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Short Communication

Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (*Fragaria* x *ananassa* Duch.)

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ABSTRACT

Studies were conducted to determine the effect of vermicompost on growth, physiological disorders, fruit yield and quality of 'Chandler' strawberry. For this, 4 levels of vermicompost (2.5, 5.0, 7.5 and 10.0 t ha^{-1}) were supplemented with inorganic fertilizers to balance fertilizer requirement of strawberry under semi-arid region of northern India. The vermicompost was incorporated into top 10 cm layer of soil, which was supplemented on the basis of chemical analysis, with amount of inorganic N, P, K fertilizer calculated to equalize the recommended dose of nutrients. Vermicompost application increased plant spread (10.7%), leaf area (23.1%) and dry matter (20.7%), and increased total fruit yield (32.7%). Substitution of vermicompost drastically reduced the incidence of physiological disorders like albinism (16.1–4.5%); fruit malformation (11.5–4.0%) and occurrence of grey mould (10.4–2.1%) in strawberry indicating that vermicompost had significant role in reducing nutrient-related disorders and disease like *Botrytis* rot, and thereby increasing the marketable fruit yield up to 58.6% with better quality parameters. Fruit harvested from plant receiving vermicompost were firmer, have higher TSS, ascorbic acid content and lower acidity, and have attractive colour. All these parameters appeared to be dose dependent and best results were achieved @ 7.5 t ha^{-1}, however, beyond this dose of vermicompost, there was not significant influence on these parameters.

1. Introduction

Vermicompost is a product of biodegradation and stabilization of organic materials by interaction between earthworms and microorganisms. It is a finely-divided, peat-like material, with high porosity, aeration, drainage, water holding capacity and microbial activity, which make it an excellent soil conditioner (Edwards and Burrows, 1988; Edwards, 1998; Atiyeh et al., 2001). Addition of different vermicomposts, produced from different sources, like cattle manure, pig manure, food waste etc., increases the rate of germination and growth, and yield of many high value crops (Atiyeh et al., 2000). Vermicompost contains plant-growth regulating materials, such as humic acids (Senesi et al., 1992; Masciandaro et al., 1997; Atiyeh et al., 2002) and plant growth regulators like auxins, gibberellins and cytokinins (Krishnamoorthy and Vajrabhiah, 1986; Grappelli et al., 1987; Tomati et al., 1988, 1990), which are responsible for increased plant growth and yield of many crops (Atiyeh et al., 2002). These plant growth-regulating materials are produced by action of microbes like fungi, bacteria, actinomycetes (Edwards, 1998; Tomati et al., 1987) etc., and earthworms. Vermicompost provides large particulate surface areas that provide many microsites for microbial activities and for strong retention of nutrients (Shi-wei and Fu-zhen, 1991). As a result, most nutrients are in available forms such as nitrates, phosphates, and exchangeable calcium and soluble potassium (Orozco et al., 1996; Edwards, 1998). Further, vermicompost application also suppresses the growth of many fungi, like *Pythium*, *Rhizoctonia* and *Verticillium*, as a result, many plant diseases are suppressed when vermicompost is applied in ample quantity in the field (Hoitink and Fahy, 1986). Sometimes, vermicompost also controls the population of plant parasitic nematodes (Johnston et al., 1995; Arancon et al., 2006). Hence, vermicompost exhibits similar effects on growth and yield of plants as shown by soil-applied inorganic fertilizers or plant growth regulators or hormones (Muscolo et al., 1999). However, most research work conducted on the use of vermicompost has only been in the greenhouse conditions, and only a few workers have reported its use and effects under field conditions.

Strawberry is one of the most important fruit crops of the world. It has become the most favourite fruit crop among the Indian growers near towns and cities, because of its remunerative prices and higher profitability, which has resulted a phenomenal increase in its area and production in the recent years (Sharma and Sharma, 2004; Sharma et al., 2006; Singh et al., 2006, 2007b). Strawberry requires higher amount of nutrients for higher

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yield of quality fruit. Consequently, efforts have been made to determine the doses of inorganic nutrients for strawberry cultivation (Sharma and Sharma, 2004). During the last 2–3 years, some reports have appeared in the literature, which clearly suggest that application of vermicompost along with chemical fertilizers result in increased yield and fruit quality (Arancon et al., 2004, 2006) mainly due to production of plant growth regulators by microorganisms during the process of vermicomposting (Muscolo et al., 1999; Atiyeh et al., 2002). However, we have reported earlier that there is production of albino and malformed fruit in large number in field-grown strawberries, which affect fruit yield and quality (Singh et al., 2007a). Hence, we hypothesized that with the use of vermicompost in strawberry, production of albino and malformed fruit may be reduced due to the presence of plant-growth-influencing substances and suppression of *Botrytis* rot in strawberry. Considering these points, we proposed to conduct systematic studies to determine the effect of different doses of vermicompost along with chemical fertilizers on growth, occurrence of albinism, fruit malformation disorders, and yield and fruit quality of 'Chandler' strawberry.

2. Methods

2.1. Experimental site and material

The studies were conducted at Central Institute of Post Harvest Engineering and Technology, Abohar (Lat 30° 09′ N, Long. 74° 13′ E, 185.6 m above mean sea level), Punjab, India during the cropping season of 2004–05 and 2005–06. This region falls in semi-arid zone having hot summers (May–June) and mild winter (December–mid-February) with annual rainfall of about 180 mm, restricted mainly during July and August. Soil of the experimental farm was sandy-loam (Ustic Haplocambid), having pH 8.42, which was low in organic carbon (0.42%), medium in available phosphorus, and high in potash. Soil was thoroughly ploughed and raised beds of 25 cm height, five meter in length and one-meter width were prepared at a distance of 50 cm. Healthy and disease free runners of 'Chandler' strawberry were procured from Dr. Y.S. Parmar University of Horticulture and Forestry, Solan and planted on raised beds at a spacing of 25 × 25 cm during first week of October every year. Irrigation was provided with micro-sprinkler system during early stage of plant establishment, which was replaced by drip system after 15 days of planting.

2.2. Treatments

The vermicompost (VC) was prepared from vegetable waste mixed with cow dung in 2:1 ratio by employing epigeic species (*Eisena foetida* Sav.) at research farm of CIPHET, Abohar, which was applied @ 2.5, 5.0, 7.5 and 10.0 t ha^{-1}, and inorganic fertilizers (NPK) served as control. Vermicompost was first analyzed for major nutrients (N = 0.92%, P = 1.21% and K = 1.45%), and on the basis of available nutrients in it, vermicompost treated plots were supplemented with appropriate amount of inorganic fertilizers, to equalize the recommended rate/dose of nutrients (120–170–150 kg NPK ha^{-1}) among the treatments (Table 1). The required quantity of vermicompost (as per treatment) and the inorganic fertilizers were applied and incorporated to the top 10 cm layer of soil in experimental beds. Plastic mulch and drip irrigation systems were installed on beds after 15 days of planting of the runners. Each treatment combination consisted of 64 plants in a plot size of 400 × 100 cm. Treatments were replicated five times in a complete randomized block design. All necessary cultural practices and plant protection measures were followed uniformly for all the plots during the entire period of experimentation.

2.3. Observations recorded

Observations on plant spread (cm), leaf area (cm^2) and plant dry weight (%) were recorded on five plants from each replication at 90, 135 and 180 days after planting (DAP). The plants were harvested for assessment of mean leaf area, fresh and dry weight. For recording leaf area, all leaves of the randomly selected plants were removed and passed through leaf area meter (Singh et al., 2007a). Leaves and stems were placed in paper bags, dried at 60 °C for 92 h and weighed to measure dry weight. Data on fruit yield and yield attributing parameters were recorded on all harvest dates. Total fruit yield was calculated by taking all the harvested fruit on each picking and thereafter, fruit which were free from injury, albinism and malformation incidence and those with *Botrytis* rot symptoms were sorted out to calculate the marketable fruit yield. Randomly selected 100 normal fruit were taken to calculate mean berry weight. The titratable acidity (TA), total soluble solids (TSS), firmness and external fruit colour were determined at each harvest. Quality parameters like acidity, TSS, ascorbic acid content were measured as per A.O.A.C. (1989).

Firmness was determined on 25 fruit samples from each replicate with texture analyzer (TA-Hdi, Stable Micro Systems, UK) with the 2 mm diameter stainless steel probe (Singh et al., 2007a). Fruit were tested equatorially at their maximum diameter with speed of cross-head at 50 cm min^{-1}. The force was expressed in Newton (N).

The fruit colour in terms of *L*, *a*, *b* values was determined using Hunterlab miniScan XE Pluscolourimeter (HAL, USA, Model45/0-L), in which, 'L' denotes the lightness or darkness, '*a*' green or red, and '*b*', blue or yellow colour of the samples. Before measuring colour of samples, the colourimeter was standardized with black and white calibration tiles provided with the instrument (Singh et al., 2007a).

Incidence of albinism and malformation fruit were determined at each harvest by counting all albino, malformed and normal fruit and represented as percentage (Singh et al., 2007a). Similarly, incidence of grey mould (*Botrytis cinerea*) was determined by counting all healthy and infected fruit at each harvest, and represented as percentage (%).

Table 1
Contribution of vermicompost and inorganic fertilizers in different treatments for meeting recommended supply of nutrients in strawberry

Treatments	N applied			P applied			K applied		
	VC (kg/ha)	IF (kg/ha)	Total (kg/ha)	VC (kg/ha)	IF (kg/ha)	Total (kg/ha)	VC (kg/ha)	IF (kg/ha)	Total (kg/ha)
Inorganic fertilizers	Nil (0.0)	120 (100.0)	120.0	Nil (0.0)	170.0 (100.0)	170.0	Nil (0.0)	150.0 (100.0)	150.0
VC @ 2.5 t ha^{-1}	23.0 (19.2)	97.0 (80.8)	120.0	30.2 (17.6)	139.8 (82.6)	170.0	36.2 (24.1)	113.8 (75.9)	150.0
VC @ 5.0 t ha^{-1}	46.0 (38.4)	74.0 (61.6)	120.0	60.5 (35.6)	109.5 (64.4)	170.0	72.5 (48.3)	77.5 (51.7)	150.0
VC @ 7.5 t ha^{-1}	69.0 (57.5)	51.0 (42.5)	120.0	90.7 (53.3)	79.3 (46.7)	170.0	108.7 (72.5)	41.3 (27.5)	150.0
VC @ 10 t ha^{-1}	92.0 (76.7)	28.0 (23.3)	120.0	121.0 (71.2)	49.0 (28.8)	170.0	145.0 (97.0)	5.0 (3.0)	150.0

VC: Vermicompost; IF: inorganic fertilizer. Figures in parenthesis indicate the percentage of total nutrients.