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Biofertilizer–An Effective Component of Integrated Nutrient Management in Aonla

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ABSTRACT

Aonla (*Emblica officinalis* Gaertn.), a member of Euphorbiaceae family, has greater efficiency to utilize the combinations of inorganic, organic and microbial sources of nutrients. The present studies emphasized the efficacy of integrated approach of nutrient management for growth of aonla trees. The plant growth attributes viz., plant height, spread and canopy volume were measured and the percentage increment was determined for the years 2019 and 2020 on the basis of the previous year. The application of 50-75% of recommended dose of fertilizers (RDF) in combination with microbial application as *Azotobacter*, *Azospirillum* and phosphate solublizing bacteria (PSB) resulted in highest plant height, spread and canopy volume with maximum increment in these parameters and lowest fruit drop percentage. Thus, application of *Azotobacter* and *Azospirillum* might be effective in free atmosphere nitrogen fixation and synthesis of plant growth promoting compounds which could result in accelerated vegetative growth in aonla trees. A direct correlation between plant spread and canopy volume was also reported under the integrated nutrient management practice.

Key words : Aonla, canopy volume, *Azotobacter*, *Azospirillum*, PSB (Phosphate solublizing bacteria)

INTRODUCTION

The Indian gooseberry (*Emblica officinalis* Gaertn.), a native to tropical South-East Asia, is grown in India since its origin (Singh *et al.*, 2016a). It is traditionally grown in Pratapgarh and its surrounding regions of Uttar Pradesh and is becoming prominent in the semi-arid regions of Maharashtra, Gujarat, Rajasthan, Andhra Pradesh, Karnataka, Tamil Nadu and the Arawali ranges in Haryana, Kandi area in Punjab and in Himachal Pradesh (Ramchandra, 2018). It belongs to Euphorbiaceae and is called as Aonla, Amlika, Amali, Ambala, Amalakamu and Nelli in different parts of the country. It can be magnificently grown under marginal wasteland, sodic soil, ravine land, arid and drought prone areas (Singh and Sharma, 2016). In this crop, flowering and fruit set coincide with spring and after the fruit set the fruits enter in dormancy throughout the summer. Further, fruit growth starts at the onset of monsoon. Therefore, water requirement during summer becomes negligible which enables aonla to be ideally grown under arid regions (Sharma *et al.*, 2019).

Indiscriminate use of inorganic sources of nutrient to provide better nutrition to plants and achieve high yield, made the soil and water quality degraded and brought stagnation in productivity of crops. Soil fertility can be restored, maintained and sustained by three ways : addition of organic residues from plants and animal sources, strengthening the soil biological process and use of synthetic fertilizers and soil amendments as per needs. Integrated nutrient management envisaged the use of chemical fertilizers in combination with organic manures, biofertilizers and other locally available nutrients sources for sustaining soil health and productivity.

There are different kinds of micro-organism present in the soils viz., bacteria, actinomycetes, fungi, algae, protozoa, viruses, etc. The numbers of each micro-organism in the soil range from a few thousands to a few millions per grain in the soil. Some micro-organisms in the soil are beneficial for plant growth. A number of associative and free-living organisms like *Azospirillum*, *Azotobacter*, cyanobacteria, vermicompost, etc. can fix atmospheric nitrogen; synthesize plant growth promoting substance such as indole acetic acid and gibberellins (Rohitha *et al.*, 2021). These both factors are supportive for growth of plants. The amount of nitrogen fixed by them has been reported to vary from 35-195 kg/ha/season.

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 phosphates by producing organic acids and convert them to available form for plants. Many authors have reported the integrated use of nutrients and biofertilizers in various fruit crops (Jugnake *et al.*, 2017; Poonia *et al.*, 2018).

Hence, application of beneficial soil microbes, particularly plant growth promoting rhizobacteria (PGPR), as cheaper and pollution free sources of nutrients for increasing plant vigour has great demand in modern agriculture. Considering the facts related to adverse effect of chemical based farming system and synergistic effect of biofertilizers the present study was undertaken to develop effective integrated nutrient management package for aonla cv. NA-7 with the objectives to evaluate influence of biofertilizers with recommended dose of NPK on growth attributes and fruit drop in aonla trees.

MATERIALS AND METHODS

The present study was conducted during two consecutive years i. e. 2019 and 2020 in ten-year-old orchard of aonla 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 trees of uniform vigour from ten-year-old aonla (cv. NA-7) orchard planted at 8.0 x 8.0 m distance were used for the experiment. 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 biofertilizers (*Azotobacter, Azospirillum* and PSB @ 100 g/tree each) was applied during the second week of January. The recommended dose of fertilizers was applied in three different proportions i. e. 100, 75 and 50% in the form of urea, single super phosphate and muriat of potash, respectively. After harvesting of previous crops, two-third of the total nitrogen and complete phosphorus and potassium were applied, while remaining dose of nitrogen was applied during onset of monsson. The fertilizer was well mixed with the soil in the trenches and then levelled. The statistical analysis for randomized block design was carried out with 11 treatments and three replications. The regression studies for levels residual plot, levels line fit plot and normal probability plot for different levels of biofertilizers were also studied to evaluate the effectiveness of all the three types of bifertilizers and their combination used in study. The treatments including biofertilizer levels have been presented in Table 1.

The vegetative parameters studied were as per the need of objectives and included plant height (m), plant spread (East-West and North-South spread) and canopy volume (m^3) with the increment percentage in these parameters. In addition to vegetative parameters, percentage of fruit drops was also estimated on the basis of counting of fruits on trees. The data were statistically analyzed as randomized block design and one-way analysis of varience.

RESULTS AND DISCUSSION

The observations on plant height (Table 2)

Table 1. Treatments used in study and the levels depicting the biofertilizer types in different treatments (0 indicates absence, while 1 indicates presence of biofertlizers in the secquence of *Azotobacter, Azospirillum* and PSB)

Symbol	Treatments	Levels
T_0	Full dose of NPK (1000 : 500 : 1000 g/tree) control	000
T_1	¾th dose of NPK/tree+100 kg FYM	000
T_2	¾th dose of NPK/tree+100 kg FYM+*Azotobacter*	100
T_3	¾th dose of NPK/tree+100 kg FYM+*Azospirillum*	010
T_4	¾th dose of NPK/tree+100 kg FYM+PSB	001
T_5	¾th dose of NPK/tree+100 kg FYM+*Azotobacter*+*Azospirillum*+PSB	111
T_6	½ dose of NPK/tree+100 kg FYM	000
T_7	½ dose of NPK/tree+100 kg FYM+*Azotobacter*	100
T_8	½ dose of NPK/tree+100 kg FYM+*Azospirillum*	010
T_9	½ dose of NPK/tree+100 kg FYM+PSB	001
T_{10}	½ dose of NPK/tree+100 kg FYM+*Azotobacter*+*Azospirillum*+PSB	111

confirmed that T_5 showed the maximum plant height (14.33 and 14.83 m) followed by T_{10}, T_2 and T_3 during both the years i. e. 2019 and 2020, respectively, revealing no significant difference among each other. The least plant height (13.93 and 14.03 m) was observed in control, while T_9, T_1 and T_6 did not result in any significant increase in plant height over control during first year but exhibited significant variation in the second year. The increment in plant height (Table 2), estimated in percentage, was recorded in T_5 (1.85 and 5.40%) followed by T_6 (3.41 and 4.67%) and T_{10} (2.14 and 3.93%) which might be associated with INM approach having 25% replacement of RDF by biofertilizers application.

Table 2. Plant height and percentage increment in height of aonla (cv. NA-7) trees after application of biofertilizers as component of INM

Treatment	Plant height (m)			Increment in height (%)	
	Initial	2019	2020	2019	2020
T_0	13.82	13.93	14.03	0.80	1.52
T_1	13.86	13.96	14.16	0.72	2.16
T_2	14.05	14.26	14.46	1.49	2.92
T_3	14.03	14.23	14.38	1.43	2.49
T_4	14.00	14.21	14.33	1.50	2.36
T_5	14.07	14.33	14.83	1.85	5.40
T_6	13.48	13.94	14.11	3.41	4.67
T_7	13.96	14.14	14.26	1.29	2.15
T_8	13.92	14.06	14.22	1.01	2.16
T_9	13.85	13.96	14.18	0.79	2.38
T_{10}	14.00	14.30	14.55	2.14	3.93
Mean	13.91	14.12	14.32	1.49	2.92
S. E. (diff.)		0.057	0.0226		
C. D. (P=0.05)		0.1207	0.0471		

It was evident from the observations given in Table 3 that the tree spread increased with increasing level of nutrients. The maximum plant spread (7.53 and 7.65 m) was noticed with the application of ¾th dose of NPK+100 kg FYM+*Azotobacter*+*Azospirillum*+PSB (T_5) followed by T_{10} and T_2. Hence, T_5 was significantly superior to the remaining treatments during both the years except T_{10} in the second year. The minimum tree spread was revealed in control (7.11 and 7.13 m) during both the years i. e. 2019 and 2020, while the treatments T_8, T_6 and T_9 did not show any significant increase in plant spread over the control during both the years. Likewise increment in plant height, the average speed of aonla trees was reported with T_5 (3.86 and 5.52%) and T_6 (3.39 and 6.06%) in 2019 and 2020, respectively.

Table 3. Plant spread and percentage increment in spread of aonla (cv. NA-7) trees after application of biofertilizers as component of INM

Treatment	Plant spread (m)			Increment in spread (%)	
	Initial	2019	2020	2019	2020
T_0	7.00	7.11	7.13	1.57	1.86
T_1	7.05	7.21	7.25	2.27	2.84
T_2	7.20	7.36	7.40	2.22	2.78
T_3	7.16	7.30	7.33	1.96	2.37
T_4	7.12	7.28	7.31	2.25	2.67
T_5	7.25	7.53	7.65	3.86	5.52
T_6	7.02	7.16	7.18	1.99	2.28
T_7	7.10	7.25	7.31	2.11	2.96
T_8	7.08	7.18	7.21	1.41	1.84
T_9	7.03	7.15	7.16	1.71	1.85
T_{10}	7.09	7.33	7.52	3.39	6.06
Mean	7.10	7.26	7.31	2.25	3.00
S. E. (diff.)		0.063	0.045		
C. D. (P=0.05)		0.1329	0.0939		

The canopy volume was significantly influenced by different treatments during 2019 and 2020 (Table 4). Application of ¾th dose of NPK+100 kg FYM+*Azotobacter*+*Azospirillum*+ PSB (T_5) revealed maximum canopy volume (492.17 and 530.46 m^3) followed by T_{10} and T_2 during the years 2019 and 2020, respectively. Treatment T_5 proved to be significantly superior to all the other treatments except T_{10} in first year, while in second year it was found to be superior to all the treatments. The control showed the minimum value of canopy volume (433.37 and 439.14 m^3) during first and second year, respectively. In similarity with the annual increment in plant spread, the canopy volume was also increased with the highest percentage in T_5 (18.13 and 27.32) and T_{10} (16.62 and 20.08) in the year 2019 and 2020, respectively. A direct correlation was also repeated between plant spread and canopy volume confirming the canopy volume as function of aonla plant spread.

Observations on various vegetative growth attributes indicated that application of biofertilizers increased plant height, spread and tree canopy volume (Rattan *et al.*, 2020) in different combinations, but the treatment combination of ¾th dose of NPK and 100 kg FYM along with *Azotobacter*, *Azospirillum* and PSB showed better vegetative growth than full dose of NPK alone. The increase in growth parameters of aonla cv. NA-7 by NPK, FYM and biofertilizers application may be due to better availability of the nutrients as well as their

Table 4. Canopy volume and percentage increment in canopy of aonla (cv. NA-7) trees after application of biofertilizers as component of INM

Treatment	Canopy volume (m^3)			Increment in canopy volume (%)	
	Initial	2019	2020	2019	2020
T_0	400.25	433.37	439.14	8.27	9.72
T_1	408.16	444.06	451.52	8.80	10.62
T_2	412.42	473.48	485.61	14.81	17.75
T_3	411.12	469.68	475.31	14.24	15.61
T_4	410.00	460.27	470.93	12.26	14.86
T_5	416.62	492.17	530.45	18.13	27.32
T_6	401.82	437.90	447.89	8.98	11.47
T_7	409.00	460.30	467.68	12.54	14.35
T_8	406.14	445.40	457.84	9.67	12.73
T_9	404.26	438.01	449.48	8.35	11.19
T_{10}	412.40	480.93	495.23	16.62	20.08
Mean	408.38	457.78	470.10	12.06	15.06
S. E. (diff.)		6.862	5.2876		
C. D. (P=0.05)		14.315	11.0297		

effective utilization by the plants as like the fertigation treatment (Bahadur *et al.*, 2021). Subash and Rafat (2016) also reported positive effect of *Azotobacter* and *Azospirillum* on yield attributing traits of sesame. Similar findings have been acknowledged by Insaf *et al.* (2017) in *Pisum*, Latif and Mustafa (2019) in Gerbera and Rattan *et al.* (2020) in kinnow. Thus, an increase in growth parameters may be due to the stimulating and beneficial effect of biofertilizers in solublizing and utilization of nitrogen and biosynthesis of plant growth regulators like IAA and GA (Lallawmkima *et al.*, 2018a, b).

The marked effect of different treatments on vegetative growth may be due to the fact that absorbed nitrogen combined with carbohydrates in leaves could lead to the synthesis of amino acids, nucleic acid, proteins, chlorophyll, alkaloid and amides (Spehia *et al.*, 2020; Singh *et al.*, 2021). These

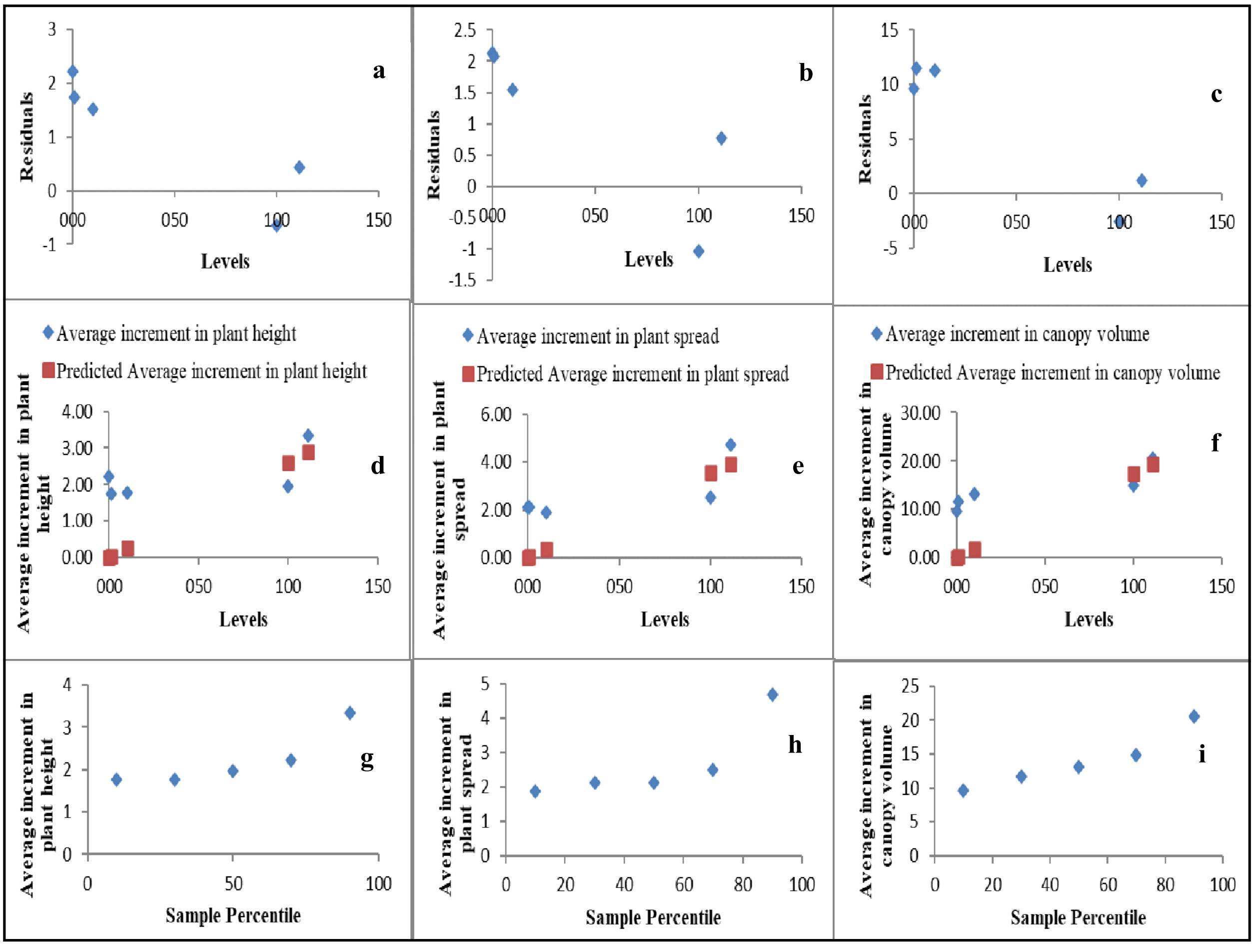

Fig. 1. Regression study for levels residual plot (a-c), levels line fit plot (d-f) and normal probability plot (g-i) for different levels of biofertilizers [Levels are : 000, 100, 010, 001, 111, where, 0 indicates absence, while 1 indicates presence of biofertlizers in the secuence of *Azotobacter, Azospirillum* and PSB].

metabolites are involved in building up of new tissues and are related to a number of metabolic steps (Singh *et al.*, 2018a). Biofertilizers are known to enrich the soil by way of biological N-fixation and improving the availability of different nutrients to plants (Singh and Singh, 2019). Thus, the integrated approach of nutrient availability had significant effect on growth and yield parameters which might be associated with better nutrient uptake and utilization and can be confirmed by the improved soil and leaf nutrient status (Singh *et al.*, 2016b; Anmol and Singh, 2018; Singh *et al.*, 2018b; Elsayed *et al.*, 2020).

The regression study for levels residual plot (Fig. 1, a-c), levels line fit plot (Fig. 1, d-f) and normal probability plot (Fig. 1, g-i) for different levels of biofertilizers confirmed a very high positive residual value for average increment in plant height (a), average increment in plant spread (b) and average increment in canopy volume (c) at level of 000 (no biofertilizers), 001 (only PSB) and 010 (only *Azospirillum*); however, it was closer to zero at level of 100 (only *Azotobacter*) and at 111 (including all the three biofertilizers). These observations further corresponded to a wider gap between actual and predicted value for 000, 001 and 010 level with actual value higher than the predicted value. Thus, it was clear that for plant growth all the three biofertlizers were effective to compensate the replacement of RDF up to the level of 25 to 50% as per the various treatments. However, the sample percentile value which was higher (nearly 90) at greater increment in plant height, plant spread and canopy volume confirmed the inclusion of all the three biofertilizers (level 111) will be the best substitute for RDF as in case of T_5 and T_{10} in comparison with individual application. This was due to variation in the functioning of these biofertilizers like PSB making phosphorus available to plants, *Azospirillum* was microaerophilic and predominantly surface-colonizing bacteria, while *Azotobacter* was aerobic and endophytic diazotrophs (Lallawmkima *et al.*, 2018a, b).

The percentage fruit drop (Fig. 2) recorded during the experiment also confirmed lowest fruit drop under T_5 (64.45 and 56.83) followed by T_{10} (70.58 and 58.58) during the years 2019 and 2020, respectively. The reduction in fruit drop might be associated with the greater

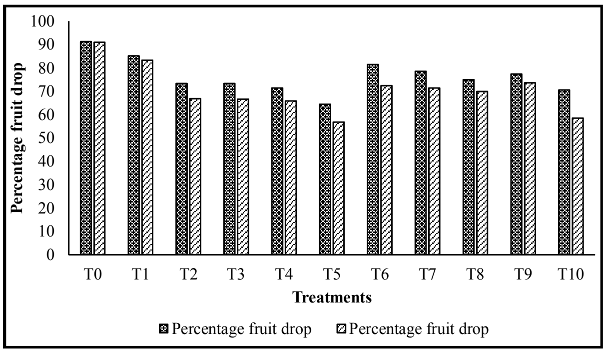

Fig. 2. Percentage fruit drop in aonla after application of biofertilizers as a component of INM.

synthesis and translocation of photosynthates and plant growth promoter particularly auxin which was common attribute of *Azotobacter* (Subash and Rafat, 2016; Singh and Sharma, 2016; Poonia *et al.*, 2018).

CONCLUSION

The application of *Azotobacter*, *Azospirillum* and PSB (100 g/tree each) in combination with 3/4th of RDF resulted in greater plant height, tree spread and canopy volume with highest degree of increment. This was further concluded that replacement of 25% or 50% RDF by combined application of *Azotobacter*, *Azospirillum* and PSB will be effective approach for better growth and reduced fruit drop in aonla.

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