J. Hortic. Sci.
Vol. 19(1), 2024

https://doi.org/10.24154/jhs.v19i1.2633

Short Communication

Investigation on promising progenies of Dragon fruit (*Hylocereus* spp.)

Karunakaran G.[1], Sakthivel T.[2], Arivalagan M.[3], Lakshmana Reddy D.C.[4], Tripathi P.C.[5] and Kalaivanan D.[6]

[1&2]Division of Fruit Crops, [3&4]Division of Basic Sciences, [6]Division of Natural Resource Management
ICAR-Indian Institute of Horticultural Research, Bengaluru - 560089, India
[5]Horticultural Science Division, Indian Council of Agricultural Research, New Delhi - 110012, India
Corresponding author Email: Ganesan.Karunakaran@icar.gov.in

ABSTRACT

Dragon fruit (*Hylocereus* spp.) is an exotic vine cactus, rich in vitamin C and antioxidants, commonly known as 'pitaya' is a weather resilient crop. In order to develop superior varieties, a large number of progenies obtained from open pollinated seedling of cvs. Hiryur red, Vietnam pink and Vietnam red were raised and evaluated. To broaden the genetic base with desired traits, seeds of Hirehalli red and Hirehalli white were irradiated with gamma rays (500, 600 and 700 Gy), EMS (2.25, 2.5 and 2.75%) and sodium azide (0.04, 0.05 and 0.06%) and evaluated for horticultural traits. Three elite progenies such as CHESH-D1, CHESH-D2, and CHESH-D3 were obtained from open pollinated seedlings of cvs. Hiryur red, Vietnam red and Vietnam pink, respectively, and one EMS (2.5%) treated mutant i.e. CHESH-DE were selected based on their morphological and yield traits. The selection CHESH-D1 performed superior with highest fruit weight (507.71 g) and yield (39.50 kg/ pole) compared to CHESH-D2 and CHESH-D3. The biochemical characters namely, TSS (15.35 ^{o}B), total sugars (5.95 g), reducing sugars (4.91 g) and betalains (21.2 mg BCE) were recorded highest in CHESH-D2, and one EMS (2.5%) treated mutant from cv. Hirehalli red showed better adaptability and dwarfness. These elite progenies are at final stage of performance assessment to be released as variety in India.

Keywords: Betalains, dwarfness, genetic variability, mutation, reducing sugar

INTRODUCTION

Dragon fruit (*Hylocereus* spp.) is a perennial climbing cactus, commonly known as Pitaya, has recently drawn much attention among the Indian growers owing to its high value premium fruits as well as numerous health benefits. Pitaya is native of southern Mexico, Guatemala and Costa Rica and it was introduced to India during late 90's, and the area under its cultivation is drastically increasing (Karunakaran et al., 2019). Its commonly cultivated species *viz.*, *Hylocereus undatus* has white pulped fruits and pink skin and *Hylocereus polyrhizus* has red pulped fruits with pink skin (Arivalagan et al., 2021). Consumers are attracted by the exotic nature of dragon fruit with their bright red skin and varying pulp colour. The fruits are rich in fibre, polyphenols, sugars, vitamins, phytochemicals, amino acids and betalain pigment (Al-Mekhlafi et al., 2021).

The diversity of *Hylocereus* is least exploited in recently laid orchards in India (Pavithra et al., 2023). Currently, available varieties of dragon fruit which have been planted in farmers' field are primary introductions from other countries. Till date, there are no findings on crop improvement programme of dragon fruit for varietal evaluation in India. Recent crop improvement approaches through introduction and selection in Taiwan and Vietnam has resulted in a few self-fertile and productive pitaya varieties (Zee et al., 2004). In India, red/pink pulped dragon fruits are preferred by the growers due to their better adaptability to wide range of climate and higher yield potential. Distant hybridization favours the transfer of genes between genetically distant species of plants. It is majorly practised when there are no sources of genes coding for desirable traits available within a certain plant species and to obtain superior hybrid genotypes. In this background, a systematic baseline assessment on Crop improvement through selection, hybridization and mutation was takenup simulatneously to broaden genetic base and to develop a variety for wider adaptability, dwarfness, early flowering, biotic and abiotic stress tolerance, improved fruit quality (attractiveness, shelf-life), or higher levels of bioactive compounds in the fruit.

The systematic study of dragon fruit crop improvement was initiated at ICAR-Indian Institute of Horticultural Research, Experimental Farm, Hirehalli (Latitude: 28^0 38', Longitude: 77^0 11'E and Altitude: 842 m above mean sea level), Tumakuru, Karnataka, India during 2018-2022 by collecting the prevailing genetic diversity from their respective growing areas. The breeding work was carried out by raising large number of open pollinated population of cvs. Hiriyur red, Vietnam pink and Vietnam red. The fruit samples were randomly collected from each seedling of three cultivars, were used as base material for collection of seeds followed by raising a population of individual cultivar for evaluation and characterization.

Induced mutation can broaden the genetic base and helps to develop population with desired traits. Hence, a trial was taken up by irradiating seeds of cvs. Hirehalli red and Hirehalli white with gamma rays (500, 600 and 700 Gy), chemical mutagens (EMS 2.25, 2.5 and 2.75%) and sodium azide (0.04, 0.05 and 0.06%). The treated seeds were washed under running water for 1 hour to remove the residues. The untreated seeds were sown as control. The M_2 population was raised through cuttings and evaluated for horticultural traits. The elite progenies such as CHESH-D1, CHESH-D2, and CHESH-D3 from open pollinated progenies of cvs. Hiryur red, Vietnam red and Vietnam pink, respectively, and one mutant i.e. CHESH-DE treated with EMS (Ethyl Methane Sulfonate) at 2.5% were identified (Fig. 1). The experiment was laid out in randomized block deisgn with four treatments replicated five times.

For biochemical analysis, around 5 g of sample of each dragon fruit was extracted in 10 mL of aqueous ethanol using an ultrasonic bath for 30 minutes in dark at 60°C. After centrifugation at 7000 rpm for 15 min, the supernatant was collected. Then re-extraction of residue and the supernatant thus collected was pooled and ethanol from the pooled extract was removed using flash evaporator. Further, the ethanol free extracts were re-suspended in 5 mL of water and stored at -20 °C until further analysis. The extract was used to determine the quality traits following standard methods (Arivalagan et al., 2021). Total soluble sugar content in the extract was estimated using phenol-sulphuric acid method (DuBois et al., 1956), and reducing sugar content was determined using Nelson-Somogyi's method (Somogyi, 1952). The total betalains were determined as per Castellar et al. (2003). FRAP assay was carried out for anti-oxidant activity (Benzie & Strain, 1996). The collected data were analyzed using OPSTAT software (Sheron et al., 1998).

In the present study, promising selections were made from open pollinated progenies of three cultivars showed variation in terms of morphological and biochemical traits (Table 1 & 2). Considering pomological traits as an important variation, the three dragon fruit progenies were categorized *i.e.*, the selection CHESH-D1 resulted in round shaped fruits with red pulp having dense bracts, CHESH-D2 had oval fruits with red pulp, while, CHESH-D3 had fruits of round shape with pink pulp; medium dense bracts on the surface. The EMS (2.5%) mutant i.e. CHESH-DE yielded fruits with medium number of bracts, smooth surface, round fruits having pale pulp with pink blush. These differences among the pulp colour of the progenies might be due to parental character or natural variation occured during outcrossing. According to the researchers, there are number of dragon fruit species, which vary among themselves for fruit pulp colour (pink, red, white, purplish-red, yellow *etc.*). Upon outcrossing, the variation may be inherited in the progenies for pulp colour (Hamidah et al.,

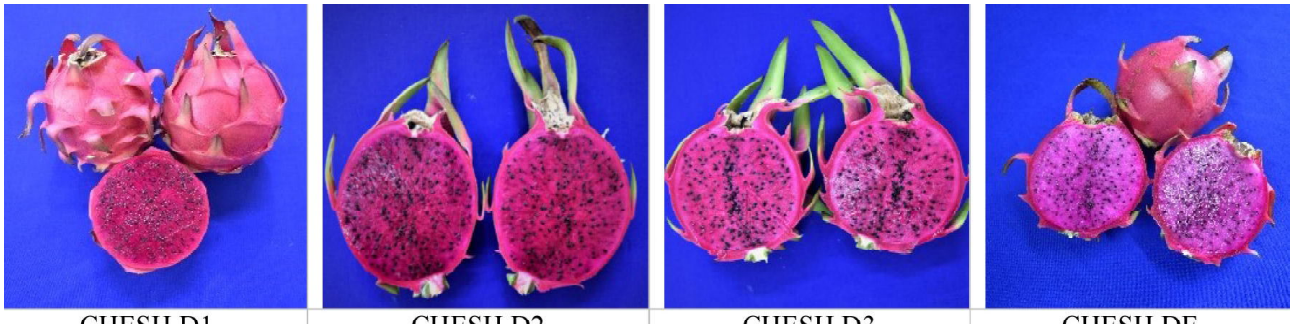

Fig. 1: Cross section of elite progenies of Dragon fruit

Table 1 : Evaluation of open pollinated and mutant dragon fruit progenies for morphological traits

Parameter	Days from bud initiation to anthesis	Anthesis to maturity (first wave)	Bud length during anthesis (cm)	Bud width during anthesis (cm)	Length of pericarpal (cm)	Length of perianth (cm)	Style length (cm)	No. of stigma lobes	No. of bracts	Length of apical bract (cm)	Width of basal bract (cm)	Apical cavity (cm)
CHESH-D1	23.00	34.80	33.63	5.89	12.91	20.72	26.24	29.31	28.59	5.70	1.95	1.05
CHESH-D2	22.63	33.88	28.35	6.05	12.72	17.05	26.88	25.98	23.11	8.85	2.73	1.91
CHESH-D3	22.38	34.63	28.64	7.00	10.24	20.19	28.11	25.14	24.96	8.42	2.57	1.98
CHESH-DE	23.38	35.38	27.94	6.02	10.16	17.78	21.88	21.75	16.63	5.98	2.20	1.68
SEm±	0.59	0.74	0.84	0.07	0.50	0.45	0.32	0.45	1.29	0.27	0.14	0.11
CD at 5%	NS	NS	1.82	0.16	1.10	0.98	0.69	0.99	2.82	0.60	0.30	0.25
CV (%)	4.05	3.35	4.46	1.89	6.91	3.77	1.94	2.81	8.83	5.96	9.20	10.80

Table 2 : Evaluation of open pollinated and mutant of dragon fruit progenies for fruit yield and quality traits

Parameter	Fruit Shape	Pulp colour	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Pulp weight (g)	Skin weight (g)	Skin thickness (mm)	Fruit yield/pole (kg)	pH	TSS (°B)	Total sugar (g)	Reducing sugar (g)	Betalains (mg BCE)	Antioxidant potential (µmol TE)
CHESH-D1	Round	Red	507.71	16.73	15.42	404.52	103.19	2.86	39.50	5.37	14.50	5.06	4.82	20.40	467
CHESH-D2	Oval	Red	442.25	15.45	9.25	353.74	88.51	4.12	19.00	5.04	15.35	5.95	4.91	21.20	412
CHESH-D3	Round	Pink	422.00	18.05	14.99	267.85	154.15	3.14	22.00	5.32	14.00	5.45	4.21	19.00	399
CHESH-DE	Round	White pulp with pink shade	379.18	18	7.99	260.11	119.07	3.02	17.10	5.35	14.80	5.75	4.66	18.57	388
SEm±	-	-	56.98	1.47	1.04	47.20	21.74	0.50	12.36	1.77	1.08	1.78	1.62	1.07	1.15
CD at 5%	-	-	26.15	0.68	0.48	21.66	9.98	0.23	6.18	0.86	0.50	0.49	0.81	0.44	0.21
CV (%)	-	-	10.69	8.32	7.39	12.15	14.51	9.12	1.04	3.61	5.15	13.21	14.92	8.49	3.90

BCE: Betacyanin equivalent; TE: Trolox equivalent

2017). The descriptive characterization of progenies from crosses showed a wide variability for many morpho-agronomic traits in olive (León et al., 2004a; Avidan et al., 2012; Klepo et al., 2013).

Statistical analysis revealed that there was no significant difference among the progenies for number of days taken from bud initiation to anthesis and anthesis to maturity. On an average, the days taken from initiation to anthesis (22 to 23 days) and anthesis to maturity (34 to 35 days). Among these elite progenies, the maximum bud length during anthesis (33.63 cm), pericarpel length (12.91 cm), length of perianth (20.72 cm), number of stigma lobes (29.31) and bracts (28.59), fruit weight (507.71 g), breadth (15.42 cm), pulp weight (404.52 g), skin weight (103.19 mm), fruit yield per pole (39.50 kg), pH (5.37) and antioxidant content (467 µmol TE) were recorded in CHESH-D1. The highest number of stigma lobes (29.31), maximum width of basal bract (2.73 cm), skin thickness (4.12 mm), better biochemical constituents *viz.*, TSS (15.35 ^{o}B), total sugars (5.95 g), reducing sugars (4.91 g) and betalains (21.2 mg BCE) were recorded highest in CHESH-D2. The selection CHESH-D3 recorded maximum bud width (7.00 cm), style length (28.11 cm) and apical cavity (1.98 cm).

The variation in the elite progenies might be due to the genotypic characters of pollen source of unknown parent associated with environmental factors and agronomic practices. The results are in conformity with the findings of Nieddu et al. (2006). Further, Kammapana et al. (2013) reported that the differences in fruit characters might be due to physiological changes at different phases of dragon fruit development.

The mutant progeny CHECH-DE beared fruits weighing (379.18 g) with pulp weight (260.11 g), TSS (14.80 ^{o}B), total sugar (5.75 g), betalains (18.57 mg BCE) and antioxidant potential (388 µmol TE). Lower dosage and short duration of EMS treatment showed positive effect on plant height, biomass, mineral uptake and biochemical parameters (Shukla et al., 2023). The improvement in fruit quality with lower concentration of EMS may be attributed to the fact that EMS at a lower dose induces hormones which are responsible for yield and quality. Physiological changes in mutant fruits occur due to ethyl methane sulphonate mutagen treatment (Kumar et al., 2017).

CONCLUSION

Dragon fruit holds greater economic value due to its capacity to promote human wellbeing. Extensive trials were initiated to develop new varieties with promising horticultural traits. One such attempt was made towards crop improvement, resulting in three promising open pollinated types and a mutant progeny. Upon comparative study, CHESH-D1 showed better performance in the field with highest individual fruit and pulp weight & photo insensitive nature, CHESH-D2 has higher TSS with total sugar content, CHESH-D3 fruits has medium bracts on surface and mutant progeny CHESH-DE is marked for variant pulp colour, better performance in terms of adaptability and dwarfness. Further, this elite progeny will be released for commercial cultivation, which is notably a first attempt towards varietal development of dragon fruit in India.

REFERENCES

Al-Mekhlafi, N. A., Mediani, A., Ismail, N. H., Abas, F., Dymerski, T., Lubinska-Szczygeł, M., Verasilp, S., & Gorinstein, S. (2021). Metabolomic and antioxidant properties of different cultivars and origins of dragon fruit. *Microchemical Journal, 160*, 105. https://doi.org/10.1016/j.microc.2020.105687.

Arivalagan, M., Karunakaran, G., Roy, T. K., Dinsha, M., Sindhu, B. C., Shilpashree, V. M., Satisha, G. C., & Shivashankara. K. S. (2021). Biochemical and nutritional characterization of dragon fruit (*Hylocereus* species). *Food Chemistry, 353*, 129426. https://doi.org/10.1016/j.foodchem.2021.129426.

Avidan, B., Meni, Y., & Lavee, S. (2012). Inheritance potential of fruit quality traits within olive (*Olea europaea* L.) cultivars. *Acta Horticulturae, 949*, 105–111. https://doi.org/10.17660/ActaHortic.2012.949.14.

Benzie, I. F. F. & Strain, I. J. (1996). Ferric reducing ability of plasm (FRAP) as a measure of antioxidant power. The FRAP assay. *Analytical Biochemistry*, 239, 70-76.

Castellar, R., Obon, J. M., Alacid, M., & Fernández Lopez, J. A. (2003). Colour properties and stability of betacyanins from Opuntia fruits. *Journal of Agricultural and Food Chemistry*, *51*(9), 2772-2776. https://doi.org/10.1021/jf021045h.

DuBois, K. M., Gilles, A., Hamilton, J. K., Rebers, P. A., & Smith, F. (1956) Colorimetric method for determination of sugars and related substances. *Analytical Chemistry*, *28*, 350–356. http://dx.doi.org/10.1021/ac60111a017.

Hamidah, H. Tsawab, & Rosmanida. (2017). Analysis of *Hylocereus* spp. diversity based on phenetic method. AIP conference proceedings *1854*, 020012, Indonesia. https://doi.org/10.1063/1.4985403.

Kammapana, L., Buanong, M., Techavuthiporn, C., Jitareerat, P., Wongs-Aree C., Yamauchi N., & Srilaong, V. (2013). SEM studies on the morphology of 'white pulp' dragon fruit. *Acta Horticulturae*, *989*, 85-90. https://doi.org / 10.17660 /Acta Hortic.2013. 989. 8.

Karunakaran, G., Arivalagan, M., & Sriram, S. (2019). Dragon fruit country report from India. In: Workshop "Dragon fruit network: Marketing and the whole value chain" and steering committee meeting. Organized by FFTC and VAAS-SOFRI at Vietnam, 105-112 p.

Klepo, T., De la Rosa, R., Satovic, Z., Leon, L., & Belaj, A. (2013). Utility of wild germplasm in olive breeding. *Scientia Horticulturae*, *152*, 92–101. https://doi.org/10.1016/J.SCIENTA.2012.12.010.

Kumar, M., Kumar, M., & Veena Chaudhary. (2017). Effect of seed treatment by ethyl methane sulphonate (EMS) on fruit quality of papaya (*Carica papaya* L.) cv. Pusa Dwarf. *International Journal of Applied Chemistry, 13*(1), 145-150. http://dx.doi.org/10.5958/2230-7338.2016.00012.4.

Leon, L., Rallo, L., Del Rio, C., & Martin, L. M. (2004a). Variability and early selection on the seedling stage for agronomic traits in progenies from olive crosses. *Plant Breeding, 123*, 73–78. https://doi.org/10.1046/j.0179-9541.2003.00920.x.

Nieddu, G., Chessa, I., & Barberis, A. (2006). Characterization of seedlings obtained from open pollinated 'Gialla' cactus pear (*Opuntia ficus-indica*). Proc. Vth International. Congress on Cactus Pear and Cochineal. *Acta Horticulturae*, *728*. https://doi.org/10.17660/ActaHortic.2006.728.13.

Pavithra, G., Karunakaran, G., Sivaramakrishna, V. N. P., Sakthivel, T., Arivalagan, M., & Lakshmana Reddy D. C. (2023). Variability of morphological characters in the hybrid progenies of dragon fruit. *The Pharma Innovation Journal*, *12*(7), 2426-2429.

Sheoran, O. P., Tonk, D. S., Kaushik, L. S., Hasija, R. C., & Pannu, R. S. (1998). Statistical software package for agricultural research workers. Department of Mathematics Statistics. CCS HAU, Hisar (pp. 139-143).

Shukla K. K., Kishore, K., Ankita Sahu, Pradhan, K., Nayak, R. K., & Dash, S. N. (2023). Influence of Chemical mutagen on germinability, growth and biochemical attributes of dragon fruit (*Selenicereus undatus*). *National Academy Science Letters, 46*(4): 281–284. https://doi.org/10.1007/s40009-023-01259-2.

Somogyi, M. (1952). Notes on sugar determination. *Journal of Biological Chemistry*, *195*, 19-23.

Zee, F., Yen, C. R., & Nishina, M. (2004). Pitaya (dragon fruit, strawberry pear). *Fruits and Nuts*, *9*, 1-3.

(Received : 04.3.2024; Revised : 03.5.2024; Accepted : 06.5.2024)