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Long term effect of INM on aonla (*Emblica officinalis*) and soil quality under rainfed hot semi-arid environment

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ABSTRACT

The experiment was conducted on seven and eight years old aonla (*Emblica officinalis* Gaertn) tree of NA-7 to study the influence of various levels of organic (FYM and biofertilizers) and inorganic (NPK) sources of nutrients on morphometrix, productivity and quality attributes of aonla and soil quality during 2009-10 and 2010-11 under hot semi-arid ecosystem. Significant improvement was recorded in soil quality by application of different combinations of NPK, FYM and biofertilizers. The vegetative growth, yield and quality of aonla were influenced significantly by different sources of nutrients. The maximum vegetative growth was recorded in the plants which were applied with standard doses of NPK which was followed by farmyard manure plus 50% of the standard dose of NPK. The maximum mean yield per plant (48.45 kg) was recorded in the plants treated with standard doses of NPK followed by FYM + 50% of standard dose of NPK (45.27 kg). TSS, total sugar, vitamin C and total phenols were influenced considerably by the application of different organic sources of nutrients being highest in T_5 (FYM + *Azotobactor* + VAM) treatment. The soil properties in terms of pH and EC declined whereas hydraulic conductivity, organic carbon increased from their initial values with the application of various organic sources of nutrient in different combinations, while pH, EC, hydraulic conductivity, bulk density and organic carbon of the basin soil treated with standard dose of NPK were not improved considerably.

Key words: *Aonla*, Biofertilizers, FYM, Inorganic, Organic

Aonla or Indian gooseberry (*Emblica officinalis* Gaertn) is hardy plant and known for its highly nutritive values. The tree is being grown successfully across the country in varied agro-climatic conditions in an area of more than 50000 ha with the production of 1.75 lakh tonnes (Pathak *et al.* 2005). Its cultivation has gained significance in Gujarat, because of its wider adaptability to harsh edapho-climatic conditions; higher productivity and general freedom from severe attack of insect, pest and diseases. In the recent years, aonla has been identified as an ideal plant for various kinds of wastelands of arid and semi-arid ecosystem (Pathak and Pathak 2001, Korwar *et al.* 2006). The demand of aonla fruit is increasing day by day owing to its utilization in cosmetic, pharmaceutical and processing industries (Tarai and Ghosh 2005). Since, aonla is consumed for its medicinal and nutraceutical properties, its organic production has gained great significance during the recent years.

In recent years, decline in soil health with respect to physical, chemical and biological properties is evident owing to indiscriminate use of fertilizers. Continuous use of chemical fertilizers without organic fertilizers causes problem of soil health, while use of organic fertilizers without augmentation of inorganic fertilizers may not be able to meet the high nutrient requirement of the crop due to low nutrient content and slow acting in nature (Marathe *et al*. 2003). Application of biofertilizers into the soil enhances microbial activity and soil fertility. Further, due to increase in the cost of chemical fertilizer coupled with their limited production, it has become essential to evolve low cost input management practices for sustainable production of quality fruit (Pathak 2003 and Pathak *et al.* 2005). Like other crops, in aonla too, integrated nutrient management is the key factor to achieve higher yield per unit area with improved produce quality. Integrated nutrient management encourages integration of different sources of nutrients such as organic, biological and inorganic fertilizers etc. In view of the factors like increasing demand of organically grown fruits by consumers coupled with unsustainable productivity, organic farming is claimed to be most benign alternative, for which role of organic manure and biofertilizers become important for sustainable production with quality fruits. Keeping the utility of organically produced aonla in view, an experiment was attempted by integrating the microbial and chemical

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fertilizers to find out its effect on soil properties and plant health, fruit yield and quality of aonla variety NA 7.

MATERIALS AND METHODS

A field experiment was conducted on aonla cv NA 7 at Central Horticultural Experiment Station (CIAH), Gujarat. The treatments were; T_1, Standard dose of NPK; T_2, FYM + 50% of recommended dose of NPK; T_3, FYM + *Azotobactor* + PSB; T_4, FYM + *Azospirillum* + PSB; T_5, FYM + *Azotobactor* + VAM; T_6, FYM + *Azospirillum* + VAM. Biofertilizers; *Azotobactor*, *Azospirillum*, PSB and VAM were applied @ 250g per tree/year soon after first rain of monsoon season. FYM @ 30 kg/tree and NPK @ 100, 75 and 50 g were applied during first year. The FYM @ 5 kg/tree/year and NPK doses were increased in same proportion every year. Thus, the dose of FYM was applied @ 60 kg and 65 kg per tree during 2009-10 and 2010-11, respectively, while chemical fertilizer, viz. NPK were applied at the rate of 700, 525 and 350 g/tree during 2009-10, and 800, 600 and 400 g/ tree during 2010-11, respectively in two split doses (last week of June and first week of September). The soil was analyzed for organic carbon, EC, pH, N, P and K (Bhargava and Raghupati 1993), and soil bulk density and hydraulic conductivity (Page *et al.*1982) before the initiation of the experiment. The experimental soil was characterized with low organic carbon (4.3 g/kg), low N (180.65 kg/ha), medium K (115.10 kg/ha) and P (11.00 kg/ha). The initial values of pH, EC, bulk density, hydraulic conductivity (HC) were recorded to the tune of 7.60, 0.13 dS/m, 1.39 mg/m and HC 0.32 cm/hr, respectively. The experiment was laid out in randomized block design with six treatments and four replications considering two plants as unit. The soil depth ranged from 0.70 to 1.0 m and it is derived from mixed alluvial basalt, quartzite, granite, and layers of limestone, and the region falls under semi-arid hot climate. The uniform cultural practices were applied to the experimental trees, which were grown purely under rainfed condition of hot semi-arid ecosystem of western India. The observations were recorded on yield and yield attributing characters and fruit quality was analyzed following method suggested in AOAC (1990).

RESULTS AND DISCUSSION

Soil properties

Perusal of data indicated that the physico-chemical properties of soil were influenced significantly by use of different kind of sources of nutrients (Table 1). The results of the study of various organic and inorganic sources of nutrients on soil reaction (pH) revealed that the treated basin soil declined from its initial value of 7.60 to 6.60, 6.70, 6.71 and 6.72 during 2009-10 with T_5, T_3, T_6 and T_4, respectively, whereas it declined from its initial value to 6.52, 6.62, 6.64 and 6.65 during 2010-11 with T_5, T_3, T_6 and T_4, respectively, however pH of the basin soil was not influenced significantly with the application of NPK alone (T_1). The EC of the soil decreased from its initial value 0.13 dS/m to 0.11 and 0.10 dS/m being lowest in T_5, but the differences among the treatments were found to be non-significant. This decrease in soil pH and EC may be attributed to the continuous use of organic manure which releases various organic acids upon its decomposition and leaching of salts to the lower layers of the soil during rainy season. A decrease in pH of soil under farmyard manure may be due to the activation of Al^{3+} and continuous release of basic cation upon its decomposition and gravitational movement of those cations into lower horizons of soil. These results are in close conformity with the findings of Srikanth *et al.* (2000) and Marathe *et al.* (2003). In the tree basin, addition of farmyard manure and biofertilizers decreased the bulk density from its initial value 1.39 mg/m^3 to 1.28, 1.29, 1.32 and 1.33 mg/m^3 in 2009-10 with the treatments T_5,T_3, T_6 and T_4 and 1.25,1.27 and 1.30 mg/m^3 in 2010-11 in the treatments T_5, T_3 and T_2 respectively, while bulk density was recorded maximum in T_1 (1.36 mg/m^3) which may be due to increase in organic matter in soil. Hydraulic conductivity was observed the highest in FYM + *Azotobactor* + VAM (T_5) followed by FYM + *Azotobactor* + PSB (T_3) and it was recorded lowest in T_1 (NPK alone). The bulk density and hydraulic conductivity were not much influenced by treatments comprising the inorganic sources of nutrients (T_1). The results suggested that the application of manures reduced the bulk density and compactness of the soil particles and improved the hydraulic conductivity. These findings are in agreement with the results of Ram and Rajput (2000) and Srikanth *et al.* (2000).

Organic carbon and NPK content of basin soil was enhanced by the application of various types of manure used in different combinations (Table 2). The organic carbon increased from its initial value 4.30 g/kg to 5.25, 5.20, 5.15, 5.10, 5.00 and 4.33g/kg (2009-10) and 5.35, 5.30, 5.23 5.21, 5.20 and 4.40/kg (2010-11) in the treatment T_5, T_3, T_4, T_6, T_2 and T_1, respectively, which may be due to application of farmyard manure and different biofertilizers. However, maximum build up of organic carbon was observed in FYM + *Azotobactor* + VAM (T_5), which were found to be 22.09 and 24.41 per cent increment from their initial value. Organic manure may have increased organic carbon content by adding organic matter directly in the basin soil. These results are in accordance with the findings reported by Korwar *et al.* (2006). Available N was recorded maximum with the application of standard dose of NPK (T_1) followed by FYM + 50 % of the standard dose of NPK (T_2), FYM + *Azotobactor* + VAM (T_5) and FYM + *Azotobactor* + PSB (T_3). Addition of organic manure improved the physical properties of soil thus creating favourable conditions for microbial activity resulting to an increase in the nutrient availability. These findings are in agreement with the results of Srikanth *et al.* (2000) and Tarai and Ghosh (2003). Available P concentration increased to 16.00, 15.50, 15.25, 14.78 kg/ha from the initial value 11.00 kg/ha in T_1, T_2, T_5 and T_3, respectively in 2009-10, while it was increased from its initial value 11.00 k/ha to 19.85, 17.00, 16.80, 16.12, 15.43 and 15.00 kg/ha with the treatments T_1, T_2, T_5,

T_3, T_4, and T_6, respectively in 2010-11. Release of P in the soil from unavailable to available forms because of reaction of organic acids produced after decomposition of organic manure. More or less similar results have been reported by Korwar *et al.* (2006) and Srikanth *et al*. (2000). The average increase in K was observed maximum in standard dose of NPK(T_1), whereas it increased from initial value 116.60 to 129.31, 123.28 and 121.36 kg/ha in T_1, T_2 and T_5, respectively. There was slight increase in soil K content which might be due to release of fixed K owing to reaction of organic acids. These results are in consonance with the findings as reported by Korwar *et al.* (2006).

Vegetative characters

An effect of application of various kinds of manures, biofertilizers and fertilizers significantly influenced the vegetative growth of plant (Table 3). Among the different combinations of organic and inorganic sources of nutrients evaluated, the growth in terms of plant height, root stock girth, scion girth and plant spread was recorded the highest from the plants treated with standard dose of NPK (T_1) followed by FYM + 50 % of standard dose of NPK (T_2), FYM + *Azotobactor* + VAM (T_5) and the minimum growth was recorded with FYM + *Azospirillim* + VAM (T_4). The average annual extension of plant height (61.25 cm), rootstock girth (5.57 cm), scion girth (4.77 cm) and plant spread (50.85 cm) were recorded with T_1 followed by T_2, T_5 and T_3. The minimum plant height (57.47cm) was recorded in T_6, whereas rootstock girth (5.04 cm), scion girth (3.94 cm) and plant spread (43.03 cm) were found to be the minimum in T_4 among all the treatment combinations of fertilizers, farmyard manure and biofertilizers. Differences in the growth among various treatments might be due to availability of nutrients by various sources of nutrients. These results are in accordance with the findings as reported by Balota *et al.* (1995), Srikanth *et al.* (2000), Korwar *et al.* (2006), Patel *et al.* (2009) and Nazir *et al.* (2012).

Yield and yield attributing characters

The fruit yield and yield attributing characters of NA 7 aonla were influenced significantly by the different sources of organic and inorganic nutrients (Table 4). In general, plants treated with inorganic fertilizers were pronounced by more fruit yield than organic sources of nutrients. The mean yield/plant (48.45 kg), fruit weight (42.86 g), fruit length (4.07 cm) and fruit width (4.17 cm) were recorded maximum with standard dose of NPK (T_1) followed by FYM + 50 % of standard dose of NPK (T_2) and FYM + *Azotobactor* +VAM (T_5), while minimum yield was recorded in T_4 (39.50 kg) followed by T_6 (40.13 kg). Similar trend was also observed with respect to fruit pulp and seed weight during both the years. The increase in the yield might be attributed owing to increase in the availability of nutrients to the plants. These findings are in accordance with the results of Patel *et al.* (2005) in mango, Pathak *et al*. (2005) and Korwar *et al.* (2006) in aonla, Manjunatha *et al.* (2006) in sapota, Ranjan and Ghosh (2006) in sweet orange and Goswami *et al.* (2012) in guava under different agro-climatic conditions.

Quality characters

In general, application of organic manure along with biofertilizers recorded significantly better quality fruits as compared to full dose of NPK (Table 5). The results obtained from the study revealed that the maximum total soluble solids was recorded 8.62^0 brix with the application of FYM + *Azotobactor* + VAM (T_5) followed by T_3, T_6 and T_2, however it was recorded the lowest in T_4 followed by T_1. Total sugar (5.05%) was recorded highest in T_5 (FYM + *Azotobactor* + VAM) followed by T_3, T_6 and T_2, whereas maximum vitamin C content was observed (396.08 mg/ 100g) in T_5 followed by T_3, T_2 and T_6. Total phenols (180.07mg/100g) were recorded the highest with FYM + *Azotobactor* + VAM (T_5) followed by T_2, T_3 and T_6. However, the maximum reduction in acidity was noted 2.07 % with the application of FYM + *Azotobactor* + VAM (T_5) (followed by T_3 (FYM + *Azotobactor* + PSB) among the different treatment combinations. Different treatment combinations of organic and inorganic sources of nutrients could not exert significant effect on the acidity of fruit. These results are in conformity with the findings as reported by Day *et al.* (2005) in guava, Pathak and Tiwari (2002), Pathak *et al.* (2005) and Korwar *et al.* (2006) in aonla, Gautam *et al.* (2012) in mango. The quality improvement in fruits may be due to proper supply of nutrients and induction of growth hormones which might have stimulated cell division, cell elongation, and better transportation of water uptake and accumulation of nutrients. This may be attributed owing to improved fertilizer use efficiency with application of organic sources of nutrients. Thus, it can be inferred from the present study that the use of farmyard manure, biofertilizers over long period and NPK in different combinations improved the soil quality and availability of nutrients to the plants which resulted into better plant growth, yield and quality attributes of aonla variety NA 7 under rainfed conditions of hot semi-arid ecosystem of western India.

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