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Research review paper

Role of biotechnological interventions in the improvement of castor (*Ricinus communis* L.) and *Jatropha curcas* L.

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ABSTRACT

Castor and Jatropha belong to the Euphorbiaceae family. This review highlights the role of biotechnological tools in the genetic improvement of castor and jatropha. Castor is monotypic and breeding programmes have mostly relied on the variability available in the primary gene pool. The major constraints limiting profitable cultivation are: vulnerability to insect pests and diseases, and the press cake is toxic which restrict its use as cattle feed. Conventional breeding techniques have limited scope in improvement of resistance to biotic stresses and in quality improvement owing to low genetic variability for these traits. Genetic diversity was assessed using protein based markers while use of molecular markers is at infancy. *In vitro* studies in castor have been successful in shoot proliferation from meristematic explants, but not callus-mediated regeneration. Genetic transformation experiments have been initiated for development of insect resistant and ricin-free transgenics with very low transformation frequency. In tropical and subtropical countries jatropha is viewed as a potential biofuel crop. The limitations in available germplasm include; lack of knowledge of the genetic base, poor yields, low genetic diversity and vulnerability to a wide array of insects and diseases. Great scope exists for genetic improvement through conventional methods, induced mutations, interspecific hybridization and genetic transformation. Reliable and highly efficient tissue culture protocols for direct and callus-mediated shoot regeneration and somatic embryogenesis are established for jatropha which indicates potential for widening the genetic base through biotechnological tools. Assessment of genetic diversity using molecular markers disclosed low interaccessional variability in local *Jatropha curcas* germplasm. The current status and future prospects of *in vitro* regeneration, genetic transformation and the role of molecular tools in the genetic enhancement of the two-oilseed crops are discussed.

Contents

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1. Introduction

The Euphorbiaceae family occurs mainly in the tropics, express mixed relationship with several other groups, and includes plants producing the most important economic products such as para rubber (*Hevea brasiliensis*), castor oil (*Ricinus communis* L.), tung oil (*Aleurites fordii*) and cassava meal (*Manihot esculenta*). Castor and jatrophas are commercially important non-edible oilseed crops in the Euphorbiaceae with spurges and croton forming very large genera (Hutchinson, 1964).

Castor (*Ricinus communis* L. $2n=20$) whose origin is believed to be Abyssinia is industrially important for production of non-edible oil. It is distributed throughout the tropics and subtropics, and is well adapted to the temperate regions. The major castor producing countries are India, China, Brazil, USSR, and Thailand, while the major importing countries are the USA, the USSR, the EEC and Japan. India is the leading producer of castor in the world (FAOSTAT, 2006) with an annual production of about 0.73 Mt. India accounts for nearly 60% of the world's production of castor (FAOSTAT, 2006). Castor is important as a source of vegetable and medicinal oil and has numerous benefits to humanity. The oil has many industrial uses; dehydrated castor oil is used in the paint and varnish industry, manufacture of a wide range of sophisticated products like nylon fibers, jet engine lubricants, hydraulic fluids, plastics, artificial leather, manufacture of fiber optics, bulletproof glass and bone prostheses and as an antifreeze for fuels and lubricants utilized in aircraft and space rockets (Scarpa and Guerci, 1982; Ogunniyi, 2006). This has led to a steady increase in the demand for castor oil on the world market. Interest in Jatropha (*Jatropha curcas* $2n=22$) is for use of its seed oil as a sustainable alternative source of biofuels (Jones and Miller, 1991; Openshaw, 2000). This review highlights the current status and future prospects of molecular and biotechnological tools for genetic improvement of castor and jatropha.

2. Genetic improvement and variety development

2.1. Castor

Previously genetic improvement of castor was confined to the exploitation of naturally occurring genetic variability in the base population and limited selection for traits of interest to humans. Mass selection and pedigree methods have been employed for developing elite genotypes with desirable attributes (Moshkin, 1986; Weiss, 2000; Hegde et al., 2003). India has made significant progress in development of hybrids during the last three decades (Hegde et al., 2003). Based on the exotic pistillate line TSP-10R (Classen and Hoffman, 1950), the first hybrid castor, GCH-3, was developed. Subsequently, the development of indigenous pistillate line, VP-1, based on TSP-10R, has given new impetus to hybrid castor development which resulted in the release of three hybrids, GAUCH-1, GCH-2 and GCH-4 during 1990s and ten more high yielding hybrids later on (Hegde et al., 2003). However, extensive cultivation of the varieties and hybrids under different management practices has made them vulnerable to a number of biotic and abiotic stresses. Major diseases include wilt (*Fusarium oxysporum* spp *ricini*), root rot (*Macrophomina phaseolina*), bacterial blight (*Xanthomonas ricini*), botrytis grey rot, seedling blight (*Phytophthora colocasiae*), and economically important insects are semilooper (*Achoea janata*), capsule borer (*Dichrocrocis puncitiferalis*), *Spodoptera litura*, red hairy caterpillar (*Amsacta albistriga*), jassids (*Empoasca flavescens*), white fly (*Trialeurodes ricini*) (Kolte, 1995). New sources of resistance/tolerance to biotic and abiotic stresses are in constant demand by the breeders.

2.2. Genetic diversity in castor

The genus *Ricinus* is monotypic and *R. communis* is the only species with the most polymorphic forms known (Weiss, 2000). Several of these forms were designated as species (*R. communis*, *R. macrocarpus*, *R. microcarpus*) (Weiss, 2000) but they are intercrossable and fertile and are not true species. All the varieties investigated cytologically are diploids ($2n=20$), and castor is presumed to be a secondary-balanced polyploid with a basic number of $x=5$ (Singh, 1976). Many of the morphological differences might be due to genic differences, cryptic inversions, duplications, etc., rather than to changes in the whole chromosome complement (Perry, 1943). Cytological variations included presence or absence of a secondary constriction, presence or absence of a particular heterochromatic segment, size and length differences of particular heterochromatic segments (Paris et al., 1980). However variations in the degree of chromosome spreading and attenuation of heterochromatin could not be correlated with phenotypic characteristics (Paris, 1981).

2.3. Castor breeding

Success in breeding for yield stability is limited by a low genetic variability for productivity traits and sources of resistance to diseases and pests (Weiss, 2000; Hegde et al., 2003). Hence, breeders have to resort to alternative approaches like mutations, wide (intergeneric) hybridization and use of biotechnological tools for creation of genetic variability and incorporation of desired traits (Sujatha, 1996; Lavanya et al., 2003). Many studies have been done on the effect of irradiation on castor seed and seedlings aimed at producing mutants with desired characteristics. The importance of mutations in castor is demonstrated by inducing productive semi-dwarfs with higher yield potential and earlier maturity, loss of daylength sensitivity and identification of variants for sex expression (Kulkarni and Ankineedu, 1966; Ankineedu et al., 1968; Donini et al., 1984; Lavanya et al., 2003). However, mutation technique using radiations could not be exploited for development of genotypes resistant/tolerant to various biotic stresses.

2.4. Jatropha

In tropical and subtropical countries, jatropha has a potential as a biofuel crop. Among the oil-bearing tree species, jatropha is desired due to its drought hardiness, rapid growth, easy propagation, low cost of seeds, high oil content, small gestation period, wide adaptation, production on good and degraded soils and the optimum plant size that makes the seed collection more convenient (Jones and Miller, 1991; Francis, 2005). Worldwide, introduction of jatropha for varied purposes met with limited success due to unreliable seed and oil yields and low economic returns. The available germplasm lacks information on the genetic base, yields are poor, has low genetic diversity and is vulnerable to insect pests and diseases. A few varieties have been selected in different countries. Available planting material is indeterminate with variability in yield components and oil content, which are strongly influenced by environment (Heller, 1996). Jatropha has been domesticated, and there is an immediate need to breed for superior genotypes. The objectives should aim at higher seed yield