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UMA SHANKAR

Department of Botany,
North-Eastern Hill University,
Shillong 793 022, India
e-mail: arshuma@yahoo.com

Occurrence of vivipary in *Jatropha curcas* L.

Jatropha curcas L. (Euphorbiaceae), a drought-resistant, photo-insensitive perennial plant, is a potential source of non-edible biodiesel-producing energy crop[1,2]. *Jatropha* is a multipurpose tree with a long history of cultivation in the tropical and subtropical regions of the world[3]. It is a native to Central America and occurs mainly at lower altitudes (0–500 m) in areas with an annual temperature of well above 20°C. Two species of *Jatropha* that are grown include *J. curcas* and *J. glandulifera*. *J. curcas* is mainly promoted for bio-diesel because of higher oil content (up to 48%), whereas *J. glandulifera* is known for its beautiful flowers and oil content (up to 27%). The plant can tolerate extremes in temperature, but not frost and water stagnation. It grows almost everywhere – even on gravely, sandy, acidic and alkaline soils, with pH ranging from 5.5 to 8.5. It can thrive in the poorest stony soils.

Vivipary is the process by which seeds germinate within the fruit, followed by subsequent embryo development before the seeds are dispersed from the parent plant. The germination of viviparous seeds usually occurs while they are still on the parent plant (precocious germination), a relatively unusual phenomenon in angiosperms[4]. Vivipary has been reported in fewer than 100 flowering plant families[4], representing less than 0.1% of angiosperms. The best known cases of vivipary in angiosperms are documented in mangroves of Rhizophoraceae and Avicenniaceae[5]. To our knowledge, there is no report of vivipary in *J. curcas*. The objective of this correspondence is to document the occurrence of viviparous seeds in *J. curcas*, and leave clues for further research on understanding the viviparous nature in *J. curcas* and its ecological and evolutionary significance.

The Plant Metabolic Engineering Group at Dhirubhai Ambani Life Sciences Centre (DALC), Navi Mumbai, has initiated work on mass propagation[2] and development of transgenic *Jatropha*. To support regular explant collection, we have planted around 250 plants (Figure 1 *a*) inside the DALC Campus situated at Rabale (lat. 19°15′N, long. 72°99′E). The rainy season in this area is mostly confined to the south-west monsoon, with 80% of the rainfall during June–October (60–70 days). On an average, the area receives 2500–3500 mm of rainfall. The area has marine humid–pre-humid climate with more humidity and less diurnal variations. Relative humidity varies from 41 to 97%, the driest days being in winter and wettest ones in July.

The first finding of peculiar phenomenon of vivipary was observed in the above populations (Figure 1 *a*) during heavy monsoon, from late June through early August 2007. The mother plants were two years old and they had fully developed mature fruits. It was observed that during continuous rainfall, the inflorescence head gets wet and the seeds begin to germinate. A well-developed, white root system first emerged from the posterior portion of the dry fruit (Figure 1 *b*). The seeds in several stages of germination, viz. tiny embryos emerging from the seed coat to young, healthy seedlings with small cotyledons, elongated hypocotyls and radicals, including fully grown seedlings were found in mature fruits (Figure 1 *c–f*), while they were still attached to the mother plant. Some of the seedlings finally got detached and fell on the ground due to their own weight, when the radicle embedded into the soil got established into a plant. This type of seedling establishment through germination on the plant is extremely uncommon in this environment. Thus, it is an example of true vivipary which was favoured by excessive atmospheric moisture or wet condition experienced by the plant after seed ripening.

Although we do not have a conclusive explanation for this phenomenon in *J. curcas*, we presume that various intrinsic and extrinsic factors of the plant may be involved, namely physiology, soil condition, temperature and dry spell followed by high humidity induced by heavy rainfall. Vivipary, a phenomenon characterized by lack of dormancy, is important because, in addition to being a relatively unusual event in nature, it has been interpreted as a specialized trait of evolutionary and biological significance,

Figure 1. ***a***, *Jatropha curcas* L. habitat, mother plants. ***b***, Emergence of radicle (bar = 1 cm); ***c***, ***d***, Elongated hypocotyls showing reduced radicle base (bar = 2.5 cm). ***e***, Germinated seeds with complete plantlet still attached to the mother plant (bar = 2.5 cm). ***f***, Various germination stages of viviparous seeds (bar = 1 cm).

providing new avenues for survival and as a mechanism for protecting the embryo from drought and other stress conditions[5].

It is worth noting that in *J. curcas*, seeds have limited viability. They lose almost 50% viability within 15 months of seed maturity. Vivipary is an unconventional reproductive means deserving more attention in the laboratory and the field. It is possible that the seeds lack a dormancy period because they lack compounds or leaching of compounds that prevent seeds from germinating. Therefore, even before the first harvest of seeds from the parent tree, they are likely to germinate on receiving suitable environmental conditions. The sprouted seeds or seeedlings develop into independent plants when they fall on suitable soil media. It is probably a useful trait if one is aiming at the greening of barren lands; for example, afforestation projects. A commercial planter needs to take the precocious germination of *J. curcas* seeds into consideration, particularly in high humid regions while harvesting fruits. The physiologically matured yellow fruits should be harvested without much delay. If harvesting is delayed by few days, most of the seeds germinate under high humid conditions, thus reducing the seed yield per unit area with a threat to sustainable *Jatropha* farming. This report hopefully helps in knowing maturity index for *Jatropha* growers. In conclusionn, occurrence of vivipary in *J. curcas* can be interpreted as an adaptive reproductive strategy that enables seedlings to establish more rapidly. There is ample opportunity to investigate the ecophysiological and evolutionary significance of vivipary in *Jatropha*.

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AJAY C. DEORE
T. SUDHAKAR JOHNSON*

Plant Metabolic Engineering Group,
Reliance Life Sciences,
Dhirubhai Ambani Life Sciences Centre,
Thane–Belapur Road,
R-282, Rabale,
Navi Mumbai 400 701, India
**For correspondence.*
e-mail: ts_johnson@relbio.com