The Pharma Innovation Journal 2022; 11(5): 2324-2327

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(5): 2324-2327

www.thepharmajournal.com
Received: 21-03-2022
Accepted: 31-04-2022

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Effect of Biofertilizers and Organic Fertilizers on Growth and Yield of Strawberry cv. Camarosa

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Abstract
The present investigation was carried out in the naturally ventilated polyhouse under the department of Horticulture, Lovely Professional University, Phagwara, Jalandhar, Punjab during the year 2021-2022 to examine the effects of bio-fertilizer and organic manure applications on growth and yield of organically grown strawberry (*Fragaria ×ananassa* Duch.) cv. Camarosa. The experiment was laid out in a completely randomized design with nine treatments and control in three replications of each treatment. Bio-fertilizers helps in reducing detrimental effect of hazardous chemical residues which is left by the inorganic fertilizers in the soil. Organic manure like vermicompost enhances the soil physical properties, soil pH, water holding capacity, increase the nutrient availability and its plant absorption as it adds micro and macro nutrients to the soil. The results revealed that highest plant growth (plant length, plant height) was observed in treatment T3 (Cocopeat @100g plant^{-1}), while the highest number of leaves per plant, number of flowers per plant and number of fruits per plant was recorded from treatment T9 (Vermicompost @50g plant^{-1} + Neem cake @50g plant^{-1} + Cocopeat @50g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}). Consequently, the maximum total yield was observed in T9 (Vermicompost @50g plant^{-1} + Neem cake @50g plant^{-1} + Cocopeat @50g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}) treated plants and the minimum was in T0 (control). The combined application of organic manures and biofertilizers has shown great impact to improve growth and crop yield. Henceforth, it is concluded that the combined application of biofertilizers and organic manures must be implemented for higher sustainable production of strawberries mainly under organic farming system.

Keywords: Bio-fertilizer, organic manure, vermicompost, strawberry, growth, yield

Introduction
Strawberry (*Fragaria ×ananassa* Duch.) is one of the most popular soft berry fruits, consumed worldwide which are widely grown hybrid species, the hybridization of two American species *i.e.*, *Fragaria chilioensis* Duch. and *Fragaria verginiana* Duch. (Singh *et al*., 2015; D'Urso *et al*., 2015) [12, 2]. The fruit is originated from Europe in the 18th century and almost other countries developed their own varieties during the 19th century. Almost all the cultivated varieties of strawberry are octaploid (2n = 8x = 56) in nature. The genus *Fragaria* of the family Rosaceae (subfamily Rosoideae) comprises of 20 wild species among which three are naturally occurring hybrid species and also the modern cultivated strawberry i.e., *Fragaria* × *ananassa* Duch, was originated in Asia, North America, Europe and South America (Li *et al*., 2011) [7].

Strawberry is an herbaceous fruit crop which acts as annual in sub-tropical and perennial in cool-season and is prominent as the fruit is highly admired for its pleasant taste, delicious flavour, attractive colour, expediency, high yield and good quality (Khalid *et al*., 2020) [5]. Anthocyanins, phenolic compounds and ascorbic acid are the major components among the phytochemicals of the fruit, which provide medicinal properties (*viz*., antioxidant, anticarcinogenic, anti-inflammatory, anti-neuro degenerative) (D'Urso *et al*., 2015; Fernandes *et al*., 2012; Domingues *et al*., 2018) [2, 4, 3].

The employment of organic fertilizers and biofertilizers seems to be an array of aspiration in this direction inputs. Organic fertilizer like vermicompost, a product of biodegradation and stabilization of organic materials due to interaction between earthworms and micro-organisms, possess nearly all the nutrients required in available form by plant such as nitrates, exchangeable calcium, phosphates and soluble potassium (Negi *et al*., 2021; Kumar *et al*., 2018) [8, 6]. Moreover, biofertilizers are the products of living microorganisms which are occurring naturally and these microorganisms are detached from the cultivated soil or rhizosphere of the plant (Negi *et al*., 2011; Sawana *et al*., 2014; Borriss, 2017) [9, 10, 1].

These promote plant growth and have different traits that has positive impact on both soil and the host plant and thus provide massive ecological benefits as compared to inorganic chemicals (Shen *et al*., 2011) [11]. Consequently, these microbes improve fertility and biological activities of soil to increase crop production.

The main goal of this study was to evaluate the results obtained in the experiment to examine the effects of biofertilizers and organic fertilizers on growth and yield of strawberry fruits that had undergone different treatments.

Materials and Methods

Experimental Site and Material

The investigation was carried out in a naturally ventilated polyhouse under the department of Horticulture, Lovely Professional University, Phagwara, Jalandhar, Punjab during the year 2021-2022. The runners of strawberry plants (cv. Camarosa) were used in the experiment acquired from AKS strawberry of Solan (Himachal Pradesh). The organic manures and biofertilizers (Vermicompost, neem cake, cocopeat, Azotobacter, PSB) were provided by university store for the treatments. The strawberry runners were planted on November, 2021 in a bed size of 40 x 2m^2 with a drip irrigation system underneath. The bed was divided into ten equal segments, each of 4m in length. The spacing of the experiment was 30cm between the rows and 45cm between the plants.

Treatments

The experiment was conducted with soil application of organic manures and biofertilizers. For the experiment, organic manure (*viz*., vermicompost, neem cake, cocopeat) and biofertilizers (PSB, *Azotobacter*) were used. The experiment was laid out in completely randomized design with nine treatments and control along with three replications in each treatment. The treatments were T0 (control), T1 (Vermicompost @100g plant^{-1}), T2 (Neem Cake @100g plant^{-1}), T3 (Cocopeat @100g plant^{-1}), T4 (*Azotobacter* @2.5g plant^{-1}), T5 (PSB @2.5g plant^{-1}), T6 (Vermicompost @100g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}), T7 (Neem cake @100g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}), T8 (Cocopeat @100g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}), T9 (Vermicompost @50g plant^{-1} + Neem cake @50g plant^{-1} + Cocopeat @50g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}).

Results and Discussion

Investigation revealed that the biofertilizers and organic manures significantly influence the plant growth parameters (plant length, plant height, number of leaves per plant, number of flowers per plant) and yield of strawberry fruit var. Camarosa.

Effect of biofertilizers and organic fertilizers on growth and yield of strawberry

According to Table 1, at 150 days after planting, the highest plant height (25.67cm) was recorded from T3(Cocopeat @100g plant^{-1}) treated plants followed by T2 (25.00cm), T9 (23.00cm), T1 (21.33cm) and T5 (21.33cm) and minimum plant height was in treatment T6 (17.00cm). The highest plant length (30.00cm) was observed in T3 (Cocopeat @100g plant^{-1}) treated plants followed by T2 (25.67cm), T1 (25.33cm), T5 (24.67cm) and minimum plant length was in T6 and T7 treated plants with 21.33cm.

Table 1: Effect of biofertilizers and organic fertilizers on growth and yield of 'Camarosa' fruits

Treatments	Plant height (cm)	Plant Length (cm)	No. of Leaves per plant	No. of Flowers per plant	No. of Fruits per plant	Yield per plant (g)
T0	20.00	23.00	63	6.67	4.37	39.36
T1	21.33	25.33	72	13.67	12.99	199.43
T2	25.00	25.67	76	11.78	10.60	211.60
T3	25.67	30.00	75	8.33	7.50	105.60
T4	19.33	24.33	60	9.33	8.70	132.90
T5	21.33	24.67	68	12.33	11.72	245.94
T6	17.00	21.33	57	7.67	6.90	82.80
T7	21.00	21.33	45	9.11	8.80	123.20
T8	17.67	23.33	54	8.44	7.10	99.40
T9	23.00	23.00	89	14.11	13.40	278.20
CD (0.5%)	3.37	3.85	6.90	1.27	1.24	33.39
S.Em (±)	1.14	1.31	2.32	0.43	0.42	11.24

Moreover, the maximum number of leaves per plant (89) was recorded from T9 (Vermicompost @50g plant^{-1} + Neem cake @50g plant^{-1} + Cocopeat @50g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}) treated plants followed by T2 (76), T3 (75), T1 (72) and least number of leaves per plant was in T7 (45) treated plants. The maximum number of flowers per plant (14.11) was recorded from plants of treatment T9 (Vermicompost @50g plant^{-1} + Neem cake @50g plant^{-1} + Cocopeat @50g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}) followed by T1 (13.67), T5 (12.33), T2 (11.78) and the minimum in T0 (control).

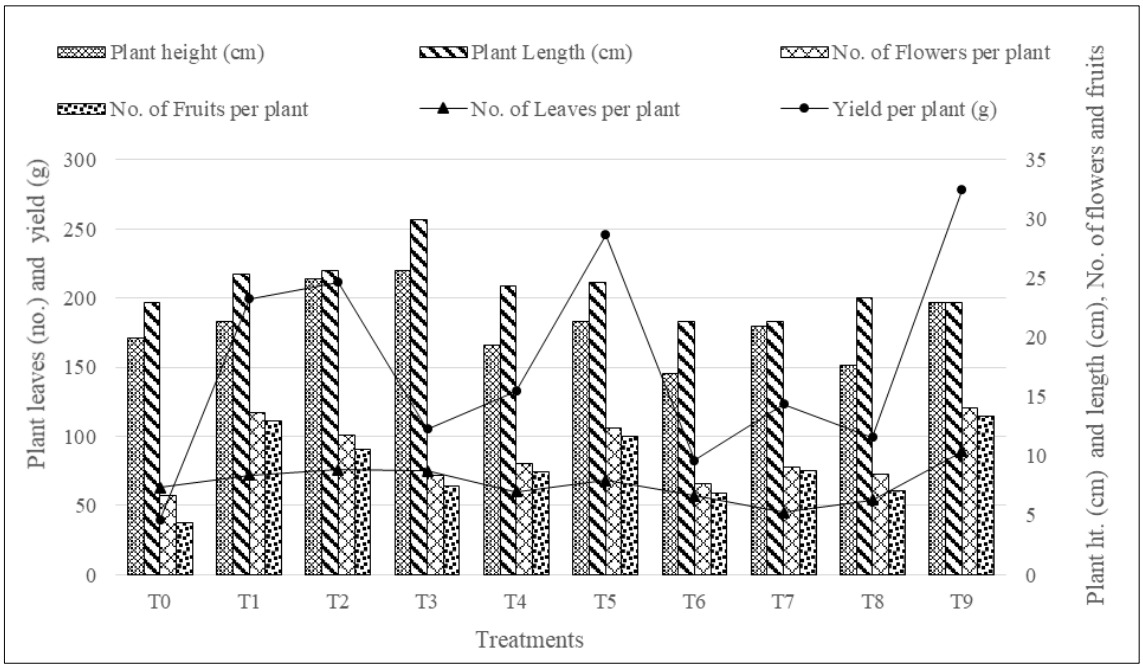

Fig 1: Effect of Biofertilizers and Organic fertilizers on vegetative growth and yield of Strawberry cv. Camarosa

The maximum number of fruits per plant (13.40) was recorded from plants of treatment T9 (Vermicompost @50g plant^{-1} + Neem cake @50g plant^{-1} + Cocopeat @50g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}) followed by T1 (12.99), T5 (11.72), T2 (10.60) and the minimum in T0 (control). Also, the maximum total yield per plant (278.20 g plant^{-1}) was recorded from T9 (Vermicompost @50g plant^{-1} + Neem cake @50g plant^{-1} + Cocopeat @50g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}) treated plants followed by T5 (245.94 g plant^{-1}), T2 (211.60 g plant^{-1}), T1 (199.43 g plant^{-1}) and the minimum in T0 (control).

The maximum yield was observed in T9 (Fig. 1), this may be due to the availability of organic matter and nutrients in soil enhanced by application of biofertilizers and organic manures. The plants absorb more minerals and nutrients and thus increase in number of leaves and growth of plant. Increasing in number of leaves helps in accumulation of carbohydrates through more photosynthetic activity done by plant which utilized for fruit development. Hence the number of leaves improves the quantity of flowers and fruits which results in high total yield. The findings were reported by Singh *et al*., (2015) [12] and Verma and Rao (2013) [13].

Conclusion

From the above findings, it can be concluded that the combined application of biofertilizers and organic manures (i. e., Vermicompost @50g plant^{-1} + Neem cake @50g plant^{-1} + Cocopeat @50g plant^{-1} + *Azotobacter* @1g plant^{-1} + PSB @1g plant^{-1}) produce better yield and growth of strawberry plants as there is an increase in nutrient availability of soil to the host plant. Therefore, it may be beneficial to use for higher sustainable production of strawberry fruits. Moreover, this may be a supportive tool to develop sustainable agricultural operations as a principle to organic farming which is the necessary inflated demand of the time.

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