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EFFECT OF TIME OF PRUNING ON GROWTH AND YIELD OF ASSAM LEMON (*CITRUS LIMON* L. BURM.)

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ABSTRACT

This experiment aims to study the effect of time of pruning on growth and yield of Assam lemon and to determine the effort to avail Assam lemon fruits during lean period. Among the treatments, the highest increase in plant height (18.82%) and number of laterals (4.62) per primary shoot was observed in T₁ (pruned on 1st May). Leaf production per terminal shoot was highest (19.33) in T₂ (pruned on 15 May). Average number of hermaphrodite flowers (96.09) male flowers (96.70) and total number of (192.79) were highest in T₁₂ (pruned on 15th October) and plants under this treatment also recorded the highest fruit set (58.44%), fruit retention (92.01%), average number of fruits per plant per month (51.55) and number of fruits per plant per year (360.85). These values were found to be the lowest in plants pruned in May (T₁ and T₂).

Key words : Assam lemon, Pruning, Flowering, Crop regulation.

Introduction

Citrus, one of the most important fruit crop genres, is a member of the Rutaceae family and is native to Asia's subtropical and tropical areas. Many significant species are there in this genus including mandarins, limes, lemons, grapefruits, pummelo and oranges. One of the most common and popular citrus fruits found in Assam is the Assam lemon, also known as 'Kajinemu' or 'Nemutenga', which is an indigenous lemon of Assam (Bhattacharya and Dutta, 1956) and has a certain uniqueness in terms of quality that is primarily attributable to its place of origin namely Assam. In Assam, lemon and lime cover around 15.90 thousand hectares and produce 157.32 thousand metric tonnes, with a total citrus production of 369.56 thousand metric tonnes (Anonymous, 2022).

Scientific name of Assam lemon is *Citrus limon* L. Burm., which belongs to the family Rutaceae of the natural order 'Geraniales'. The plants are vigorous, bushy, spreading habit and have moderately dense foliage. The

plant bears both bisexual and staminate flowers. The uniqueness of the fruits lies in its bearing habit. Assam lemon has a tendency of cluster bearing habit on newly emerged shoots which generally produces seedless fruits with 9-12 segments. The skin of the fruits become smooth, glossy and light green in colour on maturity and become dull yellow in colour when fully ripe.

Citrus having a naturally sympodial growth habit will develop in to a large bush if it is left unpruned. Pruning has many advantages like managing canopy architecture, changing the biochemical system and promoting early flowering (Singh *et al.*, 2009). Singh *et al.* (2004) observed that citrus trees, which were begun to decline in vigour, yield and size of fruit, required pruning in order to improve their condition. The main goal of pruning is to control overly vigorous vegetative growth in order to improve the tree's structure and direct new, healthy growth. Pruning also helps to improve the production of fruits with good quality. Assam lemon plants are

responsive to pruning, which encourages the development of more numbers of new shoots and flowers are born terminally on the newly emerged shoots resulting higher production of fruits. As per recommended package of practices for Assam, Assam lemon plants are pruned during October and fruits are available from April in the next year. But demand of the fruits in the market is very high during November to March in Assam and cost of each fruit ranges from Rs. 8/- to Rs 10/- in the market. Considering these facts, the present study was undertaken to study the effect of time of pruning to study the growth and yield of Assam lemon and to make the fruits available during lean period.

Materials and Methods

The research was conducted in the ICR Farm, Biswanath College of Agriculture during 2022-23. The study used Randomized Block Design consisting of 3 replication and 12 treatments namely T_1 : pruning on 1st May, T_2 : pruning on 15th May, T_3 : pruning on 1st June, T_4 : pruning on 15th June, T_5 : pruning on 1st July, T_6 : pruning on 15th July, T_7 : pruning on 1st August, T_8 : pruning on 15th August, T_9 : pruning on 1st September, T_{10} : pruning on 15th September, T_{11} : pruning on 1st October and T_{12} : pruning on 15th October. Increase in plant height after 6 month of pruning i.e after first harvest, number of laterals per primary shoot and number of leaves per terminal shoot were the growth parameters observed. Yield attributing character observed during the experiment were number of male, hermaphrodite and total flower production per plant per month, fruit set percentage, fruit retention percentage, fruits harvested at different months, fruits per plant per month and estimated number of fruits per plant per year. Observations made during the field experimentation and data obtained from laboratory determinations were subjected to analysis of variance by Randomized Block Design (RBD). Significance or non-significance of the variance due to treatments were determined by calculating the respective 'F' values by the following method given by Gomez and Gomez (2010). The statistical analysis of the data on the mean values of individual characters was analysed using Microsoft Excel (MS-Office ver. 2021). Graphs were also prepared by using Microsoft Excel (MS-Office ver. 2021).

Results and Discussion

Effect of time of pruning on growth characters

Time of pruning had no significant variations in plant height recorded after pruning and after first harvest. But pruning time has significant effect on increase in plant height percentage and the highest increase in plant height (18.82%) was observed in T_1 (Pruned on 1st May) closely

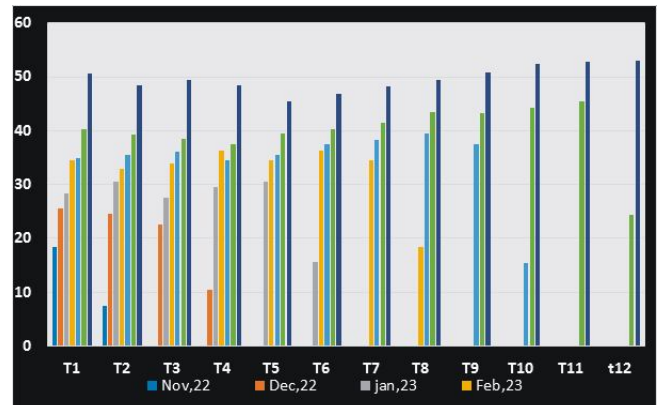


Fig. 1 : Effect of time of pruning on numbers of fruits harvested at different month.



Plate 1 : Pruning of Assam lemon plants in the experimental plot.



Plate 2 : Assam lemon plants after pruning.

followed by T_2 (Pruning on 15th May). Although, among the treatments there were no significant variation regarding no. of laterals per primary shoot, the highest average number (4.62) of laterals per primary shoot was

Table 1 : Effect of pruning on plant height.

Treatments	Plant height after pruning (m)	Plant height after first harvest (m)	Increase in height (%)
T ₁ (Pruning on 1 st May)	1.70	2.02	18.82
T ₂ (Pruning on 15 th May)	1.81	2.13	17.64
T ₃ (Pruning on 1 st June)	1.87	2.20	17.46
T ₄ (Pruning on 15 th June)	1.89	2.22	17.57
T ₅ (Pruning on 1 st July)	1.81	2.11	16.40
T ₆ (Pruning on 15 th July)	1.89	2.20	16.23
T ₇ (Pruning on 1 st August)	1.91	2.22	15.67
T ₈ (Pruning on 15 th August)	1.85	2.14	15.38
T ₉ (Pruning on 1 st September)	1.95	2.25	14.89
T ₁₀ (Pruning on 15 th September)	1.88	2.16	14.72
T ₁₁ (Pruning on 1 st October)	1.89	2.17	14.68
T ₁₂ (Pruning on 1 st Sept)	1.95	2.21	13.16
SE(d)	NS	NS	1.16
CD (P=0.05)			2.40

Table 2 : Effect of time of pruning on number of lateral shoots per primary shoot and leaves per terminal shoot.

Treatments	Number of laterals per primary shoot	Number of leaves per terminal shoot
T ₁ (Pruned on 1 st May)	4.62	19.22
T ₂ (Pruned on 15 th May)	4.54	19.33
T ₃ (Pruned on 1 st June)	4.53	19.18
T ₄ (Pruned on 15 th June)	4.48	19.06
T ₅ (Pruned on 1 st July)	4.45	18.95
T ₆ (Pruned on 15 th July)	4.44	18.67
T ₇ (Pruned on 1 st August)	4.42	18.53
T ₈ (Pruned on 15 th August)	4.45	18.33
T ₉ (Pruned on 1 st September)	4.42	17.73
T ₁₀ (Pruned on 15 th September)	4.41	17.61
T ₁₁ (Pruned on 1 st October)	4.39	17.16
T ₁₂ (Pruned on 15 th October)	4.35	16.92
SE(d)	0.07	0.28
CD (P=0.05)	NS	0.59

found in T₁ (Pruning on 1st May) followed by T₂ (Pruning on 15th May). Likewise, T₂ (Pruning on 15th May) also produced the highest no. of leaves per terminal shoot (19.33) followed by T₁ (Pruning on 1st May). This result is corroborated with the finding of Adhikari and Kandel (2015) in Guava where pruning in early May resulted in significantly higher number of leaves per shoot. A significantly lower proportion of new axils sprouted were

observed on shoots pruned during Dec-March than those pruned during June-September.

This study revealed that in case of all the growth characters *i.e.* increase in height, number of laterals per primary shoot and numbers of leaves per terminal shoot, plants pruned in May (1st May and 15th May) outperformed all the other treatments. These findings are in conformity with Pittaway (2002), who reported that practice of pruning during summer months showed significantly stronger vegetative growth as compared to those pruned during winter. It might be due to prevalent adequate temperature (28.36^oC to 33.48^oC) and humidity for the better growth of Assam lemon trees as optimum temperature for citrus growth is 25-30^oC and vegetative growth increases with increasing temperature up to 35^oC (Abobatta, 2019).

Effect of time of pruning on yield attributing characters

From the experiment it was evident that time of pruning had significant influence on production of male, female and hermaphrodite flower. The highest average number of male flowers (96.70) and hermaphrodite flower per plant per month (96.09) was recorded in T₁₂ (pruned on 15th October), while the lowest male (72.90) and hermaphrodite flower (69.88) was observed to be produced by the plants pruned on 1st May (T₁). Total flower production also showed the same trend as that of male and hermaphrodite flower. The total average number of flowers was found to be highest (192.79) in T₁₂ (pruned

on 15th October) followed by T₁₁ (pruned on 1st October). The lowest average total flower (142.78) was observed in T₁ (pruned on 1st May). The reason behind this was that after pruning, plants of T₁ (pruned on 1st May) received high temperature which reduces flowering during the month of June, July, August and September which ultimately decreased the average no. of male, hermaphrodite and total flower in T₁ (Pruned on 1st May). But in T₁₂ (Pruned on 15th October) plants started producing flower from the last week of December. During the period from December to March, prevailing low winter temperature was ideal for flowering, which increased flowering which ultimately resulted in highest no. of male, female and hermaphrodite in T₁₂ (pruned on 15th October) as under subtropical conditions, citrus flowering occurs primarily during the spring following the inductive winter season (Furr and Armstrong, 1956; García-Luis *et al.*, 1995; Monselise and Halevy, 1964). During winter, low-temperature conditions cause the inactivity of buds while inducing them to be able to flower (Moss, 1969 and Reuther *et al.*, 1973). As for flower intensity, greater accumulation of hours of low temperature increases floral induction, thus increasing number of flowers per tree, number of flowers per node, and sprouting (Poerwanto and Inoue, 1990; Valiente and Albrigo, 2004). The most effective temperatures for induction appear to be in the 10 to 15°C range (Moss, 1969; Valiente and Albrigo, 2004).

It was also evident (Table 5) that time of pruning had significant influences in the percentage of fruit set among the treatment. The maximum number of fruit set (58.44%) was recorded in T₁₂ (pruned on 15th October) while the lowest fruit set (55.04%) was observed on T₄ (pruned on 15th June). Fruit set is primarily regulated by the numbers of flowers, additional competition with flush and other fruitlets, temperature and moisture balanced against evaporative demand (Albrigo, 2004). Very high temperature during bloom results in excessive flower abscission which in turn reduce the fruit set percentage (Albrigo, 2004). Plants of T₁ experienced high temperature for relatively longer period than any other treatment which may reduce the fruit set percentage by increasing flower abscission.

From the data (Table 5), it was evident that there was significant variation in retention percentage of fruits due to different treatments. Fruit retention was maximum (92.01%) in T₁₂ (pruned on 15th October) while the lowest (87.76%) fruit retention was recorded in T₁ (pruned on 1st May). In citrus 3 distinct wave of fruit drop occurs namely post bloom drop, summer drop or June drop and

Table 3 : Effect of time of pruning on average number of male flowers, hermaphrodite flower and total flower production per plant per month.

Treatments	Number of		
	Hermaphrodite flower	Male flower	Total flower
T ₁ (Pruned on 1 st May)	69.88	72.90	142.78
T ₂ (Pruned on 15 th May)	69.92	73.79	143.71
T ₃ (Pruned on 1 st June)	69.99	74.92	144.91
T ₄ (Pruned on 15 th June)	71.33	75.27	146.60
T ₅ (Pruned on 1 st July)	73.00	76.09	149.09
T ₆ (Pruned on 15 th July)	76.03	79.52	155.55
T ₇ (Pruned on 1 st August)	77.96	80.43	158.39
T ₈ (Pruned on 15 th August)	80.61	82.44	163.05
T ₉ (Pruned on 1 st September)	83.83	85.17	169.00
T ₁₀ (Pruned on 15 th September)	84.73	85.75	170.48
T ₁₁ (Pruned on 1 st October)	91.42	91.94	183.36
T ₁₂ (Pruned on 15 th October)	96.09	96.70	192.79
SE(d)	2.43	2.12	4.53
CD (P=0.05)	5.05	4.41	9.41

Table 4 : Effect of pruning on fruit set percentage and fruit retention percentage.

Treatments	Fruit set (%)	Fruit retention(%)
T ₁ (Pruned on 1 st May)	55.04	87.76
T ₂ (Pruned on 15 th May)	55.33	88.26
T ₃ (Pruned on 1 st June)	56.30	88.89
T ₄ (Pruned on 15 th June)	56.36	89.00
T ₅ (Pruned on 1 st July)	56.97	89.17
T ₆ (Pruned on 15 th July)	57.52	89.75
T ₇ (Pruned on 1 st August)	57.83	90.11
T ₈ (Pruned on 15 th August)	57.64	90.24
T ₉ (Pruned on 1 st September)	57.84	90.49
T ₁₀ (Pruned on 15 th September)	58.21	91.06
T ₁₁ (Pruned on 1 st October)	58.35	91.36
T ₁₂ (Pruned on 15 th October)	58.44	92.01
SE(d)	0.47	0.33
CD (P=0.05)	0.98	0.68

pre-harvest drop (Rattanpal, 2019). In T₁ (Pruned on 1st May), plants started producing fruits from June onwards and experienced heavy fruit drop due to June drop or summer drop which may be the reason of low fruit retention in T₁. Besides these 3 waves of fruit drop, fruit drop also occurs due to exposure of plant to environmental or physiological stress. Water stress, high temperature, nutrient deficiency and frost for long time are the main cause of physiological fruit drop in citrus (Rattanpal, 2019). Heavy rainfall from May- October, 2022 which, might

Table 5 : Effect of pruning on no. of fruits harvested in different months.

Treatments	Nov, 2022		Dec, 2022		Jan, 2023		Feb, 2023		March, 2023		April, 2023		May, 2023		Total
	1-15 th	15 th -30 th	1-15 th	15-30 th	1-15 th	15-30 th	1-15 th	15-30 th	1-15 th	15-30 th	1-15 th	15-30 th	1-15 th	15-30 th	
T ₁	8.33	10.00	12.50	13.00	13.33	15.00	16.50	18.00	16.00	19.00	19.33	21.00	24.66	26.00	235.65
T ₂		7.50	11.50	13.00	14.50	16.00	16.50	16.50	17.00	18.50	19.33	20.00	28.50	20.00	221.83
T ₃			10.50	12.00	13.50	14.00	16.00	18.00	17.50	18.50	21.00	17.50	26.33	23.00	207.83
T ₄			10.50	10.50	14.50	15.00	16.33	20.00	19.50	15.00	19.50	18.00	26.00	22.50	196.83
T ₅					16.50	14.00	18.50	16.00	17.50	18.00	20.50	19.00	24.00	21.00	185.50
T ₆						15.67	16.00	20.33	18.50	19.00	18.33	22.00	22.83	24.00	176.66
T ₇							17.50	17.00	18.00	20.33	18.50	23.00	23.16	25.00	162.49
T ₈								18.50	18.00	21.50	20.50	23.00	25.33	23.00	146.83
T ₉									17.50	20.00	21.00	22.33	24.50	26.33	131.66
T ₁₀										15.50	21.33	23.00	24.50	28.00	112.33
T ₁₁											20.00	25.50	25.33	26.5	98.33
T ₁₂												24.33	25.67	27.33	77.33

have led to dropping of the developing fruit lets from the plants resulting lower yield of plants was the cause of low fruit retention percentage in T₁. High temperature during the period from June- September may also contribute to this. However, in T₁₂, plants started producing fruits from December onwards. Due to ambient temperature, regular irrigation, availability of nutrient physiological fruit drop may occur at a low rate which may be the probable reason of high fruit retention percentage in T₁₂ (pruned on 15th October).

From the Table 5, it can be clearly seen that the maximum number of fruits (235.65) harvested during this period of 7 months (November-May) was observed in T₁ (pruned on 1st May) followed by T₂ (pruned on 15th May) while the lowest (77.33) was observed in T₁₂ (pruned on 15th October) followed by T₁₁ (pruned on 1st October). It was because of availability of fruits for a longer period in T₁ *i.e.* from November to May and availability of fruits for a very short time in T₁₂ *i.e.* during April-May.

Imposition of different pruning time had significant influences in average number of fruits harvested per plant per month. Results revealed that maximum number of fruits (51.55) harvested per plant per month was recorded in T₁₂ (pruned on 15th October) followed by T₁₁ (pruned 1st October). The minimum average number of fruits (33.66) harvested per plant per month was recorded in T₁ (pruned on 1st May). From Table 6, it could be opined that there were significant differences in estimated number of fruits harvested per plant per year due to different pruning treatments. Results revealed that maximum estimated number of fruits (360.85) per plant per year was recorded in T₁₂ (pruned on 15th October) followed by T₁₁ (pruned on 1st October as in T₁₂ and T₁₁, period after pruning (Oct – Nov) coincide with the peak flowering season as combined effect of low temperature and water deficit has been proved to increase the ratio of floral shoots and the total number of flowers (Southwick and Davenport, 1986)

From the present study, it may be concluded that time of pruning has significant effect on growth and yield parameters of Assam lemon. In Assam lemon, pruning is considered to be an essential practice for quality fruit production as if we left the Assam lemon trees unpruned, the plants might produce fruits throughout the year but management of the canopy would become a problem and productivity of plants would become low. According to recommended package of practice Assam lemon plants should be pruned during Autumn season preferably in the month of October. The plants pruned in the month of October produced the mature fruits from April onwards

Table 6 : Effect of pruning on average no. of fruits per plant per month and estimated number of fruits per plant per year.

Treatments	Average number of fruits per plant per month	Estimated number of fruits per plant per year
T ₁ (Pruned on 1 st May)	33.66	235.65
T ₂ (Pruned on 15 th May)	34.12	238.84
T ₃ (Pruned on 1 st June)	34.63	242.41
T ₄ (Pruned on 15 th June)	35.78	250.46
T ₅ (Pruned on 1 st July)	37.10	259.70
T ₆ (Pruned on 15 th July)	39.25	274.80
T ₇ (Pruned on 1 st August)	40.62	284.35
T ₈ (Pruned on 15 th August)	41.95	293.65
T ₉ (Pruned on 1 st September)	43.88	307.16
T ₁₀ (Pruned on 15 th September)	44.93	314.51
T ₁₁ (Pruned on 1 st October)	49.16	344.12
T ₁₂ (Pruned on 15 th October)	51.55	360.85
SE(d)	0.69	3.25
CD (P=0.05)	1.44	6.75

and there was market glut due to high availability of fruits and the growers get low return. From the results obtained in the study, it could be mentioned that mature fruits could be harvested during the lean period (November-February) when the plants were pruned from May to June. Productivity of plants pruned during May-June might be lower as compared to the plants pruned during October, but because of higher prices of fruits during lean period, farmers would be able to get better economic return.

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