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SABUJEEMA

An International Multidisciplinary e-Magazine

Volume 1 | Issue 5 | August, 2021

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THE POTENTIAL VALUE OF APOMIXIS IN FRUIT CROPS PRODUCTION

[Article ID: SIMM0107]

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ABSTRACT

Apomixis is a genetically controlled reproductive process by which embryos and seeds develop in the ovule without female meiosis and egg cell fertilization. The major advantage of apomixis over sexual reproduction is the possibility to select individuals with desirable gene combinations and to propagate them as clones. In contrast to clonal propagation through somatic embryogenesis or in vitro shoot multiplication, apomixis avoids the need for costly processes, such as the production of artificial seeds and tissue culture. It simplifies the processes of commercial hybrid and cultivar production and enables a large-scale seed production economically in both seed- and vegetatively propagated crops. In vegetatively reproduced plants (e.g., potato), the main applications of apomixis are the avoidance of phytosanitary threats and the spanning of unfavorable seasons. Because of its potential for crop improvement and global agricultural production, apomixis is now receiving increasing attention from both scientific and industrial sectors. Also, investigations on the components of apomixis, i.e., apomeiosis, parthenogenesis, and endosperm development without fertilization, genetic screens for apomictic mutants and transgenic approaches to modify sexual reproduction by using various regulatory genes are receiving a major effort. These can open new avenues for the transfer of the apomixis trait to important crop species and will have far-reaching potentials in crop improvement regarding agricultural production and the quality of the products.

Keywords: Apomixis, Global agricultural production, Reproduction,

INTRODUCTION

Apomixis, is refers to the occurrence of a sexual reproductive process in the place of normal sexual processes involving reduction division and fertilization. It was first reported by Leuwenhock as early as 1719 in Citrus seeds. Apomixis is widely distributed among higher plants. More than 300 species belonging to 35 families are apomictic. The inheritance of apomixis had been established in some species, and molecular mapping studies had been initiated. The molecular relationships between apomictic and sexual reproduction, however, were completely unknown. Recently, comparative developmental features of apomixis have been considered in light of the now considerable knowledge accumulated about ovule and female gametophyte development, and seed formation in sexual plants. We focus on the initiation and progression of apomixis in plants that naturally express the trait. Since 1993, there has been a growing understanding of the complexity that underlies apomixis; some contentious issues have been resolved and others raised. There also have been significant advances in terms of new model systems and approaches being used to study apomixis. We structure the wider discussion around the knowledge of apomixis we have accumulated from our study of Hieracium species, or hawkweeds, a model system we established, and consider additional factors that should be taken into account to induce apomixis in crops. The continued comparative analyses of apomictic and sexual reproduction at the fundamental level in appropriate model systems remains essential for the development of successful strategies for the greater application and manipulation of apomixis in agriculture.

Types of Apomixis:

1. Recurrent Apomixis
2. Non-recurrent Apomixis
3. Adventitiouse embryony
4. Vegetative Apomixis
5. Polyembryony

POTENTIAL VALUE OF APOMIXIS IN FRUIT CROP PRODUCTION:

Apomixis is an attractive trait for the enhancement of crop species because it mediates the formation of large genetically uniform populations and perpetuates hybrid vigor through successive seed generations. Many agronomic advantages of apomixis can be envisioned: the rapid generation and multiplication of superior forms through seed from novel, currently underused germplasms; 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. The value of these opportunities will vary between crops and between production systems. For farmers in the developed world, the greatest benefit is expected to be the economic production of new, advanced, 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. However, 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. There also are few apomictic species of significant relatedness available for use in introgression programs, which may explain at least some of the difficulties experienced when attempts have been made to introduce apomixis into crops through hybridization. For example, major programs aimed at introducing apomixis into maize from the wild relative Tripsacum dactyloides have been under way now for decades, yet they have proven unsuccessful in terms of generating apomictic plants with agronomically acceptable levels of seed set. Difficulties also have been encountered in efforts to produce apomictic lines of hybrid millet (Morgan et al., 1998; Savidan, 2001). Even if successful, it seems likely that introgression lines would provide limited flexibility in terms of practical capacity to manipulate apomixis in agricultural breeding systems. Current breeding efforts with apomictic crop species, such as the forage grasses Brachiaria and Panicum, are frustrated by the need to use complex breeding strategies to accommodate the inaccessibility of the female gamete to generate hybrid progeny. We believe, therefore, that the best solution would be the introduction of apomixis into crops in an inducible format, permitting its use during seed increase but allowing for its silencing during hybridization. To achieve this, information will be required concerning the genes that control the trait, their interrelationship with sexual processes, and the impact the trait might have on seed yield, viability, and quality for a given plant.

The two sexual processes, self-and cross fertilization, followed by segregation, tend to alter the genetic composition of plants reproduced through amphimixis. Inbreeding and uncontrolled out breeding also tend to break heterozygote superiority in such plants. On the contrary, apomicts tend to conserve the genetic structure of their carriers.

They are also capable of maintaining heterozygote advantages generation after generation. Therefore, such a mechanism might offer a great advantage in plant breeding where genetic uniformity maintained over generation for both homozygosity, and heterozygosity is the choicest goal.

Additionally, apomixis may also affect an efficient exploitation of maternal influence, if any, reflecting in the resultant progenies, early or delayed because it causes the perpetuation of only maternal individuals and maternal properties due to prohibition of fertilization. Maternal effects are most common in horticultural crops, particularly fruit trees and ornamental plants.

1. Production of clonally uniform Planting material:

Production of clonally uniform plants has developed in to an industry all over the world. Apomixis has been observed in some horticultural plants including Apple, Citrus, Mango and Mangosteen, and berries but it is not evident in most agricultural crops (Carman, 1997). The process provides a practical and usef ul means of assuring clonal seed propagation but are dependent on percentage of apomictic seedlings germinating from harvested seeds relative to zygotic seedlings. Apomictic seedlings are uniform and vigorous in contrast to usually weaker and variable hybr id seedlings that might also germinate from a poly-embryonic seed. Commercial utilization of apomixis is exploited in Citrus and in Apple industry. Many Citrus scions and rootstocks form poly-embryonic seeds by adventitious embryony and apomictic seedlings are used primarily for uniform rootstock production as well as for direct planting especially in Acid lime and Mandarins. In Citrus, nucellar embryony is generally essential in citrus rootstocks because it al lows nurseries to propagate trees on highly heterozygous, but genetically uniform seedling populations. This reduces variation in stock and scion performance in comparison. Popular apple rootstocks like Mallus toringoides and Mallus sikkimensis are apomict ic and this could be exploited for large scale multiplication of uniform rootstocks.

2. Elimination of viruses:

Apomictic seedlings are currently used for elimination or reduction of seed borne viruses/diseases. In citrus, use of grafting material from in fected trees for nursery propagation 296 is primarily responsible for dissemination of virus and virus like diseases, which ultimately affect longevity and productivity of the orchards. Apomictic or nucellar seedlings are suitable for screening out pathoge ns such as viruses, which in many cases are not transmitted by seed. Apple proliferation (AP) is a serious disease of Apple in Europe. Natural resistance was found in apomictic Malus sieboldiiderived genotypes which can be used as rootstocks. In several apomictic Apple rootstock selections derived from crosses between M. domestica and the apomictic species M. sieboldii and M.

sargentii are natural resistance towards Apple proliferation was observed. Therefore, a promising way to control AP disease, is the use of resistant apomictic rootstocks.

3. Apomictic seedlings are helpful for identification:

Apomictic seedlings are helpful for identification as trifoliate leaf character in citrus (Trifoliate orange), is found in apomictic seedlings.

4. Ability to survive under stresses conditions:

Apomictic seedling plants have the ability to survive under local stresses like extreme climate conditions or under pathogen pressure, would be fixed and used in propagation.

5. Propagation of endangered cultivars:

Large gen etic advances can be made in a single step by selecting a single unique superior plant from a seedling population and reproducing it asexually by vegetative propagation. Exploitation of apomixis should play a key role in case of sexually propagated crops. This may occur when propagating minor commercial cultivars, establishing collections, transporting through quarantine barriers, or beginning a nuclear stock program. Because, such a plant becomes the sole representative of that clone in future propagation, it constitutes a new source clone. Propagation then takes place in a sequential pattern in both time (vertical) and space (horizontal), and provides an historical vegetative pedigree for the cultivar.

CONCLUSION

In general, apomixis is not conducive to fitness in evolution as it does not foster the propagation of new genes in a population and as it generally serves only to reduce genetic diversity. Many apomictic species retain some ability to reproduce sexually. Here, their apomictic trait enables them to thrive in environments where pollination is impossible but then, when conditions allow, they are also able to resume sexual reproduction. Hence, apomixis offers a species an enhanced ability to adapt to and survive in difficult environments. This characteristic can thus be viewed as a ‘refuge’ behaviour which is a potentially advantageous evolutionary adaptation. In addition, it was found in the data collected that most apomictic plants are polyploid. It may provide more opportunities for variation in plants. At the same time, multiple genetic material can attenuate adverse mutations, resulting in a higher proportion of apomixis. If apomixis can be engineered into sexual crops in a controlled manner, its future impact on agricultural systems has the potential to be both widespread and profound. Apomixis will allow clonal seed production and this will enable seed quality to be raised and seed production costs lowered. This in turn will lower the input costs of fruit and vegetable production while also raising yields and making them more consistent. It is generally agreed the introduction of apomixis to agronomically important crops will revolutionize agriculture. A better understanding of the inheritance patterns for apomixis is fundamental for facilitating the identification of candidate genes, which in turn is essential for engineering apomixis into sexual crops.

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