

Effect of foliar application of various concentrations of NAA and GA₃ on fruiting, yield and quality attributes of Ber cv. Banarasi Karaka.

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ABSTRACT

To study the effect of foliar application of different concentrations of NAA and GA₃ on fruiting, yield and quality of ber, an investigation was carried out in the Garden, Department of Fruit Science, C.S.A. University of Agriculture and Technology, Kanpur during the year 2021-22 on ber cv. Banarasi Karaka fruit. Results of the investigation revealed that the significantly main effect among the spray of various concentrations of NAA 30 ppm results, maximum number of fruit set (165.50), minimum fruit drop (85.15%), maximum fruit retention (14.45%), fruit weight (18.32g), yield (44.02 kg/tree), volume (16.17 cc), length (4.36cm), diameter (2.56cm), pulp weight (16.12g), total soluble solids (15.48⁰B) and total sugars (10.32%) against control (water) treatment. Spray with various concentrations of GA₃ showed significant results, having maximized number of fruit sets (160.00), minimum fruit drop (89.16%), maximum fruit retention (10.16%), weight (15.95g), yield (36.78kg/tree), volume (16.17cc), length (4.36cm), diameter (2.56cm), pulp weight (16.12 g), total soluble solids (15.48⁰B) and total sugars (10.32%) were recorded with spray of 30ppm GA₃ against control (water spray) treatment. Interaction effect among various concentration of NAA and GA₃ has significantly maximized with fruit retention (16.24%), volume (16.70cc), length (4.47cm), diameter (2.61cm), pulp weight (17.55 g) and total sugars (10.59%), while non-significantly results showed highest number of fruit set (167.00), minimum fruit drop (83.76%), maximum fruit weight (19.40g), fruit yield (45.70 kg/tree), and total soluble solids (16.62⁰B) with application of NAA and GA₃ @30ppm against control (water spray) treatment. This study revealed that for realizing higher fruiting, fruit yield and quality of ber plants should be spread with GA₃ and NAA @30ppm under North Indian Plains condition of Uttar Pradesh, India.

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Keywords: GA₃, NAA, Ber, Fruiting, Yield, Physico-chemical characteristics

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Introduction-

The ber (*Ziziphus mauritiana*) is a vigorous growing, spreading tree with almost vine-like drooping branches, that belongs to the family Rhamnaceae. This species is evergreen and leaves are densely tomentose on their undersurface. The ber fruits are borne in the axil of leaves on the young growing shoots of the current year. Hence, regular annual pruning is necessary to induce healthy growth which will provide a maximum fruit-bearing area on the tree. With wide commercialization, many physiological problems related to flowers and fruit drop, embryo abortion, poor flowering and fruit setting, abnormal and small size fruits, etc.

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were observed which caused huge losses to the growers. In order to minimize these problems, over the years many experiments and advancements have been done, and among them, usage of NAA and GA₃ is one of the most adopted hormones and is utilized to improve flowering, fruiting, yield and quality of fruit.

PGRs (Plant Growth Regulators) are involved in a variety of physiological processes, including vegetative propagation, induction of seed **lessens**, increased fruit set, prevention of pre-harvest fruit drop, blooming regulation, fruit size inhibition, and flower and fruit **thinning**. NAA (Auxin) improved the quality of numerous fruits by **increasing fruit sets**, decreasing fruit drops, and **increasing fruit sets**. Auxin concentration in the plant is increased to prevent abscission. Fruit drop is also prevented by NAA (Auxin), which strengthens the pedicle. Fruit drop is prevented by a high auxin level in the abscission **zone**.

Gibberellins have mostly been used to manipulate a variety of physiological events and are economically employed to increase the quality of fruit in crops such as berries, grapes, citrus, cherries, and apples, etc. In fruit crops, three physiological phenomena have been highlighted: rachis cell elongation, blossom thinning, and berry **growth**. Apart from that GA₃ is the most effective in breaking dormancy and causing rapid germination of seeds. **Gibberellin** influences bolting by stimulating cell division and cell elongation in the sub-apical meristems. Gibberellins have been found very reliable in producing **parthenocarpy**. Keeping there in view, the present experiment was carried out in the north Indian plains of Uttar Pradesh, India.

Materials and Methods -

The experiment was carried out in the Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) during 2021-2022. The experiment comprised 16 treatments **combined** with four concentrations each NAA **of** (0, 10, 20 and 30 ppm) and GA₃ (0, 10, 20 and 30 ppm) under a completely randomized block design (factorial) with three replications. The experimental orchard consisted of 48-year-old well-established, healthy and uniform trees of ber cultivar 'Banarasi Karaka' spaced at 10×10 meters distance. Foliar applications of the treatments **are** uniformly sprayed all over the tagged branch in the morning hours with the help of a fine nozzle foot sprayer. The observations were recorded from each treatment of all three replications viz., initial fruit sets, fruit drop (%), retention(%), length (cm), diameter (cm), volume (cc), weight (g), yield (kg/tree), pulp weight (g), total soluble solids (°B) and total sugars (%). Physical parameters were analyzed using standard methodology and chemical parameters using methods as suggested in **AOAC (1980)**. **Statically** data was analysed according to the method suggested **by Panse and Sukhantme (1985)**.

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Results and Discussion:

Fruiting attributes:

Application of NAA and GA₃ significantly influenced fruiting attributes viz., Initial fruit set, drop (%), and retention (%) in ber (Table 1). The main effect among various concentrations of NAA maximized initial fruit set (165.50) was recorded when the plant was treated with 30 ppm NAA (N₃) closely followed by 160.50 with a spray of 20 ppm NAA (N₂), whereas, a minimum fruit set (151.75) was found in plants kept under control (N₀) treatment. The enhancement of the initial fruit set was indicated in a range from 151.75 to 165.50 and the improvement of the fruit set was increased by 0.09% and 0.05% due to sprays of NAA @ 30 ppm. These results corroborate the finding of Tiwari et al., (2017) in Aonla, Badal and Tripathi (2021a) in guava. The initial fruit set was significantly influenced by different concentrations of gibberellic acid. Foliar feeding of 30 ppm of GA₃ recorded maximum initial fruit set (160.00) followed by 159.25 in plants treated with 20 ppm of GA₃ (G₂), while minimum fruit set (156.75) was recorded in plants kept under control (G₀) treatment. It probably might be due to providing the right concentration of GA₃ during investigation causing enhancement of vegetative growth of the plants and GA₃ hastening the production of more photosynthesis towards the fruit-bearing area which contributed to increased initial fruit set in plants. These findings are corroborated with the reports of Tripathi and Shukla in strawberry (2008), Anushiet al., (2021) in mango.

An interaction effect among various concentrations of NAA and GA₃ was found non-significant. Maximum fruit set (167) was observed with a spray of NAA 30 ppm and GA₃ 30 ppm (N₃G₃ treatment) followed by 166 with 20 ppm NAA with 30 ppm GA₃ (N₂G₂). The minimum initial fruit set (150) was observed under control (N₀ G₀) treatment. These findings are corroborated with the reports of Bankar and Prasad (1990).

Foliar application of NAA and GA₃ gradually minimized fruit drops and increased fruit retention as compared to control. Application of NAA @ 30 ppm significantly reduced fruit drop (85.55%) and increased fruit retention (14.45%) followed by NAA @ 20 ppm noting 89.70% of fruit drop and 10.30% fruit retention. Significantly maximum fruit drop (94.16%) with minimum fruit retention (5.84%) was recorded in plants kept under control (N₀). Reduction in fruit drop was ascertained due to sprays of NAA treatments and decreased by 9.12 and 4.71% over control (N₀). When the auxin content of the fruits becomes low, fruit drop occurs due to the formation of an abscission layer and retention of fruit are ultimately decreased. The exogenous application of NAA might have increased the concentration of auxin in plants which possibly induced to reduction of fruit drop and fruit retention. These findings are in accordance with the reports of Kumar and Tripathi (2009) on strawberry, Lal

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et al., (2016) in litchi, *Tripathi and Viveka Nand* (2022) in Aonla, *Badal and Tripathi* (2021a) in guava, *Tiwari et al.*, (2017) in Aonla, *Tripathi and Viveka Nand* (2022) in aonla.

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Gibberellic acid also positively and consistently influenced fruit retention and drop in ber and plants treated with 30ppm GA₃ significantly minimized (89.16%) fruit drop with increased retention (10.84%) and closely followed by GA₃ 20 ppm (90.20% and 9.98% respectively). Significantly maximum fruit drop (91.35%) and minimum retention (8.65%) was obtained in plants kept under control (G₀). As a result, fruit drop was reduced by 2.38 and 1.24% less than control (G₀) with increased fruit retention as reported by 13.31 to 25.35%. Application of GA₃ may have enhanced auxin production, which has prevented fruit drop in the current study. The increase in fruit retention and reduced fruit drop might be due to the effectiveness of different chemicals as well as GA₃ on the metabolic activity of the plant and improved source-sink relationship which favorably influenced the metabolic status resulting in better check of fruit drop and enhancing retention of the more number of fruits on the plants. These findings are supported by *Bhadauria et al.*, (2018) in Aonla and *Anushi et al.*, (2021) in mango, and *Yadav and Chaturvedi* (2005). Interaction between NAA and GA₃ was found to be significant and the combined treatment of N₃ × G₃ expressed a significantly minimum 83.76 % fruit drop and maximum fruit retention (16.24%) followed by N₃ G₂ (85.19% and 14.81% respectively). Significantly maximum noted under controlled (N₀ G₀) recording 94.88 % fruit drop and 5.12% of fruit retention. These findings are found to be in accordance with reports of *Chaurasiya et al.*, (2019) in ber.

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Physical attributes:

The physical attributes viz., fruit length (cm), diameter (cm) and volume (cc) of ber was significantly influenced by NAA treatment and plant treated with 30ppm of NAA proved most effective and maximized the fruit length (4.36cm), diameter (2.56cm) and fruit volume (16.17cc) during experimental period, whereas minimum fruit length (3.17cm), diameter (2.15cm), fruit volume (11.92cc) were recorded in treatment produced from plants kept under control (N₀). The enhancement range of fluctuated fruit length from 3.17 to 4.36cm, diameter from 2.15 to 2.56cm and volume from 11.92 to 16.17cc, respectively were recorded over the control. The superiority in fruit length, fruit diameter and fruit volume were increased due to NAA treatment. It could be attributed to its role in cell division, cell elongation and decreased intracellular space in monocarpic cells, all of which could have improved plant health and resulted in healthier and larger fruit. These findings are in line with reports of *Tripathi et al.*, (2019) in mango, *Badal and Tripathi* (2021b) in guava and *Tiwari et al.*, (2017) in Aonla, *Tripathi and Viveka Nand* (2022) in aonla.

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Gibberellic acid also affected positively in terms of fruit length, diameter and volume and treatment with 30ppm of GA₃ (G₃) significantly enhanced fruit length (3.90cm), diameter (2.43cm) and volume (14.55cc). Fruits produced from untreated plants (G₀) showed minimum values for these parameters i.e. 3.62cm, 2.35cm and 13.45cc, respectively. The improvement range varies from 3.62 to 3.90cm for fruit length, 2.35 to 2.43cm for fruit diameter and 13.45 to 14.55cc for volume over the control during the respective year of investigation. The increase in fruit size caused by GA₃ treatment could be attributed to a considerable increase in cell division and cell elongation. These discoveries are also linked to active photosynthesis in the plant, with photosynthesis being translocated to the fruits, presumably resulting in larger fruits. Shukla *et al.*, (2011), Tripathi *et al.*, (2018) in Aonla, Dubey *et al.*, (2017), Tripathi and Shukla, (2007) in strawberry. The interaction effect of NAA × GA₃ was found non-significant with respect to fruit length i.e., at 30ppm of NAA × GA₃ (N₃ × G₃) produced maximum fruit length (4.47cm) as compared to control (N₀ G₀) in which minimum fruit length (3.07cm) was observed, whereas, fruit diameter and volume were have significant positive effect, showing maximum fruit diameter (2.61cm) and volume (16.70cc) as compared to control (N₀ G₀) which showing the minimum value of (2.11cm and 11.40cc, respectively). These findings are consistent with Tripathi *et al.*, (2019) in mango.

Application of NAA and GA₃ significantly decreases the length of stone and diameter of stone in ber. Plants treated with 30ppm NAA (N₃) significantly minimized the length of stone and diameter of stone (1.53 and 0.84cm, respectively) as compared to control (N₀) where these were found maximum (2.63 and 1.13cm, respectively). These findings are in agreement with the reports of Singh *et al.*, (2001) in ber and Rathod *et al.*, (2019) in Aonla.

Gibberellin consistently and positively minimizes stone length and stone diameter in ber. Its 30ppm GA₃ (G₃) concentration proved most effective (1.89 and 0.94cm respectively) as compared to the control (G₀) which proved maximum stone length and diameter (2.18 and 1.13 cm respectively) during the present investigation. These results may have been associated with the active performance of photosynthesis in the plant and they were translocated to the stones which caused to decrease in stone size. These findings are in line with reports of Tripathi *et al.*, (2018) in aonla. The interactive effect of NAA associated with GA₃ did not differ significantly but further improvement was observed over mean values and combined treatment of N₃ × G₃ recorded minimum stone length (1.42cm), whereas maximum stone length (2.79cm) was recorded under control (N₀ G₀). In respect of stone diameter was found positively significant and plants treated with 30ppm @ NAA and 30ppm of GA₃ (N₃G₃) significantly minimized diameter of stone (0.80cm). The maximum diameter of stone (1.17cm) was recorded under control (N₀G₀).

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Yield Attributes:

Foliar feeding of NAA and GA₃ significantly enhanced fruit weight, pulp weight and fruit yield of ber {Fig. 1 (a) and (b)}. The fruit weight (18.32g), pulp weight (16.12g) and fruit yield (44.02 kg/tree) **was** enhanced significantly when the plant was treated with 30ppm NAA **as compared to the rest of all other treatments**, whereas, the **poorest** values of fruit weight (11.95g), pulp weight (7.04g) and fruit yield (22.82 kg/tree) were found in plants kept under control (N₀). In **the current** study, the growth regulator NAA may have boosted the synthesis of additional photosynthates and their translocation to the fruits, resulting in higher fruit and pulp weight which ultimately enhanced the yield. These results are in agreement with the respects of **Singh et al., (2005)** in Mango, **Tiwari et al., (2017)** in Aonla, **Kumar and Tripathi (2009)** in strawberry, **Tripathi and Vivekanand (2022)** in aonla.

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All the yield attributory parameters *i.e.*, fruit weight, pulp weight and fruit yield were improved with different doses of gibberellic acid and 30ppm of GA₃ emphatically improved fruit weight (15.95g), pulp weight (12.73g) and fruit yield (36.78 kg/tree) as compared to control (G₀) which show minimum fruit weight (14.30g), pulp weight (10.39g) and fruit yield (31.75 kg/tree). These findings are in support with the reports of **Tripathi et al., (2018)** in Aonla, **Dubey et al., (2017)** in strawberry.

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The interaction effect between NAA x GA₃ was recorded as non-significant in terms of fruit weight, pulp weight and fruit yield and 30ppm of NAA and 30ppm of GA₃ (N₃ G₃) treated plants produced maximum fruit weight (19.40g), pulp weight (17.55g) and fruit yield (45.70 kg/tree) closely followed with treatment N₃ G₂ which expressed fruit weight of 18.70g, pulp weight of 16.59g and fruit yield of 44.49 kg/tree. Significantly minimum fruit weight (11.10 g), pulp weight (5.75g) and fruit yield (20.78 kg/tree) were recorded under control (N₀ G₀). These findings are in line with reports of **Kale et al., (2000)** in Ber.

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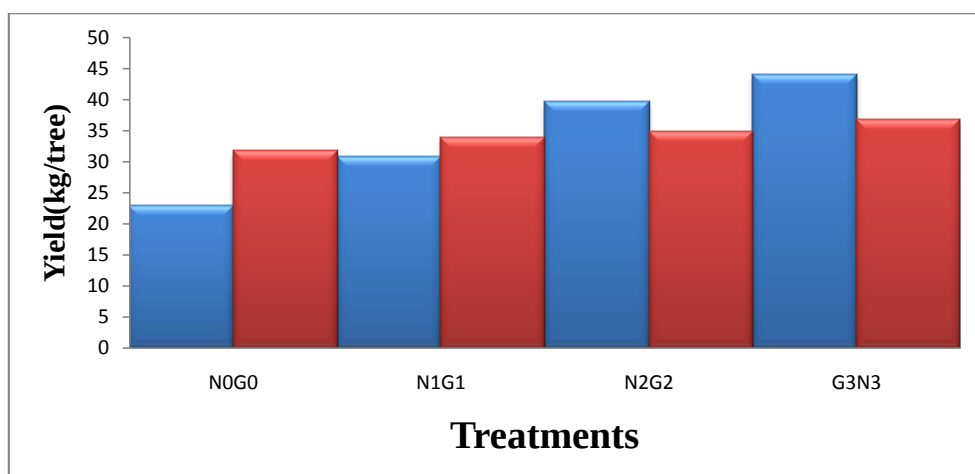


Fig. 1(a): Effect of NAA and gibberellic acid on yield (kg/tree).

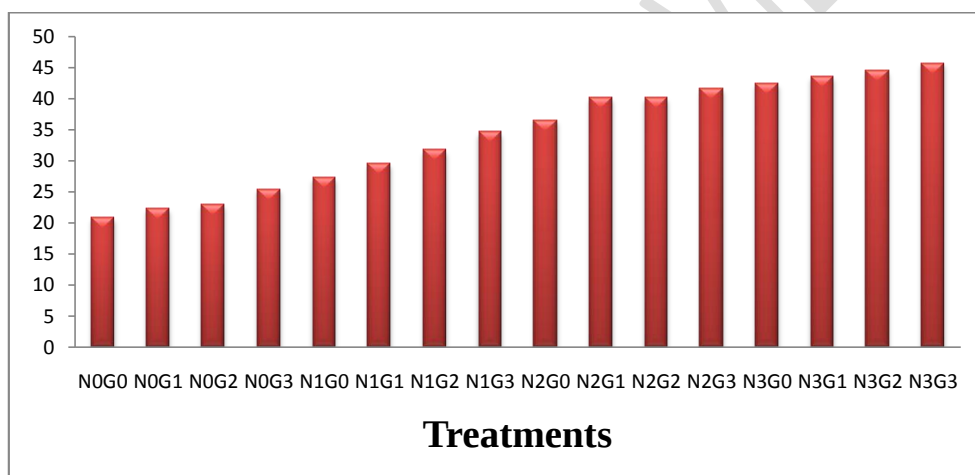


Fig. 1(b): Effect of NAA, gibberellic acid and their interaction on yield (kg/tree).

Chemical Quality Parameters-

NAA and GA₃ significantly enhanced the chemical quality of fruits *i.e.*, TSS and total sugars when plants were treated with different concentrations of these hormones. Significantly maximum TSS (15.48⁰Brix) and total sugar (10.32%) was recorded under 30ppm of NAA (N₃) treated plants followed by treatment of 20ppm NAA (N₂) which exhibited TSS of 14.43⁰Brix and total sugar of 9.62%. The plants kept under the control exhibited a minimum TSS (12.39⁰Brix) and total sugars (8.39%). The application of the growth regulators (NAA) may have produced a redirection of more solid metabolites towards developing fruits, boosting amylase activity, and therefore increasing total soluble solid content by converting

starch into simple sugar. **Kumar and Tripathi (2009) in strawberry, Badal and Tripathi (2021b) in guava.**

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Different concentrations of GA₃ also improve TSS and total sugars content in fruits and its 30ppm dose of GA₃ (G₃) was found most effective in respect of TSS and total sugars, which exhibited a maximum value of TSS (14.45⁰Brix) and total sugars (9.56%) followed by 20ppm of GA₃ (G₂), which exhibited values of 13.93⁰Brix and 9.43%, respectively. Significantly minimum TSS (13.59⁰Brix) and total sugars (9.06%) were recorded under control (G₀). GA₃ may cause an increase in the **inactivation** of the amylase enzyme, which is responsible for the conversion of starch to sugar and is linked to an increase in TSS and total sugars content of fruit. These findings collaborated with the findings of **Verma et al., (2021) in strawberry, Shukla et al., (2011), Tripathi et al., (2018) in aonla and Anushiet al., (2021) in mango.**

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The interaction effect between NAA x GA₃ produced significant effect on TSS and total sugar content and 30ppm of NAA combined with 30ppm GA₃ (N₃xG₃) was found most effective **exhibited maximum TSS (16.62⁰Brix) and total sugars (10.59%) followed by N₃G₂ recorded TSS of (15.24⁰Brix) and total sugars content i.e., 10.42% over its control (N₀G₀), which showed minimum values 12.15⁰Brix and 8.11% respectively. These findings are in line with the reports of Ram et al., (2005) in Ber.**

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Reference-

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Table 1: Effect of NAA and GA₃ and their interaction on fruit drop, retention and growth attributes of Ber

Treatments	Initial fruit set	Fruit drop (%)	Fruit retention (%)	Fruit weight (g)	Fruit volume(cc)
N ₀	151.75	94.16	5.84	11.95	11.92
N ₁	156.25	92.17	7.83	13.97	13.25
N ₂	160.50	89.70	10.30	16.00	14.72
N ₃	165.50	85.55	14.45	18.32	16.17
S.E(m)±	0.05	0.28	0.23	0.28	0.08
CD at 5%	1.45	0.83	0.67	0.83	0.24
G ₀	156.75	91.35	8.65	14.30	13.45
G ₁	158.00	90.87	9.13	14.72	13.85
G ₂	159.25	90.20	9.80	15.27	14.22
G ₃	160.00	89.16	10.84	15.95	14.55
S.E(m)±	0.50	0.28	0.23	0.28	0.08
CD at 5%	1.45	0.83	0.67	0.83	0.24
N ₀ G ₀	150	94.88	5.12	11.10	11.40
N ₀ G ₁	151	94.52	5.48	11.70	11.70
N ₀ G ₂	153	93.97	6.03	12.20	12.20
N ₀ G ₃	153	93.28	6.72	12.80	12.40
N ₁ G ₀	154	92.82	7.18	13.50	12.60
N ₁ G ₁	156	92.38	7.62	13.60	13.10
N ₁ G ₂	157	92.01	7.99	14.10	13.50
N ₁ G ₃	158	91.48	8.52	14.70	13.80
N ₂ G ₀	159	90.94	9.06	15.20	14.20
N ₂ G ₁	160	90.08	9.92	15.80	14.50
N ₂ G ₂	161	89.66	10.34	16.10	14.90
N ₂ G ₃	162	88.15	11.85	16.90	15.30
N ₃ G ₀	164	86.77	13.23	17.40	15.60
N ₃ G ₁	165.1	86.50	13.50	17.80	16.10
N ₃ G ₂	166	85.19	14.81	18.70	16.30
N ₃ G ₃	167	83.76	16.24	19.40	16.70
S.E(m)±	1.01	0.57	0.46	0.57	0.17
CD at 5%	NS	NS	1.34	NS	0.48

Comment [B91]: fruit set, drop, retention, weight and volume of Ber

Table 2: Effect of NAA and GA₃ and their interaction on yield and quality attributes of Ber

Treatments	Fruit length(cm)	Fruit diameter(cm)	Pulp weight(g)	T.S.S (°B)	Total sugars (%)
N ₀	3.17	2.15	7.04	12.39	8.39
N ₁	3.53	2.35	10.00	13.42	8.96
N ₂	4.00	2.56	12.90	14.42	9.62
N ₃	4.36	2.56	16.12	15.48	10.32
S.E(m)±	0.05	0.05	0.12	0.18	0.05
CD at 5%	0.14	0.15	0.36	0.54	0.15
G ₀	3.62	2.35	10.39	13.59	9.06
G ₁	3.72	2.40	11.08	13.74	9.24
G ₂	3.82	2.43	11.85	13.93	9.43
G ₃	3.90	2.43	12.73	14.45	9.56
S.E(m)±	0.05	0.05	0.12	0.18	0.05
CD at 5%	0.14	0.15	0.36	0.54	0.15

Comment [B92]: fruit length, diameter, pulp weight, TSS and TS

N ₀ G ₀	3.07	2.11	5.75	12.15	8.11
N ₀ G ₁	3.13	2.13	6.70	12.24	8.32
N ₀ G ₂	3.21	2.16	7.49	12.38	8.52
N ₀ G ₃	3.28	2.19	8.24	12.80	8.62
N ₁ G ₀	3.36	2.22	9.17	13.12	8.75
N ₁ G ₁	3.48	2.36	9.55	13.28	8.90
N ₁ G ₂	3.60	2.39	10.24	13.57	9.04
N ₁ G ₃	3.71	2.42	11.04	13.72	9.18
N ₂ G ₀	3.82	2.56	11.79	14.17	9.36
N ₂ G ₁	3.94	2.58	12.59	14.31	9.51
N ₂ G ₂	4.07	2.62	13.11	14.54	9.75
N ₂ G ₃	4.17	2.49	14.12	14.68	9.87
N ₃ G ₀	4.26	2.52	14.86	14.93	10.03
N ₃ G ₁	4.34	2.55	15.48	15.14	10.25
N ₃ G ₂	4.40	2.58	16.59	15.24	10.42
N ₃ G ₃	4.47	2.61	17.55	16.62	10.59
S.E(m)±	0.10	0.10	0.25	0.37	0.10
CD at 5%	0.28	0.30	0.72	NS	0.30

Comment [B93]: general comments:

- i. The language used is very poor
- ii. It is mainly focused on reporting of the results with out being discussed well.
- iii. The discussion should be based on the significant results. Do not discuss non-significant results.
- iv. If the main effects and interaction effects are significant, the discussion should be based on the interaction effect. Otherwise, if the main effects are significant and the interaction effects are non-significant, the discussion should be based on the main effects.
- v. The supporting literatures results should be mentioned for strengthening your discussion.
- vi. Without considering the mean separation letters, how the readers understand the results are significant or not. You only showed the mathematical difference rather than the statistical difference.
- vii. The result table is not placed in appropriate location.