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Studies on effect of foliar sprays of nutrients on growth and quality of apple ber (*Zizyphus mauritiana*)

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Abstract
The present research entitled "Effect of different levels of pruning and plant nutrients on vegetative growth, yield and quality of Apple ber (*Zizyphus mauritiana*)" was carried out during May, 2019 to January, 2020 at Horticulture Research Station (HRS), Konda Mallepally, Nalgonda District, Telangana. The experiment was laid in factorial randomized block design with 21 treatments 3 replications. The results pertaining to growth parameters shoot length (76.07 cm), number of shoots for branch (26.64) were noticed with the Urea 1.0%. The results pertaining to quality parameters maximum total soluble solids (12.46 ºBrix), reducing sugars (6.29%), non-reducing sugars (7.50%), and total sugars (12.47%) and Ascorbic acid (81.0%) and and shelf life (17.07 days) are exhibited by the application of 1.5% Potassium Nitrate. significantly affected by treatments of pruning during experiment.

Keywords: Apple ber, potassium nitrate, calcium chloride, urea and water spray

Introduction
Apple ber (*Ziziphus mauritiana*) is a Thailand variety ber and hardy minor tropical fruit, belongs to the family Rhamnaceae. Apple ber is developed by grafting Thailand green apple with Thai local ber. This fruit resembles green apple in its appearance and tastes like ber, hence the name Apple ber. It is also called as Apple plum or Jujube berry. The genus *Ziziphus* comprises about 40 species distributed throughout the tropical and subtropical regions of the world. Among various species, *mauritiana* is commercially cultivated for its nutritive and edible fruits. It is popularly known as poor man's fruit of tropics.

In India apple ber cultivation first started in Maharashtra, later extended to other states like Gujarat and Telangana. In Telangana it is cultivated commercially in Hyderabad, Mahbubnagar, Medak, Warangal and Khammam districts. It is also popularly known as "Telangana Apple" in Telangana state. The weight of each fruit is 60-150g. It is very attractive, sweet, crispy and juicy. In recent years farmers are showing interest in cultivation of apple ber when compared to ber due to its unique traits like thorn less nature, high yielding, early crop, ease of cultivation in terms of harvesting and wider adaptability to grow in any type of soil with less consumption of water. It has ability to withstand extreme summer, heavy rains, heavy winds and extreme winter.

Material and Methods
The experiment was conducted at existing 4 years aged apple ber orchard at Department of Horticulture, Horticulture Research Station, SKLTSHU, Konda Mallepally, Nalgonda District, Telangana State during 2019-2020. The materials used, techniques adopted and observation recorded during the course of investigation. The experiment was laid out in Factorial Randomized Block Design (FRBD) in three replications with 21 treatment combinations comprised of three levels of *viz*., foliar spray of nutrients N_1- Potassium Nitrate @ (1.0%), N_2- Potassium Nitrate @ (1.5%), N_3- Urea @ (0.5%), N_4- Urea |@ (1.0%), N_5- Calcium Chloride @ (0.25%), N_6- Calcium Chloride @ (0.50%), N_7- Water spray (control).

Observations recorded
Number of shoots emerged per branch: The number of main branches present in Apple ber tree was counted as primary branches. The number of secondary branches on each primary branch was counted and average was computed to express as number of secondary branches.

Shoot length (cm): It was recorded from the base to the apex of the shoot with the help of a meter scale and expressed in cm.

Total soluble solids (˚Brix): Total soluble solids of apple ber pulp was determined by using a hand refractometer, 0-32 scale (Erma, Japan) corrected at 20ºC and expressed in ˚Brix (Ranganna, 1986) [10] at the time of harvest.

Total sugars (%): Total sugars in apple ber juice were determined by Lane and Eynon (AOAC, 1980) method. The 25 ml of sample was taken from the 100 ml of sample in to a conical flask, and added 5 ml of HCL to the sample kept for 24 hr. in dark place. Volume was made up to 100 ml. In another conical flask add 5ml of each Fehling A and B Fehling and 25 ml of distilled water was also added. Two drops of methylene blue indicator to the solution and put on hot flame when bubbles were formed and then titrated against sample that was taken in to burette. Formation of brick red colour was the end point and noted the titre value and substituted in the following formula:

$$\text{Total sugars (\%)} = \frac{\text{Factor value x Dilution 1 x Dilution 2 x 100}}{\text{Titre value x weight of sample x Aliquot taken (ml)}}$$

Reducing sugars (%): Reducing sugars were estimated by the procedure given by Lane and Eynon (AOAC, 1980) method. According to this method 10 gm of fruit juice was taken, blended with 25-50 ml of distilled water and transferred to 250ml of volumetric flask. Then 2 ml of 45% lead acetate was added to the sample, kept it for ten minutes it turned to white colour colloidal matter. Sample was filtered through Whatman no.1 filter paper. Then add 2 ml of Potassium Oxalate 22% to remove excess lead. Total sample was made up to 100 ml volume in conical flask. Mixed well and filtered through Whatman no.1 filter paper and this was filled into burette and used for analysis. In a conical flask Fehling A and B was taken each of 5ml and 25-30ml of distilled water was added to that solution. Add 1-2 drops of methylene blue indicator and boiled the solution against flame till bubbles appear. Then titrate sample against the filtrate taken in burette. Formation of brick red colour indicates for the end point. Noted the titre value and substituted in the following formula:

$$\text{Reducing sugars} = \frac{\text{Factor value (0.05) x dilution x 100}}{\text{Titre value x weight of sample}}$$

Non-reducing sugars (%): The non-reducing sugar content in apple ber juice was determined by subtracting the total sugars from the reducing sugars.

Non reducing sugars = Total sugars – Reducing sugars

Titrable Acidity (%): Acidity was estimated by adopting the procedure described by Ranganna (1986) [10]. Ten grams of sample was ground with pestle and mortar and transferred to volumetric flask and volume was made up to 100 ml with distilled water. The extracted juice is filtered through Whatman No.1filter paper. An aliquot of 10 ml was taken into a conical flask and 2-3 drops of phenolphthalein indicator was added and then titrated against 0.1N NaOH. Appearance of light pink colour denotes the end point. It was calculated using the following formula and expressed in percentage. (Eq. wt. of citric acid = 0.064).

$$\text{Acidity (\%)} = \frac{\text{Titre x Normality of NaOH x Eq. Wt. of acid x volume made up x100}}{\text{Volume of sample taken for estimation x weight of sample x 100}} \text{ X100}$$

Ascorbic acid (mg / 100ml of juice): Ascorbic acid in apple ber juice was determined by the procedure elicited by the (AOAC, 1997) method. Ascorbic acid reduced oxidation-reduction indicator dye, 2, 6- phenolindophenol to colourless solution. After the ascorbic acid was oxidized to dehydro ascorbic acid, excess dye changes to pink color in acid solution. At end point, excess unreduced dye was rose pink in acid solution 2.5 ml of apple ber juice was homogenized well with 20 ml of 3% metaphosphoric acid and filtered through double layers dye of muslin cloth. The filtrate was titrated with 2, 6- dichlorophenol indophenol solution. The amount of vitamin C in the extract was determined by comparing with the titration curve of standard vitamin C solution. Result was expressed in mg/100ml of juice.

Calculations

$$\text{Ascorbic acid (mg /100 g)} = \frac{\text{Titre x Dye factor x Vol. made up}}{\text{Wt. of sample x Aliquot taken}} \text{ X100}$$

Shelf life (days): The shelf life of fruits was determined by recording the number of days the fruits remained in good condition during storage without spoilage. When the spoilage of fruits exceeded 50% it was considered as the end of shelf life or storage life and recorded the number of days.

Results and Discussion

1. Shoot length (cm)

The collective data revealed that significant variation was recorded in foliar spray of plant nutrients. The highest shoot length (78.83 cm) was noticed with 1% Urea followed by 0.25% Calcium Chloride (77.17 cm) and 0.5% Calcium chloride whereas, minimum shoot length (63.77 cm) was noticed in water spray (Table 1)

The increase in vegetative growth of the ber plant by foliar spray of urea may be attributed to the association of nitrogen in synthesis of protoplasm and in the primary manufacture of amino acids and increasing auxin activities. As results meristematic activities increased which in turn increase the vegetative growth. (Shankar *et al.*, 2002) [13].

2. Number of shoots emerged per branch

The collective data revealed that significant variation was recorded in different foliar spray of plant nutrients. The highest number of shoots emerged per branch (26.94) was noticed with 1% Urea closely followed by 0.25% Calcium Chloride (26.94) and minimum number of shoots emerged per branch (25.88) was noticed in water spray (Table 2).

The increase in vegetative growth of the ber plant by foliar spray of urea may be attributed to the association of nitrogen in synthesis of protoplasm and in the primary manufacture of amino acids and increasing auxin activities. As results meristematic activities increased which in turn increase the vegetative growth. (Shankar *et al.*, 2002) [13].

3. Total Soluble Solids (ºBrix)

Significant difference was noted in relation to foliar sprays of plant nutrients. The highest total soluble solids was recorded with 1.5% Potassium Nitrate (12.74 ºBrix) followed by 0.5% Urea (12.39 °Brix). The lowest total soluble solids were obtained in control (11.50 °Brix) (Table 3).

The highest total soluble solids (12.46 °Brix) was observed in treatment pruning at 30 cm which was followed by pruning at 20 cm (11.89 °Brix) and significantly superior over the other treatments. While the lowest total soluble solids (11.79 °Brix) was obtained in control.

findings of Sheikh and Rao (2002) [14] in pomegranate, Prakash *et al.* (2012) [7] in guava, Sahar and Hameed (2014) [11] in guava and Dahapute *et al.* (2018) [2] in custard apple.

4. Total Sugars (%)

Significant difference was noted in relation to foliar spray of nutrients. The highest total sugars (13.00%) was observed with water spray followed by potassium nitrate 1.5% which is on par with calcium chloride 0.25% (12.33%) and lowest total sugars (11.16%) was recorded in un pruned trees with (Table 4).

The maximum total sugars (14.00%) were observed in treatment pruning at 30 cm in combination with 1.5% Potassium Nitrate. This might due to increase nutrient uptake by the trees and consequently more synthesis of carbohydrates and other metabolites and their translocation to the fruits. These results are in conformity with the findings of Kadam *et al.* (2018) [4] in custard apple.

5. Reducing sugars (%)

Significant difference was noted in relation to different foliar sprays of plant nutrients; the highest reducing sugar (6.06%) was observed in 1.5% Potassium Nitrate and followed by 0.50% Calcium Chloride (6.00%) and reducing sugars (5.21%) was recorded in water spray (Table 5).

Spraying plant nutrients found to be effective in increasing the reducing sugar content of fruit. Pruning play major role in sugars metabolism and translocation and similar results were reported by Sutanu *et al*. (2017) [15] in pomegranate.

6. Non-reducing sugars (%)

The data regarding the non-reducing sugars (%) of apple be was significantly affected by foliar sprays of nutrients. The treatment, Potassium Nitrate (1.5%) recorded highest non-reducing sugars (7.40%) which was on par with 1% Potassium Nitrate (6.69%). However, lowest non-reducing sugars (5.83%) was observed in control (Table 6).

plant nutrients application and pruning probably augmented the conversion of starch to sugar and it has also been opined that plant growth regulators application and pruning increases transportation of sugars, hydrolysis of complex polysaccharides into simple sugars, synthesis of metabolites and rapid translocation of photosynthates and minerals from other parts of the plant to developing fruits (Sankar *et al.*, 2013) [12]. These findings are in agreement with those of Rajput and Chand (1975) [8], Vikas *et al.* (2013) [16], Pandey *et al*. (1988) [6].

7. Titrable acidity (%)

The collective data revealed that significant variation was recorded in plant nutrients. The maximum titrable acidity (0.45%) was observed in control followed by on par with 0.25% Calcium Chloride (0.43%).and 1% potassium nitrate (0.43%) However, lowest titrable acidity (0.39%) was observed in the 1.5% Potassium Nitrate. and on par with 0.5% Calcium Chloride (0.35%) (Table 7).

The titrable acidity was significantly increased with application of nutrients. This is due to its action on converting complex substances into simple ones, which enhances the metabolic activity in fruits. It results in increased total sugar of fruit and decreases the ascorbic acid and the same results found by Prakash *et al*. (2012) [7] in guava.

8. Ascorbic acid (mg/100 ml of juice)

The data presented in the Table 4.3.6 revealed that there were significant differences in the ascorbic acid with the plant nutrients. The treatment, Potassium Nitrate 1% & 1.5% recorded with maximum ascorbic acid (78.60 and 81.00%) and lowest ascorbic acid (73.00%) was observed in control (Table 8).

It results in increased total sugar of fruit and decreases the ascorbic acid and the same results found by Prakash *et al.* (2012) [7] in guava, Baiea *et al.* (2015) [1] in mango, Shashank *et al.* (2016) [13] in anola, Krishna *et al*. (2017) [5] in guava, Ramesh and Singh (2015) [9] in aonla.

9. Shelf life (Days)

The Table 9 revealed that there was significant differences in the shelf life at ambient temperature However, the maximum shelf life (17.07 days) was noted in 0.5% calcium chloride and minimum shelf life (15. 02 days) was recorded in control.

In the present investigation, shelf life increased with calcium sprays might be due to the fact that calcium, as a constituent of the cell wall, plays a important role in forming cross-bridges, which influence cell wall strength and regarded the last barrier before cell separation. Calcium spray during fruit development provides a safe mode of supplementing endogenous calcium to fresh fruits. Calcium having profound effect on the cell wall (Goutam *et al*. 2010) [3].

Table 1: Effect of different levels of pruning and foliar sprays of nutrients on shoot length (cm) of Apple ber (*Zizyphus mauritiana*).

Treatments	**Nutrients spray (B)**							
Pruning (A)	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**N_6**	**N_7**	**Mean**
P_1- Medium pruning (20 cm) on previous season growth	80.33	60.50	65.50	75.50	70.50	73.50	65.33	70.05^{b}
P_2- Heavy pruning (30 cm) on previous season growth	72.50	62.50	74.50	90.50	85.50	83.50	63.50	76.07^{a}
P_3- Control (Un pruned)	61.50	70.16	72.50	70.50	75.50	74.35	62.50	69.57^{c}
Mean	71.44^{C}	64.38^{E}	70.83^{D}	78.83^{A}	77.17^{B}	77.16^{B}	63.77^{F}	
	"F" Test			SE(m)±		CD at 5%		
Factor (A)	*			0.040		0.114		
Factor(B)	*			0.061		0.175		
A×B	*			0.106		0.303		

Table 2: Effect of different levels of pruning and foliar sprays of nutrients on number of shoots for branch of Apple ber (*Zizyphus mauritiana*)

Treatments	Nutrients spray (B)							
Pruning (A)	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**N_6**	**N_7**	**Mean**
P_1- Medium pruning (20 cm) on previous season growth	24.50	25.50	26.50	27.50	27.66	28.50	26.33	26.64^{a}
P_2- Heavy pruning (30 cm) on previous season growth	25.50	23.83	24.50	29.50	28.50	23.16	25.88	25.88^{b}
P_3- Control (Un pruned)	25.16	24.16	26.50	23.50	24.50	24.33	25.50	24.81^{c}
Mean	25.05^{F}	24.50^{G}	25.83^{C}	26.94^{A}	26.88^{B}	25.33^{D}	25.88^{E}	
	"F" Test			SE(m)±		CD at 5%		
Factor (A)	*			0.078		0.223		
Factor(B)	*			0.119		0.340		
A×B	*			0.206		0.596		

Table 3: Effect of different levels of pruning and foliar sprays of nutrients on total soluble solids (°Brix) of Apple ber (*Zizyphus mauritiana*)

Treatments	Nutrients spray (B)							
Pruning (A)	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**N_6**	**N_7**	**Mean**
P_1- Medium pruning (20 cm) on previous season growth	11.52	12.08	12.52	11.55	11.61	12.05	11.90	11.89^{b}
P_2- Heavy pruning (30 cm) on previous season growth	12.00	14.13	12.50	12.03	12.00	13.00	11.60	12.46^{a}
P_3- Control (Un pruned)	11.80	12.00	12.16	12.02	11.56	12.03	11.00	11.79^{c}
Mean	11.77^{E}	12.74^{A}	12.39^{B}	11.86^{D}	11.72^{E}	12.36^{C}	11.50^{F}	
	F Test			SE(m)±		CD at 5%		
Factor (A)	*			0.04		0.13		
Factor(B)	*			0.07		0.20		
A×B	*			0.12		0.35		

Table 4: Effect of different levels of pruning and foliar sprays of nutrients on total sugars (%) of Apple ber (*Zizyphus mauritiana*)

Treatments	Nutrients spray (B)							
Pruning (A)	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**N_6**	**N_7**	**Mean**
P_1- Medium pruning (20 cm) on previous season growth	12.50	12.00	12.49	12.00	12.00	12.48	11.50	12.14^{b}
P_2- Heavy pruning (30 cm) on previous season growth	13.00	14.00	11.66	12.16	12.98	11.52	12.00	12.47^{a}
P_3- Control (Un pruned)	12.50	13.00	12.00	11.50	12.03	12.00	11.16	12.02^{c}
Mean	12.66^{B}	13.00^{A}	12.05^{D}	11.88^{E}	12.33^{C}	12.33^{C}	11.55^{F}	
	F Test			SE(m)±		CD at 5%		
Factor (A)	*			0.04		0.12		
Factor(B)	*			0.06		0.19		
A×B	*			0.11		0.34		

Table 5: Effect of different levels of pruning and foliar sprays of nutrients on reducing sugars (%) of Apple ber (*Zizyphus mauritiana*)

Treatments	Nutrients spray (B)							
Pruning (A)	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**N_6**	**N_7**	**Mean**
P_1- Medium pruning (20 cm) on previous season growth	5.56	5.33	5.00	4.33	6.00	6.00	5.56	5.39^{B}
P_2- Heavy pruning (30 cm) on previous season growth	6.33	7.50	6.16	5.50	5.50	7.00	5.57	6.29^{A}
P_3- Control (Un pruned)	5.66	5.36	5.36	5.00	5.50	5.00	4.50	5.19^{C}
Mean	5.85^{C}	6.06^{A}	5.50^{D}	4.94^{F}	5.83^{C}	6.00^{B}	5.21^{E}	
	F Test			SE(m)±		CD at 5%		
Factor (A)	*			0.069		0.197		
Factor(B)	*			0.105		0.312		
A×B	*			0.183		0.524		

Table 6: Effect of different levels of pruning and foliar sprays of nutrients on non-reducing sugars (%) of Apple ber (*Zizyphus mauritiana*)

Treatments	Nutrients spray (B)							
Pruning (A)	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**N_6**	**N_7**	**Mean**
P_1- Medium pruning (20 cm) on previous season growth	6.73	6.83	8.00	7.70	6.46	6.00	5.63	6.76^{b}
P_2- Heavy pruning (30 cm) on previous season growth	6.43	8.23	6.76	7.00	6.83	7.66	6.00	6.98^{a}
P_3- Control (Un pruned)	6.90	7.13	7.00	6.60	6.40	5.70	5.86	6.51^{c}
Mean	6.69^{C}	7.40^{A}	7.25^{B}	6.56^{D}	6.56^{D}	6.45^{E}	5.83^{F}	
	F Test			SE(m)±		CD at 5%		
Factor (A)	*			0.051		0.732		
Factor(B)	*			0.079		0.112		
A×B	*			0.137		0.442		

Table 7: Effect of different levels of pruning and foliar sprays of nutrients on titrable acidity (%) of Apple ber (*Zizyphus mauritiana*)

Treatments	Nutrients spray (B)							
Pruning (A)	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**N_6**	**N_7**	**Mean**
P_1- Medium pruning (20 cm) on previous season growth	0.47	0.38	0.35	0.40	0.45	0.40	0.46	0.42^{b}
P_2- Heavy pruning (30 cm) on previous season growth	0.38	0.30	0.43	0.35	0.38	0.35	0.47	0.38^{a}

P_3- Control (Un pruned)	0.45	0.45	0.46	0.45	0.43	0.45	0.48	0.45^c
Mean	0.43^B	0.39^D	0.41^C	0.38^D	0.43^B	0.40^C	0.45^A	
	F Test			SE(m)±		CD at 5%		
Factor (A)	*			0.004		0.013		
Factor(B)	*			0.007		0.021		
A×B	*			0.012		0.031		

Table 8: Effect of different levels of pruning and foliar sprays of nutrients on ascorbic acid (mg/100ml of juice) of Apple ber (*Zizyphus mauritiana*).

Treatments	**Nutrients spray (B)**							
Pruning (A)	N_1	N_2	N_3	N_4	N_5	N_6	N_7	Mean
P_1- Medium pruning (20 cm) on previous season growth	78.60	80.02	78.00	77.30	77.00	76.00	79.90	78.14^a
P_2- Heavy pruning (30 cm) on previous season growth	78.01	81.00	76.00	77.00	78.00	74.00	73.00	76.71^b
P_3- Control (Un pruned)	76.03	73.00	75.00	76.00	74.00	77.00	78.66	75.66^c
Mean	77.55^B	78.00^A	76.33^F	76.77^D	76.33^F	75.66^E	77.22^C	
	F Test			SE(m)±		CD at 5%		
Factor (A)	*			0.04		0.13		
Factor(B)	*			0.07		0.20		
A×B	*			0.12		0.34		

Table 9: Effect of different levels of pruning and foliar sprays of nutrients on shelf life (days) of Apple ber (*Zizyphus mauritiana*).

Treatments	**Nutrients spray (B)**							
Pruning (A)	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**N_6**	**N_7**	**Mean**
P_1- Medium pruning (20 cm) on previous season growth	16.82	16.35	16.27	16.00	16.24	17.66	13.96	16.08^B
P_2- Heavy pruning (30 cm) on previous season growth	15.50	17.00	15.67	17.20	15.17	18.33	16.18	16.53^A
P_3- Control (Un pruned)	14.50	15.50	15.00	15.00	15.53	15.66	14.00	15.02^C
Mean	15.34^F	16.28^B	15.64^D	15.75^C	15.65^D	17.07^A	15.43^E	
	F Test			SE(m)±		CD at 5%		
Factor (A)	*			0.10		0.30		
Factor(B)	*			0.16		0.47		
A×B	*			0.28		0.81		

Significant at (0.05 –p LOS), NS- Non- Significant
Means with similar alphabets did not differe significantly.
Values are compared with respective C.D values.
N_1 - Potassium Nitrate @1.0% N_2 - Potassium Nitrate @ 1.5%
N_3- Urea @ 0.5% N_4 - Urea @ 1.0%
N_5 - Calcium Chloride @ 0.25% N_6 - Calcium Chloride @ 0.50%
N_7 - Water spraying

Conclusion

From the above results, it was concluded that among the different plant nutrients Potassium Nitrate @ 1.5% + 30 cm Prununing can be recommended which showed positive effect on growth and quality parameter.

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