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Knowledge level of farmers on Recommended Package of Practices of Assam Lemon (*Citrus limon* L. Burm) Cultivation

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Abstract— *Assam lemon is a unique citrus variety of Assam valued for its aroma, thin peel, juiciness, and near-seedless character. Despite its economic potential, productivity has not reached the desired level due to partial or incomplete adoption of scientific recommendations. The present study was conducted in Tinsukia district of Assam with a sample of 120 Assam Lemon growers. Data were collected and analysis was carried out using frequency and percentage. The results indicated that farmers exhibited high awareness of basic practices such as soil suitability, planting season, recommended varieties, irrigation, and orchard maintenance. However, considerable gaps existed in technical areas including scientific propagation techniques, pit preparation, plant spacing, canopy training, balanced fertilizer application, and use of micronutrients. Pest and disease management was largely confined to traditional methods, with limited adoption of chemical and preventive measures. In contrast, knowledge of harvesting practices was relatively better, as it is more experience-based and directly linked to market quality. The findings highlight that while indigenous knowledge has helped sustain Assam lemon cultivation, inadequate adoption of recommended package of practices remains a major constraint.*

Keywords— ***Assam lemon, Knowledge, Package of Practices, Frequency and Percentage***

I. INTRODUCTION

Citrus is regarded as one of the most significant fruit crops cultivated worldwide. In 2022, the global citrus cultivation area was estimated at about 9.8 million hectares, producing nearly 158.8 million metric tonnes (FAOSTAT, 2023). The average productivity across the world stands at around 16.2 tonnes per hectare, though this figure fluctuates among countries due to differences in climate, farming practices, and input use (FAO, 2023). In India, citrus fruits occupy an important place in the horticultural sector. The annual productivity of citrus in the country during 2022–23 was reported to be 10.30 MT/ha (MoAFW, 2023). In the year 2023–24, India exported fruits and vegetables worth USD 1.814 billion, with citrus fruits such as oranges among the major contributors (APEDA, 2024). The principal citrus-growing states in the country include Andhra Pradesh, Maharashtra, Madhya Pradesh, Rajasthan, Karnataka, Assam, and Arunachal Pradesh.

Assam is home to several indigenous citrus species, of which the Assam Lemon (*Citrus limon* L. Burm), locally known as 'Kaji Nemu,' holds special importance (Gogoi, 2023). This variety is recognized for its characteristic elongated shape, thin rind, high juice content, and unique fragrance. Its near seedless nature

further distinguishes it from other lemon cultivars in India. Assam lemon has also entered the global market: in 2021 about 1200 kg of the fruit was exported from Chirang district to the UK, followed by 600 kg from Baksa in 2022 (G Plus, 2021). More recently, in 2023, approximately 5000 pieces were exported to London from Tinsukia district (The Sentinel, 2024). In 2015–16 the area, production, and productivity were 13,173 hectares, 108,492 MT, and 8236 kg/ha respectively (Statistical Handbook of Assam, 2016) which increased significantly to 18,036 hectares, 178,872 MT, and 9841 kg/ha during 2023–24 (Directorate of Horticulture and Food Processing, 2023–24). This steady growth demonstrates the rising economic significance of Assam lemon in the state's horticultural landscape.

The Government of Assam declared Assam lemon as the state fruit (*Jatiya Phal*) on 13th February 2024, while it had already received the Geographical Indication (GI) tag in 2019 under the "Geographical Indication of Goods (Registration and Protection) Act, 1999." The GI recognition enhanced its brand value, market potential, and economic prospects for the region. Assam's subtropical humid climate also provides ideal conditions for its cultivation, ensuring good productivity per unit area.

With the demand for Assam lemon steadily increasing, it has become a vital source of livelihood and income for rural farmers. However, despite this economic importance, the productivity potential is not fully realized, largely because of gaps in farmers' knowledge and adoption of the recommended package of practices (POP). While traditional experience enables farmers to carry out basic practices such as soil selection, planting season, and irrigation, technical aspects like scientific propagation, canopy management, nutrient application, and integrated pest management remain poorly adopted. Therefore, assessing the knowledge level of growers on recommended practices is essential for identifying existing gaps and guiding interventions that can enhance yield, quality, and profitability of Assam lemon cultivation. Keeping in view all these factors, the following objective was undertaken to conduct the study

Objective: To study the knowledge level of farmers on recommended package of practices on Assam Lemon Cultivation.

II. MATERIALS AND METHOD

Tinsukia district of Assam consisted of three sub-division namely Tinsukia, Margherita and Doomdooma. The Tinsukia subdivision was selected purposively as it has the highest numbers of Assam Lemon growers. There are eleven ADO circles in Tinsukia district, out of which two ADO circles namely Kakapather and Dholla. Four villages from each ADO circle were selected and from each village 15 numbers of Assam lemon growers were selected. Thus, a total of 120 Assam lemon growers from the district of Tinsukia, Assam were selected with a multi staged sampling procedure from eight sampled villages. Data was collected with the help of a one-to-one interview method. For collecting data, a structured scheduled was used. Data analysis was done using statistical tool such as frequency and percentage.

In order to test the reliability of the items Kuder Richardson (KR-20) reliability test was conducted. The result of the test indicate that the items are highly reliable.

Test name	**No. of items**	**Result**
Kuder Richardson (KR-20) reliability test	30	0.799

III. RESULT

Table 1. Distribution of respondents according to their level of knowledge on recommended package of practice. n=120

Sl. No.	**Category**	***f***	**(%)**	**Mean**	**SD**
1	Low (<16.48)	22	18.34	21.20	4.72
2	Medium (16.68-25.92)	62	51.66		
3	High (>25.92)	36	30.00		
	Total	**120**	**100**		

Findings from Table 1 reveal that the majority of respondents (51.66%), fell under the medium knowledge level category. Additionally, 30.00 per cent of the respondents had high and 18.34 per cent of the respondents had low level of knowledge on recommended package on Assam Lemon cultivation practices. The result shows that majority of respondents had only an moderate level of knowledge concerning the recommended package of

practices for Assam lemon cultivation. This points to an existing gap in the flow of knowledge and information among the growers. Limited awareness of improved scientific methods, modern equipment, and updated cultivation practices can negatively impact overall productivity. Hence, the results underline the importance of strengthening farmers' awareness and providing well-structured training programs on recommended practices, which could substantially enhance their knowledge base and ultimately boost the production and productivity of Assam lemon.

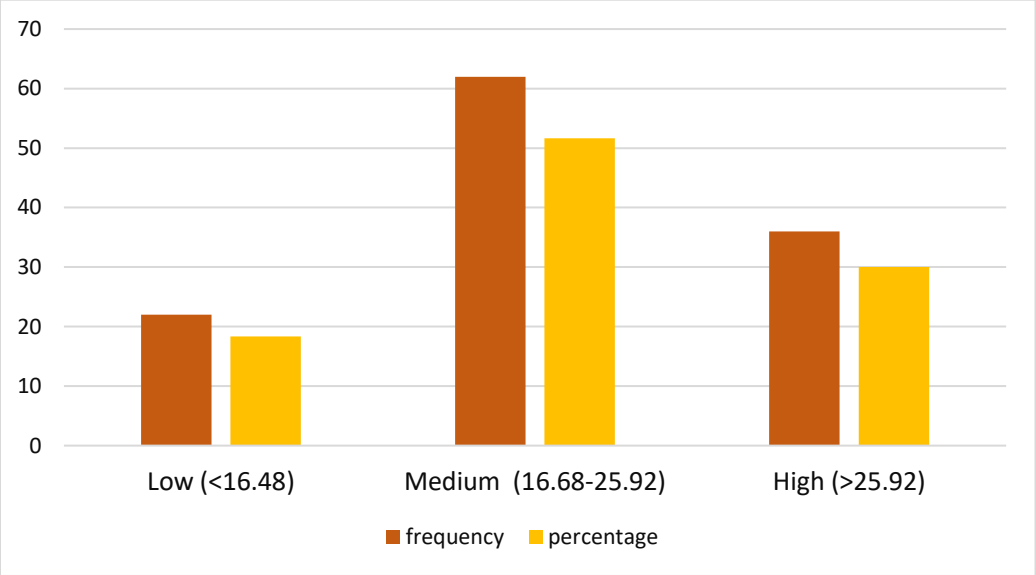

Fig 1. Distribution of respondents according to their knowledge level on recommended package of practices

Table 2. Distribution respondents according to their knowledge on recommended package of practices on Assam lemon cultivation.n=120

Sl no	statement	frequency	Percentage (%)
A	**SOIL AND SITE SELECTION**		
1	Do you know that loamy soil (3m depth) is ideal for Assam lemon?	110	91.67
2	Do you know that waterlogged condition is not suitable for Assam lemon cultivation?	120	100
B	**PROPAGATION METHODS**		
1	Do you use stem cutting, leaf-bud cutting, and air layering for propagation?	102	85.00
2	Do you prepare stem cuttings (18-20 cm) with proper node cuts?	19	15.83
3	Do you plant stem cuttings at 20 cm × 15 cm spacing?	20	16.67
4	Do you treat cuttings with IBA (2500 ppm) or other root stimulants like seradax and rootex?	75	62.50
5	Do you propagate between March and August for best results?	65	54.17
6	Do you plant leaf-bud cuttings at 10 cm × 5 cm spacing?	6	5.00
7	Do you treat cuttings with IBA (2500 ppm) or other root stimulants like seradax and rootex?	9	7.5
8	Do you propagate between March and August for best results?	3	2.5

<table>
<tr><td>C</td><td colspan="3">PLANTING TIME, CULTIVAR AND SPACING</td></tr>
<tr><td>1</td><td>Do you plant Assam lemon between May and August?</td><td>120</td><td>100</td></tr>
<tr><td>2</td><td>Do you use cultivar CRS-AL-1/CRS-AL-2/ CRS AL-3/ CRS-AL-4 (seedless variety)</td><td>120</td><td>100</td></tr>
<tr><td>3</td><td>Do you prepare 0.5m × 0.5m pits with a soil-manure mix?</td><td>11</td><td>9.17</td></tr>
<tr><td>4</td><td>Do you maintain 3m × 3m spacing between plants?</td><td>10</td><td>8.33</td></tr>
<tr><td>D</td><td colspan="3">PRUNING AND TRAINING</td></tr>
<tr><td>1</td><td>Do you remove side branches up to 50-60 cm for a strong trunk?</td><td>25</td><td>20.83</td></tr>
<tr><td>2</td><td>Do you prune diseased, injured, and crossing branches regularly?</td><td>99</td><td>82.50</td></tr>
<tr><td>3</td><td>Do you cut ground-touching branches close to the laterals?</td><td>45</td><td>37.50</td></tr>
<tr><td>E</td><td colspan="3">MANURE AND FERTILIZER APPLICATION</td></tr>
<tr><td>1</td><td>Do you use two split fertilizer applications (Feb/Mar & Oct/Nov).?

<table>
<tr><td>Year</td><td>FYM</td><td>N</td><td>P_2O_5</td><td>K_2O</td></tr>
<tr><td>1st</td><td>5 kg</td><td>150g</td><td>100g</td><td>145g</td></tr>
<tr><td>2nd</td><td>10 kg</td><td>300g</td><td>200g</td><td>290g</td></tr>
<tr><td>3rd</td><td>15 kg</td><td>450g</td><td>300g</td><td>435g</td></tr>
<tr><td>4th</td><td>20 kg</td><td>600g</td><td>400g</td><td>580g</td></tr>
</table>
</td><td>21</td><td>17.50</td></tr>
<tr><td>2</td><td>Do you apply fertilizers 15-45 cm away from the trunk?</td><td>7</td><td>5.83</td></tr>
<tr><td>3</td><td>Do you spray 0.2% Polymax or Multiplex for micronutrients?</td><td>2</td><td>1.7</td></tr>
<tr><td>F</td><td colspan="3">IRRIGATION AND ORCHARD MANAGEMENT</td></tr>
<tr><td>1</td><td>Do you weed your orchard monthly?</td><td>120</td><td>100</td></tr>
<tr><td>2</td><td>Do you use paddy straw or plastic mulch for weed control?</td><td>88</td><td>73.33</td></tr>
<tr><td>3</td><td>Do you irrigate during dry spells?</td><td>120</td><td>100</td></tr>
<tr><td>G</td><td colspan="3">INTERCROPPING</td></tr>
<tr><td>1</td><td>Do you grow seasonal vegetables and leguminous crops as intercrop?</td><td>21</td><td>17.50</td></tr>
<tr><td>2</td><td>Do you grow betelnut, pineapple, papaya as intercrop?</td><td>38</td><td>31.66</td></tr>
<tr><td>H</td><td colspan="3">PEST AND DISEASE MANAGEMENT</td></tr>
<tr><td>1</td><td>For leaf miner do you use monocrotophos @ 2.5 g/l of water or Rogor@ 1.5 ml/l of water?</td><td>7</td><td>5.83</td></tr>
<tr><td>2</td><td>For Trunk borer/ Bark eating caterpillar do you Prune and burn affected shoots and inject petrol in holes and plug with mud or cotton web?</td><td>92</td><td>76.66</td></tr>
<tr><td>3</td><td>For Anthracnose/Dieback/Twig blight do you cut affected portion and paste Bordeaux paste?</td><td>19</td><td>15.83</td></tr>
<tr><td>I</td><td colspan="3">HARVESTING</td></tr>
<tr><td>1</td><td>Do you harvesting criteria is when attain full size and develop attractive green to little yellow colour</td><td>99</td><td>82.50</td></tr>
<tr><td>2</td><td>Do you know that Assam lemons are ready for harvesting from June to July and December to January?</td><td>95</td><td>17.50</td></tr>
</table>

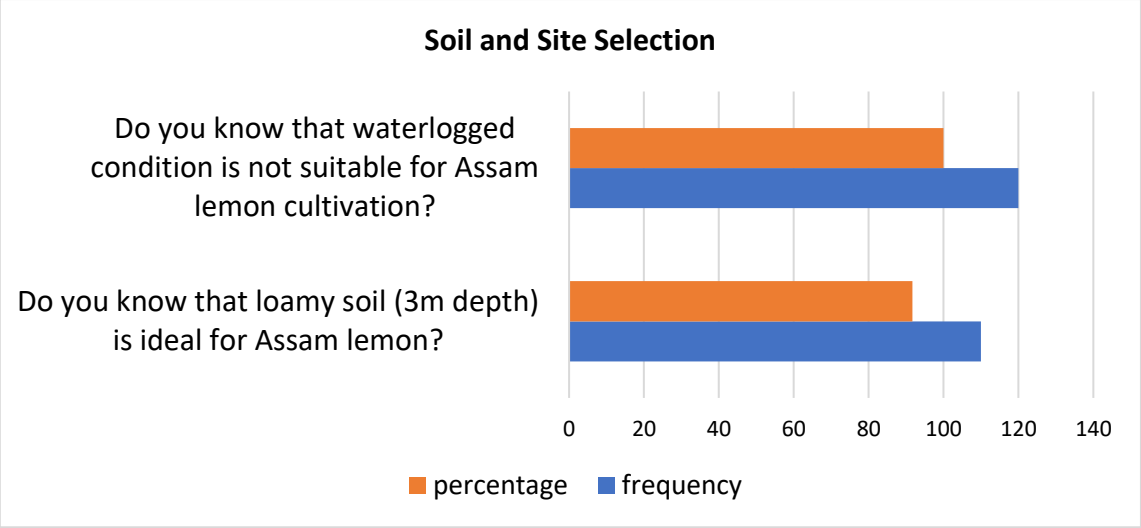

Fig 1. Distribution of respondents according to their knowledge on soil and site selection

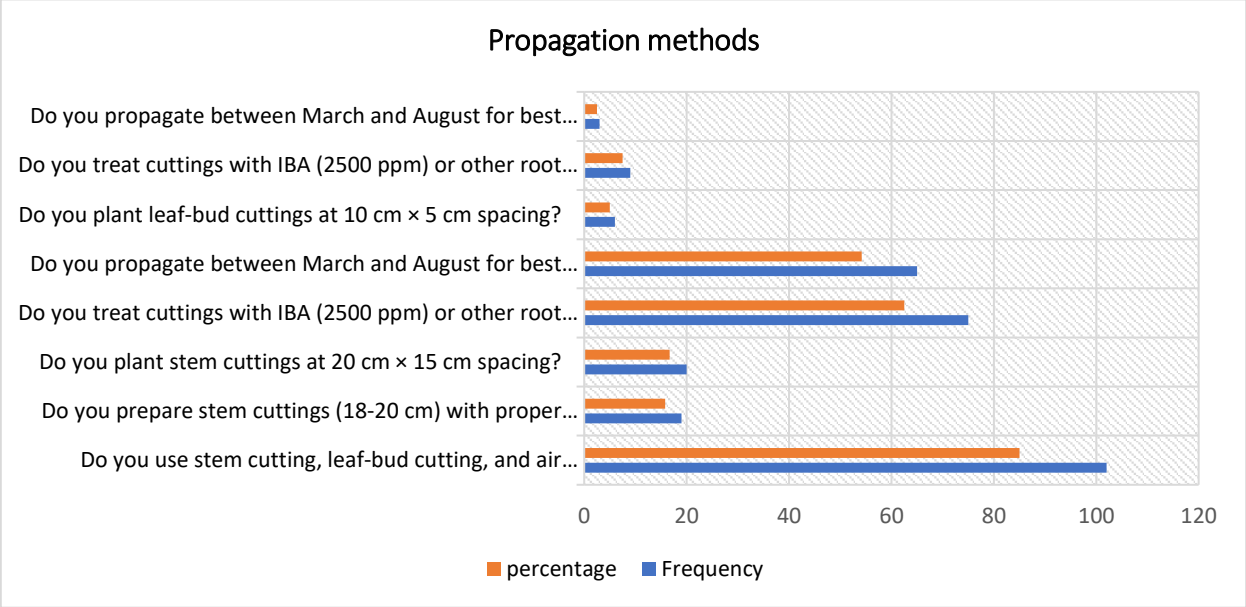

Fig 2. Distribution of respondents according to their knowledge on Propagation Methods

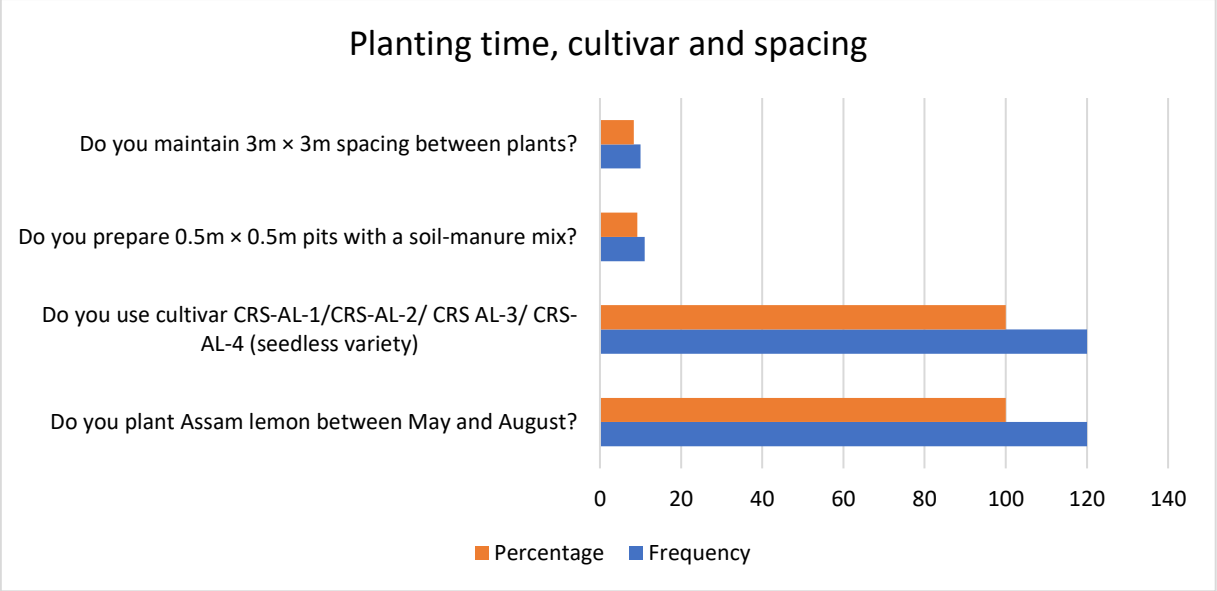

Fig 3. Distribution of respondents according to their knowledge on planting time, cultivar and spacing

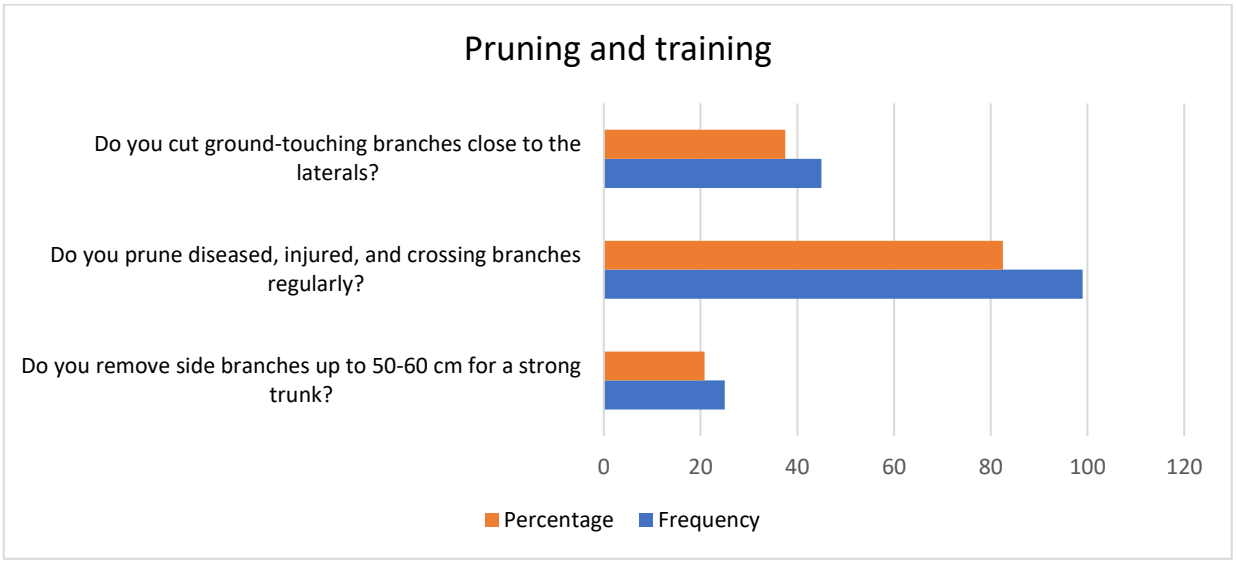

Fig 4. Distribution of respondents according to their knowledge on Pruning and training

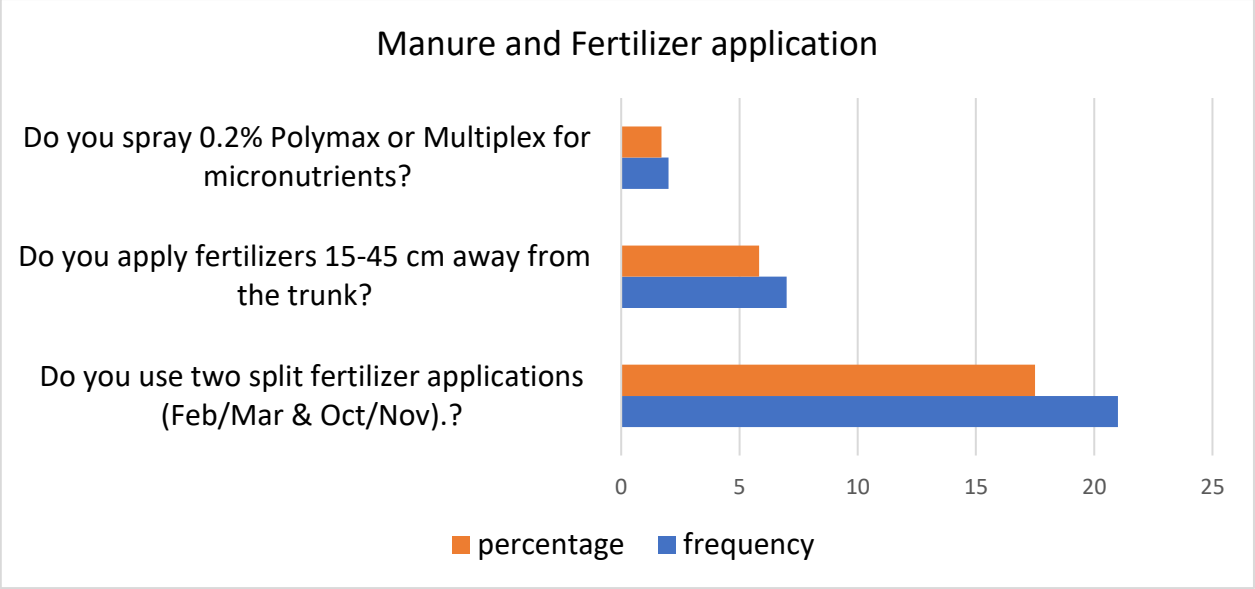

Fig 5. Distribution of respondents according to their knowledge on Manure and Fertilizer application

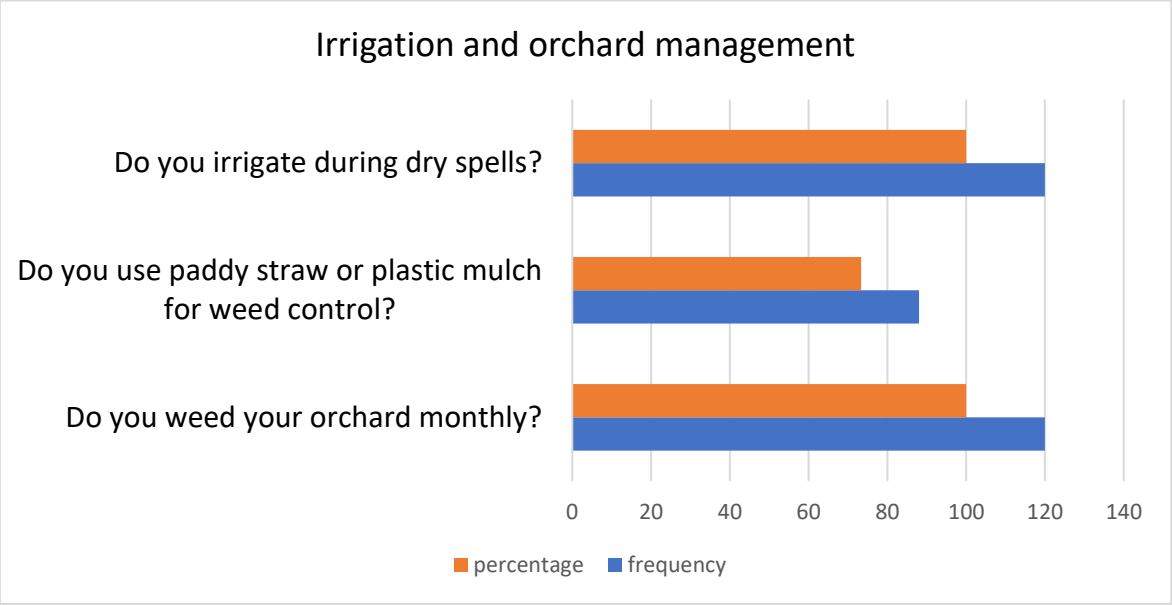

Fig 6. Distribution of respondents according to their knowledge on Irrigation and orchard management.

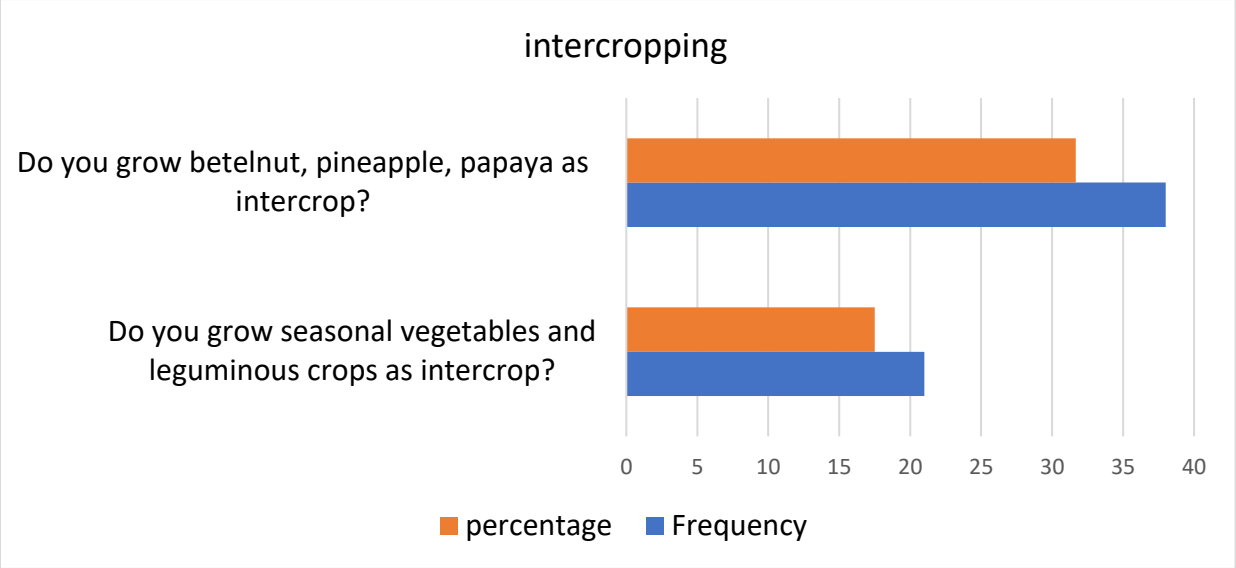

Fig 7. Distribution of respondents according to their knowledge on intercropping

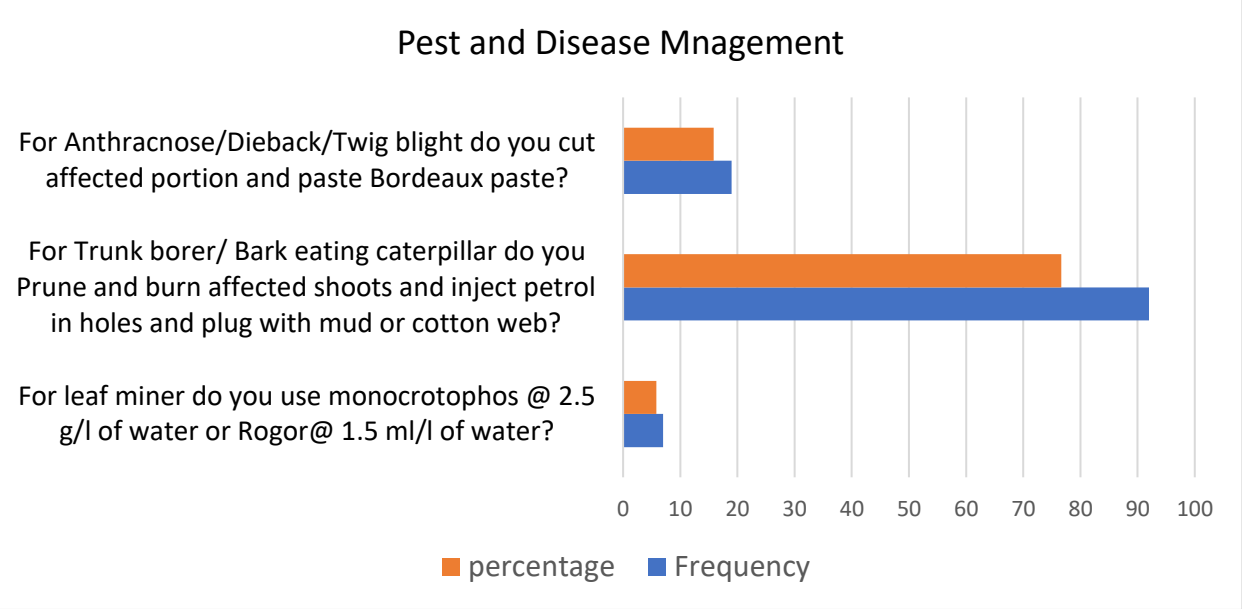

Fig 8. Distribution of respondents according to their knowledge on Pest and Disease Management

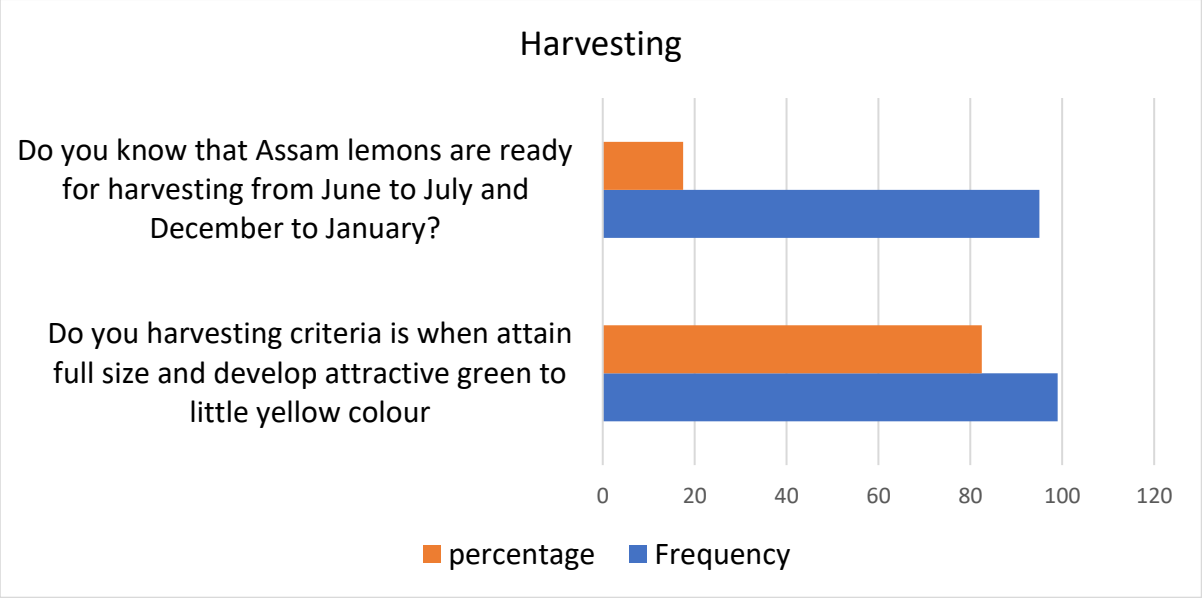

Fig 9. Distribution of respondents according to their knowledge on harvesting of Assam lemon

IV. DISCUSSION

A. Soil and Site Selection

Table 1 reflects that all 91.67 percent of the respondents were aware that loamy soil with a depth of about three meters is ideal for Assam lemon cultivation and 100 per that waterlogged conditions are unsuitable. This reflects a strong base of traditional and experiential knowledge among farmers, as soil suitability and drainage are easily observed in practice. The reason for this high awareness is that generations of farmers have experienced better growth and survival of lemon in well-drained soils, while losses under waterlogged conditions have made the disadvantage evident.

B. Propagation Methods

As depicted from table 1 and fig 2, it is noted that a majority of Assam lemon farmers (85.00%) in the sampled area knew about common propagation methods such as stem cutting, leaf-bud cutting, and air layering. However, when it came to technical details, adoption was very low. Only 15.83% prepared stem cuttings of 18–20 cm length with proper nodes, and just 16.67% followed the recommended spacing of 20 × 15 cm. Around 62.5% used IBA or root stimulants, while 54.17% were aware of the correct propagation season (March–August). In contrast, adoption of leaf-bud cutting recommendations was very poor—only 5% followed proper spacing, 7.5% treated with IBA, and 2.5% propagated during the right season. The probable reason behind this gap is lack of technical training and nursery management skills. Farmers generally depend on simple indigenous methods that are easier to apply, while more scientific techniques require inputs, skill, and guidance, which are not easily available in rural areas.

C. Planting Time, Cultivar, and Spacing

From table 1 and fig 3, it can be found excellent awareness regarding planting time and improved varieties, with all respondents reporting that Assam lemon should be planted between May and August and that CRS-AL seedless varieties are desirable. However, very few followed proper pit preparation (9.17%) and spacing recommendations (8.33%). This may be attributed due to the fact that pit preparation requires more labour and resources, while spacing is often compromised due to small landholdings, where farmers prefer high-density planting to maximize the number of trees per unit area. This reflects a tendency to prioritize short-term yield over long-term orchard sustainability.

D. Pruning and Training

Data presented in table 1 and fig 4 reveals that most of the farmers (82.5%) practiced pruning of diseased and crossing branches, indicating that visible disease management is well understood. However, only 20.83% removed side branches up to 50–60 cm to develop a strong trunk, and 37.5% removed ground-touching branches. This shows that while farmers are proactive in addressing immediate health issues of the tree, they neglect systematic training practices that are essential for orchard structure and long-term productivity. The reason behind is that training techniques are more technical in nature, requiring scientific understanding, whereas disease-pruning provides quick and visible benefits that farmers are more inclined to adopt.

E. Manure and Fertilizer Application

Table 1 and fig 5 discloses that manure and fertilizer application practices showed very poor adoption. Only 17.5% of farmers applied fertilizers in two splits (February/March and October/November), and a mere 5.83% applied fertilizers at the correct distance from the trunk. Practices such as micronutrient application through foliar spray were seen to be very low i.e only 1.7 per cent of the respondents were found to use and have knowledge about micronutrients. The reasons include the high cost of fertilizers and micronutrients along with limited awareness of balanced nutrition, lack of extension services, and the traditional dependence on farmyard manure (FYM), which is more accessible and affordable compared to chemical inputs.

F. Irrigation and Orchard Management

Irrigation and orchard management practices were found to be well adopted. All respondents (100%) reported irrigating during dry spells and carrying out monthly weeding. Additionally, 73.33% practiced mulching with paddy straw or plastic as depicted in table 1 and fig 6. The high adoption of these practices can be attributed to their visible and immediate impact on plant survival, moisture conservation, and weed suppression. Farmers recognize these benefits through direct observation, which encourages them to consistently implement these practices without requiring much technical guidance.

G. Intercropping

Table 1 and fig 7 reveals that intercropping was found to be limitedly practiced by Assam Lemon growers of the sampled area. Only 17.50% of the farmers grew vegetables and legumes as intercrops, whereas 31.66% were seen to cultivate crops like betelnut, pineapple, and papaya along with Assam lemon. The probable reason behind this trend is that many farmers fear nutrient and moisture competition between crops and lemon trees, leading to hesitation in adopting intercrops. At the same time, crops like betelnut and pineapple are more popular because they are high-value cash crops and are considered compatible with lemon cultivation, thus providing additional income security to the growers.

H.Pest and Disease Management

The adoption of pest and disease management practices among farmers was found to be uneven as noted in Tabe 1 and fig 8. Only 5.83% of respondents reported using chemicals such as monocrotophos or Rogor for controlling leaf miner, showing very poor awareness of recommended chemical measures. In contrast, a large proportion (76.66%) managed trunk borer or bark-eating caterpillar by pruning and burning affected shoots and injecting petrol in holes before plugging them with mud or cotton. This reflects a preference for practical and locally known methods over chemical control. For diseases such as anthracnose, dieback, and twig blight, only 15.83% of farmers followed the practice of cutting the affected portion and applying Bordeaux paste. The reason for such variation is that most farmers rely on simple physical or indigenous measures that they have learned traditionally, while technical recommendations like chemical sprays or Bordeaux paste are less popular due to lack of knowledge, high input cost, and limited accessibility to plant protection chemicals in rural areas.

J. Harvesting

As presented in table 1and fig in terms of harvesting practices, 82.50% of respondents were aware of the correct maturity indicators, i.e., harvesting when fruits attain full size and develop an attractive green to slightly yellow colour. Similarly, 79.16% knew the correct harvesting seasons, which are June–July and December–January. This indicates that most farmers possess adequate knowledge about when and how to harvest Assam lemon. The probable reason for this high awareness is that harvesting is a visible and practical activity, and farmers have learned proper timing and criteria through continuous experience in the field. Unlike technical practices such as pruning or fertilizer application, harvesting is straightforward and directly linked to market quality and price, which makes farmers more conscious of following proper guidelines.

V. CONCLUSION

The study indicated that farmers showed strong awareness of fundamental practices such as appropriate soil and site selection, suitable planting seasons, use of recommended varieties, irrigation, and basic orchard maintenance. Nevertheless, notable gaps were observed in the adoption of more technical practices, including scientific propagation methods, pit preparation, proper spacing, canopy management through pruning, and balanced fertilizer application. In terms of pest and disease control, growers mostly relied on traditional or indigenous measures, while the use of recommended chemical treatments and micronutrient sprays was found to be minimal. Harvesting practices reflected comparatively higher knowledge levels, likely because they are straightforward and directly observable in the field. Overall, the findings suggest that although farmers' traditional experience has supported the continuation of Assam lemon cultivation, limited adoption of scientific practices remains a barrier to achieving higher yields and profitability. Therefore, enhancing farmer capacity through training,

ensuring timely access to quality inputs, and strengthening extension support are essential steps toward bridging these gaps and promoting Assam lemon as a sustainable and commercially rewarding fruit crop.

ACKNOWLEDGEMENT

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