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Effect of FYM and bio-fertilizer on fruit yield and quality in aonla (*Emblica officinalis* Gaertn.) cv. Chakaiya

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Abstract
The present investigation entitled "Effect of FYM and Biofertilizer on fruit yield & quality in Aonla (*Emblica officinalis* Gaertn.) cv. Chakaiya" was conducted during February-December 2023 at the Central Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj (Uttar Pradesh) Which was carried out in Statistical Design adopted for the experiment was (RBD) having three replications ten treatments combinations. The current investigation's findings indicate that the treatment T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB outstands in all the aspects with significant results in Yield and Quality parameters. Quality parameters like Flowering period (31.33 days), Fruits per plant (1817.67), Length (3.93 cm), Diameter (4.37 cm), Weight (44.13 gm), Days to maturity (104.33 days), Yield (81.50 kg) and Quality parameters like TSS (12.53 ^{o}Brix), pH (3.99), Total acidity (2.37%), Ascorbic acid (471.47 mg/100 g) which was followed by 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The lowest observation recorded in T_0 control. Treatment with FYM, azotobacter and PSB with N:P:K improves fruit yield and quality as compared to the control.

Keywords: FYM, azotobacter, PSB, maturity, pH, yield, quality, Chakaiya, aonla

Introduction
Aonla (*Emblica officinalis* Gaertn.) often known by the name Indian gooseberry. It is a native of the Indian sub-continents, relates to the Euphorbiaceae family. Next to the Barbados cherry, it has the highest concentration of vitamin C (400–1300 mg/100 g from pulp) of any fruit. (Mandal *et al.*, 2013) [8]. well-known for its therapeutic and medicinal qualities and regarded as a wonder fruit by those who are health-conscious (Kaur *et al.*, 2019) [6].

Higher Aonla growth and yields may be achieved by a combination of nutrient management, soil type, and fertility. A common explanation for reduced yields in aonla has been identified as inadequate nutrition. One of the most important elements that significantly influences the production and quality of Aonla is crop nutrition. (Mustafa *et al.*, 2013) [9]. Thus, a healthy input is essential for developing plants as well as mature fruit-bearing trees. The indiscriminate application of chemical fertilizers has had a negative impact on the fertility of the soil, the quality of the water, the quantity and quality of produce, and the level of insect resistance. (Kalloo, 2003) [4].

The Bundelkhand region has enormous potential for alternative land use systems, especially agri-horti systems that include aonla on marginal, less productive soils (Pathak and Bhatt, 2001) [10]. Aonla is not only nutritious and therapeutic, but it is also quite profitable for small and marginal farmers to cultivate (Singh and Mishra, 2007) [13]. In the semi-arid regions of Bundelkhand, intensive farming in the form of orchards is being carried out with positive results. (Goyal *et al.*, 2008) [2]. However, there isn't much information on the potential for an aonla-based agri-horti system in this area.

Fruit is commonly used to make hair oil, a well-known Ayurvedic medication that is high in vitamin C and helps in issues with the teeth, gums, stomach, and eyes. Products like preserves (murabha), pickles, Aonla candy, squash, jam, chutney, and so on are also made from fresh fruit.

Aonla is widely spread over the Orissa, West Bengal, Chota Nagpur, Himalayan area, Bihar and Karnataka in India. It has 1,04,000 hectares of total cultivated land under aonla, with an annual production of 12,72,000 MT (PIB Delhi). On other hand, it is 92,000 hectare of land and production of 10,39,000 MT (NHB 2018-19).

Materials and Methods

The present investigation entitled "Effect of FYM and Biofertilizer on fruit yield & quality in Aonla (*Emblica officinalis* Gaertn.) cv. Chakaiya" was conducted during February-December 2023 at the Central Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj (Uttar Pradesh).

Experimental site, climate and weather

The experimental site is located on the left side of Allahabad- Rewa Road, in close proximity to the Yamuna River, at a distance of approximately 8 km from Allahabad city. it comes under subtropical climate zone with summer and winter temperatures in this range situated at altitude of 25.85 °C N and longitude of 81.15°E. This location is located 78 meters above mean sea level in South east of Uttar Pradesh. The temperature might fall to as low as 4 °C in winter and as high as 47 °C during the summer. This region experiences over 1013.4 mm of rainfall on average from July to September during the monsoon, with a few rare showers during the winter.

Fruit Yield Parameters

(I): Duration of flowers

Flowering duration was measured in terms of number of days from the initiation of flowering to the termination of flowering.

(II): Numbers of fruit/plant

At each picking, the total number of fruits on each plant was counted separately, and the average number of fruits per plant was determined.

(III): Length of fruit (cm)

Using a digital Vernier calliper, the length of the fruits was measured at harvest in centimeters from the vertical center of four fruits randomly selected and their average were calculated.

(IV): Diameter of fruit (cm)

Using a Vernier Calliper, the diameters of the fruits were determined by measuring their maximum thickness in centimeters at the time of harvest which were randomly selected and their average were calculated.

(V): Fruit weight (g)

Three fruits were weighed on a physical balance, and the average result was given in grams by Kaur *et al.*, (2019) [6] in Aonla.

(VI): Days to maturity

Maturity duration was measured in terms of number of days to the maturity of fruit as changing of color to yellowness, glossy appearance by Killadi *et al.*, (2015) [5].

(VII): Yield per Tree (Kg)

After every fruit on the tree was removed, the total weight was recorded. The fruit production was given as kg/tree by Kaur *et al.*, (2019) [6] in Aonla & Singh *et al*., (2018) [14] in Aonla.

Quality parameters

(I): Total soluble solids (^{0}Brix)

Using a hand refractometer, the quantity of total soluble solids (T.S.S.) in the ripened fruit juice was calculated by Ram *et al.*, (2007) [12] in Aonla

(II): pH of Fruit

The pH of the fruit juice was determined using a pH meter. The pH electrode is first calibrated using a reference buffer solution whose pH readings are known to fall within the measurement range. The electrode is submerged in the sample solution until a stable reading is obtained in order to measure pH.

(III): Total acidity (%)

The basic acid-alkali titration technique, as outlined in A.O.A.C. in 1970, was used to determine acidity. Using a pipette, 20 ml of fruit juice was obtained and put into a 100 ml container. After giving it a good shake, 0.25 ml of the diluted fruit juice was pipetted into a 250 ml beaker. Three drops of Phenolphthalein indicator were then added to the mixture. Juice was titrated with alkali solution drop by drop while stirring continuously until the pink end point was achieved. The burette was then filled with N/10 NaOH solution. The % acidity was computed using end point values that were recorded.

$$\text{Total acidity \%} = \frac{128 \times \text{titer value}}{1000}$$

(IV): Ascorbic acid (mg/100 g)

By using a pestle and mortar to crush 5 grams of fruit pulp with 3 percent metaphosphoric acid as a buffer, the ascorbic acid level was determined. After filtering the extract, a 100 ml volume was created. A 5 ml sample was titrated up to the appearance of a light pink color using a 2, 6-Dichlorophenol indophenol dye solution. Ascorbic acid milligrams per 100 grams of fruit pulp were used to express the results (A.O.A.C., 1970).

Dye factor = 0.5/ Titrate value of standard ascorbic acid

$$\text{Ascorbic acid} = \frac{\text{Titrate value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Aliquot taken} \times \text{Weight of sample taken}} \times 100$$

Treatment combination

Treatment no.	Treatment Combinations
T_0	Control
T_1	100% RDN of NPK + 10 kg FYM plant^{-1}
T_2	75% RDN of NPK + 20 kg FYM plant^{-1}
T_3	50% RDN of NPK + 30 kg FYM plant^{-1}
T_4	100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter
T_5	75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter
T_6	50% RDN of NPK + 30 kg FYM plant^{-1} + 150 g Azotobacter
T_7	100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB
T_8	75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB
T_9	50% RDN of NPK + 30 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB

Results and Discussion

(A) Fruit Yield Parameters (Table 1)

Duration of flowering

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on Duration of flowering. However, the maximum duration (31.33) of flowering was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB was followed by T_8 (27.67) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The minimum duration (18.67) of flowering was recorded in T_0.

No. of Fruits per Plant

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on No. of Fruits per Plant. However, the maximum No. (1817.67) of fruits was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB was followed by T_8 (1788.33) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The minimum No. (1282.33) of fruit was recorded in T_0.

Length of Fruit (cm)

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on Length of Fruit (cm). However, the maximum Length (3.93) of fruits was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB was followed by T_8 (3.90) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The minimum Length (3.10) of fruit was recorded in T_0.

Diameter of Fruit (cm)

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on Diameter of Fruit (cm). However, the maximum Diameter (4.37) of fruits was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB was followed by T_8 (4.17) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The minimum Diameter (3.50) of fruit was recorded in T_0.

Weight of Fruit (g)

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on Weight of Fruit (g). However, the maximum Weight (44.13) of fruits was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB was followed by T_8 (41.93) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The minimum Weight (24.73) of fruit was recorded in T_0.

Days to maturity

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on days to maturity. However, the minimum days (104.33) to maturity of fruits was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB was followed by T_8 (105.00) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The mixiumum days (113.00) to maturity of fruit was recorded in T_0.

Yield per tree (Kg)

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on Yield per tree. However, the maximum (81.50) Yield was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB was followed by T_8 (75.70) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The minimum (40.17) Yield was recorded in T_0.

Quality parameters (Table 2)

Total Soluble Solids (°Brix)

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on TSS. However, the maximum (12.53) TSS was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB was followed by T_8 (12.00) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The minimum (8.87) TSS was recorded in T_0.

pH of fruit

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on pH of fruit. However, the minimum (3.99) pH of fruits was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB was followed by T_8 (4.13) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The mixiumum (4.73) pH of fruit was recorded in T_0.

Total Acidity (%)

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on Total Acidity (%). However, the maximum (2.37) Total Acidity (%) was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB

was followed by T_8 (2.20) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The minimum (1.77) Total Acidity (%) was recorded in T_0.

Ascorbic acid (mg/100 g)

It is expressed through the layout of the table that there was significant effect of FYM and Biofertilizer with various treatments on Ascorbic acid (mg/100 g). However, the maximum (471.47) Ascorbic acid (mg/100 g) was recorded in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB was followed by T_8 (470.63) 75% RDN of NPK + 20 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB. The minimum (436.77) Ascorbic acid (mg/100 g) was recorded in T_0.

Table 1: Shows Tr. No. Duration of Flowering No. of Fruits/Plant Length of Fruit (cm) Diameter of Fruit (cm) Weight of Fruit (g) Days to Maturity and its Yield/Tree (kg)

Tr. No.	Duration of Flowering	No. of Fruits/Plant	Length of Fruit (cm)	Diameter of Fruit (cm)	Weight of Fruit (g)	Days to Maturity	Yield/Tree (kg)
T_0	18.67	1282.33	3.10	3.50	24.73	113.00	40.17
T_1	19.67	1400.00	3.30	3.67	36.57	109.33	55.70
T_2	19.67	1476.00	3.40	3.63	37.23	108.83	56.70
T_3	20.67	1486.67	3.53	3.90	29.50	108.67	49.13
T_4	19.33	1569.33	3.67	3.77	35.43	107.50	63.57
T_5	22.00	1648.67	3.50	3.53	35.57	107.33	60.50
T_6	21.00	1684.67	3.70	3.87	37.87	106.83	69.83
T_7	31.33	1817.67	3.93	4.37	44.13	104.33	81.50
T_8	27.67	1788.33	3.90	4.17	41.93	105.00	75.70
T_9	26.00	1742.67	3.77	4.13	39.33	105.67	69.73
SE.d.	1.53	28.65	0.17	0.13	2.08	0.36	3.02
C.D. at 5%	3.21	60.20	0.36	0.27	4.37	0.77	6.34

Table 2: Shows Tr. No. TSS (oBrix) pH of Fruit Total Acidity (%) and its Ascorbic acid (mg/100 g)

Tr. No.	TSS (ºBrix)	pH of Fruit	Total Acidity (%)	Ascorbic acid (mg/100 g)
T_0	8.87	4.73	1.77	436.77
T_1	10.27	4.36	1.87	459.47
T_2	11.20	4.29	1.83	462.73
T_3	10.90	4.36	1.87	449.80
T_4	10.80	4.62	2.13	462.87
T_5	10.77	4.16	2.07	452.80
T_6	11.57	4.41	2.10	449.97
T_7	12.53	3.99	2.37	471.47
T_8	12.00	4.13	2.20	470.63
T_9	11.80	4.25	2.10	469.63
SE.d.	0.73	0.16	0.12	5.06
C.D. at 5%	1.53	0.33	0.26	10.63

Discussion

Biofertilizers (Azolla, Azotobacter, PSB, Azospirillum, and Azolla) are substances that colonize the rhizosphere, or the inside of the plant, and increase the host plant's availability or supply of primary nutrients, hence promoting growth (Hazarika and Ansari, 2007) [3]. Highly effective phosphate solubilizing microorganisms (PSM) found in the PSB develop and release organic acids, which dissolve and render available to the plants unavailable phosphates such as tricalcium, iron, and aluminum phosphates. (Muralidharan and Perumal, 2010) [11]. Main nutrients for plants which is phosphorus, that promotes rapid growth and development and helps plants to tolerate disease. When there is need to raising the amount of accessible P2O5 to the soil, PSB is found as the most successful strain of phosphate-solubilized bacteria. An aerobic, Free-living nitrogen fixer is called an Azotobacter. When mixed to the soil, they grow quickly and form a huge population in the rhizosphere. They fix atmospheric N and obtain nourishment from the organic materials found in soil and root exudates. After dying and decomposing, the fixed nitrogen in Azotobacter cells is nitrified, and plants use that nitrogen which got from Azotobacter plasma.

Conclusion

When the results come at board, it is concluded that treatment with in T_7 100% RDN of NPK + 10 kg FYM plant^{-1} + 150 g Azotobacter + 100 g PSB recorded as the best treatment in terms of Fruit Yield and Quality of Aonla. For FYM and biofertilizer application in Aonla, this treatment believed to be most suitable which is economic with a benefit-cost ratio of (3.38).

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