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Impact of Different Pruning Severity and Nutrient Management on Growth and Yield of Lemon cv. Assam Lemon (*Citrus limon* Burm.)

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Abstract

Like many other citrus species, the lemon (Citrus limon Burm.) presents a number of diverse forms slightly varying from each other. Pruning is one of the important approaches for the canopy management of citrus. The result of pruning on growth parameters have been reported by various workers. It is also a highly nutrient responsive perennial fruit crop and requires adequate nutrition for proper growth and yield of the plants. A field experiment was laid out in two factorial Randomized Block Design with four levels of pruning, seven levels of nutrient, consisting .recommended dose of fertilizers (RDF) and different combinations of organic manure (Vermicompost), inorganic fertilizer, bio-fertilizer (Azotobacter), mycorrhiza (VAM) and their interaction during 2013 to 2015. The investigation revealed that all the vegetative parameters viz. trunk girth (32.74cm, 33.26cm and 33.13cm) and its percentage increase (1.25%, 2.88% and 4.56%), canopy volume (85.22 m³, 100.03 m³ and 125.84 m³) and its percentage increase (31.66%, 56.21% and 114.24%), number of laterals per primary shoot (9.53, 11.87 and 10.80) and its percentage increase (31.65%, 63.64% and 98.25%) and leaf chlorophyll content (1.45%, 1.94% and 2.56%) and its percentage increase (48.61%, 98.41% and 172.80%) was recorded best in highest level of pruning with 75% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza at 6th, 12th and 18th month after pruning. Among the three season of cropping Ambebahar recorded the best result in respect to yield (total number of fruits/plant) followed by Mrig and Hasthbahar.

Keywords

Assam lemon; Growth and yield; Nutrient management; Pruning

Introduction

Citrus (*Citrussp.*), often regarded as 'queen of fruits' [1], are well known as one of the world's major fruit crops that are produced in many countries with tropical and sub-tropical climate. It belongs to the family Rutaceae which consisting of 140 genera and 1300 species. It accounts for 3.7% (255.2 Thousand ha) of total area under fruit and 3.1% (2523.5 Thousand MT) of total fruit production with a productivity of 9.9 MT/ha. In West Bengal, the major lemon belts

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are Cooch Behar, Jalpaiguri, North and South 24 parganas and West and East Midnapur [2]. The most distinctive characteristics of the lemon fruit are oval to elliptical in shape with highly fragrant rind and have high acidity levels. Assam Lemon is one of the important dwarf cultivars of lemon, suitable for high density planting, extensively grown in the north-eastern parts of India [3]. In northern parts of West Bengal, it is early bearing with three fruiting season, *viz*. April-May, August-September and November-December. The earlier vegetative flushes of the previous season growth generally are more productive [4]. So pruning is very much essential to manipulate various aspects of vegetative and fruiting. Impact of Pruning and Nutrient Management on Growth and Yield of Lemon

The cultural practice of pruning of stems increases vegetative and floral responses. By modifying the architecture of the aerial parts, shoot pruning profoundly affects tree growth and photosynthesis. Accelerated growth of shoots is generally observed after pruning and, depending on growth conditions, equilibrium between shoots and roots can be reached [5]. As lemon plants bears three times in an year, proper manuring and fertilization has to be resorted for obtaining highest yields and quality production which depends upon healthy and sturdy tree growth [6]. Furthermore, beside application of soul chemical fertilizers in traditional way, combine application of organic, inorganic and bio-fertilizers need to resort for avoiding the deleterious effect of chemical fertilizers and as well as improves physical properties of soil by increasing nutrient and water holding capacity, total pore space, aggregate stability, erosion resistance and temperature insulation. However, a little information is available about the response of lemon against pruning and nutrient management for this area. Keeping in view the present investigation was conducted to study the impact of pruning intensity and nutrient management in growth and yield of lemon cv. Assam lemon.

Materials and Methods

Experimental Site

The present investigation was carried out during 2013 and 2015 on 7 years old lemon cv. Assam lemon plants planted at $3m \times 3m$ spacing at Instructional farm of Uttar BangaKrishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, which was situated at $26^{0}19'86"$ N latitude and $89^{0}23'53"$ E longitude with an altitude of 43 meters above mean sea level.

Treatments and design

There were 4 levels of pruning, namely P₀- No pruning (Control), P₁- 25 cm pruning from the terminal portion of the shoot, P₂- 50 cm pruning from the terminal portion of the shoot, P₃- 75 cm pruning from the terminal portion of the shoot and 7 treatments of nutrient management *viz*. N₁- 100% Recommended Dose of Fertilizer (N@210g/ plant-P@140g/plant-K@210g/plant), N₂- Vermicompost (20 kg/ plant) + Azotobacter (18 g/plant) + Vesicular Arbuscular Mycorrhiza (150 g/plant), N₃- Vermicompost, N₄- 75% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza, N₅- 75% RDF + Vermicompost, N₆- 50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N₇- 50% RDF + Vermicompost were applied alone and in combination with different levels of the pruning. The experiment was laid out in two factorial asymmetrical

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randomized block design (RBD) and 28 treatment combination (4 levels of pruning and 7 levels of nutrient) with 3 replications and 6 plants were kept in each treatment. All levels of pruning were done on 21st November, 2013, after harvesting of Mrigbahar. Nitrogenous fertilizer was applied in two split doses. Firstly, half dose of nitrogen and full dose of phosphorus, potassium and vermicompost were applied in February, 2014 and rest half of nitrogen was applied in April, 2014. Azotobacter and Vesicular Arbuscular Mycorrhiza were applied in December, 2013, after harvesting of Mrigbahar.

Observation recorded

All the vegetative parameters were recorded at initial stage and after that at 6 month interval after pruning. Height of the plant (m) was measured with the help of measuring tape and stick from the ground to top of the plant. Spread of the plant (m) was recorded at maximum width of the crown with the help of a measuring tape in both North-South and East-West direction at right angles. Plant girth (cm) was measured with the help of measuring tape at the maximum diameter of the trunk above the ground level. Canopy volume (m³) of a plant was measured by using height and spread of this particular plant. The formula is: canopy volume = $4/3 \pi a^2 b$, where $a = \frac{1}{2}$ of plant height and b = average of east - west and north - south spread [7]. Percentage increase in canopy volume was measured by: [(Final volume - Initial volume) / Initial volume] × 100. For number of laterals five primary branches were randomly tagged in each of six selected plants and newly formed laterals arisen from those selected primary branch were counted. Percentage increase in number of laterals per primary shoot was measured by: [(Final number of laterals - Initial number of laterals) / Initial number of laterals] × 100. Total Leaf chlorophyll (mg total chlorophyll/g tissue) was extracted by homogenizing of 1 g fresh leaves in 10 ml of 80% acetone. After filtering, extract fill up to 10 ml in volume, the chlorophyll content was determined via an UV-Vis spectrophotometer (Perkins Elmar) from the acetone extract at 645 nm and 663 nm, as described by Witham et al. [8]. Total chlorophyll content as mg in 1 gram of plant tissue was calculated as: mg total chlorophyll/g tissue = $[20.2 (D_{645}) + 8.02 (D_{663})]$. (V/1000 weight), where D = Absorbance values. Percentage increase in leaf chlorophyll content was measured by: [(Final leaf chlorophyll content - Initial leaf chlorophyll content) / Initial leaf chlorophyll content] × 100. The number of fruits harvested under each treatment was recorded from six randomly selected trees and the average number of fruits harvested from six trees was calculated for each treatment likewise.

Statistical Analysis

Analysis of variance (one way classified data) for each parameter was performed using ProcGlm of Statistical Analysis System (SAS) software (version 9.3). Mean separation for different treatment under different parameter were performed using Least Significant Different (LSD) test ($P \le 0.05$). Normality of residuals under the assuming of ANOVA was tested using Kolmogrov-Smirnov, Shapiro-Wilk, Cramer-Von Mises and Anderson Darling procedure using Proc-Univariate procedure of SAS (version 9.3). Data transformation was done followed by the method of Gomez and Gomez [9].

Results and Discussion

Plant height (m)

The data pertaining to plant height has been presented in Table 1. Observation revealed that the plant height was increased in all the treatments up to the end of experiment. Significant variation with respect to plant height was observed among several pruning

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treatments except in percent increase at 12th month after pruning, where plant height is statistically at par under all pruning level. Maximum plant height (3.56 m, 3.78 m and 4.29 m) and its percentage increase (6.18%, 12.82% and 28.08%) was recorded in highest level of pruning P_{2} (75 cm pruning from the terminal portion of the shoot) at 6th, 12th and 18th month after pruning followed by medium level P₂ (50 cm pruning from the terminal portion of the shoot) of pruning (3.52 m, 3.74 m and 4.24 m; 5.76%, 12.18% and 27.61%) after 6th, 12th and 18th months after pruning. The lowest plant height and its percentage increase was observed in (P_o) unpruned plants (3.42 m, 3.61 m and 3.91 m; 4.36%, 10.64% and 20.22%) at 6th, 12th and 18th month after pruning. The effect of different nutrient treatments was significant in plant height except it's percent increase at 6th, 12th and 18th month after pruning, where the data's were statistically at par. It cleared that treatments have no effect on percentage increase in height. The highest plant height (3.58 m, 3.65 m and 4.06 m) and its percentage increase (6.18%, 12.82% and 28.08%) was recorded in N_4 (75% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) at 6^{th} , 12^{th} and 18^{th} month after pruning followed by N₆ (50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) (3.44 m, 3.65 m and 4.04 m; 4.55%, 11.05% and 22.93%). Lowest plant height (3.27 m, 3.45 m and 3.76 m) and its percentage increase (3.36%, 8.94% and 18.57%) was observed in N_3 (Vermicompost) at 6th, 12th and 18th month after pruning. These results are in line with that of Nath and Baruah [10] who reported that highest level of pruning gave the best result as it caused better movement of air and light in to the inner part and thereby resulted in greater photosynthesis. This increased photosynthesis activity of the plants leads to higher accumulation of the photosynthates, which were utilized by developing shoots, leading to increase in plant height.

Trunk girth (cm)

Observation revealed that the trunk girth was significantly increased in all the treatments up to the end of experiment (Table 2). However, the data's were statistically at par under P₁ and P₂ level at 6th, 12th and 18th month after pruning. Maximum trunk girth (31.06 cm, 31.43 cm and 31.60 cm) and its percentage increase (0.94%, 2.18% and 3.92%) was recorded in highest level of pruning $\rm P_{_3}(75~cm$ pruning from the terminal portion of the shoot) at 6th, 12th and 18th month after pruning followed by medium level P₂ (50 cm pruning from the terminal portion of the shoot) of pruning (28.71 cm, 29.01 cm and 29.24 cm; 0.70%, 1.73% and 2.92%). The lowest trunk girth and its percentage increase was observed in (P₀) unpruned plants (25.48 cm, 25.67 cm and 27.09 m; 0.58%, 1.34% and 2.45%) after 6th, 12th and 18th months after pruning. Several nutrient treatments have significant effect on percentage increase of trunk girth at 12th and 18th months after pruning. The highest trunk girth (27.10 cm, 27.34 cm and 27.67 cm) and its percentage increase (0.63%, 1.51% and 2.51%) was recorded in N₄ (75% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) at 6th, 12th and 18th month after pruning followed by N₆ (50% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) (26.90 cm, 27.12 cm and 27.50 cm; 0.62%, 1.44% and 2.49%). Lowest trunk girth (24.47 cm, 24.65 cm and 25.05 m) and its percentage increase (0.56%, 1.31% and 2.12%) was observed in N₂ (Vermicompost) at 6th, 12th and 18th month after pruning. Combination of organic, bio-fertilizer with highest amount of inorganic fertilizers gave the best result as biofertilizer increased the availability of nutrients by increasing the absorption and mobilization of nutrients which was supplied by organic and inorganic fertilizers resulted better food reserve and enhanced trunk girth [11,12].

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	Initial	6 months after pruning		12 months after pruning		18 months after pruning	
Treatments	Height (m)	Height (m)	Increase in height (%)	Height (m)	Increase in height (%)	Height (m)	Increase in height (%)
P ₀	3.28c	3.42c	4.36(2.09)c	3.61c	10.64(3.26)a	3.91d	20.22(4.50)c
P ₁	3.29bc	3.46bc	5.06(2.25)bc	3.66b	11.37(3.37)a	4.08c	24.12(4.91)b
P ₂	3.33ab	3.52ab	5.76(2.40)ab	3.73b	12.18(3.49)a	4.24b	27.61(5.25)a
P ₃	3.35a	3.56a	6.182.49)a	3.78a	12.82(3.58)a	4.29a	28.085.30)a
SEm (±)	0.02	0.03	0.08	0.03	0.10	0.02	0.07
LSD(P ≤ 0.05)	0.06	0.09	0.23	0.07	NS	0.06	0.20
N ₁	3.28a	3.42ab	4.36(2.09)a	3.61ab	10.64(3.26)a	3.91bcd	20.22(4.50)a
N ₂	3.21a	3.51ab	3.43(1.85)a	3.50b	9.03(3.00)a	3.81cd	18.76(4.33)a
N ₃	3.17a	3.27b	3.36(1.83)a	3.45b	8.94(2.99)a	3.76d	18.57(4.31)a
N ₄	3.29a	3.58a	4.76(2.18)a	3.65a	11.18(3.34)a	4.06a	23.52(4.85)a
N ₅	3.29a	3.43ab	4.49(2.12)a	3.65ab	10.993.32)a	4.04ab	22.92(4.79)a
N ₆	3.29a	3.44a	4.55(2.13)a	3.65ab	11.05(3.32)a	4.04ab	22.93(4.79)a
N ₇	3.29a	3.43ab	4.42(2.10)a	3.65ab	10.98(3.31)a	4.03abc	22.54(4.75)a
SEm (±)	0.03	0.04	0.11	0.03	0.13	0.03	0.10
LSD(P ≤ 0.05)	NS	0.12	NS	0.05	NS	0.08	NS

 Table 1: Effect of pruning and nutrient management on plant height of lemon cv. Assam lemon.

**Means with the same letter are not significantly different.

 P_0^- No pruning (Control), P_1^- 25 cm pruning from the terminal portion of the shoot, P_2^- 50 cm pruning from the terminal portion of the shoot, P_3^- 75 cm pruning from the terminal portion of the shoot and 7 treatments of nutrient management viz. N_1^- 100% Recommended Dose of Fertilizer (N@210g/plant-P@140g/plant-K@210g/plant), N_2^- Vermicompost (20 kg/plant) + Azotobacter (18 g/plant) + Vesicular Arbuscular Mycorrhiza (150 g/plant), N_3^- Vermicompost, N_4^- 75% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N_7^- 50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N_7^- 50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N_7^- 50% RDF+ Vermicompost

Table 2: Effect of pruning and nutrient management on trunk girth of lemon cv. Assam lemon.

	Initial	6 months after pruning		12 months after p	runing	18 months after pruning	
Treatments	Trunk girth (cm)	Trunk girth (cm)	Increase in girth (%)	Trunk girth (cm)	Increase in girth (%)	Trunk girth (cm)	Increase in girth (%)
P ₀	25.33c	25.48c	0.58(0.76)d	25.67c	1.34(1.16)c	27.09c	2.45(1.57)d
P ₁	28.17b	28.35b	0.64(0.80)c	28.61b	1.57(1.25)c	28.91b	2.68(1.64)c
P ₂	28.51b	28.71b	0.70b(0.84)	29.01b	1.73(1.32)b	29.24b	2.92(1.71)b
P ₃	30.77a	31.06a	0.94(0.97)a	31.43a	2.18(1.48)a	31.60a	3.92(1.98)a
SEm (±)	0.69	0.69	0.02	0.69	0.03	0.69	0.02
LSD(P ≤ 0.05)	1.96	1.95	0.05	1.96	0.09	1.96	0.07
N ₁	25.33a	25.48a	0.58(0.76)a	25.67a	1.34(1.16)ab	27.09a	2.45(1.57)bcd
N ₂	24.70a	24.84a	0.58(0.76)a	25.03a	1.33(1.15)ab	25.97a	2.30(1.52)cd
N ₃	24.33a	24.47a	0.560.75)a	24.65a	1.31(1.14)b	25.05a	2.12(1.46)d
N ₄	26.93a	27.10a	0.63(0.79)a	27.34a	1.51(1.23)a	27.67a	2.51(1.58)a
N ₅	26.33a	26.49a	0.61(0.78)a	26.70a	1.40(1.18)ab	27.19a	2.46(1.57)ab
N ₆	26.73a	26.90a	0.62(0.79)a	27.12a	1.44(1.20)ab	27.50a	2.49(1.58)abc
N ₇	26.33a	26.49a	0.60(0.77)a	26.69a	1.37(1.17)ab	27.14a	2.46(1.57)abcd
SEm (±)	0.91	0.91	0.02	0.91	0.04	0.92	0.03
LSD(P ≤ 0.05)	NS	NS	NS	NS	0.12	NS	0.09

**Means with the same letter are not significantly different.P₀- No pruning (Control), P₁- 25 cm pruning from the terminal portion of the shoot, P₂- 50 cm pruning from the terminal portion of the shoot and 7 treatments of nutrient management viz. N₁- 100% Recommended Dose of Fertilizer (N@210g/plant-P@140g/plant-K@210g/plant), N₂- Vermicompost (20kg/plant) + Azotobacter (18g/plant) + Vesicular Arbuscular Mycorrhiza (150g/plant), N₃- Vermicompost, N₄- 75% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza, N₅- 75% RDF + Vermicompost, N₆- 50% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N₇- 50% RDF + Vermicompost

Plant spread (N-S)

The data on plant spread (N-S) presented in Table 3 indicated the significant variation under different pruning levels. However the datas were statistically at par under P_1 and P_2 level at initial, 6th month and 12th month, and under P_2 and P_3 level at 18th month after pruning Results indicated that the Plant spread (N-S) was increased in all the treatments up to the end of experiment. Maximum plant height (5.03 m, 5.29 m and 5.95 m) and its percentage increase (6.52%, 13.04% and 40.23%) was recorded in highest level of pruning P_3 (75 cm pruning from the terminal portion of the shoot) at 6th, 12th and 18th month after pruning followed by medium level P₂ (50 cm pruning from the terminal portion of the shoot) of pruning (4.74 m, 5.01 m and 5.72 m; 5.61%, 11.37% and 37.26%) after 6th, 12th and 18th months after pruning. The lowest plant spread (N-S) and its percentage increase was observed in (P₀) unpruned plants (3.99 m, 4.17 m and 4.88 m; 4.85%, 10.03% and 28.07%) at 6th, 12th and 18th month after pruning. Plant spread (N-S) were statistically at par at initial, 12th month (only percentage increase) and 18th month (only spread) after pruning. The highest plant spread (N-S) (5.02 m, 4.43 m and 5.10 m) and its percentage increase (4.98%, 10.09% and 28.33%)

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	Initial	6 months after pruning		12 mon	ths after pruning	18 months after pruning	
Treatments	spread (E-W) (m)	spread (E-W) (m)	Increase in spread (E- W) (%)	spread (E-W) (m)	Increase in spread (E- W) (%)	spread (E-W) (m)	Increase in spread (E- W) (%)
P ₀	3.82c	4.29c	12.33(3.51)c	4.83c	26.53(30.98)c	5.25c	27.73(31.76)c
P ₁	4.39b	4.99b	13.83(3.72)b	5.63b	28.28(32.14)b	5.83b	30.82(33.71)bc
P ₂	4.49b	5.13b	14.15(3.76)b	5.81b	29.15(32.71)b	5.99b	33.90(35.61)ab
P ₃	4.94a	5.68a	14.96(3.87)a	6.48a	31.20(33.96)a	6.31a	37.66(37.88)a
SEm (±)	0.11	0.13	0.03	0.15	0.32	0.09	1.34
LSD(P ≤ 0.05)	0.31	0.38	0.08	0.41	0.90	0.25	3.80
N ₁	3.82ab	4.29ab	12.33(3.51)ab	4.83ab	26.53(30.98)a	5.25abc	27.73(31.76)a
N ₂	3.81ab	4.28ab	12.27(3.50)ab	4.81ab	26.27(30.85)a	5.19bc	26.66(31.11)a
N ₃	3.80b	4.28b	11.86(3.44)b	4.80b	26.23(30.79)a	5.12c	26.32(30.85)a
N ₄	4.10a	4.65a	13.40(3.66)a	5.19a	27.67(31.76)a	5.60a	30.04(33.21)a
N ₅	3.93ab	4.45ab	12.69(3.56)ab	4.71ab	27.38(31.56)a	5.35ab	28.77(32.46)a
N ₆	3.99ab	4.52ab	13.30(3.65)ab	5.09ab	27.55(31.69)a	5.81abc	29.28(32.77)a
N ₇	3.92ab	4.40ab	12.35(3.51)ab	4.89ab	26.77(31.18)a	5.31abc	27.80(31.82)a
SEm (±)	0.14	0.18	0.04	0.19	0.42	0.12	1.77
LSD(P≤0.05)	0.41	0.50	0.10	0.54	NS	0.33	NS

Table 3: Effect of pruning and nutrient management on plant spread (E-W) of lemon cv. Assam Lemon.

**Means with the same letter are not significantly different.

 P_0 - No pruning (Control), P_1 - 25 cm pruning from the terminal portion of the shoot, P_2 - 50 cm pruning from the terminal portion of the shoot, P_3 - 75 cm pruning from the terminal portion of the shoot and 7 treatments of nutrient management viz. N_1 - 100% Recommended Dose of Fertilizer (N@210g/plant-P@140g/plant-K@210g/plant), N_2 - Vermicompost (20kg/plant) + Azotobacter (18g/plant) + Vesicular Arbuscular Mycorrhiza (150g/plant), N_3 - Vermicompost, N_4 - 75% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza, N_5 - 75% RDF+ Vermicompost, N_6 - 50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N_7 - 50% RDF+ Vermicompost

was recorded in N₄ (75% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) at 6th, 12th and 18th month after pruning followed by N₆ (50% RDF+ Vermicompost + Impact of Pruning and Nutrient Management on Growth and Yield of Lemon: Azotobacter + Vesicular Arbuscular Mycorrhiza) (4.14 m, 4.34 m and 5.09 m; 4.93%, 10.05% and 28.27%). Lowest plant spread (N-S) (3.49 m, 3.72 m and 4.48 m) and its percentage increase (3.09%, 9.66% and 28.03%) was observed in N₃ (Vermicompost) at 6th, 12th and 18th month after pruning. Combination of organic, bio-fertilizer with highest amount of inorganic fertilizers gave the best result as biofertilizer increased the availability of nutrients by increasing the absorption and mobilization of nutrients which was supplied by organic and inorganic fertilizers resulted better food reserve which enhanced plant spread [11,12].

Plant spread (E-W)

Experiment results revealed that the plant spread (E-W) was increased significantly in all the treatments up to the end of experiment (Table 4). Results showed that data's were statistically at par under P, and P, level at initial, 6th month and 12th month except under P, and P₁ at 18th month after pruning (only percentage increase). Maximum plant spread (E-W) (5.68m, 6.48m and 6.31 m) and its percentage increase (14.96%, 31.20% and 37.66%) was recorded in highest level of pruning P_{2} (75 cm pruning from the terminal portion of the shoot) at 6th, 12th and 18th month after pruning followed by medium level P₂ (50 cm pruning from the terminal portion of the shoot) of pruning (5.13 m, 5.81 m and 5.99 m; 14.15%, 29.15% and 33.90%). The lowest plant spread (E-W) and its percentage increase was observed in (P_o) unpruned plants (4.29 m, 4.83 cm and 5.25 m; 12.33%, 26.53% and 27.73%) after 6th, 12th and 18th months after pruning. Different nutrient treatments had significant effect on plant spread (E-W) except in percentage increase at 12th and 18th month after pruning. The highest plant spread (E-W) (4.65m, 5.19m and 5.60m) and its percentage increase (13.40%, 27.67% and 30.04%) was recorded in N₄ (75% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) at 6th, 12th and 18th month after pruning followed by N₆ (50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) (4.52 m, 5.09 m and 5.81 m; 13.30%, 27.55% and 29.28%). Lowest plant spread (E-W) (4.28 m, 4.80 m and 5.12 m) and its percentage increase (11.86%, 26.23% and 26.32%) was observed in N₃ (Vermicompost) at 6th, 12th and 18th month after pruning. Observation revealed that all the data's were statistically at par under different treatment combination. These results are in agreement with the findings recorded by Nath and Baruah [10], Boughalleb et al. [11], Kundu et al. [12] and Lal and Dayal [13].

Canopy volume (m³)

The data pertaining to canopy volume has been presented in Table 5, were significantly different under different pruning level. However the datas of percentage increase in canopy volume were statistically at par at 6th and 12th month after pruning under Po and P₁. Observation revealed that the plant height was increased in all the treatments up to the end of experiment. Maximum canopy volume (70.94 m³, 82.54 m³ and 112.13 m³) and its percentage increase (25.43%, 47.52% and 102.29%) was recorded in highest level of pruning P_{a} (75 cm pruning from the terminal portion of the shoot) at 6th, 12th and 18th month after pruning followed by medium level P₂ (50 cm pruning from the terminal portion of the shoot) of pruning (63.97 m³, 75.98 m³ and 104.10 m³; 22.76%, 46.45% and 99.90%) after 6th, 12th and 18th months after pruning. The lowest canopy volume and its percentage increase was observed in (P_a) unpruned plants (51.50 m³, 60.49 m³ and 77.15 m³; 18.31%, 40.90% and 89.86%) at 6th, 12th and 18th month after pruning. Observation showed that nutrient treatments were resulted in significant variation in the datas except percentage increase at 12th month after pruning. The highest canopy volume (64.77 m³, 65.91 m³ and 87.93 m³) and its percentage

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	Plant spread (N-S) direction							
	Initial	6 months	after pruning	12 month	is after pruning	18 months after pruning		
Treatments	plant spread (N-S) (m)	plant spread (N-S) (m)	Increase in plant spread (N-S) (%)	plant spread (N-S) (m)	Increase in plant spread (N-S) (%)	plant spread (N-S) (m)	Increase in plant spread (N-S) (%)	
Po	3.79c	3.99c	4.85(2.20)c	4.17c	10.03(3.17)b	4.88c	28.07(32.01)d	
P ₁	4.23b	4.44b	5.13(2.26)bc	4.66b	10.16(3.19)b	5.40b	29.59(32.96)c	
P ₂	4.50ab	4.74ab	5.61(2.37)b	5.01b	11.37(3.37)b	5.72a	37.26(37.64)b	
P ₃	4.71a	5.03a	6.52(2.55)a	5.29a	13.04(3.61)a	5.95a	40.23(39.35)a	
SEm (±)	0.13	0.12	0.06	0.14	0.09	0.10	0.42	
LSD(P ≤ 0.05)	0.35	0.34	0.18	0.38	0.27	0.29	1.20	
N ₁	3.79a	3.99abc	4.85(2.20)ab	4.17ab	10.03(3.17)a	4.88a	28.07(32.01)ab	
N ₂	3.79a	3.98bc	4.79(2.19)ab	4.17ab	10.05(3.17)a	5.12a	28.03(31.95)b	
N ₃	3.39a	3.49c	3.09(1.76)b	3.72b	9.66(3.11)a	4.48a	28.03(31.95)b	
N ₄	4.03a	5.02a	4.98(2.23)a	4.43a	10.09(3.18)a	5.10a	28.33(32.14)a	
N ₅	3.83a	4.01abc	4.87(2.21)ab	4.21ab	10.05(3.17)a	4.94a	28.15(32.08)ab	
N ₆	3.95a	4.14abc	4.93(2.22)ab	4.34ab	10.05(3.17)a	5.09a	28.27(32.14)a	
N ₇	3.81a	4.33abc	4.85(2.20)ab	4.20ab	10.03(3.17)a	4.89a	28.10(32.01)ab	
SEm (±)	0.17	0.16	0.08	0.18	0.12	0.14	0.56	
LSD(P ≤ 0.05)	NS	0.45	0.24	0.51	NS	NS	1.58	

Table 4: Effect of pruning and nutrient management on plant spread (N-S) of lemon cv. Assam Lemon.

**Means with the same letter are not significantly different.

 P_0^- No pruning (Control), P_1^- 25 cm pruning from the terminal portion of the shoot, P_2^- 50 cm pruning from the terminal portion of the shoot, P_3^- 75 cm pruning from the terminal portion of the shoot and 7 treatments of nutrient management viz. N_1^- 100% Recommended Dose of Fertilizer (N@210g/plant-P@140g/plant-K@210g/plant), N_2^- Vermicompost (20kg/plant) + Azotobacter (18g/plant) + Vesicular Arbuscular Mycorrhiza (150g/plant), N_3^- Vermicompost, N_4^- 75% RDF+ Vermicompost, N_6^- 50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N_7^- 50% RDF+ Vermicompost

increase (42.16%, 44.98% and 93.06%) was recorded in N₄ (75% RDF + Vermicompost + Azotobacter + Vesicular ArbuscularMycorrhiza) at 6th, 12th and 18th month after pruning followed by N₆ (50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) (53.62 m³, 65.18 m³ and 85.71 m³; 19.26%, 44.90% and 92.73%). However, canopy volume (43.48 m³, 52.67 m³ and 67.60 m³) and its Impact of Pruning and Nutrient Management on Growth and Yield of Lemon

percentage increase were minimum (15.16%, 39.25% and 78.68%) in N₃ (Vermicompost) at 6th, 12th and 18th month after pruning. These results are in line with that of Nath and Baruah [11] who reported that highest level of pruning gave the best result as it caused better movement of air and light in to the inner part and thereby resulted in greater photosynthesis. This increased photosynthesis activity of the plants leads to higher accumulation of the photosynthetic, which were utilized by developing shoots, leading to increase in plant vigour.

Number of laterals per primary shoot

Observations revealed that the number of laterals per primary shoot was significantly increased in all the treatments up to the end of experiment (Table 6). Maximum number of laterals per primary shoot (7.70, 9.33 and 10.17) and its percentage increase (25.43%, 54.54% and 80.13%) was recorded in highest level of pruning P_3 (75 cm pruning from the terminal portion of the shoot) at 6th, 12th and 18th month after pruning followed by medium level P_2 (50 cm pruning from the terminal portion of pruning (6.71, 8.09 and 9.60; 20.85%, 44.26% and 74.97%). The lowest number of laterals per primary shoot and its percentage increase was observed in (P_0) unpruned plants (4.50, 6.13 and 7.83; 16.56%, 35.03% and 65.17%) after 6th, 12th and 18th months after pruning. The significantly highest

number of laterals per primary shoot (5.96, 6.78 and 8.50) and its percentage increase (18.27%, 38.25% and 71.12%) was recorded in N. (75% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) at 6th, 12th and 18th month after pruning followed by N_e (50% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) (5.86, 6.99 and 8.47; 17.29%, 38.06% and 70.84%). Lowest number of laterals per primary shoot (5.03, 5.37 and 7.40) and its percentage increase (14.78%, 30.49% and 52.45%) was observed in N₂ (Vermicompost) at 6th, 12th and 18th month after pruning. These results are in agreement with Nath and Baruah [10] and Guimond et al. [14] who reported that higher level of pruning increases number of laterals in lemon and bing cherry which might be due to simply removal of hormonal influence (and resource sink) of the apical meristem plays a large role in shifting basal meristem determination to ward new shoots and floral initiation. Similar results also found by Kovaleski et al. [15] in highbush blue berry varieties cv. 'Emerald' and 'Iewel'.

Total leaf chlorophyll content (mg/g fresh weight)

Recorded observations on leaf chlorophyll content have been presented in Table 7. It was significantly increased in all the pruning treatments up to the end of experiment. Maximum leaf chlorophyll content (1.39 mg/g fresh weight, 1.85 mg/g fresh weight and 2.46 mg/g fresh weight) and its percentage increase (47.65%, 96.56% and 163.63%) were recorded in highest level of pruning P_3 (75 cm pruning from the terminal portion of the shoot) at 6th, 12th and 18th month after pruning followed by medium level P_2 (50 cm pruning from the terminal portion of the shoot) of pruning (1.34 mg/g fresh weight, 1.78 mg/g fresh weight and 2.38 mg/g fresh weight; 46.82%, 95.14% and 161.90%). The lowest leaf chlorophyll content (1.21 mg/g fresh

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	Canopy volume							
	Initial	Initial 6 months after pruning			after pruning	18 months after pruning		
Treatments	Canopy volume (m³)	Canopy volume (m³)	Increase in canopy volume (%)	Canopy volume (m³)	Increase in canopy volume (%)	Canopy volume (m³)	Increase in canopy volume (%)	
P ₀	43.44d	51.50d	18.31(25.33)c	60.49d	40.90c	77.15d	89.86(9.48)d	
P ₁	48.77c	58.89c	20.82(27.13)bc	70.55c	45.80bc	93.83c	94.74(9.73)c	
P ₂	52.05b	63.97b	22.76(28.52)ab	75.98b	46.45b	104.10b	99.90(9.99)b	
P ₃	56.59a	70.94a	25.43(30.26)a	82.54a	47.52a	112.13a	102.29(10.11)a	
SEm (±)	0.98	1.40	0.67	1.47	1.20	1.80	0.07	
LSD(P ≤ 0.05)	2.79	3.98	1.89	4.17	3.40	5.09	0.20	
N ₁	43.44abc	51.50cd	18.31(25.33)c	60.49bc	40.90a	77.15bcd	89.86(9.48)abc	
N ₂	40.96bc	53.33cd	30.21(33.34)bc	57.25bc	40.12a	72.99cd	79.13(8.90)bc	
N ₃	37.83c	43.48d	15.16(22.95)ab	52.67c	39.25a	67.60d	78.68(8.87)c	
N ₄	45.96a	64.77a	42.16(40.51)a	65.91a	44.98a	87.93a	93.06(9.65)a	
N ₅	43.89ab	52.40bc	19.44(26.13)bc	64.43ab	43.87a	84.82abc	92.53(9.62)ab	
N ₆	44.94ab	53.62ab	19.26(26.06)ab	65.18ab	44.90a	85.71ab	92.73(9.63)a	
N ₇	43.80abc	53.91bcd	23.32(28.86)c	62.84bc	43.72a	82.75abc	90.94(9.54)abc	
SEm (±)	1.30	1.86	0.88	1.94	1.59	2.38	0.09	
LSD(P ≤ 0.05)	3.69	5.26	2.50	5.51	NS	6.73	0.27	

Table 5: Effect of pruning and nutrient management on canopy volume of lemon cv. Assam Lemon.

**Means with the same letter are not significantly different. P_0 - No pruning (Control), P_1 - 25 cm pruning from the terminal portion of the shoot, P_2 - 50 cm pruning from the terminal portion of the shoot and 7 treatments of nutrient management viz. N_1 - 100% Recommended Dose of Fertilizer (N@210g/plant-P@140g/plant-K@210g/plant), N_2 - Vermicompost (20kg/plant) + Azotobacter (18g/plant) + Vesicular Arbuscular Mycorrhiza (150g/plant), N_3 - Vermicompost, N_4 - 75% RDF+ Vermicompost, N_6 - 50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza, N_5 - 75% RDF+ Vermicompost, N_6 - 50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N_7 - 50% RDF+ Vermicompost

 Table 6: Effect of pruning and nutrient management on number of laterals/ primary shoot of lemon cv. Assam Lemon.

	Initial	Initial 6 months after pruning			after pruning	18 months after pruning	
Treatments	Number of laterals/ primary shoot	Number of laterals/ primary shoot	Increase in number of laterals/ primary shoot (%)	Number of laterals/ primary shoot	Increase in Number of laterals/ primary shoot (%)	Number of laterals/ primary shoot	Increase in Number of laterals/primary shoot (%)
P ₀	4.67c	4.50c	16.56(4.07)d	6.13c	35.03d	7.83d	65.17(53.85)c
P ₁	5.27bc	6.25b	18.90(4.35)c	7.34b	39.46c	8.83c	72.33(58.24)b
P ₂	5.53b	6.71b	20.85(4.57)b	8.09b	44.26b	9.60b	74.97(60)b
P ₃	6.13a	7.70a	25.43(5.04)a	9.33a	54.54a	10.17a	80.13(63.51)a
SEm (±)	0.25	0.28	0.46	0.37	0.41	0.19	1.04
LSD(P ≤ 0.05)	0.71	0.78	1.30	0.93	1.17	0.53	2.94
N ₁	4.67a	4.50ab	16.56(4.07)ab	6.13ab	35.03cd	7.83ab	65.17(53.85)cd
N ₂	4.53a	5.21ab	14.80(3.85)b	5.97ab	31.43de	7.57ab	62.01(51.94)cd
N ₃	4.40a	5.03b	14.78(3.84)b	5.37b	30.49e	7.40b	52.45(46.43)d
N ₄	5.13a	5.96a	18.27(4.27)a	6.78a	38.25a	8.50a	71.12(57.48)a
N ₅	4.73a	5.51ab	16.92(4.11)ab	6.42ab	36.59bc	8.37ab	69.66(56.60)bc
N ₆	5.00a	5.86ab	17.29(4.16)a	6.99ab	38.06ab	8.47ab	70.84(57.29)ab
N ₇	4.73a	5.53ab	16.64(4.08)ab	6.41ab	35.50c	8.33ab	68.02(55.55)bc
SEm (±)	0.33	0.37	0.61	0.43	0.55	0.25	1.37
LSD(P ≤ 0.05)	NS	1.04	1.72	1.23	1.55	0.71	3.89

**Means with the same letter are not significantly different.

 P_0 - No pruning (Control), P_1 - 25 cm pruning from the terminal portion of the shoot, P_2 - 50 cm pruning from the terminal portion of the shoot, P_3 - 75 cm pruning from the terminal portion of the shoot and 7 treatments of nutrient management viz. N_1 - 100% Recommended Dose of Fertilizer (N@210g/plant-P@140g/plant-K@210g/plant), N_2 - Vermicompost (20kg/plant) + Azotobacter (18g/plant) + Vesicular Arbuscular Mycorrhiza (150g/plant), N_3 - Vermicompost, N_4 - 75% RDF + Vermicompost, N_6 - 50% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N_7 - 50% RDF + Vermicompost

weight, 1.60 mg/g fresh weight and 2.29 mg/g fresh weight) and its percentage increase (43.66 %, 90.45 % and 156.61%) were observed in (P₀) unpruned plants after 6th, 12th and 18th months after pruning. Observation revealed that different nutrient treatments have no effect on leaf chlorophyll content. The highest leaf chlorophyll content (1.29 mg/g fresh weight, 1.71 mg/g fresh weight and 2.33 mg/g fresh

weight) and its percentage increase (45.06 %, 92.58 % and 160.01%) was recorded in N₄ (75% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) at 6th, 12th and 18th month after pruning followed by N₆ (50% RDF+ Vermicompost + Azotobacter + Vesicular ArbuscularMycorrhiza) (1.28 mg/g fresh weight, 1.70 mg/g fresh weight and 2.33 mg/g fresh weight; 44.94%, 92.13% and

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	Initial	6 months after pruning		12 months after pruning		18 months after pruning	
Treatments	Chlorophyll (%)	Chlorophyll (%)	Increase in Chlorophyll (%)	Chlorophyll (%)	Increase in Chlorophyll (%)	Chlorophyll (%)	Increase in Chlorophyll (%)
Po	0.89d	1.21c	43.66b	1.60c	90.45(9.51)b	2.29c	156.61(12.51)b
P ₁	0.91c	1.31b	46.24ab	1.74bc	93.74a(9.68)b	2.36b	160.92(12.69)ab
P ₂	0.93b	1.34b	46.82ab	1.78b	95.14(9.75)a	2.38b	161.90(12.72)ab
P3	0.98a	1.39a	47.65a	1.85a	96.56(9.83)a	2.46a	163.63(12.79)a
SEm (±)	0.01	0.02	1.31	0.03	0.06	0.22	0.11
LSD(P ≤ 0.05)	0.02	0.04	3.71	0.08	0.16	0.06	0.30
N ₁	0.89a	1.21a	43.66a	1.60a	90.45(9.51)a	2.29a	156.61(12.51)a
N ₂	0.88abc	1.26a	43.17a	1.67a	90.27(9.50)a	2.29a	153.60(12.39)a
N ₃	0.86bc	1.23a	42.71a	1.62a	87.71(9.37)a	2.27a	152.59(12.35)a
N ₄	0.89a	1.29a	45.06a	1.71a	92.58(9.62)a	2.33a	160.01(12.65)a
N ₅	0.89ab	1.28a	44.49a	1.70a	91.79(9.58)a	2.29a	157.89(12.57)a
N ₆	0.89abc	1.28a	44.94a	1.70a	92.13(9.60)a	2.33a	158.70(12.60)a
N ₇	0.84c	1.28a	44.42a	1.70a	91.02(9.54)a	2.29a	157.16(12.54)a
SEm (±)	0.01	0.02	1.73	0.04	0.07	0.03	0.14
$LSD(P \le 0.05)$	0.02	NS	NS	NS	NS	NS	NS

Table 7: Effect of pruning and nutrient management on leaf chlorophyll content of lemon cv. Assam Lemon

**Means with the same letter are not significantly different.

 P_0^- No pruning (Control), P_4^- 25 cm pruning from the terminal portion of the shoot, P_2^- 50 cm pruning from the terminal portion of the shoot, P_3^- 75 cm pruning from the terminal portion of the shoot and 7 treatments of nutrient management viz. N_4^- 100% Recommended Dose of Fertilizer (N@210g/plant-P@140g/plant-K@210g/plant), N_2^- Vermicompost (20kg/plant) + Azotobacter (18g/plant) + Vesicular Arbuscular Mycorrhiza (150g/plant), N_3^- Vermicompost, N_4^- 75% RDF + Vermicompost, N_6^- 50% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N_7^- 50% RDF + Vermicompost + Vermicompost

Table 8: Effect of pruning and nutrient management on yield (Total number of Harvested fruits) of lemon cv. Assam Lemon.

	Ambe bahar	Mrig bahar	Hasth bahar
Treatments	Total number of Harvested fruits	Total number of Harvested fruits	Total number of Harvested fruits
Po	103d	46d	12d
P ₁	219c	129c	39c
P ₂	146b	88b	27b
P ₃	107a	59a	16a
SEm (±)	1.13	0.93	0.89
LSD(P ≤ 0.05)	3.20	2.63	2.52
N ₁	103e	46d	12de
N ₂	96f	39e	11ef
N ₃	80g	36e	8f
N ₄	114a	60a	17a
N ₅	110c	51c	16bc
N ₆	112b	54b	16ab
N ₇	107d	48d	14cd
SEm (±)	1.49	1.23	1.17
LSD(P ≤ 0.05)	4.23	3.48	3.33

**Means with the same letter are not significantly different.

 P_0 - No pruning (Control), P_1 - 25 cm pruning from the terminal portion of the shoot, P_2 - 50 cm pruning from the terminal portion of the shoot, P_3 - 75 cm pruning from the terminal portion of the shoot and 7 treatments of nutrient management viz. N_1 - 100% Recommended Dose of Fertilizer (N@210g/plant-P@140g/plant-K@210g/plant), N_2 - Vermicompost (20kg/plant) + Azotobacter (18g/plant) + Vesicular Arbuscular Mycorrhiza (150g/plant), N_3 - Vermicompost, N_4 - 75% RDF + Vermicompost, N_6 - 50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza and N_7 - 50% RDF + Vermicompost

158.70%). Lowest leaf chlorophyll content (1.23 mg/g fresh weight, 1.62 mg/g fresh weight and 2.27 mg/g fresh Impact of Pruning and Nutrient Management on Growth and Yield of Lemon

weight) and its percentage increase (42.71%, 87.71% and 152.59%) was observed in N₃ (Vermicompost) at 6th, 12th and 18th month after pruning. It might be due to the fact that Azotobacter stimulates nutrient uptake especially nitrogen which has role in the assimilation of numerous amino acids that are subsequently incorporated in proteins and nucleic acid, which provides framework for chloroplast, mitochondria and other structures in which the most

of the biochemical reactions occurs and resulted in to increase in chlorophyll content of leaves, photosynthetic efficiency, translocation of metabolites from the source to sink [16].

Total number of harvested fruits

Significant variation with respect of number of harvested fruits was observed in three seasons under different pruning and nutrient treatments. The data pertaining to total number of harvested fruits revealed that maximum number of harvested fruits was recorded (Table 8) in P_1 (25 cm pruning from the terminal portion of the

shoot) at Ambe, Mrig and Hasthbahar (219, 129 and 39) followed by P_2 (50 cm pruning from the terminal portion of the shoot) (146, 88 and 27) at Ambe, Mrig and Hasthbahar. However, the lowest number of harvested fruits was observed in (P_a) unpruned plants (103, 46 and 12) at Ambe, Mrig and Hasthbahar respectively. The significantly highest number of harvested fruits was recorded (114, 60 and 17) in N₄ (75% RDF + Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) at Ambe, Mrig and Hasthbahar followed by N₆ (50% RDF+ Vermicompost + Azotobacter + Vesicular Arbuscular Mycorrhiza) (112, 54 and 16). Lowest number of harvested fruits (80, 36 and 8) was observed in N₃ (Vermicompost) at Ambe, Mrig and Hasthbahar respectively. Increased number of harvested fruits might be due to NPK in association of biofertilizer, VAM and Vermicompost at desired amount, enhanced leaf chlorophyll content resulting in accumulation of more photosynthates, ultimately resulted in more number of fruits at harvest [11,12]. Singh et al. [17] also found the same results in papaya cv. Pusa Dwarf.

Conclusions

From the foregoing discussion, it can be concluded that efficient management of organic, inorganic and biofertilizers rather than sole organic or inorganic is essential to improve vigourand yield of lemon plants. Besides this, prunings have a significant effect in increasing the flower bearing shoots. Hence, light pruning (25 cm pruning from the terminal portion of the shoot) along with integrated use of fertilizers *viz.* 75% RDF + Vermicompost + Azotobacter + Vesicular ArbuscularMycorrhiza proved as best in terms of total fruits per plants in lemon cv. Assam lemon as compared to plants under control.

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