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Effect of foliar application of GA_3 and NAA on yield and quality of ber (*Ziziphus mauritiana* Lamk.) cv. "Banarasi Karaka"

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Abstract
The investigation was conducted at Horticulture Garden CSA University of Agriculture and Technology, Kanpur during the year 2020-21. The experiment entitled 'effect of foliar application of GA_3 and NAA on yield and quality of ber (*Ziziphus mauritiana* Lamk.) cv. Banarasi Karaka'. The sprays of 30 ppm NAA significantly maximized (4.24 cm) length of fruit against control (N_0) recorded 3.91 cm length. GA_3 20 ppm significantly enhanced (4.48 cm) fruit length and the minimum of 3.86 cm showed under control. Significantly maximum 2.58 cm diameter obtain with NAA 30 ppm followed by NAA 40 ppm (2.46 cm) over control (N_0) revealed 2.19 cm diameter. GA_3 20 ppm significantly revealed 2.62 cm diameter against control (2.23 cm). Significantly maximum of 2.74 cm diameter exhibited under interactive treatment N_2 G_1 followed by N_3 G_1 (2.70 cm) against control 2.17 cm. NAA 20 ppm maximized of 14.57g fruit weight being significant against the minimum of 13.31g fruit weight indicated with control (N_0). GA_3 20 ppm significantly enhanced (14.60g) fruit weight against control (G_0) (13.38 g) interactive treatment N_1 G_1 induced significantly maximum 15.87 g fruit weight against control N_0 G_0 (12.96 g). The yield was significantly increase under NAA 30 ppm dose (34.16 kg/tree) followed by NAA 40 ppm (33.36 kg/tree) against control (27.60 kg). Treatment of GA_3 40 ppm significantly maximum (37.63 kg/tree) yield over control G_0 (26.31 kg). Interactive treatment N_2 G_3 maximized (42.48 kg yield/tree) followed by N_3 G_3 (41.20 kg) over control N_0 G_0 (25.54 kg). NAA 40 ppm induced significantly maximum of 14.18 ^{0}Brix TSS content against control N_0 (12.82 ^{0}Brix). GA_3 20 ppm dose significantly improved (14.03 ^{0}Brix) TSS content over control G_0 (13.13 ^{0}Brix). Significantly maximum of 15.14 ^{0}Brix TSS content was revealed with interactive treatment N_3 G_1 against control N_0 G_0 (12.82 ^{0}Brix). Treatment of NAA 20 ppm significantly maximized (107.78 mg/100g pulp) ascorbic acid over control N_0 (86.26 mg). GA_3 40 ppm significantly induced the maximum 107.50 mg ascorbic acid content/ 100g pulp against control G_0 (75.71 mg). The maximum of 128.56 mg ascorbic acid was recorded under interactive treatment of N_1 G_3 over control N_0 G_0 (75.29 mg).

Keywords: NAA, GA_3, yield, TSS, ascorbic acid and total sugar

Introduction
Ber is popularly known as 'King of arid fruit'. It is and ancient and important acidic fruit of India. It is called as 'Chinese date' or 'Chines fig' and commonly considered as Poor man's fruit. It is most important fruit for getting high economic return, low cost of cultivation and wide adoptability and ability to stand drought. Punjab, Utter Pradesh, Haryana, Rajasthan, Madhya Pradesh, Bihar, Maharashtra, Assam, Andhra Pradesh, Tamil Nadu and West Bengal are the growing states of India. There are various aspects which are used during the last 50-year considerable research work has been done in the country on variety, propagation, Irrigation, Training and pruning etc. To increase the yield and quality of ber fruits. Production of poor quality fruit is a matter of common experience. It would be there for worthwhile to improve the yield and quality of fruit crops by foliar application of plant growth regulators. Among plant growth regulators NAA and GA_3 are prominent due to this ability these are taken for improving of quality yield of different fruit as well as in ber it also improves fruit drop and enhances fruit retention in ber. Thus, in present investigation these harmons being very useful for improving quality yield of ber fruits and obtaining good returns to the orchardist and farmers.

Materials and Methods

The present investigation was conducted at Horticulture Garden of CSA University of Agriculture and Technology, Kanpur during the year 2020-21. The experiment consisting 16 treatments replicated thrice in Factorial Completely Randomized Design. There were 16 plants of ber was taken and on each plant three similar branches were selected and used as a treatment unit. Two growth regulators NAA and GA_3 both are comprised with the same four levels i.e. 0, 20, 30 and 40 ppm. Such way there was 16 treatments N_0 G_0, N_0 G_1, N_0 G_2, N_0 G_3, N_1 G_0, N_1 G_1, N_1 G_2, N_1 G_3, N_2 G_0, N_2 G_1, N_2 G_2, N_2 G_3, N_3 G_0, N_3 G_1, N_3 G_2 and N_3 G_3 were taken. Each treatment allotted one experimental unit (one branch) by randomization for spraying of above treatments at pre blooming and pea stage of fruits. All the manurial requirement irrigation, weeding and plant protection measures are provided as per recommendations. The observations on physical properties of ber (Length, diameter, volume, weight and yield) were measured and weighed with routine methods. The chemical attributes (TSS, ascorbic acid and total sugars) are analyzed to following standard procedures.

Result and Discussion

The data pertaining to the effect of GA_3 and NAA on yield attributes and quality of ber fruit are presented in table- 1 to 6. The treatments of different doses of GA_3 and NAA and their interactive treatments significantly influenced yield attributes and quality parameter of ber fruits.

Fruit length

The significantly maximum fruit length (4.24 cm) was noted in NAA 30 ppm dose followed by NAA 40 ppm (4.14 cm) over control (3.91 cm). Length of fruits increased by NAA 30 ppm might be due to promoting cell division, cell elongation and decreased volume of intracellular space in the monocarpic cell. These result are in line with reports of Meena *et al.*, (2013) [12], Arora *et al.*, (2014) [1] in ber. GA_3 20 ppm significantly improved 4.48 cm fruit length over control G_0 (3.86 cm). GA_3 might be enhanced in cell division and cell elongation which promoted length of Fruit. These findings are collaborated with the reports of Pandey (1999) [13] and Ram *et al.*, (2005) [14] in ber. Interactive effect of NAA x GA_3 treatments did not exert significant variation.

Fruit diameter

NAA 30 ppm significantly hastened the maximum of 2.58 cm diameter followed by NAA 40 ppm (2.46 cm) over control N_0 (2.19 cm). NAA treatments enhanced diameter of fruit due to its involment in cell division, cell elongation which ultimately induced to diameter of fruits. These findings are in agreement with the reports of Pandey (1999) [13], Singh *et al.*, (2001) [18] and Arora *et al.*, (2014) [1] in ber. GA_3 20 ppm significantly maximized (2.62 cm) diameter over control G_0 (2.23 cm). Possibly this increase on diameter may associated with active performance of photosynthetes which translocated to the fruits caused to increase in fruit size. These findings are in line with the reports of Pandey (1999) [13] and Ram *et al.*, (2005) [14] in ber. Interactive treatment N_2 G_1 significantly enhanced (2.74 cm) diameter followed by N_3 G_1 (2.70 cm) over control N_0 G_0 (2.17 cm).

Fruit weight

Significantly the highest fruit weight 14.57 g observed with NAA 20 ppm treatment followed by NAA 30 ppm (14.31 g) over control N_0 (13.31 g). NAA might have improve the synthesis of more photosynthetes and their movement towards fruiting area may have increased fruit weight. These results inconformity with those Bal *et al.*, (1986) [3] and Haidry *et al.*, (1997) [8] in mango. Significantly highest 14.60 g fruit weight was recorded under GA_3 20 ppm followed by GA_3 30 ppm (14.20 g) over control G_0 (13.38 G). probably GA_3 may enhanced the deposition of solids which caused to increase cell size by improving accumulation of water in intracellular space which might be enhanced to fruit weight. These findings get support to the reports of in ber and Rokaya *et al.*, (2016) [15] in mandarin. Interactive treatment N_1 G_1 induced to maximum of 15.87 g fruit weight followed by N_2 G_1 (15.61 g) over control N_0 G_0 (12.96 g). These findings are in line with reports of Kale *et al.*, (2000) [9] and Masalkar and Wavhal (1991) [11] in ber.

Yield

Treatment of NAA 30 ppm revealed significantly maximum 14.16 kg/tree yield followed by NAA 40 ppm (33.36 kg) over control N_0 (27.60 kg) these results in conformity with those of Singh *et al.*, (2001) [18] in ber and Haidry *et al.*, (1997) [8], Singh *et al.*, (2005) [17] in mango. GA_3 40 ppm significantly induced highest yield (37.63 kg/tree) followed by GA_3 30 ppm (32.96 kg) over control G_0 (26.31 kg/tree). The findings are gets support to the reports of Banker and Prasad (1990) [2] in ber and Rokaya *et al.*, (2016) [15] in mandarin. Interactive treatment N_2 G_3 significantly maximized (42.48 kg/tree) followed by N_3 G_3 (41.20 kg) against control N_0 G_0 (25.54 kg/tree). These findings are in line with the reports of Kale *et al.*, (2000) [9] and Masalkar and Wavhal (1991) [11] in ber.

Total soluble solids

NAA 40 ppm significantly maximized (14.18 ^{0}Brix) TSS content followed by NAA 30 ppm (13.99 ^{0}Brix) over control N_0 (12.82 ^{0}Brix). NAA might have caused diversion of more solids metabolites towards developing fruits and increasing amylase activity and thus, there was conversion of starch into simple sugar thereby enhancing TSS content. These findings are similar with accordance of Bhati and Yadav (2003) [4] in ber and Haidry *et al.*, (1997) [8], Gupta and Brahamchari (2004) [7] in mango. 14.03% TSS content was significantly maximized with GA_3 20 ppm followed by GA_3 30 ppm (13.56 ^{0}Brix) over control G_0 (13.13%). These findings are in line with the reports of Kale *et al.*, (2000) [9] in ber and Rokaya *et al.*, (2016) [15] in mandarin. Interactive treatment N_3 G_1 significantly increased 15.14 ^{0}Brix TSS followed by N_2 G_1 (14.62 ^{0}Brix) over control N_0 G_0 (12.82 ^{0}Brix). These findings are in line with the reports of Banker and Prasad (1990) [2], Ram *et al.*, (2005) [14], Gill and Bal (2013) [6] in ber.

Ascorbic acid

NAA 20 ppm significantly enhanced (107.78 mg ascorbic acid/ 100g pulp) followed by its 30 ppm dose (95.55 mg) over control N_0 (86.26 mg) these findings are collaborated with reports of Bal *et al.*, (1986) [3] and Singh *et al.*, (2001) [18] in ber. 40 ppm GA_3 significantly maximized (107.50 mg) followed by GA_3 30 ppm (102.02 mg) over control G_0 (75.71 mg). The increase in ascorbic acid content may have resulted owing to enhanced synthesis of ascorbic acid due to favorable metabolic activity involving certain enzyme and metabolic ions possibly under the influence of GA_3. These findings are in line with the reports of Dhillan and Singh (1968) [5]. Masalkar and Wavhal (1991) [11] in ber. Significantly maximum of 128.56 mg ascorbic acid /100 g pulp was elaborated under combined treatment of N_1 G_3 (114.37 mg)

over control N_0 G_0 (75.29 mg). These findings are conformity with the reports of Pandey (1999) [13] in ber Singh and Singh (2015) [16] in aonla.

Total sugar

Treatment of NAA 30 ppm significantly revealed maximum of 9.56% total sugar followed by NAA 40 ppm (9.51%) over control N_0 (8.83%). Increase in total sugar may attributed due to NAA which may accelerated the conversion of starch and other polysaccharide in soluble from of sugar which promoted sugar content. These findings are similar with accordance of Kale *et al.*, (1999) [10] in ber and Yadav *et al.*, (2010) [20] in aonla. Significantly maximum of 9.93% total sugar was recorded with GA_3 20 ppm followed by GA_3 30 ppm (9.29%) over control N_0 G_0 (8.87%). Probably GA_3 increasing fruit sweetness might be due to photosynthetic activity and formation of more carbohydrates content and its transportation are maximised within the fruit. Under the influences of growth regulator GA_3 sugar are quickly converted in to their derivatives by reaction involving of glycolytic pathway. These results are in line with the reports of Kale *et al.*, (1999) [10], Yadav and Chaturvedi (2005) [19] in ber. Significantly maximum of 10.59% total sugar was recorded under interactive treatment N_2 G_1 followed by N_3 G_1 (10.26%) against control N_0 G_0 (8.76%).

Table 1: Effect of foliar application of GA_3 and NAA on length of ber fruit (cm)

Treatment NAA \ GA_3	G_0 (Control)	G_1 (GA_3 20ppm)	G_2 (GA_3 30ppm)	G_3 (GA_3 40ppm)	Mean	sources	S.E.D.	C.D.
N_0 (Control)	3.46	4.24	3.96	3.99	3.91	NAA	0.024	0.05
N_1 (NAA 20ppm)	3.67	4.43	4.06	4.09	4.06	GA_3	0.024	0.05
N_2 (NAA 30ppm)	3.83	4.68	4.24	4.23	4.24	NAAxGA_3	0.049	N.S.
N_3 (NAA 40ppm)	3.76	4.57	4.10	4.13	4.14			
Mean	3.86	4.48	4.09	4.11				

Table 2: Effect of foliar application of GA_3 and NAA on diameter of fruit ber (cm)

Treatment NAA \ GA_3	G_0 (Control)	G_1 (GA_3 20ppm)	G_2 (GA_3 30ppm)	G_3 (GA_3 40ppm)	Mean	sources	S.E.D.	C.D.
N_0 (Control)	2.17	2.40	2.11	2.09	2.19	NAA	0.020	0.04
N_1 (NAA 20ppm)	2.19	2.66	2.33	2.29	2.36	GA_3	0.020	0.04
N_2 (NAA 30ppm)	2.34	2.74	2.63	2.61	2.58	NAAxGA_3	0.41	0.08
N_3 (NAA 40ppm)	2.22	2.70	2.49	2.45	2.46			
Mean	2.23	2.62	2.39	2.36				

Table 3: Effect of foliar application of GA_3 and NAA on fruit weight in ber (g)

Treatment NAA \ GA_3	G_0 (Control)	G_1 (GA_3 20ppm)	G_2 (GA_3 30ppm)	G_3 (GA_3 40ppm)	Mean	sources	S.E.D.	C.D.
N_0 (Control)	12.96	13.37	13.48	13.42	13.31	NAA	0.204	0.41
N_1 (NAA 20ppm)	13.76	15.87	14.71	13.96	14.57	GA_3	0.204	0.41
N_2 (NAA 30ppm)	13.46	15.61	14.36	13.81	14.31	NAAxGA_3	0.408	0.83
N_3 (NAA 40ppm)	13.34	13.56	14.25	15.43	14.14			
Mean	13.38	14.60	14.20	14.15				

Table 4: Effect of foliar application of GA_3 and NAA on fruit yield of ber (kg/tree)

Treatment NAA \ GA_3	G_0 (Control)	G_1 (GA_3 20ppm)	G_2 (GA_3 30ppm)	G_3 (GA_3 40ppm)	Mean	Sources	S.E.D.	C.D.
N_0 (Control)	25.54	26.03	28.72	30.11	27.60	NAA	0.510	1.04
N_1 (NAA 20ppm)	26.26	29.88	32.30	36.75	31.30	GA_3	0.510	1.04
N_2 (NAA 30ppm)	26.81	31.67	35.70	42.48	34.16	NAAxGA_3	1.021	2.08
N_3 (NAA 40ppm)	26.64	30.46	35.14	41.20	33.36			
Mean	26.31	29.51	32.96	37.63				

Table 5: Effect of foliar application of GA_3 and NAA on Total soluble solids in ber fruits (^{0}Brix)

Treatment NAA\GA_3	G_0 (Control)	G_1 (GA_3 20ppm)	G_2 (GA_3 30ppm)	G_3 (GA_3 40ppm)	Mean	Sources	S.E.D.	C.D.
N_0 (Control)	12.82	12.94	12.80	12.74	12.82	NAA	0.112	0.23
N_1 (NAA 20ppm)	12.96	13.42	13.21	13.14	13.18	GA_3	0.112	0.23
N_2 (NAA 30ppm)	13.25	14.62	14.05	14.06	13.99	NAAxGA_3	0.225	0.46
N_3 (NAA 40ppm)	13.48	15.14	14.18	13.92	14.18			
Mean	13.13	14.03	13.56	13.46				

Table 6: Effect of foliar application of GA_3 and NAA on Ascorbic acid in ber fruit (mg/100g pulp)

Treatment NAA\ GA_3	G_0 (Control)	G_1 (GA_3 20ppm)	G_2 (GA_3 30ppm)	G_3 (GA_3 40ppm)	Mean	sources	S.E.D.	C.D.
N_0 (Control)	75.29	85.21	91.10	93.45	86.26	NAA	0.559	1.14
N_1 (NAA 20ppm)	76.03	114.37	112.18	128.56	107.78	GA_3	0.559	1.14
N_2 (NAA 30ppm)	75.74	100.08	107.46	106.94	97.55	NAAxGA_3	1.118	2.28
N_3 (NAA 40ppm)	75.79	98.72	97.36	101.05	93.23			
Mean	75.71	99.59	102.02	107.50				

Table 7: Effect of foliar application of GA_3 and NAA on Total sugars in ber fruit (%)

Treatment NAA \ GA_3	G_0 (Control)	G_1 (GA_3 20ppm)	G_2 (GA_3 30ppm)	G_3 (GA_3 40ppm)	Mean	Sources	S.E.D.	C.D.
N_0 (Control)	8.76	8.91	8.86	8.78	8.83	NAA	0.078	0.16
N_1 (NAA 20ppm)	8.88	9.96	9.18	9.05	9.27	GA_3	0.078	0.16
N_2 (NAA 30ppm)	8.91	10.59	9.43	9.30	9.56	NAAxGA_3	0.155	0.32
N_3 (NAA 40ppm)	8.95	10.26	9.68	9.16	9.51			
Mean	8.87	9.93	9.29	9.07				

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