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Integrated Application of Inorganic, Organic Sources and Biofertilizers on Nutrient Status of Soil and Aonla Leaves under Sub-Tropics of Madhya Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted at the Horticulture Research CRC Farm – 1 of the Department of Horticulture, School of Agriculture, ITM University Gwalior (M.P.) during the year 2019 and 2020 to study the Influence of Integrated Nutrient Management on nutrient status of soil and aonla leaves under sub-tropics of Madhya Pradesh. The experiment was laid out in the randomized block design with three replications and eleven treatments viz. (control) - RDF (1000: 500:1000 g/ tree), 3/4thof RDF + FYM, 3/4th of RDF + FYM + Azotobacter (100 g), 3/4th of RDF + FYM+ Azospirillum (100 g),

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3/4th of RDF + FYM+ PSB (100 g), 3/4thof RDF + FYM+ Azotobacter + Azospirillum + PSB(100 g/tree each), ½ of RDF + FYM, 1/2 of RDF + FYM+ Azotobacter (100 g), 1/2 of RDF + FYM + Azospirillum(100 g), ½ of RDF + FYM + PSB(100 g), ½ of RDF + FYM + Azotobacter + Azospirillum + PSB (100 g/tree, each. The results revealed that among different treatments, application of ½ of RDF + FYM + Azotobacter + Azospirillum + PSB recorded higher microbial population, available nitroge, phosphorus, potassium and available soil zinc, copper and boron which was followed by application of 1/2 of RDF + FYM+ Azotobacter (100 g). Thus, application of ½ of RDF + FYM + Azotobacter + Azospirillum + PSB was found to best for improving the soil nutrient status which will in turn help in improving the yield of Aonla.

Keywords: Gooseberry; biofertilizers; nutrient; Emblica officinalis Gaertn.

1. INTRODUCTION

The Indian gooseberry (*Emblica officinalis* Gaertn.), a native to tropical South – East Asia, belongs to family Euphorbiaceae and is known as Amla, Amlika, Amali, Ambala, Amalakamu and Nelli in different parts of the country. It can be successfully grown under marginal wasteland, sodic soil, ravine land, arid and drought prone areas. In this crop flowering and fruit set takes place in spring and soon after the fruit enter dormancy without any growth throughout the summer till the monsoon breaks. Therefore, plants do not require irrigation during summer and this makes aonla the most ideal crop for arid region [1].

There are different kinds of micro-organism present in the soils *viz.,* bacteria, actinomycetes, fungi, algae, protozoa, viruses, etc. The number of each micro-organism in the soil range from a few thousands to a few millions per grains 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, etc. can fix atmospheric nitrogen. In addition to nitrogen fixation these organisms are also known to synthesize plant growth promoting substance such as Indole Acetic Acid, Gibberellins etc. The amount of nitrogen fixed by them has been reported to vary from 35-195 kg/ha/season. The rhizobium-legumes symbiosis could meet more than 80% N need of legume crops and increase the yield of pulse crops by 10-15%. Inoculation of seeds with efficient strains of Azotobacterand Azospirillum contribute only about 15-20 kg fertilizer equivalent N/ha in different crops. Integrated use of P solublizing bacteria with low graded rock phosphate contributes about 30-35 kg P_2O_5 /ha in neutral to slightly alkaline soils. 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 [2]. 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. Use of 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. Integrated use of chemical fertilizers with biofertilizers markedly increase fertilizer use efficiency and minimize their losses and leakage [3]. 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 animals 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 [4], (Tarai and Gosh, 2006; Vedamini et al., 2006). Chemical fertilizers and organic manures have been shown to produce higher crop yield than when each is applied alone. There is a need to develop strategies to bridge the gap particularly in the intensively cultivated areas where the soils are rapidly exhausting. The best remedy for this is to adopt integrated nutrient supply and use of management system. Keeping in view above fact, integrated application of inorganic, organic sources and biofertilizers on nutrient status of soil and aonla leaves was conducted.

2. MATERIALS AND METHODOLOGIES

2.1 Experimental Site

The field experiment was conducted during 2019 and 2020 by selecting 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 meter in ten-year-old orchard of aonla cv. NA-7 located at the Department of Horticulture, ITM, University Gwalior, MP (India).

2.2 Treatment Details

The experiment was laid out in randomized block design with eleven treatments and three replications. The treatments are: T_0- Full dose of NPK (1000:500:1000 g/tree) control; T_1- three-fourth dose of NPK/tree + 100 kg FYM; T_2- three-fourth dose of NPK/tree + 100 kg FYM + Azotobacter; T_3- three-fourth dose of NPK/tree + 100 kg FYM + Azospirillum; T_4- three-fourth dose of NPK/tree + 100 kg FYM + PSB; T_5- three-fourth dose of NPK/tree + 100 kg FYM +Azotobacter Azospirillum+ PSB; T_6- half dose of NPK/tree +100 kg FYM; T_7-half dose of NPK/tree +100 kg FYM + Azotobacter; T_8- half dose of NPK/tree +100 kg FYM + Azospirillum; T_9- half dose of NPK/tree +100 kg FYM + PSB; T_{10}- half dose of NPK/tree +100 kg FYM + Azotobacter + Azospirillum + PSB.

2.3 Crop Management

The treatments include 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 NPK fertilizers were 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 trenches of 20-25 cm width and 10-15 cm depth 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.

2.4 Observation Recorded

The observation on macro and micro nutrient elements in the soil was carried out for available nitrogen (alkaline $KMnO_4$ method as suggested by Subbaiah and Asija, [5]), available phosphorus [6] and the blue colour intensity was measured calorimetrically using 660 nm wavelengths [7], available potassium (neutral normal ammonium acetic extract of soil through a flame photometer) and available micronutrients (Lindsay and Norvell, [8], Atomic Absorption Spectrophotometer). Soil samples, were collected in January and December during the both years i.e., 2019 and 2020 from a distance of 1-1.5 m from the main trunk of the tree. However, the samples were taken from a uniform depth of 0-15 cm, subsequently. The observation on leaf nutrient content was done through following steps:

Leaf Sampling Technique: The middle portion of the shoots was sampled from the indeterminate shoots for the analysis of nutrients as suggested by Pareek [9]. Shoots were selected from all the middle portion of a tree from each treatment [10] during December.

Washing: After sampling, leaves were gently washed in running tap water to remove the dust, soil particles and spray residues. Then the leaves were washed with distilled water.

Drying: The washed samples of leaves were put into brown paper bags as such. The samples were then dried in an oven at $60^0C \pm 1^0C$ for 48 hours to get a constant dry weight [11].

Grinding and Storage: After drying, the samples were ground by Willey Mill with a 40 mesh screen to obtain fine powdered samples. These samples were stored in dry and air tight labelled glass tubes till analysis. The stored samples were further dried, before analysis, at a temperature of 65^0 C for two hours.

These samples were then analyzed for N, P, K, Zn, B and Cu by using the methods as described earlier. The data were analyzed as per the method suggested by Gomez and Gomez [12].

3. RESULTS AND DISCUSSION

3.1 Microbial population in Aonla Rhizosphere

The data related to the population of total bacteria is presented in Table 1 revealed that the maximum amount of population (101.14 x 10^5/g of soil) was recorded with the application of half dose of NPK/tree +100 kg FYM + Azotobacter + Azospirillum + PSB followed by $1/2^{th}$ dose of NPK + 100 kg FYM along with PSB. The population of Bio fertilizers gradually increased with the decrease in application of nitrogen fertilizer, the least population being recorded with full dose of NPK alone as a control. Panigrahi and Behera [13], Yadav [14] and Yadav [15] also observed increased Azotobacter population at lower level of nitrogen which is in conformity with the present findings. The population of soil microorganism is highly dependent on the soil, climatic condition and rhizosphere zone of a particular plant. However, it may be concluded that the population, in general, increase in tropical region with the proportionate reduction in nitrogen application.

3.2 Soil Nutrient Status

The observations on available soil nitrogen content presented in Table 2, indicated that the soil nitrogen was generally reduced after harvest of the crop in 2019 and 2020 indicating the utilization of nutrients for the fruit production. The highest nitrogen content (235.720 and 239.420 kg/ha) in soil, available soil phosphorus content, potassium content (194.800 and 201.400 kg/ha), maximum zinc content (0.53 and 0.55 mg/ha), boron content (0.58 and 0.60 mg/ha) and high copper content (0.61 and 0.65 mg/ha) was observed with the application of three-fourth dose of NPK/tree + 100kg FYM +Azotobacter Azospirillum+ PSB. This could be due to fact that 3/4th dose of NPK, 100 kg FYM along with bio fertilizers (Azotobacter, Azospirillum and PSB) contributed to maximum available soil nitrogen. It was observed that the amount of available soil nitrogen was influenced by Bio fertilizers and FYM. The use of FYM and Bio fertilizers (Azotobacter, Azospirillum and PSB)

Table 1. Effect of NPK, FYM and biofertilizers on total bacterial population in rhizosphere of aonla plants (Cell x 10^5 /g Soil)

Treatments	2019				2020			
	December*	March	August	October	December**	March	August	October
T_0	15.32	26.64	39.42	34.64	32.48	28.45	34.82	25.62
T_1	16.45	29.32	41.26	36.84	33.66	35.42	44.12	30.80
T_2	17.07	33.78	49.39	43.24	40.42	42.46	52.18	36.43
T_3	17.00	30.72	48.34	42.24	36.84	38.60	50.14	35.32
T_4	17.05	25.42	39.64	33.20	34.58	36.42	45.16	38.36
T_5	17.10	43.65	59.39	50.24	42.64	48.86	60.18	41.36
T_6	15.80	39.30	63.30	56.34	32.70	40.84	65.15	33.42
T_7	22.34	58.63	88.15	85.42	56.42	63.42	92.14	81.46
T_8	18.65	51.62	86.16	83.62	54.32	58.16	90.64	75.36
T_9	18.42	50.30	83.14	73.26	51.62	56.18	88.68	71.42
T_{10}	26.43	79.42	96.14	90.14	63.18	76.42	101.14	91.82
S.Em±	0.894	1.909	2.864	2.764	1.768	2.070	2.928	2.999
C.D at 5% level	1.865	3.98	5.975	5.767	3.689	4.318	6.109	6.257

** Before first inoculation; ** Before second inoculation*

Table 2. Effect of NPK, FYM and Biofertilizers on available soil nitrogen, phosphorus and potassium (kg/ha)

Treatments	Available soil N (kg/ha)		Available soil P (kg/ha)		Available soil K (kg/ha)	
	2019	2020	2019	2020	2019	2020
T_0	217.72	218.73	12.20	13.10	183.22	192.33
T_1	221.42	222.86	12.63	13.80	186.30	192.83
T_2	226.42	228.26	14.10	18.64	191.84	197.20
T_3	225.68	227.20	15.75	20.66	189.66	194.00
T_4	222.80	224.30	17.68	23.20	185.60	193.93
T_5	235.72	239.42	17.82	24.10	194.80	201.40
T_6	218.12	219.60	12.53	13.20	184.11	192.57
T_7	225.20	227.40	13.07	16.40	189.78	195.20
T_8	224.10	225.60	12.95	17.60	188.68	192.33
T_9	221.10	221.56	13.83	17.80	185.40	192.83
T_{10}	230.42	234.80	16.40	21.20	191.86	198.47
S.E(diff)	1.038	0.893	0.400	0.714	0.883	2.401
CD at 5% level	2.166	1.864	0.836	1.491	1.842	5.010

Table 3. Effect of NPK, FYM and Biofertilizers on available soil Zinc, Boron and Copper (mg/ha)

Treatments	Available soil Zn		Available soil B		Available soil Cu	
	2019	2020	2019	2020	2019	2020
T_0	0.40	0.40	0.47	0.49	0.49	0.51
T_1	0.42	0.43	0.49	0.50	0.52	0.54
T_2	0.46	0.48	0.51	0.53	0.56	0.59
T_3	0.47	0.49	0.53	0.55	0.55	0.57
T_4	0.48	0.50	0.56	0.58	0.53	0.55
T_5	0.50	0.52	0.56	0.59	0.61	0.65
T_6	0.41	0.42	0.50	0.54	0.50	0.51
T_7	0.42	0.51	0.53	0.55	0.55	0.57
T_8	0.44	0.46	0.54	0.56	0.53	0.54
T_9	0.41	0.42	0.55	0.57	0.51	0.52
T_{10}	0.53	0.55	0.58	0.60	0.58	0.61
S.E(diff)	0.0086	0.0093	0.0128	0.012	0.0112	0.0094
CD at 5% level	0.0180	0.0194	0.0268	0.025	0.0233	0.0197

supplemented the use of inorganic fertilizers to a considerable extent. The application of bio fertilizers along with different dose of NPK and FYM was effective to maintain the nitrogen level of the soil as the microbial population under such treatments was much higher and the fertility of the soil. Similar result was also found by Usha et al. [16]. Further, with regards to the available soil zinc, boron and copper, was observed that the available soil zinc and boron was significantly increased by the application of ½ dose of NPK + 100 kg FYM+ Bio fertilizers (Azotobacter, Azospirillum and PSB) Further, its availability was reduced after harvest due to higher utilization of nutrients by the crop. It indicates that increased availability before harvest of the crop was due to better mineralization and congenial soil temperature prevailing at that time. This is in conformity with the findings of Tisdale et al. [17] and Sharma et al. [18].

4. CONCLUSIONS

Thus, application of ½ of RDF + FYM + Azotobacter + Azospirillum + PSB recorded higher microbial population, available nitroge, phosphorus, potassium and available soil zinc, copper and boron which was followed by application of 1/2 of RDF + FYM+ Azotobacter (100 g). Thus, application of ½ of RDF + FYM + Azotobacter + Azospirillum + PSB was found to best for improving the soil nutrient status which will in turn help in improving the yield of Aonla.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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