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Studies on Vegetative Growth of Dragon Fruit [*Hylocereus costaricensis* (Web.) Britton and Rose] as Influenced by Nano Urea, Urea, FYM and Vermicompost

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ABSTRACT

Nano-fertilizer has emerged as a promising alternative that ensures high crop production and soil restoration. Among them, Nano urea increases nitrogen availability to crop by more than 80% resulting in higher nutrient use efficiency and crop yield. The present investigation was carried out to depict the best treatment combination of nano urea, vermicompost and FYM on dragon fruit crop growth. The experiment consisted of 8 treatments laid out in Randomized Block Design with 3 replications under the subtropical condition of Lucknow (UP) under slightly alkaline soil. There was a significant increase in vegetative growth by nano urea in terms of various growth characters. Results suggested that nano urea was beneficial and resulted very close to the recommended dose of fertilizers (RDF). And, among the treatments under study, the nano urea @ 6 ml/l may be recommended for dragon fruit growth, since it produced maximum vegetative growth in slightly alkaline soil.

Keywords Dragon fruit, Growth, Nano urea, FYM, Vermicompost.

INTRODUCTION

Dragon fruit [*Hylocereus costaricensis* (Web.) Britton and Rose] belongs to the family Cactaceae, having chromosome number 2n=22, is a recently introduced exotic fruit crop in India. It is popular in various names in different areas (Pitaya, Night blooming cereus, Strawberry pear, Queen of night, Jesus in the cradle, Honorable queen, Belle of night). It originated in Mexico, Central and South America (Britton and Rose 1963, Morton 1987 and Mizrahi *et al*. 1997) and is now cultivated in China, Australia, Hawaii, Indonesia, Guatemala, Israel, Taiwan, Malaysia, Vietnam and Thailand. In India, it is mainly grown in parts of Maharashtra, Karnataka and Gujarat, West Bengal, Uttar Pradesh. Three types of dragon fruits are popular in India viz., *Hylocereus undatus* (red skinned fruit with white flesh), *H. megalanthus* (yellow skinned fruit with white flesh), *H. costaricensis* syn. *H. Polyrhizus* (red skinned fruit with red flesh) (Hunt 2006, Hamidah *et al*. 2017). Dragon fruit is best eaten as fresh in the form of juice, jam or preserves (Perween *et al*. 2018) or dried fruit or processed

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products like ice cream, cookies, candies, jam, wines, shake, for special beverages or as flavor for all kinds of drinks and ingredients of various recipes and sometimes used as a natural coloring agent in various drinks and beverages (Sonawane 2017). It is a good source of minerals, glucose, fructose, dietary fiber and vitamins (Rao and Sasanka 2015) and well-known for its rich vitamin C, phosphorus, calcium as well as anti-oxidant contents (Morton 1987) along with B group vitamins (LeBellec *et al*. 2006). Whereas, seeds contain 50% of essential fatty acids namely, Linoleic acid and Linolenic acid (Sonawane 2017). Regular consumption of dragon fruit greatly controls the asthma, cough, cholesterol, helps in preventing cancer, boosts immune power.

Dragon fruit crop is cultivated with easy agronomic practices with low maintenance cost and require minimal after care due to less attack of pests and diseases (Maji 2019). Dragon fruit is not an exhaustive fruit crop but has a superficial root system, which requires a high dose of nutrients for good harvest. Judicious application of fertilizers and manures is necessary for higher fruit yield with better quality. Nano-fertilizer has emerged as a promising alternative that ensures high crop production and soil restoration. Nano urea is a nanotechnology based agri-input which provides nitrogen to plants. These fulfil the plant nutrient requirement as a fertilizer since, Nano urea is bio-available to plants because of its desirable particle size about 20-50 nm and more surface area (10000 times over 1 mm urea prill) and number of particles (55000, nitrogen particles over 1mm urea prill). Hence, Nano urea increases nitrogen availability to crop by more than 80% resulting in higher nutrient use efficiency and crop yield (Anon 2022). Nano urea is responsible for influencing both qualitative as well as quantitative aspects of dragon fruit. Keeping these facts in view a field experiment was conducted to assess the efficiency of nano urea along with urea, vermicompost and FYM on growth of dragon fruit plant.

MATERIALS AND METHODS

The present investigation was conducted at the dragon fruit orchard of the Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India, (26°55′ N and 80°54′ E, 123 m above MSL) during 2021- 2022. The experimental site comes under sub tropical climate having slightly alkaline soil (pH 8.2). The experiment was comprised of 8 treatments (T_0 - Control (water spray), T_1 – RDF, T_2 - 75% N_2 through Urea + 1.5 ml/l Nano Urea, T_3 - 50% N_2 through Urea + 3 ml/l Nano Urea, T_4 - 25% N_2 through urea + 4.5 ml/l Nano Urea, T_5 - 6 ml/l Nano Urea, T_6 - 50 % N_2 through Urea + 1.5 ml/l Nano Urea + 2 kg/plant vermicompost, T_7 - 50% N_2 through Urea + 1.5 ml/l Nano Urea + 4 kg/plant FYM) which were laid out in Randomized Block Design with 3 replications. There were 24 poles each having 4 plants planted at 4 m x 2 m spacing. The base area of 1 m radius was cleaned for fertilizer and irrigation management. Plants along with new growth are tied up with pole regularly for better support.

Nano urea was collected from IFFCO Bhawan - 8, IFFCO State Office, Gokhle Marg, Lucknow (UP) which had desirable particle size about 20-50 nm and more surface area (10000 times over 1 mm urea prill) and number of particles (55000, nitrogen particles over 1mm urea prill. Well rotted FYM @ 16 kg / pole, Vermicompost @ 8 kg/pole and recommended dose of fertilizer @ 200g N_2, 225g P_2O_5, 137.5g K_2O / Pole (Nangare *et al*. 2020) were applied in two split doses first during November 2021 and second during February 2022 (end of winter). Chemical fertilizers, vermicompost and FYM were applied as soil application followed by irrigation whereas nano urea was applied twice as foliar spray as per treatment combination. Observations were recorded for its vegetative growth like plant length, number of primary branches, number of segments of main stem, number of areoles, stem thickness, stem circumference, number of spines, distance between two areoles, arch height and chlorophyll content using standard methods of biochemical analysis (Thimmaiah 2009). To test the significance of variance in the data obtained from the various vegetative growth characters, the technique of analysis of variance was adopted as suggested by Panse and Sukhatme (1985) for Randomized Block Design (RBD). Significance of difference in the treatment effect was tested through 'F' test at 5% level of significance and critical difference (CD) was calculated, wherever the result found significant or not.

Table 1. Effect of nano urea, vermicompost and FYM on increase of plant length and primary branches from 30 days to 90 days after treatment.

Treatments	Plant length at 30 DAT (cm)	Increase in plant length			Plant length at 90 DAT (cm)	Increase in length at 90 DAT (cm) (from 75 days to 90 days)	Total increase (cm) (from 30 days to 90 days)
		Increase in length at 45 DAT (cm) (from 30 days to 45 days)	Increase in length at 60 DAT (cm) (from 45 days to 60 days)	Increase in length at 75 DAT (cm) (from 60 days to 75 days)			
T_0	174.90	3.93	3.23	6.40	192.50	4.03	17.60
T_1	146.43	5.67	5.73	11.23	175.23	6.17	28.80
T_2	189.57	5.60	6.47	10.30	216.47	4.53	26.90
T_3	145.17	4.90	4.80	13.30	172.13	3.97	26.97
T_4	124.47	5.63	5.63	14.47	154.83	4.63	30.37
T_5	176.70	4.60	4.83	14.90	207.27	6.23	30.57
T_6	159.40	6.40	6.00	10.23	186.93	4.90	27.53
T_7	149.53	5.80	4.87	11.57	176.07	4.30	26.53
SEm(±)		1.050	1.028	1.714		0.922	2.502
CD (p=0.05)		2.25	2.20	3.68		2.16	5.37

Table 1. Continued.

Treatments	Number of primary branches at 30 DAT (cm)	Increase in primary branches			Number of primary branches at 90 DAT	Increase in number of primary branches at 90 DAT (from 75 days to 90 days)	Total increase (from 30 days to 90 days)
		Increase in number of primary branches at 45 DAT (from 30 days to 45 days)	Increase in number of primary branches at 60 DAT (from 45 days to 60 days)	Increase in number of primary branches at 75 DAT (from 60 days to 75 days)			
T_0	7.67	2.00	3.33	4.00	17.33	0.33	9.67
T_1	7.00	2.00	3.67	3.67	17.00	0.67	10.00
T_2	5.67	3.33	5.00	3.67	18.33	0.67	12.67
T_3	2.00	4.00	6.33	7.00	19.67	0.33	17.67
T_4	2.33	1.00	3.00	3.67	10.67	0.67	8.33
T_5	1.67	0.33	2.00	3.33	8.00	0.67	6.33
T_6	4.00	2.67	6.00	5.00	18.67	1.00	14.67
T_7	4.00	3.33	3.67	2.00	13.67	0.67	9.67
SEm(±)		2.386	3.446	1.212		0.163	1.231
CD (p=0.05)		5.12	7.39	3.56		0.412	3.72

T_0 - Control (water spray), T_1 - (RDF), T_2 - (75% N_2 through Urea + 1.5 ml/l Nano Urea), T_3 - (50% N_2 through Urea + 3 ml/l Nano Urea), T_4 - (25% N_2 through urea + 4.5 ml/l Nano Urea), T_5- (6 ml/l Nano Urea), T_6 - (50 % N_2 through Urea + 1.5 ml/l Nano Urea + 2 kg/plant vermicompost), T_7 - (50% N_2 through Urea + 1.5 ml/l Nano Urea + 4kg/plant FYM).

RESULTS AND DISCUSSION

Plant length

Table 1 showed that maximum increase (6.40 cm) in plant length at 45 days (from 30 days) was recorded under treatment T_6 (50% N_2 through Urea + 1.5 ml/l Nano urea + 2 kg/plant vermicompost) and at 60 DAT it was maximum on T_2 (75% N_2 through urea + 1.5 ml/l nano urea). There was no specific pattern of increase since T_5 showed the highest increase at 75 DAT and 90 DAT followed by T_1. It was also calculated that T_5 caused maximum total increase from 30 DAT to 90 DAT and control plants recorded minimum increase. However, at various stages of growth, the highest rate of increase in plant length was observed at 75 DAT from 60 DAT, which might be due to rise in temperature (end of winter) for the experimental area as evident from meteorological data. Overall, it was noticed that maximum total increase from 30 days to 90 days was recorded at T_5 which might be because of the desirable particle size and more surface area

of nano urea which increases its availability to crop by more than 80%, resulting increase in plant length (Anon 2022). Kumar *et al*. (2020) also reported that nano fertilizers significantly increased plant growth and yield.

Number of primary branches/plant

In case of increase in number of primary branches, maximum increase (4.0) at 45 DAT was noticed under T_3 (50% N_2 through urea + 3 ml/l nano urea) similar to increase at 60 DAT and 75 DAT followed by T_6 which showed maximum increase at 90 DAT from 75 DAT. It was also estimated that T_3 caused a maximum total increase from 30 DAT to 90 DAT. However, at various stages of growth, the highest rate of increase in the number of primary branches was observed on increase at 75 DAT from 60 DAT (Table 1).

Number of segments per plant

There was no significant change in number of segments at 45 DAT, however, at 60, 75 and 90 DAT it was observed maximum on T_3 (50% N_2 through urea + 3 ml/l nano urea).

Number of areoles per segment

There was a non significant variation on increase in number of areoles also. However, it was seen that maximum increase (1.0 cm) in length at 45 days from 30 days was recorded under treatment T_1 (RDF) and at 60 DAT it was maximum on T_4 (25% N_2 through urea + 4.5 ml/l nano urea). While, at 75 DAT it was maximum in untreated control. But, there was no specific pattern on increase since T_1 showed highest increase at 90 DAT and also recorded the highest total increase from 30 days to 90 days followed by T_0 (Table 2).

Stem thickness

It was seen that T_5 (6 ml/l nano urea) caused maximum increase in stem thickness at 45 DAT and at 60 DAT, it was maximum on T_6. Similarly, T_6 also showed highest increase at 75 DAT and 90 DAT as well as showed maximum total increase from 30 DAT to 90 DAT. However, the highest rate of increase in stem thickness was observed on increase at 60 DAT from 45 DAT.

Stem circumference

The maximum increase (0.47 cm) in stem circumference at 45 DAT from 30 DAT was noticed under T_1 (RDF) which was continued at 60 DAT and 75 DAT. But, at 90 DAT from 75 DAT the maximum increase was recorded in T_3 (Table 3). However, the total increase from 30 DAT to 90 DAT was seen under T_1. The highest rate of increase in stem circumference

Table 2. Effect of nano urea, vermicompost and FYM on increase of number of segments and areoles from 30 days to 90 days after treatment.

Treatments	Number of segments per plant at 30 DAT (cm)	Increase in number of segments per plant at 45 DAT (cm) (from 30 days to 45 days)	Increase in number of segments per plant at 60 DAT (cm) (from 45 days to 60 days)	Increase in number of segments per plant at 75 DAT (cm) (from 60 days to 75 days)	Number of segments per plant at 90 DAT (cm)	Increase in number of segments per plant at 90 DAT (cm) (from 75 days to 90 days)	Total increase (cm) (from 30 days to 90 days)
			Increase in number of stem segments				
T_0	5.33	0	0.00	1.00	6.67	0.33	1.33
T_1	5.33	0	0.33	1.67	7.67	0.33	2.33
T_2	4.00	0	0.33	1.00	5.67	0.33	1.67
T_3	3.33	0	0.67	1.33	6.00	0.67	2.67
T_4	4.67	0	0.33	1.33	6.67	0.33	2.00
T_5	5.33	0	0.33	1.00	6.67	0.00	1.33
T_6	4.67	0	0.67	1.33	7.33	0.67	2.67
T_7	3.67	0	0.00	1.00	5.00	0.33	1.33
SEm(±)			0.432	0.351		0.459	0.538
CD (p=0.05)			0.93	0.75		0.98	1.15

Table 2. Continued.

Treatments	Number of areoles per segment at 30 DAT (cm)	Increase in number of areoles per segment at 45 DAT (cm) (from 30 days to 45 days)	Increase in number of areoles per segment at 60 DAT (cm) (from 45 days to 60 days)	Increase in number of areoles per segment at 75 DAT (cm) (from 60 days to 75 days)	Number of areoles per segment at 90 DAT (cm)	Increase in number of areoles per segment at 90 DAT (cm) (from 75 days to 90 days)	Total increase (cm) (from 30 days to 90 days)
		Increase in number of areoles					
T_0	20.33	0.33	0.67	4.00	26.00	0.67	5.67
T_1	20.33	1.00	1.33	2.67	26.67	1.33	6.33
T_2	29.00	0.00	1.00	2.00	32.67	0.67	3.67
T_3	25.33	0.67	0.67	2.00	29.67	1.00	4.33
T_4	14.00	0.67	1.67	2.33	19.00	0.33	5.00
T_5	11.33	0.67	1.33	1.67	15.67	0.67	4.33
T_6	19.00	0.67	1.00	1.67	23.00	0.67	4.00
T_7	11.67	0.66	0.67	1.33	14.67	0.33	3.00
SEm(±)		0.508	0.484	0.756		0.383	1.086
CD (p=0.05)		1.09	1.05	1.62		0.82	2.33

was observed on increase at 90 DAT from 75 DAT, which might be due to rise in temperature during the period. Law-Ogbomo and Law-Ogbomo (2009) reported that NPK fertilizer applications significantly increase plant stem girth in maize.

Number of spines per areoles

It was seen that the maximum increase in the number of spines at 45 days from 30 days under treatment T_5 (6 ml/l nano urea) and at 60 DAT it was observed maximum on T_2. Whereas, T_5 showed the highest increase at 75 DAT from 60 DAT and continued to 90 DAT. It was also calculated that T_2 caused maximum increase from 30 DAT to 90 DAT but the increase was non significant (at 5% level of probability) (Table 4).

Distance between areoles

It was seen that maximum increase in distance between areoles at 45 DAT was recorded in T_4 and at 60 DAT it was maximum observed on T_2 (75% N_2 through urea + 1.5 ml/l nano urea). While, T_1 showed the highest increase at 75 DAT and at 90 DAT under T_0. It was also calculated that T_1caused a maximum increase from 30 DAT to 90 DAT and T_7 recorded

Table 3. Effect of nano urea, vermicompost and FYM on increase of stem thickness and stem circumference from 30 days to 90 days after treatment.

Treatments	Stem thickness at 30 DAT (cm)	Increase in stem thickness at 45 DAT (cm) (from 30 days to 45 days)	Increase in stem thickness at 60 DAT (cm) (from 45 days to 60 days)	Increase in stem thickness at 75 DAT (cm) (from 60 days to 75 days)	Stem thickness at 90 DAT (cm)	Increase in stem thickness at 90 DAT (cm) (from 75 days to 90 days)	Total increase (cm) (from 30 days to 90 days)
		Increase in stem thickness					
T_0	3.89	0.04	0.03	0.05	4.03	0.01	0.14
T_1	4.67	0.03	0.03	0.05	4.78	0.01	0.12
T_2	3.53	0.04	0.03	0.06	3.07	0.02	0.14
T_3	3.42	0.02	0.04	0.06	3.57	0.03	0.15
T_4	3.10	0.02	0.05	0.04	3.23	0.02	0.13
T_5	3.28	0.07	0.22	0.09	3.68	0.03	0.41
T_6	3.73	0.01	0.24	0.13	4.14	0.03	0.41
T_7	4.24	0.02	0.03	0.06	4.35	0.01	0.11
SEm(±)		0.055	0.089	0.050		0.014	0.033
CD (p=0.05)		0.12	0.19	0.11		0.03	0.07

Table 3. Continued.

Treatments	Stem circumf-erence at 30 DAT (cm)	Increase in stem circumf-erence at 45 DAT (cm) (from 30 days to 45 days)	Increase in stem circumference Increase in stem circumf-erence at 60 DAT (cm) (from 45 days to 60 days)	Increase in stem circumf-erence at 75 DAT (cm) (from 60 days to 75 days)	Stem circumf-erence at 90 DAT (cm)	Increase in stem circumf-erence at 90 DAT (cm) (from 75 days to 90 days)	Total increase (cm) (from 30 days to 90 days)
T_0	13.23	0.10	0.13	0.30	13.87	0.10	0.63
T_1	13.67	0.47	0.27	0.43	14.87	0.03	1.20
T_2	11.33	0.07	0.27	0.47	12.23	0.10	0.90
T_3	10.93	0.23	0.17	0.30	12.13	0.50	1.20
T_4	9.77	0.03	0.17	0.30	10.33	0.07	0.57
T_5	10.77	0.13	0.07	0.27	11.40	0.17	0.63
T_6	12.00	0.23	0.17	0.30	12.83	0.13	0.83
T_7	13.73	0.10	0.13	0.33	14.50	0.20	0.77
SEm(±)		0.114	0.065	0.133		0.129	0.311
CD (p=0.05)		0.25	0.14	0.29		0.28	0.60

the minimum increase. However, at various stages of growth, the highest rate of distance between areoles was observed on increase at 75 DAT from 60 DAT.

Arch height

There was a non significant variation on increase in arch height at 30, 45, 60, 75, 90 DAT and total increase from 30 to 90 days (Fig.1). However, maximum increase (2.13 cm) at 45 DAT was recorded under T_3 (50% N_2 through Urea + 3 ml/l Nano urea) and at 60 DAT it was recorded maximum on T_2 (75% N_2 through urea + 1.5 ml/l Nano Urea). While, T_5 showed the highest increase at 75 DAT and at 90 DAT it was under treatment T_7. The rate of increase in arch height was observed higher at 75 DAT from 60 DAT, which might be due to rise in temperature and due to favorable conditions.

The result and discussion of the present investigation indicated that vegetative growth was significantly affected by different stages of treatments

Table 4. Effect of nano urea, vermicompost and FYM on increase of number of spines and distance between areoles from 30 days to 90 days after treatment.

Treatments	Number of spines per areoles at 30 DAT (cm)	Increase in number of spines per areoles at 45 DAT (cm) (from 30 days to 45 days)	Increase in number of spines Increase in number of spines per areoles at 60 DAT (cm) (from 45 days to 60 days)	Increase in number of spines per areoles at 75 DAT (cm) (from 60 days to 75 days)	Plant length at 90 DAT (cm)	Increase in number of spines per areoles at 90 DAT (cm) (from 75 days to 90 days)	Total increase (cm) (from 30 days to 90 days)
T_0	3.36	0.01	0.01	0.02	3.40	0.01	0.04
T_1	4.09	0.01	0.01	0.04	4.18	0.03	0.09
T_2	3.67	0.10	0.17	0.18	4.12	0.00	0.46
T_3	4.27	0.03	0.03	0.06	4.40	0.01	0.12
T_4	3.88	0.19	0.07	0.07	4.22	0.01	0.34
T_5	3.61	0.24	0.10	0.06	4.02	0.01	0.41
T_6	3.98	0.04	0.04	0.06	4.14	0.01	0.16
T_7	4.20	0.14	0.10	0.14	4.60	0.02	0.40
SEm(±)		0.118	0.088	0.076		0.008	0.101
CD (p=0.05)		0.25	0.19	0.16		0.02	0.30

Table 4. Continued.

Treatments	Distance between areoles at 30 DAT (cm)	Increase in distance between areoles at 45 DAT (cm) (from 30 days to 45 days)	Increase in distance between areoles at 60 DAT (cm) (from 45 days to 60 days)	Increase in distance between areoles at 75 DAT (cm) (from 60 days to 75 days)	Distance between areoles at 90 DAT (cm)	Increase in distance between areoles at 90 DAT (cm) (from 75 days to 90 days)	Total increase (cm) (from 30 days to 90 days)
		Increase in distance between areoles					
T_0	2.87	0.15	0.07	0.09	3.35	0.17	0.48
T_1	2.31	0.04	0.10	0.23	2.70	0.01	0.38
T_2	2.34	0.09	0.13	0.13	2.71	0.02	0.37
T_3	2.51	0.12	0.12	0.16	2.93	0.01	0.42
T_4	1.96	0.20	0.05	0.04	2.14	0.01	0.30
T_5	2.47	0.03	0.03	0.05	2.60	0.01	0.13
T_6	2.13	0.07	0.03	0.06	2.29	0.01	0.16
T_7	2.60	0.03	0.02	0.04	2.71	0.02	0.11
SEm(±)		0.121	0.059	0.021		0.012	0.097
CD (p=0.05)		0.26	0.13	0.08		0.04	0.27

which might be due to rise in temperature and other favorable conditions due to better fertilizer use efficiency when nano urea was applied. The higher rate of increase in vegetative growth was also attributed due to improvement in chlorophyll content of the stem sample as presented in Fig. 1. The better nitrogen use efficiency might be due to the desirable particle size (20-50 nm) and more surface area of nano urea which increases its availability to crop by more than 80%, resulting in an increase in plant length (Anon 2022). A field trial by Kumar *et al.* (2021) showed that an increase of 6.87 % yield in Wheat, 9.38 % in Maize, 9.34 % in Barley when the plot treated with Farmers Field Practices (50% N) + 1 Spray of Nano-N+ 1 Spray of Nano Zn+ 1 Spray of Nano-Cu (Kumar *et al*. 2020). According to Rahale (2010), Nano fertilizer enhanced nutrient use efficiency by up to 45 % over control. It was found that rice seedlings grown in carbon nanomaterial-enriched media had better root growth and shoot establishment than control seedlings. The use of nano fertilizer has led to increased plant growth. These results were in agreement with the results of Abdel wahab *et al*. (2019) on improving seed germination of radish. Subbaiya *et al*. (2012) reported that K nano fertilizer and humic acid increased root growth and improved the root system effectiveness that lead to increase the plant height and the plant growth (Ghosh *et al*. 1981).

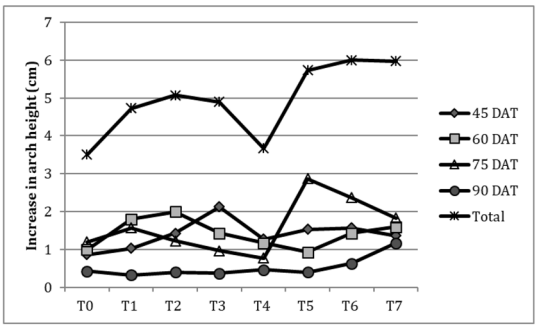

Fig. 1. Increase in arch height of dragon fruit with application of nano urea along with urea, FYM and vermicompost.

CONCLUSION

On the basis of results obtained in the present investigation, it can be concluded that application of nano urea is beneficial which resulted in a very close to recommended dose of fertilizers. Among the treatments under study, the nano urea @ 6 ml/l may be suggested for dragon fruit growth, Since, it produced maximum vegetative growth in terms of stem length, stem thickness and higher plant branches.

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