ABSTRACT

This paper reports on the propagation of *Talinum cuneifolium* through stem cuttings. It is popularly known as Ceylon spinach and is used as a leafy vegetable in the tropics. In the present study, stem cuttings of *T. cuneifolium* were successfully propagated in soil and hydroponic media. Propagated plants flowered extensively within a week under both conditions. Stem cuttings of plants in hydroponic media initiated adventitious roots within a week. The growth and development of vegetative propagules, flowers and adventitious roots were determined at different periods of the experiment. Our study indicated that *T. cuneifolium* can be propagated through stem cutting within 7-days of culturing. Furthermore, hydroponically grown shoots with adventitious roots can serve as an ideal experimental system for toxicity bioassays (rhizofiltration) in the field of environmental research.

Keywords: Ceylon spinach, hydroponic, rhizodegradation, rhizofiltration, soil multiplication, toxicity bioassay

INTRODUCTION

The commercial production of ornamental plants is of a great economic importance in worldwide agriculture. The ornamental industry has widely applied *in vitro* propagation for large-scale plant multiplication of elite superior varieties. The propagation through shoot cutting of herbaceous plants has wide applications in ornamental plant production and the interest in ornamental or foliage plant production is increasing rapidly as a result of their economic importance and their diversity. In soil, propagation through seed germination is a way to develop *Talinum* plants but the propagation rate is slow. It has been reported that peony (*Paeonia*) plants, producing offspring through seed germination, can maintain the superior characteristics of parent plants (Halda and Waddick 2004). The soil system may affect seedlings because of variable availability of nutrients and soil texture. It is reported that in *Talinum*, soil nutrients like phosphorus, potassium and nitrogen in different combinations and pH cause variations in stem weight, leaf width or leaf area.

![Fig. 1 Propagation of *T. cuneifolium* in field, greenhouse and hydroponic conditions.](image)
(Ukpong and Moses 2001). In vitro propagation, by means of stem cuttings, is a common tool for rapid expansion and multiplication of plants and also has been widely established for various ornamental plants. In vitro propagation is a key tool in plant biotechnology that exploits the totipotency of plant cells. The main advantage of in vitro (vegetative) propagation is to produce a large number of vegetative propagules, adventitious roots and leaves. It is a reliable way of multiplying plants in a short period of time (Jain and Ochatt 2010). The regeneration of adventitious roots in excised leafy plant shoots is a crucial phenomenon and rooting ability depends on many endogenous and exogenous factors such as species, type of cuttings, composition of nutrient medium, season of propagation, environment and propagation system (Németh 1986; Hartmann et al. 2002).

Members of the Portulacaceae family i.e. Portulaca, Calandrinia, Lewisi and Talinum are known to bear ornamental and attractive flowers (Hickey and King 1981; Foxcroft et al. 2008). Talinum cuneifolium (Ceylon spinach) is a terrestrial herbaceous plant with erect, simple or branching stems (Fig. 1A). It is a small genus with 50 species mostly found in the tropics, subtropics and warmer parts of the world (Hickey and King 1981; Watson and Dallwitz 1992). Talinum cuneifolium is relatively easy to grow and has attractive foliage under an ideal environment and stem cuttings of plants are a ready means of propagation of these plants in both soil and hydroponic media (Fig. 1B, IC). Talinum cuneifolium flowers and fruits throughout the year and flowers are small and showy, open in the morning and close in the late afternoon (Fig. 1D). Apart from its ornamental value, Talinum species are widely used as leafy vegetable plants in the tropics including India, Arabia, Africa and America (Table 1). In south-eastern States of Nigeria, Talinum is being cultivated and considered as a highly desirable vegetable plant (Ukpong and Moses 2001). Almost all its parts are useful and used as traditional medicine and leaves are a good source of antioxidant micronutrients (xanthophyll carotenoids) such as lutin (89.79 mg/100 g DW) and zeaxanthin (1.22 mg/100 g DW), in higher concentration, in the leaves (Khoda et al. 1992; Lakshminarayana et al. 2007). Talinum cuneifolium shows close resemblance with T. triangulare in habit, gross morphological characters and base chromosome numbers but differ in only pollen morphology. The former belonging to pollen type III and later to pollen type II (Nyanayo 1992).

The aim of this study was to propagate T. cuneifolium both in soil and hydroponic media. Further, we studied the influence of soil and hydroponic media on the growth rate of vegetative propagules and regeneration potential of T. cuneifolium plants. The study was performed to explore the stem cutting method in order to promote additional experimental applications.

### MATERIALS AND METHODS

#### Plants

T. cuneifolium is a succulent perennial that inhabits soil communities along the perimeter of rock outcrops. Materials required for these experiments were collected from a field bank maintained as stock plant at the University of Hyderabad, India. Stem cuttings were excised from the branching portion by hand with a sharp razor blade. The average cutting diameter of each plant shoot was 30-50 mm and shoot height ranged from about 17-22 cm. The rooting test of each plant species involved three replication, each consisting of 8 cuttings. Immediately after excision from the stock plants, the cuttings were propagated in soil and hydroponic media without any wetting agent treatment.

#### Propagation in soil

Stem cuttings of T. cuneifolium plants were potted in 5-L cement pots filled with a mixture of red soil and sand (pH-6.8) in a greenhouse with an average daily minimum temperature of 23°C and a maximum of 31°C; the relative humidity ranged between 60-75%. Inside the greenhouse the photosynthetic photon flux density (PPFD) ranged from 900-1200 µmol m⁻² s⁻¹ with an average sunlight of 6-8 h day⁻¹. Potted T. cuneifolium plants were watered daily and examined for the formation of flowers and vegetative propagules.

#### Propagation in hydroponic medium

T. cuneifolium stem cuttings were placed in a conical flask containing 100 ml of 10% modified Hoagland’s solution (Hoagland and Arnon 1950) under a 16 h photoperiod at 28 ± 2°C in laboratory conditions. Plants were kept for 3-weeks for acclimatization and regeneration of adventitious roots. The pH of the solution was maintained at 4.8. Nutrient solution was replaced every 3-4 days to provide a fresh dose of nutrient elements and to avoid algal growth. Algal culture binds to the root outer surface and reduces the absorption of nutrient elements and inhibits root growth.

#### Rating of propagules and rooting in hydroponic medium

Adventitious root formation in T. cuneifolium stem cuttings was calculated after a rooting period of 7-, 14- and 21-days. Rooting of cuttings was not always successful and the percentage of non-surviving cuttings was calculated at 7-days. Cuttings that survived were used to analyze the mean number of vegetative propagules, mean root length and fresh weight (FW) at three different sampling periods (7-, 14- and 21-days) to evaluate the commercial quality of stem cuttings.

#### Statistical analysis

The experiments were repeated three times and the data presented corresponds to the mean values ± S.E. (standard errors) of three replicates (Microsoft Office 2003). Significant differences of these data were calculated using one-way analysis of variance (ANOVA) and Tukey’s test (SIGMASTAT 9.0). P values < 0.05 were considered significantly different and denoted by different letters.

### RESULTS AND DISCUSSION

#### Propagation in soil

Talinum is a succulent herb that grows in shallow soil habitats with rock exposures. Members of this genus are considered as rock-outcrop species, many of which grow on granite, serpentine, sandstone, and limestone rocks (Black and Murdy 1972; Ware and Pinion 1990). During the expe-
riment, potted plants were observed daily to understand their ability to acclimatize in soil. In the soil system survival rate of the plant cuttings was 87% at 7-days. Potted cuttings were healthy and flowered within a week of culture (Fig. 1E). In the soil system, stem cuttings of 21- and 14-days showed a 3.2- and 2.3-fold increase, respectively in the number of flowers more than 7-days stem cuttings. Similarly, stem cuttings propagated for 21-days showed a 1.4-fold increase in the number of flowers more than stem cuttings propagated for 14-days (Table 2). Talinum is pre-dominantly self-pollinated or vegetatively propagated. Thus, for 21-days the vegetative propagules showed a 4.2- and 1.6-fold increase more than 7- and 14-days, respectively. Furthermore, 14-days cuttings showed a 2.6-fold increase in the number of propagules more than 7-days cuttings (Table 2). Results of our observation confirmed that T. cuneifolium plants are mostly multiplied through vegetative propagation and produced numerous vegetative propagules on their senescing stem tips. The number of flowers and vegetative propagules were increased and directly dependent on propagation periods (Table 2). Shoot tip explants are routinely used for the propagation of ornamental plants, including Ardisia japonica (Roh et al. 2005), Begonia tuberosa, Ranunculus asiaticus L., Dianthus caryophyllus L., Jasminum officinale L. (Jain and Ochatt 2010), Ebenus crotica (Hatzi-azarou et al. 2001), Pelargonium x hortorum (Druege et al. 2007), Rosa hybrida L. (Bredmose and Hansen 1995) and Zantedeschia albomaculata (Chang et al. 2003). The sustainable growth of T. cuneifolium makes continuous demands on soil properties and it is necessary to restore the nutrients and increase the sustainability of soil by the application of nutrients and organic manure. Soil multiplica-tion is a powerful tool for large-scale propagation of ornamental plants and further, having application for phytoremediation. Phytoremediation is a cost-effective, nonintrusive technique and an emerging green technology that uses the ability of certain plant species to remove toxic metals from the soil. It has been reported that Portulaca oleracea, another member of the Portulacaceae family, can survive for a longer periods in spite accumulating more toxic metals than reported hyperaccumulators such as Helianthus annuus and Brassica juncea in the presence of an electroplating effluent (Jenista et al. 2010).

**Propagation in hydroponic medium**

In laboratory conditions, Talinum plants can be maintained effortlessly in hydroponic media. Plants were observed with adventitious roots and flowers in hydroponic media (Fig. 1F). Results of our study showed that the propagation of stem cuttings in hydroponic media and laboratory condi-tions generally produced a high survival rate of 94% at 7-days. The higher percentage of survival of cuttings showed that plants grew easily in hydroponic media. Plants grown well in the nutrient solution and root primordia at the base of stem cuttings were observed within one week of culture. Root parameters such as length and FW of adventitious roots and leaf blades. Very rapid development of adventitious roots. In terms of vegetative propagules and adventitious roots in T. cuneifolium cuttings was promoted by hydroponic media and growth conditions. The growth of T. cuneifolium is directly dependent on the growth of roots in hydroponic media because the growth and survival of terrestrial plants are related to the potential ability of roots to absorb water and nutrient elements from the soil or growth media (Eapen et al. 2005). The advantages of water culture are that plant roots are suspended only in water medium and avoid soil, containing salts and soil-borne microorganisms. They may interrupt nutrient uptake and plant growth by precipitating salts or affecting the pH of the solution. On the other hand, hydroponic cul-ture provides only liquid nutrient medium to plants and a generous availability of nutrients promote rapid plant growth.

Hydroponically cultivated adventitious roots of several terrestrial plants were used for rhizofiltration, a process used for absorbing or precipitating toxic metals effectively from a polluted site (Dushenkov et al. 1995). Adventitious roots of Talinum plants have the potential to absorb heavy metals and might be useful for a new rhizofiltration system. Talinum plants could absorb heavy metals and were used for absorption experiments of heavy metals i.e. Pb, Cd, Ni, Cu (Rajkumar et al. 2009). Absorption of heavy metal content induces some ultrastructure modifications in root tissues concerning the increase in cell wall thickness (Probst et al. 2009). Heavy metal accumulation in plant tissues causes the synthesis of small cysteine-rich peptides, phytoche-latins (PCs) or metallothioneins (MTs), which bind to the metals and form peptide-metal complexes and detoxify them. These properties develop a characteristic to absorb more heavy metals in the plant. Probst et al. also reported that roots of Vicia faba absorbed more metals than stems and leaves. The order of metal accumulation was root > leaf > stem for all heavy metals except for Pb and Cd where the order was root > stem > leaf (Probst et al. 2009). The methods of propagation in hydroponic media have a signifi-cant influence on the production of adventitious roots and new leaves. Very rapid development of adventitious roots in Talinum plants indicates that a one-week period required for the establishment of a potential plant propagation system.

**Table 2** Analysis of number of flowers and vegetative propagules in propagated stem cutting in soil medium and root length, root fresh weight and vegetative propagules in hydroponic media after 7-, 14- and 21-days, respectively.

<table>
<thead>
<tr>
<th>In soil medium</th>
<th>7-days</th>
<th>14-days</th>
<th>21-days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flowers (per plant)</td>
<td>0.63 ± 0.15 a</td>
<td>1.45 ± 0.15 ab</td>
<td>2.04 ± 0.23 bc</td>
</tr>
<tr>
<td>Mean propagules (%)</td>
<td>50 ± 10 a</td>
<td>129 ± 12 ab</td>
<td>208 ± 15 bc</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In hydroponic media</th>
<th>7-days</th>
<th>14-days</th>
<th>21-days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean roots fresh weight (g)</td>
<td>0.155 ± 0.01 a</td>
<td>0.56 ± 0.02 b</td>
<td>0.93 ± 0.04 c</td>
</tr>
<tr>
<td>Mean root length (cm)</td>
<td>3.61 ± 0.23 a</td>
<td>10.85 ± 0.5 b</td>
<td>17.45 ± 0.5 c</td>
</tr>
<tr>
<td>Mean propagules (%)</td>
<td>68 ± 12 a</td>
<td>144 ± 13 ab</td>
<td>256 ± 23 c</td>
</tr>
</tbody>
</table>

* Mean values ± S.D. of three replicate (n = 8). The values at each time point not sharing a common letter are not significantly different (P < 0.05) between groups within a row as determined by analysis of variance (ANOVA) and Tukey’s multiple range test.
for rhizofiltration. Furthermore, with the help of adventitious roots we can study the effect of foliar retention, absorption of heavy metals and also various aspects of abiotic stresses in root tissues.

*Talinum cuneifolium* can be grown in soil and hydroponic media. It can be used as an indoor and outdoor ornamental plant. Thus, *T. cuneifolium* with high vegetative propagation potential would serve as an ideal experimental system for different fields of plant science research.

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**REFERENCES**

Black CB, Murdy WH (1972) The evolutionary origin of *Talinum tereffiolium* Pursh. Botanical Gazette 133 (4), 405-410


Hoagland DR, Arnon DI (1950) The water-culture method for growing plants without soil. *California Agricultural Experiment Station Circular* 347, 1-32


