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Effect of Organic Manures and Bio-Fertilizers on Plant Growth and Yield of Dragon Fruit (*Hylocereus undatus* (Haworth) Britton & Rose.) and (*Hylocereus polyrhizus* (F.A.C. *Weber*) under Eastern Dry Zone of Karnataka

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ABSTRACT

A study was conducted in the farmer's field at Suradhenupura, Doddaballapur taluk, which is located 20 kms away from University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru during the year 2019-2021 to investigate the 'Effect of organic manures and bio- fertilizers on plant growth and yield of dragon fruit (*Hylocereus undatus* (Haworth) Britton & Rose.) and (*Hylocereus polyrhizus* (F.A.C. *Weber*) under Eastern Dry Zone of Karnataka'. The experiment was planned by adopting randomized complete block design (RCBD) consisting of 13 treatments with three replications. Each pillar consisted of four plants. Maximum plant height of 385.83 cm and 395.67 cm, number of branches per plant of 7.74 and 7.83, circumference of main stem of 14.98 cm and 15.10 cm, number of new sprouts of 6.50 and 6.52, plant spread from North to South of 174.15 cm and 180.59 cm, plant spread from East to West of 167.33 cm and 172.90 cm, stem diameter of 19.55 cm and 19.74 cm and height of new shoot of 65.45 cm and 68.21 cm, maximum yield of 4.5 kg plant^{-1} and 18.33 kg pillar^{-1} and 6 kg plant^{-1} and 24 kg pillar^{-1} was obtained in both white and pink fleshed dragon fruit, respectively. Among different treatments, T_{-13} comprising of 100 per cent N through vermicompost + PSB @ 10 kg ha^{-1} along with VAM @ 10 kg ha^{-1} showed superiority in growth and yield of white fleshed and pink fleshed dragon fruits.

Keywords : Dragon fruit, FYM, Vermicompost, Poultry manure, Bio-fertilizers, *Hylocereus*

DRAGON FRUIT (*Hylocereus* spp.) also known as pitaya is the newly introduced super fruit in India. It is a fast growing perennial vine cactus belongs to Cactaceae family originated from Mexico and South America. Dragon fruit has spread to Tropical and Subtropical America, Asia, Australia and Middle East. Recently, Dragon fruit is being cultivated as fruit crop in 22 tropical countries, such as Australia, Cambodia, China, Columbia, Ecuador, Guatemala, Hawaii, Indonesia, Israel, Japan, Laos, Malaysia, Mexico, New Zealand, Nicaragua, Peru, Philippines, Spain, Sri Lanka, Taiwan, Thailand, South Western USA and Vietnam (Barbeu, 1990, Wu and Chen, 1997).

The fresh fruit contains 83.00 to 88.00 per cent moisture, 0.16 to 0.23 g protein, 0.21 to 0.61g fats and 0.70 to 0.90 per cent fibre. Every 100 g of fresh fruit pulp contains 6.30 to 8.8 mg of calcium, 30.20 to 36.10 mg of phosphorous, 0.50 to 0.65 mg of iron, 8.00 to 9.00 mg of vitamin-C and the pink-fleshed fruit contain a pigment called betacyanin containing up to 150 to 200 mg per 100 g of fruit (Tripathi *et al.*, 2016).

It is gaining more popularity among the growers within short period of time because of its attractive fruit color and melting pulp embedded with edible black seeds and has medicinal properties indicating that playing role in management of asthma, cough, cholesterol, high blood pressure, relieves stomach disorders, good for heart health, helps in preventing cancer, prevents congenital glaucoma, boosts immune power, reduces arthritis pain, good for pregnant women, prevents renal bone disease, good for bone health, repairs body cells, helps in improving appetite, good for eye health, boosts brain health, flowers are used in Aromatherapy (Nurliyana *et al*., 2010, Liaotrakoon *et al*., 2013, Tao *et al.*, 2014 and Choo & Yong., 2011).

Dragon fruits have recently been traded in the international market, and it has become Vietnam's most

popular export crop, fetching attractive price. Over all dragon fruit is promisingly a new crop in India and it has great potential for its cultivation in Arid and semiarid tracts, but the availability of manurial requirement especially through organic sources for its cultivation is a major constraint in this crop. Available reports indicate that, the crop has to be fertilized frequently in early phase of growth. The recommended fertilizer application of nutrients in Bangladesh is 135 g N, 78 g P_2O_5, 63 g K_2O g plan T^1 $year^{-1}$ along with 5 kg decomposed cowdung in four equal instalments (Chakma *et al*., 2014)

Since dragon fruit can be grown organically without the use of pesticides or inorganic fertilizers, it has market appeal as a safe organic fruit. Cattle or poultry manure, as well as well-decomposed compost, may be used as organic manures. Because of the good international demand for organically grown fruits, instead of producing by using chemical fertilisers, several countries are now using organic manures. Majority of European countries prefer organically grown dragon fruit, providing Indian opportunity to export organically produced dragon fruit.

The availability of scientific information on use of organic forms of nutrition for dragon fruit cultivation is very scarce, as it is new crop introduced across the world for cultivation. However the bio-fertilizers and organic manures, including crop residues may improve the soil productivity. Farm yard manures is proven source of nutrients in orchard but its availability is quite inadequate (Singh *et al*., 2011).

Hence, there is a need to understand the importance of organic manures on this crop. Therefore, the current study was undertaken to determine the effect of organic manures and bio-fertilizers on plant growth and yield of dragon fruit.

Material and Methods

During the year 2019-2021, a field study on 'Effect of organic manures and bio-fertilizers on plant growth and yield of dragon fruit under eastern dry zone of Karnataka'. The experiment was conducted in the farmer's field at Suradhenupura, Doddaballapur taluk, located 20 kms away from UAS, GKVK, Bengaluru. The experimental site is situated at 13^0 20' E latitude and 77^0 56' E longitude at an elevation of 908 m above MSL, consisting of red sandy loam with uniform fertility having soil pH range of 6.23 to 6.26. The mean maximum and minimum temperatures during the period of experimentation were 36.50 C and 20.80 ^{0}C, respectively and mean maximum and minimum relative humidity were 79 and 45 per cent, respectively. The major rainfall was received from South-West monsoon between June and September and from North-Eastern monsoon between October and December.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 13 treatments and three replications consisting of organic manures and bio-fertilizers for both white fleshed and pink fleshed dragon fruit *viz*., T_1- Control (no manure), T_2-100 per cent N through FYM, T_3-100 per cent N through FYM + PSB @ 10 kg ha^{-1}, T_4-100 per cent N through FYM + VAM @ 10 kg ha^{-1}, T_5-100 per cent N through FYM + PSB @ 10 kg ha^{-1} + VAM @ 10 kg ha^{-1}, T_6-100 per cent N through poultry manure, T_7-100 per cent N through poultry manure + PSB @ 10 kg ha^{-1}, T_8- 100 per cent N through poultry manure + VAM @ 10 kg ha^{-1}, T_9-100 per cent N through poultry manure + PSB @ 10 kg ha^{-1} + VAM @ 10 kg ha^{-1}, T_{10}-100 per cent N through vermicompost, T_{11}- 100 per cent N through vermicompost + PSB @ 10 kg ha^{-1}, T_{12}- 100 per cent N through vermicompost + VAM @ 10 kg ha^{-1}, T_{13}- 100 per cent N through vermicompost + PSB @ 10 kg ha^{-1} + VAM @ 10 kg ha^{-1}.

The treatments were imposed to dragon fruit plants with split dose of organic manures at four installments, first imposition was done after one month of pruning, second imposition was done after one month of first treatment imposition, third imposition was done before one month of flowering and the last imposition was done before fruiting of dragon fruit plants. Other cultural operations were attended to keep the plots clean and plant protection measures were carried out for effective management of pest and diseases during the period.

Results and Discussion

Plant Height (cm)

Plant height of dragon fruit, influenced by different treatments consisting of organic manures and bio-fertilizers was recorded and the values for plant height were significantly higher in treatment T_{13} (385.83 cm and 395.67 cm), however it was on par with T_{12} (382.40 cm and 388.03 cm), T_{11} (375.83 cm and 383.43 cm) and T_{10} (375.47 cm and 377.27 cm).

The treatment T_1 recorded significantly lower value (248.53 cm and 280.27 cm) at 120 days after treatment imposition for white fleshed and pink fleshed dragon fruit respectively (Fig. 1). This might be due to the fact that application of vermicompost resulted in release of various nutrients and also growth stimulating substances excreted by earthworms. Thus, increase in growth could be attributed to fixing of the atmospheric nitrogen by nitrogen fixing bacteria, solubilization and mobilization of nutrients by PSB and VAM by Ghosh *et al*. (2014) in orange.

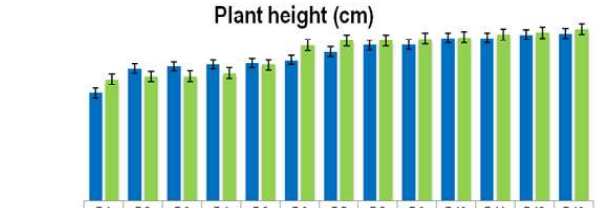

Fig. 1: Effect of organic manures and bio-fertilizers on plant height of white and pink fleshed dragon fruit at120 days after treatment imposition

Number of Branches per Plant

There were significant differences observed with respect to number of branches in white and pink fleshed dragon fruit. At the stage of final harvest, treatment T_{13} recorded significantly higher number of branches (7.74 and 7.83) per plant, followed by T_{12} (7.24 and 7.64), T_{11} (6.68 and 7.42) and T_{10} (6.17 and 7.04), while the lowest value was recorded in T_1 (2.98 and 3.17) at harvest in white and pink fleshed pitaya respectively (Fig. 2). This might be due to the fact that the presence of vermicompost around root zone of plants throughout the period of growth, which is a source of humus, PSB and VAM act as N-fixers and making nutrients available to plants, this might have resulted in the higher values with respect to number of branches per plant. These results are in conformity with the results of Ghosh *et al*. (2014) in orange.

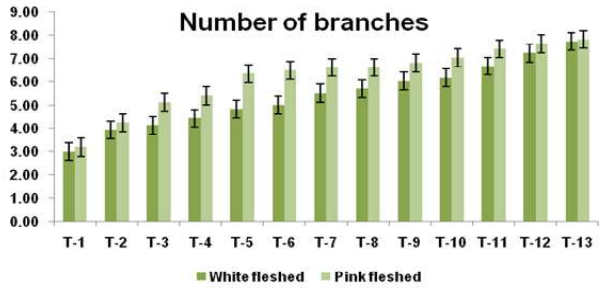

Fig. 2: Effect of organic manures and bio-fertilizers on number of branches per plant in white and pink fleshed dragon fruit at harvest

Circumference of Main Stem (cm)

The data on circumference of main stem of white fleshed and pink fleshed dragon fruit influenced by different treatments consisting of organic manures and bio-fertilizers was found significantly higher in T_{13} (14.98 cm and 15.10 cm) followed by T_{12} (14.51 cm and 14.88 cm), T_{11} (14.03 cm and 13.66 cm) and T_{10} (13.44 cm and 12.84 cm), while it was recorded significantly lower values in treatment T_1 (9.65 cm and 9.40 cm), respectively, at harvest (Fig. 3).

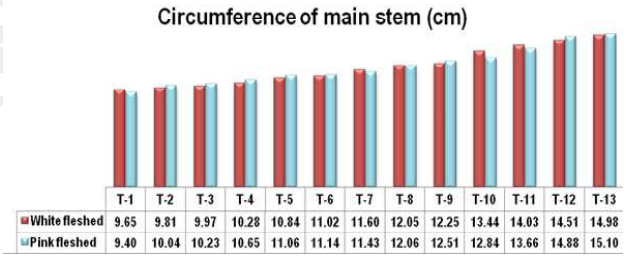

Fig. 3: Effect of organic manures and bio-fertilizers on circumference of main stem in white and pink fleshed dragon fruit at harvest

It might be attributed due to the increased biological nitrogen fixation, better organic nitrogen utilization, better development of root system and the possible synthesis of plant growth regulators like IAA, GA and cytokinins with the combined application of bio-fertilizers and organic manures which was also observed by Ghosh *et al*. (2014) in orange.

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Number of New Sprouts

In white and pink fleshed pitaya, the data pertaining to highest number of new sprouts was found significantly higher in T-$_{13}$ (6.50 and 6.52) followed by T-$_{12}$ (6.22 and 6.31), T-$_{11}$ (6.03 and 6.10) and T-$_{10}$ (5.96 and 6.01), while the significant lowest value was recorded in T-$_{1}$ (3.06 and 3.18), respectively, at harvest (Fig. 4). This might be due to the increased nutrient availability from the organic source of manure and increased availability of atmospheric nitrogen might have influenced to increase various endogenous hormonal levels in the plant tissues. These results are in conformity with the observations made by Ghosh *et al*. (2014) in orange.

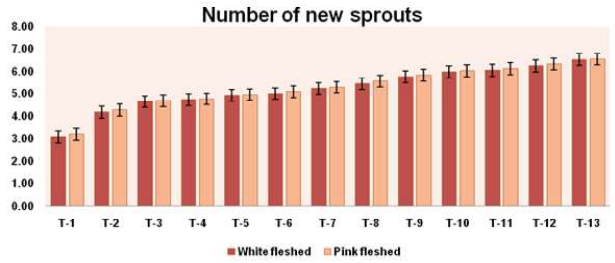


Fig. 4: Effect of organic manures and bio-fertilizers on number of new sprouts in white and pink fleshed dragon fruit at harvest

Plant Spread : North to South (cm)

The results showed significant differences in case of plant spread from north-south direction at harvest as influenced by different treatments. The highest plant spread was recorded in treatment T-$_{13}$ (174.15 cm and 180.59 cm) followed by T-$_{12}$ (163.20 cm and 166.52 cm), T-$_{11}$ (156.11 cm and 153.47 cm) and T-$_{10}$ (141.18 cm and 143.51 cm). The lowest plant spread from north-south direction was recorded in treatment T-$_{1}$ (62.74 cm and 69.00 cm) in white and pink fleshed dragon fruit, respectively (Fig. 5 and Fig. 6). This might be due to the fact that FYM enhances the release and uptake of nitrogen. This nitrogen helps in the synthesis of tryptophan which is a precursor for the biosynthesis of auxins which hastened the metabolic activities in the plants resulting in stimulation and increased plant spread. These results are in conformity with the findings of Rani *et al*. (2013) in Litchi.

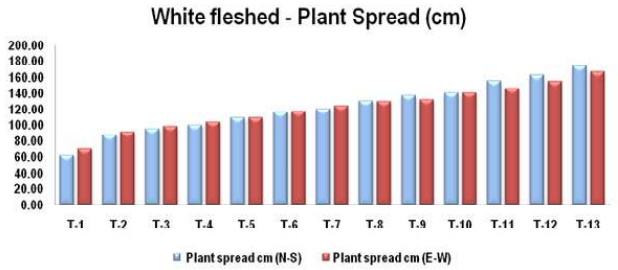


Fig. 5: Effect of organic manures and bio-fertilizers on plant spread (north to south) (east to west) in white fleshed dragon fruit at harvest

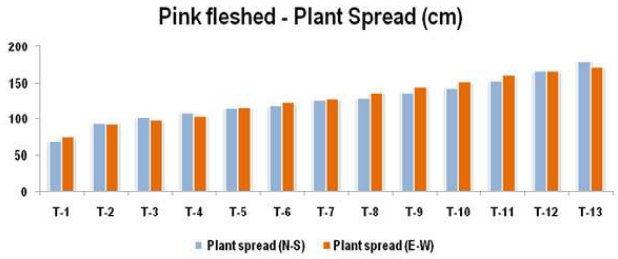


Fig. 6: Effect of organic manures and bio-fertilizers on plant spread (north to south) (east to west) in pink fleshed dragon fruit at harvest

Plant Spread: East to West (cm)

The results revealed that highest plant spread from east to west was found maximum in treatment T-$_{13}$ (167.33 cm and 172.90 cm), followed by T-$_{12}$ (155.13 cm and 167.13 cm), T-$_{11}$ (146.83 cm and 161.00 cm) and T-$_{10}$ (141.43 cm and 152.43 cm). The lowest plant spread from east to west direction was recorded in treatment T-$_{1}$ (70.41 cm and 5.60 cm) in white fleshed and pink fleshed dragon fruit, respectively (Fig. 5 and Fig. 6). According to Khehra and Bal (2014) increase in plant spread might be due to supply of nutrients with increased activity of soil microorganisms. Since nitrogen is an important constituent of nucleoprotein, amino acids and amino-sugars, hence increase in plant spread as a result of nitrogen availability.

Stem Diameter (cm)

The data on stem diameter was found significantly higher in the treatment T-$_{13}$ (19.55 cm and 19.74 cm) and was on par with T-$_{12}$ (19.51 cm and 19.67 cm), T-$_{11}$ (19.40 cm and 19.52 cm) and T-$_{10}$ (19.25 cm and 19.40 cm), while the lowest significant value was recorded in treatment T-$_{1}$ (17.93 cm and 17.96 cm) in

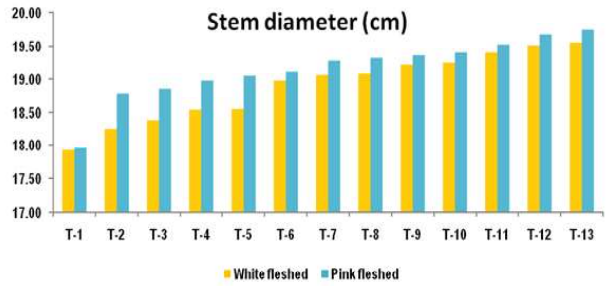
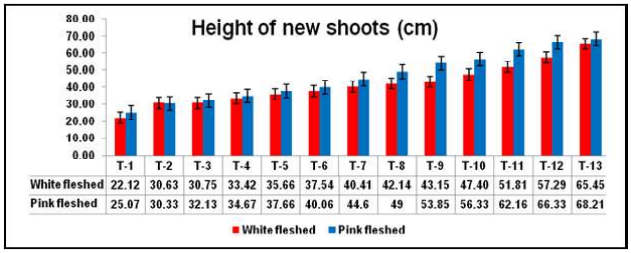


Fig. 7: Effect of organic manures and bio-fertilizers on stem diameter in white and pink fleshed dragon fruit at harvest

white fleshed and pink fleshed pitaya, respectively (Fig. 7). The increase in stem diameter could be attributed to the stimulatory activity of microflora in the rhizosphere leading to increased nutrient availability and hence vigorous plant growth and diameter of stem. These results are in agreement with the findings of Ghosh *et al*. (2014) in orange.

Height of New Shoot (cm)

The height of new shoot significantly differed among the treatments and was recorded highest shoot height in treatment $T-_{13}$ (65.45 cm and 68.21 cm) followed by $T-_{12}$ (57.29 cm and 66.33 cm), $T-_{11}$ (51.81 cm and 62.16 cm) and $T-_{10}$ (47.40 cm and 56.33 cm). The least shoot height was recorded in treatment $T-_{1}$ (22.12 cm and 25.07 cm), respectively in white and pink fleshed dragon fruits (Fig. 8). The results are in conformity with Choudhary (2016) that PSB and VAM altered various enzymatic activities in plants such as peroxidase, catalase etc., which promotes cell elongation, root and shoot growth and carbohydrate metabolism in Ber.



	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9	T-10	T-11	T-12	T-13
White fleshed	22.12	30.63	30.75	33.42	35.66	37.54	40.41	42.14	43.15	47.40	51.81	57.29	65.45
Pink fleshed	25.07	30.33	32.13	34.67	37.66	40.06	44.6	49	53.85	56.33	62.16	66.33	68.21

Fig. 8: Effect of organic manures and bio-fertilizers on height of new shoot in white and pink fleshed dragon fruit at harvest

Yield parameters

The results revealed that there was a significant difference among the treatments. The maximum number of fruits per plant and per pillar was observed in $T-_{13}$ (20.83 and 83) and lowest number of fruits per plant and per pillar were observed in $T-_{1}$ (5 and 20), respectively for white fleshed dragon fruit (Table 1). Similarly, maximum number of fruits per plant and per pillar was observed in $T-_{13}$ (25 and 100) and lowest number of fruits per plant and per pillar were observed in $T-_{1}$ (7 and 28), respectively for pink fleshed dragon fruit (Table 1).

The highest fruit yield per plant and fruit yield per pillar was observed in treatment $T-_{13}$ (4.50 and 18.33 kg, respectively). On the other hand, the lowest fruit yield per plant and fruit yield per pillar was found in $T-_{1}$ Control (1.17 and 6.33 kg) for the white fleshed dragon fruit (Table 1). Whereas, pink fleshed dragon fruit also showed significant differences where the highest fruit yield per plant and fruit yield per pillar was observed in treatment T_{13} (6.00 and 24.00 kg, respectively). On the other hand, the lowest fruit yield per plant and fruit yield per pillar was found in $T-_{1}$ Control (2.08 and 8.33 kg) (Table 1).

The most beneficial effect of these treatments might be due to plant growth promoters and improvement in the physical, chemical and biological properties of the soil and it also stimulated soil micro-biological activities, which improved the growth of the plants. These results are in conformity with the findings of Muthu and Ponnuswami (2013) in Noni, Dwivedi (2013) in Guava, Vanilarasu *et al*. (2014) and Selvamani (2014) in Banana.

On the basis of results obtained, in the present investigation it is concluded that 100 per cent N applied through vermicompost + PSB @ 10 kg ha^{-1} + VAM @ 10 kg ha^{-1} was proved significant for improving combination when compared to other treatments with respect to obtaining maximum plant growth (plant height, number of branches per plant, circumference of main stem, number of new sprouts, plant spread, stem diameter and height of new shoots) and yield for both white and pink fleshed dragon fruits. Therefore, data of present study indicated that combined application of organic manures and bio-fertilizer proved to enhance better growth of dragon fruit plants.

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TABLE 1

Effect of organic manures and bio-fertilizers on yield and yield attributes of white and pink fleshed dragon fruit

Treatments	White fleshed dragon fruit				Pink fleshed dragon fruit			
	No. of fruits per plant	No. of fruits per pillar	Yield per plant (kg)	Yield per pillar (kg)	No. of fruits per plant	No. of fruits per pillar	Yield per plant (kg)	Yield per pillar (kg)
T_1	5.0	20	1.17	6.33	7.0	28	2.08	8.33
T_2	10	40	2.50	10.00	10	36	2.62	10.50
T_3	10	40	2.50	10.33	12	48	3.00	12.00
T_4	12	48	3.00	12.00	12	48	3.08	12.33
T_5	12	48	3.00	12.33	12	48	3.17	12.67
T_6	12	48	3.00	12.67	14	56	3.50	14.00
T_7	14	56	3.50	14.00	14	56	3.50	14.00
T_8	14	56	3.50	14.00	14	56	3.58	14.33
T_9	14	56	3.50	14.33	16	64	4.08	16.33
T_{10}	14	56	3.50	14.67	16	64	4.42	17.67
T_{11}	16	64	4.00	16.00	21	84	5.25	21.00
T_{12}	16	64	4.00	16.80	22	88	5.50	22.00
T_{13}	20.83	83	4.50	18.33	25	100	6.00	24.00
Mean	13.06	52.23	3.21	13.22	14.92	59.69	3.83	15.32
F- test	*	*	*	*	*	*	*	*
S. Em±	0.02	0.16	0.05	0.22	0.16	0.16	0.07	0.29
C.D @ 5 %	0.07	0.47	0.13	0.64	0.47	0.47	0.21	0.84
C.V	0.31	0.53	2.50	2.85	1.86	0.46	3.31	3.27

Note : T_1-Control; T_2-100 per cent N through FYM; T_3-100 per cent N through FYM + PSB @ 10 kg ha^{-1}; T_4-100 per cent N through FYM + VAM @ 10 kg ha^{-1}; T_5-100 per cent N through FYM + PSB @ 10 kg ha^{-1}+ VAM @ 10 kg ha^{-1}; T_6-100 per cent N through poultry manure; T_7-100 per cent N through poultry manure + PSB @ 10 kg ha^{-1}; T_8-100 per cent N through poultry manure + VAM @ 10 kg ha^{-1}; T_9-100 per cent N through poultry manure + PSB @ 10 kg ha^{-1} + VAM @ 10 kg ha^{-1}; T_{10}-100 per cent N through vermicompost; T_{11}-100 per cent N through vermicompost + PSB @ 10 kg ha^{-1}; T_{12}-100 per cent N through vermicompost + VAM @ 10 kg ha^{-1}; T_{13}-100 per cent N through vermicompost + PSB @ 10 kg ha^{-1} + VAM @ 10 kg ha^{-1}

Economics

Dragon fruits are sold in the market at Rs.250-300 per kg, but the price at which the farmer is selling the fruits is approximately Rs.160 per kg. Pink fleshed fruits are preferred more in the market than the white fleshed fruits.

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