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Influence of length of cutting on root and shoot growth in dragon fruit (*Hylocereus undatus*)

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ABSTRACT

An experiment was conducted at ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Vasad, Gujarat during 2016–17 to observe the influence of different cuttings lengths on root and shoot growth in dragon fruit for optimizing/standardizing the length of cutting for diverse environmental/edaphic conditions. Presently, farmers are cultivating dragon fruit in harsh climates and degraded lands, where establishment of plants is challenging. Hence, quality planting material is prerequisite for achieving success. The results showed that length of new shoots, dry weight of shoots and fresh weight of roots were higher when 35–40 cm long cutting was used for multiplication at 30 days of planting (DAP), whereas increase in fresh weight of shoots, number of 1st order roots and length of longest 1st order root were highest when 20–25 cm long cuttings were utilized. However, at 60 DAP, length of new shoots (33.06 cm), dry weight of shoots (32.56 g), number of 1st order roots (7.25) and length of longest 1st order root (32.37 cm), fresh and dry weight of roots (12.52 g and 4.75 g respectively) recorded highest in larger cuttings, i.e. above 30–35 cm cutting length, whereas fresh weight of shoots was highest in 25–30 cm cutting length while least values were observed in smaller cuttings. Therefore, though dragon fruit is propagated with ranges of cutting lengths, larger cuttings (40±5 cm) are recommended for better growth and development.

Key words: Cutting, Multiplication, Planting material, Rooting, Shoot length

Dragon fruit [(*Hylocereus undatus* (Berger) Britton & Rose] is rich in several vitamins, minerals and essential fatty acids (Morton 1987) and a good source of betalins (Vinas *et al.* 2012). Due to its high industrial and medicinal importance and economic potential it is being taken up in cultivation worldwide (Ortiz-Hernandez and Carrillo-Salazar 2012). In India, it has been recently introduced and cultivation is being taken up in different parts. Due to its hardy nature, less water and fertilizer requirement, it could be taken up in poor soils and harsh climatic conditions with little care. Dragon fruit can be propagated by seed and/or cutting, but the propagation by cutting is most common and easy practice for which entire segment of cladode or cuttings varies from 10-60 cm length are used (Zee *et al.* 2004).

Length of cuttings plays an important role in rooting and it is key variable determining the rooting success (Leakey 2004). Further, cutting length optimization is very essential as longer cuttings could result in wastage of propagation material whereas shorter might lead to poor rooting and establishment. Further, rooting varies with length of cutting used for propagation from species to species. For instance; higher length of cutting resulted into greater success in *Tinospora crispa* (Aminah *et al.* 2015). On the contrary, shorter cuttings (10 cm) produced higher rooting (15 and 20 cm) in *Larix kaempferi* (Wang *et al.* 1997). Whereas, intermediate cuttings also resulted into better rooting (Naidu and Jones 2017). However, no significant effect of cutting length on the rooting was reported in *Allanblackia floribunda* (Atangana and Khasa 2008).

In India, farmers are multiplying the dragon fruit with ranges of cladode segment or cutting lengths, as no standardized length of cladode is recommended. The use of below standard cutting length will result in poor success during establishment. Keeping above facts in mind, it is essential to observe the influence of different cuttings lengths on root and shoot growth in dragon fruit which will be crucial for standardizing the length of cutting for diverse environmental/edaphic conditions.

MATERIALS AND METHODS

The present study was carried out during the months of September-November, 2016–17 at the ICAR-Indian Institute of Soil and Water Conservation Research Centre, Vasad, Gujarat (latitude and longitude of 73.08 °E and 22.46 °N and 35 m amsl). The average monthly maximum temperature during the experiment ranged from 32.8°

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(September) to 32.2° (November), whereas average monthly minimum temperature ranged from 22.6° (September) to 11.1° (November). The mean monthly relative humidity ranged from 91.7–92.9% during the experimental period. The healthy and disease free cuttings of different lengths were taken and kept in shade for callus formation for a week. Before beginning of the experiment the cuttings were made of various lengths, viz. 10–15 cm, 15–20 cm, 20–25 cm, 25–30 cm, 30–35 cm, 35–40 cm and 40–45 cm. The soil was sandy loam in texture (*Fluventic Ustochrepts*), well drained in nature, it was taken from ravine bed. The soil organic carbon, soil *p*H and electrical conductivity of the soil used were 0.3%, 7.60 and 0.22 dS/m respectively, and soil bulk density was 1.52 g/cm^3, whereas infiltration capacity was 2.1 cm/h. The cuttings were planted in polythene bags (30 × 12 cm) filled with growing media (ravine bed soil and FYM @2:1 ratio) with uniform planting depth (about 6 cm) and irrigated immediately and kept in shade net having 50% shade. Cuttings were irrigated twice in a week and proper moisture was ensured throughout the experiment. As a plant protective measure chloropyriphos and bavistin @0.1% each were applied after two weeks of planting to avoid the termite and fungal infections. The cuttings were uprooted at 30 and 60 days after planting (DAP) and washed immediately with tap water to remove the adhered soil and cleaned with tissue paper. After measuring fresh weight of shoots and roots, length of new shoots and roots, cuttings were transferred to hot air oven (70°C) for drying until constant weight to assess the biomass on the dry weight basis. The experiment was conducted in Completely Randomised Design (CRD) with 7 treatments and 4 replications. Statistical analysis was performed using analysis of variance (ANOVA) followed by Tukey's test. Analyses were performed using SPSS (16.0) software. P ≤0.05 was considered as significant.

RESULTS AND DISCUSSION

The results at 30 DAP showed that treatments did not reach to the level of significance in producing new shoots and growth of new shoots. However, highest increase in fresh weight of shoots (70.23%) was observed with 20–25 cm long cuttings, significantly different from rest of treatments except the cuttings of 10–15 cm and 15–20 cm, contrary to this, the highest dry weight of shoots (27.80 g) was seen in 35–40 cm long cuttings which was statistically similar to those obtained from 40–45 cm long cuttings but found statistically significant from other treatments (Table 1). Fresh weight of the plant indicates water and assimilate present in the plant tissues, whereas dry weight gives actual assimilates. Cuttings with the length greater than 35 cm had more dry matter compared to smaller cuttings and were able to synthesize higher photosynthates or store more carbohydrates and this also might be because larger cuttings could have managed to maintain the balance between photosynthesis and transpiration (Leakey and Coutts 1989) and source-sink interaction (Gifford *et al.* 1984), very much essential for rooting.

The highest number of 1st order roots (7.50) at 30 DAP was recorded in 20–25 cm long cuttings, which was found statistically similar to 35–40 cm long cuttings. Further, longer 1st order roots (22.38 cm) were also witnessed in 20–25 cm long cuttings with significant difference from rest of the treatments (Table 2). Carbohydrates are considered as principle source of energy for the rooting (Philipson 1988) and thus root initiation and growth is largely dependent upon amount of photosynthates transferred from the source. The treatment with 20–25 cm long cuttings could have managed to transport more carbohydrates for formation of new roots which might have resulted in production of longer and higher number of roots. The highest fresh weight of roots (7.82 g) was observed with 35–40 cm long cuttings that differed significantly from other treatments (Table 2). Similar results were observed in case of dry weight of roots (Table 2). In plants, the net exporters of photosynthates are called as source, whereas net importers are the sink (Ho 1988) and the relationship between sources and sink plays major role in growth and development of plant. The dependency of shoot upon root and vice versa occurs throughout the plant life (Kozlowski 1971) and synergetic role between them greatly influence and regulates overall plant growth and development (Davies and Zhang 1991). The results of dry weight of shoot and fresh and dry weight of root at 30 DAP have shown that the cuttings with length 35–40 cm resulted in higher food reserve on dry basis and higher fresh and dry weight of roots, this indicates establishment of source-sink link in these cuttings which might have resulted in transportation of food reserve to the sink simultaneously with the production of new photosynthates. Thus, these results show significant influence on length of cutting on

Table 1 Effect of different length of cuttings on various shoot parameters of dragon fruit at 30 DAP

Cutting length (cm)	No. of new shoots	Shoot length (cm)	Increase in shoot weight (%)	Dry weight of shoot (g)
10-15	0.84 (0.25) ± 0.13a	1.05 (0.95) ± 0.34 a	68.66 ± 1.24a	4.05 ± 0.39d
15-20	1.09 (0.75) ± 0.13a	1.56 (2.38) ± 0.40 a	65.98 ± 1.92a	7.18 ± 0.38cd
20-25	0.97 (0.50) ± 0.15a	1.90 (4.50) ± 0.69 a	70.23 ± 1.08a	10.85 ± 0.63c
25-30	0.93 (0.50) ± 0.22a	1.17 (1.50) ± 0.46 a	34.98 ± 0.38d	16.53 ± 0.61b
30-35	0.84 (0.25) ± 0.13a	1.65 (4.88) ± 0.94 a	47.70 ± 0.73b	18.97 ± 0.59b
35-40	0.84 (0.25) ± 0.13a	1.86 (6.87) ± 1.14 a	45.36 ± 0.61bc	27.80 ± 1.12a
40-45	0.93 (0.50) ± 0.22a	1.34 (2.50) ± 0.63 a	42.07 ± 0.69c	25.74 ± 1.58a
CD (P=0.05)	NS	NS	4.91	3.94

Values in the parenthesis are original values of transformed values. Values are means ± standard error of four replicates. Means followed by same letter are not significantly different from each other at 5% significant level according to Tukey's test.w

Table 2 Effect of different length of cuttings on various root parameters of dragon fruit at 30 DAP

Cutting length (cm)	Number of 1st order roots	Length of longest 1st order root (cm)	Fresh weight of roots (g)	Dry weight of roots (g)
10-15	2.75 ± 0.25d	4.88 ± 0.23d	0.45 ± 0.02f	0.26 ± 0.03f
15-20	5.58 ± 0.29bc	11.88 ± 0.65c	0.88 ± 0.05f	0.47 ± 0.49f
20-25	7.50 ± 0.65a	22.38 ± 0.94a	3.38 ± 0.12c	1.75 ± 0.34c
25-30	3.75 ± 0.25cd	13.63 ± 0.94bc	1.43 ± 0.11e	0.77 ± 0.12e
30-35	4.75 ± 0.48bcd	14.13 ± 0.59bc	4.49 ± 0.50b	2.46 ± 0.37b
35-40	6.25 ± 0.63ab	13.63 ± 0.63bc	7.82 ± 0.45a	3.21 ± 0.30a
40-45	5.00 ± 0.41bc	16.33 ± 0.97b	2.76 ± 0.31d	1.33 ± 0.19d
CD (P=0.05)	2.07	3.46	0.43	0.21

Values are means ± standard error of four replicates. Means followed by same letter are not significantly different from each other at 5% significant level according to Tukey's test.

Table 3 Effect of different length of cuttings on various shoot parameters of dragon fruit at 60 DAP

Cutting length (cm)	No. of new shoots	Shoot length (cm)	Increase in shoot weight (%)	Dry weight of shoot (g)
10-15	1.50 ± 0.29a	10.06 ± 0.21c	134.26 ± 3.89ab	5.54 ± 0.47c
15-20	1.25 ± 0.25a	8.83 ± 0.71c	87.36 ± 2.77d	8.45 ± 0.41c
20-25	1.25 ± 0.25a	17.63 ± 0.66b	135.85 ± 5.68ab	10.55 ± 0.41c
25-30	2.25 ± 0.25a	18.61 ± 0.67b	150.06 ± 4.60a	17.23 ± 1.46b
30-35	1.75 ± 0.48a	7.08 ± 0.71c	95.60 ± 2.22cd	32.56 ± 1.25a
35-40	1.50 ± 0.29a	33.06 ± 2.81a	114.45 ± 10.39bc	28.15 ± 1.86a
40-45	2.25 ± 0.25a	11.28 ± 1.03c	107.16 ± 4.07cd	32.16 ± 1.62a
CD (P=0.05)	NS	5.74	24.94	5.40

Values are means ± standard error of four replicates. Means followed by same letter are not significantly different from each other at 5% significant level according to Tukey's test.

various root attributes such as number of 1st order roots, fresh and dry weight of roots, and length of longest 1st order root etc. Similar findings were reported by Aminah *et al.* (2015), OuYang (2015), and Atangana and Khasa (2008).

The results of cuttings studied at 60 DAP showed that the maximum number of new shoots were recorded in 40-45 cm and 25-30 cm long cuttings but did not reach the level of significance (Table 3). However, the cutting lengths resulted in significant variations in the growth of new shoots and the highest length of new shoots (33.06 cm) was observed in 35–40 cm long cuttings which significantly differed from rest of treatments (Table 3). These results reveal that different length of cuttings though resulted in insignificant effect on production of new shoots but showed significant effect on growth of new shoots in dragon fruit at initial stages of growth. The treatment with the 35–40 cm long cuttings resulted in highest increase in length of new shoots, whereas smaller cuttings resulted in least increase in shoot length. This could be due to the fact that larger cuttings have higher photosynthetic reserve (Naidu and Jones 2009) and in addition to this, the cuttings under this treatment could have managed to maintain balance between roots and shoot growth, photosynthesis and transpiration and other growth promoting substances. In this experiment also, larger cuttings have shown higher shoot weight on dry basis which ultimately indicates higher food reserve in larger cuttings. The treatment having 25–30 cm long cuttings resulted in highest increase in fresh weight of shoots (150 %) without differing statistically significant with 10–15 and 20–25 cm long cuttings, whereas least increment in fresh weight of shoots (87%) was observed in the treatments with 15-20 cm long cuttings. However, the highest dry weight of shoots was observed in the treatments with more than 30 cm long cuttings, which are significantly different from rest of the treatments, i.e. smaller cuttings, whereas it was least in below 20 cm long cuttings (Table 3). This indicates higher length of cuttings in dragon fruit resulted into production of higher photosynthates which was directly reflected into higher dry weight of shoots. The production of higher photosynthates by larger cuttings is well documented in the earlier findings of researchers, which is obvious due to it is due high photosynthesis rates.

The treatment with 40–45 cm long cuttings also resulted in the greatest number of 1st order roots (7.25) which was found significantly different from rest of the treatments except 25-30 cm long cuttings, whereas treatment with 15-20 cm long cuttings resulted into least number of 1st order roots (Table 4).The longest 1st order root (32.37 cm) was observed in 40-45 cm long cuttings without differing statically with 35-40 and 25-30 cm long cuttings but these treatments shown statistically significant difference from rest of the treatments whereas, length of longest 1st order root was seen minimum (13.38 cm) in the 10-15 cm long cuttings (Table 4). The highest fresh and dry weight of roots (12.52 g and 4.75 g) was observed in 40-45 cm long cuttings which is significantly different from other treatments whereas lowest fresh weight and dry weight of roots was observed in smaller cuttings (Table 4). The treatments with higher cutting lengths resulted in to greatest length of longest 1st order root, number of 1st order roots, and fresh and dry weight of roots as compared to smaller lengths of cuttings. These results are supported or in line with the

Table 4 Effect of different length of cuttings on various root parameters of dragon fruit at 60 DAP

Cutting length (cm)	No. of 1st order roots	Length of longest 1st order root (cm)	Fresh weight of root (g)	Dry weight of root (g)
10-15	4.25 ± 0.25bcd	13.38 ± 0.77c	2.26 ± 0.16e	1.36 ± 0.16bc
15-20	2.75 ± 0.25d	18.63 ± 0.55bc	2.63 ± 0.25e	1.22 ± 0.19c
20-25	4.00 ± 0.41bcd	20.43 ± 0.91b	4.93 ± 0.49cd	2.25 ± 0.17bc
25-30	5.50 ± 0.65ab	30.12 ± 0.72a	5.16 ± 0.50bc	2.20 ± 0.20bc
30-35	3.00 ± 0.41cd	23.50 ± 0.54b	4.48 ± 0.47cd	1.59 ± 0.67bc
35-40	5.00 ± 0.41bc	31.12 ± 2.39a	7.28 ± 0.50b	2.53 ± 0.33b
40-45	7.25 ± 0.63a	32.37 ± 2.03a	12.52 ± 1.39a	4.75 ± 0.50a
CD (P=0.05)	2.08	6.12	2.20	1.22

Values are means ± standard error of four replicates. Means followed by same letter are not significantly different from each other at 5% significant level according to Tukey's test.

results obtained in other plants, e.g. *Eucalyptus* sp. (Naidu and Jones 2009), *Lavandula dentata* (Bona *et al.* 2012), *Duranta repenes* (Okunlola 2013) and *Tinospora crispa* (Aminah *et al.* 2015), wherein larger cuttings produced significantly higher rooting and/or large numbers of roots per cutting. In the present study also, the longer cuttings of dragon fruit showed higher dry weight of shoots which means higher photosynthates and therefore higher food material was available and would have been transferred to the sink, i.e. roots, which resulted into growth and development of roots consequently lengthier roots. Further, it has been seen in many species that, larger the cuttings higher will be the photosynthates and also the fact that root growth is governed by carbohydrates in leaves and stem (Philipson 1988). In addition to this, the larger cuttings compared to smaller ones could have managed well to maintain balance between shoot and root growth and might have able to give positive feedback to each other which resulted into supply of food reserve to the sink and maintenance of photosynthesis at the source (Gifford *et al.* 1984).

This study shows the significant effect of lengths of cuttings on shoot and root growth in dragon fruit. The results at the initial phase indicated that medium or intermediate lengths of cuttings though had good response by initiating shoot and root growth but could not maintain the balance between root and shoot growth and development throughout the experiment as compared to the larger cuttings. The larger cuttings resulted in higher shoot and root growth over the time compared to intermediate and smaller ones. Therefore, for planting of dragon fruit, though it can be multiplied with different ranges of cutting lengths, the larger cutting length (40±5 cm) could be recommended for planting, which will result in better growth and development of shoots and roots, balance between source and sink and other growth promoting substances etc. which ultimately result in higher success during out planting and earlier reproductive phase.

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REFERENCES

Aminah H M, Ahmad Fauzi S, Tariq Mubarak H and Hamzah M. 2015. Effect of Hormone and Cutting Length on the Rooting of *Tinospora crispa*. *International Journal of Scientific and Research Publications* **5**(3): 1–4.

Atangana A R and Khasa P D. 2008. Preliminary survey of clonal variation in rooting of *Allanblackia floribunda* leafy stem cuttings. *Canadian Journal of Forestry Research* **38**: 10–5.

Bona C M, Biasetto I R, Masetto M, Deschamps C and Biasi L A. 2012. Influence of cutting type and size on rooting of *Lavandula dentata* L. *Revista Brasileira de Planta Medicinals Botucatu* **14**(1): 8–11.

Davies W J and Zhang J. 1991. Root signals and the regulation of growth and development of plants in drying soil. *Annual Review of Plant Physiology and Molecular Biology* **42**: 55–76.

Gifford R M, Thorne J H, Hitz W D, Giaquinta R T. 1984. Crop productivity and photoassimilate partitioning. *Science* **225**(4664):801–8.

Ho L C. 1988. Metabolism and compartmentation of imported sugars in sink organs in relation to sink strength. *Annual Review of Plant Physiology and Molecular Biology* **39**: 355–78.

Kowalczyk K and Kobryn J. 1999. Effect of selected factors on rooting time of cuttings, biology of flowering and yield of some pepino (*Solanum muricatum* Aiton) forms. *Zeszyty Problemowe Postępow Nauk Rolniczych* **466**: 503–12.

Kozlowski T T. 1971. *Growth and Development of Trees: Cambial Growth, Root Growth, and Reproductive Growth*, Vol 2. Academic Press, New York.

Leakey R R B. 2004. Physiology of vegetative reproduction. *Encyclopaedia of Forest Sciences,* pp 1655-68. Burley J, Evans J, and Youngquist J A (Eds). Academic Press, London.

Leakey R R B and Coutts M P. 1989. The dynamics of rooting *Triplochiton scleroxylon* cuttings: their relation with leaf area, node position, dry weight accumulation, leaf water potential and carbohydrate composition. *Tree Physiology* **5**: 135–46.

Morton J. 1987. Cactaceae: strawberry pear and related species. *Fruits Of Warm Climate*s, pp 347-8. Morton J F (Eds). Miami, Florida.

Naidu R D and Jones N B. 2009. The effect of cutting length on the rooting and growth of subtropical *Eucalyptus* hybrid clones in South Africa, Southern Forests. *Journal of Forest Science* **71**(4): 297–301.

Okunlola A I. 2013. The effects of cutting types and length on rooting of *Duranta repens* in the nursery. *Global Journal of Human Social Science Geography, Geo-Sciences, Environmental & Disaster Management* **13** (3): 380–90.

Ortiz-Hernandez Y D and Carrillo-Salazar J A. 2012. Pitahaya (*Hylocereus spp.*): a short review. *Comunicata Scientiae* **3**(4): 220–37.

OuYang F, Wang J and Li Y. 2015. Effects of cutting size and exogenous hormone treatment on rooting of shoot cuttings in Norway spruce [*Picea abies* (L.) Karst.]. *New Forests* **46**: 91–105.

Philipson J. 1988. Root growth in Sitka spruce and Douglas-fir transplants: dependence on the shoot and stored carbohydrates. *Tree Physiology* **4**(2): 101–08.

Vinas M, Fernández-Brenes M, Azofeifa A and Jimenez V M. 2012. In vitro propagation of purple pithaya (*Hylocereus costaricensis* [F.A.C. Weber] Britton & Rose) cv. Cebra. *In Vitro Cellular and Development Biology-Plant* **48**(5): 469–77.

Wang X S, Wang J H, Wang Y C, Dong X G, Chang G S and Cui Z L. 1997. Effect of cutting length on rooting and growth of two-year old plantlets of *Larix kaempferi* in the nursery. *Journal of Forest Resource* **10**: 659–62.

Zee F, Yen C R and Nishina M. 2004. Pitaya (Dragon fruit, Strawberry pear). Cooperative Extension service, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa Honolulu, Hawaii.