



Flowering, yield and quality of ber (*Ziziphus mauritiana* Lamk.) cultivars

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ABSTRACT

The present investigation was conducted during 2024-25 at the Instructional Farm, Department of Fruit Science, College of Horticulture, Banda University of Agriculture and Technology, Banda (U.P.). The experiment was laid out in a Randomized Block Design with seven cultivars (Thai Apple, Gola, Banarasi Karaka, Umran, Seb, Elaichi, and Kaithli) and three replications to evaluate flowering behaviour, yield, and physico-chemical attributes. Significant differences were observed among cultivars for all parameters studied. Flower initiation occurred from the first to third week of September, and all cultivars exhibited axillary bearing. 'Gola' recorded the highest pollen viability (90.89%), while 'Thai Apple' showed early flowering and superior fruit retention (45.67%). The maximum initial fruit set (26.52%) and yield (58.28 kg plant⁻¹) were recorded in 'Kaithli'. 'Thai Apple' produced heavier fruits (44.66 g) with higher pulp weight (41.58 g). In terms of biochemical attributes, 'Kaithli' recorded the highest TSS (18.25 °Brix), TSS: acid ratio (67.66), and total sugars (11.31%) with minimum acidity (0.27%), whereas 'Thai Apple' showed maximum ascorbic acid content (102.29 mg 100g⁻¹). Based on overall performance, 'Thai Apple' and 'Kaithli' were found superior and are recommended for commercial cultivation under Bundelkhand conditions.

Key words: Ber, flowering, pollen viability, fruit set, fruit retention.

INTRODUCTION

Ber (*Ziziphus mauritiana* Lamk.) is an important indigenous fruit crop widely cultivated in India and China due to its adaptability to arid and semi-arid climates. In India, it is grown extensively in states such as Punjab, Uttar Pradesh, Haryana, Rajasthan, Madhya Pradesh, Bihar, Maharashtra, Assam, Andhra Pradesh, Tamil Nadu, and West Bengal. According to the Department of Agriculture and Farmers Welfare (2021–22), ber occupies about 54,000 ha with a production of approximately 5.96 lakh metric tonnes in India. Ber bears mixed buds containing both vegetative and floral primordia. Flowering generally progresses from the base to the apex of the branch, and fruits attain maturity about 150–154 days after fruit set (Pareek *et al.*, 11). Pollen viability plays a crucial role in fruit set, hybridization, and overall productivity, as a high proportion of sterile pollen may reduce yield. Studies on pollen morphology and physiology are also important for taxonomic classification and varietal improvement (Nair, 8).

Ber is highly tolerant to high temperatures; however, temperatures above 35°C during flowering and fruit set may adversely affect yield (Pareek,

10). Since growth and development are largely temperature-dependent, varietal performance varies across agro-climatic regions (Dillon, 2). In the Bundelkhand region of Uttar Pradesh, limited information is available regarding flowering behaviour, pollen viability, yield, and fruit quality of different ber cultivars. Therefore, systematic evaluation of cultivars under this agro-climatic condition is essential to identify high-yielding and superior quality varieties for commercial cultivation.

MATERIALS AND METHODS

The field experiment was conducted during the 2024-25 season at Banda University of Agriculture and Technology (BUAT), Banda, Uttar Pradesh, India. The experimental site is located at 24°53'–25°55' N latitude and 80°07'–81°34' E longitude and is characterized by a sub-tropical climate with black soil. The region experiences hot summers with temperatures reaching up to 47.75°C and an average annual rainfall of approximately 850-900 mm, concentrated mainly between July and September. The study was carried out on uniform, six-year-old Ber plants. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Seven Ber cultivars served as the treatments: Thai Apple, Gola, Banarasi Karaka, Umran, Seb, Elaichi, and Kaithali. On each sample plant, branches were

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tagged to record the dates of flowering initiation and cessation to determine the total flowering duration. Pollen viability was assessed using 1% acetocarmine stain under a microscope. The percentage of initial fruit set, subsequent fruit drop, and final fruit retention were calculated by counting flowers and developing fruits on tagged branches from the pea stage through to harvest. Total fruit yield (kg/plant) was recorded at harvest. A representative sample of fruits was used to measure physical characteristics, including fruit length (cm), width (cm), volume (cc), fresh weight (g), dry weight (g), pulp weight (g), and stone weight (g). From these data, the specific gravity and pulp-to-stone ratio were calculated. The fruit juice was analysed for key biochemical constituents. Total Soluble Solids (TSS, °Brix) were measured with a hand refractometer. Titratable acidity (as % citric acid) was determined by titration against 0.1 N NaOH. Ascorbic acid (mg/100g) was estimated using the 2, 6-dichlorophenol-indophenol dye titration method. Total sugars, reducing sugars, and non-reducing sugars and the TSS/acid ratio was also calculated.

RESULTS AND DISCUSSION

Flowering was noted from the third week of September to the second week of November. The end

of blooming (85–90% flower opening) was recorded in the last week of September for early cultivars, while total flowering completion spanned from the third week of October to the second week of November (Table 1). These timelines align with the findings reported by Yamdagni *et al.* (20). Furthermore, variability in the flowering period has been observed under Hisar conditions (Nehra *et al.*, 9), suggesting that flowering phenology is governed by an interaction between genetic makeup and environmental factors such as temperature, humidity, and precipitation (Singh *et al.*, 16).

Significant differences were observed in the duration from flowering to fruit set. ‘Thai Apple’ exhibited the shortest flowering duration (43 days), while ‘Umran’ showed the longest (66 days), followed by ‘Kaithali’ (56.33 days). These findings are in conformity with Choudhary *et al.* (1), who recorded maximum full blooming in ‘Gola,’ and highlight the cultivar-specific nature of reproductive phenology. Pollen viability is a critical determinant of fertilization success. ‘Gola’ recorded the highest pollen viability (90.89%), while ‘Thai Apple’ recorded the lowest (65.33%) (Fig. 1). Regarding fruit set, ‘Thai Apple’ took the minimum time (32.67 days) from flowering to set, whereas ‘Umran’ required the maximum time

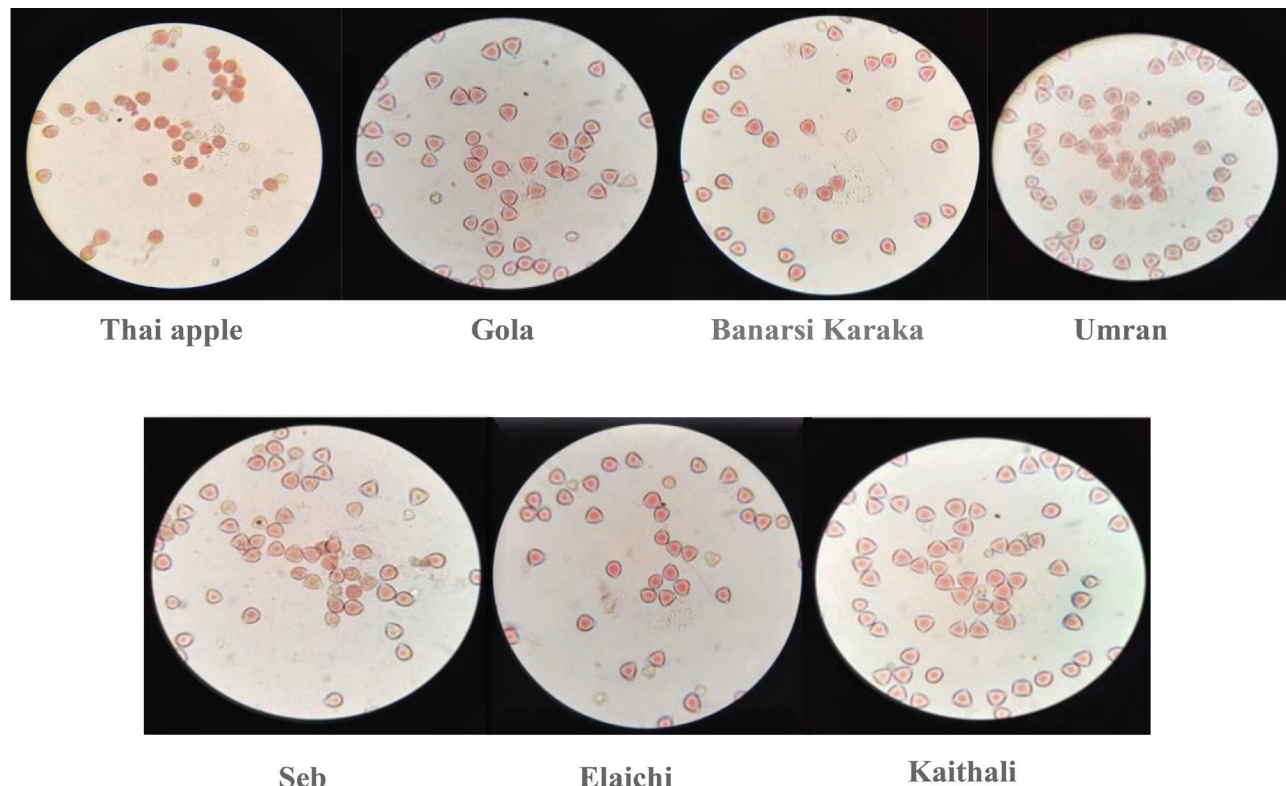


Fig. 1. Evaluation of pollen viability among different cultivars of ber.

Table 1: Flowering behaviour of ber cultivars.

Cultivars	Flowering habit	Initiation of blooming	End of blooming
Thai Apple	Auxiliary bearing	3rd week Sep	24 -31 Oct
Gola	Auxiliary bearing	3rd week Sep	28 Oct-03 Nov
Banarasi Karaka	Auxiliary bearing	2nd week Sep	27 Oct- 03 Nov
Umran	Auxiliary bearing	2nd week Sep	06 -13 Nov
Seb	Auxiliary bearing	3rd week Sep	31 Oct-06 Nov
Elaichi	Auxiliary bearing	2nd week Sep	17 -28 Oct
Kaithali	Auxiliary bearing	2nd week Sep	29 Oct-06 Nov

(40.33 days). These results are supported by Raja (13) and Sharif *et al.* (15). Significant variation in the fruit set percentage was observed across all varieties; 'Kaithali' recorded the maximum set (26.52%), while 'Elaichi' recorded the minimum (14.90%). Such variations are likely due to the inherent genetic characteristics of the cultivars, as noted by Singh *et al.* (17) in 'Banarasi Karaka' (46.83%). The shedding of flowers and immature fruits is a natural thinning process, often influenced by pollination efficiency and environmental stress (Fig. 2).

Fruit drop is a major constraint in ber production, often caused by unsuccessful fertilization or ovule degeneration during the early stages of development. In this study, 'Kaithali' exhibited the highest fruit drop (71.62%), while 'Thai Apple' recorded the minimum (54.33%). Consequently, 'Thai Apple' showed the highest fruit retention (45.67%), followed by 'Gola' (41.98%). In terms of productivity, 'Kaithali' produced the highest yield (58.28 kg/plant), followed by 'Umran' (57.28 kg/plant). 'Elaichi' recorded the lowest yield (35.62 kg/plant), which can be attributed to its lower number of fruits per plant and higher rates of fruit drop during subsequent developmental stages. These yield figures align with those reported by Tarai and Ghosh (18). These findings mirror the variability reported by Choudhary *et al.* (1), who observed fruit drop ranges between 39.59% and 72.77% across different cultivars. 'Thai Apple' (T1) significantly outperformed other cultivars in fruit volume (39.31 cc) and specific gravity (1.14), followed by 'Seb' (29.46 cc; 1.09) and 'Kaithali' (27.88 cc; 1.06). The lowest values were recorded in 'Elaichi' (15.62 cc; 0.91) (Fig. 3).

'Thai Apple' recorded the maximum fruit weight (44.66 g), dry weight (13.83 g), and stone weight (3.08 g). In contrast, 'Elaichi' recorded the minimum values

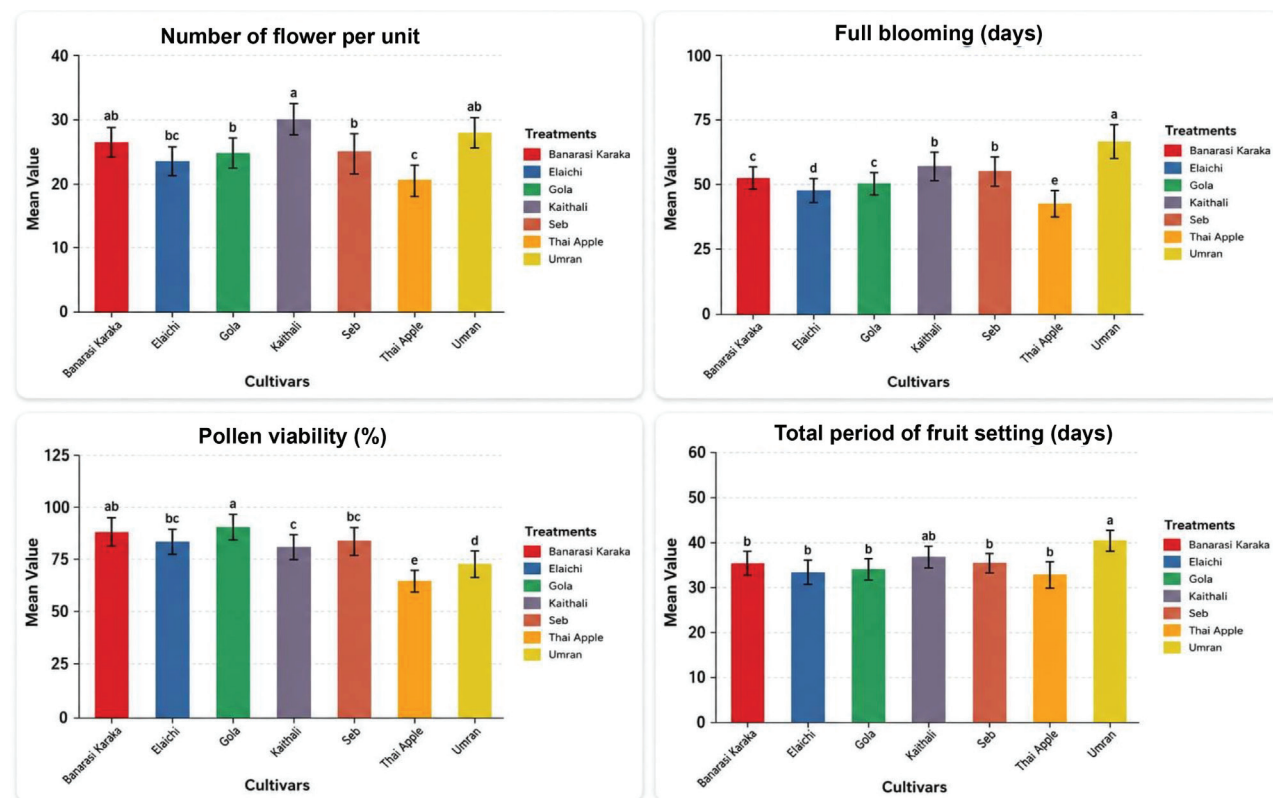


Fig. 2. Study on number of flowers per units, full blooming, pollen viability and total period of fruit setting.

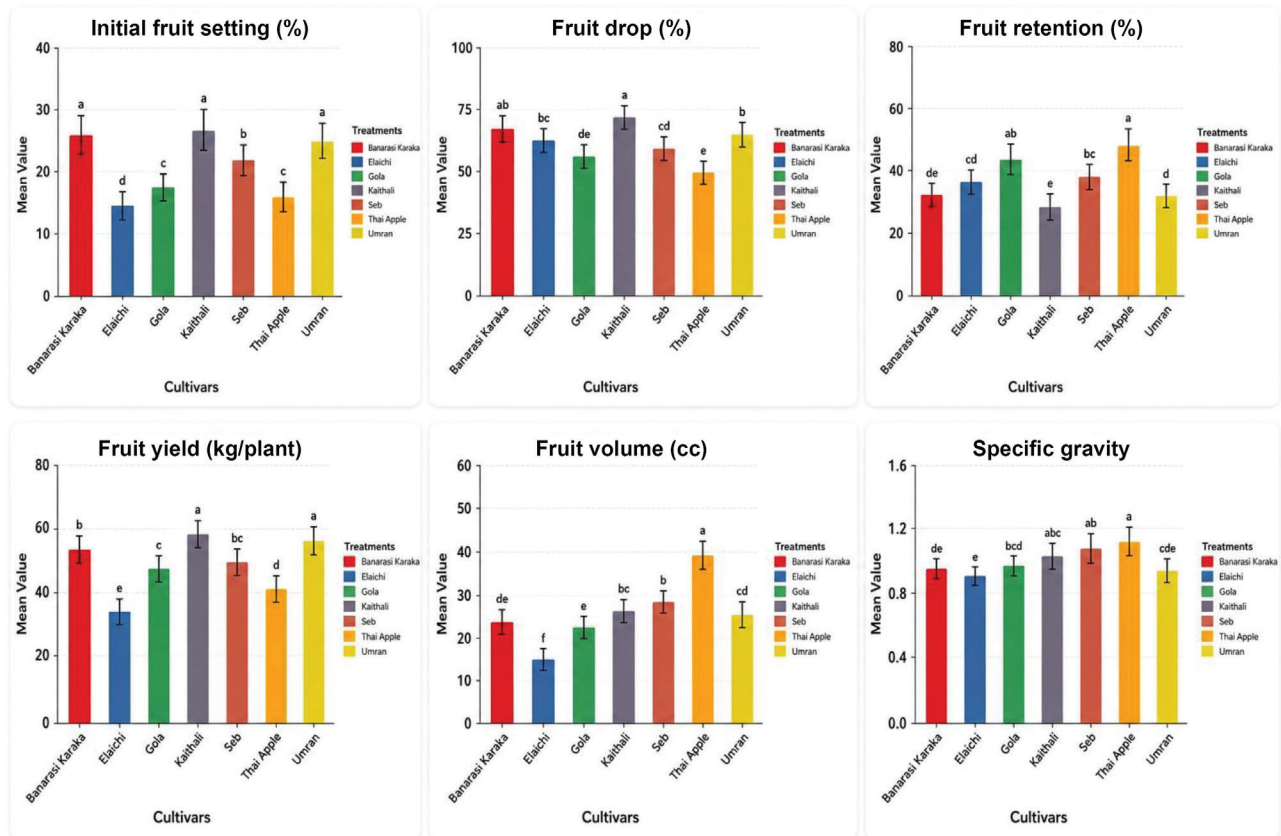


Fig. 3. Study on initial fruit set, fruit drop, fruit retention, yield, fruit volume and specific gravity of different ber cultivars.

for these parameters. Differences in fruit weight among cultivars are often attributed to the duration of fruit maturation on the plant. Increased nutrient and water uptake, alongside efficient photosynthate translocation from source to sink, likely contribute to higher fruit weight (Patil *et al.*, 12). The pulp weight varied significantly, from 12.65 g in 'Elaichi' to 41.58 g in 'Thai Apple.' Similarly, the pulp-to-stone ratio was highest in 'Thai Apple' (13.55) and lowest in 'Elaichi' (7.90). As noted by Kumar *et al.* (4), an increase in fruit weight is closely linked to pulp weight and the deposition of food material. 2018). 'Thai Apple' exhibited the greatest fruit length (6.18 cm) and width (4.18 cm), while 'Elaichi' recorded the lowest. These variations in fruit size are likely due to the differential ability of cultivars to uptake nutrients and their distinct genetic architectures (Kumari *et al.*, 7).

The TSS values ranged from 13.35°B ('Thai Apple') to 18.25°B ('Kaithali'). The higher TSS in 'Kaithali' and 'Umran' (17.84°B) may result from the efficient conversion of polysaccharides into simple sugars during ripening (Kumar *et al.*, 4). Conversely, 'Thai Apple' recorded the highest titratable acidity (0.72%), while 'Kaithali' recorded the minimum (0.27%). This reduction in acidity during ripening

is generally attributed to the conversion of organic acids into sugars or their utilization in respiration (Ram *et al.*, 14). The TSS: acid ratio, a key indicator of fruit palatability, was highest in 'Kaithali' (67.66) and lowest in 'Thai Apple' (18.64). For ascorbic acid (Vitamin C), 'Thai Apple' recorded the maximum content (102.29 mg/100g), whereas 'Kaithali' recorded the minimum (76.53 mg/100g). These variations are likely linked to varietal traits and local environmental factors (Kumar *et al.*, 5; Teatota *et al.*, 19). 'Kaithali' proved superior in sugar content, recording the highest reducing sugars (6.70%), non-reducing sugars (4.64%), and total sugars (11.31%). 'Thai Apple' recorded the lowest values across all sugar categories. The accumulation of sugars during ripening is typically inversely related to moisture content. These results are consistent with the findings of Ibrahim *et al.* (3).

All cultivars exhibited axillary-bearing habits. 'Umran' recorded the earliest flower initiation (first week of September), while 'Thai Apple' was the latest to initiate flowering (third week of September). The maximum number of bearing units was observed in 'Kaithali' (30.00), while the minimum was found in 'Thai Apple' (21.00). 'Elaichi' was the earliest to

complete flowering (mid-October), whereas 'Umran' showed the most delayed flowering conclusion (mid-November). The flowering duration was shortest in 'Thai Apple' (21.67 days) and longest in 'Umran' (32.33 days). 'Gola' recorded the highest pollen viability at 90.89%. Regarding fruit set, the longest total setting period was noted in 'Umran' (40.33 days) and the shortest in 'Thai Apple' (32.67 days). The maximum initial fruit set percentage was recorded in 'Kaithali' (26.52%), while the minimum was observed in 'Elaichi' (14.90%).

Significant variation was observed in fruit drop and retention. The highest fruit drop was recorded in 'Kaithali' (71.62%), while the lowest was in 'Thai Apple' (54.33%). Consequently, 'Thai Apple' achieved the maximum fruit retention (45.67%), whereas 'Kaithali' had the minimum (28.39%). In terms of productivity, 'Kaithali' produced the highest yield (58.28 kg/plant), while 'Elaichi' recorded the minimum (35.62 kg/plant).

'Thai Apple' proved superior in nearly all physical parameters, recording the maximum fruit volume (39.31 cc), average fruit weight (44.66 g), dry fruit

weight (13.83 g), stone weight (3.08 g), and pulp weight (41.58 g). It also exhibited the highest pulp-to-stone ratio (13.55) and fruit dimensions (length: 6.18 cm; width: 4.18 cm). Conversely, 'Elaichi' recorded the lowest values for fruit weight (14.28 g), volume (15.62 cc), length (3.40 cm), and pulp-to-stone ratio (7.90). The highest specific gravity was recorded in 'Thai Apple' (1.14) and the lowest in 'Elaichi' (0.91) (Fig. 4).

'Kaithali' excelled in sugar-related quality traits, recording the maximum TSS (18.25° Brix), TSS: acid ratio (67.66), reducing sugars (6.70%), non-reducing sugars (4.64%), and total sugars (11.31%), while maintaining the minimum titratable acidity (0.27%). In contrast, 'Thai Apple' recorded the lowest values for TSS (13.35° Brix), TSS: acid ratio (18.64), and total sugars (6.87%), but it contained the highest ascorbic acid (Vitamin C) content at 102.29 mg/100g and the highest titratable acidity (0.72%). The minimum ascorbic acid content was observed in 'Umran' (74.31 mg/100g) (Fig. 5).

In summary, for farmers in the Bundelkhand region of Uttar Pradesh, 'Kaithali' is recommended

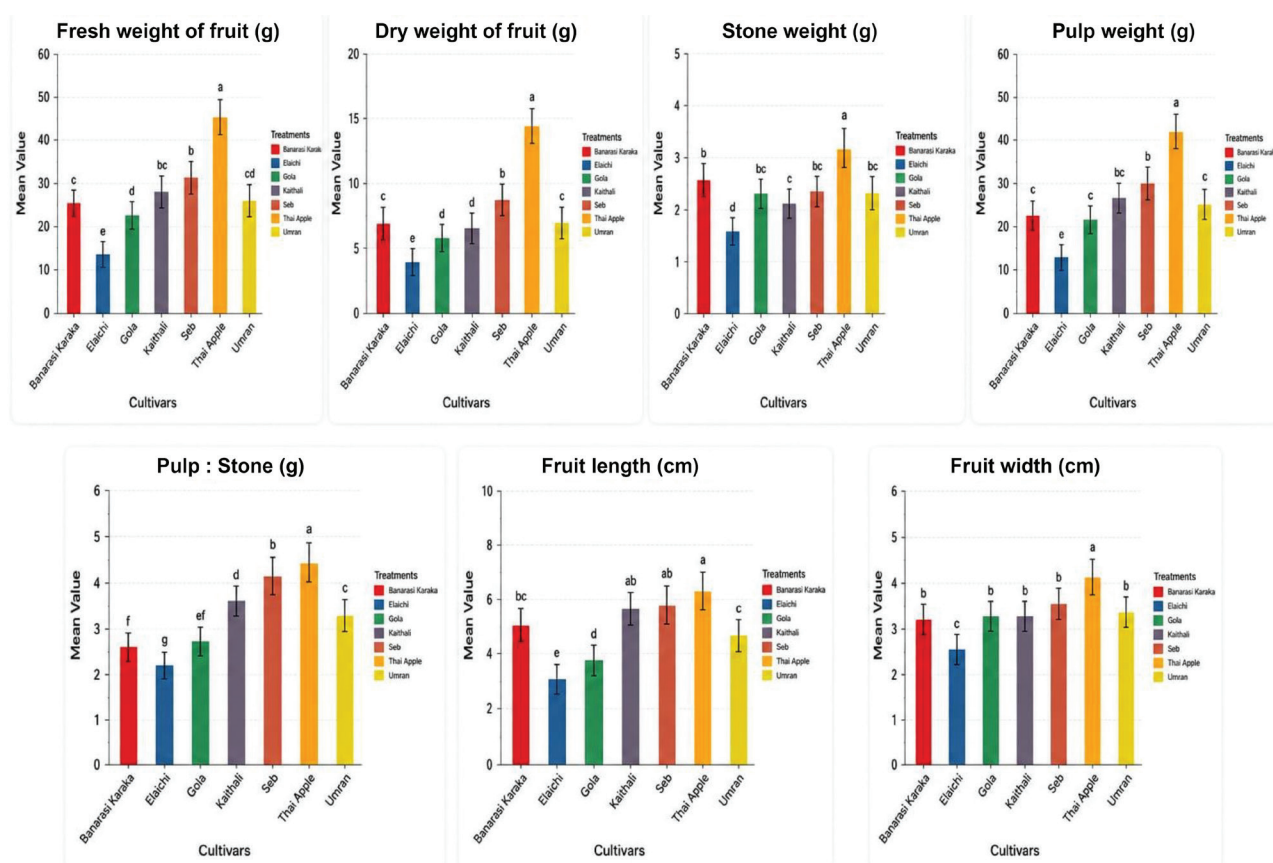


Fig. 4. Study on physical attributes fresh weight of fruit, dry weight of fruit, stone weight, pulp weight, pulp: stone, fruit length and fruit width of different ber cultivars.

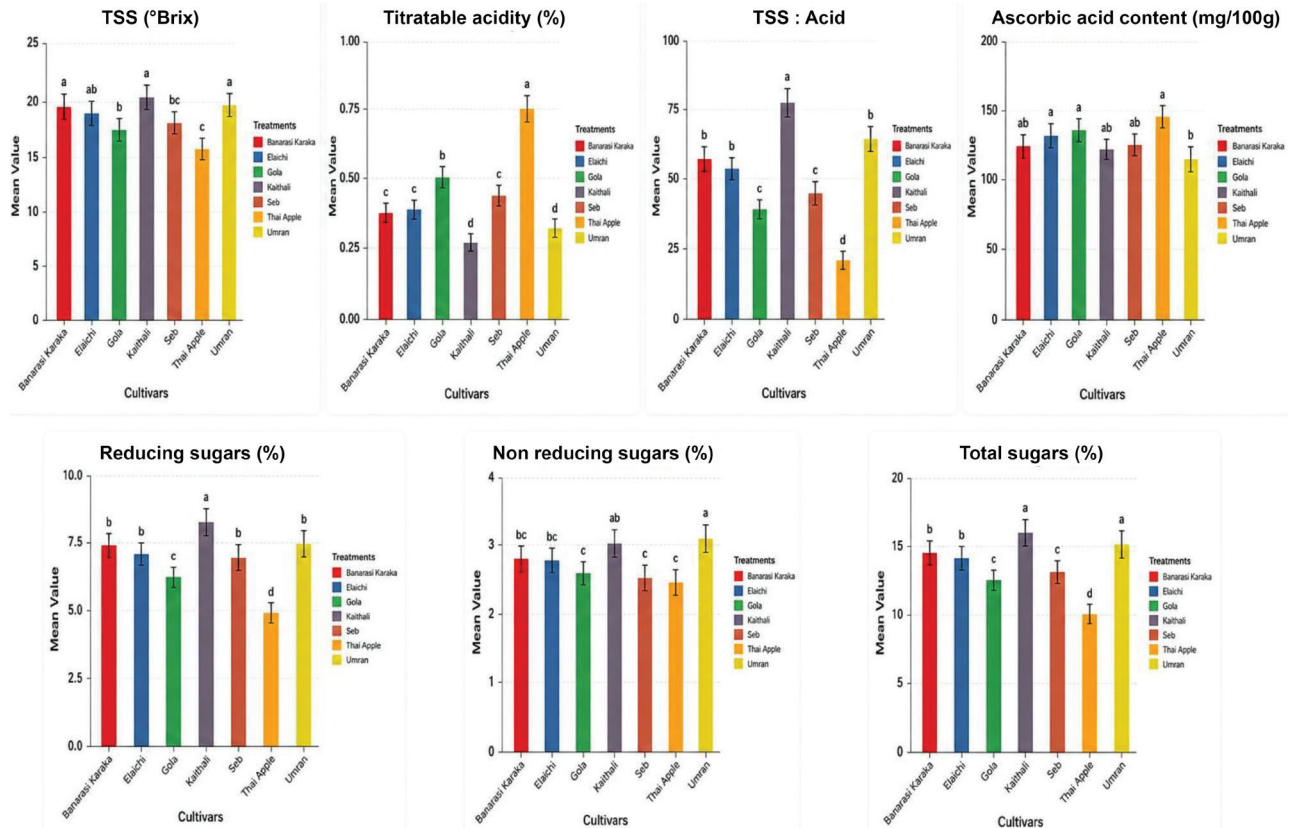


Fig. 5. Study on chemical attributes TSS, titratable acidity, TSS: acid ratio, ascorbic acid, reducing sugars, non-reducing sugars and total sugars of different ber cultivars.

for its high yield and sweetness, while ‘Thai Apple’ is recommended for its superior fruit size and Vitamin C content. These findings facilitate the selection of appropriate cultivars to meet specific market demands and improve the economic returns for ber growers.

AUTHOR'S CONTRIBUTION

Conceptualization of research (KY, OP), designing of the experiments (OP, KY), contribution of experiment materials (KY, BKS), execution of lab experiments (KY, J, VG), analysis of data interpretation (KY, BS) and preparation of manuscript (KY, SCS, PS).

DECLARATION

The authors confirm that no conflicts of interest are associated with this work.

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