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Effect of Anchoring Materials on the Growth and Development of *Luffa cylindrica*

[1]Raj Singh, [2]Indu Sharma, [3]Anju Rani, [4]Chhaya Singh, and [5]Pooja Sharma*

Author's Affiliation
[1,5]Department of Bio-Sciences and Technology, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana 133207, India
[2]Department of Biotechnology, NIMS Institute of Allied Medical Science & Technology, NIMS University Rajasthan, Jaipur, Rajasthan 303121, India
[3]Department of Botany, Keral Verma Subharti College of Science, Swami Vivekananda Subharti University, Meerut, Uttar Pradesh 250001, India.
[4]Department of Botany, Government Degree College, Thalisain, Uttarakhand 246285, India.

***Corresponding Author:**
Pooja Sharma
Department of Bio-Sciences and Technology, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana 133207, India
E-mail: pooja0029@gmail.com

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Abstract
Some climbing plants use tendrils as efficient strategies to anchor and support their weights while they grow upwards. This research is mainly focused on the essential functions of tendrils that wrap around the support in a soft state by a coiling and then lignify or stiffen to strengthen the attachment. The study revealed that, anchoring material play a significant role in growth and development climbing plants. The tendrils helps to find a suitable host on which they can climb is one of the most important organs of vine. The five types of anchoring material were used in this investigation to test their suitability as supportive material *viz.* coconut rope, thin steel wire, tree trunk, dry branches of plants and metal fence spike wire. The tendril coiling in coconut rope found poor as compared to thin steel wire, they coiled only a small fiber on the surface of rope. The tree trunk and dry branches of plants were serve good anchoring materials to climb the tree as well as healthy vine growth and fruit size. The metal fence spike wire mounted on wall were also found suitable for further vine growth and yield of *Luffa.* This study revealed the suitability of anchoring material for the cultivation of *Luffa cylindrica.*

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1. INTRODUCTION

Luffa cylindrica M. Roem. is an annual climbing plant belonging to cucurbitaceae family. It is an important vegetable crop originated from America (Mazali and Alves, 2005). Luffa (*Luffa cylindrica* (L.) Roem syn L. *aegyptiaca* Mill) commonly known as sponge gourd. It includes 5 to 7 different species but only 2 species (*L. cylindrica* and *L. acutangula* (L.) are edible. Other 2 species *L. graveolens* and *L. echinata* are comes in the category of wild species. Luffa is a diploid species including 26 chromosomes (2n = 26) and cultivated *via* cross-pollination (Bal et al., 2004).

At global level, the core contributing countries for luffa production are China, Korea, India, Japan and Central America (Bal et al., 2004). In India the Luffa is widely grown in Uttar Pradesh, Bihar, West Bengal, Orissa, Assam, Andhra Pradesh and Kerala states. Due to its high nutritive value, sponge gourds are cultivated for the production of mature green fruit (as vegetable) as well as dry fruits. The fruits of sponge gourd are cylindrical in shape. Its outer green color skin is smooth in texture. The inner white flesh layer is rich in fiber content as well as in vitamins and have similar flavor to bitter melon (Kameswari and Narayanamma, 2011; Prasad et al., 2009). The Luffa fruit attains the maximum height of 1-2 feet. A fully ripened sponge gourd contains high fiber content which has been utilized as cleansing agent, table mats and shoe-soles etc.

L. cylindrica is cultivated in sub-tropical area that needs warm summer temperature conditions. It can be grown from tropical to subtropical climatic conditions but flourish more in warm and humid conditions. They attain maximum growth and fruiting in rainy season (Choudhary et al., 2014). It was known that Luffa have a long history of cultivation in the tropical countries of Asia and Africa. Indo-Burma is reported to be the center of diversity for sponge gourd.

Cucurbitaceae family members have lianous plant bodies, leaves are petiolate, exstipulate, alternating, often palmately veined, simple, or sedately complex, with extra-floral nectaries. Tendrils are lateral to the leaf base (petiole), generally one to four tendrils found at each node, branching, simple-lobed, with a non-spiraling base (Okoli, 2013). It is a common example of convergent evolution as tendrils have evolved numerous times in angiosperms. Based on anatomy, they are showing angled stems with bicollateral vascular bundles arranged in two concentric rings. (Edeoga and Okoli, 2018; Kolb and Muller, 2005).

Climbing plants can be a model system to study the decision-making regarding suitable anchor as they show rapid movement in response to environmental cues (Gianoli, 2015). For climbing plants, a suitable host on which they can climb is one of the most important factors affecting their growth and development (Gianoli et al., 2005). They can perceive several cues from the host plants to locate the host plants quickly (Strong and Ray, 1975). However, there is a large variation in the values of the host as a coiling support. For example, when support diameter increases beyond a certain point, climbing plants are unable to maintain force that facilitate coiling and attachment to the support (Goriely and Neukirch, 2006). Thus, a supportive material with a large diameter is not suitable for coiling and climbing. In fact, negative associations have been reported between the support diameter and colonization success (Nabe-Nielsen, 2001). However, it is not known that climbing plants itself determined to avoid an unsuitable host by changing their coiling response depending on the quality of the support or not. To maintain the attachment and coiling around a support that is too large in diameter results in loss of time and energy. For tendril bearing climbing plants, it would be beneficial to avoid supportive material with large diameters.

To test the ability to make decision power towards selective host material by climbing plants, we focused on *Cayratia japonica*, a perennial vine of Vitaceae family. Previously, it was reported that the tendrils of *C. japonica* have the ability to discriminate and avoid unsuitable hosts by detecting the chemical cues (Fukano and Yamawo, 2015; Fukano, 2017). In this study, we investigated the ability of *Luffa cylindrica* to detect the physical support to climb. The research revealed that tendrils of *Luffa cylindrica* able to observe the different anchoring materials and avoid unsuitable materials. We also examined the supportive diameter and the tendril length affect the coiling success rate as well as vine growth and yield.

2. MATERIAL AND METHODS

The experiment was conducted at the Botanical garden of Maharishi Markandeshwar (Deeemed to be) University, Mullana, Ambala in 2021. The seeds of *Luffa* were planted in well moisten soil in the month of July (30.2753^0N, 77.0476^0E). The experiment was laid out with five types of anchoring materials for *Luffa cylindrica* crops. This experiment included five different materials *viz.* coconut rope, thin steel wire, tree trunk, dry branches of plants and metal fence spike wire. The parameters of plant growth were analyzed *viz.* tendril coiling, length, leaf size and yield of crop.

3. RESULTS

The plants were immerged in the month of July, 2021 and all showed healthy growth. The plants were further provided with different anchoring materials for vine growth (Table 1). The tendril coiling in coconut rope were poor as compared to thin steel wire, they coiled only a small fiber on the surface of rope (Figure 1). The tree trunk and dry branches of plants were serve good anchoring materials to climb the tree as well as healthy vine growth and fruit size. The metal fence spike wire mounted on wall were also found suitable for further vine growth and yield of *Luffa cylindrica.*

Table 1: Plant growth responses to different Anchoring materials in *Luffa cylindrica*

S. No.	Anchoring materials	Plant growth responses in *Luffa cylindrica*
1.	Coconut rope	Poor tendril coiling of rope, retardation of vine length and leaf size
2.	Thin Steel wire	Poor tendril coiling of wire, retardation of vine length as well as leaf and fruit size
3.	Tree trunk	Good tendency to climb the tree with healthy vine growth and fruit size
4.	Dry branches of plants	Good tendril coiling, vine growth and yield
5.	Metal fence spike wire	Good tendril coiling, vine growth and yield

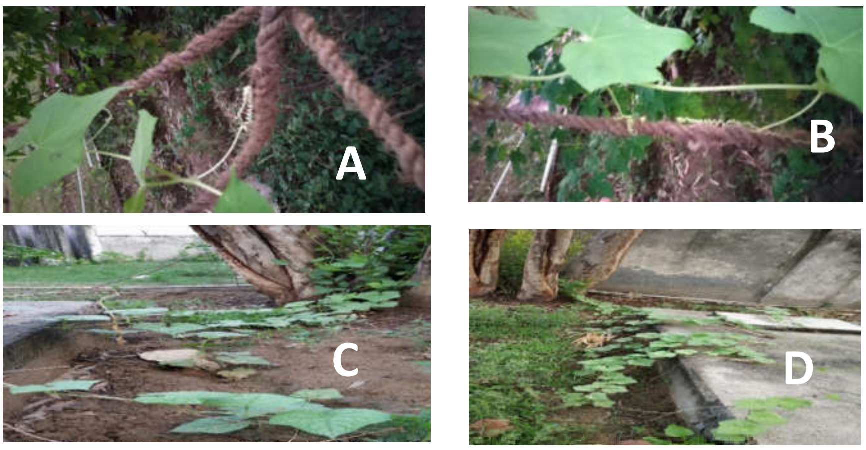

Figure 1: Different anchoring materials in *Luffa cylindrica* (A) and (B) coconut rope, **(C) and (D)** Tree trunk and dry branches of plants

4. DISCUSSION

Lianas use efficient attachment strategies to attach their bodies to a support as they grow thus reducing the amount of organic material needed to reach great heights (Rowe and Speck, 2014; Burris et al., 2018; Fiorello et al., 2020). Tendrils, elongated structures that wrap around a support in response to trigger are a common mechanism for plant attachment in unstructured environments (Fig. 1). The tendrils coil helically around a scaffold by asymmetric contraction of fibers in their structure, which results in attachment to that scaffold (Gerbode et al., 2012). In this case, the asymmetric contraction is probably the result of differential lignification, variations in the orientation of cellulose fibrils, or differential water affinities leading to unequal water output by some cells, which causes increased cell contraction (Gerbode et al., 2012). After coiling, the tendril material lignifies, which leads to a considerable stiffening of the tissue and thus to a further strengthening of the attachment. In this study tendril coiled only a small fiber on the surface of rope, the tendril also showed the negative associations with thin steel wire. Recently, growing evidences suggest that plants could also perceive cues with different values and change their phenotypes plastically according to the values of the cue and their own conditions (Simon et al., 2016). In this sense, plants can be regarded as being capable of making decisions (Reid et al., 2015). Therefore, it is expected that behavioural and physiological mechanisms underlying the plants' decision-making are largely caused by non-integrated local reactions (Karban, 2008; Trewavas, 2005).

5. CONCLUSION

Luffa cylindrica are popularly cultivated for mature-green fruit vegetable because of its high nutrient value. In India the crop is widely grown in Uttar Pradesh, Bihar, West Bengal, Orissa, Assam, Andhra Pradesh and Kerala. For climbing plants, finding a suitable host plant on which they can climb is one of the most important factors affecting their growth and development. *Luffa* is a tendril bearing climbing plants, the findings revealed that tendrils of *Luffa cylindrica* able to detect the different anchoring materials and thus avoid unsuitable materials. The tree trunk, dry branches of plants and metal fence spike wire were serve good anchoring materials to climb as well as further vine growth and yield of *Luffa cylindrica.*

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