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Studies on combining effect of media and biofertilizers on survival, rooting and establishment of dragon fruit (*Hylocereus costaricensis* L.) cuttings under protected and open field conditions

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Abstract
The present investigation was conducted at Fruit science block, Department of Fruit science College of Horticulture, Anantharajupeta, Annamayya district, Andhra Pradesh during the year 2022. The experiment was laid out in a factorial completely randomized design (FCRD) for shoot growth parameters of dragon fruit cuttings with two factors and three replications under two growing conditions i.e., open field and shade net. Treatment combinations has showed the significant difference. Among the different treatment combinations used media containing of soil + cocopeat + vermicompost enriched with biofertilizer combination of Azotobacter + PSB + VAM has recorded minimum days taken to sprout initiation under open field than shade net conditions and maximum shoot diameter and number of sprouts has recorded under shade net when compared to open field conditions.

Keywords: biofertilizer, shoot growth parameters, vermicompost, dragon fruit cuttings, open field, shade net

Introduction
Dragon fruit (*Hylocereus undatus* Britton & Rose) is an edible, fast growing, perennial epiphytic vine resemblance to cacti belongs to the family of Cactaceae. It is native to tropical and subtropical forest regions of Mexico and Central South America (Mizrahi *et al.*, 1996) [11]. It is a recently introduced exotic fruit to India and is considered to be promising and remunerative. The genus Hylocereus contains 16 species and it can be categorized into three different species based on the skin and pulp color, i.e., *Hylocereus undatus* (red skin, white pulp), *Hylocereus polyrhizus* (red skin and red pulp), *Hylocereus costaricensis* (red skin and red pulp) and *Hylocereus megalanthus* (yellow peel and white pulp) (Nerd *et al.*, 2002) [12]. Usually, dragon fruit is propagated sexually by seed and asexually by grafting and stem cutting. The cheapest and convenient method of propagation is by stem cutting. Though seed propagation method is very simple but are not true to type due to cross pollination (Andrade *et al.*, 2005) [2]. The plants propagated through stem cuttings starts flowering within 12 to 18 months after planting Growing media is the important factor for the plants that give anchorage to the plants and provide essential nutrients required by the plants.The growing media enriched with biofertilizers possess the advantages like more availability of nutrients in the available forms through natural process like nitrogen fixing, phosphorus solubilizing and stimulate plant growth through the synthesis of growth promoting substances. They build up soil microflora and there by maintains soil health. So, the present investigation was carried out to study the effect of media and biofertilizers and their interaction on shoot growth of dragon fruit cuttings.

Material and Methods
The present experiment was carried out under open field and shade net conditions at Fruit Science Block, Department of Fruit Science, College of Horticulture, Anantharajupeta, Annamayya district, Andhra Pradesh during the year 2022 to study the combining effect of media and biofertilizers on survival, rooting and establishment of dragon fruit (*Hylocereus costaricensis* L.) cuttings under protected and open field conditions which was falls under southern agro-climatic zone pf Andhra Pradesh at an elevation of 162 m (531. Feet) above

mean sea level and geographically it lies between 13° 59' North latitude and 79° 19'East longitude. The present experiment was laid out in factorial completely randomized design with 2 factors, biofertilizers (6 levels: B_1: Control, B_2: Azotobacter (@ 2%) B_3: Phosphorous solubilizing bacteria (PSB @ 2%), B_4: Vesicular Abruscular Mycorrhizal (VAM @ 2%), B_5: Azotobacter @ 2% + PSB @ 2% + VAM @ 2%, B_6: Arka microbial consortium (AMC @ 2%) and media [2 levels: M_1: Soil + Cocopeat + FYM (1:1:1), M_2: Soil + Cocopeat + Vermicompost (1:1:1) with 12 treatment combinations replicated thrice. Cuttings were planted during the first week of March in polybags of 12' x14' inches pinned with 2 to 3 holes in each were filled with media enriched with different biofertilizers used in the experiment. The observation on days taken to sprout initiation, number of sprouts per cutting and shoot diameter recorded at 60,90,120 DAP. The data recorded from the present studies were subjected to analysis by using standard method suggested by Panse and Sukhatme (1967) [18].

Results and Discussion

1. Days taken to sprout initiation (open field)

Data collected on days taken to sprout initiation as influenced by media and biofertilizers and their interaction under open field are presented in Table 1. Biofertilizer combinations contained Azotobacter + PSB + VAM (B_5) showed significantly less (28.52 days) time for sprout initiation and it is followed by Azotobacter (B_2) (29.96 days), PSB (B_3) (32.27 days), VAM(B_4) (33.02 days), AMC (B_6) (34.05 days), whereas control (B_1) has taken comparatively more (35.94 days) time for sprout initiation. The data showed that dragon fruit cuttings recorded minimum number of days to initial sprouting (30.48 days) in the rooting media, M_2 (soil + cocopeat + vermicompost) compared to M_1 (soil + cocopeat + FYM) (34.31 days). In the interaction of media and biofertilizers, media containing soil +cocopeat + vermicompost inoculated with biofertilizers Azotobacter + PSB + VAM (B_5M_2) showed less time (27.63 days), which was on par with B_2M_2 (27.75 days) followed by (B_5M_1) (29.42 days) and more no of days was recorded in B_1M_1 (37.61 days).

2. Days taken to sprout initiation (shade net)

Data Analysed on days taken to sprout initiation as influenced by media and biofertilizers and their interaction under shade net are presented in Table 1. Biofertilizer combinations with Azotobacter + PSB + VAM (B_5) demonstrated significantly less (33.11 days) time for sprout initiation, followed by Azotobacter (B_2) (33.85 days), PSB (B_3) (35.88 days), VAM (B_4) (36.84 days), and AMC (B_6) (38.40 days), while control (B_1) has taken comparably more (41.16 days) time for sprout initiation. It was observed that cuttings of dragon fruit were found to have a shorter time to their first sprouting (34.28 days) in rooting media M_2 (soil + cocopeat + vermicompost) than M_1 (soil + cocopeat + FYM) (38.80 days). When media and biofertilizers interacted, media including soil + cocopeat + vermicompost inoculated with biofertilizers Azotobacter + PSB + VAM (B_5M_2) showed less time (30.47 days), which was on par with B_2M_2 (31.19 days), followed by (B_3M_2) (33.44 days), and maximum no of days were recorded in B_1M_1 (42.63 days). Earliest sprout initiation was observed under Azotobacter + PSB +VAM. This may be due to increase level of plant growth regulators in the cutting. Therefore, the physiological processes involved in rooting and sprouting of cuttings were completed earlier as a result of the increased amount of auxins (PGR's). Additionally, according to Slankis (1973) [15], biofertilizer raised the concentration of plant growth regulators in the plants. Vermicompost has a higher nitrogen content and is vital for cellular processes, growth, electron transport, and photosynthetic rate. It is also a vital source of proteins needed for metabolic processes that occur during growth and development (Chaplin and Westwood, 1980) [6]. Media containing soil + sand + vermicompost might be provided congenial condition for early sprouting in cuttings. Similar results were reported by Awasthi *et al*. (2008) [3] in guava and Minz (2021) [10] in dragon fruit cuttings.

3. Number of sprouts per cutting (open field)

At 60, 90,120 DAP significant differences were observed on the parameter number of sprouts per cutting among different growing media, biofertilizers and interaction of media and biofertilizer under open field as depicted in the Table 2. Among different biofertilizers used highest (2.65, 3.71 and 5.50 at 60, 90 and 120 DAP respectively) number of sprouts per cutting was recorded in the media inoculated with the biofertilizers Azotobacter + PSB + VAM (B_5) followed by Azotobacter (B_2) (2.57,3.43 and 5.35 at 60, 90, 120 DAP respectively), PSB (B_3) (2.43, 3.28 and 5.24 at 60, 90 and 120 DAP respectively respectively),VAM(B_4) (2.35, 3.23 and 5.22 at 60, 90 and 120 DAP respectively), AMC(B_6) (2.23, 3.18 and 5.17 at 60, 90 and 120 DAP respectively).The minimum response was observed (2.12, 3.10 and 5.09 at 60, 90 and 120 DAP respectively) in the control (B_1). Number of sprouts per cutting was obtained highest (2.50, 3.37 and 5.30 at 60, 90 and 120 DAP respectively) in the media contained soil + cocopeat + vermicompost (M_2) and lowest (2.28, 3.28 and 5.22 at 60, 90 and 120 DAP respectively) number of sprouts was observed in soil + cocopeat + FYM (M_1).The combination of biofertilizers Azotobacter + PSB + VAM inoculated media of soil + cocopeat + vermicompost (B_5M_2) recorded highest (2.78, 3.85 and 5.62 at 60, 90 and 120 DAP respectively) number of sprouts per cutting. Whereas, lowest (1.96, 3.04 and 5.02 at 60, 90 and 120 DAP respectively) was recorded in the uninoculated media (B_1M_1).

4. Number of sprouts per cutting (Shade net)

As depicted in Table 3, at 60, 90, and 120 DAP, significant differences were found in the parameter number of sprouts per cutting among various growing media, biofertilizers, and interactions of media and biofertilizer under shade net. The media inoculated with the biofertilizers Azotobacter + PSB + VAM (B_5) recorded the highest number of sprouts per cutting (3.77, 4.65, and 6.56 at 60, 90, and 120 DAP respectively), followed by Azotobacter (B_2) (3.65,4.56 and 6.46 at 60, 90, and 120 DAP respectively), PSB (B_3) (3.56, 4.46, and 6.35 at 60, 90, and 120 DAP respectively), VAM(B_4) (3.43, 4.36 and 6.29 at 60, 90 and 120 DAP respectively), AMC(B_5) (3.25, 4.23 and 6.23 at 60, 90 and 120 DAP respectively). The control showed the least reaction (2.86, 3.82, and 5.33 at 60, 90, and 120 DAP, respectively) (B_1). At 90 DAP under shade net B_5 & B_2 were found statistically at par with each other under the present study. At 120 DAP B_5 & B_2 were also found statistically on par with each other. The media containing soil + cocopeat + vermicompost (M_2) produced the maximum number of sprouts per cutting (3.57, 4.50, and 6.31 at 60, 90, and 120 DAP, respectively), while soil + cocopeat + FYM produced the lowest number of sprouts (3.27, 4.20, and 6.09 at 60, 90, and 120 DAP, respectively) (M_1). The highest number of sprouts per cutting (3.92, 4.72, and 6.78 at 60, 90, and 120 DAP, respectively) were recorded in the biofertilizer mixture of Azotobacter + PSB + VAM inoculated media of soil + cocopeat + vermicompost (B_5M_2). The uninoculated media recorded the lowest (2.44, 3.42, and 5.22 at 60, 90, and 120 DAP, respectively) values (B_1M_1). At 90 DAP, biofertilizers Azotobacter + PSB + VAM applied media of soil + cocopeat + vermicompost (B_5M_2) showed maximum (4.72) number of sprouts, which was on par with B_2M_2 (4.65), B_3M_2 (4.58) and B_5M_1 (4.58) was observed. And at 120 DAP, B_5M_2 (6.78) was statistically on par with B_2M2 in the interaction (6.65). The ability to produce more sprouts is due to the use of biofertilizers, which assisted in the creation of beneficial hormones and growth factors, which in turn increased cell division, cell multiplication, and increased assimilation and accumulation of food resources. Similar results were observed in apple by Raman (2012) [13] and Abdullahi *et al.* (2012) [1] shea tree. Vermicompost enriched media enhanced plant photosynthetic capacity and biomass production, which in turn raised the number of leaves per seedling (Surakshitha and Kumar, 2015) [16]. This finding was supported by Kaur (2017) [9] in mango and Bhardwaj (2014) [4] in papaya cv. Red Lady.

5. Shoot diameter (cm) (open field)

The data pertaining to the diameter of shoot as influenced by media, biofertilizers and their interactions in an open field are presented in Table 4. The mixture applied with Azotobacter + PSB + VAM (B_5) recorded the largest shoot diameter (3.05, 3.15, and 3.23 cm at 60, 90 and 120 DAP, respectively), and it is followed by Azotobacter (B_2) (2.99, 3.11 and 3.17 cm at 60, 90 and 120 DAP respectively) PSB (B_3) (2.95,3.07 and 3.14 cm at 60, 90, and 120 DAP respectively), VAM(B_4) (2.92, 3.05 and 3.12 cm at 60, 90 and 120 DAP respectively), AMC(B_5) (2.87, 3.03 and 3.10 cm at 60, 90 and 120 DAP respectively), The uninoculated seedlings had the smallest shoot diameter (2.81, 2.93, 3.00 cm at 60, 90 and 120 DAP, respectively) (B_1) In biofertilizer treatments, B_5 and B_2 were statistically on par at 60 DAP and 120 DAP. Similarly, B_5 was statistically on par with B_2 and B_3 at 90 DAP, Soil + cocopeat + vermicompost (M_2) had the highest shoot diameter (2.96, 3.08, and 3.15 cm at 60, 90, and 120 DAP, respectively) and the lowest (2.90, 3.03, and 3.11 cm at 60, 90, and 120 DAP, respectively) in the media containing FYM (M_1). M_1 and M_2 were statistically on par at 120 DAP. The interaction between media and biofertilizers is found to be non-significant in terms of shoot diameter.

6. Shoot diameter (cm) (shade net)

Data on shoot diameter as influenced by media, biofertilizers, and their interactions under shade net are presented in Table 5. The combination of Azotobacter, PSB, and VAM (B_5) recorded the largest shoot diameter at 60, 90, and 120 DAP (3.16, 3.28, and 3.42 cm, respectively), followed by Azotobacter (B_2) (3.12, 3.25, and 3.40 cm, at 60, 90, and 120 DAP, respectively respectively), PSB (B_3) (3.11, 3.23, and 3.38 cm, at 60, 90, and 120 DAP, respectively respectively), VAM (B_4) (3.09, 3.22, and 3.30 cm, at 60, 90, and 120 DAP, respectively respectively)), AMC (B_5) (3.04, 3.19, and 3.23 cm, at 60, 90, and 120 DAP, respectively respectively), and then the control (B_1) (2.95, 3.11, and 3.23 cm, at 60, 90, and 120 DAP, respectively).At 60 DAP, B_5 was statistically on par with B_2 and B_3 in biofertilizer treatments. Similarly, at 90 and 120 DAP, B_5 was statistically on par with B_2, B_3, and B_4. Data revealed that in growing media M_2 (soil + cocopeat + vermicompost) dragon fruit cuttings recorded highest shoot diameter (3.12, 3.25 and 3.38 cm at 60, 90, and 120 DAP, respectively) when compared to the cuttings grown in M_1 (soil + cocopeat + FYM) media (3.04, 3.18, and 3.32 cm at 60, 90, and 120 DAP, respectively). At 120 DAP, M_1 and M_2 were statistically on par with each other. Regarding shoot diameter, it is discovered that the interaction between media and biofertilizers is not significant. Increased shoot diameter was due to the uptake of NPK by the plants which was improved by the biofertilizers used. The results of Verma *et al.* (2019) [17] in dragon fruit and Rana *et al.* (2020) [14] research on sweet orange were in accordance with these findings. The beneficial nutrients provided by the media, according to Borah *et al.* (1994) [5], caused the diameter of the seedlings to increase. Both Ganeshnauth *et al.* (2018) [7] study on pepper plants and Karagöz *et al.* (2019) [8] study on gladiolus found similar results.

Table 1: Effect of media and biofertilizers on days taken to sprout initiation in dragon fruit cuttings under open field and shade net conditions.

Biofertilizers (B)	Days taken to sprout initiation					
	Open field			Shade net		
	Media(M)					
	M_1	**M_2**	**Mean**	**M_1**	**M_2**	**Mean**
B_1	37.61	34.27	35.94	42.63	39.70	41.16
B_2	32.17	27.75	29.96	36.52	31.19	33.85
B_3	35.17	30.57	32.87	38.31	33.44	35.88
B_4	35.24	30.79	33.02	39.55	34.13	36.84
B_5	29.42	27.63	28.52	35.75	30.47	33.11
B_6	36.22	31.89	34.05	40.03	36.76	38.40
Mean	34.31	30.48		38.80	34.28	
Factors	S.Em±		CD @ 5%	S.Em±		CD @ 5%
Biofertilizers (B)	0.27		0.78	0.29		0.83
Media (M)	0.15		0.45	0.16		0.48
B x M	0.38		1.10	0.40		1.18

Table 2: Effect of media and biofertilizers on number of sprouts per cutting in dragon fruit under open field conditions.

Biofertilizers (B)	No of sprouts per cutting								
	Open field								
	60 DAP			90 DAP			120 DAP		
	Media (M)								
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
B1	1.96	2.27	2.12	3.04	3.16	3.10	5.02	5.16	5.09
B2	2.46	2.68	2.57	3.43	3.43	3.43	5.32	5.37	5.35
B3	2.32	2.54	2.43	3.25	3.32	3.28	5.24	5.24	5.24
B4	2.29	2.40	2.35	3.23	3.24	3.23	5.22	5.22	5.22
B5	2.53	2.78	2.65	3.58	3.85	3.71	5.38	5.62	5.50
B6	2.12	2.34	2.23	3.14	3.22	3.18	5.17	5.17	5.17
Mean	2.28	2.50		3.28	3.37		5.22	5.30	
Factors	S.Em±		CD @ 5%	S.Em±		CD @ 5%	S.Em±		CD @ 5%
Biofertilizers (B)	0.02		0.06	0.03		0.09	0.03		0.09
Media (M)	0.01		0.03	0.02		0.05	0.02		0.05
B x M	0.03		0.08	0.04		0.12	0.04		0.12

Table 3: Effect of media and biofertilizers on number of sprouts per cutting in dragon fruit under shade net conditions.

Biofertilizers (B)	No of sprouts per cutting								
	Shade net								
	60 DAP			90 DAP			120 DAP		
	Media (M)								
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
B_1	2.44	3.27	2.86	3.42	4.22	3.82	5.22	5.44	5.33
B_2	3.58	3.72	3.65	4.47	4.65	4.56	6.26	6.65	6.46
B_3	3.44	3.67	3.56	4.33	4.58	4.46	6.26	6.45	6.35
B_4	3.32	3.53	3.43	4.26	4.46	4.36	6.25	6.32	6.29
B_5	3.62	3.92	3.77	4.58	4.72	4.65	6.34	6.78	6.56
B_6	3.19	3.31	3.25	4.11	4.35	4.23	6.21	6.25	6.23
Mean	3.27	3.57		4.20	4.50		6.09	6.31	
Factors	S.Em±	CD @ 5%		S.Em±	CD @ 5%		S.Em±	CD @ 5%	
Biofertilizers(B)	0.03	0.10		0.05	0.13		0.05	0.15	
Media(M)	0.02	0.06		0.03	0.08		0.03	0.09	
B x M	0.05	0.14		0.06	0.19		0.07	0.21	

Table 4: Effect of media and biofertilizers on Shoot diameter (cm) in dragon fruit cuttings under open field conditions

Biofertilizers (B)	Shoot diameter (cm)								
	Open field								
	60 DAP			90 DAP			120 DAP		
	Media (M)								
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
B_1	2.77	2.85	2.81	2.90	2.95	2.93	2.98	3.02	3.00
B_2	2.95	3.03	2.99	3.08	3.14	3.11	3.14	3.19	3.17
B_3	2.92	2.97	2.95	3.04	3.09	3.07	3.12	3.16	3.14
B_4	2.89	2.94	2.92	3.03	3.07	3.05	3.10	3.15	3.12
B_5	3.02	3.07	3.05	3.11	3.19	3.15	3.19	3.26	3.23
B_6	2.84	2.89	2.87	3.01	3.05	3.03	3.08	3.13	3.10
Mean	2.90	2.96		3.03	3.08		3.11	3.15	
Factors	SE m±	CD@5%		SE m±	CD@5%		SE m±	CD@5%	
Biofertilizers (B)	0.028	0.080		0.028	0.081		0.025	0.073	
Media (M)	0.016	0.046		0.016	0.047		0.015	0.042	
B x M	0.039	NS		0.039	NS		0.036	NS	

(NS-Non-Significant)

Table 5: Effect of media and biofertilizers on Shoot diameter (cm) in dragon fruit cuttings under shade net conditions

Biofertilizers (B)	Shoot diameter (cm)								
	Shade net								
	60 DAP			90 DAP			120 DAP		
	Media (M)								
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
B_1	2.90	2.99	2.95	3.08	3.14	3.11	3.19	3.26	3.23
B_2	3.09	3.15	3.12	3.22	3.28	3.25	3.36	3.44	3.40
B_3	3.08	3.14	3.11	3.20	3.26	3.23	3.35	3.41	3.38
B_4	3.06	3.12	3.09	3.19	3.25	3.22	3.33	3.40	3.36

B_5	3.10	3.21	3.16	3.23	3.34	3.28	3.38	3.46	3.42
B_6	3.00	3.08	3.04	3.18	3.21	3.19	3.27	3.34	3.30
Mean	3.04	3.12		3.18	3.25		3.32	3.38	
Factors	SE m±	CD @ 5%		SE m±	CD @ 5%		SE m±	CD @ 5%	
Biofertilizers (B)	0.023	0.067		0.024	0.070		0.039	0.115	
Media (M)	0.013	0.039		0.014	0.040		0.023	0.066	
B x M	0.033	NS		0.034	NS		0.056	NS	

(Ns-Non-Significant)

M_1: Soil + Cocopeat + Farm yard manure
M_2: Soil + Cocopeat + Vermicompost
B_1: Control
B_2: Azotobacter
B_3: Phosphorous solubilizing bacteria (PSB)
B_4: Vascular Arbuscular Mycorrhizal (VAM)
B_5: Azotobacter + PSB + VAM
B_6: Arka microbial consortium

Conclusion

Experimental results revealed that the media containing soil, cocopeat and vermicompost with biofertilizers of Azotobacter + PSB + VAM (B_5M_2) recorded minimum number of days taken to sprout initiation (27.63 days) under open field than shade net conditions (30.47 days) and also maximum number of sprouts (3.92, 4.72, 6.78 at 60, 90 and 120 days respectively) under shade net than open field conditions. But in shoot diameter the interaction between media and biofertilizers shows non-significant both in open field and shade net conditions.

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