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International Journal of Complementary & Alternative Medicine

Mini Review

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Molecular farming: hosting plants as green factories

Volume 7 Issue 4 - 2017

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Received: April 11, 2017 | **Published:** June 09, 2017

Mini-review

Agricultural biotechnology provided several novel tools to make fine tuning of genome structure and alternate the traits of interest in plants in a way that have never been possible before. One of the major beneficial outcomes of this technology is genetically modified (GM, transgenic) plants in which one or several genes have been inserted into plant genome from various sources by using different means such as *Agrobacterium tumefaciens*or particle bombardment.[1,2] Organel genome of certain plant species also become as target to generate transplastomic plants.[3,4] Although GM plants have come along with a number of controvertial issues,[1] the global planting area of GM plants constantly increased during last two decades and reached to 181.5billion ha all around the world.[5] Therefore, agricultural biotechnology is one of the most adaptive technologies used in plant production. However, the traditional use of transgenic plants has recently expanded beyond for food and feed production, and newer generations of GM plants hosted novel applications such as pharmaceutical manufacturing in agricultural scale.[6]

The traits of GM plants have mainly been classified into three groups:[7] First-generation GM crops involved in improvements of agronomic traits such as resistance to pests, herbicides or diseases. Second-generation of GM crops focused on biofortification of food or feed products such as golden rice or bioremediation.[8,9] Third-generation of GM plants were designed to produce special substances such as plant based pharmaceuticals or chemicals used for industrial purposes. Different terms are used to define the use of GM plants for the production of such therapeutics.[10,11] The term 'Pharming' is generally used to refer the use of plants for the production of pharmaceuticals although it often describes the use of animals for the production of drugs.[12] Therefore, the production of recombinant pharmaceutical proteins by using GM plants is spesifically defined as Plant Molecular Farming or Molecular Pharming per se and their products are defined as Plant-made Pharmaceuticals (or therapeutics) (PMP) or Plant Molecular Farming to avoid confusion with animal based techniques.[13,14] On the other hand, Biomanufacturing or Biopharmaceuticals also appear in the literature for the use of biological organisms to manufacture products of interest or pahrmaceuticals from biological organisms, respectively.[12] In addition, the term molecular farming is also used for the commercial nonpharmaceutical products of GM plants such as antibodies, enzymes, and growth factors that are used as research-grade or diagnostic reagents, cosmetic ingredients, biosensors, and biocatalysts to facilitate bioremediation.[15–17] Although most of them are currently produced on a small to medium scale, making it possible to rely on contained growing facilities rather than field cultivation,[16] the full potential of molecular farming will only be realized if large-scale production can be achieved.[18]

In the past, molecular farming was not an atractive expression system due to competitive traditional platforms. However, approval of the first plant-based biopharmaceutical in 2012 provided an emerging apportunity that transgenic plants can be used as an alternative production systems not only for medical practices of biopharmaceuticals but also for the commercial nonpharmaceutical products.[19–22] Therefore, recent advances in transgenic plant technology also revealed specific platforms and regulatory guidelines that unique products can be produced more successfully in plants than by bacteria or memmelian cells.[23,24] For instance, proteins extracted from transgenic plants grown in a field scale represent a promising strategy for affordable vaccine production that combines innovations in medical science and plant biology. One of the most lucrative new applications of biotechnology-derived enzymes is enzymatic biodiesel products since they are nonpolluting and carbon-neutral fuel.[25] In addition, the expression of polymer-degrading enzymes in plants would be cost effective compared to traditional platforms, and the enzymes could be purified and be used as crude extracts, or be preferably expressed in the biofuel crop directly.[11] The biorefinery concept of plant molecular farming will allow the design of low-waste processes in which all raw materials are converted into useful products.[23] The growth of the biofuel, paper manufacturing industry and food/feed additive industries may be involved more in plant molecular farming since the production of nonpharmaceutical antibodies in various formats has been demonstrated for applications in diagnostics, food processing, and quality validation in the past.[26–28]

Conclusion

In conclusion, along with those current prospects and future potantial appoturnities mantioned above, molecular farming may not run away from the safety issues of genetically modified plants. An appropriate choice of host plant species e.g., self-fertilizing non-crop plants will be an important parameter in future aplications. Recent developments in omics technologies and precise genome editing tools such as CRISPR-cas9 may accelerate the adaption of plant based biological manufacturing to turn GM plants in green factories.

Acknowledgments

None.

Conflicts of interest

Author declares there are no conflicts of interest.

Funding

None.

References

1. Mehrotra S, Goyal V. Agrobacterium-mediated gene transfer in plants and biosafety considerations. *Appl Biochem Biotechnol.* 2012;168(7):1953–1975.
2. Hensel G, Kastner C, Oleszczuk S, et al. Agrobacterium-mediated gene transfer to cereal crop plants: current protocols for barley, wheat, triticale, and maize. *Int J Plant Genomics*. 2009;2009:835608.
3. Alfano EF, Lentz EM, Bellido D, et al. Expression of the Multimeric and Highly Immunogenic Brucella spp. Lumazine Synthase Fused to Bovine Rotavirus VP8d as a Scaffold for Antigen Production in Tobacco Chloroplasts. *Front Plant Sci.* 2015;6:1170.
4. Lentz EM, Garaicoechea L, Alfano EF, et al. Translational fusion and redirection to thylakoid lumen as strategies to improve the accumulation of a camelid antibody fragment in transplastomic tobacco. *Planta*. 2012;236(2):703–714.
5. James C. A global overview of biotech (GM) crops: adoption, impact and future prospects. *GM Crops*. 2010;1(1):8–12.
6. Paul MJ, Thangaraj H, Ma JK. Commercialization of new biotechnology: a systematic review of 16 commercial case studies in a novel manufacturing sector. *Plant Biotechnol J.* 2015;13(8):1209–1220.
7. Qaim M. The Economics of Genetically Modified Crops. *Annu Rev Resour Econ.* 2009;1:665–694.
8. Sarma H, Islam NF, Prasad MN. Plant-microbial association in petroleum and gas exploration sites in the state of Assam, north-east India-significance for bioremediation. *Environ Sci Pollut Res Int.* 2017;24(9): 8744–8758.
9. Sakpirom J, Kantachote D, Nunkaew T, et al. Characterizations of purple non-sulfur bacteria isolated from paddy fields, and identification of strains with potential for plant growth-promotion, greenhouse gas mitigation and heavy metal bioremediation. *Res Microbiol.* 2017;168(3):266–275.
10. Brown DP, Rogers DT, Gunjan SK, et al. Target-directed discovery and production of pharmaceuticals in transgenic mutant plant cells. *J Biotechnol*. 2016;238:9–14.
11. Ma JK, Barros E, Bock R, et al. olecular farming for new drugs and vaccines. Current perspectives on the production of pharmaceuticals in transgenic plants. *EMBO Rep*. 2005;6(7):593–599.
12. Norris S .Molecular Farming. Parliamentary information and research service: *PRB.* 2005;05–09E.
13. Hassan SW, Waheed MT, Lossl AG. New areas of plant-made pharmaceuticals. *Expert Rev Vaccines*. 2011;10(2):151–153.
14. Price B. Conference on plant-made pharmaceuticals. 16-19 March 2003, Quebec City, Quebec, Canada. *IDrugs.* 2003;6(5):442–445.
15. Gomord V, Sourrouille C, Fitchette AC, et al. Production and glycosylation of plant-made pharmaceuticals: the antibodies as a challenge. *Plant Biotechnol J*. 2004;2(2):83–100.
16. Holtz BR, Berquist BR, Bennett LD, et al. Commercial-scale biotherapeutics manufacturing facility for plant-made pharmaceuticals. *Plant Biotechnol J*. 2015;13(8):1180–1190.
17. Robertson WO. Tomorrow today: plant-made pharmaceuticals. *Vet Hum Toxicol*. 2003;45(3):165–166.
18. Greenham T, Altosaar I. Molecular strategies to engineer transgenic rice seed compartments for large-scale production of plant-made pharmaceuticals. *Methods Mol Biol.* 2013;956:311–326.
19. Daniell H, Streatfield SJ, Wycoff K. Medical molecular farming: production of antibodies, biopharmaceuticals and edible vaccines in plants. *Trends Plant Sci.* 2001;6(5):219–226.
20. Johnson R, Jiskoot W. Models for evaluation of relative immunogenic potential of protein particles in biopharmaceutical protein formulations. *J Pharm Sci*. 2012;101 (10):3586–3592.
21. Zhu J. Mammalian cell protein expression for biopharmaceutical production. *Biotechnol Adv*. 2012;30(5):1158–1170.
22. Pelosi A, Shepherd R, Walmsley AM. Delivery of plant-made vaccines and therapeutics. *Biotechnol Adv*. 2012;30(2):440–448.
23. Schillberg S, Raven N, Fischer R, et al. Molecular farming of pharmaceutical proteins using plant suspension cell and tissue cultures. *Curr Pharm Des*. 2013;19(31):5531–5542.
24. Twyman RM, Stoger E, Schillberg S, et al. Molecular farming in plants: host systems and expression technology. *Trends Biotechnol.* 2003;21(12):570–578.
25. Fischer R, Emans N, Schuster F, et al. Towards molecular farming in the future: using plant-cell-suspension cultures as bioreactors. *Biotechnol Appl Biochem.* 1999;30(Pt 2):109–112.
26. Schillberg S, Fischer R, Emans N. Molecular farming of recombinant antibodies in plants. *Cell Mol Life Sci.* 2003;60(3):433–445.
27. Fischer R, Liao YC, Hoffmann K, Molecular farming of recombinant antibodies in plants. *Biol Chem*. 1999b;380(7-8):825–839.
28. Tschofen M, Knopp D, Hood E, et al. Plant Molecular Farming: Much More than Medicines. *Annu Rev Anal Chem (Palo Alto Calif).* 2016;9(1):271–294.