



Studies Influenced by Bio-fertilizers and Organic Manures on Flowering Behaviour and Yield Attributes of Dragon Fruit

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Dragon fruit (*Hylocereus* spp.) is a exotic and newly introduced super fruit crop of India. The flowering behavior of this plant is crucial for breeding and hybridization. As a fact, there are no such scientific studies has been conducted, the current research is focused on the flowering behavior and yield of red and white fleshed dragon fruit types. From the year 2019 to 2021, the experiment was carried out in the field of a progressive farmer. Treatments consisted of T₁ - Control, T₂ - 100% N through FYM, T₃ - 100% N through FYM + PSB @ 10kg/ha, T₄ - 100% N through FYM + VAM @ 10kg/ha, T₅ - 100% N through FYM + PSB @ 10kg/ha + VAM @ 10 kg/ha, T₆ - 100% N through poultry manure, T₇ - 100% N through poultry manure + PSB @ 10 kg/ha, T₈ - 100% N through

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poultry manure + VAM @ 10kg/ha, T₉ - 100% N through poultry manure + PSB @ 10kg/ha + VAM @ 10kg/ha, T₁₀ - 100% N through vermicompost, T₁₁ - 100% N through vermicompost + PSB @ 10kg/ha, T₁₂ - 100% N through vermicompost + VAM @ 10 kg/ha, T₁₃ - 100% N through vermicompost + PSB @ 10kg/ha + VAM @ 10kg/ha. The data was pooled for two successive years on red fleshed and white fleshed type dragon fruit and the results revealed that treatment T₁₃ comprising of 100 per cent N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹ had significantly greater impact on flowering and yield parameters.

Keywords: *Hylocereus spp*; bio-fertilizers; organic manures; dragon fruit; PSB; VAM.

1. INTRODUCTION

“*Hylocereus* spp, often known as dragon fruit and native to Central South America, is a newly introduced super fruit in India that belongs to the family Cactaceae. It is a perennial climbing cactus known as the Scaly Fruit, Strawberry Pear, Honourable Queen, Jesus in the Cradle, Queen of Night, Belle of Night and Night Blooming Cereus, which only blooms at night and has a strong smell that lasts for only one night” [1]. It is a long-day plant that blooms from April to November, occasionally until December, and in four to six flushes, sometimes seven [2]. Young stems and fresh flower buds are consumed as vegetables, while dried stems and flowers are employed in homemade medicine as well as the flowers contains fragrance which is used in aromatherapy [3].

The blooms of dragon fruit were originally employed for ornamental purposes, but with the creation of edible fruit rich in nutrients, fruit cultivation began all over the world. Dry flowers are eaten as vegetables in Taiwan [4]. There is a scarcity of literature on the morphology of dragon fruit in general, as well as on flowering and yield characteristics. The flower of red dragon fruit [*Hylocereus polyrhizus* (F.A.C Weber) Britton and Rose] has an average length of 25-30 cm with borders on the outer reddish perianth segments, especially at the terminals and very small and yellowish stigma lobes. Its scarlet fruit (length: 10-12 cm; weight: 130-350 g) is rectangular and coated in small scales having red flesh with many small black seeds, pleasant flesh texture and good taste.

White type of dragon fruit botanically known as [*Hylocereus undatus* (Haworth.) Britton and Rose] plant has long and green stems that are horny in the age margins. Flowers are quite long (up to 29 cm), with green or yellow-green outer perianth segments and pure white inner perianth segments. Its rosy-red fruit (length: 15-22 cm; weight: 300-800 g) is rectangular and covered in

large and long scales that are red and green at the tips. It has white flesh with numerous small black seeds, a pleasing flesh texture, and a decent taste.

Organic farming, often known as eco-farming or biological farming, is an environmentally benign alternative to traditional farming. The use of organic sources such as FYM, vermicompost, poultry manure, sheep manure, goat manure, compost, in conjunction with liquid organic manures such as cow urine, panchagavya, vermiwash, bio-digested liquid, jeevamruta, PSB, VAM, azotobacter, rhizobium, and so on, deserves priority for long-term production and better on-farm resource utilisation. Its principles can be found in ecology, a study that studies the interactions between living creatures and their surroundings [5].

In India, there is no such scientific data available on the impact of organic manures and bio fertilizers on flowering and yield of the red and white dragon fruit types. The goal of the current experiment was to determine how organic manures and bio-fertilizers affected the flowering and yield of the red and white dragon fruit types.

2. MATERIALS AND METHODS

An investigation was conducted on flowering and yield attributes of two types of dragon fruit with the influence of organic manures and bio-fertilizers. The experiment was carried out in the field with thirteen treatments and three replications. “Treatments comprising viz. T₁ - Control, T₂ - 100% N through FYM, T₃ - 100% N through FYM + PSB @ 10kg/ha, T₄ – 100% N through FYM + VAM @ 10kg/ha, T₅ - 100% N through FYM + PSB @ 10kg/ha + VAM @ 10 kg/ha, T₆ - 100% N through poultry manure, T₇ - 100% N through poultry manure + PSB @ 10 kg/ha, T₈ - 100% N through poultry manure + VAM @ 10kg/ha, T₉ - 100% N through poultry manure + PSB @ 10kg/ha + VAM @ 10kg/ha, T₁₀ – 100% N through vermicompost, T₁₁ – 100%

N through vermicompost + PSB @ 10kg/ha, T₁₂ – 100 % N through vermicompost + VAM @ 10 kg/ha, T₁₃ – 100% N through vermicompost + PSB @ 10kg/ha + VAM @ 10kg/ha". Two year's data i.e. 2019-20 and 2020-21, for various parameters were pooled and analysed for analysis of variance according to Gomez and Gomez (1984) with the help of SAS software using RCBD design further pooled and given ranks according to Duncan Multiple Range Test.

Observations were recorded for Days to first flower open and were expressed in days. The tagged flowers were watched for flower bud opening and shutting. The time required was documented and reported in hours (hrs). The total number of flowers from each pillar was counted until the harvest, and the average number of flowers per plant was calculated and recorded. Using a 30 cm long stainless steel scale, the length of the flowers was tagged and measured from the base to the tip when the flower had fully opened. The mean results were represented in centimeters (cm). After the flower had fully opened, the width of the tagged flowers was measured from base to tip using a thick thread and the measurement was expressed in centimeters (cm). At the time of harvest, the number of fruits per pillar was physically counted and noted. It was calculated how many fruits there should be on each pillar. Each time fruit was harvested, the weight of the fruit per pillar was recorded. From this information, the total yield per plant was calculated and expressed in kilograms (Kg). The number of plants that may

be accommodated in a hectare was multiplied by the yield per pillar to get the yield per hectare, which was then stated in tonnes per hectare (t ha⁻¹).

3. RESULTS AND DISCUSSION

3.1 Days to First Flower Open

3.1.1 Red fleshed type

It is evident from the pooled values (Table. 1), that the application of organic manures in combination with bio-fertilizers was significantly influenced on the days to first flowering. The lesser days taken for earliest flower open (418.74 days) was observed in plants treated with 100 per cent N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹ (T₁₃) while the maximum days taken (493.72) was recorded in treatment T₁ (Control).

3.1.2 White fleshed type

The data presented in Table. 1 on pooled analysis revealed that, the application of organic manures in combination with bio-fertilizers in combination was significantly influenced the days to first flowering. The least number of days required for earliest flower open (441.77 days) was observed in plants treated with 100 per cent N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹(T₁₃) while the highest number of days (508.67) taken to first flowering was recorded in treatment T₁ (Control).



Fig. 1. Length of the flower



Fig. 2. Breadth of the flower
Various flower parameters recorded during experimentation



Yield of white type



Yield of red type



Yield of red and white type



Fig. 3. Packaging
Fruit yield and packaging

The earliness in flowering may be due to the higher net assimilation rate on account of better growth leading to the production of endogenous metabolites released from earthworm castings (vermicompost) in optimum level enabling early flowering. These results are in conformity with the findings reported by Perween and Hasan [6] in Dragon fruit.

3.2 Duration of Flowering

3.2.1 Red fleshed type

The pooled data (Table. 1) of two successive years (2019-20 and 2020-21) showed non-significant with respect to duration of flowering. However, the maximum duration of flowering (9.61 hours) was observed in the treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) while the minimum duration of flowering (9.02 hours) was noticed in treatment T₁ (Control).

3.2.2 White fleshed type

The pooled data (Table. 1) of both the years (2019-20 and 2020-21) showed non-significant with respect to duration of flowering, the maximum duration (9.32 hours) for flowering was observed in the treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) while the minimum duration (8.85 hours) was noticed in treatment T₁ (Control).

This may be due to the longer availability of nutrients during the growth period from vermicompost might have enhanced the duration of flowering. Similar, results have been reported by Perween and Hasan [6] in Dragon fruit.

3.3 Number of Flowers Per Plant

3.3.1 Red fleshed type

From the pooled data (Table. 2) of two successive years of study, it was observed that, number of flowers per plant varied from 12.17 to 6.90. Among different treatments, plants treated with 100 per cent N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹ (T₁₃) has recorded higher number of flowers per plant (12.17), while the least number of flowers per plant (6.90) was recorded in T₁ (Control).

3.3.2 White fleshed type

The pooled data (Table. 2) of both the years showed maximum number of flowers per plant in

the treatment T₁₂ (100% N through vermicompost + VAM at 10 kg ha⁻¹) (9.83) while the minimum number of flowers per plant (5.61) was noticed in treatment T₁ (Control).

It may be due to availability of sufficient nutrients during the reproductive stage, provided by vermicompost and bio-fertilizers like VAM, which facilitated mobilization of micro nutrients and PSB supporting in solubilization of phosphate in soil, which ultimately reflected on flowering. Results obtained are in close conformity with the findings of Perween and Hasan [6] in Dragon fruit, Yadav et al. [7] in Mango.

3.4 Length of the Flower

3.4.1 Red fleshed type

The pooled data (Table. 3) of two years of study also showed non-significant with respect to the length of flower, however recorded maximum length of flower (27.24 cm) in the treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) and the minimum length of flower (26.51 cm) was observed in treatment T₁ (Control).

3.4.2 White fleshed type

The pooled data (Table. 3) of two years of study also showed non-significant among the treatments with respect to length of the flower and it was observed maximum length (25.63 cm) in treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) and the minimum value (25.05 cm) was recorded in treatment T₁ (Control).

This is due to genetic character of dragon fruit plant. However, the increased nutrient availability from the organic manures and bio-fertilizers have increased various endogenous hormonal level in the plant tissues which was present in worm castings (vermicompost) which might be responsible for enhanced tube growth, which ultimately little difference in the length of flower. The above results are in conformity with the findings of Perween and Hasan [6] in Dragon fruit and Yadav et al. [7] in Mango.

3.5 Breadth of the Flower

3.5.1 Red fleshed type

The pooled data (Table. 3) of two years of study also showed non-significant among treatments with respect to breadth of flower, however it was observed maximum of 15.16 cm in the treatment

T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) and the minimum breadth of flower (15.09 cm) was recorded in treatment T₁ (Control).

3.5.2 White fleshed type

The pooled analysis (Table. 3) of data also showed non-significant with respect to breadth of the flower, and it was observed higher (15.09 cm) in treatment T₅ (100% N through poultry manure + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) and the minimum (15.04 cm) was observed in T₁ treatment (Control).

This may be due to the genetical character of dragon fruit plant for flower breadth. However, increase in photosynthate production and phosphorous content in farm yard manure and longer availability of nutrients during the reproductive period from vermicompost might have enhanced the cell elongation. This little increase in the breadth of flower may be due to direct role in plant nutrition as the poultry manure having high nitrogen that improves the reproductive growth and makes the nutrient available for the flower growth. The findings are in close conformity with Perween and Hasan [6] in Dragon fruit, Marathe et al. [8] in Pomegranate.

3.6 Number of Fruits Per Plant

3.6.1 Red fleshed type

From the pooled analysis of two successive years (Table. 4), it was observed that number of fruits per plant varied between 11.00 and 37.50 respectively. Among the different treatments, plants which were imposed with the treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) showed maximum number of fruits per plant (37.50) while the least number of fruits (11.00) noticed in treatment T₁ (Control).

3.6.2 White fleshed type

The pooled analysis of data (Table. 4) showed maximum number of fruits (33.42) per plant in the treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹ + VAM at 10 kg ha⁻¹) followed by treatment T₁₂ (24.00), while the minimum number of fruits (7.50) was noticed in treatment T₁ (Control).

The increase in the number of fruits per plant was due to the fact that the vermicompost

increased microbial activity in the soil which led to high soil fertility and these characters had beneficial effect on production of more number of fruits and also due to better metabolic activities in the plant which ultimately led to high protein and carbohydrate synthesis. These observations are in line with the report of Hoe [9] in Dragon fruit, Binopal et al. [10] in Guava, Singh et al. [11] in Strawberry.

3.7 Number of Fruits Per Pillar

3.7.1 Red fleshed type

The perusal of data depicted in Table. 4 with respect to number of fruits per pillar in red fleshed type dragon fruit differed significantly among the treatments with organic manures along with bio-fertilizers during both the years (2019-20 and 2020-21) as well as from pooled analysis.

“From the pooled data of two years of study, it was observed that highest number of fruits per pillar(150.00) was found in treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) while the least fruits per pillar (44.00) was noticed in treatment T₁ (Control)” [22].

3.7.2 White fleshed type

The pooled analysis of data (Table. 4) showed maximum number of fruits per pillar (133.50) in treatment T₁₃ (100% N through vermicompost + VAM at 10 kg ha⁻¹) while the minimum value (30.00) was noticed in treatment T₁ (Control).

The increase in the number of fruits per pillar may be due to the fact that the applied vermicompost increased microbial activity in the soil which led to better soil fertility and had beneficial effect on production of more number of fruits. It might be also due to better metabolic activities in the plant which might have ultimately increased protein and carbohydrate levels. These observations are in conformity with the findings of Hoe [9] in Dragon fruit, Binopal et al. [10] in Guava, Yadav et al. [7] in Mango, Ghosh et al. [12] in Orange, Singh et al. [11] in Strawberry.

3.8 Fruit Yield Per Plant

3.8.1 Red fleshed type

The pooled (Table. 5) results also showed significant variation with respect to fruit yield per plant, and the highest value(18.69 kg plant⁻¹) was

noticed in treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) while the least fruit yield (2.96 kg plant⁻¹) was observed in treatment T₁ (Control).

3.8.2 White fleshed type

The pooled analysis (Table. 5) of data showed maximum fruit yield (14.46 kg plant⁻¹) in treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹ + VAM at 10 kg ha⁻¹) followed by treatment T₁₂ (10.11 kg plant⁻¹). The minimum yield of the fruit (2.28 kg plant⁻¹) was noticed in T₁ (Control).

This is due to increase in various endogenous hormonal levels in the plant tissues due to applied vermicompost along with bio-fertilizers which might be responsible for enhanced pollen germination and pollen tube growth, ultimately increased the fruit set as well as number of fruit per plant, which might have directly influenced the fruit yield. These results are in line with the observation made by Hoe [9] in Dragon fruit, Ibe et al. [13] in Citrus and Iqbal et al. [14] in Strawberry.

3.9 Fruit Yield Per Pillar

3.9.1 Red fleshed type

The pooled results of two years of study (Table. 5) also showed significant variation with respect to fruit yield. The highest value (74.73 kg pillar⁻¹) was noticed in treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) followed by treatment T₁₂ (68.03 kg pillar⁻¹) while the least (11.81 kg pillar⁻¹) was observed in treatment T₁ (Control).

3.9.2 White fleshed type

“The pooled data (Table. 5) of both the years (2019-20 and 2020-21) showed maximum fruit yield (57.80 kg pillar⁻¹) in treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹ + VAM at 10 kg ha⁻¹) and the lowest fruit yield (9.13 kg pillar⁻¹) was noticed in treatment T₁ (Control)” [15].

This is due to increase in various endogenous hormonal levels in the plant tissues due to applied vermicompost along with bio-fertilizers which might be responsible for enhanced pollen germination and pollen tube growth, ultimately increased the fruit set as well as number of fruit per plant, which might have directly influenced the fruit yield. These results are in line with the

observation made by Hoe [9] in Dragon fruit, Ibe et al. [13] in Citrus and Iqbal et al. [14] in Strawberry.

3.10 Estimated Fruit Yield Per Acre

3.10.1 Red fleshed type

The data presented with respect to estimated fruit yield per acre of red fleshed type dragon fruit differed significantly among the organic manures and bio-fertilizers during both the years (2019-20 and 2020-21) as well as pooled analysis is furnished in Table 6. From the pooled data of two years of study, it was observed that, estimated fruit yield per acre varied between 5.90 t and 37.36 t. Among the different treatments imposed, plants which were treated with 100 per cent N through vermicompost + PSB at 10 kg ha⁻¹ + VAM at 10 kg ha⁻¹ (T₁₃) recorded maximum yield (37.36 t acre⁻¹) followed by treatment T₁₂ (34.01 t acre⁻¹), while least fruit yield (5.90 t acre⁻¹) was noticed in treatment T₁ (Control).

3.10.2 White fleshed type

The pooled data (Table. 6) of both the years (2019-20 and 2020-21) showed maximum estimated fruit yield (28.90 t acre⁻¹) in the treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹ + VAM at 10 kg ha⁻¹) followed by treatment T₁₂ (20.81 t acre⁻¹), while the minimum estimated fruit yield (4.57 t acre⁻¹) was noticed in treatment T₁ (Control).

Higher yield response owing to application of organic manures along with bio-fertilizers ascribed to improved physical, chemical and biological properties of soil resulted in better supply of plant nutrients which was mobilised and solubilised, in turn led to good crop growth and yield. Similar results were reported by Hoe [9] in Dragon fruit. Shivakumar [16] in Papaya and Barne et al. [17] in Guava.

3.11 Estimated Fruit Yield Per Hectare

3.11.1 Red fleshed type

From the analysis of pooled data (Table. 6) of two successive years indicated that estimated fruit yield per hectare varied between 14.77 t ha⁻¹ and 93.42 t ha⁻¹. Among the different treatments imposed, plants which were provided with 100 per cent N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹ (T₁₃) provided maximum yield (93.42 t ha⁻¹) while the lowest fruit yield (14.77 t ha⁻¹) was noticed in treatment T₁ (Control) [18,19].

Table 1. Days to first flower open and duration of flowering in red and white fleshed dragon fruit during the years 2019-20 and 2020-21 as influenced by bio-fertilizers and organic manures

Treatments	Days to first flower open (days)						Duration of flowering (hrs)					
	Red fleshed			White fleshed			Red fleshed			White fleshed		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T ₁	494.77 ^a	492.67 ^a	493.72 ^a	509.67 ^a	507.67 ^a	508.67 ^a	9.00	9.03 ^e	9.02	8.67	9.04 ^d	8.85
T ₂	466.96 ^b	479.67 ^{ab}	473.31 ^b	496.67 ^b	499.33 ^b	498.00 ^b	9.33	9.06 ^e	9.20	9.00	9.05 ^{cd}	9.03
T ₃	464.32 ^{bc}	477.00 ^{bc}	470.66 ^b	494.33 ^b	498.33 ^b	496.33 ^{bc}	9.33	9.07 ^e	9.20	9.00	9.06 ^{cd}	9.03
T ₄	463.00 ^c	475.33 ^{bc}	469.17 ^{bc}	492.33 ^{bc}	495.00 ^b	493.67 ^{cd}	8.67	9.15 ^{cde}	8.91	8.33	9.11 ^{cd}	8.72
T ₅	458.62 ^d	464.33 ^{bcd}	461.48 ^{cd}	488.00 ^c	496.33 ^b	492.17 ^d	8.67	9.22 ^{bcd}	8.94	8.33	9.11 ^{cd}	8.72
T ₆	455.63 ^{de}	462.67 ^{cd}	459.15 ^d	482.33 ^d	487.67 ^c	485.00 ^e	9.33	9.22 ^{bcd}	9.28	9.00	9.14 ^{bcd}	9.07
T ₇	451.83 ^{ef}	457.67 ^{de}	454.75 ^{de}	480.07 ^d	480.33 ^d	480.20 ^f	8.67	9.15 ^{de}	8.91	8.67	9.10 ^{cd}	8.89
T ₈	448.13 ^g	452.00 ^{def}	450.07 ^{ef}	480.67 ^d	475.00 ^e	477.83 ^{fg}	9.67	9.24 ^{bcd}	9.45	9.33	9.18 ^{bc}	9.26
T ₉	445.43 ^{gh}	447.00 ^{ef}	446.22 ^{fg}	478.67 ^{de}	472.67 ^e	475.67 ^g	9.33	9.15 ^{cde}	9.24	9.00	9.11 ^{cd}	9.05
T ₁₀	441.98 ^h	441.33 ^f	441.66 ^{gh}	474.67 ^e	466.33 ^f	470.50 ^h	9.00	9.29 ^{bc}	9.15	9.33	9.26 ^{ab}	9.30
T ₁₁	435.48 ⁱ	438.33 ^{fg}	436.91 ^h	469.07 ^f	452.67 ^g	460.87 ⁱ	9.33	9.30 ^b	9.32	9.00	9.06 ^{cd}	9.03
T ₁₂	429.07 ^j	423.00 ^{gh}	426.04 ⁱ	454.77 ^g	445.67 ^h	450.22 ^j	9.33	9.46 ^a	9.40	9.00	9.04 ^d	9.02
T ₁₃	421.14 ^k	416.33 ^h	418.74 ⁱ	445.53 ^h	438.00 ⁱ	441.77 ^k	9.67	9.56 ^a	9.61	9.33	9.31 ^a	9.32
Mean	452.03	455.95	453.99	480.52	478.08	479.30	9.18	9.22	9.20	8.92	9.12	9.02
S.Em±	1.33	5.25	2.78	1.78	1.64	1.20	0.38	0.05	0.19	0.45	0.04	0.22
C.D. @ 5%	3.88	15.33	7.90	5.21	4.80	3.40	NS	0.14	NS	NS	0.13	NS
C.V. (%)	0.51	2.00	1.50	0.64	0.60	0.61	7.21	0.93	3.61	8.81	0.83	4.20

NS: Non-significant

NOTE: Mean values in a column having dissimilar letter/s indicate significant differences and similar letters indicate statistically non-significant at 0.05 levels of significance

Table 2. Number of flowers per plant in red and white fleshed dragon fruit during the years 2019-20 and 2020-21 as influenced by bio-fertilizers and organic manures

Treatments	Number of flowers/plant					
	Red fleshed			White fleshed		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T ₁	5.33 ^d	8.47 ^g	6.90 ^h	4.00	7.22 ^g	5.61 ^g
T ₂	6.33 ^{cd}	9.59 ^{fg}	7.96 ^{fgh}	5.00	9.00 ^f	7.00 ^{ef}
T ₃	5.67 ^d	9.61 ^{fg}	7.64 ^{gh}	4.33	9.20 ^{ef}	6.77 ^f
T ₄	6.67 ^{bcd}	9.77 ^{efg}	8.22 ^{efg}	5.67	9.22 ^{ef}	7.45 ^{def}
T ₅	7.67 ^{abc}	9.97 ^{efg}	8.82 ^{def}	5.33	9.74 ^{ef}	7.54 ^{def}
T ₆	8.00 ^{ab}	10.23 ^{ef}	9.12 ^{de}	5.67	10.19 ^{de}	7.93 ^{cde}
T ₇	7.33 ^{abc}	10.30 ^{ef}	8.82 ^{def}	6.00	10.26 ^{de}	8.13 ^{cde}
T ₈	8.00 ^{ab}	10.47 ^{ef}	9.24 ^{de}	6.67	10.30 ^{de}	8.49 ^{bcd}
T ₉	8.33 ^a	11.33 ^{de}	9.83 ^{cd}	5.67	11.33 ^{cd}	8.50 ^{bcd}
T ₁₀	8.00 ^{ab}	12.67 ^{cd}	10.33 ^c	5.00	12.67 ^{ab}	8.83 ^{abc}
T ₁₁	8.00 ^{ab}	13.67 ^{bc}	10.83 ^{bc}	6.00	13.00 ^{ab}	9.50 ^{ab}
T ₁₂	8.33 ^a	14.82 ^{ab}	11.58 ^{ab}	6.00	13.67 ^a	9.83 ^a
T ₁₃	8.67 ^a	15.67 ^a	12.17 ^a	6.33	12.33 ^{bc}	9.33 ^{ab}
Mean	7.41	11.27	9.34	5.51	10.63	8.07
S.E.m \pm	0.53	0.55	0.38	0.68	0.41	0.35
C. D @ 5%	1.54	1.61	1.08	NS	1.19	1.02
C.V. (%)	12.30	8.45	10.00	14.42	6.64	7.53

NS: Non-significant

NOTE: Mean values in a column having dissimilar letter/s indicate significant differences and similar letters indicate statistically non-significant at 0.05 levels of significance

Table 3. Length and breadth of the flower in red and white fleshed dragon fruit during the years 2019-20 and 2020-21 as influenced by bio-fertilizers and organic manures

Treatments	Length of the flower (cm)						Breadth of the flower (cm)					
	Red fleshed			White fleshed			Red fleshed			White fleshed		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T ₁	27.00	26.02	26.51	25.00	25.10	25.05	15.127	15.060	15.093	15.047	15.033	15.040
T ₂	27.34	26.22	26.78	25.00	25.10	25.05	15.143	15.120	15.132	15.067	15.077	15.072
T ₃	27.30	26.14	26.72	25.22	25.42	25.32	15.143	15.103	15.123	15.067	15.063	15.065
T ₄	27.18	26.10	26.64	25.22	25.53	25.37	15.160	15.110	15.135	15.083	15.067	15.075
T ₅	27.22	26.14	26.68	25.44	25.44	25.44	15.117	15.133	15.125	15.113	15.067	15.090
T ₆	27.81	26.20	27.01	25.22	25.45	25.34	15.093	15.120	15.107	15.050	15.080	15.065
T ₇	27.44	26.16	26.80	25.19	25.45	25.32	15.137	15.097	15.117	15.057	15.060	15.058
T ₈	27.84	26.03	26.94	25.21	25.44	25.33	15.147	15.160	15.153	15.053	15.063	15.058
T ₉	27.26	26.18	26.72	25.22	25.48	25.35	15.143	15.157	15.150	15.077	15.050	15.063
T ₁₀	27.77	26.18	26.98	25.21	25.42	25.32	15.147	15.120	15.133	15.057	15.057	15.057
T ₁₁	27.65	26.49	27.07	25.44	25.44	25.44	15.137	15.127	15.132	15.077	15.057	15.067
T ₁₂	27.62	26.29	26.96	25.22	25.44	25.33	15.143	15.143	15.143	15.073	15.070	15.072
T ₁₃	27.95	26.52	27.24	25.67	25.59	25.63	15.157	15.160	15.158	15.060	15.057	15.058
Mean	27.49	26.21	26.85	25.25	25.41	25.33	15.138	15.124	15.131	15.068	15.062	15.065
S.Em±	0.21	0.30	0.19	0.17	0.16	0.12	0.019	0.024	0.015	0.167	0.014	0.083
C. D @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	1.31	1.96	1.71	1.17	1.06	1.18	0.220	0.275	0.241	1.922	0.166	1.348

NS: Non-significant

NOTE: Mean values in a column having dissimilar letter/s indicate significant differences and similar letters indicate statistically non-significant at 0.05 levels of significance

Table 4. Fruit yield on count basis in red and white fleshed dragon fruit during the years 2019-20 and 2020-21 as influenced by bio-fertilizers and organic manures

Treatments	Number of fruits per plant						Number of fruits per pillar					
	Red fleshed			White fleshed			Red fleshed			White fleshed		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T ₁	7.00 ^h	15.00 ^h	11.00 ^j	5.00 ^f	10.00 ⁱ	7.50 ^k	28.00 ^h	60.00 ^j	44.00 ^k	20.00 ^f	40.00 ^k	30.00 ^l
T ₂	9.00 ^g	23.00 ^g	16.00 ⁱ	10.00 ^e	12.00 ^h	11.00 ^j	36.00 ^g	92.00 ⁱ	64.00 ^j	40.00 ^e	48.00 ^j	44.00 ^k
T ₃	12.00 ^f	25.00 ^g	18.50 ^h	10.00 ^e	14.00 ^g	12.00 ⁱ	48.00 ^f	100.00 ^h	74.00 ⁱ	40.00 ^e	56.00 ^j	48.00 ^j
T ₄	12.00 ^f	25.00 ^g	18.50 ^h	12.00 ^d	15.00 ^g	13.50 ^h	48.00 ^f	100.00 ^h	74.00 ⁱ	48.00 ^d	60.00 ^h	54.00 ⁱ
T ₅	12.00 ^f	25.00 ^g	18.50 ^h	12.00 ^d	15.00 ^g	13.50 ^h	48.00 ^f	100.00 ^h	74.00 ⁱ	48.00 ^d	60.00 ^h	54.00 ⁱ
T ₆₀	14.00 ^e	28.00 ^f	21.00 ^h	12.00 ^d	18.00 ^f	15.00 ^g	56.00 ^e	112.00 ^g	84.00 ^h	48.00 ^d	72.00 ^g	60.00 ^h
T ₇	14.00 ^e	30.00 ^{ef}	22.00 ^g	14.00 ^c	18.00 ^f	16.00 ^f	56.00 ^e	120.00 ^f	88.00 ^g	56.00 ^c	72.00 ^g	64.00 ^g
T ₈	14.00 ^e	32.00 ^e	23.00 ^f	14.00 ^c	19.00 ^{ef}	16.50 ^{ef}	56.00 ^e	128.00 ^e	92.00 ^f	56.00 ^c	76.00 ^f	66.00 ^f
T ₉	16.00 ^d	37.00 ^d	26.50 ^e	14.00 ^c	20.00 ^e	17.00 ^e	64.00 ^d	148.00 ^d	106.00 ^d	56.00 ^c	80.00 ^e	68.00 ^e
T ₁₀	16.00 ^d	43.00 ^c	29.50 ^d	14.00 ^c	26.00 ^d	20.00 ^d	64.00 ^d	172.00 ^c	118.00 ^c	56.00 ^c	104.00 ^d	80.00 ^d
T ₁₁	21.00 ^c	45.00 ^{bc}	33.00 ^c	16.00 ^b	30.00 ^c	23.00 ^c	84.00 ^c	120.00 ^f	102.00 ^e	64.00 ^b	120.00 ^c	92.00 ^c
T ₁₂	22.00 ^b	47.00 ^b	34.50 ^b	16.00 ^b	32.00 ^b	24.00 ^b	88.00 ^b	180.00 ^b	134.00 ^b	64.00 ^b	128.00 ^b	96.00 ^b
T ₁₃	25.00 ^a	50.00 ^a	37.50 ^a	20.83 ^a	46.00 ^a	33.42 ^a	100.00 ^a	200.00 ^a	150.00 ^a	83.00 ^a	184.00 ^a	133.50 ^a
Mean	14.92	32.69	23.81	13.06	21.15	17.11	59.69	125.54	92.62	52.23	84.62	68.42
S.Em±	0.16	0.75	0.39	0.02	0.56	0.28	0.16	2.56	1.28	0.16	0.54	0.28
C.D. @ 5%	0.47	2.19	1.11	0.07	1.64	0.79	0.47	7.48	3.64	0.47	1.57	0.80
C.V. (%)	1.86	3.97	4.03	0.31	4.59	3.99	0.46	3.54	3.39	0.53	1.10	1.01

NS: Non-significant

NOTE: Mean values in a column having dissimilar letter/s indicate significant differences and similar letters indicate statistically non-significant at 0.05 levels of significance

Table 5. Fruit yield on weight basis in red and white fleshed dragon fruit during the years 2019-20 and 2020-21 as influenced by bio-fertilizers and organic manures

Treatments	Fruit yield (Kg/plant)						Fruit yield (Kg/pillar)					
	Red fleshed			White fleshed			Red fleshed			White fleshed		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T ₁	1.63 ⁱ	4.28 ^l	2.96 ^m	1.24 ^g	3.32 ^k	2.28 ^l	6.52 ^l	17.10 ^l	11.81 ^l	4.96 ^k	13.30 ^k	9.13 ^m
T ₂	3.13 ^h	8.32 ^k	5.73 ^l	2.99 ^f	4.28 ^l	3.63 ^k	12.53 ^k	33.29 ^k	22.91 ^k	11.96 ⁱ	17.13 ^j	14.54 ^l
T ₃	4.46 ^g	9.31 ⁱ	6.88 ^k	3.14 ^f	5.05 ⁱ	4.10 ^j	17.84 ^j	37.25 ^j	27.55 ^j	12.56 ^j	20.18 ⁱ	16.37 ^k
T ₄	4.70 ^g	9.94 ^j	7.32 ^j	3.86 ^e	5.47 ^h	4.67 ⁱ	18.80 ⁱ	39.74 ^j	29.27 ^j	15.44 ⁱ	21.89 ^{hi}	18.66 ^j
T ₅	4.89 ^g	10.94 ⁱ	7.92 ⁱ	4.02 ^e	5.67 ^h	4.85 ⁱ	19.57 ^h	43.76 ^j	31.66 ⁱ	16.07 ^h	22.68 ^h	19.38 ⁱ
T ₆₀	5.69 ^f	12.52 ^h	9.10 ^h	4.20 ^e	6.90 ^g	5.55 ^h	22.77 ^g	50.07 ^h	36.42 ^h	16.81 ^g	27.62 ^g	22.22 ^h
T ₇	6.33 ^e	13.77 ^g	10.05 ^g	4.96 ^d	7.07 ^g	6.01 ^g	25.30 ^f	55.08 ^g	40.19 ^g	19.85 ^f	28.28 ^{fg}	24.07 ^g
T ₈	6.50 ^e	14.93 ^f	10.71 ^f	5.21 ^{cd}	7.56 ^f	6.39 ^f	26.01 ^e	59.71 ^f	42.86 ^f	20.84 ^e	30.26 ^f	25.55 ^f
T ₉	7.47 ^d	17.59 ^e	12.53 ^e	5.32 ^{cd}	8.12 ^e	6.72 ^e	29.89 ^d	70.35 ^e	50.12 ^e	21.27 ^e	32.47 ^e	26.87 ^e
T ₁₀	7.55 ^d	20.89 ^d	14.22 ^d	5.49 ^c	10.65 ^d	8.07 ^d	30.22 ^d	83.55 ^d	56.88 ^d	21.94 ^d	42.59 ^d	32.27 ^d
T ₁₁	10.08 ^c	22.10 ^c	16.09 ^c	6.40 ^b	12.43 ^c	9.41 ^c	40.34 ^c	88.42 ^c	64.38 ^c	25.58 ^c	49.73 ^c	37.65 ^c
T ₁₂	10.72 ^b	23.30 ^b	17.01 ^b	6.58 ^b	13.63 ^b	10.11 ^b	42.88 ^b	93.18 ^b	68.03 ^b	26.33 ^b	54.52 ^b	40.43 ^b
T ₁₃	12.43 ^a	24.94 ^a	18.69 ^a	8.88 ^a	20.03 ^a	14.46 ^a	49.71 ^a	99.75 ^a	74.73 ^a	35.50 ^a	80.10 ^a	57.80 ^a
Mean	6.58	14.83	10.71	4.79	8.48	6.63	26.34	59.33	42.83	19.16	33.90	26.53
S.Em±	0.16	0.22	0.13	0.13	0.08	0.07	0.16	1.31	0.65	0.21	0.71	0.34
C.D. @ 5%	0.46	0.65	0.37	0.37	0.24	0.20	0.46	3.82	1.84	0.61	2.07	1.00
C.V. (%)	4.13	2.59	2.08	4.56	1.66	1.80	1.04	3.82	3.70	1.88	3.62	2.24

NS: Non-significant

NOTE: Mean values in a column having dissimilar letter/s indicate significant differences and similar letters indicate statistically non-significant at 0.05 levels of significance

Table 6. Total fruit yield per acre and per hectare in red and white fleshed dragon fruit during the years 2019-20 and 2020-21 as influenced by bio-fertilizers and organic manures

Treatments	Estimated fruit yield (t acre ⁻¹)						Estimated fruit yield (t ha ⁻¹)					
	Red fleshed			White fleshed			Red fleshed			White fleshed		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T ₁	3.25 ^m	8.55 ^l	5.90 ^m	2.48 ⁱ	6.65 ^k	4.57 ^l	8.15 ^h	21.38 ^j	14.77 ^j	6.20 ⁱ	16.62 ^k	11.41 ^l
T ₂	6.26 ^l	16.64 ^k	11.45 ^l	5.98 ^h	8.56 ^j	7.27 ^k	15.64 ^g	41.61 ⁱ	28.63 ⁱ	14.96 ^h	21.41 ⁱ	18.18 ^k
T ₃	8.92 ^k	18.63 ^j	13.78 ^k	6.28 ^h	10.09 ⁱ	8.18 ^j	22.30 ^f	46.57 ^{hi}	34.44 ^h	15.70 ^h	25.23 ⁱ	20.47 ^j
T ₄	9.40 ^j	19.87 ^j	14.64 ^j	7.72 ^g	10.94 ^{hi}	9.33 ⁱ	23.48 ^f	49.68 ^{gh}	36.58 ^h	19.30 ^g	27.36 ^h	23.33 ⁱ
T ₅	9.78 ⁱ	21.88 ⁱ	15.83 ⁱ	8.04 ^{fg}	11.34 ^h	9.69 ⁱ	24.46 ^f	54.70 ^g	39.58 ^h	20.09 ^{fg}	28.34 ^h	24.21 ⁱ
T ₆₀	11.39 ^h	25.04 ^h	18.22 ^h	8.41 ^f	13.81 ^g	11.11 ^h	28.47 ^e	62.59 ^f	45.53 ^g	21.02 ^f	34.52 ^g	27.77 ^h
T ₇	12.65 ^g	27.54 ^g	20.09 ^g	9.92 ^e	14.14 ^g	12.03 ^g	31.63 ^{de}	68.85 ^{ef}	50.24 ^{fg}	24.81 ^e	35.34 ^g	30.08 ^g
T ₈	13.01 ^f	29.85 ^f	21.43 ^f	10.42 ^d	15.13 ^f	12.77 ^f	32.52 ^d	74.63 ^e	53.57 ^{fg}	26.05 ^d	37.82 ^f	31.94 ^f
T ₉	14.94 ^e	35.17 ^e	25.05 ^e	10.64 ^{cd}	16.24 ^e	13.44 ^e	37.36 ^c	87.93 ^d	62.64 ^e	26.59 ^{cd}	40.59 ^e	33.59 ^e
T ₁₀	15.11 ^d	41.77 ^d	28.44 ^d	10.97 ^c	21.30 ^d	16.13 ^d	37.77 ^c	104.43 ^c	71.10 ^d	27.43 ^c	53.24 ^d	40.34 ^d
T ₁₁	20.17 ^c	44.21 ^c	32.19 ^c	12.79 ^b	24.87 ^c	18.83 ^c	50.42 ^b	110.52 ^{bc}	80.47 ^c	31.98 ^b	62.17 ^c	47.08 ^c
T ₁₂	21.44 ^b	46.59 ^b	34.01 ^b	13.16 ^b	27.26 ^b	20.21 ^b	53.60 ^b	116.48 ^b	85.04 ^b	32.91 ^b	68.15 ^b	50.53 ^b
T ₁₃	24.85 ^a	49.87 ^a	37.36 ^a	17.75 ^a	40.05 ^a	28.90 ^a	62.14 ^a	124.69 ^a	93.42 ^a	44.38 ^a	100.13 ^a	72.26 ^a
Mean	13.17	26.66	21.41	9.58	16.95	13.27	32.92	74.16	53.54	23.96	42.38	33.17
S.Em±	0.02	0.43	0.22	0.13	0.30	0.17	1.31	2.26	1.31	0.35	0.61	0.35
C.D. @ 5%	0.06	1.27	0.61	0.38	0.88	0.47	3.83	6.59	3.81	1.02	1.78	0.98
C.V. (%)	0.25	2.53	2.47	2.34	3.07	3.07	6.90	5.27	4.22	2.52	2.49	2.55

NS: Non-significant

NOTE: Mean values in a column having dissimilar letter/s indicate significant differences and similar letters indicate statistically non-significant at 0.05 levels of significance

3.11.2 White fleshed type

The pooled data (Table. 6) of both the years (2019-20 and 2020-21) showed maximum estimated fruit yield (72.26 t ha⁻¹) in treatment T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹ + VAM at 10 kg ha⁻¹) while the minimum estimated fruit yield (11.41 t ha⁻¹) was noticed in treatment T₁ (Control) [20,21].

The increased fruit yield may be due to the fact that the applied vermicompost enhanced microbial activity in the soil which led to high soil fertility and this had beneficial effect on better metabolic activities in the plant which ultimately increased protein and carbohydrate synthesis in turn obtained high crop yield. The observations made are in line with the findings of Hoe [9] in Dragon fruit, Binopal et al. [10] in Guava, Yadav et al. [7] in Mango and Ghosh et al. [12] in Orange [22].

4. CONCLUSION

From the present study it is concluded that the treatment consisting of T₁₃ (100% N through vermicompost + PSB at 10 kg ha⁻¹+ VAM at 10 kg ha⁻¹) gave the best results followed by treatment T₁₂- 100% N through vermicompost + VAM @ 10 kg/ha on flowering and yield attributes. The combination effect of organic manures and bio-fertilizers can be suggested for organic cultivation of dragon fruits.

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