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Effect of Fruit Thinning on Quantity and Quality of Apricot Fruit "Blenheim Cv Clone #7359"

Akhter Mohammad Doranai✉[1], Ghulam Rasoul Samadi[2]

[1] Scholar of M.SC. Degree at Horticulture Department of Kabul, Agriculture Faculty, Kabul, Afghanistan
[2] Department of Horticulture, Agriculture Faculty, Kabul University, Kabul, Afghanistan
✉E-mail: akhterbasam73a@gmail.com (corresponding author)

ABSTRACT

Optimizing fruit thinning strategies requires a balanced regulation of source–sink relationships; however, limited information is available on the combined effects of fruit spacing and fruit-to-leaf ratio (FLR) under semi-arid conditions. This study evaluated the interactive influence of fruit spacing and FLR on yield components and fruit quality of apricot using a factorial experiment arranged in a RCBD design. The trial was conducted during the 2025 growing season at the Badam Bagh Research Farm, Kabul, Afghanistan. Two factors were tested at five levels each: fruit spacing (control, 5, 7.5, 10, and 12.5 cm) and FLR (control, 25, 30, 35, and 40 leaves per fruit). Growth, yield, physicochemical attributes (fruit size, weight, total soluble solids, titratable acidity, pH, firmness), and sensory characteristics were evaluated. Data were analysed using STAR software. Fruit spacing significantly influenced most yield and quality parameters, whereas FLR showed limited effects. A spacing of 10 cm markedly enhanced fruit weight, largest diameter, firmness, total soluble solids, and acidity compared with the control, while a spacing of 12.5 cm maximized fruit length. No significant interaction effects were observed for most traits, and FLR significantly affected only fruit flavour. These findings indicate that moderate fruit spacing (10 cm) effectively improves apricot productivity and quality by optimizing assimilate distribution under Kabul agro-climatic conditions.

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INTRODUCTION

Apricots (*Prunus armeniaca L)* are categorized under "stone Fruits," along with peaches, plums, almonds, and cherries, due to their seed being enclosed in a hard, stone-like endocarp. The apricot tree (from the Latin meaning 'early ripe') belongs to the genus *Prunus* in the Rosaceae (rose) family. This Fruit is native to temperate Asia, first discovered growing wild on the mountain slopes of China, and later long cultivated in Armenia. The Apricot tree is of medium size, usually held under 5.5 M by pruning. The Fruit is generally globose to slightly oblong, 31.75–63.5 mm in diameter; the Fruit flesh is yellow and whitish, and the skin is whitish and yellow or blushed red (Anon, 2007). The early Apricot bloom is susceptible to frost damage. Also, the Fruit is subject to cracking in humid climates, thus limiting commercial production in the United States primarily to states west of the Rocky Mountains (Siddiq et al., 2012).

Apricot is one of the most economically important fruit crops in the Prunus genus, with an attractive, delicious, and high vitamin and mineral content. Fruit was cultivated in the temperate climates of all continents worldwide (Yehia et al., 2019). Various components of Apricot are useful in treating various disorders of the human body. Apricot is rich in Iron, with traces of calcium, and is an excellent source of vitamins A, C, E, and the B-complex, such as niacin and riboflavin; thus, it is a very good source for preventing anemia. It increases hemoglobin levels in our bodies. The high laxative content of apricots makes them a medicine for treating constipation. Cellulose and pectin help good bowel movements by retaining water. During fever, Apricot juice, along with honey, quenches thirst and helps eliminate waste from the body. Various skin-related diseases, such as scales, eczema, sunburn, and itching, may be cured by Consuming Apricot juice (Fatima et al., 2018). Cyanogenic glycosides (found in seeds, bark, and leaves of most stone Fruits) are found in high concentration in Apricot seeds. Laetrile, a purported alternative cancer treatment, is extracted from Apricot seeds. As early as 502, Apricot seeds were used to treat tumors, and in the seventeenth century, apricot oil was used in England to treat tumors and ulcers (Mehta, 2012).

Apricots are considered among the most delicious temperate tree fruits. The fruit contains different levels of photochemicals, such as Vitamins, carotenoids, and Polyphenols, which contribute significantly to its taste, color, and nutritive value. Generally, apricot fruit has great nutritional value because of fiber, minerals (K, Ca, Fe, Mg, Zn, P and Se) and low energy intake (50 Kcal 100 g-1 fresh weight) that combined with the nutraceutical plus-value (Vitamin C, A, Carotenoids, Phenols, Thiols, Thiamine, Riboflavin, Niacin and Pantothenic acid) make apricots' healthy (Devrari et al, 2017).

Vavilov, (1951) placed Apricot in three centers of origin for cultivated plants 1) the Chinese center that comprises mountainous regions of Central and Western China together with the adjacent lowlands, 2) the Central Asiatic center that includes Afghanistan, northwest India and Pakistan, Kashmir, Tajikistan, Uzbekistan, Xinjing province in China and western Tien Shan, 3) the Near-Eastern center including the interior of Asia Minor, Transcaucasia, Iran, and Turkmenistan (Vavilov, 1951). Apparently, apricots were first cultivated in China. Here is Chinese written evidence of Apricot cultivation cited by De Candolle (1886), dating from the end of the 3rd millennium *BC.* In Central Asia, Apricot cultivation was introduced more recently, around I–II millennia *BC.* In accordance with this dating, modern excavations in southern Turkmenistan and Uzbekistan lack evidence for the use of Fruit and nuts in western Central Asia before 1500 *BC (Zhebentyayeva* et al, 2012).

Commonly, Apricot Fruit setting is higher than normal; therefore, fruit thinning is needed. If one-year apricot trees bear heavy fruit, then maybe that tree did not bear fruit or did not bear good fruit. This situation is called an alternate habit(Jangid et al.; 2023). Excessive Fruit set in tree causes several problems include, break of brunch due to heavy weight, deterioration of fruit color, decline in fruit taste quality decrease in fruit size and finally it is cause small fruit production. Under favorable conditions, apricots usually set abundant flowers (Arba et al.; 2022). However, high fruit numbers lead to imbalance of fruit to leaf ratio and consequently to smaller, less desirable fruit, alternate bearing, limb breakage, pre-mature fruit drop, delayed fruit maturation and reduced fruit quality, exhaustion of reserves and reduced cold hardiness (Roussos et al, 2011).

It is well established that heavy bearing of peach trees adversely affects fruit size and quality, resulting in poor returns to growers. In addition, limb breakage under heavy crop load and increased susceptibility to late winter frost, particularly in the temperate zones, are other adverse effects of heavy bearing (Patel et al., 2014).

Proper fruit thinning improves light interception, nutrient allocation, and assimilate distribution within the canopy, thereby enhancing fruit weight, size, color, shape, and flavor. Although thinning may reduce total yield, it generally increases marketable yield by producing larger, higher-quality fruits, thereby requiring a balance between fruit load and fruit size (Stanley, 2016). In many apricot-producing regions, excess fruit is manually removed to improve fruit size and commercial value. The timing and intensity of thinning are critical, as the optimal period typically extends from 2 weeks before flowering to 3 weeks after (Arba & Farhat, 2022).

Finally, limited cultivar-specific information is available regarding the quantitative and qualitative responses of the Blenheim apricot to hand fruit thinning under semi-arid agro-climatic conditions. Therefore, this study was conducted to evaluate the effects of hand-fruit thinning intensity on yield components and physicochemical quality attributes to determine an optimal thinning strategy.

This research addressed the following questions:

1. How does hand fruit thinning intensity influence fruit size, weight, and marketable yield?
2. What are the effects of thinning on key quality parameters such as total soluble solids, titratable acidity, and fruit firmness?

MATERIALS AND METHODS

This research was conducted at the Badam Bagh Research Farm, Kabul, Afghanistan. The experimental orchard was planted in 2006 with the Blenheim apricot variety, with a plant spacing of 5.5 × 5.5 meters. The study was conducted during the spring and summer of 2025. The research site is located at 34.5667° N, 69.1833° E, at an altitude of approximately 1800 meters above sea level. The experimental field is flat and irrigated using a basin irrigation system. Detailed information on the factors and treatments is provided in Table 1.

***Table 1**. Factors and treatment details*

Factor A		Factor B	
Treatments	**Distance between two fruits**	**Treatments**	**Number of leaves**
A1	5 cm between two Fruits	B1	25 leaves per Fruit
A2	7.5 cm between two Fruits	B2	30 leaves per Fruit
A3	10 cm between two Fruits	B3	35 leaves per Fruit
A4	12.5 cm between two Fruits	B4	40 leaves per Fruit
A5	No distance between two Fruits	B5	Cheek or control treatment

Trees were carefully selected to ensure uniformity in age (all trees were 18 years old), spacing, vegetative growth, and other morphological characteristics. Five trees with similar growth, vigor, and physical condition were chosen for the experiment. Each tree represented all five treatments, with ten treatments applied per tree.

A Factorial experiment in a Randomized Complete Block Design (RCBD) was used. Since field conditions such as soil fertility, temperature, and light are not uniform in real-world experiments, the RCBD design allows for the isolation of these variations, enabling more accurate measurement of treatment effects. The field experiment was therefore arranged in an RCBD with 2 replications and 25 treatments. Collected data were analyzed using the Statistical Tools for Agriculture Research (STAR) software.

Materials used in this study included measurement tools (meter, tape, calipers, small and large scales, refractometer for TSS determination), a penetrometer for firmness measurement, a shear for thinning, notebooks, and a computer for data processing and analysis.

The study considered three types of parameters for analysis: chemical, measurable, and sensory evaluation. Chemical parameters included fruit TSS, fruit acidity, and fruit pH. Measurable parameters included the largest and smallest fruit diameter, fruit length, fruit firmness, individual fruit weight, and treatment-wise fruit weight. Sensory evaluation parameters included fruit appearance, color, flavor, taste, and overall acceptance.

FINDINGS & DISCUSSION

The results were presented in well-organized and standardized tables to ensure clarity and transparency. Appropriate statistical indicators were included, and each table included a clear explanation. All abbreviations were defined in footnotes to avoid ambiguity. Furthermore, the findings were discussed in comparison with relevant published studies and supported by citations from reputable scientific sources.

Total soluble solids (° Brix)

The (a) factor (fruit thinning) had a statistically significant effect on fruit TSS (Table 2). The TSS parameter was significantly increased at the A3 thinning level, reaching a maximum of 19.14 (Table 2). In contrast, the (b) factor and the interaction between (a) and (b) were not statistically significant at the 5% probability level.

Table 2. *Effect of fruit spacing and leaf number on fruit TSS*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	16.25	16.50	16.50	16.50	17.25	**16.60** [b]
A2	18.00	19.50	18.25	18.25	18.00	**18.40** [a]
A3	19.25	19.25	20.05	18.50	18.65	**19.14** [a]
A4	19.25	18.75	16.25	16.75	17.25	**17.65** [ab]
A5	17.50	15.50	16.25	15.75	15.75	**16.15** [b]
Factor B means	**18.05**	**17.90**	**17.46**	**17.15**	**17.38**	

Factors	F- test	LSD (0.01)	CV
Factor A	**	1.53	
Factor B	Ns	-	6.95
A x B	Ns	-	

Factor A: Distance between two fruits; **Factor B**: Number of leaves per fruits; **Ns**: not significant; ******: P ≤ 0.01 (highly significant) ; **LSD**: least significant difference; **CV**: Coefficient of Variation; **Within** each column, means followed by different lowercase letters (a, b, c, …) indicate significant differences according to the LSD test.

The observed increase in TSS at the A3 level can be explained by an improved source–sink balance within the canopy. By decreasing fruit number, thinning reduces sink competition, allowing a greater proportion of leaf-derived assimilates to be allocated to the remaining fruits. This improved carbohydrate distribution promotes greater sugar gathering and soluble solid concentration in individual fruits. The increase in TSS at the A3 level is attributed to enhanced carbohydrate allocation to the remaining fruits, which ultimately increased soluble solids accumulation. These results are consistent with previous studies reporting that fruit TSS is influenced by thinning practices (Link, 2000; Mika & Buler., 2011; Rab et al., 2012).

Fruit Acidity (%)

The (b) factor and the interaction between (a) and (b) were not statistically significant (Table 3). In contrast, the (a) factor (fruit thinning) had a highly significant effect (Table 3). The lowest acidity value (0.53) was observed at the A3 thinning level, while the highest value (0.96) was recorded at the A5 level (Table 3).

Table 3. *Effect of fruit spacing and leaf number on fruit acidity*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	0.90	0.55	0.80	0.70	0.50	**0.69** [b]
A2	0.60	0.60	0.50	0.70	0.80	**0.64** [b]
A3	0.60	0.55	0.55	0.55	0.40	**0.53** [b]
A4	0.50	0.40	0.60	0.70	0.50	**0.54** [b]
A5	0.55	1.10	0.95	1.10	1.10	**0.96** [a]
Factor B means	**0.63**	**0.64**	**0.68**	**0.75**	**0.66**	

Factors	F- test	LSD (0.01)	CV
Factor A	**	0.25	
Factor B	Ns	-	29.41
A x B	Ns	-	

The results clearly demonstrate that fruit thinning is an important management practice affecting apricot fruit acidity. Moderate thinning (A3–A4) resulted in lower acidity, potentially producing sweeter fruits, while severe thinning (A5) maintained higher acidity and delayed maturation. Therefore, thinning intensity should be carefully managed depending on the desired harvest time and market preference for sugar–acid balance. Fruit acidity decreased progressively as the fruit matured, accompanied by a decline in pH. Fruit thinning appeared to delay the maturation process by slowing the reduction in apricot fruit acidity. These findings are consistent with previous studies demonstrating that thinning plays a key role in regulating fruit acidity (Dennis, 2000; Tahir & Hamid, 2002; Byers, 2003).

Fruit pH

The (a) factor (fruit thinning) was statistically significant at the 1% probability level (Table 4). In contrast, the (b) factor and the interaction between (a) and (b) did not have a significant effect on fruit pH (Table 4). Among the treatments, A3 and A2 thinning levels recorded the highest pH values, 4.51 and 4.34, respectively, and are recommended for optimizing this parameter.

***Table 4**. Effect of fruit spacing and leaf number on fruit pH*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	3.80	4.15	3.85	4.30	3.95	**4.01** b c
A2	4.30	4.55	4.45	3.85	4.55	**4.34** a b
A3	4.50	4.45	4.50	4.70	4.40	**4.51** a
A4	4.60	3.80	4.15	4.25	4.25	**4.21** a b c
A5	4.10	3.85	4.20	3.70	3.85	**3.94** c
Factor B means	**4.26**	**4.16**	**4.23**	**4.16**	**4.20**	

Factors	F- test	LSD (0.01)	CV
Factor A	**	0.36	
Factor B	Ns	-	6.95
A x B	Ns	-	

The increase in fruit pH can be attributed to the redistribution of carbohydrates and organic acids: removal of excessive fruit allows the remaining fruits to receive more carbohydrates, including glucose, fructose, and sucrose. Higher sugar concentrations reduce the perception of acidity and slightly neutralize hydrogen ions, thereby increasing fruit pH. These findings are consistent with previous studies showing that fruit thinning significantly influences fruit pH (Chen et al., 2020; Martínez et al., 2019; Keller & Mill., 2023).

Fruit largest diameter (cm)

Fruit thinning significantly increased the largest fruit diameter. The (a) factor (fruit thinning) was statistically significant at the 1% probability level, whereas the (b) factor and the interaction between (a) and (b) were not significant at the 5% probability level (Table 5). Among the treatments, the A3 thinning level produced the largest fruit diameter, measuring 3.93 mm (Table 5).

Table 5. *Effect of fruit spacing and leaf number on the weight of the largest fruit diameter*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	3.73	3.83	3.89	4.19	3.74	**3.87** [a]
A2	3.87	3.83	3.85	3.79	4.01	**3.87** [a]
A3	3.92	3.86	3.98	3.93	3.98	**3.93** [a]
A4	3.77	3.84	4.08	3.69	3.96	**3.87** [a]
A5	3.61	3.91	3.62	3.58	3.70	**3.68** [b]
Factor B means	**3.78**	**3.85**	**3.88**	**3.84**	**3.88**	

Factors	F- test	LSD (0.05)	CV
Factor A	**	0.16	
Factor B	Ns	-	4.53
A x B	Ns	-	

The highest mean diameter (3.93 cm) was observed at A3, suggesting that moderate fruit spacing provided optimal conditions for fruit growth. Adequate spacing reduces competition among fruits for carbohydrates, water, and nutrients, thereby improving cell expansion and overall fruit size. However, excessive spacing (A5) did not increase fruit diameter; instead, it reduced it. These results are consistent with previous studies reporting that fruit thinning significantly increases the largest fruit diameter (Stanley., 2016; Missang et al., 2011; Link, 2000).

Smallest diameter **(cm)**

The (a) factor (fruit thinning), the (b) factor FLR, and their interaction had no significant effect on the smallest fruit diameter (Table 6).

Table 6. *Effect of fruit spacing and leaf number on the weight of the smallest fruit diameter*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	3.28	3.32	3.43	3.48	3.34	**3.37**
A2	3.35	3.55	3.40	3.34	3.27	**3.38**
A3	3.44	3.39	3.43	3.40	3.50	**3.43**
A4	3.37	3.40	3.50	3.23	3.47	**3.39**
A5	3.24	3.68	3.25	3.20	3.26	**3.32**
Factor B means	**3.33**	**3.46**	**3.40**	**3.33**	**3.36**	

Factors	F- test	LSD (0.05)	CV
Factor A	Ns	-	
Factor B	Ns	-	4.15
A x B	Ns	-	

Fruit length(cm)

The (a) factor (fruit thinning) was statistically significant at the 5% probability level (Table 7). Among the (a) factor treatments, A3 and A4 levels recorded the highest values and were assigned different letters in mean separation.

Table 7. Effect of fruit spacing and leaf number on fruit weight and fruit length.

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	3.34	3.43	3.48	3.38	3.25	**3.37** [a b]
A2	3.68	3.32	3.32	3.19	3.33	**3.37** [a b]
A3	3.54	3.40	3.46	3.46	3.56	**3.48** [a]
A4	3.32	3.34	3.64	3.35	3.49	**3.43** [a]
A5	3.27	3.44	3.25	3.16	3.26	**3.28** [b]
Factor B means	**3.43**	**3.39**	**3.43**	**3.31**	**3.38**	

Factors	F- test	LSD (0.05)	CV
Factor A	*	0.13	
Factor B	Ns	-	4.13
A x B	Ns	-	

*: P ≤ 0.05 (significant) ;

Fruit growth in length, similar to diameter, is largely dependent on cell division and cell expansion during early developmental stages. Proper thinning improves the source–sink balance, enhancing carbohydrate allocation to remaining fruits. However, excessive thinning (A5) may reduce the tree's overall sink demand, potentially limiting hormonal signals that stimulate fruit enlargement. These results are consistent with previous studies reporting that fruit thinning significantly affects fruit length (Arba et al., 2022; Patel et al., 2014; Dennis, 2000).

***Weight fruit^{-1}*(g)**

The (a) factor (fruit thinning) was statistically significant at the 1% probability level (Table 8), whereas the (b) factor and the interaction between (a) and (b) were not significant at the 5% probability level (Table 8). The maximum fruit weight reflects greater growth and can be considered an indicator of effective assimilate utilization, resulting from the fruit's sink strength. When assimilates are efficiently allocated, fruit weight increases significantly.

***Table 8**. Effect of fruit spacing and leaf number on weight per fruit*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	29.57	32.57	33.85	35.94	29.68	**32.32** [a b]
A2	33.35	34.29	32.60	35.02	30.94	**33.24** [a]
A3	33.56	32.99	36.57	35.25	36.41	**34.95** [a]
A4	34.17	34.17	37.09	29.81	34.09	**33.86** [a]
A5	28.65	34.86	27.78	28.61	30.15	**30.01** [b]
Factor B means	**31.86**	**33.77**	**33.58**	**32.93**	**32.25**	

Factors	F- test	LSD (0.01)	CV
Factor A	**	2.93	
Factor B	Ns	-	7.12
A x B	Ns	-	

Fruit weight is strongly influenced by carbohydrate availability and the efficiency of assimilate partitioning. Proper thinning reduces competition among fruits, enhances photosynthetic efficiency per fruit, and improves nutrient uptake. Moderate thinning likely achieved an ideal source–sink balance, promoting better cell enlargement and dry matter accumulation. These findings are consistent with previous studies reporting that different levels of fruit thinning significantly influence fruit weight (Bashir et al., 2023; Jia et al., 2023; Whitfield et al., 2016).

Weight treatment^{-1} (Kg)

The recorded data were analyzed using STAR software, and the results indicated that the (a) factor (fruit thinning), the (b) factor FLR, and their interaction were not statistically significant at the 5% probability level (Table 9).

***Table 9**. Effect of fruit spacing and leaf number on weight per treatment*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	0.90	1.01	1.20	1.23	0.79	**1.03**
A2	1.27	1.60	0.92	1.13	1.26	**1.23**
A3	1.18	0.89	1.65	0.88	1.06	**1.13**
A4	1.06	1.32	1.41	1.25	1.14	**1.23**
A5	1.73	0.90	1.67	0.95	1.80	**1.41**
Factor B means	**1.22**	**1.14**	**1.37**	**1.09**	**1.21**	

Factors	F- test	LSD (0.05)	CV
Factor A	Ns	-	
Factor B	Ns	-	33.29
A x B	Ns	-	

Fruit firmness (Kg)

The results indicated that the (a) factor (fruit thinning) was statistically significant at the 1% probability level (Table 10). Among the treatments, the A4 thinning level produced the highest fruit firmness (2.51 kg), whereas the A5 level recorded the lowest value (2.02 kg).

***Table 10**. Effect of fruit spacing and leaf number on fruit firmness*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	2.05	1.75	2.20	2.15	1.90	**2.01** b
A2	2.25	2.05	1.95	2.20	2.15	**2.12** b
A3	2.05	2.20	2.75	2.40	2.40	**2.36** a b
A4	2.30	2.65	2.75	2.80	2.05	**2.51** a
A5	2.35	2.15	2.05	1.65	1.90	**2.02** b
Factor B means	**2.20**	**2.16**	**2.34**	**2.24**	**2.08**	

Factors	F- test	LSD (0.01)	CV
Factor A	**	0.38	
Factor B	Ns	-	13.78
A x B	Ns	-	

Fruit firmness is closely associated with cell wall structure, calcium accumulation, and ripening rate. Proper thinning improves nutrient availability (especially calcium and potassium) per fruit and enhances dry matter accumulation, which contributes to stronger cell walls and delayed softening. These findings are consistent with previous studies reporting that different levels of fruit thinning significantly affect fruit firmness (Carlos et al., 2006; Stanley., 2016; Jia et al., 2023).

Fruit appearance

The results indicated that the (a) factor (fruit thinning), the (b) factor FLR, and their interaction were not statistically significant at the 5% probability level (Table 11). Although numerical differences were observed across all thinning levels, they were not statistically significant at the 5% level.

***Table 11**. Effect of fruit spacing and leaf number on fruit appearance*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	4.14	4.57	4.14	4.29	3.71	**4.17**
A2	4.57	4.43	4.29	4.00	4.57	**4.37**
A3	4.29	3.86	4.14	4.14	4.86	**4.26**
A4	4.57	4.71	4.29	3.71	4.00	**4.26**
A5	3.57	4.14	3.86	4.00	4.14	**3.94**
Factor B means	**4.23**	**4.34**	**4.14**	**4.03**	**4.26**	

Factors	F- test	LSD (0.05)	CV
Factor A	Ns	-	
Factor B	Ns	-	16.96
A x B	Ns	-	

Fruit color

For this parameter, the results indicated that the (a) factor (fruit thinning) and the interaction between (a) and (b) factors were statistically significant at the 5% probability level, whereas the (b) factor FLR was not significant at the 5% probability level (Table 12). Among all thinning treatments, the A3B5 combination produced the highest value (5.00) and is therefore recommended for optimizing this parameter. Fruit thinning allows the remaining fruits to maintain a proper balance of auxin and gibberellin, which influences both fruit development and skin color.

***Table 12**. Effect of fruit spacing and leaf number on fruit color*

Factor A	Factor B				
	B1	B2	B3	B4	B5
A1	3.71^{b} AB	4.39^{a} A	4.14^{a} AB	4.14^{a} AB	3.43^{c} B
A2	4.71^{a} A	4.43^{a} AB	3.86^{a} B	4.14^{a} AB	4.43^{ab} AB
A3	4.71^{a} AB	3.86^{a} C	4.29^{a} ABC	4.00^{a} BC	5.00^{a} A
A4	4.71^{a} A	4.57^{a} A	4.14^{a} AB	3.71^{a} B	4.00^{bc} AB
A5	3.71^{b} A	4.00^{a} A	3.71^{a} A	4.00^{a} A	4.00^{bc} A

Factors	F- test	LSD (0.05)	CV
Factor A	*	-	
Factor B	NS	-	17.9
A x B	*	0.78	

Within each row, means followed by different uppercase letters (A, B, C, …) indicate significant differences according to the LSD test.

Improved fruit color under moderate spacing (A2–A4) may be attributed to better light penetration into the canopy and improved assimilate distribution. Adequate spacing reduces shading among fruits and enhances the synthesis of anthocyanins and carotenoids, which are responsible for fruit coloration. Fruit color development is highly sensitive to light intensity, temperature, and source–sink balance. Proper thinning combined with optimal leaf retention can enhance sunlight penetration and improve pigment synthesis. These findings are consistent with previous studies reporting that fruit thinning significantly affects fruit color in peach and apricot (Milosevic et al., 2015; Deshmukh et al., 2022; Bashir et al., 2023).

Fruit flavor

The results indicated that the (a) factor (fruit thinning) was statistically significant for this parameter, whereas the (b) factor FLR and the interaction between (a) and (b) were not significant at the 5% probability level (Table 13). Among all (a) factor treatments, the A2 thinning level recorded the highest value (4.34 a) and shared the same letter with A1 and A3, while the lowest value (3.89) was observed in the A5 treatment.

***Table 13**. Effect of fruit spacing and leaf number on fruit flavor*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	3.86	4.71	4.29	4.29	3.43	**4.12** a
A2	4.57	4.43	4.57	4.00	4.14	**4.34** a
A3	4.57	3.86	4.14	3.71	4.43	**4.14** ab
A4	4.71	4.57	4.00	3.71	3.86	**4.17** b
A5	3.86	4.14	3.71	3.86	3.86	**3.89** b
Factor B means	**4.31**	**4.34**	**4.14**	**3.91**	**3.94**	

Factors	F- test	LSD (0.05)	CV
Factor A	*	0.34	
Factor B	Ns	-	17.44
A x B	Ns	-	

Flavor is largely determined by the balance between sugars and organic acids, as well as the accumulation of aromatic compounds. Proper thinning improves carbohydrate allocation to individual fruits, enhancing sugar accumulation and improving the sugar–acid ratio. However, excessive thinning may accelerate ripening or alter metabolic balance, potentially reducing optimal flavor development. These results are consistent with previous studies demonstrating that fruit thinning significantly influences fruit flavor (Canli & Tutar, 2014; Wu et al., 2002; Bashir et al., 2023; Etienne et al., 2013).

Fruit taste

Statistical analysis indicated that the (a) factor (fruit thinning), the (b) factor (fruit-to-leaf ratio, FLR), and their interaction were not statistically significant at the 5% probability level (Table 14). Although numerical differences were observed among the treatments, these differences were not statistically significant.

Table 14. Effect of fruit spacing and leaf number on fruit taste.

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	3.87	4.15	4.29	4.57	3.57	**4.09**
A2	4.43	3.71	4.14	4.00	4.29	**4.11**
A3	4.29	4.00	4.29	4.00	4.43	**4.20**
A4	4.14	4.57	4.00	4.00	4.29	**4.20**
A5	4.57	4.43	4.00	4.14	4.14	**4.26**
Factor B means	**4.26**	**4.17**	**4.14**	**4.14**	**4.14**	

Factors	F- test	LSD (0.05)	CV
Factor A	NS	-	
Factor B	Ns	-	18.24
A x B	Ns	-	

Overall acceptance

The (a) factor (fruit thinning), the (b) factor FLR, and their interaction were not statistically significant at the 5% probability level (Table 15).

***Table 15**. Effect of fruit spacing and leaf number on fruit overall acceptance*

Factor A	Factor B					Factor A means
	B1	B2	B3	B4	B5	
A1	3.97	4.29	4.29	4.04	4.14	**4.15**
A2	5.00	4.57	4.14	4.00	4.57	**4.46**
A3	4.57	4.00	4.43	4.00	4.71	**4.34**
A4	4.57	4.71	4.29	4.14	4.29	**4.40**
A5	4.14	4.43	4.14	4.00	4.43	**4.23**
Factor B means	**4.45**	**4.40**	**4.26**	**4.04**	**4.43**	

Factors	F- test	LSD (0.05)	CV
Factor A	NS	-	
Factor B	Ns	-	16.94
A x B	Ns	-	

CONCLUSION

This study showed that fruit thinning improved both fruit quality and quantity in apricots. The A3(10 cm between two Fruits) thinning level had the greatest positive effect on TSS, acidity, pH, colour, equatorial diameter, and fruit weight, while A4 improved firmness and flavour. Thinning reduces competition for carbohydrates, allowing remaining fruits to reach their maximum size without affecting tree vigour. Therefore, A3 thinning is recommended. Fruit thinning should be performed after the June drop or at the onset of pit hardening to ensure uniform fruit size, consistent ripening, and stable production. Hand thinning is the most effective method, particularly because early apricot flowers are susceptible to spring frost.

Recommendations

Apricot orchardists should perform fruit thinning to balance fruit load with tree capacity, thereby enhancing both fruit quantity and quality. The optimal timing for thinning is at the onset of pit hardening, which ensures stable fruit set. Hand thinning is recommended for small orchards due to its precision. In contrast, chemical thinning is better suited to large orchards, provided it is applied cautiously based on cultivar and chemical type. A spacing of approximately 10 cm between fruits is advised to achieve uniform growth and optimal fruit development.

AUTHORS CONTRIBUTIONS

- **Akhter Mohammad Doranai** – Conceptualized the study, designed the experimental layout, collected data, performed data analysis, and drafted the manuscript.
- **Ghulam Rasoul Samadi** – Contributed to the methodology design and interpreted the results.
- **Ahmad Jawid Zamany** – Conceptualized the study, assisted in the experimental layout, and contributed to data collection.
- **All authors** – Reviewed and approved the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding authors upon reasonable request.

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