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Response of nutrient supplementation through organics on growth, yield and quality of pomegranate

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ABSTRACT

The study was carried out on pomegranate (*Punica granatum* L.) cv. 'Bhagwa' to investigate efficacy of organics on plant nutrient uptake, growth behaviour, fruit yield and quality attributes, disease incidence and soil health. Organic nutrient sources, namely, farm yard manure (FYM), vermicompost (VC), poultry manure (PM), and *insitu* green manuring (GM) through sun hemp (*Crotalaria juncea* L.), *exsitu* GM through Glyricidia (*Gliricidia sepium*), Karanj (*Pongamia pinnata*) and neem (*Azadirachta indica*), and recommended dose of inorganic fertilizers against control were evaluated. The results revealed significant decrease in soil pH and electrical conductivity and substantial increase in soil organic carbon content in all organic manuring treatments over control. Application of FYM had the highest availability of most of the nutrients (P: 64.4 and K: 578.7 kg ha^{-1}; Cu: 15.1, Zn: 2.30 and Mn: 8.4 ppm) in the soil. Three years pooled data showed that the highest P (0.182%), K (1.06%) and Fe (176.7 ppm) contents in the leaves were supplied by PM, while N (2.33%) was by FYM. Although, during first year, vegetative growth of the plants was better in inorganic fertilizers than other treatments, second year onwards it was increased significantly in FYM, VC and GM with sun hemp treatments. Maximum fruit yield was obtained with the application of PM (3.96 kg tree^{-1}) followed by FYM (3.86 kg tree^{-1}). All of the organic manuring treatments resulted in improved fruit quality characteristics *viz.* fruit juice content, juice acidity, TSS and TSS: acid ratio as compared to inorganic fertilizers. Organic manuring with neem recorded the lowest disease index (5.84) on plants. Similarly, increased microbial load in the rhizosphere soil in terms of *P. fluorescence* (20.3×10^{-4} cfu g^{-1}) and *Azotobacter chroococcum* (17.4×10^{-3} cfu g^{-1}) population was recorded in FYM. *A. niger* (13.6×10^{-4} cfu g^{-1}) and PSM (15.6×10^{-5} cfu g^{-1}) activity was higher in GM with Karanj and Sun hemp, respectively.

1. Introduction

Pomegranate (*Punica granatum* L.) is an important fruit crop of arid and semi-arid regions of the world. It has a very high export potential owing to its antioxidant and nutraceutical values (Newman and Lansky, 2007). Consumer demand for fresh and processed products like juice, wine, syrup and *anardana* an acidulant is also escalating day by day (Saxena et al., 1984). With increasing health consciousness, the demand for organically produced pomegranate fruits is growing in Middle East, America and European countries. Although native to hot dry regions of Iran, Afghanistan and adjoining areas (De Candolle, 1967) pomegranate has been widely cultivated in Mediterranean regions of Asia, Africa and Europe. India is one of the leading producers of pomegranate in world having area over 1.13 lakh ha with annual production 7.44 lakh tonnes. In India, predominantly, pomegranate is cultivated in vast areas of marginal lands having very low organic carbon content (Marathe et al., 2015) and microbial population where yields were limited due to deficiency of more than 2–3 nutrients (Raghupati and Bhargava, 1998).

Under these circumstances, during last few decades attempts are being made to improve production by adopting practice of high external input agriculture (HEIA). In due course of time, indiscriminate use of, fertilizers, pesticides and other chemicals has resulted in irrecoverable deterioration of soil physical, chemical and microbiological heath coupled with unsustainable productivity

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in many traditional pomegranate belts. The problem seems to be compounded further where organic manures find no place in fertilizer application programme. These problems warrant a revision of ongoing agricultural practices and adoption of some new alternative strategies. In view of this, concepts like organic pomegranate cultivation, claimed to be the benign alternative for sustainable production, would play a vital role. The role of soil organic matter is well established in improving physic-chemical properties (Marathe et al., 2009) and governing the nutrient fluxes (Marathe et al., 2012) in sweet orange as well as increasing microbial biomass (Marathe et al., 2010, 2011; Mir et al., 2015) in pomegranate.

Considering the medicinal importance of pomegranate fruits and plant parts as a whole, more rational approach to organic cultivation including exploitation of various locally available organics such as farm yard manure, vermicompost, poultry manure and green manuring should be practically implemented to rejuvenate the depleted soil fertility and enrich the available pool of nutrients to the plants, which could benefit the crop having long maturity time. In this background information, the present study, therefore, was focussed and planned with the objective to evaluate the efficacy of various sources of organic and green manures on cropping behaviour, soil properties, nutrient uptake and quality attributes of pomegranate under hot semi-arid tropical climate of central India.

2. Materials and methods

2.1. Experimental site

The field experiment was conducted during 2007–2013 at the research farm of ICAR – National Research Centre on Pomegranate, Solapur, Maharashtra, India located at 17°6′ N latitude, 75°90′ E longitude, at an altitude of 487 m above mean sea level. The climate of the study area is semi-arid, with hot summer, moderate winter and mean annual maximum and minimum temperature of 40.4 °C and 14.9 °C, respectively. The average annual rainfall of 694 mm occurs mostly during the months of July–September.

2.2. Experimental setup

The original experimental site was barren land, full of gravels and weathered murrum having montmorillonitic mineralogy. As per land capability classification it was classified under Group V land having soil depth and coarse fragment limitations. Taxonomically the soil is classified as Entisol (Lithic Ustorthents). The physico-chemical properties of the soil were: pH 7.66, electrical conductivity 0.18 dS m^{-1}, organic carbon 0.38% and calcium carbonate 6.24%. The available N, P and K content of surface soil were 190.0, 11.5 and 238.4 kg ha^{-1}, respectively. Trapezoidal pits of 1.50 × 1.50 m top and 1.20 × 1.20 m bottom width having 0.6 m depths were dug in the field at plantation spacing of 4.5 × 4 m. The pits were refilled with pond soil and used for plantation.

2.3. Experimental design

The experiment was laid out in a randomized block design comprising of 9 treatments with 3 replications having 3 plants per replication. Various treatments were – nutrient application through various organic sources *viz*., farm yard manure (FYM) (T_1), vermicompost (VC) (T_2), poultry manure (PM) (T_3), *insitu* green manuring (GM) with sun hemp (*Crotalaria juncea* L.) (T_4), *exsitu* green manuring with Glyricidia (*Gliricidia sepium*) (T_5), *exsitu* green manuring with Karanj (*Pongamia pinnata*) (T_6), *exsitu* green manuring with neem, (*Azadirachta indica*) (T_7), recommended dose of nutrients supplied through inorganic fertilizers (T_8) and control (T_9) i.e. without any fertilization. Organic manures were computed on N-equivalent basis. The nutritional status of various organics used in the present study is mentioned in Table 1. Green manure crop sun hemp was grown near the plant for the period of 60 days during rainy season in tree basin (4.5 × 4 sq. m area) and was incorporated at the time of flowering during the last week of August. Chopped lopping of other green manure crops was buried in plant basin and covered with soil. Recommended dose of fertilizers was 250 g N + 125 g P + 125 g K during second year and 500 g N + 125 g P + 250 g K to bearing trees during third year. Sources of inorganic fertilizers used were urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O). Urea was applied in three split doses. Full dose of P_2O_5, K_2O and one third N was applied with the onset of monsoon in June month. The remaining quantity of N was applied in two equal split doses at 2 months interval.

2.4. Crop husbandry

Farm yard manure at the rate of 20 kg per pit was applied in each pit and thoroughly mixed with soil material before plantation of the seedlings. In all the treatments, 150-days-old air-layered saplings of pomegranate cv. 'Bhagwa' were planted during October 2007 and maintained by adopting similar cultivation practices. Organic manuring treatments were imposed on two year old plants from 2009. Due to severe infestation of bacterial blight disease, as a management practice, plants were cut to ground level during October 2010. All plant debris were disinfected by spraying bleaching powder on the surface and irradicated. Again plants were allowed to grow and treatments were imposed. Standard package of practices was followed for growing plants.

2.5. Soil analysis

Composit soil samples at 30 cm depth (45 cm away from the drip line of the tree) and weighing up to 1 kg, were collected before fruiting season (year 2012) and analysed for various chemical properties and fertility status. Soil pH and electrical conductivity (EC) were measured in a 1:2.5 (w/v) aqueous solution while calcium carbonate was determined following standard procedure (Jackson, 1973). Soil organic carbon was determined according to wet oxidation method (Walkley and Black, 1934). Available N was determined by alkaline permanganate method (Subbiah and Asija, 1956). Available P was estimated by Olsen's extractant (0.05 N $NaHCO_3$, pH 8.50) method (Watanabe and Olsen, 1965). Available K was determined by extracting the soil with neutral normal ammonium acetate method (Morwin and Peach, 1951). The DTPA-extractable micronutrients, *viz*. Fe, Mn, Zn and Cu were determined by the method of Lindsay and Norvell (1978) using Atomic Absorption Spectrophotometer (Perkin Elmer, USA make Analyst 400).

2.6. Leaf nutrient content

A representative leaf sample of 50 fully matured and expanded current season leaves located at the 8th to 10th position from apex were collected (Bhargava and Dhandar, 1987; Marathe and Dhinesh Babu, 2015) during every year. The collected leaf samples were washed thoroughly in sequence with water, liquid soap, acidic water and glass redistilled water and dried in shade for four days followed by oven drying at 70 °C till it achieved constant weight. The dried samples were ground, mixed well and used for analysing total N by micro-kjeldhal steam distillation method. The samples were further digested in di-acid (nitric acid – perchloric acid in 9:4 v/v ratio) mixture and used for analysing P using Vanadomolybdo phosphoric acid method, K using flame photometer, Ca and Mg by titrimetric method employing disodium salt of EDTA (Chapman and Pratt, 1961). Micronutrients *viz*. Fe, Zn, Mn