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Effect of different organic manures and bio-fertilizers on growth of red and white fleshed dragon fruit under Bangalore conditions

Ayesha Siddiqua, Srinivasappa KN and Arshad Khayum

Abstract
A field experiment was conducted to study the influence of organic manures and bio-fertilizers on plant growth parameters during the years 2019 to 2021 on two different types of dragon fruit in Mr. Sandeep Gowda's field located at Suradhenupura, which is 20 kms away from, UAS, GKVK, Bengaluru. The experiment was laid out in randomized complete block design (RCBD) with thirteen treatments replicated thrice. Treatments comprising *viz*. T1 – Control (No manure), 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 @ 10 Kg/ha + VAM @ 10kg/ha, T6 - 100% N through poultry manure, T7 - 100% N through poultry manure + PSB @ 10kg/ha, T8 - 100% N through poultry manure + VAM @ 10kg/ha, T9 - 100% N through poultry manure + PSB @ 10 Kg/ha + VAM @ 10kg/ha, T10 - 100% N through vermicompost, T11 - 100% N through vermicompost + PSB @ 10kg/ha, T12 - 100% N through vermicompost + VAM @ 10kg/ha, T13 - 100% N through vermicompost + PSB @ 10 Kg/ha + VAM @ 10kg/ha. The pooled data from two year study for red and white fleshed dragon fruit 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 higher effect on the parameters maximum plant height (409.85 and 396.73 cm), number of branches per plant (9.43 and 9.32), plant spread in North-South (180.96 and 175 cm) and East-West directions (168.33 and 170.16 cm), circumference of the main stem (19.76 and 19.55 cm), diameter of the stem (15.12 and 14.98 cm), number of new sprouts (7.03 and 6.80) and height of the new shoot (70.14 and 22.49 cm).

Keywords: FYM, VAM, PSB, red fleshed type dragon fruit, white fleshed type dragon fruit

Introduction
Dragon fruit (*Hylocereus* spp.) is considered as most neoteric and newly recognized fruit crop introduced to India. It is a perennial climbing cactus belongs to family Cactaceae and sub-family Cactoideae. It is commonly known as Pitaya 'The Scaly Fruit', Strawberry Pear, Honourable Queen, Jesus in the Cradle, Queen of Night, Belle of Night and Night Blooming Cereus which only flowers at night and blooms with high fragrance that typically last for one night (Martin *et al.*, 1987) [11]. Dragon fruit has originated from tropical and sub-tropical forest regions of Mexico and Central South America (Mizrahi and Nerd, 1996) and is being cultivated in 22 tropical countries such as Australia, Cambodia, China, Columbia, Ecuador, Guatemala, Hawaii, Indonesia, Israel, Japan, Laos, Malaysia, Mexico, New Zealand, Nicaragua, Peru, The Philippines, Spain, Sri Lanka, Taiwan, Thailand, South-Western USA and Vietnam (Barbeu, 1990; Wu and Chen, 1997) [2, 20]. Dragon fruit has received worldwide recognition as a fruit crop and as well as an ornamental plant. It is a fast-growing perennial climber which requires vertical support to grow. The stem is a succulent vine with many-branched segments on it. Each segment bears three to five wavy wings with one to three spines or no spines at all. The aerial roots of dragon fruit stem cling to the support, allowing the plant to ascend and stay upright. The edible portion of the fruit is white and red, studded with numerous edible tiny black soft seeds. The fruit is round to oblong in shape, with red, or yellow coloured skin with green scales. There are three species of dragon fruit *viz*., *Hylocereus undatus* (Haworth) Britton and Rose having red-coloured rind with white flesh; *Hylocereus polyrhizus* (F.A.C. Weber) Britton and Rose has red-coloured rind with red flesh and *Selinecereus megalanthus* having yellow-coloured rind with white flesh (Lalit *et al*.,2018) [9].
Dragon fruit can be grown organically without applying inorganic fertilizers or pesticide. It has market potential as a healthy organic fruit. Organic manures like, cattle or poultry manure or well-decomposed compost are being used for improving growth and quality of fruits by

producing phytohormones, enhancing the uptake of plant nutrients thus help in sustainable crop production through maintenance of soil fertility and productivity (Singh *et al*., 2011) [18]. The current trend in many countries is to use organic manures without any chemical fertilizers due to high international demand for organically produced fruits. Most of the European countries prefer organically grown dragon fruit which creates a platform for India to export dragon fruits to various countries and generate income. Important considerations under organic farming are nutrient management and total elimination of chemical fertilizers which harmfully affect the soil health is necessary for the use of organic nutrients.

The availability of scientific information on use of organics for dragon fruit cultivation is very scanty as it is a newly introduced crop across the world. To address this constraint, an investigation was carried out on "Effect of organic manures and bio-fertilizers on plant growth of dragon fruit (*Hylocereus undatus* and *Hylocereus polyrhizus*)"

Material and Methods

A field experiment was conducted during 2019-2021 on the effect of different organic manures and bio-fertilizers on growth of red and white fleshed dragon fruit under Bangalore conditions. The experiment was conducted in the farmer's field at Suradhenupura, Doddaballapur taluk, located 20 kms away from UAS, GKVK, Bengaluru. The experiment was planned by adopting randomized complete block design (RCBD) consisting of 13 treatments with 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 @ 10 Kg/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 @ 10 Kg/ha, T9 - 100% N through poultry manure + PSB @ 10 Kg/ha
+ VAM @ 10 Kg/ha, T10 - 100% N through vermicompost, T11 - 100% N through vermicompost + PSB @ 10 Kg/ha, T12 - 100% N through vermicompost + VAM @ 10 Kg/ha, T13 - 100% N through vermicompost + PSB @ 10 Kg/ha + VAM @ 10 Kg/ha. The observations were recorded on the parameters like plant height, number of branches per plant, plant spread (North-South and East – West) directions, circumference of the main stem, stem diameter, number of new sprouts, length of new shoot. Two year data was pooled and analysed using SAS software for testing DMRT.

Results and Discussion

Plant height

Red fleshed type

The data pertaining to plant height as influenced by different organic manures and bio-fertilizers in red fleshed type during the years 2019-20 and 2020-21 as well as pooled analysis is presented in (Table 1). During the year 2019-2020, significantly maximum plant height (395.67 cm) was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1). Least plant height (280.27 cm) was recorded in treatment T1 (Control).Similarly in the year 2020-21, significantly highest plant height (424.03 cm) was noticed in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least plant height of 325.78 cm was observed in treatment T1 (Control). The pooled data of two years (2019-2020 and 2020-2021) showed significantly higher plant height of 409.85 cm in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and minimum plant height of 303.02 cm was recorded in treatment T1 (Control).

White fleshed type

The data pertaining to plant height as influenced by different organic manures and bio-fertilizers in white fleshed type of dragon fruit during the years 2019-20 and 2020-21 as well as pooled data is presented in (Table 1). In the year 2019-20, significantly highest plant height (385.83 cm) was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least plant height (248.53 cm) was observed in treatment T1 (Control). Similarly, the result with respect to plant height during the year 2020-21 was also found to be significant. Maximum plant height (407.63 cm) was noticed in the treatment T13 (100% N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) while the minimum plant height (320.00 cm) was recorded in treatment T1 (Control). The analysed pooled data of two years of study (2019-2020 and 2020-21) revealed that the maximum plant height (396.73 cm) was recorded in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and it was least (284.27 cm) in the treatment T1 (Control).

This may be due to the fact that the availability of vermicompost around the plants throughout the period of growth, which is a source of humus, N- fixers and nutrients, might have resulted in recording the higher values of plant height. These results are in agreement with the findings of Kumar *et al.* (2019) [8] in Dragon fruit, Ghosh *et al*. (2014) [4] in Orange, Webster (2005) [19] in Grape, Binepal *et al*. (2013) [3] in Guava.

Number of branches per plant

Red fleshed type

The perusal data presented in Table 1 indicates that, different organic manures and bio-fertilizers in red fleshed type had significant influence on number of branches per plant during both the years (2019-20 and 2020-21) as well as pooled data. During the year 2019-20, the maximum number of branches per plant (7.83) was recorded in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and it was least (3.17) in treatment T1 (Control). Similarly in the year 2020-21, the maximum number of branches per plant (11.03) was recorded in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and least number of branches (9.57) was found in treatment T1 (Control). It was evident from analysed pooled data that treatments showed significant differences with respect to number of branches per plant. The maximum value (9.43) was observed in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least value (6.37) was recorded in T1 (Control).

Table 1: Plant height and number of branches per plant in red and white fleshed dragon fruit during the years 2019-20 and 2020-21

Treatments	Plant height (cm)						Number of branches/plant					
	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
T1	280.27e	325.78g	303.02h	248.53f	320.00e	284.27h	3.17g	9.57e	6.37g	2.97k	7.23g	5.10j
T2	286.80e	353.62f	320.21g	305.13e	354.21d	329.67g	4.24f	10.71d	7.48f	3.92j	8.81f	6.37i
T3	287.43e	367.47ef	327.45g	311.03de	368.24cd	339.64fg	5.14e	10.75cd	7.95e	4.12ij	8.81f	6.46hi
T4	294.47e	370.35ef	332.41fg	315.13de	369.33cd	342.23fg	5.41e	10.76cd	8.08e	4.44hi	8.82f	6.63gh
T5	314.30d	374.77de	344.53f	318.12de	370.06cd	344.09fg	6.35d	10.81bcd	8.58d	4.84gh	8.88ef	6.86fg
T6	359.57c	382.15cde	370.86e	325.17d	377.92bcd	351.55ef	6.50d	10.85abcd	8.68d	5.01g	9.06def	7.04f
T7	370.27bc	383.10cde	376.68de	345.00c	386.60abc	365.80de	6.62cd	10.86abcd	8.74cd	5.51f	9.17de	7.34e
T8	370.30bc	387.53cd	378.92cde	359.77bc	388.37abc	374.07cd	6.62cd	10.86abcd	8.74cd	5.70ef	9.22d	7.46e
T9	373.83bc	391.77bc	382.80cde	361.10bc	394.30abc	377.70bcd	6.81cd	10.90abcd	8.86cd	6.03 de	9.55c	7.79d
T10	377.27bc	392.58bc	384.92bcd	375.47ab	400.26ab	387.87abc	7.04bc	10.94abc	8.99bc	6.17d	9.81bc	7.99d
T11	383.43ab	394.78bc	389.11bc	375.83ab	403.86ab	389.85ab	7.42ab	10.98ab	9.20ab	6.68c	10.07b	8.38c
T12	388.03ab	404.80b	396.42b	382.40a	404.51ab	393.46a	7.64a	10.99ab	9.32a	7.24b	10.78a	9.01b
T13	395.67a	424.03a	409.85a	385.83a	407.63a	396.73a	7.83a	11.03a	9.43a	7.74a	10.90a	9.32a
Mean	344.74	380.98	362.86	339.12	380.41	359.76	6.22	10.77	8.49	5.41	9.32	7.37
S.Em±	6.14	5.78	3.55	5.70	9.14	5.17	0.18	0.07	0.10	0.16	0.10	0.09
C.D. @ 5%	17.91	16.87	10.37	16.65	26.67	15.10	0.54	0.22	0.29	0.45	0.29	0.28
C.V. (%)	3.08	2.63	1.70	2.91	4.16	2.49	5.13	1.20	2.01	4.98	1.84	2.22

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

T1: Control (No manure)
T2: 100 % N through farm yard manure
T3: 100 % N through farm yard manure + PSB at 10 Kg ha-1
T4: 100 % N through farm yard manure + VAM at 10 Kg ha-1
T5: 100 % N through farm yard manure + PSB at 10 Kg ha-1 + VAM at 10 Kg ha-1
T6: 100 % N through poultry manure
T7: 100 % N through poultry manure + PSB at 10 Kg ha-1
T8: 100 % N through poultry manure + VAM at 10 Kg ha-1
T9: 100 % N through poultry manure + PSB at 10 Kg ha-1 + V
T10: 100 % N through vermicompost
T11: 100 % N through vermicompost + PSB at 10 Kg ha-1
T12: 100 % N through vermicompost + VAM at 10 Kg ha-1
T13: 100 % N through vermicompost + PSB at 10 Kg ha-1+ V

White fleshed type

The data pertaining to number of branches per plant in white fleshed type as influenced by different organic manures and bio-fertilizers during the years 2019-20 and 2020-21 as well as pooled data is also presented in (Table 2). In the year 2019-20, significantly highest number of branches per plant (7.74) was recorded in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) followed by treatment T12 (7.24) and it was found least (2.97) in treatment T1 (Control). During the year 2020-21, highest number of branches per plant (10.90) was found in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the minimum number of branches (7.23) was recorded in treatment T1 (Control). The analysis of pooled data revealed that the highest number of branches per plant (9.32) was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least (5.10) was noticed in T1 (Control).

This was due to the fact that, vermicompost improves microbial distribution and moisture retention capacity of the soil that results in greater enzymatic (phosphatase and urease) activities which improved the growth and ultimately might have reflected in number of branches per plant. This is in accordance with findings of Yadav *et al*. (2011) [21] in Mango, Binepal *et al*. (2013) [3] in Guava.

Plant spread

Plant spread in North-South directions Red fleshed type

Significant variations were observed in red fleshed type among the treatments with respect to North-South plant spread in both the years (2019-2020 and 2020-21) as well as in pooled data is presented in (Table 2). During the year 2019-20, the highest spread of the plant (180.59 cm) in North-South directions was recorded with the application of 100 per cent N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1 (T13) it was least (69.00)in treatment T1 (Control). During the year 2020-21, the highest spread of the plant (181.33 cm) in North-South directions was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) followed by treatment T12 (164.00 cm) with treatment T11 while the least (96.00 cm) was observed in treatment T1 (Control). Analysed pooled data of both the years showed that the highest plant spread (180.96 cm) in North-South directions was found in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) while the lowest spread (82.50 cm) was observed in treatment T1 (Control).

White fleshed type

The perusal data presented in Table 2 indicated that, different organic manures and bio-fertilizers in white fleshed type had significant influence on plant spread in North-South directions during both the years (2019-20 and 2020-21) and also in pooled data. During the year 2019- 2020, the maximum spread of the plant in North-South directions per plant (174.15 cm) was observed in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) the least (62.74 cm) was recorded in treatment T1 (Control). Similarly, in the year 2020- 21, the maximum spread of the plant in North-South directions per plant (175.85 cm) was observed in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the minimum (101.33 cm) was found in treatment (T1) Control. It is evident from analysed pooled data that treatments indicating significant differences in spread of the plant in North-South directions. The maximum value

(175.00 cm) was observed in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) the least value(82.04 cm) was recorded in treatment T1 (Control).

It was due to the fact that the composition of vermicompost for higher nutrient availability supporting higher accumulation of photosynthates in the plant accompanied by VAM and PSB solubilizing and mobilizing the organic form of nutrients available in soil which ultimately increased the plant spread. The results obtained in this aspect are in agreement with Kumar *et al.* (2019) [8] in Dragon fruit, Sabarad *et al.* (2004) [16] in Banana, Raina *et al.* (2011) [14] in Apple and Archana (2008) [1] in Plum.

Plant spread in East-West directions Red fleshed type

It is apparent from the data presented in Table 2 that during the year 2019-20, the highest plant spread (172.90 cm) in East-West directions was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least (75.60 cm) was observed in treatment T1 (Control). Similarly, during the year 2020-21, the highest plant spread (163.77 cm) in East-West directions was recorded in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least (70.07 cm) was observed in treatment T1 (Control). The analysis of pooled data of two years study (2019-20 and 2020-21) revealed that, the maximum spread of the plant (168.33 cm) in East-West directions was noticed in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least (72.84 cm) was observed in T1 (Control).

White fleshed type

The perusal of data presented in Table 2 indicated that different organic manures and bio-fertilizers in white fleshed type of dragon fruit had significant influence on spread of the plant in East- West directions during both the years (2019-20 and 2020-21) as well as pooled data. During the year 2019-20, the maximum spread of the plant in East- West directions (167.33 cm) was recorded in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least (70.41cm) was recorded in T1 (Control). Similarly, in the year 2020-21, the maximum spread of the plant in East- West directions (172.99 cm) was observed in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the minimum (72.67 cm) was found in (T1) Control. It was evident from the analysed pooled data that treatments showed significant differences with respect to spread of the plant in East-West directions. The maximum value (170.16 cm) was recorded in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least value (71.54 cm) was recorded in treatment T1 (Control).

Table 2: Plant spread of red and white fleshed dragon fruit in North – South and East- West directions during the years 2019-20 and 2020-

Treatments	Plant spread in North - South directions (cm)						Plant spread in East - West directions (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
T1	69.00k	96.00i	82.50j	62.74j	101.33h	82.04j	75.60m	70.07i	72.84m	70.41l	72.67l	71.54m
T2	93.82j	118.33h	106.08i	88.03i	128.15g	108.09i	93.50l	91.54h	92.52l	91.37k	89.33k	90.35l
T3	101.63ij	122.33gh	111.98h	95.18h	136.77fg	115.98h	98.11k	97.85g	97.98k	98.43j	95.33j	96.88k
T4	109.2 hi	125.00fg	117.13g	100.22h	140.67f	120.45gh	105.10j	101.00g	103.05j	104.50i	101.00i	102.75j
T5	115.77gh	130.33ef	123.05f	109.43g	140.67f	125.05g	116.57i	112.87f	114.72i	110.03h	115.33h	112.68i
T6	118.70fg	133.33e	126.02f	117.05f	143.26f	130.16f	123.37h	115.97f	119.67h	117.53g	125.27g	121.40h
T7	126.13ef	141.33d	133.73e	121.01f	145.51ef	133.26f	128.03g	125.67e	126.85g	124.73f	126.65g	125.69g
T8	128.90e	145.00d	136.95e	130.97e	153.33de	142.15e	136.87f	129.00e	132.93f	130.27e	135.49f	132.88f
T9	137.47d	152.00c	144.73d	137.95d	157.33cd	147.64d	145.40e	134.11d	139.76e	132.17e	142.67e	137.42e
T10	143.51d	155.10c	149.30d	141.18d	159.16bcd	150.17d	152.43d	140.10c	146.27d	141.43d	153.67d	147.55d
T11	153.47c	161.67b	157.57c	156.11c	164.15bc	160.13c	161.00c	144.33c	152.67c	146.83c	160.67c	153.75c
T12	166.52b	164.00b	165.26b	163.20b	168.22ab	165.71b	167.13b	155.00b	161.07b	155.13b	167.33b	161.23b
T13	180.59a	181.33a	180.96a	174.15a	175.85a	175.00a	172.90a	163.77a	168.33a	167.33a	172.99a	170.16a
Mean	126.52	140.44	133.48	122.86	147.26	135.06	128.92	121.64	125.28	122.32	127.57	124.94
S.Em±	2.82	2.20	2.17	1.74	3.10	1.97	1.28	1.56	0.87	1.55	1.87	1.34
C.D. @ 5%	8.23	6.43	6.32	5.09	9.06	5.74	3.73	4.54	2.55	4.53	5.47	3.91
C.V. (%)	3.86	2.72	2.81	2.46	3.65	2.52	1.72	2.22	1.21	2.20	2.54	1.86

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 significant

T1: Control (No manure)
T2: 100 % N through farm yard manure
T3: 100 % N through farm yard manure + PSB at 10 Kg ha-1
T4: 100 % N through farm yard manure + VAM at 10 Kg ha-1
T5: 100 % N through farm yard manure + PSB at 10 Kg ha-1 + VAM at 10 Kg ha-1
T6: 100 % N through poultry manure
T7: 100 % N through poultry manure + PSB at 10 Kg ha-1
T8: 100 % N through poultry manure + VAM at 10 Kg ha-1
T9: 100 % N through poultry manure + PSB at 10 Kg ha-1 + V
T10: 100 % N through vermicompost
T11: 100 % N through vermicompost + PSB at 10 Kg ha-1
T12: 100 % N through vermicompost + VAM at 10 Kg ha-1
T13: 100 % N through vermicompost + PSB at 10 Kg ha-1+ V

It was due to the fact that the vermicompost supported for higher nutrient availability in turn supporting higher accumulation of photosynthates in the plant enriched by VAM and PSB, solubilizing and mobilizing the organic form of nutrients from fixed form of soil which ultimately contributed to increased plant spread. The results obtained in this aspect

are in agreement with Kumar *et al.* (2019) [8] in Dragon fruit, Sabarad *et al.* (2004) [16] in Banana, Raina *et al.* (2011) [14] in Apple and Archana (2008) [1] in Plum.

Circumference of the main stem Red fleshed type

It is evident from the data presented in Table 3 that treatments varied significantly with respect to circumference of the main stem of red fleshed type in both the years (2019-20 and 2020-21) as well as in pooled analysis. During the year 2019-20, the highest circumference of the main stem (19.74 cm) was recorded in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least (17.96 cm) was observed in T1 (Control). Similarly, during the year 2020-21, the maximum value on circumference of the main stem (19.77 cm) was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and minimum value (17.96 cm) was observed in T1 (Control). The analysed pooled data of two successive years indicated that the maximum value on circumference of the main stem (19.76 cm) was noticed in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) while the minimum circumference of main stem (17.96 cm) was observed in T1 (Control).

White fleshed type

Significant variations were observed in white fleshed type of dragon fruit among the treatments with respect circumference of main stem during both the years (2019-20 and 2020-21) as well as in pooled data (Table 3). During the year 2019-20, the highest circumference of the main stem (19.55 cm) was observed with the application of 100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1 T13 wile the least
(17.93 cm) was observed in T1 (Control). Similarly, in the year 2020-21, the highest circumference of the main stem (19.56 cm) was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least (17.97 cm) was observed in treatment T1 (Control). Pooled data of both the years (2019-20 and 2020-21) showed that the highest circumference of the main stem (19.55 cm) was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) while the lowest circumference (17.95 cm) was observed in treatment T1 (Control).

This might be due to that the combined application of vermicompost along with bio-fertilizers would have enhanced the fertility status of soil and bio-fertilizers supports the solubilization and mobilization of nutrients helping in promotion of stem diameter. The results are in conformity with the studies of Kumar *et al.* (2019) [8] in Dragon fruit, Kumar and Kumar (2013) [7] in Mango, Hebbera *et al.* (2006) in Sapota.

Diameter of stem Red fleshed type

Significant differences were observed among the treatments with respect to diameter of the stem in red fleshed type during both the years (2019-20 and 2020-21) as well as pooled analysis of investigation. The perusal of data presented in Table 3 revealed that, significantly highest diameter of the stem (15.10 cm) was registered in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and the least diameter (9.40 cm) was recorded in treatment T1 (Control) during 2019-20. Similarly, in the year 2020-21, the highest diameter of the stem (15.13 cm) was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) while the least (9.44 cm) was observed in treatment T1 (Control). The analysis of pooled data revealed that the maximum diameter of the stem(15.12 cm) was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) while the minimum diameter of the stem (9.42 cm)was observed in treatment T1 (Control).

White fleshed type

During the year 2019-20 the highest diameter of stem (14.98 cm) was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) (14.98 cm) while the least diameter (9.65 cm) was recorded in treatment T1 (Control) presented in Table 3. Similarly in the year 2020-21, maximum diameter of the stem (14.99 cm) was noticed in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and least (9.66 cm) was recorded in treatment T1 (Control). The analysed pooled data for two years (2019-20 and 2020-21) showed the maximum diameter of the stem (14.98 cm) in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1). While, the least (9.66 cm) was recorded in T1 (Control).

This increase in the stem diameter may be due to the fact that, the application of vermicompost increased microbial activity in the soil which may have led to high soil fertility and combined application of bio-fertilizers like VAM and PSB had beneficial metabolic activities in the plant. This in turn led to high protein and carbohydrate synthesis and elongation of cells inside the plant

Table 3: Circumference of the main stem and diameter of the stem red and white fleshed dragon fruit during the years 2019-20 and 2020-21

Treatments	Circumference of the main stem (cm)						Diameter of stem (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
T1	17.96h	17.96l	17.96l	17.93e	17.97h	17.95i	9.40i	9.44h	9.42j	9.65i	9.66l	9.66k
T2	18.79g	18.81k	18.80k	18.24d	18.24g	18.24h	10.04h	10.06gh	10.05i	9.81i	9.85k	9.83jk
T3	18.86g	18.89j	18.88j	18.39d	18.39f	18.39gh	10.23gh	10.25fgh	10.24hi	9.97hi	9.94k	9.96j
T4	18.98f	18.98i	18.98i	18.54d	18.55e	18.54fg	10.65fg	10.69efg	10.67gh	10.28h	10.38j	10.33i
T5	19.05ef	19.07h	19.06h	18.55d	18.63e	18.59f	11.06ef	11.06defg	11.06fg	10.84g	10.90i	10.87h
T6	19.12e	19.13g	19.13g	18.98c	18.95d	18.96e	11.14ef	11.19def	11.16fg	11.02g	11.08h	11.05h
T7	19.28d	19.28f	19.28f	19.06c	19.03d	19.05e	11.43e	11.70cde	11.57ef	11.60f	11.62g	11.61g
T8	19.32cd	19.32ef	19.32ef	19.08c	19.08d	19.08de	12.06d	12.08bcd	12.07de	12.05e	12.06f	12.06f
T9	19.36cd	19.36e	19.36de	19.22bc	19.25c	19.24cd	12.51cd	12.54bc	12.53cd	12.25e	12.28e	12.26e
T10	19.40c	19.41d	19.41d	19.25abc	19.26c	19.26bc	12.84c	12.95b	12.90c	13.44d	13.46d	13.45d
T11	19.52b	19.55c	19.54c	19.40ab	19.41b	19.40ab	13.66b	14.62a	14.14b	14.03c	14.01c	14.02c

T12	19.67a	19.68b	19.68b	19.51ab	19.54ab	19.53a	14.88a	14.95a	14.92a	14.51b	14.54b	14.52b
T13	19.74a	19.77a	19.76a	19.55a	19.56a	19.55a	15.10a	15.13a	15.12a	14.98a	14.99a	14.98a
Mean	19.16	19.17	19.16	18.90	18.91	18.91	11.92	12.05	11.99	11.88	11.91	11.89
S.Em±	0.04	0.02	0.02	0.11	0.05	0.05	0.19	0.38	0.15	0.13	0.04	0.07
C.D. @ 5%	0.10	0.05	0.06	0.31	0.14	0.16	0.56	1.11	0.45	0.39	0.11	0.19
C.V. (%)	0.32	0.14	0.18	0.98	0.43	0.49	2.81	5.44	2.24	1.95	0.52	0.97

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

T1: Control (No manure)
T2: 100 % N through farm yard manure
T3: 100 % N through farm yard manure + PSB at 10 Kg ha-1
T4: 100 % N through farm yard manure + VAM at 10 Kg ha-1
T5: 100 % N through farm yard manure + PSB at 10 Kg ha-1 + VAM at 10 Kg ha-1
T6: 100 % N through poultry manure
T7: 100 % N through poultry manure + PSB at 10 Kg ha-1
T8: 100 % N through poultry manure + VAM at 10 Kg ha-1
T9: 100 % N through poultry manure + PSB at 10 Kg ha-1 + V
T10: 100 % N through vermicompost
T11: 100 % N through vermicompost + PSB at 10 Kg ha-1
T12: 100 % N through vermicompost + VAM at 10 Kg ha-1
T13: 100 % N through vermicompost + PSB at 10 Kg ha-1+ V

Number of new sprouts Red fleshed type

The data pertaining to number of new sprouts of red fleshed type of dragon fruit as influenced by organic manures and bio-fertilizers during the year 2019-20 and 2020-21 as well as from the pooled data is presented in Table 4. During the year 2019-20, the maximum number of new sprouts (6.52) was observed in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) while the least (3.18) was recorded in treatmentT1 (Control). Similarly, in the year 2020-21, the higher number of new sprouts (7.54) was observed in the treatment T13 (100 % N through vermicompost + PSB at 10 kgha-1+ VAM at 10 kg ha-1) while the least number of new sprouts (4.03) was recorded in treatment T1 (Control). It is evident from the two years (2019-20 and 2020-21) pooled data that all the treatments showed significant differences for number of new sprouts per plant and was found maximum (7.03) in treatment consisting of 100 per cent N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1(T13) while the least (3.60) was recorded in treatment T1 (Control).

White fleshed type

During the year 2019-20 the highest number of new sprouts (6.50) was noticed in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) (6.50) followed by treatment T12 (6.22), while the least value (3.06) was recorded in treatment T1 (Control) as indicated in (Table 4). Similarly in the year 2020-21, significantly maximum number of new sprouts (7.09) was recorded in treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) and lowest value for number of new sprouts (3.88) was observed in treatment T1 (Control). The pooled data for two years (2019-20 and 2020-21) showed the maximum number of new sprouts (6.80) in treatment consisting of 100 per cent N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1 (T13). While, the minimum value (3.47) was noticed in T1 (Control). This may be attributed to better availability of nutrients particularly nitrogen uptake by crop. As vermicompost increases the microbial activity in the soil, resulting in high soil fertility, as well as the combined application of bio-fertilizers such as VAM and PSB, had beneficial metabolic activities in the plant, resulting in high protein and carbohydrate synthesis and cell elongation in the plant system. This has resulted in higher biomass production, has reflected by production of additional sprouting and simultaneously increased number of new sprouts. The results are in agreement with the findings of Kumar *et al.* (2019) [8] in Dragon fruit, Singh *et al.* (2010) [17] in Strawberry, Kumar and Kumar (2013) [7] in Mango.

Length of new shoot Red fleshed type

It is revealed from the data presented in Table 4 that length of new shoot in red fleshed type differed significantly among treatments consisting of different organic manures and bio-fertilizers during the years 2019-20 and 2020-21as well as pooled data. During the year2019-20, the maximum length of new shoot (68.21 cm) was observed in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1) while the least length of new shoot (25.07 cm) was recorded in treatment T1 (Control). Similarly, in the year 2020-21, the maximum length of new shoot (72.07 cm) was observed in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1), while the least value (27.67) was recorded in treatment T1 (Control). From the pooled values of two years study, it was observed that length of new shoot varied from 70.14 cm to 26.37 cm. Among the different treatments, plants treated with 100 per cent N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1 (T13) recorded maximum value for length of new shoot (70.14 cm), while the minimum (26.37 cm) was recorded in the treatment T1 (Control).

White fleshed type

It is revealed from the data presented in Table 4 that the length of new shoot in white fleshed type differed significantly among the organic manures and bio-fertilizers treated plants during both the years (2019-20 and 2020-21) as well as from pooled data. During the year 2019-20, the maximum length of new shoot(65.45 cm) was recorded in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1),while the least length (22.12 cm) was recorded in treatment T1 (Control). Similarly, in the year 2020-21, the maximum length of new shoot (69.33 cm) was observed in the treatment T13 (100 % N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1)which, while the least value (22.85 cm) was noticed in treatment T1 (Control). From the pooled values of two years of study, it was observed that length of new shoot varied from 67.39 cm to 22.49 cm. Among the different treatments, plants treated with 100 per cent N through vermicompost + PSB at 10 kg ha-1+ VAM at 10 kg ha-1 (T13) recorded maximum value(67.39 cm), while the least value (22.49 cm) was recorded in treatment T1 (Control).

The increase in length of new shoot with the application of

vermicompost and bio-fertilizers may be due to the simulative activity of microflora in the rhizosphere which has led to availability of nutrients and vigorous growth of the plant. The increase in plant growth parameters might have also be due to build-up of colonies with the applied bio-fertilizer (PSB and VAM) inoculates and their growth promoting substances as reported by Kumar *et al.* (2019) [8] in Dragon fruit, Binepal *et al*. (2013) [3] in Guava, Ghosh *et al*.(2014) [4] in Orange.

Table 4: Number of new sprouts and length of new shoot of red and white fleshed dragon fruit during the years 2019-20 and 2020-21

Treatments	Number of new sprouts						Length of new shoot (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
T1	3.18k	4.03h	3.60k	3.06j	3.88i	3.47k	25.07j	27.67l	26.37l	22.12i	22.85i	22.49j
T2	4.26j	4.31gh	4.29j	4.17i	4.21hi	4.19j	30.33i	31.33k	30.83k	30.63h	30.33h	30.48i
T3	4.66i	4.63fg	4.65i	4.63h	4.40gh	4.52i	32.13hi	32.67jk	32.40k	30.75h	31.00h	30.87i
T4	4.75hi	4.73fg	4.74hi	4.71h	4.58gh	4.65hi	34.67gh	35.00ij	34.83j	33.42gh	34.33g	33.88h
T5	4.94gh	4.92f	4.93h	4.90g	4.70g	4.80h	37.66fg	37.33i	37.50i	35.66fg	36.00fg	35.83h
T6	5.07fg	5.77e	5.42g	4.99g	5.15f	5.07g	40.06f	41.67h	40.87h	37.54f	38.67ef	38.10g
T7	5.28f	5.87de	5.58fg	5.22f	5.62e	5.42f	44.60e	46.00g	45.30g	40.41e	41.00e	40.71f
T8	5.55e	6.08de	5.82ef	5.44e	6.05d	5.75e	49.00d	51.00f	50.00f	42.14e	44.33d	43.24e
T9	5.82d	6.35cd	6.09de	5.74d	6.33cd	6.03d	53.85c	55.33e	54.59e	43.15e	46.33d	44.74e
T10	6.01cd	6.62bc	6.31cd	5.96c	6.54bc	6.25cd	56.33c	58.30d	57.31d	47.40d	50.07c	48.74d
T11	6.10bc	6.77bc	6.43bc	6.03c	6.70abc	6.37bc	62.16b	64.33c	63.25c	51.81c	58.77b	55.29c
T12	6.31ab	7.02b	6.67b	6.22b	6.80ab	6.51b	66.33a	69.23b	67.78b	57.29b	60.67b	58.98b
T13	6.52a	7.54a	7.03a	6.50a	7.09a	6.80a	68.21a	72.07a	70.14a	65.45a	69.33a	67.39a
Mean	5.27	5.74	5.50	5.20	5.54	5.37	46.18	47.84	47.01	41.37	43.36	42.36
S.Em±	0.08	0.17	0.10	0.06	0.14	0.08	1.07	0.95	0.71	0.96	1.04	0.70
C. D. @ 5%	0.23	0.51	0.27	0.16	0.41	0.23	3.11	2.78	2.02	2.81	3.03	1.98
C.V. (%)	2.54	5.24	4.27	1.85	4.39	3.67	4.00	3.45	3.70	4.04	4.14	4.02

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

T1: Control (No manure)
T2: 100 % N through farm yard manure
T3: 100 % N through farm yard manure + PSB at 10 Kg ha-1
T4: 100 % N through farm yard manure + VAM at 10 Kg ha-1
T5: 100 % N through farm yard manure + PSB at 10 Kg ha-1 + VAM at 10 Kg ha-1
T6: 100 % N through poultry manure
T7: 100 % N through poultry manure + PSB at 10 Kg ha-1
T8: 100 % N through poultry manure + VAM at 10 Kg ha-1
T9: 100 % N through poultry manure + PSB at 10 Kg ha-1 + V
T10: 100 % N through vermicompost
T11: 100 % N through vermicompost + PSB at 10 Kg ha-1
T12: 100 % N through vermicompost + VAM at 10 Kg ha-1
T13: 100 % N through vermicompost + PSB at 10 Kg ha-1+ V

Conclusion

The findings of two years (2019-20 and 2020-21) of research and also pooled analysis of data showed that the application of 100 per cent N through vermicompost + PSB at 10 kg ha-1 + VAM at 10 kg ha-1 followed by 100 per cent N through vermicompost + VAM at 10 kg ha-1 influenced on the plant growth. Based on the performance of growth aspects observed in present study, it can be it can be inferred that combined application of organic manures and bio-fertilizers is beneficial for vegetative growth of dragon fruit production.

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