Effect of foliar application of various concentrations of NAAand GA_3on fruiting, yield and qualityattributes of Ber cv. Banarasi Karaka, India

ABSTRACT

To study the effect of foliar application of different concentrations of NAA and GA_3 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 thesignificantly 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 (15.48^{0}B) and total sugars (10.32%) against control (water) treatment. Spray with various concentrations of GA_3 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 (15.48^{0}B) and total sugars (10.32%) were recorded with spray of 30ppm GA_3against control (water spray) treatment.Interaction effect among various concentration of NAA and GA_3 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 highestnumber 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 (16.62^{0}B) with application of NAA and GA_3 @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 GA_3 and NAA @30ppm under North Indian Plains condition of Uttar Pradesh, India.

Keywords: GA_3, NAA, Ber, Fruiting, Yield,Physico-chemical characteristics

Introduction-

The ber (*Ziziphus mauritiana*) is a vigorous growing, spreading tree with almost vine-like drooping branches, that belongs to the family Rhamnaceae. Thisspecies 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.

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 NAAand GA_3 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 $GA_3$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 treatmentscombinedwithfour concentrations each NAA of (0, 10, 20 and 30 ppm) and GA_3 (0, 10, 20 and 30 ppm) under a completely randomizedblock design (factorial) with three replications. The experimental orchard consisted of 48-year-oldwell-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(^{0}B) and total sugars(%).Physical parameters were analyzed using standard methodology and chemical parameters using methods as suggested in **AOAC (1980).**Staticallydata was analysed according to the method suggested by **Panse and Sukhantme (1985)**.

Results and Discussion:

Fruiting attributes:

Application of NAA and GA_3 significantly influenced fruiting attributes *viz.*, Initial fruit set, drop (%), and retention (%) in ber (Table 1).The main effect among various concentrations of NAAmaximized initial fruit set (165.50) was recordedwhen the plant was treated with 30 ppm NAA (N_3) closely followed by 160.50 witha spray of 20 ppm NAA (N_2),whereas, a minimum fruit set (151.75) was found in plants kept under control (N_0) 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 30ppm of GA_3 recorded maximum initial fruit set (160.00) followed by 159.25 in plants treated with 20ppm of GA_3(G_2), while minimum fruit set (156.75) was recorded in plants kept under control (G_0)treatment. It probably might be due to providing the right concentration of GA_3 during investigation causing enhancement of vegetative growth of the plants and GA_3 hastening the production of more photosynthesis towards the fruit-bearing area which contributed to increasedinitial fruit set in plants. These findings are collaborated with the reports of **Tripathi and Shukla** in strawberry (2008), **Anushi*et al.*, (2021)** in mango.

An interaction effect amongvarious concentrations of NAA and GA_3 was found non-significant. Maximumfruit set(167) was observed witha spray of NAA 30ppm and $GA_3$30ppm (N_3G_3treatment) followed by 166 with 20ppm NAA with 30ppm GA_3(N_2G_2). The minimum initial fruit set (150) was observed under control (N_0 G_0) treatment.These findings are collaborated with the reports of **Bankar and Prasad (1990).**

Foliar application of NAA and GA_3 gradually minimized fruit drops and increased fruit retention as compared to control. Application of NAA @ 30ppm 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 (N_0). Reduction in fruit drop was ascertained due to sprays of NAA treatments and decreased by 9.12 and 4.71% over control (N_0). Whenthe 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**

***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 andViveka Nand (2022)** in aonla.

Gibberellic acid also positively and consistently influenced fruit retention and drop in ber and plants treated with 30ppm GA_3 significantly minimized (89.16%) fruit drop with increased retention (10.84%) and closely followed by GA_3 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 GA_3 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 GA_3on 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 $GA_3$was found to be significant and the combined treatment of $N_3 \times G_3$ expressed a significantly minimum 83.76 % fruit drop and maximum fruit retention (16.24%) followed by N_3 G_2 (85.19% and 14.81% respectively). Significantly maximum noted under controlled (N_0 G_0) 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.**

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 (N_0).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 guavaand Tiwari*et al*., (2017) in Aonla, Tripathi and Viveka Nand (2022) in aonla.**

Gibberellic acid also affected positively in terms of fruit length, diameter and volume and treatment with 30ppm of GA_3 (G_3) significantly enhanced fruit length (3.90cm), diameter (2.43cm) and volume (14.55cc). Fruits produced from untreated plants (G_0) showed minimum valuesfor 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 GA_3 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 × GA_3 was found non-significant with respect to fruit length *i.e.*, at 30ppm of NAA× GA_3 ($N_3 \times G_3$) produced maximum fruit length (4.47cm) as compared to control (N_0 G_0) 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 (N_0 G_0) 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 GA_3 significantly decreasesthe length of stone anddiameter of stone in ber. Plants treated with 30ppm NAA (N_3) significantly minimizedthe length of stone anddiameter of stone (1.53and 0.84cm, respectively) as compared to control (N_0) 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 andstone diameter in ber. Its 30ppm GA_3 (G_3) concentration proved most effective (1.89 and 0.94cm respectively) as compared to the control (G_0) which proved maximum stone length anddiameter (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 GA_3 did not differ significantly but further improvement was observed over mean values and combined treatment of $N_3 \times G_3$ recorded minimum stone length (1.42cm), whereas maximum stone length (2.79cm) was recorded under control (N_0 G_0).In respect of stone diameter was found positively significant and plants treated with 30ppm @ NAA and 30ppm of GA_3 (N_3G_3) significantly minimized diameter of stone(0.80cm). The maximum diameter of stone (1.17cm) was recorded under control (N_0 G_0).

Yield Attributes:

Foliar feeding of NAA and GA_3 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 (N_0). 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 Viveka Nand (2022)** in aonla.

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 GA_3 emphatically improved fruit weight (15.95g), pulp weight (12.73g) and fruit yield (36.78 kg/tree) as compared to control (G_0) 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.

The interaction effect between NAA x GA_3 was recorded as non-significant in terms of fruit weight, pulp weight and fruit yield and 30ppm of NAA and 30ppm of GA_3 (N_3 G_3) treated plants produced maximum fruit weight (19.40g), pulp weight (17.55g) and fruit yield (45.70 kg/tree) closely followed with treatment N_3 G_2 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 (N_0 G_0). These findings are in line with reports of **Kale *et al.*, (2000)**in Ber.

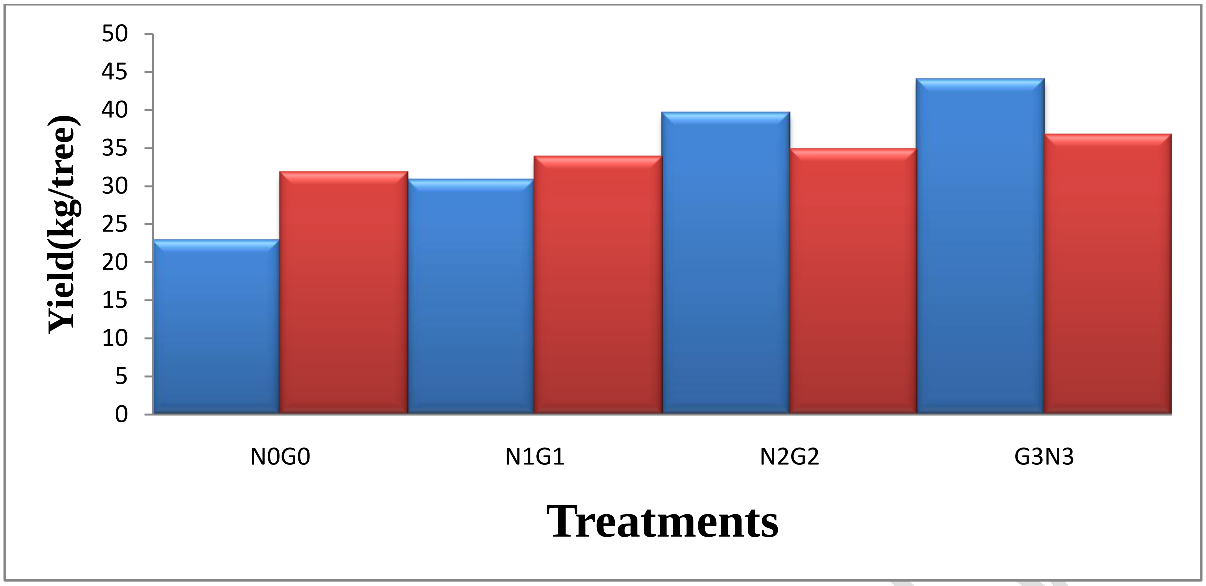

Fig. 1(a): Effect of NAA and gibberellic acid on yield (kg/tree).

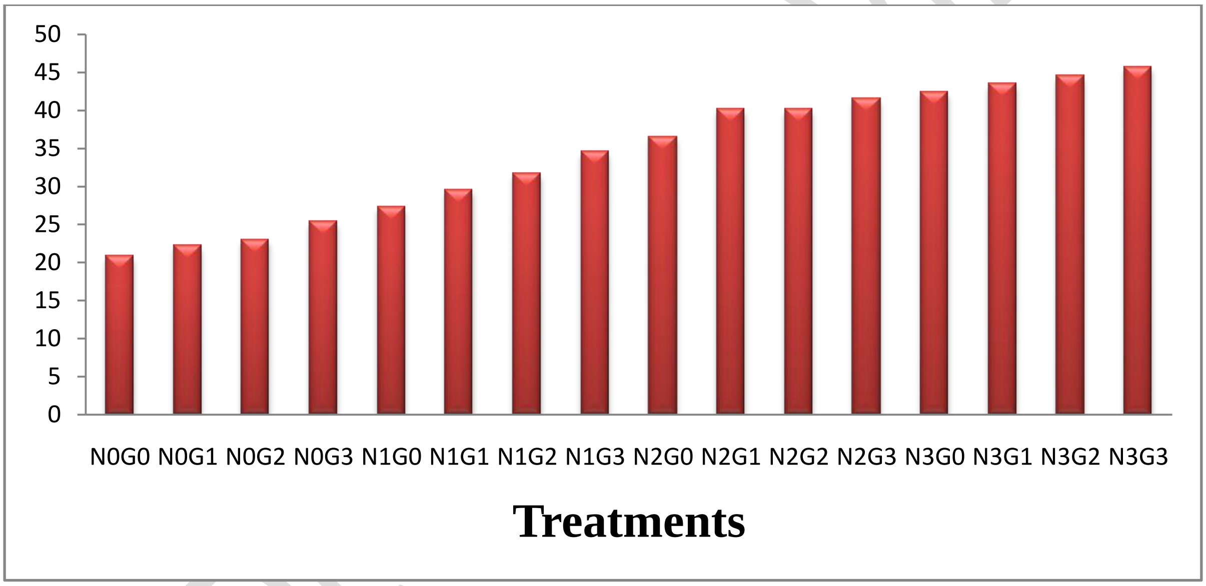

Fig. 1(b): Effect of NAA, gibberellic acid and their interaction on yield (kg/tree).

Chemical Quality Parameters-

NAA and GA_3 significantly enhanced the chemical quality of fruits *i.e.*,TSS and total sugars when plantswere treated with different concentrations of these hormones. Significantly maximum TSS (15.48^{0}Brix) and total sugar (10.32%) was recorded under 30ppm of NAA (N_3) treated plants followed by treatment of 20ppm NAA (N_2) which exhibited TSS of 14.43^{0}Brix and total sugarsof 9.62%. The plants kept under the control exhibited a minimum TSS (12.39^{0}Brix)andtotal 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.**

Different concentrations of GA_3 also improve TSS and total sugarscontent in fruits and its 30ppm dose of $GA_3(G_3)$ was found most effective in respect of TSS and total sugars, which exhibited a maximum value of TSS (14.45^0Brix) and total sugars (9.56%) followed by 20ppm of GA_3 (G_2), which exhibited values of 13.93^0Brix and 9.43%, respectively. Significantly minimum TSS (13.59^0Brix) and total sugars (9.06%) were recorded under control (G_0). GA_3 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 Anushi*et al.*, (2021)** in mango.

The interaction effect between NAA x GA_3 produced significant effect on TSS and total sugar content and 30ppm of NAA combined with 30ppm GA_3 ($N_3 \times G_3$) was found most effective exhibited maximum TSS(16.62^0Brix) andtotal sugars (10.59%) followed by N_3G_2 recorded TSS of (15.24^0Brix) and total sugars content *i.e.*,10.42% over its control (N_0G_0), which showed minimum values 12.15^0Brix and 8.11% respectively. These findings are in line with the reports of **Ram *et al.*, (2005)** in Ber.

Conclusion

This study revealed that for realizing higher fruiting, fruit yield and quality of ber plants should be spread with GA_3 and NAA @30ppm under North Indian Plains condition of Uttar Pradesh, India.

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Table 1:Effect of NAA and GA_3 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_0G_0	150	94.88	5.12	11.10	11.40
N_0G_1	151	94.52	5.48	11.70	11.70
N_0G_2	153	93.97	6.03	12.20	12.20
N_0G_3	153	93.28	6.72	12.80	12.40
N_1G_0	154	92.82	7.18	13.50	12.60
N_1G_1	156	92.38	7.62	13.60	13.10
N_1G_2	157	92.01	7.99	14.10	13.50
N_1G_3	158	91.48	8.52	14.70	13.80
N_2G_0	159	90.94	9.06	15.20	14.20
N_2G_1	160	90.08	9.92	15.80	14.50
N_2G_2	161	89.66	10.34	16.10	14.90
N_2G_3	162	88.15	11.85	16.90	15.30
N_3G_0	164	86.77	13.23	17.40	15.60
N_3G_1	165.1	86.50	13.50	17.80	16.10
N_3G_2	166	85.19	14.81	18.70	16.30
N_3G_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

Table 2:Effect of NAA and GA_3 and their interaction on yield and quality attributes of Ber

Treatments	Fruit length(cm)	Fruit diameter(cm)	Pulp weight(g)	T.S.S (^{0}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
N_0G_0	3.07	2.11	5.75	12.15	8.11
N_0G_1	3.13	2.13	6.70	12.24	8.32
N_0G_2	3.21	2.16	7.49	12.38	8.52
N_0G_3	3.28	2.19	8.24	12.80	8.62
N_1G_0	3.36	2.22	9.17	13.12	8.75
N_1G_1	3.48	2.36	9.55	13.28	8.90
N_1G_2	3.60	2.39	10.24	13.57	9.04
N_1G_3	3.71	2.42	11.04	13.72	9.18
N_2G_0	3.82	2.56	11.79	14.17	9.36
N_2G_1	3.94	2.58	12.59	14.31	9.51
N_2G_2	4.07	2.62	13.11	14.54	9.75
N_2G_3	4.17	2.49	14.12	14.68	9.87
N_3G_0	4.26	2.52	14.86	14.93	10.03
N_3G_1	4.34	2.55	15.48	15.14	10.25
N_3G_2	4.40	2.58	16.59	15.24	10.42
N_3G_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