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Studies on leaf to fruit ratio on growth, yield and quality of custard apple

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Abstract
An experiment entitled "Studies on leaf to fruit ratio on growth, yield and quality of Custard apple" was carried out at Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year 2018-19. The experiment was laid out in Randomized Block design with eight treatments *viz.*, T_1-Leaf to Fruit Ratio-20:1,T_2-Leaf to Fruit Ratio-25:1, T_3-Leaf to Fruit Ratio-30:1, T_4-Leaf to Fruit Ratio-35:1, T_5-Leaf to Fruit Ratio-40:1, T_6-Leaf to Fruit Ratio-45:1, T_7-Leaf to Fruit Ratio-50:1 and T_8-Control replicated thrice.
The results revealed that, the yield contributing parameters *viz*., number of fruits per plant, fruit yield per plant and fruit yield per hectare were recorded highest in control treatment but the graded fruit yield was found to be significant in the plant in which leaf fruit ratio was maintained 50:1 (LFR 50:1). The physical character in respect of Average fruit weight, pulp weight, pulp to rind ratio were found maximum in treatment leaf to fruit ratio-50:1 (LFR 50:1).

Keywords: Leaf to fruit ratio (LFR), crop load, fruit thinning, leaf thinning, partitioning of dry matter

Introduction
Custard apple is the most favourable fruit crop in India. It belongs to the family Annonaceae. It is known by different names, such as Sitaphal or Sharifa in India. However sugar apple and sweetsop in other countries. In India, custard apple is grown and mainly marketed in regional or national trade (George and Nissen, 1987) [13]. It is known for its wider adaptability to soil and climatic conditions and freedom from pest and diseases. It is popular by virtue of its spontaneous spread in forest, waste lands, rocky slope and other uncultivated places. Its nutritional value and wide uses in processing industries as well as in manufacturing bio-pesticides.
It is proving boon to the arid zones of Maharashtra because of their wider adaptability, comparatively freeness from pests and diseases, hardy nature, known to thrive under diverse soil and climatic conditions and also escape from grazing animals.
In fruit trees, the developing fruit are the major sink, and productivity and quality depend on an adequate source-sink relationship. An optimum leaf to fruit ratio can ensure that those fruit size and quality are adequate. Limiting the number of leaves per fruit and number of fruits per tree often improves fruit size and quality by enhancing the assimilates partitioned to the remaining fruit (Costa & Vizzotto, 2010) [4].
However, for achieving the good size and optimum quality of fruits, the proper balance between the source and the sink is quint essential, where heavy bearing becomes a major problem with time, leading to production of poor quality fruits. However, the concept of leaf to fruit ratio is not new, but such studies have been restricted to high value crops like apple, grapes, dates etc. Moreover, it also varies with the species, cultivar and agro-ecological conditions. According to Guirado *et al*. (2000) [8] estimated current recommendations in Spain for Cherimoya is to limit yield to 14–15 t/ha, because increasing crop load beyond supposedly reduces fruit size and quality.
In this view, present study was designed with an objectives to study the effect of leaf to fruit ratio on fruit growth, yield and quality of Custard apple as well as find out suitable leaf to fruit ratio for better fruit size, maximum fruit yield and quality of Custard apple.

Materials and Methods

The present experiment was conducted at Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year 2018-19. Eleven year old healthy plants of custard apple *cv.* Balanagar were selected for the study as per uniformity in growth, shape and vigour. The experiment was conducted in Randomized Block Design with eight treatments, which were replicated three times. The treatments were imposed in the second week of August (when fruit was about marble size). All plants were subjected to uniform cultural practices for the entire course of investigation.

Treatment details

Sr. No.	Treatment No.	Treatment Details
1	T_1	Leaf to Fruit Ratio-20:1
2	T_2	Leaf to Fruit Ratio-25:1
3	T_3	Leaf to Fruit Ratio-30:1
4	T_4	Leaf to Fruit Ratio-35:1
5	T_5	Leaf to Fruit Ratio-40:1
6	T_6	Leaf to Fruit Ratio-45:1
7	T_7	Leaf to Fruit Ratio-50:1
8	T_8	Control

Observations recorded on fruit yield (kg/tree), fruit weight (g), pulp weight (g), seed weight (g) and pulp: rind ratio (%). Fruit qualities in terms of total soluble solids (%), acidity (%), total sugars (%), reducing sugar (%) and non-reducing sugar (%) were also recorded. In respect of chemical analysis Titrable acidity was estimated by titrating 1 ml juice against 0.1 N NaOH using phenolphthalein as indicator (Ranganna, 1979) [11]. The total sugar content of pulp was determined by using dinitrosalicyclic acid (DNS) method and expressed in terms of percentage as suggested by Miller (1972) [10]. As per Anon., (2007) [1], the grading of fruits was done according to the weight for different classes *viz*., 'A' grade (300 gm and above), 'B' grade (above 200 gm) and 'C' grade (150-200 gm and below).

The experimental data collected during the course of investigation were analyzed with Randomized Block Design programme on computer by adopting standard statistical techniques of analysis of variance (Gomez and Gomez, 1984) [6].

Results and Discussion

Yield and yield contributing parameters

Number of Fruits/ plant

Data (figure 1) showed the significant difference among the LFR treatments for number of fruits per plant. In case of number of fruits per plant, significantly maximum (62) fruits per plant were recorded in treatment T_8 (Control) followed by (44) fruits per plant in treatment T_2 (LFR-25:1) whereas minimum (42) fruits per plant were recorded in treatment T_7 (LFR-50:1), T_6 (LFR-45:1) and T_4 (LFR-35:1) similarly.

Fruit yield/ plant (Kg/plant)

Data (figure 1) showed the significant difference among the LFR treatments for fruit yield per plant. In respect of fruit yield per plant, significantly maximum (11.86 Kg/plant) yield were recorded in treatment T_8 (Control) followed by (10.12 Kg/plant) T_7 (LFR-50:1). Whereas minimum (8.58 Kg/plant) yield was recorded in treatment T_1 (LFR-20:1).

Fruit yield/ ha (tons/ha)

Data (figure 1) showed the significant difference among the LFR treatments for fruit yield per hectare. In respect of yield, significantly maximum (7.41 tons/ha) yield was recorded in treatment T_8 (Control) followed by (6.32 tons/ha) T_7 (LFR-50:1). Whereas minimum (5.36 tons/ha) yield was recorded in treatment T_1 (LFR-20:1).

From the data presented in Table 2, it revealed that trees which were kept as control (no LFR maintained) gives more number of fruits per plant, fruit yield per plant and yield. It might be due to the fact that there were no thinning of fruits in control. Meland (2009) [9] reported that in Apple fruit thinning causes a significant reduction in number of fruit as well as yield per tree. Similar results were found by Deshmukh *et al*. (2012) [5] in low chilling peach cv. Flordasun.

Number of different grade fruits

The data (Table 1) in respect of fruit yield of different grade fruit (Number) was significantly influenced by various LFR treatments. The different grade fruits were separated as per weight after harvesting and grade wise counting of fruits followed.

In respect of Grade A (above 300 g), significantly the maximum (10) A grade fruits per plant were recorded in the treatment T_7 (LFR-50:1), which was followed by (6) A grade fruits were recorded in treatment T_6 (LFR-45:1) and T_5 (LFR-40:1) each. Whereas the minimum (3) A grade fruits were recorded in treatment T_1 (LFR-20:1) followed by T_2 (LFR-25:1) and T_8 (Control).

In respect of Grade B (above 200 g), the maximum (14) B grade fruits per plant were recorded in the treatment T_8 (Control-No LFR), which was statistically at par with (13) B grade fruits in treatment T_7 (LFR-50:1). Whereas the minimum (10) B grade fruits were recorded in treatment T_1 (LFR-20:1).

In respect of Grade C (above 150-200 g), significantly the maximum (18) C grade fruits per plant were recorded in the treatment T_8 (Control) followed by (14) C grade fruits per plant T_1 (LFR-20:1). Whereas the minimum (11) C grade fruits were recorded in treatment T_5 (LFR-40:1) and T_7 (LFR-50:1).

In respect of Grade D (below 150 g), significantly the maximum (27) D grade fruits per plant were recorded in the treatment T_8 (Control) followed by (16) D grade fruits per plant T_1 (LFR-20:1) and T_2 (LFR-25:1). Whereas the minimum (9) D grade fruits were recorded in treatment T_7 (LFR-50:1).

The results are in agreement with the findings of Chanana and Beri (2004) [2], who also observed that girdling plus thinning done 2 weeks after full bloom resulted in higher fruit weight in peach.

Yield of different grade fruits (kg/plant)

The data (Table 1) in respect of fruit yield of different grade fruit (Kg/plant) was significantly influenced by various LFR. The different grade fruits were separated as per weight after harvesting.

In respect of Grade A (above 300 g), significantly the maximum (3.67 Kg) A grade fruits per plant were recorded in the treatment T_7 (LFR-50:1) followed by (2.41 Kg) A grade fruits per plant in T_6 (LFR-45:1). Whereas the minimum (1.14 Kg) A grade fruits per plant were recorded in T_1 (LFR-20:1).

In respect of Grade B (above 200 g), the maximum (3.50 Kg) B grade fruits per plant were recorded in the treatment T_8 (Control) which was at par with (3.25 Kg) B grade fruits in the T_5 (LFR-40:1). Whereas the minimum (2.58 Kg) B grade fruits per plant were recorded in T_1 (LFR-20:1).

In respect of Grade C (above 150-200 g), significantly the maximum (3.09 Kg) C grade fruits per plant were recorded in the treatment T_8 (Control) followed by (2.51 Kg) C grade fruits per plant in T_1 (LFR-20:1). Whereas the minimum (1.93 Kg) C grade fruits per plant were recorded in T_7 (LFR-50:1).

In respect of Grade D (below 150 g), significantly the maximum (4 Kg) D grade fruits per plant were recorded in T_8 (Control) followed by (2.35 Kg) D grade fruits per plant in T_1 (LFR-20:1) and T_2 (LFR-25:1) each. Whereas the minimum (1.35 Kg) D grade fruits per plant were recorded in treatment T_7 (LFR-50:1).

The results are in agreement with the findings of Deshmukh *et al*. (2012) [5] who reported, the increase in LFR improved the fruit weight, fruit length, fruit diameter and pulp weight parameters in Flordasun peach and recorded the highest fruit size and weight with 45:1 followed by 35:1 and 55:1 leaf fruit ratio.

Physicochemical parameters

Physical parameters

The data (figure 2.) in respect of Average fruit weight (g), Pulp weight (g) and Pulp: Rind ratio was significantly influenced by various LFR, where in case of seed weight the treatments were found statistically non-significant. The observations were measured after fruit harvesting in analytical laboratory.

In respect of average fruit weight, significantly the maximum (245.58 g) fruit weight was recorded in the T_7 (LFR-50:1) which was followed by (211.50 g) in the treatment T_6 (LFR-45:1). Whereas the minimum (126.33 g) fruit weight was recorded in treatment T_8 (Control). In respect of pulp weight, significantly the maximum (150.83 g) pulp weight was recorded in the treatment T_7 (LFR-50:1) which was followed by (110.50 g) in the treatment T_6 (LFR-45:1). Whereas the minimum (54 g) pulp weight was recorded in treatment T_8 (Control). For Pulp: Rind ratio, significantly the maximum (1.71) ratio was recorded in the treatment T_7 (LFR-50:1) followed by (1.36) in the treatment T_6 (LFR-45:1). Whereas the minimum (0.92) ratio was recorded in treatment T_1 (LFR-20:1).

From the data presented in figure 2. revealed that with increase in LFR, Average fruit weight, pulp weight and pulp: rind ratio shows increasing trend. The tree having maximum LFR had the maximum fruit and pulp weight, these results are also in conformity with Shivangi Arvind *et al*. (2018) [12] in Guava, Chanana *et al*. (1998) [3] in Peach and Deshmukh *et al*. (2012) [5] in Peach. Also the seed weight is independent of crop load. Similar observation was reported by Gonzalez and Cuevas (2008) [7] in Cherimoya.

Correlation analysis

Data regarding correlation of leaf to fruit ratio with yield contributing parameters *viz*., Average fruit weight, Number of Fruits per plant, Fruit yield (kg/ plant) and Fruit yield (tons/ ha) are presented in Table 2.

Correlation studies reveal that correlation between leaf to fruit ratio and Average fruit weight was found to be positively significant in LFR 50:1 and significant but negative in LFR 20:1. Similarly in case of number of fruits per plant correlation studies reveals that correlation between leaf to fruit ratio and number of fruits per plant was found to be positively significant in LFR 30:1 and significant but negative in LFR 40:1.

In respect of fruit yield (kg/ plant) correlation studies reveals that correlation between leaf to fruit ratio and Fruit yield (kg/ plant) was found to be significant but negative in LFR 30:1 and positive in LFR 45:1. Whereas correlation between leaf to fruit ratio and fruit yield (tons/ ha) found to be non-significant in all treatments.

Data regarding correlation of leaf to fruit ratio with different grade fruits yield *viz*., Grade A, Grade B, Grade C and Grade D are presented in Table 3.

Correlation studies reveal that correlation between leaf to fruit ratio and yield of Grade A fruits were found to be positively significant in LFR 50:1. Whereas correlation between leaf to fruit ratio and yield of Grade C fruits were found positively significant in LFR 30:1 and significant but negative in LFR 45:1.

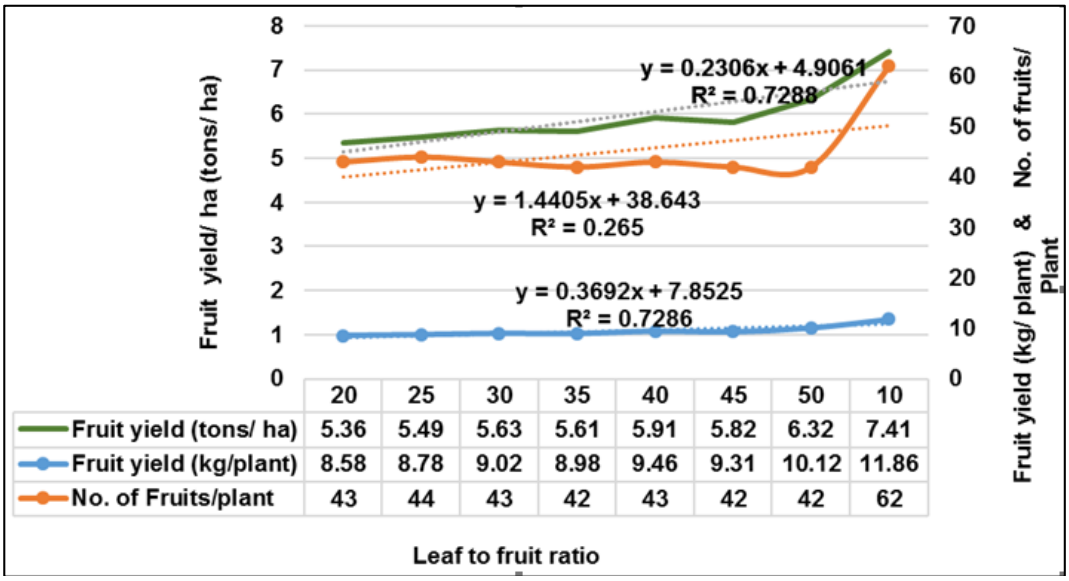

Fig 1: Effect of Leaf to fruit ratio on number of fruits/ plant, Fruit yield /plant and fruit yield/ha.

Table 1: Effect of LFR on number of different grade fruit and yield of different grade fruit (kg/plant)

Treatment		Number of different grade fruit				yield of different grade fruit (kg/plant)			
		Grade A	Grade B	Grade C	Grade D	Grade A	Grade B	Grade C	Grade D
T_1	LFR=20:1	3	10	14	16	1.14	2.58	2.51	2.35
T_2	LFR=25:1	3	11	13	16	1.27	2.83	2.33	2.35
T_3	LFR=30:1	5	12	14	12	1.77	3.00	2.39	1.85
T_4	LFR=35:1	5	12	12	13	1.90	3.08	2.10	1.90
T_5	LFR=40:1	6	13	11	13	2.28	3.25	1.98	1.95
T_6	LFR=45:1	6	12	13	11	2.41	2.92	2.33	1.65
T_7	LFR=50:1	10	13	11	9	3.67	3.17	1.93	1.35
T_8	Control	3	14	18	27	1.27	3.50	3.09	4.00
	'F' Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.49	0.64	0.65	0.95	0.19	0.16	0.11	0.14
	CD at 5%	1.50	1.93	1.98	2.87	0.57	0.48	0.35	0.43

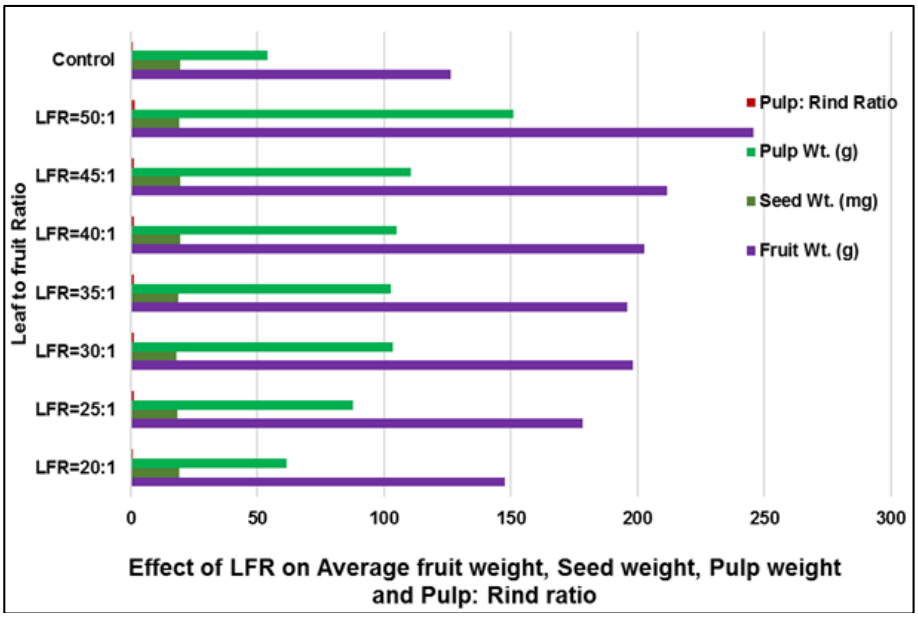

Fig 2: Effect of Leaf to fruit ratio on Average fruit weight, Seed weight, Pulp weight and Pulp: Rind ratio

Table 2: Correlation of Leaf to fruit ratio with yield contributing parameters

Treatments	Average fruit weight	Number of Fruits per plant	Fruit yield (kg/ plant)	Fruit yield (tons/ ha)
LFR 20:1	-0.977*	-0.189	0.934	-0.357
LFR 25:1	0.577	0.756	-0.423	0.891
LFR 30:1	-0.982	0.982*	-0.992**	0.869
LFR 35:1	-0.908	-0.596	-0.419	-0.486
LFR 40:1	-0.593	-0.971*	0.140	-0.878
LFR 45:1	0.456	-0.629	0.997**	-0.529
LFR 50:1	0.992**	0.189	-0.866	0.171
Control	-0.814	0.189	-0.608	0.570

** Significance at 1 per cent level;
* Significance at 5 per cent level

Table 3: Correlation of Leaf to fruit ratio with different Grade fruits yield

Treatments	A grade fruits	B grade fruits	C grade fruits	D grade fruits
LFR 20:1	-0.866	0.556	0.189	-0.536
LFR 25:1	0.499	0.756	0.532	0.277
LFR 30:1	0.655	0.866	0.999**	0.541
LFR 35:1	0.003	-0.498	-0.866	-0.547
LFR 40:1	-0.866	0.087	-0.558	-0.866
LFR 45:1	-0.521	0.189	-0.971*	0.011
LFR 50:1	0.999**	-0.756	0.009	0.866
Control	0.521	0.001	0.693	-0.359

** Significance at 1 per cent level;
* Significance at 5 per cent level

Conclusion

The growth and vegetative parameters in respect of leaf area, chlorophyll content, shoot and leaf carbohydrate content and physical character in respect of fruit size, average fruit weight, pulp weight, pulp to rind ratio were found maximum in leaf to fruit ratio-50:1. Though the fruits per plant, fruit yield per plant and fruit yield per hectare were recorded highest in control but the maximum number of A grade fruits /plant and fruit yield of A grade fruits/ plant was found in leaf to fruit ratio-50:1. In case of grade B, C and D maximum number of fruits /plant and fruit yield / plant was recorded in Control.

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