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Effect of Pruning and Micronutrient Sprays on Physico-chemical Properties of Ber

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Authors' contributions

This work was carried out in collaboration among all authors. Author BS designed the study and wrote the first draft of the manuscript. Authors UK, AS and RS supervised the investigation. Author SS managed the literature searches. Authors MC and JM performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was undertaken to study the effect of pruning height and micronutrients on the physicochemical properties of ber. The experiment was conducted in the farmer's field at Manikpur area of Bongaigaon district, Assam (26^{0}26′51″ North latitude and 90^{0}46′47″ East longitude) for two consecutive years. Two types of Thailand ber were exposed to two different pruning heights and eight different micronutrient spray combinations. Results depicted that Roundish ovate reddish type variety performed better. The highest total sugar content (14.91%), TSS/acid ratio (44.07) and ash

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content (2.66%) were observed at a pruning height of 75 cm. Among micronutrients, borax at 0.5% and zinc sulphate ($ZnSO_4$) at 0.5% in combination proved to be better in terms of total sugar (14.83%) and ash content (2.64%). So, the experiment proved that a pruning height of 75 cm from the ground level and spraying of borax 0.5% and zinc sulphate 0.5% in combination, were better compared to the other treatments.

Keywords: Ash content; ber; sugar; titratable acidity; TSS.

1. INTRODUCTION

Ziziphus mauritiana Lamk., the Indian ber of the Rhamnaceae family occupies an important place among minor fruits of India. India produces around 513 thousand metric tons of ber annually from around 50 thousand hectares [1]. This fruit crop has been in cultivation in India since very ancient times. The sage Vedavyasa was also popular as 'Badrayan' (the person residing in ber forest) as he created his cottage in the forest where plenty of ber plants were there [2]. The nutritious fruit ber is superior to apple in terms of vitamin C, calcium, phosphorus and protein [3].

Annual pruning is mandatory in ber as it bears fruits on the current season growth [3]. Again, it has been noticed that micronutrients play vital role in fruit set, fruit retention, fruit development and the quality of ber. Boron proved its efficiency in increasing the blooming and retention of flowers and developing seeds and fruit [4]. The stimulation of carbohydrates and proteins in plant cells, as well as the formation of DNA are regulated by the micronutrient zinc, besides its role in the biosynthesis of indole-3-butyric acid [5]. Therefore, an experiment was conducted to assess the role of pruning and micronutrients in the physico-chemical properties of two types of Thailand ber varieties under Assam condition.

2. MATERIALS AND METHODS

The experiment was conducted for two years, 2020-21 and 2021-22, in a farmer's field located at Manikpur area of Bongaigaon district, Assam, India ($26^0 26'51''$ North latitude and $90^0 46'47''$ East longitude). The soil was strongly acidic (pH = 5.1) with high organic carbon content (1.03%).

Two types of Thailand bers were selected as study material, *viz.,* V_1: Round green type, V_2: Roundish ovate reddish type. Heading back system of pruning was followed and two different heights of pruning were considered for the experiment (P_1: 50 cm from the ground level and P_2: 75 cm from the ground level). Pruning was performed just after harvest during March. Borax (11% B) and zinc sulphate (33% Zn) were the two micronutrient sources taken for the study with various levels as N_0: No micronutrient, N_1: Borax 0.4%, N_2: Borax 0.5%, N_3: $ZnSO_4$ 0.4%, N_4: $ZnSO_4$ 0.5%, N_5: Borax 0.4% + $ZnSO_4$ 0.4%, N_6: Borax 0.4% + $ZnSO_4$ 0.5%, N_7: Borax 0.5% + $ZnSO_4$ 0.4%, N_8: Borax 0.5% + $ZnSO_4$ 0.5%. The spraying of micronutrients were done twice, first at fruit set and the next one at 30 days after the first spray. The experimental plots were laid out in three factorial RBD.

2.1 Moisture Content (%)

The moisture content was determined by following standard procedure with the help of the following formula –

$$\text{Moistutre content (\%)} = \frac{\text{Fresh weight (g)} - \text{Dry weight(g)}}{\text{Fresh weight (g)}} \times 100$$

2.2 Total Soluble Solids (TSS)

The fresh fruit was cut into pieces after removal of seed. To make the homogenous mixture, the cut pieces were ground. Then juice was extracted and filtered with a muslin cloth. A drop of juice was placed in the digital hand refractometer to measure the TSS (^{0}Brix) at room temperature.

2.3 Reducing Sugar (%)

Lane-Eynon method was used for determining the reducing sugar.

$$\text{Reducing sugar (\%)} = \frac{\text{mg of invert sugar} \times \text{dilution} \times 100}{\text{titre value} \times \text{weight of sample}}$$

Where, mg of invert sugar = Factor 0.05

2.4 Total Sugar (%)

To determine the total sugar, the Lane-Eynon method was executed.

$$\text{Total invert sugar (\%)} = \frac{\text{mg of invert sugar} \times \text{dilution} \times \text{second volume make up} \times 100}{\text{titre value} \times \text{weight of sample} \times \text{sample kept overnight}}$$

Where, mg of invert sugar = Factor 0.05

Sucrose (%) = {Total invert sugar (%) – Reducing sugar (%)} $\times 0.95$

Total sugar (%) = Sucrose (%) + Reducing sugar (%)

2.5 Non-reducing Sugar (%)

The value of non-reducing sugar was directly calculated by using following formula –

Non-reducing sugar (%) = Total sugar (%) – Reducing sugar (%)

2.6 Titratable Acidity (%)

The titratable acidity was determined in percentage following the procedure prescribed in AOAC [6]. Titratable acidity was calculated in terms of percentage anhydrous citric acid.

$$\text{Titratable acidity (\%)} = \frac{\text{Titre value} \times \text{N} \times \text{V} \times \text{equivalent weight of citric acid} \times 100}{\text{weight of sample} \times \text{aliquot} \times 1000}$$

Where, N = Normality of alkali and V = Volume made up

2.7 TSS/acid Ratio

The ratio of TSS and acid is an important aspect in relation to consumer preference. It was calculated by dividing the value of TSS by the value of titratable acidity.

2.8 Ash Content (%)

The ash content was determined by burning out all the organic material present in the sample in a temperature of 600°C in a muffle furnace [6]. The following calculation was used to find out the ash content –

$$\text{Ash (\%)} = \frac{W_1 - W}{W_2 - W} \times 100$$

Where, W = Weight of the crucible
W_1 = Weight of sample heated at 600°C
W_2 = Weight of crucible + sample

The relevant parameters of the study were subjected to standard statistical procedures [7].

3. RESULTS AND DISCUSSION

The recorded physico-chemical parameters were taken as per standard protocol as mentioned in the materials and methods and are presented and discussed hereunder.

3.1 Moisture Content (%)

Table 1 shows that only variety significantly influenced the fruit moisture content, whereas pruning height and micronutrient sprays had no significant effect on fruit moisture. Variety V_1 recorded maximum moisture of 79.36 percent, which is in conformity with the works of other research workers [8].

3.2 TSS (^{0}Brix)

All three factors *viz.,* variety, pruning height and application of micronutrients significantly affected the total soluble solid content in fruits (Table 1). A TSS value of 15.00 ^{o}Brix in the variety V_2 was the highest and 4.61 ^{o}Brix was noticed in pruning height P_2. This resulted in higher accumulation of photosynthates and minerals in pruned trees, leading to the highest content of TSS in medium pruned trees [9]. Medium pruning (P_2) performed better regarding the TSS content of peach cv. Flordaking [10]. Among the micronutrients, the highest TSS was found in N_8 (14.58 ^{o}Brix) and the lowest in N_0 (13.95 ^{o}Brix). Researchers also observed significant differences among various ber varieties [11]. An open plant canopy allows more sunlight penetration. Boron alone, or in association with Zn had positive influence on fruit TSS content. Boron mediated transport of higher assimilates might be the reason for this [12].

3.3 Total Sugar (%)

As depicted by Table 2, the amount of total sugar in fruit was significantly influenced by variety, pruning and micronutrient treatments. Among varieties, V_2 showed significantly higher total sugar content (15.14%) than V_1 (13.54%). The significant deviation in total sugar content of fruits due to variety tallies the experimental finding of [11]. Pruning height of 75 cm from the ground level (P_2) found to be significantly superior to pruning height of 50 cm from the ground level (P_1) in terms of total sugar content with values of 14.91 and 13.77 percent, respectively. Similarly, a higher amount of total sugar was achieved in 50 percent pruning intensity due to the accumulation of more photosynthates and nutrients in pruned shoots [13]. Among micronutrient levels, N_8 showed significantly higher total sugar content (14.83%) than all other levels, whereas N_0 exhibited the lowest quantity of total sugar (13.86%). The effect of boron can be attributed to its vital role in the translocation of sugar by formation of a 'sugar-borate complex' with sugar in higher plants [14]. Zinc mediated metabolism of starch and nucleic acid might be the cause for the positive effect of this micronutrient in increasing the total sugar content [15].

3.4 Reducing Sugar (%)

The data pertaining to reducing sugar content in fruits also followed the same trend as total sugar content. Table 2 illustrates that reducing sugar content was significantly influenced by variety, level of pruning and micronutrient treatments. Among varieties, V_2 showed significantly higher level of reducing sugar content (8.08%) compared to V_1 (7.37%). Significant difference as a result of variety was also obtained by [8]. Pruning level P_2 (7.99%) performed better than P_1 (7.45%) in terms of reducing sugar content. More synthesis of photosynthates in moderately pruned apple trees as illustrated by [16] might be the probable cause of significant variation achieved due to pruning. As in case of total sugar content, N_8 exhibited significantly higher

Table 1. Moisture and TSS content as influenced by variety, pruning height and micronutrient sprays

Treatments	Moisture (%)			TSS (°Brix)		
	2020 – 21	2021 – 22	Pooled	2020 – 21	2021 – 22	Pooled
V_1	79.73	78.98	79.36	13.53	13.46	13.49
V_2	78.29	78.76	78.52	14.91	15.09	15.00
$CD_{P=0.05}$	**1.18**	**1.00**	**0.70**	**0.07**	**0.05**	**0.04**
P_1	79.23	78.59	78.91	13.86	13.92	13.89
P_2	78.79	79.15	78.97	14.58	14.63	14.61
$CD_{P=0.05}$	**NS**	**NS**	**NS**	**0.07**	**0.05**	**0.04**
N_0	79.46	79.35	79.41	13.91	13.99	13.95
N_1	78.88	79.25	79.07	14.01	14.07	14.04
N_2	79.49	77.96	78.73	14.09	14.12	14.10
N_3	78.91	79.38	79.15	14.16	14.18	14.17
N_4	78.68	80.00	79.34	14.20	14.22	14.21
N_5	79.56	78.10	78.83	14.27	14.32	14.29
N_6	77.10	79.45	78.28	14.35	14.43	14.39
N_7	79.88	79.09	79.49	14.46	14.53	14.49
N_8	79.13	77.23	78.18	14.53	14.63	14.58
$CD_{P=0.05}$	**NS**	**NS**	**NS**	**0.15**	**0.10**	**0.09**

Table 2. Total and reducing sugar content as influenced by variety, pruning height and micronutrient sprays

Treatments	Total sugar (%)			Reducing sugar (%)		
	2020 – 21	2021 – 22	Pooled	2020 – 21	2021 – 22	Pooled
V_1	13.58	13.49	13.54	7.41	7.32	7.37
V_2	15.26	15.03	15.14	8.13	8.03	8.08
$CD_{P=0.05}$	**0.06**	**0.05**	**0.04**	**0.03**	**0.03**	**0.02**
P_1	13.84	13.69	13.77	7.51	7.40	7.45
P_2	15.00	14.83	14.91	8.04	7.94	7.99
$CD_{P=0.05}$	**0.06**	**0.05**	**0.04**	**0.03**	**0.03**	**0.02**
N_0	13.92	13.80	13.86	7.54	7.47	7.50
N_1	14.05	13.92	13.99	7.60	7.52	7.56
N_2	14.17	14.03	14.10	7.65	7.57	7.61
N_3	14.31	14.17	14.24	7.72	7.63	7.67
N_4	14.44	14.26	14.35	7.78	7.67	7.72
N_5	14.57	14.35	14.46	7.83	7.70	7.77
N_6	14.67	14.47	14.57	7.89	7.76	7.83
N_7	14.76	14.58	14.67	7.95	7.81	7.88
N_8	14.89	14.77	14.83	8.00	7.90	7.95
$CD_{P=0.05}$	**0.13**	**0.11**	**0.08**	**0.07**	**0.07**	**0.05**

Table 3. Non reducing sugar and titratable acidity content as influenced by variety, pruning height and micronutrient sprays

Treatments	Non reducing sugar (%)			Titratable acidity (%)		
	2020 – 21	2021 – 22	Pooled	2020 – 21	2021 – 22	Pooled
V_1	6.17	6.18	6.17	0.32	0.31	0.32
V_2	7.13	7.00	7.07	0.53	0.53	0.53
$CD_{P=0.05}$	**0.040**	**0.031**	**0.023**	**0.008**	**0.008**	**0.006**
P_1	6.33	6.30	6.31	0.49	0.48	0.48
P_2	6.96	6.88	6.92	0.37	0.36	0.36
$CD_{P=0.05}$	**0.040**	**0.031**	**0.023**	**0.008**	**0.008**	**0.006**
N_0	6.39	6.33	6.36	0.48	0.48	0.48
N_1	6.45	6.41	6.43	0.47	0.46	0.46
N_2	6.52	6.47	6.49	0.45	0.44	0.45
N_3	6.59	6.55	6.57	0.44	0.42	0.43
N_4	6.67	6.59	6.63	0.43	0.42	0.42
N_5	6.74	6.64	6.69	0.41	0.40	0.41
N_6	6.77	6.71	6.74	0.40	0.40	0.40
N_7	6.81	6.77	6.79	0.38	0.37	0.37
N_8	6.89	6.86	6.88	0.38	0.38	0.38
$CD_{P=0.05}$	**0.086**	**0.065**	**0.049**	**0.016**	**0.017**	**0.012**

Table 4. TSS/acid ratio and ash content as influenced by variety, pruning height and micronutrient sprays

Treatments	TSS:acid			Ash (%)		
	2020 – 21	2021 – 22	Pooled	2020 – 21	2021 – 22	Pooled
V_1	44.08	46.57	45.33	2.37	2.38	2.37
V_2	28.90	29.25	29.07	2.65	2.66	2.65
$CD_{P=0.05}$	**0.861**	**1.016**	**0.655**	**0.015**	**0.013**	**0.010**
P_1	30.02	30.63	30.33	2.35	2.39	2.37
P_2	42.96	45.19	44.07	2.66	2.65	2.66
$CD_{P=0.05}$	**0.861**	**1.016**	**0.655**	**0.015**	**0.013**	**0.010**
N_0	31.14	31.34	31.24	2.39	2.41	2.40
N_1	31.40	33.25	32.32	2.43	2.44	2.44
N_2	33.74	34.89	34.32	2.45	2.46	2.46
N_3	34.02	36.96	35.49	2.48	2.48	2.48
N_4	35.30	38.32	36.81	2.51	2.52	2.51
N_5	38.34	39.26	38.80	2.53	2.54	2.53
N_6	39.06	40.61	39.83	2.56	2.57	2.57
N_7	43.09	42.98	43.04	2.60	2.62	2.61
N_8	42.33	43.56	42.94	2.63	2.64	2.64
$CD_{P=0.05}$	**1.827**	**2.155**	**1.389**	**0.031**	**0.028**	**0.020**

content of reducing sugar (7.95%) compared to all other levels. Again, N_0 exhibited the lowest content reducing sugar (7.50%). Besides aiding in sugar transport, source to sink movement of growth regulators is also regulated by boron [17]. Conversion of starch to sugar through hydrolysis is promoted by zinc. As a result, significantly higher amount of reducing sugar in zinc treated fruits were obtained [18].

3.5 Non-reducing Sugar (%)

Table 3 depicted that all the factors *i.e.* variety, pruning level and micronutrient sprays, had significant effect on the non-reducing sugar content of Thailand ber fruit. The variety V_2 (7.07%) was significantly superior to V_1 (6.17%) in terms of non-reducing sugar content. This variation occurred because of significant diversity in total sugar and reducing sugar content among varieties. In case of pruning, P_2 (6.92%) performed significantly better than P_1 (6.31%) in regards to non-reducing sugar content of fruits. More assimilation of food material increased the non-reducing sugar content in medium pruned ber trees [9]. Similar observations in ber were also reported earlier [19]. Non-reducing sugar content of N_8 was significantly higher (6.88%) compared to all other micronutrient treatments, while, N_0 exhibited the lowest content non reducing sugar (6.36%). As a result of significant impact of boron and zinc on total sugar and reducing sugar, significant effect of these micronutrients were also noticed in case of non-reducing sugar content.

3.6 Titratable Acidity (%)

Significant variations were noted in the titratable acidity of fruits in regards to variety, pruning and micronutrient level (Table 3). Variety V_1 recorded significantly lower titratable acidity of 0.32 per cent, while compared with V_2 (0.53%). As found in the current study, significant effect of variety on titratable acidity of fruits were also noticed by other workers [11]. In pruning, P_2 exhibited the lowest titratable acidity of 0.36 percent compared to P_1 (0.48%). Reduction in pruning intensity significantly reduced the titratable acidity in the present investigation, which conforms the illustration of [20], which could be attributed to either the conversion of acid to sugar or the utilization of acids in the process of metabolism. Among different levels of micronutrients, N_7 recorded the lowest level of titratable acidity with value of 0.37 percent, which was at par with 0.38 percent recorded in N_8. Further, the highest titratable acidity was found in N_0 (0.48%). The probable cause for the phenomenon might be the conversion of acids to sugar due to reversal of glycolytic pathway or acids utilized in respiration as a substrate or both [21].

3.7 TSS/acid Ratio

The ratio of total soluble solid and acid differed significantly with respect to variety, pruning and micronutrient levels (Table 4). A significantly higher value of 45.33 was observed in V_1, while V_2 recorded a value of 29.07. In regards to pruning height, P_2 exhibited a significantly higher TSS/acid ratio of 44.07 than P_1 (30.33). The ratio of TSS/acid was the maximum in N_7 (43.04) closely followed by N_8 (42.94). The lowest TSS/acid ratio was found in N_0 (31.24) closely followed by N_1 (32.32). Interaction studies revealed significant difference of TSS/acid ratio among various interaction (Table 4). More TSS and less titratable acidity tends to higher TSS/acid ratio and vice versa. The probable reasons already discussed which led to variation in TSS and titratable acidity. The significant variation in TSS and titratable acidity led to significant changes in TSS/acid ratios.

3.8 Ash Content (%)

A view of Table 4 enlightened that all the factors *i.e.* variety, pruning height and micronutrient levels had significant influence on the ash content of Thailand ber fruits under study. The ash content of V_2 was 2.65 percent, significantly superior to V_1 (2.37%). As observed in the current investigation, significant varietal differences among Thai apple ber accessions were also observed [8]. Significantly higher ash content was witnessed in P_2 (2.66%) compared to P_1 (2.37%). Moderate pruning provides more open canopy of ber plants, which aids in penetration of more sun rays leading to more production of photosynthates [2], which in turn triggers changes in ash content. The micronutrient treatment N_8 was found to be the best in terms of ash content and the value of 2.64 per cent was significantly higher than all other micronutrient treatments. The lowest ash content was detected in N_0 with a value of 2.40 percent. Application of micronutrient boron enhances the uptake and transport of other nutrients, *viz*., N, P, K, Cu, Zn and Fe from soil [22] which instigated increase in ash content of fruits. Zinc influenced ash content positively being a constituent of the enzyme carbonic anhydrase, which is a mandatory enzyme for photosynthesis [23].

4. CONCLUSION

In the present study, it was revealed that Roundish ovate reddish type variety (V_2) was superior to the Round green type variety (V_1) in terms of physico-chemical parameters. In regards to those parameters pruning height of 75 cm (P_2) was better and micronutrient sprays with Borax 0.5% and Zinc Sulphate 0.5% (N_8) performed the best. On the basis of results, the best pruning height and micronutrient sprays can be advocated for adoption.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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