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Effect of Plant Growth Regulators and Micro Nutrient on Quality of Ber (*Zizyphus mauritiana* Lamk.) cv. Gola

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present experiment was carried out on twenty eight year old ber orchard planted under sodic soil condition, which is located at the Main Experiment Station Horticulture, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya. The objective of experiment was to assess the effect of Plant growth regulators and micro nutrient on quality of ber.The application of different growth regulators affected different characters of ber significantly *i.e.,* fruit weight, fruit size, TSS, acidity, ascorbic acid, reducing sugar, non-reducing sugar and Total sugar. The maximum fruit size, length (3.87 and 3.92 cm) and breadth (3.38 and 3.41 cm) was recorded under the treatment of **T_8**- 0.15 % Promalin + 0.5% Borax, which was statistically at par with **T_{10}**-15 ppm GA_{4+7} + 0.5 % Borax (3.79 and 3.84 cm) and (3.33 and 3.36 cm) during 2021-22 and 2022-23, respectively. The maximum fruit weight was noted (27.69g and 28.89g) under the treatment of **T_8**- 0.15 % Promalin + 0.5% Borax, which was statistically similar with **T_{10}**-15 ppm GA_{4+7} + 0.5%

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Borax (26.30 g). The higher TSS (19.42 and 19.49) ^{0}Brix was recorded under the treatment of **T_8**- 0.15 % Promalin + 0.5 % Borax, which was statistically at par with **T_{10}**-15 ppm GA_{4+7} + 0.5 % Borax (19.02 and 19.09) ^{0}Brix. The minimum Acidity (0.24% and 0.23 %) was recorded under the treatment of **T_8**- 0.15 % Promalin + 0.5 % Borax, which was statistically at par with **T_{10}**- 15 ppm GA_{4+7} + 0.5 % Borax. The maximum ascorbic acid (85.33 and 86.02) was recorded under the treatment of **T_8**- 0.15 % Promalin + 0.5 % Borax, which was statistically at par with **T_{10}**- 15 ppm GA_{4+7} + 0.5 % Borax (84.71 and 84.62). The maximum reducing sugar (6.23 and 6.25) was recorded under the treatment of **T_7**- 0.13 % Promalin + 0.5 % Borax. The maximum non-reducing sugar (7.92 and 7.95) was recorded under the treatment of **T_7**- 0.13% Promalin + 0.5 % Borax. The maximum Total sugar (14.15 and 14.20 %) was recorded under the treatment of **T_7**- 0.13 % Promalin + 0.5 % Borax.

Keywords: Acidity; boron; GA4+7; promalin (6 BA); sugars.

1. INTRODUCTION

The Indian ber (*Zizyphus mauritiana* Lamk.) belong to family Rhamnaceae and genus *Ziziphus,* which includes about fifty species, and among those, 18-20 species are native to India [1]. It is tetraploid in nature with a chromosome number 2n= 4x=48. Origin place of fruit ber is believed to be India to South - Western Asia. Ber is a very famous ancient fruit crop of India and China. It is also called as Chinese date or Chinese fig or plum. It is an important minor fruit of India, which is reported to be growing in other countries also such as Iran, Syria, Australia, USA, Russia, Myanmar *etc.* Ber is cultivated in various part of country particularly in arid and semi-arid regions comprising of 53,000 ha area, producing 5.70 lakh MT of fruits [2]. The major ber growing regions are Punjab, Haryana, Uttar Pradesh, Rajasthan, Maharashtra, Andhra Pradesh, Bihar, and Madhya Pradesh. Ber tree bears its inflorescence in the axils of leaves on current season's growth. The flowering period lasts for about two and a half months from September to November. The fruit setting starts in second week of October and continues up to first fortnight of November.

The ripe ber fruit have high nutritive values and conventionally it is considered a "Poor man's fruit". The ber fruit is richer than apple in protein, phosphorus, calcium and Vitamin'C'. and one hundred gram of edible ber contains moisture (85.9%), protein (0.8g), fat (0.1g), carbohydrates (12.88%), calcium (0.03g), phosphorus (0.03g), iron (0.8g), beta carotene (70 IU), vitamin C (50-100mg/100g pulp) etc. Ripe ber fruits are eaten fresh. Fruits is also dried and used as dessert. Its given an excellent product when candy made. Other processed products made are ber butter, ber juice or squash, RTS *etc.*

Plant bio-regulators and micronutrient such as Promalin, GA_{4+7} and borax in increase fruits size, fruits set, fruit yield, self-life and quality improvement. Promalin for increase the size and shape of the fruit. Promalin containing gibberellins and cytokine promotes both cell division and cell enlargement.

GA_{4+7} for induce fruit elongation and to increase the size and quality, fruit set, changing fruit shape and size, increasing weight of fruit, Boron is for most important in the micro nutrients. Boron also plays important role for nucleic acid and lignin synthesis, pollen tube growth, it is associated with carbohydrate and fat metabolism and translocation and transformation of sugars.

2. MATERIALS AND METHODS

The present study was conducted on twenty eight years old uniform tree of ber cv. Gola, planted at a distance of 8 m x 8 m in Main Experimental Station of Horticulture, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhaya. ($26^0.47^0$N latitude, 82.12^0E longitude of 113 meters altitude away from mean sea stratum) during 2021-22 and 2022-23. Experiment was laid out in randomized block design (RBD) which consists of ten treatments *viz.* Promalin @ 0.13% ; Promalin @ 0.15% ; GA_{4+7} @10ppm; GA_{4+7} @15ppm; Borax @0.5%; Promalin @ 0.13% + Borax 0.5%; Promalin @0.15% + Borax 0.5%; GA_{4+7} @10ppm + Borax@ 0.5%; GA_{4+7} @15ppm + Borax @0.5% and control with three replications per treatment and considering one tree per replication. Data on fruit drop was recorded periodically from October to March. Ber fruits from sprayed plants were harvested in month of March and analyzed for quality attributes.

Ten randomly selected fruits from each replication were used to assess quality attributes of ber. Physical parameters like fruit size in term of length and breadth (cm) were measured with help of vernier's calliper and expressed in centimetres. Fruit weight were recorded with the digital weighing machine and estimated in gram. Among bio-chemical parameters, TSS content was determined with hand refractometer and presented in per cent [3]. Acidity was noted as per cent of citric acid as method given by Kaur and Kalia (2017). Ascorbic acid content was expressed in mg/100g of pulp and was estimated using 2, 6-dichlorophenol indophenols dye by visual titration method [4]. Total sugar reducing, non-reducing expressed in per cent was estimated by method suggested by [4].The experiment data were analyzed following RBD to test the significance of using the Stastistix-10 software. The differences in quantified concentrations were evaluated using F test at *P*<0.05. Statistical analysis was done as described by Gomez and Gomez [5].

3. RESULTS AND DISCUSSION

3.1 Fruit Size (cm)

Fruit length (cm): The data on fruit length presented in Table 1 indicated that all treatments have a significant effect in improving the fruit length. The maximum fruit length (3.87 cm and 3.92 cm) was recorded with **T_8**- 0.15% Promalin + 0.5% Borax, which was significantly superior over the rest of the treatments and at par with **T_{10}** -15 ppm GA_{4+7} + 0.5% Borax (3.79 cm and 3.84 cm) followed by **T_9**-10 ppm GA_{4+7} + 0.5% Borax (3.64 cm and 3.69 cm), **T_5** -15 ppm GA_{4+7} (3.54 cm and 3.59 cm), **T_7-** 0.13% Promalin + 0.5% Borax (3.39 cm and 3.43 cm), **T_3-** 0.15 % Promalin (3.28 cm and 3.32 cm), **T_4-** 10 ppm GA_{4+7} (3.22 cm and 3.25 cm), **T_2**- 0.13 % Promalin (3.13 cm and 3.17 cm) and **T_6** -0.5 % Borax (3.10 cm and 3.14 cm). While, the minimum fruit length (3.08 cm and 3.11 cm) was recorded with control during 2021-22 and 2022-23, respectively.

Fruit breadth (cm): The data on fruit length presented in Table 1 have a significant effect in improving the fruit breadth. The maximum fruit breadth (3.38 cm and 3.41 cm) was recorded with **T_8** - 0.15% Promalin + 0.5% Borax, which was statistically superior over the rest of the treatments and at par with **T_{10}** - 15 ppm GA_{4+7} + 0.5% Borax (3.33 cm and 3.36 cm) and **T_9**-10 ppm GA_{4+7} + 0.5% Borax (3.32 cm and 3.35 cm). It was followed by **T_5 -**15 ppm GA_{4+7} (3.30 cm and 3.33 cm),**T_7** - 0.13% Promalin + 0.5% Borax (3.26 cm and 3.29 cm) **T_3**- 15ppm Promalin (3.22 cm and 3.25 cm),**T_4** -10 ppm GA_{4+7} (3.18 cm and 3.21 cm) and **T_2**- 0.13% Promalin (3.10 cm and 3.13 cm), **T_6**- 0.5% Borax (3.00 cm and 3.03 cm). While, the minimum fruit breadth (2.60 cm and 2.63 cm) was recorded with control during 2021-22 and 2022-23, respectively.

Fruit size was reported to be a genetic characteristic of the cultivars. The increase in size of fruit (length and width) over control as a result of foliar application of borax , Promalin (6 BA) and GA_{4+7} in present investigation might be due to their involvement in cell division, cell elongation, increased volume of intercellular spaces in the mesocarpic cells [6], Promalin, GA_{4+7} is also reported to promote growth by increasing plasticity of the cell wall followed by the hydrolysis of starch into sugar which reduces the cell water potential, resulting in the entry of water into the cell and causing elongation (Kassem et al., 2011).

Increased in fruit size with plant growth regulators and micro-nutrient application has also been reported by Stembridge and Morell [7], the maximum fruit size was obtained with the application of promalin @ 50 ppm. Unarth [8] foliar application of 25 and 50 ppm promalin sprayed in apple, Cibulsky [9], Looney [10], Comai et al. [11] in apple, Curracy and Williams [12], Eccher and Maffi [13] in apple, Pal [14] in apple.

Fruit weight (g): Data on fruit weight presented in Table 1 have a significant effect in improving the fruit weight. The maximum fruit weight (27.69 g and 28.89 g) was recorded with **T_8** - 0.15 % Promalin + 0.5 % Borax, which was at par with **T_{10}** -15 ppm GA_{4+7} + 0.5 % Borax (26.30 g in 2021-22) and significantly superior over the rest of the treatments. While, the minimum fruit weight (19.89 g and 21.09 g) was recorded with control during 2021-22 and 2022-23, respectively.

Increase in fruit weight with the spray of PGRs and micro-nutrient might be due to faster loading and mobilization into fruits [6] and involvement in hormonal metabolism, increased cell division and expansion of cell. This may also be attributed to greater photosynthetic activity, resulting the increased production and accumulation of carbohydrates and favourable effect on vegetative growth and retention of fruits, which might have increased size and weight.

Table 1. Effect of foliar feeding of plant growth regulators and micro-nutrient on fruit size and weight of ber fruit

Treatment	Parameters					
	Length (cm)		Breadth (cm)		Fruit weight (g)/fruit	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1- Control	3.08^{f}	3.11^{e}	2.60^{f}	2.63^{f}	19.89^{f}	21.09^{f}
T_2 - 0.13 % Promalin	3.13^{ef}	3.17^{de}	3.10^{d}	3.13^{de}	21.97^{de}	23.17^{de}
T_3 - 0.15 % Promalin	3.28^{cd}	3.32^{cd}	3.22^{c}	3.25^{bcd}	23.24^{cd}	24.44^{c}
T_4 - 10 ppm GA_{4+7}	3.22^{de}	3.25^{de}	3.18^{c}	3.21^{cd}	22.83^{cde}	24.03^{cd}
T_5 - 15 ppm GA_{4+7}	3.54^{b}	3.59^{b}	3.30^{b}	3.33^{abc}	23.96^{c}	25.16^{c}
T_6 - 0.5 % Borax	3.10^{f}	3.14^{e}	3.00^{e}	3.03^{e}	21.36^{ef}	22.56^{e}
T_7 - 0.13 % Promalin + 0.5 % Borax	3.39^{c}	3.43^{c}	3.26^{bc}	3.29^{abc}	23.40^{cd}	24.60^{c}
T_8 - 0.15 % Promalin + 0.5 % Borax	3.87^{a}	3.92^{a}	3.38^{a}	3.41^{a}	27.69^{a}	28.89^{a}
T_9 - 10 ppm GA_{4+7} + 0.5 % Borax	3.64^{b}	3.69^{b}	3.32^{ab}	3.35^{abc}	25.87^{b}	27.07^{b}
T_{10} -15 ppm GA_{4+7}+ 0.5 % Borax	3.79^{a}	3.84^{a}	3.33^{ab}	3.36^{ab}	26.30^{ab}	27.50^{b}
LSD (p≤0.05)	**0.113**	**0.155**	**0.079**	**0.135**	**1.699**	**1.199**

The present findings regarding the increase in fruit size and fruit weight with application of Promalin and GA_{4+7} may be due to cell division and cell elongation. These results in close conformity with results of Looney et al. [10], McArtney [15], Chen et al. [16], Ito et al. [17], Sekhar (2012) and Al-madhagi et al. [18] in strawberry. Kumar et al. [19] and Yildirim et al. [20] also found significant increase in fruit weight and size with application of Promalin and GA_{4+7} in fruit crops.

TSS (Brix^0): The data depicted in Fig. 1 that all treatments have a significant in improving the TSS. The maximum TSS (19.42 and 19.49 Brix^0) was recorded under the treatment of **T_8**- 0.15 % Promalin + 0.5 % Borax, which was statistically at par with **T_{10}**- 15 ppm GA_{4+7} + 0.5 % Borax (19.02 and 19.09) and **T_9**-10ppm GA_{4+7} + 0.5 % Borax (18.76 and 18.83) and significantly superior over rest of the treatments. While, the minimum TSS (14.80 and 14.87) was recorded under control during 2021-22 and 2022-23, respectively.

Increased TSS due to metabolic modification of starch and pectin, hydrolysis of complex polysaccharides, metabolite synthesis, and fast sugar translocation from leaves to developing fruits, foliar application of PGRs and micronutrients enhances total soluble solids (TSS) content in fruits. Total soluble solids (TSS) are also increased by Promalin and boron, with a maximum TSS of 0.5 % Borax and 0.15 % Promalin applied topically. These results are also similar with the findings of Jindal et al. [21] in apple, Pandey and Kumar [22] and Pal et al. [23] in ber cv. Gola, Montalti et al. [24] in apple, Canli et al. [25] in pear, Wismer et al. [26] in apples, Cheolku et al. [27] in pear, and Sharma [28] in apple cv. Starking Delicious.

Acidity (%): A perusal of data Fig. 1 revealed that all treatments have a significant in improving the acidity per cent. The minimum Acidity per cent (0.24 and 0.23) was recorded under the treatment of **T_8**- 0.15% Promalin + 0.5% Borax, which was statistically at par with **T_{10}**- 15 ppm GA_{4+7} + 0.5 % Borax (0.25 and 0.24) and significantly superior over rest of the treatments. While, the maximum acidity per cent (0.32 and 0.31) was recorded with control during 2021-22 and 2022-23, respectively.

The decrease in the acidity might be due to higher accumulation of sugars in fruits, better translocation of sugars into fruit tissues and conversion of organic acids into sugars by foliar application of PGRs and micro-nutrient. The reduction in the acidity under boric acid treatment might be owing to increased TSS of the fruits. These results also elucidate the finding of Jindal et al. [21] in apple cv. Starking Delicious, Canli et al. [25] in "Deveci" pear, Pandey and Kumar [22], Pal et al. [23] in ber cv. Gola, Khalid et al. [29] in Kinnow.

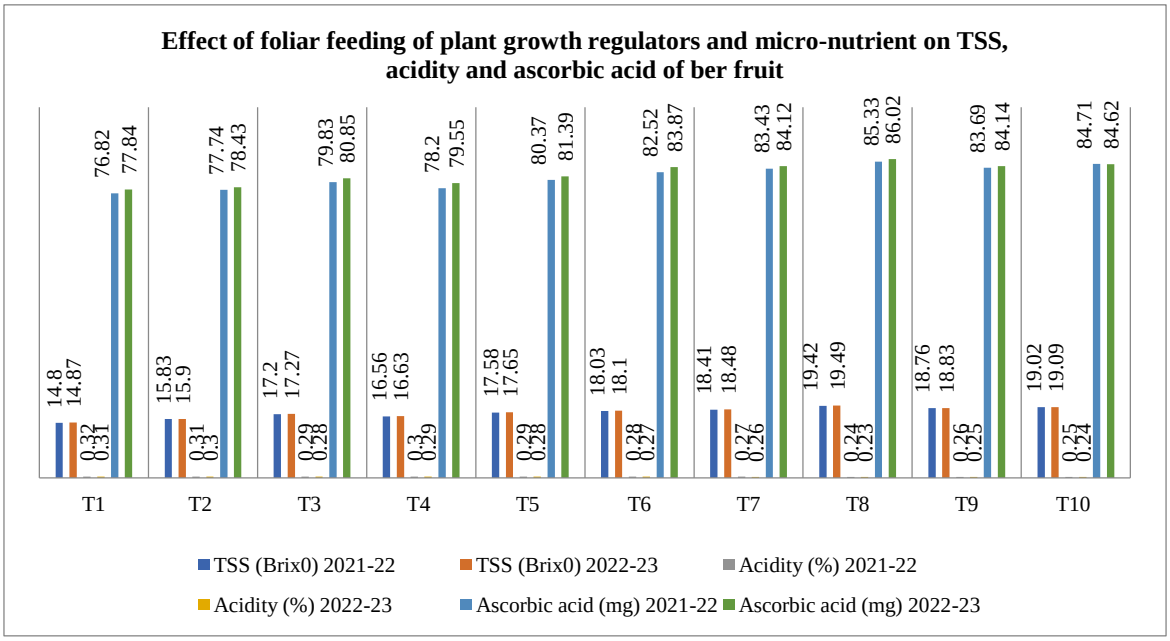

Fig. 1. Effect of foliar feeding of plant growth regulators and micro-nutrient on TSS, acidity and ascorbic acid of ber fruit

Ascorbic acid (mg): A perusal of data Fig. 1 revealed that all treatments have a significant in improving the ascorbic acid. The maximum ascorbic acid (85.33 and 86.02) was recorded with **T_8**- 0.15 % Promalin + 0.5 % Borax which was at par with **T_{10}**- 15 ppm GA_{4+7} + 0.5% Borax (84.71 and 84.62) and significantly superior over rest of the treatments. While, the minimum ascorbic acid (76.82 and 77.84) was recorded with control during 2021-22 and 2022-23, respectively.

The increase in ascorbic acid content might be speculated due to increased activity of enzyme responsible for the synthesis of the ascorbic acid precursor *i.e.,* glucose-6-phosphate or inhibition of its conversion into dehydrated ascorbic acid by enzyme ascorbic acid oxidase or both and also the reduction in the rate of respiration by these chemicals [6]. Similar result have been reported by Pal et al. [23] and Pandey and Kumar [22] in ber cv. Gola, Khalid et al. [29] in Kinnow and Cheolku et al. (2000) in pear.

Reducing sugar (%): A perusal of data depicted in Fig. 2 revealed that all treatments have a significant in improving the reducing sugar. The maximum reducing sugar (6.23 % and 6.25 %) was recorded with **T_7** - 0.13 % Promalin + 0.5 % Borax followed by **T_{10}**- 15 ppm GA_{4+7} + 0.5 % Borax, **T_9**-10 ppm GA_{4+7} + 0.5 % Borax, **T_8**- 0.15 % Promalin + 0.5 % Borax, **T_6** -Borax 0.5%, **T_5**- 15 ppm GA_{4+7}, **T_3**- 0.15 % Promalin, **T_4**- 10 ppm GA_{4+7} and **T_2**- 0.13 % Promalin. While, the minimum reducing sugar (4.47 % and 4.49 %) was recorded with control during 2021-22 and 2022-23, respectively.

Foliar spray of PGRs and micro-nutrients is helpful to increase the reducing sugar level, which could be due to accumulation of more carbohydrates to the fruit which results the better accessibility of nutrition for developing fruits and increases the reducing sugar level of fruits in present investigation. The result in conformity with those of Pandey and Kumar [22] and Pal et al. [23] in ber cv. Gola, Jindal et al. [21] in apple, Canli et al. [25] in pear and Khalid et al. [29] in Kinnow and Cheolku et al. (2000) in pear.

Non-reducing sugar (%): A perusal of data depicted in Fig. 2 revealed that significant influences in respect of improving the non-reducing sugar. The maximum non-reducing sugar (7.92 and 7.95) was recorded with **T_7**- 0.13 % Promalin + 0.5 % Borax followed by **T_{10}**- 15 ppm GA_{4+7} + 0.5 % Borax, **T_9**- 10 ppm GA_{4+7} + 0.5 % Borax, **T_8**- 0.15 % Promalin + 0.5 % Borax, **T_6** - Borax 0.5%, **T_5**- 15ppm GA_{4+7}, **T_3**- 0.15 % Promalin, **T_4**-10 ppm GA_{4+7} and **T_2**- 0.13 % Promalin. While, the minimum non-reducing sugar (5.89 % and 5.92 %) was recorded with control during 2021-22 and 2022-23, respectively.

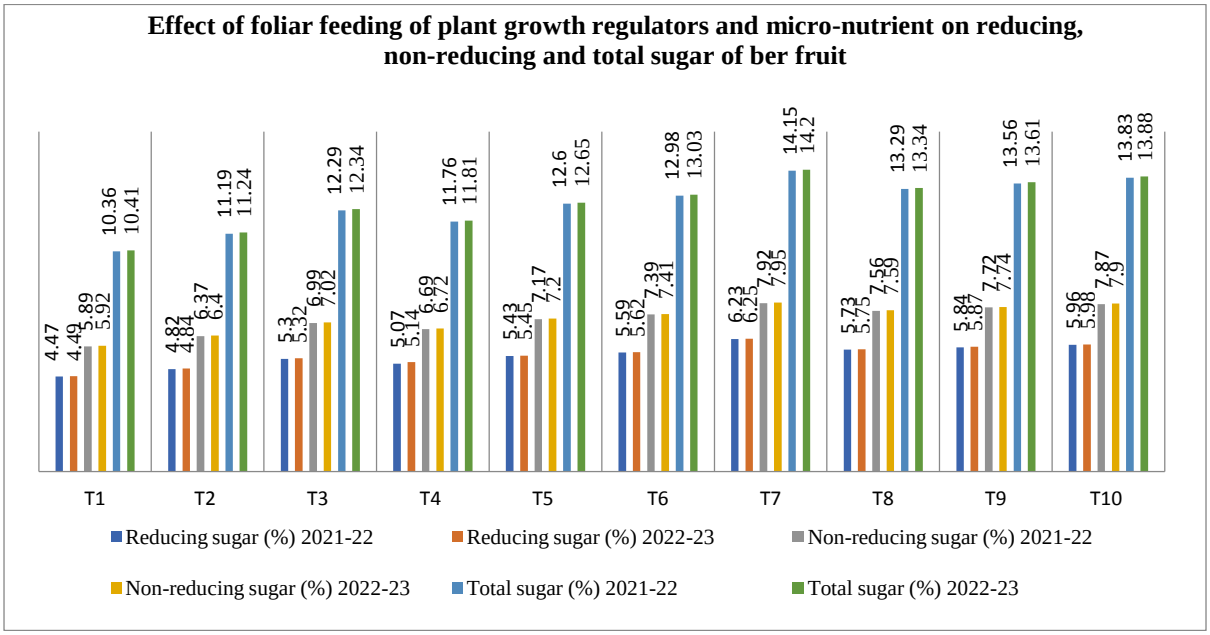

Fig. 2. Effect of foliar feeding of plant growth regulators and micro-nutrient on reducing sugar, non-reducing sugar and total sugar of ber fruit

The possible reason for increase in non-reducing sugar content of fruits was due to hydrolysis of polysaccharides to simpler form *i.e.* mono and disaccharides and better transportation of nutrients to plant from leaves to their place of utilization. These results corroborate the earlier records of Pandey and Kumar [22] and Pal et al. [23] in ber cv. Gola, Khalid et al. [29] in Kinnow, Jindal et al. [25] in apple and Cheolku et al. (2000) in pear.

Total sugar (%): The data depicted in Fig. 2 have a significant effect in improving the total sugar. The maximum total sugar (14.15 and 14.20) was recorded with T_7- 0.13 % Promalin + 0.5 % Borax and significantly superior rest of the treatments. While, the minimum Total sugar (10.36 and 10.41) was recorded with control during 2021-22 and 2022-23, respectively.

The possible reason for increase in total sugar content may be due to hydrolysis of starch yielding mono and disaccharide, which owned a simplest form of sugar and boron, Promalin and GA_{4+7} probably augmented the conversion of starch. Gauch and Dugger [30] reported that the improvement in total sugar content may be due to more translocation of sugars from leaves to developing fruits. Our results are also in line with the finding of Pandey and Kumar [22] and Pal et al.,[23] in ber cv. Gola, Chaudhary et al. [31] in Aonla, Cheolku et al. [27] in Pear, Wismer et al. [29] in Apples and Sharma [28] in Apple cv. Starking Delicious.

4. CONCLUSION

It may be concluded that the application of different growth regulators resulted that improve the characters of ber *i.e.* Fruit weight, fruit size, TSS, acidity, ascorbic acid, reducing sugar, non-reducing sugar and total sugar. The sugar and ascorbic acid, parameters were significantly affected by the application of 0.15% Promalin + 0.5% Borax (T_8) and T_{10}- 15 ppm GA_{4+7} + 0.5 % Borax. Based on cost benefit ratio T_{10}- 15 ppm GA_{4+7} + 0.5 % Borax could be recommended to farmers for commercially increasing yield and quality of ber. Normally people don't prefer Gola variety ber over apple ber due to its small size but with the application of 15 ppm GA_{4+7} + 0.5 % Borax we can increase fruit size in a very economical way resultant consumer's preference will also increase.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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