Vigour maintaining seeds for farmers

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In the past, India has made great progress in providing food security for its people. However, the growth rate of agriculture is consistently decreasing. There has also been a decline in the growth rate of foodgrain production. The challenge facing the country is achieving higher food production over the next 2–3 decades[1]. Baseline projection for total cereal demand in 2020 is 246 mt for direct human consumption[2]. The relevant question that arises is whether India would be able to increase its foodgrain production in the coming years with the net crop area remaining the same?

In a path-breaking study that has a bearing on increasing food production, the research group of Imran Siddiqi (Centre for Cellular and Molecular Biology (CCMB), Hyderabad) in collaboration with Raphael Mercier (Institut National Recherché de la Agronomique, France) and Simon Chan (University of California, Davis, USA) has demonstrated the possibility of cloning seeds that would retain hybrid vigour through generations and also allow the farmer to reuse the hybrid seed, thus saving him high input costs[3].

Many agronomic advantages of apomixis (Box 1) can be envisioned; the rapid generation and multiplication of superior forms through seed from novel, currently under used germplasm; the reduction in cost and time of breeding; the avoidance of complications associated with sexual reproduction, such as pollinators and cross-compatibility, and the avoidance of viral transfer in plants that are typically propagated vegetatively, such as potatoes[4–8].

The benefits of these opportunities will vary between crops and production systems. For farmers in the developed world, the greatest benefit is expected to be the economic production of new, advanced and high-yielding varieties for use in mechanized agricultural systems. Conversely, for farmers in the developing world, the greatest benefits are expected to relate to the breeding of robust, high-yielding varieties for specific environments, improvements in the security of the food supply and greater autonomy over variety ownership[9,10].

However, apomixis is poorly represented among crop species. The main exceptions to this appear to be tropical and subtropical fruit trees such as mango and citrus, and tropical forage grasses such as *Panicum*, *Brachiaria*, *Dichanthium* and *Pennisetum*. It is possible that the low representation of apomixis among crops arose unintentionally from a protracted human history of selecting superior plants for future cultivation. Selection for change over a parental type would work against a mechanism such as apomixis that acts to maintain uniformity. The presence of the trait among tropical fruit and grass crops may be a reflection of this effect, because focused efforts to improve these crops are comparatively recent events.

Apomixis results from changes in a small number of key events typical of sexual reproduction (Figure 1). This clearly points the way towards identifying and manipulating those elements in a synthetic approach to engineer asexual seed formation. All known mechanisms of apomixis share three developmental components: the generation of a cell capable of forming an embryo without prior meiosis (apomeiosis): the spontaneous, fertilization-independent development of the embryo (parthenogenesis) and the capacity to either produce the endosperm autonomously or use an endosperm derived from fertilization[11,12].

Significant effort is required before one can hope to successfully engineer a controlled, commercially viable form of apomixis in a wide range of target crops. We have no knowledge of the cues and genes that enable cells in the ovule to switch to an apomictic pathway. The interaction between embryo and endosperm development in apomicts is poorly understood, as is the capability of apomicts to tolerate parental genome imbalances during endosperm development that result in seed sterility in sexual plants. The role of epigenetic factors in the control of apomixis is unknown; yet they are widely implicated in the control of sexual reproduction. Similarly, molecular signalling events have been implicated in the development of both sexual and asexual structures within the plant ovule; yet the nature and role of these events in apomixis are largely unstudied to date. The continued investigation of both native apomicts and sexual systems will provide the best opportunity to elucidate the genetic and physiological factors that contribute to the control of apomixis and that ultimately will permit the controlled formation of maternally derived, genetically identical seeds in flowering plants[13].

To develop *de novo* synthesis of apomixis, Siddiqui and colleagues crossed *Arabidopsis* MiMe and dyad mutants that produce diploid clonal gametes to a

Box 1. Apomixis

Apomixis is the replacement of normal sexual reproduction by asexual reproduction or reproduction without fertilization. Because seeds are found only among angiosperm and gymnosperm taxa, this definition of apomixis limits its use to those groups of plants. Apomixis in flowering plants is defined as the asexual formation of a seed from the maternal tissues of the ovule, avoiding the processes of meiosis and fertilization, leading to embryo development.

Winkler[14] introduced the term apomixis to mean 'substitution of sexual reproduction by an asexual multiplication process without nucleus and cell fusion'.

Asexual reproduction of plants like propagation from a cutting or leaves has never been considered as apomixis but replacement of a seed by a plantlet or replacement of a flower by bulbils is apomixis.

Apomitically produced offspring are genetically identical to the parent plant. As apomictic plants are genetically identical from one generation to the next, each has the characters of true species.

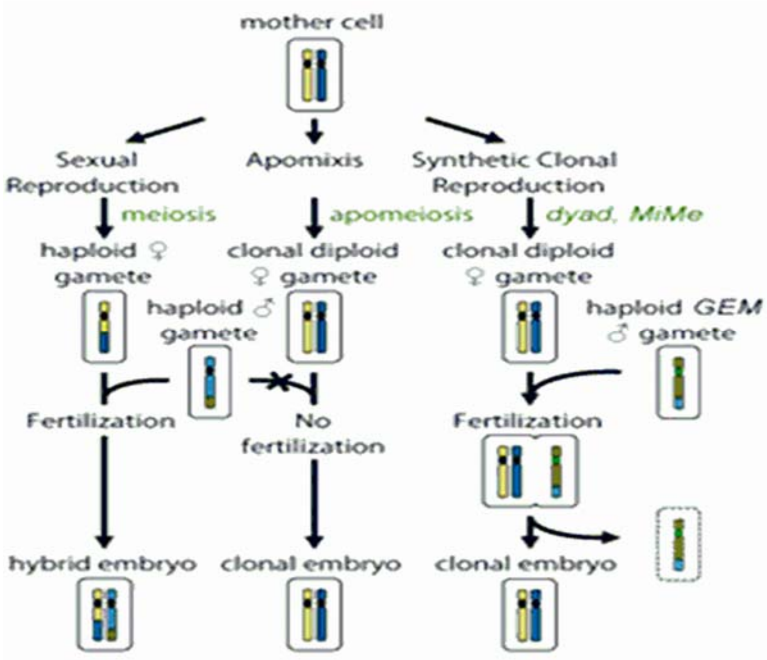

Figure 1. Schematic representation of gametes at sexual reproduction, apomixes and synthetic clonal reproduction (http://www.international.inra.fr/press).

strain whose chromosomes are engineered to be eliminated after fertilization. Up to 34% of the progeny were clones of their parent, demonstrating the conversion of clonal female or male gametes into seeds.

According to Siddiqui, the model plant, *Arabidopsis thaliana* belongs to the mustard family and shown that it is possible to retain hybrid vigour of plants by manipulating known genes that function during normal sexual reproduction and cell division. The hybrids in crops that are made by crossing two varieties lose their vitality over successive generations because of underlying genetic combinations. 'If, however, we can reproduce seeds by apomixis, then hybrid vigour will be maintained as it will be the exact clone of its parent,' Siddiqui explained.

This would reduce the cost of hybrid seed production, and the farmer would be able to multiply his own hybrid seeds and not be compelled to buy them for every planting.

The process will also cut short years of research required in traditional multiplication of hybrid seeds. However, according to CCMB scientists, the application of the fruits of their research to food crops like rice would take 5–10 years.

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Post-mortem of the Japanese earthquake provides new insights

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Much has been written about the 11 March 2011, M_w 9.1 Tohoku-Oki earthquake, that occurred off the northern Japanese coast owing to the unprecedented fury of the tsunami it generated and the destructive impact it had on a coastal nuclear power plant in northern Japan (Figure 1). It will take a long time to contain the fallout from the accident at the Fukushima (Daiichi) Nuclear Power Plant. Apart from the technical and economic challenges of the clean-up, the accident has put a rather large, indelible question mark on the future of the global nuclear power industry, particularly because of the sweeping European reaction which followed in the aftermath of the disaster, targeting the long-term closure of such critical facilities. In any case, the Japanese earthquake is a watershed event in the history of natural disasters, as it puts similar future potential coastal threats in an entirely new perspective, requiring out-of-the-box solutions.

From a scientific point of view, this earthquake has become a cause célèbre of sorts among seismologists, not in the least for the fact that it is one of the better monitored and recorded earthquakes in history. The three papers (http://scim.ag/MSimons, http://scim.ag/S-Ide and http://scim.ag/M-Sato) are but the first instalment in the expected series of papers that will be read and discussed in various forums in the years to come. These papers[1–3] analyse the earthquake