pests and fetch more prices in the market. Therefore, the natural flowering and fruiting behaviour of guava are needed to be regulated, towards the production of heavy crop load during winter season to make guava cultivation highly profitable and market oriented. Several methods have been tried to induce new vegetative growth during rainy season so that bumper crop is obtained in subsequent winter season. Crop regulation can be achieved by means of root exposure and root pruning, shoot pruning, mechanical flower thinning and chemical thinning by the use of Urea, growth substances like naphthalene acetic acid (NAA), naphthalene acid amide (NAD), 2,4-dichlorophenoxy acetic acid (2,4-D) etc. Some other methods, like withholding of irrigation water, defoliation etc. were also practiced.

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