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Response of Aonla Plant for Fruit Quality Attributes after Integrated Application of Inorganic, Organic Sources and Biofertilizers

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ABSTRACT

The nutritional value of aonla (Indian gooseberry) fruits is also influenced by the fertilization process, soil fertility and sources of nutrition. The recommended dose of fertilizers (RDF) was applied in combination with biofertilizers viz. *Azotobacter, Azospirillum* and PSB (100 g/tree each) in the rhizosphere zone of aonla trees. The fruit quality attributes observed during study were physical characteristics of ripe fruits viz., size, weight and volume of freshly harvested fruits and the chemical properties of fresh fruits viz., total soluble solids (TSS), titratable acidity using phenolphthalein as an indicator, total sugar and ascorbic acid. The statistical analysis for randomized block design was carried out with 11 treatments and three replications. The maximum fruit weight after application of T_{10} might be result of greater mobility of the photosynthates into the developing fruits. The estimation of chemical parameters of fruit viz., TSS, acidity, total sugar and ascorbic acid after application of different treatments resulted with highest TSS and sugar in treatment T_{10} (half dose of NPK, 100 kg FYM with *Azotobacter*, *Azospirillum* and PSB). The physico-chemical parameters of aonla fruits were significantly affected through application of integrated nutrient management practices consisiting inorganic, organic and biofertilizer sources.

Key words : *Azotobacter*, *Azospirillum*, biofertilizers, correlation, fruit quality, Indian gooseberry, regression

INTRODUCTION

The Indian gooseberry (*Emblica officinalis* Gaertn.) is valued for its high nutritive values, medicinal properties, processing of value-added products and herbal drugs. It is also known as 'Amrit Phal' or 'Wonder Drug' because of its great medicinal and nutritional utilization. In respect of nutritional values, it is rich source of vitamin C (650-900 mg/100 g) which is more than that of guava, citrus and tomato fruits and also contains carbohydrates (14.10-21.89%) minerals (1.2% iron), phenol, polyphenol and tannins, alkaloid and ellagic acid. It is a necessary component of 'Triphala', Chavanprash and other aurvedic preparations (Kulkarani *et al.*, 2017). Fruits are commonly used for making preserve, pickles, candy, etc. The processing potentiality of fruits is yet to be fully tapped (Tripathi *et al.*, 2015). The fruit is used as blood purifier, antioxidants, laxative, liver tonic and antibiotic and very effective remedy of diarrhoea**,** jaundice, dyspepsia, cough**,** cold, asthma and diabetes and chronic dysentery (Singh, 2020). The fruit is richest source of ascorbic acid (vitamine C) after Barbados cherry (*Malphigia glabra)* **(**Deepika and Panja, 2017), having pharmaceutical activities of phylemblin isolated from fruit pulp and antiviral activity (Khurana *et al.*, 2019).

The nutritional value of aonla fruits is also influenced by the fertilization process, soil fertility and sources of nutrition. Tropical soils are deficient in phosphorus and when a farmer adds phosphatic fertilizers, nearly 75% of it is converted to a form unavailable for plant growth. Many fungi and bacteria like *Aspergillus, Penicillium,* and *Bacillus,* etc. solublize these bound phosphates by producing organic acids and convert them to a form available to a plant growth. Recent research has shown that using a "microbial consortium" consisting of several beneficial soil micro-organisms like mycorrhizal fungi, nitrogen fixers, phosphate solublizers and biocontrol agents improves plant growth and productivity much better than inoculation with a single micro-organism. Further there is a newer micro-organism like *Paenibacillus, Pantoea, Azoarcus, Methylobacterium,* etc. with great potential in enhancing plant growth and crop productivity, on which very little work has been done in our country. An integrated use of chemical fertilizers with biofertilizers markedly increases fertilizer use efficiency, minimizes their losses and leakage and improves frtility status of soil.

Integrated nutrient supply, use of management system involves efficient and judicious supply, use or management of all the major components of plant and nutrient sources : chemical fertilizers in conjunction with animal manures, compost, green manure, legumes in cropping system, biofertilizers, crop reduces, or recyclable waste and other locally available nutrient sources for sustaining soil fertility, health and productivity. Many authors have reported the integrated use of nutrients and biofertilizers in various fruit crops (Jugnake *et al.*, 2017; Poonia *et al.*, 2018). The increase in crop productivity results from their combined effects, the synergistic effect, that helps to improve chemical, physical and biological properties of soil and consequently the soil organic matter and nutrient status; to a large extent balanced nutrient supply to crops in cropping system, and with no or minimal deleterious effect on environment, if any.

Application of non-symbiotic free living aerobic organism, *Azotobacter* and *Azospirillum* resulted in sustainable productivity of different non-leguminous crops. Many scientists were also of the view that the favourable action of *Azotobacter* on the quality of the fruits was associated with the production of biologically active substances like vitamin B-complex, auxin and cytokinin (Lallawmkima *et al.*, 2018a, b; Rohitha *et al.*, 2021). Considering the fact, the research was carried out to evaluate the response of aonla fruit for quality attributes after application of integrated nutrient practices including the FYM, biofertilizers and inorganic fertilizers as source of nutrients.

MATERIALS AND METHODS

The present study was conducted during 2019 and 2020 in ten-year-old orchard of aonla cv. NA-7 located at the Department of Horticulture, ITM, University Gwalior, M. P., India. The soil was characterized as sandy loam with average proportion of fine sand (64.77%), silt (22.76%) and clay (14.95%) with average pH of 7.71. Thirty-three plants of uniform size (canopy volume) and vigour from ten-year-old aonla cultivar 'NA-7' planted with a spacing of 8.0 x 8.0 m were selected for the experimental purpose. Routine management practices were followed in all the plants. The treatments included recommended dose of fertilizer (RDF) as 1.0 kg of nitrogen, 0.5 kg of phosphorus and 1.0 kg of potassium per tree. Farm yard manure (FYM) @ 100 kg/plant along with bio-fertilizers was applied around each tree in the second week of January.

The bio-fertilizers viz., *Azotobacter, Azospirillum* and PSB (100 g/tree each) were applied in the rhizosphere zone of aonla around the tree at a depth of 15 cm leaving 50 cm from the main trunk. The RDF was applied in form of urea, SSP and MOP, respectively. Two-third of the total nitrogen and whole of the phosphorus and potassium were applied during last week of February. Rest one-third dose of N was applied in the first week of August. The fertilizers were applied in 20-25 cm wide and 10-15 cm deep trenches made beneath the tree canopy leaving 50 cm distance from the main trunk. The fertilizer was well mixed with the soil in the trenches and then levelled. The treatments were : T_0–RDF (1000 : 500 : 1000 g/tree of NPK) as control; T_1–Three-fourth of RDF+100 kg FYM; T_2–Three-fourth of RDF+100 kg FYM+*Azotobacter*; T_3–Three-fourth of RDF+100 kg FYM+*Azospirillum*; T_4–Three-fourth of RDF+100 kg FYM+PSB; T_5–three-fourth of RDF+100 kg FYM+*Azotobacter*+*Azospirillum*+PSB; T_6–Half of RDF+100 kg FYM; T_7–Half of RDF+100 kg FYM+*Azotobacter*; T_8–Half of RDF+100 kg FYM+*Azospirillum*; T_9–Half of RDF+100 kg FYM+PSB and T_{10}–Half of RDF+100 kg FYM+*Azotobacter*+*Azospirillum*+PSB.

The observation on physical and chemical characteristics of matured aonla fruits was recorded. For physico-chemical analysis, 10 fruits were randomly selected from the total number of fruits from 20 bearing shoots. Individual fruit was washed thoroughly with water to remove adhering dirt and dust and was kept for drying at room temperature. Afterwards, the records were made on the physico-chemical properties of the fruits. The fruit quality attributes observed during study were physical characteristics of ripe fruits viz., size, weight and volume of freshly harvested fruits and the chemical properties of fresh fruits viz., total soluble solids (TSS), titratable acidity using phenolphthalein as an indicator, total sugar (Modified Lane and Eynon method as described by Ranganna) and ascorbic acid (mg/100 g pulp) using standardized 2, 6-dichlorophenol indophenols dye (AOAC and Horwitz, 2019). The statistical analysis for randomized block design was carried out with 11 treatments and three replications.

RESULTS AND DISCUSSION

The observations on the various physical attributes of aonla fruit after application of biofertilizers as additional and/or supplementary inputs showed significant variation (Table 1). Among all the biofertilizers, treatment T_{10} responded with highest average fruit size (3.70 x 4.66 and 4.00 x 4.76 cm), average fruit weight (51.82 and 52.40 g) and average fruit volume (43.36 and 44.96 cm) followed by T_5, T_9, T_4 and T_3 applications. However, the control treatment was recorded with the lowest value of physical attributes, confirming the significance of biofertilizers as additional or supplementary dose for aonla trees.

The maximum fruit weight after application of T_{10} was result of greater mobility of the photosynthates into the developing fruits as compared to the treatments involving higher dose of inorganic, organic and biofertilizers sources (Sharma *et al.*, 2013; Rattan *et al.*, 2020; Bahadur *et al.*, 2021). This further accounted for application of supplementary dose of active microbial inoculation through biofertilizers in case of reduced nitrogen application in these treatments (Kumar *et al.*, 2018).

The observations recorded on biochemical attributes of aonla fruits after application of biofertilizers as additional and/or supplementary dose of nutrient management in combination with various doses of RDF confirmed significant variation among treatments (Table 2). The findings confirmed the highest TSS (13.25 and 13.35^0 Brix), lowest acidity (2.24 and 2.22%), highest total sugar (4.623 and 5.420%) and highest ascorbic acid (551.1 and 556.21 mg/ 100 g of pulp) after T_{10} which was closely followed by T_5, T_9 and T_4, while the inferior quality was recognized in the control. The estimation of chemical parameters of fruit viz., TSS, acidity, total sugar and ascorbic acid after application of different treatments resulted as highest TSS and sugar in treatment T_{10} (half dose of NPK, 100 kg FYM with *Azotobacter*, *Azospirillum* and PSB). The nitrogen stimulated the functioning of a number of enzymes involved in the physiological process which probably caused an increase in TSS content of fruit with increasing levels of nitrogen (Spehia *et al.*, 2020; Singh *et al.*, 2021).

Increased ascorbic acid estimates in aonla fruits after different treatments were associated with significant conversion of soluble sugars into ascorbic acid (Singh *et al.*, 2018a; Singh and Singh, 2019). Finally, it can be concluded that application of half of RDF (500 : 250 : 500 g NPK)+100 kg FYM+ *Azotobacter*+*Azospirillum*+PSB per plant proved to be the most suitable treatment for improving physico-chemical characters of NA-7 aonla fruit. Thus, the integrated approach of nutrient availability had significant effect on fruit quality parameters associated with better nutrient uptake and utilization as confirmed by the improved soil and leaf nutrient status (Singh *et al.*, 2016b; Anmol and Singh, 2018; Singh *et al.*, 2018b; Spehia *et al.*, 2019a, b; Elsayed *et al.*, 2020).

The regression study showed a very high R square value (0.994) with significant effect of all the quality traits over ascorbic acid contents confirming the relation between

Table 1. Physical quality attributes of aonla fruits after application of biofertlizers as a component of INM

Treatment	Fruit length (cm)		Fruit width (cm)		Fruit weight (g)		Fruit volume (cc)	
	2019	2020	2019	2020	2019	2020	2019	2020
T_0	3.33	3.33	4.32	4.33	42.80	42.85	33.50	33.60
T_1	3.45	3.48	4.37	4.38	43.20	43.80	34.20	34.60
T_2	3.50	3.56	4.40	4.42	44.21	44.62	36.40	37.40
T_3	3.54	3.68	4.47	4.46	44.72	45.32	36.80	37.90
T_4	3.60	3.78	4.54	4.54	47.56	47.92	38.20	39.60
T_5	3.67	3.90	4.60	4.62	50.42	50.90	40.10	42.40
T_6	3.48	3.60	4.39	4.41	43.50	43.86	33.80	34.40
T_7	3.52	3.68	4.42	4.44	44.53	45.80	35.80	36.40
T_8	3.59	3.76	4.48	4.51	45.80	46.10	35.90	38.90
T_9	3.66	3.78	4.56	4.58	48.32	49.20	39.40	41.10
T_{10}	3.70	4.00	4.66	4.76	51.82	52.40	43.36	44.96
Mean	3.55	3.69	4.47	4.50	46.08	46.62	37.04	38.30
S. E. (diff.)	0.063	0.0515	0.088	0.07	1.281	1.62	1.979	1.786
C. D. (P=0.05)	0.131	0.1075	0.184	0.147	2.672	3.379	4.128	3.725

Table 2. Biochemical quality attributes of aonla fruits after application of biofertlizers as a component of INM

Treatment	TSS (^{0}Brix)		Acidity (%)		Total sugar (%)		Ascorbic acid (mg/100 pulp wt.)	
	2019	2020	2019	2020	2019	2020	2019	2020
T_0	11.50	11.40	2.53	2.58	4.21	4.21	533.86	531.86
T_1	11.83	11.92	2.48	2.49	4.22	4.23	534.82	535.20
T_2	12.20	12.30	2.40	2.37	4.30	4.32	538.40	539.42
T_3	12.33	12.38	2.34	2.31	4.31	4.33	540.12	542.82
T_4	12.66	12.90	2.29	2.28	4.36	4.37	544.88	550.66
T_5	12.80	13.10	2.28	2.25	4.42	4.46	550.22	555.21
T_6	11.75	11.80	2.35	2.32	4.24	4.25	535.39	537.86
T_7	12.00	12.33	2.30	2.29	4.28	4.29	539.42	540.49
T_8	12.40	12.40	2.35	2.33	4.31	4.34	542.86	543.86
T_9	12.90	13.30	2.26	2.24	4.32	4.35	546.80	549.82
T_{10}	13.25	13.35	2.24	2.22	4.62	5.42	551.10	556.21
Mean	12.33	12.47	2.35	2.33	4.33	4.42	541.62	543.95
S. E. (diff.)	0.41	0.272	0.056	0.026	0.023	0.011	1.769	2.542
C. D. (P=0.05)	0.855	0.567	0.118	0.0557	0.048	0.0239	3.691	5.303

Table 3. Correlation among fruit quality attributes in aonla fruits

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	1.000							
X_2	0.961	1.000						
X_3	0.926	0.984	1.000					
X_4	0.925	0.982	0.977	1.000				
X_5	0.945	0.961	0.945	0.969	1.000			
X_6	-0.927	-0.831	-0.786	-0.787	-0.849	1.000		
X_7	0.719	0.831	0.806	0.838	0.712	-0.557	1.000	
X_8	0.961	0.981	0.981	0.969	0.969	-0.847	0.729	1.000

X_1 : Average fruit length (cm), X_2 : Average fruit width (cm), X_3 : Average fruit weight (g), X_4 : Average fruit volume (cc), X_5 : TSS (°Brix), X_6 : Average acidity (%), X_7 : Total sugar (%) and X_8 : Ascorbic acid (mg/100 pulp wt.).

these fruit quality traits. Further, the positive and high correlation was reported between all traits except acidity content of fruits (X_6). The average fruit width (0.981) and the average fruit weight (0.981) were strongly and positively correlated with ascorbic acid content of aonla fruits; however, the acidity content was negatively (-0.847) correlated with ascorbic acid content (Table 3).

Thus, the evidence of correlation and regression analysis confirmed improvement in any of the biochemical parameters under study had significant effect on fruit quality, particularly ascorbic acid content in Indian gooseberry fruits after application of integrated nutrient management practices consisiting inorganic, organic and biofertilizer sources (Singh et al., 2016a). Singh and Sharma (2016) also confirmed significance of organic nutrient sources for intercropped Indian gooseberry orchard.

CONCLUSION

The fruit quality, the highest TSS (13.25 and 13.35 ^{0}Brix) and lower acidity (2.24 and 2.22%) were recorded when the plants were treated with half dose of NPK and 100 kg FYM along with biofertilizers during 2019 and 2020, respectively. This treatment also accounted for highest sugar (4.36 and 4.42%) and highest ascorbic acid content (551.10 and 556.21%) during both the years, respectively.

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