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Influence of organic and inorganic nutrient sources on soil properties and quality of *aonla* in hot semi-arid ecosystem

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ABSTRACT

An experiment was conducted on young of NA-7 *aonla* trees to evaluate the influence of various levels of organic and inorganic nutrient sources on morphomatrix, productivity and quality attributes and soil quality during 2007 and 2008 under hot semi-arid ecosystem. Significant improvement was recorded in soil quality by application of different combinations of cakes, FYM and CPP. The vegetative growth, yield and quality of *aonla* were influenced significantly by different sources of nutrients. Vegetative growth was recorded significantly highest in the plants treated with farm yard manure coupled with standard dose of NPK. Various treatment combinations of organic nutrient sources increased the fruit yield and quality. Maximum yield per plant (32.15 kg) was recorded with the plants, which were treated with FYM plus standard does of NPK. Quality parameters like TSS, total sugars, vitamin C and total phenols were influenced considerably by the application different organic sources of nutrients. The soil parameters in terms of pH, EC, bulk density, hydraulic conductivity and organic carbon were also improved significantly by different sources of organic nutrients. Considerable improvements in the soil physical and chemical properties were observed by the use of different sources of organic nutrients.

Key words: *Aonla*, organic and inorganic nutrients, FYM, cakes, CPP (Cow Pat Pit).

INTRODUCTION

Aonla (*Emblica officinalis* Gaertn), also known as Indian gooseberry, is one of the important fruit crop, well known for its nutraceutical and therapeutic properties from the ancient times in India. Owing to its hardy nature, regular and profuse bearing, ability to produce remunerative yield in various kinds of wastelands, nutritive and medicinal values, and its suitability for various value-added products, *aonla* is becoming an important fruit crop across the country. (Korwar *et al.*, 2; Pathak and Pathak, 6). Currently, *aonla* is grown over 50,000 ha area in the country with 1.75 lakh t production. Its cultivation is picking up rapidly because of its versatility to grow varied edapho-climatic conditions and its utilization in cosmetic, pharmaceutical and processing industries, the demand of fruit is increasing day by day (Tarai and Ghosh, 11). Since *aonla* is consumed for general improvement of health, its organic production becomes of higher importance (Pathak, 9).

Nutrient management affects both productivity and quality of produce and also contribute share in input cost of production. Integrated plant nutrient supply system encourages integration of different sources of nutrients organic, inorganic and biological etc. Indiscriminate use of nutrients especially chemical fertilizers is one of the major causes of decline in soil health with respect to physical, chemical and biological properties. Continuous use of chemical fertilizer without organic manure causes problem to soil health. Modern management practices have led to decline in soil organic matter, increased soil erosion and pollution of surface and ground water (Korwar *et al.*, 2). Environmental concerns and awareness of soil health has been increasing day by day, which has led to the renewed interest in organic production of high value crops. Owing to an increase in the cost of chemical fertilizer coupled with limited production, it is essential to evolve low cost input management practices for sustainable fruit production. In view of its increasing demand from consumers for fruit quality coupled with unsustainable productivity, organic farming is claimed to be most benign alternative (Pathak and Pathak, 6; Pathak *et al.*, 8). In this situation, role of organic manure and biodynamic preparations become important for sustainable production with quality fruits. Keeping these facts in view, attempts were made to find out the effect of various sources of nutrients on soil properties, yield and quality of *aonla*.

MATERIALS AND METHODS

A field experiment was conducted on young trees, of *aonla* cv. NA-7 planted in 2003, at Central Horticultural Experiment Station (CIAH), Vejalpur, Panchamahals (Godhra), Gujarat during 2007 and 2008. The treatments were; T_1, Neem cake + FYM + CPP, T_2, castor cake + FYM + CPP, T_3, ground nut

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cake + FYM + CPP, T_4, *Mahua* cake + FYM + CPP, T_5, FYM + standard dose of NPK, T_6, FYM + half of standard dose of NPK. The initial dose of FYM was 15 kg /plant and this dose was increased every year in the same proportion, therefore, the dose of FYM was applied @ 60 and 75 kg in 2007 and 2008; whereas cakes were applied @ 6 kg during both the year of experimentation. Thus, chemical fertilizer *viz*., NPK were applied at the rate of 400, 200 and 300 g / tree during 2007 and 500, 250 and 375 g/tree during 2008, 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, 1), and soil bulk density and hydraulic conductivity (Page *et al*., 5) before the initiation of the experiment. The soil was characterized with low organic carbon (4.4 g kg^{-1}), low N (178.63 kg ha^{-1}) and medium K (116.60 kg ha^{-1}) and medium P (14.00 kg ha^{-1}). The initial values of pH, EC, bulk density, hydraulic conductivity (HC) were recorded to the tune of 7.65, 0.14 dS m^{-1}, 1.40 Mg m^{-1} and HC = 0.34 cm / hr, respectively. The experiment was laid out in randomized block design with six treatments and four replications considering two plants as unit to represent one treatment. The soil depth ranged from 0.75 to 1.0 m, derived from mixed alluvial basalt, quartzite, granite, and layers of limestone, and falls under semi-arid hot climate. The uniform cultural practices were applied to the experimental trees, which were grown purely under rainfed conditions.

RESULTS AND DISCUSSION

Significant improvement in physico-chemical properties of soil was observed by use of different 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 7.65 to 6.04, 6.40, 6.90 and 7.00 with T_1, T_3, T_4 and T_2, respectively, whereas the EC of the soil decreased from its initial value 0.14 to 0.11 and 0.12 dS m^{-1} in T_1 and T_3, respectively, while differences were found to be non-significant among the T_5, T_6, T_2 and T_4. This decrease in soil pH and EC may be attributed to the continuous use of farm yard manure, which releases various organic acids upon its decomposition and leaching of salts to lower layers of the soil during rainy season. A decrease in pH of soil under farm yard 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 Masciandaro *et al.* (3).

There was significant reduction in bulk density by the application of manure, cakes and CPP. Addition of farm yard manure, cakes and CPP decreased the bulk density of the tree basin soil, which might have helped in increase of hydraulic conductivity. The maximum hydraulic conductivity (0.45 cm/h) was observed in *neem* cake + FYM + CPP (T_1), which was at par with T_3 (groundnut cake + FYM + CPP), while T_2, T_4,T_5 and T_6 showed parity with respect to hydraulic conductivity. The bulk density reduced from its initial value 1.40 Mg m^{-1} to 1.30, 1.32, 1.36 and 1.38 Mg m^{-1} in T_1, T_3, T_2, and T_4, respectively. The bulk density and hydraulic conductivity were not influenced much by treatment comprising the inorganic nutrient sources. 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 Mishra *et al.* (4) and Srikanth *et al.* (10). Organic carbon content of basin soil was increased from its initial value 4.1 g kg^{-1} to 6.3, 6, 5.9, 5.8, 5.0 and 4.8 g kg^{-1} in the treatments T_1, T_3, T_4, T_2, T_5 and T_6, respectively, whereas differences between T_5 and T_6 could reach the level of significance. However, maximum build up of organic carbon was observed in *neem* cake + FYM + CPP (T_1) treatment, *i.e.* from 4.4 to 6.3 g kg^{-1}. An increase in organic carbon in basin soil may be due to application of farmyard manure, cakes and CPP, which might have added organic matter directly to the soil. These results are in accordance with the findings reported by Korwar *et al.* (2), Mishra *et al.* (4), and Yadav *et al.* (12).

Application of organic manures and inorganic fertilizers significantly increased the build up of available N in the soil. The available N content in the soil increased with the application of manures and fertilizers in the soil. Nitrogen content was recorded the highest in the soil which were treated with FYM + standard dose of NPK (T_5) and FYM + half of the standard dose of NPK (T_6) among the various combinations of organic and in organic sources of nutrients. Available N in soil among the various combinations of organic sources was recorded the maximum with *neem* cake + FYM + CPP (T_1) and groundnut cake + FYM + CPP (T_3). Addition of farm yard manure improved the physical properties of soil thus creating favourable conditions for microbial activity resulting to an increase in the nutrient availability in the soil. These findings are in agreement with the results of Mishra *et al*. (4), Srikanth *et al*. (10), Yadav *et al.* (14), and Tarai and Ghosh (11). Available P concentration increased to 24.18, 23.00, 22.58 and 22.19 kg per ha from the initial value 17.00 kg per ha in T_5, T_1, T_6 and T_3, respectively. 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

Table 1. Effect of various organic and inorganic nutrient sources on physico-chemical properties of soil.

Treatment	pH (1:2.5)	EC (dS $m^{-1)}$	Bulk density (Mg m^{-3})	HC (cm/h)	OC (g kg^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1	6.50	0.11	1.30	0.45	6.3	190.45	22.58	121.00
T_2	7.00	0.13	1.36	0.38	5.8	180.18	21.40	119.49
T_3	6.75	0.12	1.32	0.44	6.0	185.20	22.19	121.18
T_4	6.90	0.13	1.38	0.39	5.9	184.62	20.70	120.00
T_5	7.15	0.14	1.41	0.36	4.4	220.15	24.18	124.15
T_6	7.10	0.13	1.40	0.38	4.5	210.25	23.00	122.18
CD at 5%	0.09	0.01	0.04	0.05	0.08	7.50	2.27	4.12

Table 2. Effect of various nutrient sources on annual extension of vegetative growth in *aonla*.

Treatment	Plant height (cm)	Rootstock girth (cm)	Scion girth (cm)	Plant spread (cm)
T_1	61.34	8.33	5.50	49.07
T_2	59.65	8.03	5.06	47.47
T_3	59.12	8.13	5.25	48.09
T_4	58.97	7.90	5.25	46.50
T_5	64.08	9.00	6.08	51.37
T_6	61.58	8.50	5.92	49.19
CD at 5%	2.12	0.20	0.21	1.15

Table 3. Effect of various nutrient sources of on yield and yield attributing characters in *aonla*.

Treatment	TSS (°Brix)	Total sugars (%)	Acidity (%)	Total phenols (mg/100 g)	Vitamin C (mg /100 g)
T_1	8.50	4.8	2.00	174.00	390.40
T_2	8.30	4.7	2.05	172.15	385.15
T_3	8.25	4.5	2.15	173.00	384.68
T_4	8.20	4.3	2.10	168.40	384.32
T_5	8.25	4.6	2.10	172.15	388.17
T_6	8.20	4.7	2.20	170.20	384.00
CD at 5%	NS	NS	NS	3.19	5.12

Table 4. Effect of various sources of nutrients on quality attributes of *aonla*.

Treatment	Yield/plant (kg)	Fruit weight (g)	Fruit pulp (g)	Fruit length (cm)	Fruit breadth (cm)
T_1	30.00	41.19	39.21	4.00	4.16
T_2	27.68	39.00	36.95	3.85	4.10
T_3	29.00	40.00	37.90	3.90	4.15
T_4	28.16	38.18	35.98	3.80	4.05
T_5	32.15	42.50	40.35	4.05	4.30
T_6	30.30	41.50	40.00	4.00	4.25
CD at 5%	3.15	1.10	1.02	0.09	0.08

similar results have been reported by Korwar *et al.* (2), Srikanth *et al*. (10), and Tarai and Gosh (11). The maximum increase in available K was observed in farm yard manure + standard dose of NPK, whereas it increased from initial value 116.60 to 124.15, 122.18 and 121.18 kg per ha in T_5, T_6 and T_3, respectively. There was slight increase in soil K content might be due to release of fixed K owing to reaction of organic acids. These results are in consonance with the findings of Korwar *et al.* (2), and Tarai and Gosh (11).

It is evident from the data presented in Table 2 that the organic manure and inorganic fertilizers affected plant growth significantly. Plant receiving FYM + standard dose of NPK (T_5) had the maximum annual growth extension followed by FYM + half of the standard dose of NPK (T_6). Among the different combinations of organic and inorganic sources of nutrients evaluated, growth in terms of plant height (64.08 cm), rootstock girth (9 cm), stem girth (6.08 cm) and plant spread (51.37 cm) was recorded significantly highest from the plants treated with FYM + standard dose of NPK (T_5) followed by FYM + half standard dose of NPK (T_6), *neem* cake + FYM + CPP (T_1) and minimum growth was recorded with *mahua* cake + FYM + CPP (T_4). The growth was recorded intermediate in the plants which were treated with FYM + half standard dose of NPK, FYM + *neem* cake + CPP, FYM + castor cake + CPP and FYM + ground nut cake + CPP. The increase in vegetative growth in term of plant height, stem diameter and plant spread could be attributed due to availability of nutrients by various sources of nutrients. These results are in accordance with the findings reported by Korwar *et al.* (2), Srikanth *et al.* (10), Yadav *et al.* (13), and Yadav *et al.* (14).

The fruit yield and yield attributing characters of NA-7 *aonla* were influenced significantly by the different organic and inorganic nutrient sources (Table 3). In general, plants treated with inorganic fertilizers were pronounced by more fruit yield than organic sources of nutrients. The yield per plant (32.15 kg), fruit weight (42.50 g), fruit pulp (40.35 g), fruit length (4.10 cm) and fruit width (4.30 cm) were recorded the maximum with FYM along with NPK (T_5) followed by FYM + half standard dose of NPK (T_6) and FYM + *neem* cake + CPP (T_1), while yield (27.68 kg) /tree) was recorded the minimum in T_4 (FYM + *mahua* cake + CPP). Treatments T_1, T_3 and T_6 were found to be at par with respect to yield. The maximum fruit yield per plant (32.15 kg) was recorded with standard dose of NPK + FYM (T_5) followed by (T_6) and (T_1). The increase in the yield was mainly attributed to relative increase in the availability of nutrients and better solute uptake by the plants. These findings are in accordance with the results of Korwar *et al.* (2), and Pathak *et al*. (8).

In general, application of different combination of FYM, cakes and CPP recorded better quality fruits as compared to standard dose of fertilizers (Table 4). Results of study on fruit quality in terms of TSS, total sugars, vitamin C and total phenols revealed that the different treatment combinations of organic and inorganic nutrient sources could not exert significant effect on the TSS, total sugars and acidity of the fruit, whereas total soluble solids (8.50°Brix), total sugars (4.8%) were recorded the maximum in T_1. The acidity of the fruit was the minimum (2.00%) in T_1 followed by T_2 (2.05%), while it was maximum T_6 (2.20%). Among the different treatment combinations, vitamin C (390.40 mg /100 g) and total phenols content (174 mg/ 100 g) were recorded the maximum in T_1 and minimum in *mahua* cake + FYM + CPP (T_4). However, total phenols showed parity among the treatments T_2, T_3, T_4, T_5 and T_6, while differences among the treatments T_1, T_2 and T_3 could not reach the level of significance for vitamin C content in the fruit pulp. The increased fruit quality may be explained from the fact that the different sources of nutrients enhance the nutrient availability by enhancing the capability of plants for better uptake of nutrients from rhizosphere. These results are in conformity with the findings as reported by Korwar *et al.* (2), Pathak and Tiwari (7), and Pathak *et al.* (8).

Thus, it may be inferred from the study that the application of farm yard manure, cakes, CPP and NPK in different combinations improved the soil physico-chemical properties and nutrient availability to the plants which resulted into better growth, yield and quality attributes of *aonla* under rainfed conditions of hot semi-arid ecosystem.

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