Organic production of strawberry: A review

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Abstract

Now-a-days, organic foodstuffs are being illustrious for all people around the world. Owing to the great local and global market demand of organic fruits, production of organic fruit has rapidly increased in the past one decade to prevent health issues resulting from pesticides and hazardous chemicals. Organic farming enhances soil organic carbon, soil moisture content; improve soil health, increasing productivity, microbial and earthworm population and enzymatic activity in the fruit plant. Application of different organics in combinations and in a cumulative manner can supply the nutrient requirement of fruit crops to augment the sustainability in yield and quality. The excessive usage of chemical fertilizers and pesticides particularly on those fruits, which can be eaten without removing peels such as strawberry fruit, are harmful for human health as well as decline in the bio-environmental and conventional cropping which can be solved through organic farming. It is need of hour to protect the environment and advancing degradation of soils, the negative impact of intensive fruit production, and the worsening effects of climate change (Dobrzyński et al. 2014). Keeping in view the application of chemicals fertilizers and vulnerability of diseases, the people are becoming more health consciousness thereby the demand of organic fruits are increasing which resulted in more income to the growers.

Keywords: strawberry, organic production, bio-fertilizers, yield, quality

Introduction

Strawberry is one of the important delicious and soft fruit among the berries. Diverse strawberry species grow wild in all over the world, but the cultivated strawberry is based upon two American species Fragaria chiloensis and Fragaria virginiana. Hybrid between these two species was the ancestor of all the modern strawberry cultivar (John, 1994) [34]. The fleshy fruit of strawberry is classified as an aggregate fruit (Green, 1971) [24]. Cultivated strawberry (Fragaria × ananassa Duch) is one of the legendary fruit in temperate countries. However, it can also be grown in the tropical and sub-tropical climatic conditions. It is the easiest fruits to grow in kitchen garden, decorative pots, hanging basket and are also grown in flat or raised beds as well as protected structure. It is paying back within six months after planting. In the world, the high demand on organic berry fruit plants has increased in last decades which make strawberry cultivation very demanding enterprise (Asad, 1997) [6]. It is need of hour to protect the environment and advancing degradation of soils, the negative impact of intensive fruit production, and the worsening effects of climate change (Dobrzyński et al. 2014). Keeping in view the application of chemicals fertilizers and vulnerability of diseases, the people are becoming more health consciousness thereby the demand of organic fruits are increasing which resulted in more income to the growers.

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- Impact of organic manures on growth characteristics of strawberry

a. Plant growth

Increasing demand of organic fruit, makes it highly lucrative per unit area. The macro and micro-elements are considered very essential because of sustainable growth and development of plant. Tucker (1926) [64] reported that the application of stable manure increased vegetative growth which was observed by production of more runners and their branching had direct relation to the amounts of manure applied. The stable manure also increased vegetative growth in strawberry while chemical fertilizers apparently decrease it. The nitrogen content in fresh poultry manure has almost double amount of nitrogen as compared to farmyard manure and has higher phosphorus and potassium level as reported by Cooke (1972) [16]. Sufficient amount of FYM 80-85 tonnes/ha has been recommended per planting dose during land preparation.

b. Flowering

In strawberry varied flowering season has been reported with respect to place and year to year Desai (1963). On the basis of photoperiodic responses, strawberry cultivars are mainly categorized as June bearers, ever bearers or day neutrals. June bearer cultivars are facultative as short day (SD) plant (Darrow, 1936) [18]. Long day (LD) plants required below 16°C temperature for flower bud differentiation so evergreen plants classified as Long day plants (Ito and Saito, 1962; Heide, 1977) [30]. Day neutrals strawberry cultivars were tested by Durner et al. (1984). In vigorous plants, some extra parts are common while as under unfavourable conditions, some flower plants may be suppressed. The extent to which sepal, petals and epicalyx open in are partly genetically as well as environmentally affected (Darrow, 1966). Arancon et al. (2004) [5] found that growth, flowering and yield of field strawberries exhibited a marked increase after applications of food and paper waste vermi-compots in cv. Chandler. Odongo et al. (2008) [45] reported an increase in photosynthetic production due to phosphorus contents in farm yard manure which helped to break bud dormancy and increased flowering sites. The quantum of nutrients as N, P and K and hormones provided by vermin-composts plays a significant role in increasing gibberelic acid in roots thereby breaking bud dormancy and increasing flowering buds and fruiting sites Tagliavini et al. (2005) [62]. An early onset of reproductive stage by the application of organic fertilizers has been reported by Herencia et al. (2011) [28].

c. Fruit setting

Manures containing favourable amounts of macro and micro nutrients and enhance fruit setting and fruit size and weight by the formation of carbohydrates than inorganic triple phosphate fertilizer (Odongo et al. 2008) [45]. During the process of fruit ripening, fruits represent sink for potassium and nitrogen and composts contain significant amounts of these essential nutrients. Reduction in number of fruits and flowers can be attributed to deficiency of nitrogen and phosphorus at the time of flowering which leads to reduction in flower size and abortion of female flower parts Tagliavini et al. (2005) [62].

d. Yield

Albregts and Howard (1981) [2] recorded increased yield at 27.5 mt/ha with the use of poultry manure at 18 mt/ha in the first year and reported that 36 mt/ha poultry manure caused plant damage and reduction in marketable yield due to fruit rot. Knight and Wallace (1932) [37] reported that treated with FYM were more vigorous than with chemical fertilizers. Nitrogen applied at the rate of 100 and 140 lbs. per ha gave excessive plant growth (Linberry et al., 1944) [41]. Wallace (1936) observed more yield with organic manures in strawberry. The chemical fertilizers mainly contain NPK which are leached down to sub-soil, thus contaminate it, whereas organic manures are slowly available to plants and are eco-friendly, increases yield and soil fertility (Kaul, 1998) [36]. Knight and Wallace (1932) [37] found dung much superior to chemical fertilizer in increasing yields and the best results were obtained with light annual dressing of dung at 12-13 tonnes/acre. The manure applied was 20 tones FYM; check no manure fertilizer at 40 kg N, 150 kg P₂O₅, 50 kg K₂O; however, a yield of 227.21 kg was recorded where FYM were added in combination with fertilizers. The plant grown in soil deficient or not receiving nitrogen or phosphoric acid shows varied relative yield (about 2,000 quartz/acre) but satisfactory yields (4000 quartz or more) were obtained when fertilizer contained 160 lbs P₂O₅ (Linberry et al., 1944) [41]. The manure as a whole i.e. averaging the effects of dung and chemical showed an increase of about 12 percent, dung gave somewhat larger increase than chemical about 8 percent approximately with improved fruit size and quality. An application of 30 tonnes/acre increased the yield over 12 tonnes/acre.

e. Fruit quality

Knight and Wallace (1932) [37] observed large berries by the application of FYM than control. A light dressing of bone meal (150 pounds/acre) at the end of December was reported to improve the flavour of the fruit (Anon, 1956). Moreover, application of organic manures significantly reduced the acid content of strawberry fruits over control. Wood ward (1972) [71] reported that the composition of strawberry varies from stage to stage during maturity. Advancement of maturity increases the weight, soluble solid and acidity while as chlorophyll, pH and carotenoids decrease. Similar reports were recorded wherein total phenol decreased with the advancement of fruit maturity (Spayed and Morris, 1981) [60]. El-Hamid et al. (2006) [21] registered that organic manures treated plants increase in total sugars, TSS and juice percentage.

f. Runner production

Strawberries are propagated very easily by runners in temperate areas having well moisture soil, fertilizes and proper draining system while it is very intricate to propagate in those areas where temperature goes above of 40°C during regeneration period and water logging site. Tucker (1926) [64] observed that application of stable manure increased [24] vegetative growth which was observed by production of more runners and their branching owing to sufficient organic carbon in soil Bailey (1963) [8] stated that the FYM to be the best manure for strawberry cultivation. Hughes et al. (1969) [29] observed that 20-30 tons per acre Farm Yard Manure prior to the planting runners enhances runner production. Widjajanto and Widodo (1982) [70] concluded that organic manure treated plants increased plant height, plant spread, proper growth, development and to obtain healthy runners production.

g. Root development

The strawberry plant, a herbaceous one is exceptionally shallow rooted, hence needs extra care in the nutrition as well as growing strategy. Almost 90 per cent of the roots of this
crop are spread in top six inches of soil. Usually, strawberry has two types of roots, the large primary ones and small secondary lateral roots. Rooting is active as long as soil temperature is above 45° F. Preusch et al. (2004) reported an increase in root length in strawberries with fresh and poultry litter compost compared to control (no manure) which was attributed to the role of potassium in root proliferation. Davis (1925) attributed damage to to strawberry owing to the chemical fertilizers, which increases ion concentration of soil solution. In general, there is lack of agreement with regard to strawberry nutrition with organic manures or inorganic fertilizers alone. However, since the roots of this plant are mainly present in top soil, hence respond better to organic manures than inorganic fertilizers. Ogendo et al. (2008) found that cytokinin production in roots enhanced vegetative growth and number of leaves in strawberry, and high shoot to root ratio was observed with farm yard manure and phosphorus interaction compared to control. Great variability in the nitrogen availability from different sources of organic fertilizers has been reported (Pang and Letey, 2000).

- **Impact of bio-fertilizers on strawberry**
  Bio-fertilizers are naturally stirring products with living microorganisms which are resulted from the roots or cultivated soil and don’t have any ill effect on plants health, soil health, climate and environment. Bio-fertilizers have significant role in fixing atmospheric nitrogen and phosphorus solubilisation, and these are also helpful in stimulating the plant growth hormones. Biofertilizers viz., Azotobacter, Phosphate Solubilizing Bacteria (PSB) and Azospirillum fix atmospheric nitrogen and solubilize phosphorus to increase fertility and biological activities of soil. Strawberry plants inoculated with Azotobacter significantly improve yield. Besides this, inoculated plants increased the fruit size (Rana and Chandal, 2003) (50). Tiwari et al. (1998) reported that in banana the sugar content of fruit pulp was high in plants those treated with Azotobacter. Colonization of the root system by AM fungi can change its morphological structure, e.g. the size of the roots, their topographical arrangement, and also their surface area and volume (Kapoor et al. 2008) (15). High levels of fertilization, often occurring in intensive horticulture, have a negative effect on root growth and root colonization by mycorrhizal fungi (Smith and Read 2008) (58).

  An innovative solution involves microbiological enrichment of organic fertilizers, composts, and liquid plant growth promoters with consortia of beneficial microorganisms (Sas Paszt et al., 2015) (20). Application of native mycorrhizal fungi and beneficial strains of bacteria incorporated in new bio-products ensures their better adaptation and survival in the prevailing environmental conditions, which is beneficial for long term effects on plants (Regvar et al., 2003) (52).

- **Impact of vermi-compost on strawberry**
  Vermi-composts are organic materials broken down by interactions between earthworms and micro-organisms, in a mesophilic process (up to 25°C), to produce fully-stabilized organic soil amendments with low C: N ratios. They contain both plant growth hormones and humic acids which can act as plant growth regulators. Compost is the traditional source of nutrient for small fruit crops. It can be used as a supplement or alternative and help concentrate fertility and microorganisms so that the compost treated plants increase fruit yield. Turemis (2002) reported that the highest fruit yield was noticed with banana compost treated strawberry plants. Vermi-compost (compost made from earthworm waste) application significantly increased growth and yield of strawberry (Aranccon et al., 2003) (5). Application of compost is safeguard against toxicity plant injury and also improves the physico-chemical and biological properties of soil viz., water holding capacity, attain soil moisture of field and low nutrients supply. Moreover, it is beneficial for soil microbial population.

- **Impact of organic mulches on strawberry**

  a. **Soil water**
  Application of surface organic (straw) mulch resulted in strong more precipitation water in soil by reducing storm runoff, increasing infiltration, and decreasing evaporation (Bond and Willis, 1969; Unger, 1983) (45, 11). Abdul-Baki and Teasdale (1993) (1) observed that application of mulches increased N; recycling of nutrients; abridged soil erosion, weed emergence, reduces water loss; addition of organic matter to the soil; moderate soil temperature during the hot summer months. Mathews et al. (2002) (42) reported that a synthetic mulch controlled evaporative water loss as effective as organic mulches, but it lacked some of the other benefits organic material in the soil. These results are in consonance with the findings of (Ali and Radwan 2008) (3).

  b. **Soil mineral content**
  Lakatos et al. (2001) stated that nearly all the transformation of N and C from organic material is done by micro-organisms in the soil. These micro-organisms also play a significant role in the availability and transformation of minerals like Ca, Mg, P, Mn, K, Fe and Zn, and therefore influence plant nutrition. They further revealed that the application of manure mulch to the surface also increases the number of nitrification and cellulose degrading bacteria in the soil. Microbial decomposition of organic materials like animal manure or bio-solids with high amounts of N result in a high level of N mineralization (Forge et al., 2003) (23). Shredded paper and sawdust decomposition result in the N-immobilization, because of the greater C: N ratio (Forge et al., 2003) (23).

  c. **Vegetative growth**
  Significant effects of organic and synthetic mulches on vegetative growth, flowering traits and yield on strawberry plants have been reported by several investigators (Blatt, 1984; Nestby, 1985; Haynes, 1987; Laraeu and Lamarre, 1990; Lieten and Baets, 1991) (14, 26, 39, 40). Fear and Nonnecke (1989) (22) observed that the both vegetative and reproductive strawberry plant responses can be modified by the different type organic mulches. Rebandel and Przyiseckia (1981) (51) reported that application of organic mulching materials viz., cocoa shells, sphagnum peat and composted pin bark increases number of leaves and leave size. La Mondia et al. (2002) (38) found that a sorghum-sudan grass hybrid “killed” cover crop suppressed pathogens and weeds but adversely affected strawberry growth and yields.

  d. **Weed control**
  Weed management is one of the major challenges for strawberry growers and nurserymen. Weed growth can also change the micro-climate around the runner plants, leading to higher disease pressure in regeneration of runners and fruiting stage. Among the weed control methods, mulches are important for weed control (Bilalis et al., 2002 and Jodaugené et al., 2006) (11, 32). Mulches reduce water evaporation from soil and help maintain stable soil
temperature (Ji and Unger, 2001)\(^{[31]}\). A similar result was registered by Tukey and Schoff (1963) as they suggested that the release of nutrients from decomposing mulches.

- **Integrated Management of Strawberry diseases and pests**

Diseases are very similar for both organic and conventional fruits cultivation. Major components of the organic strawberry diseases management program include: developing knowledge of the pathogen and timely application of organically approved fungicides or biological control agents or products when needed.

**a. Foliar diseases**

Leaf scorch (*Diplocarpon earliana*), Leaf spot (*Mycosphaerella fragaria*) and leaf blight (*Phomopsis obscurans*), powdery mildew caused by *Sphaerotheca macularis* and angular leaf spot or bacterial blight of strawberries caused by the bacterium *Xanthomonas fragaria* are common foliar diseases occurring on strawberry plant and their runners. These diseases can infect leaves, petioles, runners, and peduncles of the flowers, fruit stalks and caps of strawberry plants (Singh, 1996)\(^{[56]}\). Infected leaves show characteristics dark red coloured blotches usually on the upper surface (Hughes et al., 1969)\(^{[29]}\). However, leaves are coated with a grayish-white powdery mold and turn purplish or red. In irrigated fields, the fungus may also attack the fruit.

**b. Strawberry Root Diseases**

Red stele is caused by the soil-borne fungus *Phytophthora fragaria* which may persist in fields for many years. During winter and spring, the cores, or steles, of diseased roots become pinkish-red, gradually turning cinnamon brown and ultimately black. Many commercial strawberry cultivars are susceptible to the red stele fungus. *Verticillium* wilt, caused by the soil-borne fungus *Verticillium albo-atrum*, can be a major factor limiting production.

**c. Strawberry Fruit Rots**

Botrytis Fruit Rot (gray Mold) is caused by the fungus *Botrytis cinerea*. The disease causes rotting of the green ripening under favourable environmental conditions, can devastate the crop (Hughes et al., 1969)\(^{[29]}\). Anthracnose (*Colletotrichum acutatum*) disease which can affect foliage, runners, crowns and fruit (Hancock et al., 1996) and ripening (Singh, 1996)\(^{[56]}\) of strawberry under warm humid conditions.

**Control**

**a. Cultural practices**

Selected planting materials should be free from diseases, insects and pests infection and they have equal size. Virus-indexed plants obtained from a reputable nursery or govt. nurseries. Proper site selection, avoid low, poorly-drained wet areas and water lodging is especially important for control of Leather Rot and Red Stele. Removing leaves from the field as soon as the harvest season ends can significantly reduce the incidence of gray mold on fruit in June of the following year (Sutton et al., 1988).

**b. Use of disease resistant varieties**

Copper fungicides, elemental sulfur and liquid sulfur are the old “Normal” fungicides and have been used for many years in organic production systems. Protectant fungicides (Such as sulfur and copper) are not systemic and cannot move into plant tissues. The original material used was copper sulfate (also known as blue vitriol or bluestone).

**c. Mulch**

It was observed that a good layer of straw mulch is very beneficial for controlling fruit rots, especially leather rot.

**d. Organic fungicides and bio-control products for strawberry disease control**


<table>
<thead>
<tr>
<th>S. No</th>
<th>Diseases</th>
<th>Resistance cultivars/ tolerance</th>
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<tbody>
<tr>
<td>1</td>
<td>Leaf Spot</td>
<td>Midland, Redchief, Surecrop and Guardian</td>
</tr>
<tr>
<td>2</td>
<td>Leaf scorch</td>
<td>Katskill, Guardian, Midland, Redchief, Sunrise and Surecrop</td>
</tr>
<tr>
<td>3</td>
<td>Red Stele</td>
<td>Redglow, Sunrise, Guardian, Midway, Earlglownd, Redchief, Surecrop, Selite and Sparkle</td>
</tr>
<tr>
<td>4</td>
<td>Verticillium</td>
<td>Earlglow, Sunrise, Katskill, Guardian, Midway, Redchief, Surecrop, Selite and Sparkle</td>
</tr>
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</table>

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From the review, it is clear that the organic farming is very healthy and remunerative practice in strawberry production. It not only improves the quality of fruits but also provide sustainability in production for long term. Intelligent anticipatory management strategies and adaptation will be the critical components for successful and sustainable quality fruit production. The literature relevant to organic farming on soil properties, growth, yield and quality with special reference to strawberry cultivation reviewed in this paper. A thorough knowledge of the critical levels of different kinds of organics and their long term influence on soil and productivity is essential to get better growth and yields, and also to maintain optimum nutrient balancing, a prerequisite

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