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FULL LENGTH ARTICLE

Effect of methods and time of poultry manure application on soil and leaf nutrient concentrations, growth and fruit yield of tomato (*Lycopersicon esculentum* Mill)

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Abstract In order to obtain maximum economic value of plant nutrients in poultry manure and increase in tomato yield, field experiments were conducted at Owo, southwest Nigeria, during 2012 and 2013 early cropping seasons to study the effect of two methods (broadcasting on the soil surface and the incorporated) and four times (3 weeks before transplanting (3 WBTP), 0 week at transplanting (0 WATP), 3 weeks after transplanting (3 WATP), and 6 weeks after transplanting (6 WATP) of poultry manure (PM)) of applications on soil chemical properties, leaf nutrient concentrations, growth and yield of tomato. The eight treatments were factorially arranged in a randomized block design with 3 replications. Results showed that PM incorporated into the soil produced higher soil organic matter and soil and leaf N, P, K, Ca, Mg, growth and yield (0.9 t ha^{-1}) of tomato compared with broadcast method. Also PM applied at 3 WBTP had higher leaf nutrient concentrations and better growth and yield of tomato compared with 0 WATP, 3 WATP and 6 WATP. The higher yield of 3 WBTP was adduced to better synchrony between crop demand and nutrient supply. Using the mean of the two years, 3 WBTP increased tomato fruit yield by 4.0, 2.8 and 1.5 t ha^{-1} compared with 6 WATP, 3 WATP and 0 WATP, respectively. This yield difference can be economical on large scale tomato production. Therefore application of PM at 3 WBTP with incorporated method is recommended for tomato cultivation in the forest-savanna transition zone of southwest Nigeria.

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1. Introduction

Tomato (*Lycopersicon esculentum* Mill) belongs to the family Solanaceae and is one of the most widely eaten vegetables in the world because they can be eaten fresh or in many other

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processed forms. As far as global vegetable production is concerned, tomato is the most popular and third most consumed vegetable in the world next to potato and sweet potato (FAO, 2002). It consists of minerals and antioxidants such as lycopene and vitamin C which are essential for human health (Kallo, 1993; Clinton, 1998; Kanr et al., 2002). Lycopene, the most important antioxidant has been linked with reduced risk of prostrate and various other forms of cancer as well as heart diseases (Barber and Barber, 2002). Tomato is grown in all types of soils on a small scale for family use and on a commercial scale as a cash crop by the vegetable growers.

Tomato is a heavy yielder and hence requires adequate fertilizer for growth and yield (Pandey and Chandra, 2013). Although chemical fertilizers have been claimed as the most important contributor to the increase in world agricultural productivity over the past decades (Smil, 2001), the negative effects of chemical fertilizer on the soil and environment limit its usage in sustainable agricultural system (Peyvast et al., 2003). Research comparing soils of organically and chemically managed farming systems has recognized that higher soil organic matter and total N with the use of organic agriculture (Alvarez et al., 1988; Drinkwater et al., 1995). Organic material such as poultry manure is identified as a suitable organic fertilizer. Poultry manure, if properly handled is the most valuable of all animal manures. The use of poultry manure for soil fertility maintenance, growth and yield of tomato had been reported (Adekiya and Agbede, 2009; Akanni and Ojeniyi, 2007; Ewulo et al., 2008). However, inappropriate use of poultry manure can greatly reduce manure efficiency and negatively affect productivity of the soil. Also to obtain maximum economic value of plant nutrients in poultry manure it should be applied to match nutrient need of crops (Ozores-Hampton, 2012). The demand of nutrients by growing crop generally varies through the growing season, with the highest uptake associated with the period of most rapid growth. Timing of nutrient application, therefore, ensures the availability of the nutrients when the crop needs them. This will also avoid nutrient losses which can be before and after periods of crop demand which in the long run result in wastage of resources (Ndukwe et al., 2011). This aspect of manure management has not been investigated for tomato. An important part of optimizing crop response to a fertilizer nutrient is placing the nutrient in such a way that it provides rapid uptake by crop and reduces potential losses (Steward, 2006). Manure application to the soil surface may not be as effective as incorporated manure because of potential N loss (Eghball and Power, 1999). Various experiments have shown that decomposed poultry manure is the best for tomato cultivation but the method of placement and time of application are yet to be investigated. Therefore the objective of this work was to determine the effects of method and time of poultry manure application on soil chemical properties, leaf nutrient concentrations, growth and yield of tomato.

2. Material and methods

2.1. Site description and treatments

Trials were carried out at Owo (Latitude 7°12′N and Longitude 5°32′E) in Ondo State, southwest Nigeria, during the early cropping seasons of 2012 and 2013 growing seasons. The soil at Owo is an Alfisol and is classified as Oxic Tropudalf (Soil Survey Staff, 2010) or Luvisol (FAO, 1998) derived from quartzite, gneiss and schist (Agbede, 2006). The average rainfall varied from 1000 to 1240 mm. Owo has a bimodal rainfall pattern with first season commencing from March to July with dry spell in August followed by the second season from September to November. The site in 2012 was cleared from a year fallow after 2 years of maize cropping. The soil adjacent to the site was used for 2013 experiment.

The experiment on each year consisted of 2 × 4 factorial combinations of two methods: broadcasting (the poultry manure was uniformly spread over the surface of the experimental plot) and the incorporated (the poultry manure was buried into the soil) and four times of application of poultry manure: 3 weeks before planting = poultry manure applied to the soil at 3 weeks before transplanting tomato (3 WBTP), 0 week at planting = poultry manure applied to tomato at transplanting (0 WATP), 3 weeks after planting = poultry manure applied to the soil at 3 weeks after transplanting tomato (3 WATP) and 6 weeks after planting = poultry manure applied to the soil at 6 weeks after transplanting tomato (6 WATP). The poultry manure was applied at the rate of 30 t ha^{-1} to appropriate plots. The eight treatments were factorially arranged in a randomized complete block design with 3 replications. Each block comprised of 8 plots, each of which was 3 × 4 m. Blocks were 1 m apart and plots were 0.5 m apart. Adjacent soil (soil beside the first experimental site) was used for the second trial in 2013 with same experimental layout.

2.2. Land preparation, planting of tomato and application of poultry manure

The experimental plot was ploughed and harrowed once with a tractor after which a uniform rate of 30 t ha^{-1} poultry manure was applied (Adekiya and Agbede, 2009). Three weeks old local variety of tomato seedlings was transplanted to the field at a spacing of 1 × 1 m in April for years 2012 and 2013. Poultry manure at 30 t ha^{-1} was applied accordingly, viz: broadcasting and incorporated at 3 WBTP, 0 WATP, 3 WATP, 6 WATP. Weeding was done manually with hoe 3 times throughout the experiment each year.

2.3. Determination of soil properties

Prior to the commencement of the experiment in 2012 and 2013, soil samples were taken from 0 to 15 cm depths from each site. The soil samples were also bulked, air-dried and sieved using a 2 mm sieve and analyzed for particle-size, soil organic matter, total N, available P, exchangeable K, Ca and Mg, and pH. At the end of the experiment in 2012 and 2013, soil samples were also taken for routine soil analysis on plot basis. Samples were analyzed as described by Pansu and Gautheyrou (2006). Particle-size analysis was done using hydrometer method (Gee and Or, 2002). The organic matter was determined by the procedure of Walkley and Black using the dichromate wet oxidation method (Nelson and Sommers, 1996). Total N was determined by micro-Kjeldahl digestion method (Bremner, 1996), and available P was determined by Bray-1 extraction followed by molybdenum blue colorimetry (Frank et al., 1998). Exchangeable K, Ca and Mg were extracted using ammonium acetate, Thereafter, K level was