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Influence of Pruning Severity and Biofertilizers on Flowering Attributes and Yield of Lemon [*Citrus limon* (L) Burm.] cv. Assam lemon under Foothills of Arunachal Pradesh

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ABSTRACT: The present study was conducted to known the response of pruning levels and biofertilizers on flowering attributes and yield of Assam lemon. The experiment was laid out in two factorial randomized block design with three levels of pruning, five levels of biofertilizers and their interaction. The investigation revealed that the pruning 50% length of shoot (P_2) was found significantly superior over the control with respect to flowering parameters *viz.*, days required for first flowering (321.93 days), number of flowers per shoot (94.03), duration of flowering (25.13 days) and fruit yield (3.05 kg/plant)and fruit yield (3.39 t/ha). The treatment B_4 (*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant) performed better with respect to days required for first flowering (315.22 days), number of flowers per shoot (71.44), duration of flowering (27.33 days) and fruit yield (4.10 t/ha). Among the interaction treatments of pruning and biofertilizers, the treatment (P_2B_4) 50 % pruned plants fed with *Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant was found significantly superior in response of days required for first flowering (322.33 days), number of flowers per shoot (104.5), duration of flowering (17.67 days) and fruit yield (4.45 t/ha) compare to all the treatment. It can be concluded that efficient management of pruning 50% length of shoot along with biofertilizers combination rather than sole is essential for increase the flowering and yield attributes of Assam lemon.

Keywords: Assam lemon, Pruning levels, Biofertilizers, Flowering and Yield.

INTRODUCTION

Citrus is the world's most economically important fruit crop, is grown in both developed and developing countries, and is unquestionably one of the most important sources of vitamin C. A growing demand for "excellent grade fresh citrus" is also being spurred by World Health Organization recommendations (Iglesias *et al*., 2007). Assam Lemon is an important variety of lemon that is widely farmed in North-East India. It has a significant demand in national as well as international market owing to its characteristic aroma, vitamin C, carotenoids, folate, fibre**,** zero fat and rich source of natural antioxidants. It is early bearing with three fruiting seasons, *viz*., April-May, August-September, and November December the previous season growth is generally more fruitful under Arunachal Pradesh's Foothills. The main reason for the plant's diminishing output was discovered to be an unbalanced overcrowded orchard, which also resulted in a high disease-pest infestation (Singh and Dhaliwal 2004). Pruning is therefore necessary to promote sunshine penetration, which is not only effects blooming and fruit set but also improves fruit quality and colour development. Because lemon plants bear three times a year, adequate fertilizer must also be used to get the best yields and quality production (Khehra and Bal 2014). However, the continued use of chemical fertilisers has damaged soil health in terms of fertility and productivity. In such case, a combination of biofertilizers must be used to minimise the negative impact of chemical fertilisers while also improving the physical features of the soil. The main goal of this study was to find out the effect different levels of pruning and biofertilizers on flowering attributes and yield of Assam lemon under Arunachal Pradesh condition.

MATERIALS AND METHODS

The present investigation was carried out on seven years old Assan lemon orchard at the field of Citrus Fruit Block, College of Horticulture and Forestry, Pasighat, Arunachal Pradesh, Indiaduring the year 2021 to 2022, It is geographically located at 28° 04' 43" N latitude and 95° 19′26″E longitude with an altitude of 153 m above the mean sea level. The experiment was laid out in two Factorial Randomized Block Design (FRBD) and 15 treatment combination (three levels of pruning and five levels of biofertilizers) with 3 replications. There were three levels of pruning, namely P_0- No pruning (Control), P_1- 25% pruning from the terminal portion of the shoot, P_2- 50% pruning from the terminal portion of the shoot and five treatments of different biofertilizers *viz*., no. biofertilizers (B_0), PGPR (*Pseudomonas fluorescens*) @ 90g/plant (B_1), Trichoderma @ 90g/plant (B_2), Azotobacter@ 15g/plant (B_3) and combination of PGPR (*Pseudomonas fluorescens*) @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant (B_4) were applied alone and in combination with different levels of pruning.The pruning treatments were practiced in the month of February, 2021 and biofertilizers were applied to the soil from two feet away from the tree trunk in the same period as above. The crop management practices such as irrigation, weeding and other cultural practices was done at regular interval during the experimentation. The data on flowering parameters *viz*., days required for first flowering (days), number of flowers per shoot, duration of flowering (days) and fruit yield was recorded from three labelled plants for each treatment. The date of initiation of flowering on tagged branches was recorded and expressed in number of days taken for flowering after application of treatments and the total number of flowers were counted on tagged branches from all the directions and average number of flowers per branch were calculated. Similarly, duration of flowering was calculated from the date of initiation to cessation of flowering. The statistical analysis of two factor RBD for the recorded observations was performed using statistical tools. Significance and non-significance of the variance due to the different treatments were determined by calculating the respective 'F' values as given by Gomez and Gomez (2010).

RESULTS AND DISCUSSION

Days required for first flowering. The experimental result in response to days required for first flowering were showed significant under varying levels of pruning (Table 1). The results revealed that, commercial flowering initiation is highly related to pruning levels. Flowering occurred later (321.93 days) in the treatment P_2 (pruning 50% length of shoot) and earlier (301.53 days) in P_0(unpruned). Furthermore, biofertilizers statistically delayed flowering, with B_4(PGPR-*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant) flowered 315.22 days after imposition of treatments and the treatment B_0(no-biofertilizers) flowering 310 days later. Although flower initiation was earliest (296.7 days) in treatment combination P_0B_0(control) and late (322.33 days in treatment P_2B_4(pruning 50% + PGPR-*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant). the interaction influence of pruning and biofertilizers were also found significant.

The delay in blooming with pruning levels was related to the fact that the growth of new branches was more in pruned than in un-pruned plants. Furthermore, as the number of leaves increased, so did photosynthesis, allowing for late blooming and the completion of the crop cycle. In comparison to the control, pruning intensity, integrated nutrition management with biofertilizers, and their combination dramatically enhanced blooming qualities. These findings support the findings of Lal and Prasad (1980) in ber (*Zizyphus mauritiana* Lamk.) and Pawar *et al*. (1994) in pomegranate (*Punica granatum* L.) that the pruning postponed flowering. Ghosh (2015) also reported that there was a delay in flowering of lemon due to increase the vegetative growth of plant, as a result of combined effect of pruning and biofertilizers.

Table 1: Influence of pruning and biofertilizers on days required for first flowering.

Factors	B_0	B_1	B_2	B_3	B_4	Mean(P)
P_0	296.67	298.67	303.33	301.67	307.33	**301.53**
P_1	315.33	318.33	317.33	315.67	316.00	**316.53**
P_2	318.00	324.67	323.00	321.67	322.33	**321.93**
Mean(B)	**310.00**	**313.89**	**314.56**	**313.00**	**315.22**	

	S.Em±	C.D. 0.05%		
Effect of Pruning(P)	**0.107**	**0.309**		
Effect of Biofertilizers(B)	**0.178**	**0.515**		
P × B Interaction	**0.533**	**1.544**		

Number of flowers per shoot. Pruning has a considerable influence on the number of flowers, (Table 2) with the maximum number of flowers (94.03) per branch were achieved significantly superiorin the treatment P_2 (pruning 50% length of shoot) while the minimum (30.90) was obtained in the treatment P_0 (unpruned). Biofertilizers were also revealed to have a substantial impact on the number of flowers per branch, with a maximum number of flowers(71.44) in treatment B_4 (PGPR-*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant) and a minimum (46.44) number of flowers in the treatment B_0(no-biofertilizers). Similarly, the treatment B_1, B_2, B_3 were showed intermediate values (52.33), (54.55) and (59.61) respectively, with different sole biofertilizer application and the interaction impact of pruning and biofertilizers on the number of flowers per shoot was also showed substantial. The treatment P_2B_4(pruning 50% + PGPR-*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant)produced 104.5 flowers which was significant above the (P_0B_0) control (21.50).

This could be due tothe young shoot response more for flower induction and our experiment confirmed that around 40 cm length of shoots bear flowers. Pruning aids in the production of new fruiting units, increasing the number of flowers per stalk. According to the findings of Pavani (2018), the imposition of pruning and biofertilizers increased the number of flowers by increasing the number of leaves and leaf area, which may have boosted the generation and storage of increased photosynthates that were derived to the sink and generated more flowers and moderate pruning increased the number of flowers per shoot in acid lime. Findings of Anez (1998) in guava and Ghosh (2015) in lemon also were showed similar to our results.

Table 2: Influence of pruning and biofertilizers onnumber of flowers.

Factors	B_0	B_1	B_2	B_3	B_4	Mean(P)
P_0	21.50	29.33	30.66	35.66	37.33	**30.90**
P_1	32.50	40.66	41.33	41.50	72.50	**45.70**
P_2	85.33	87.00	91.66	101.66	104.50	**94.03**
Mean(B)	**46.44**	**52.33**	**54.55**	**59.61**	**71.44**	
	S.Em±	**C.D. @ 0.05%**				
Effect of Pruning(P)	**0.079**	**0.229**				
Effect of Biofertilizers(B)	**0.132**	**0.381**				
P x B Interaction	**0.395**	**1.144**				

Duration of flowering. The data presented in the Table 3 revealed that the effect of pruning had a significant influence on the duration of flowering, observed maximum duration (50.27 days) was found by treatment P_0 (unpruned), while the lowest found (25.13 days) in treatment P_2 (pruning 50% length of shoot). The biofertilizers was also shown a significant effect on the duration of flowering, where it was recorded a maximum (41.00 days) durationin treatment B_0 (no-biofertilizers) and minimum (27.33 days) in treatment B_4 (PGPR-*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant). Similarly, the interaction impact of pruning and biofertilizers was also showed

significant. It was observed that the duration of flowering was completed earliest (17.67 days) in the treatment P_2B_4 (pruning 50% + PGPR-*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant) and belated (57.67 days) in P_0B_0 (control).

The findings were supported with the results of study conducted by Pavani 2018, found that moderate pruning in acid lime increased the duration of flowering, whereas Patil *et al*. (2018) found that increasing pruning intensity decreased the duration of floweringin acid lime, which could be due to extra nutrient availability in the branches or shoots. These results agreed with those of Bajwa *et al*. (1986) in ber and Khan and Syamal (2004) in kagzi lime. The participation of biofertilizer in atmospheric nitrogen fixation and *Pseudomonas* in phosphate solubilization is responsible for a healthier soil environment, which is reflected in the tree's blossoming (Yadav *et al*., 2011). Azotobacter in combination with *T. viride* and *P. fluorescens* is a superior option for improving flowering and yield-related characteristics. However, a combination of all microbial inoculations, including biofertilizers Azotobacter, Azospirillum, PSB, and microbial pesticides *T. viride* and *P. fluorescens*, was the greatest treatment for flowering-related aspects and production, as well as greater plant survival against soil infections (Mondal *et al*., 2016).

Table 3: Influence of pruning and biofertilizers on flowering duration.

Factors	B_0	B_1	B_2	B_3	B_4	Mean(P)
P_0	57.67	54.00	49.00	46.33	44.33	**50.27**
P_1	35.00	27.33	25.00	22.00	20.00	**25.87**
P_2	30.33	28.00	25.67	24.00	17.67	**25.13**
Mean(B)	**41.00**	**36.44**	**33.22**	**30.78**	**27.33**	
	S.Em±	**C.D.@ 0.05%**				
Effect of Pruning(P)	**0.076**	**0.220**				
Effect of Biofertilizers(B)	**0.127**	**0.367**				
P × B Interaction	**0.380**	**1.100**				

Fruit yield. The results on fruit yield kg/ha and t/ha represented in Table 4 and 5 respectively. The significant influence of pruning levels and different biofertilizers showed on fruit yield of Assam lemon. Pruning at 50% (P_2) had the highest average yield (3.05 kg/plant and 3.39 t/ha) and the lowest (1.86 kg/plant and 2.06 t/ha) fruit yield was reported in the treatment P_0 (unpruned). The use of biofertilizers resulted in a significantly higher average fruit production. The Treatment B_4 (PGPR-*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant) had the highest average yield (3.69 Kg/plant and 4.10 t/ha) while treatment B_0 (No- biofertilizers) had the lowest (1.71 Kg/plant and 1.90 t/ha). The interaction of pruning and biofertilizers also had a considerable influence on average fruit production, with maximum (4.01 Kg/plant and 4.45 t/ha) yield at maturity was recorded in treatment combination P_2B_4 (pruning 50% length of shoot + PGPR-*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant), which is comparable to P_1B_4 (pruning 25% length of shoot + PGPR-*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant) 3.89 kg/plant and 4.32 t/ha whereas least (1.34 Kg/plant and 1.48 t/ha) was observed in control (P_0B_0).

It could be because, when compared to unpruned trees, a more open tree canopy with a wider leaf area allowed light to penetrate, resulting in the assimilation of more photosynthetic materials, which increased the number of laterals, leaf area, number of spurs, flower bud, fruit set, and size, thus increasing total yield and also less competition for the growth of individual fruit. Such justification was also cited by Kumar *et al.* (2014) in berand Kesner *et al.* (1981) in cherry. According to Nath and Baruah (2001), shoot cutting in Assam lemon fostered more new shoot development, resulting in a greater yield. Similarly, Mondal *et al*. (2016) also reported that combining Azotobacter with Trichoderma and *P. fluorescens* is a superior option for increasing yield-related characteristics. However, the combination of all microbial inoculations, including biofertilizers like Azotobacter and PSB and microbial pesticides Trichoderma and *P. fluorescens*, proved to be the most effective treatment for yield-related characteristics and yield, as well as greater plant survival against soil diseases. It also improves soil fertility to the greatest extent possible. Using bioinoculants like Azotobacter in conjunction with PGPRs will not only supplement various nutrients in the soil, but will also increase the quality and quantity of fruits (Pathak *et al*., 2017). Similar findings have been reported in guava (Lal *et al*., 1996; Saikh and Hulmani 1997).

Table 4: Influence of pruning and biofertilizers on fruit yield (Kg/plant).

Factors	B_0	B_1	B_2	B_3	B_4	Mean(P)
P_0	1.34	1.53	1.62	1.63	3.17	**1.86**
P_1	1.68	1.90	2.23	2.68	3.89	**2.48**
P_2	2.11	2.93	3.09	3.14	4.01	**3.05**
Mean(B)	**1.71**	**2.12**	**2.31**	**2.48**	**3.69**	
	S.Em±	**C.D. @ 0.05%**				
Effect of Pruning(P)	**0.018**	**0.053**				
Effect of Biofertilizers(B)	**0.030**	**0.088**				
P × B Interaction	**0.091**	**0.264**				

Table 5: Influence of pruning and biofertilizers on fruit yield (t/ha).

Factors	B_0	B_1	B_2	B_3	B_4	Mean(P)
P_0	1.48	1.70	1.80	1.81	3.52	**2.06**
P_1	1.86	2.11	2.48	2.98	4.32	**2.75**
P_2	2.34	3.26	3.44	3.48	4.45	**3.39**
Mean(B)	**1.90**	**2.36**	**2.57**	**2.76**	**4.10**	
	S.Em±	**C.D. @ 0.05%**				
Effect of Pruning(P)	**0.018**	**0.053**				
Effect of Biofertilizers(B)	**0.030**	**0.088**				
P x B Interaction	**0.091**	**0.263**				

CONCLUSION

In conclusion, the present result suggests that the efficient management of pruning along with biofertilizers in an efficient way would not only reduce the sole dependence on chemical fertilizers but also influence the flowering and fruiting of Assam lemon. Among several levels of pruning and biofertilizers application, high pruning (pruning 50% from the terminal portion of shoot) along with combinationof biofertilizers *viz*., PGPR-*Pseudomonas fluorescens* @ 90g/plant + Trichoderma @ 90g/plant + Azotobacter @ 15g/plant proved as best in terms of quality production of Assam lemon in this region.

FUTURE SCOPE

— The experiment entitled "Influence of Pruning Severity & Biofertilizers on Flowering Attributes and Yield of Lemon [*Citrus limon* (L) Burm.] Cv. Assam lemon Under Foothills of Arunachal Pradesh" was conducted for the first time under foothills of Arunachal Pradesh conditions hence, it may be repeated to confirm the finding of the present investigation.

— Protein, antioxidants, peel oil, flavoring compounds, and other biochemical properties can be evaluated.

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