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Genetic Transformation and Transgenic Wheat Development: An Overview

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Wheat (*Triticum aestivum* L) is a cereal crop of immense commercial significance world over. With an annual production of about 715.5 million tones, wheat is the second largest staple crop of the world and 17% of the global cultivable land is being used for wheat production [1]. The world food production needs to be increased at least by 70% in the coming 35 years so as to meet the growing food demand from an ever increasing population **[2].** Different environmental stresses, both biotic and abiotic are the major constraints in attaining the potential wheat productivity. Further, in the recent years, the changing global climate is playing a havoc on agriculture and wheat production is also been adversely affected. The world cereal output in 2012 has shown a 5.7% diminution in wheat production [3]. Wheat production in India has always been at stake of temperature variations but in present times due to increasing atmospheric temperature, the wheat production in India is being adversely effected [4]. The temperature is predicted to rise by 2.5-4.3°C by the end of the century with significant effects on food production and undernourishment and with every 1°C increase in temperature during grain filling stage in case of wheat, grain yield is expected to decline by 5.4% [5-8].

The terminal heat stress at the stage of a thesis and grain filling decreases grain size significantly leading to a declined overall production [9]. The yield and quality decline of wheat crop due to terminal heat stress is a subject of great concern which needs to be addressed by development of heat tolerant wheat genotypes [10].

Over the centuries, the combined effects of natural and human selection has led to progression of genotypes with different arrangements of traits, for instance growth pattern, temperature variation tolerance, drought, premature growth pattern, duration to maturity, grain filling duration, and quality traits. As a result, these wheat landraces turned into complex, unstable, genetically dynamic and varied populations, in balance with both biotic and abiotic stresses present in the environment. These characteristics were retained through selection, isolation, reduced migration, and limitations on out crossing and genetic recombination. The majority of landraces give poor yield in comparison to the elite high yielding genotypes developed by breeders. So over the time, most of these landraces have been lost as the newly developed high yielding genotypes are leading over most of the global cultivable land. This has led to loss of accessible gene pool which is becoming a major constraint in breeding programs. Therefore identification of genes responsible for tolerance against biotic and abiotic stresses from resources across species, genera or even kingdom and then deploying them in developing transgenic wheat through recombinant DNA technology approach is essential. For past few decades, transgenic development is gaining importance for incorporating desired traits such as herbicide tolerance, diseases resistance and quality improvement in crops of our choice [11]. Thus, this technology can be successfully deployed for developing transgenic wheat adaptable to environmental stresses and increasing wheat production in the present scenario of climate change.

Recombinant DNA technique followed by plant genetic transformation forms the basis of transgenic development protocols. The transgenic technology is a powerful tool of transferring new characteristics controlled by a single gene or several genes from across the species/genus and even kingdom to the plant genomes in order to improve their particular characteristics especially those related to superior yield, enhanced quality, increased insect and disease resistance and other beneficial properties [12]. Genetic transformation is carried out by two major methods, namely the *Agrobacterium* mediated gene transfer and other is direct gene transfer method [13,14]. Though wheat continues to be world's major food crop it was one of the last cereals to be genetically transformed. Numerous laboratories have developed the capability of wheat transformation but to date its transformation efficiency is much lower than that of other cereals. The large (17,000 Mb) and complex (hexaploid) genome, genotype-dependent tissue culture responses may lead to transgene silencing [15]. Lack of an efficient gene delivery system continues to be a major hurdle for efficient genetic transformation in wheat. Unfortunately, the genotype specific genetic transformation response further restricts the success of transgenic development in wheat [16].

Many DNA-transfer methods have been tried in wheat with varying degrees of success including electroporation, micro-injection, silicon carbide fibers, polyethylene glycol and laser-mediated uptake, but *Agrobacterium*-mediated transformation and micro particle bombardment methods have been found to be most successful. Particle bombardment method continues to form the basis of many robust and well used wheat transformation protocols [17] though it suffers from the drawback of complex transgene integration patterns like arrangement/copy number or fragmentation of the DNA during bombardment [18]. Moreover, identification and maintenance of a contamination-free regenerable callus over a period of time is difficult. This has been a driving force in the development of *Agrobacterium*-mediated wheat transformation methods [19]. Successful *Agrobacterium*-mediated *in vitro* transformation completely depends upon callus culture and plant regeneration procedures. The frequencies of callus induction and plant regeneration in tissue culture of wheat are commonly influenced by the culture medium, and genotype, explant sources [20-22]. *In planta* transformation protocol that avoids sterile conditions of tissue culture is an alternative method for wheat genetic transformation. Numerous workers have reported successful *in planta* transformation in different plant species [23,24]. Successful transformation of buck wheat and bread wheat using *Agrobacterium*-mediated *in planta* method have been reported though with very low transformation efficiency [25,26].

Genetic transformation thus forms the core of transgenic development technology and therefore for development of wheat transgenic for various abiotic stresses and biotic stress, a foolproof protocol for transformation and regeneration is must. Zhou obtained

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Roundup Ready transgenic wheat by transforming the herbicide resistance gene into the wheat cultivar Bobwhite, which displayed full resistance to the herbicide [27]. In same year Hu and co-workers reported glyphosate resistant transgenic Bobwhite IE C58 wheat using the modified *CP4-EPSPS* gene [18]. So far, no GM wheat is grown commercially, although many field tests have been conducted. It is essential to standardize a competent, cost-effective transformation protocol which works in major wheat genotypes so that the same can be followed for developing wheat transgenic against diverse abiotic and biotic stresses for the benefit of farmers and nations world over [28].

Conclusion

Transgenic approach has the potential to enhance crop production under heat stress conditions. However, the successful wheat transformation methods still remain time consuming, because it is very crucial to match the host strains, plasmids, selection systems, wheat genotypes and media composition. There are various reports of successful transformation in wheat but unfortunately most of the methods lack desirable features as simplicity and low cost so as to allow maximum access to technology. This necessitates a need to explore potential for development of a transformation system without tissue culture to make the genetic modification of this important crop simple, economical, competent and genotype independent. The method for transformation of wheat through apical meristem can revitalize the genetic improvement of this crop to cope with its rapidly increasing demand and has the potential for effective genetic transformation of other crops through growing meristem [23,29].

References

1. FAO (2015) Regional Conference for Asia and the Pacific, Malaysia. [http://www.fao.org] Accessed on: March 9, 2016.
2. FAO (2011) How to Feed the World in 2050. [http://www.fao.org/wsfs/forum2050/wsfs-forum/en/] Accessed on: March 9, 2016.
3. FAO (2012) FAO Cereal Supply and Demand Brief. [http://www.fao.org/worldfoodsituation/csdb/en/] Accessed on: March 9, 2016.
4. Howard A (1924) Crop production in India: A critical survey of its problems. Oxford University Press, Oxford.
5. IPCC (2007) Synthesis: Contribution of working groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.
6. Nelson GC (2009) Climate Change: Impact on Agriculture and Costs of Adaptation, International Food Policy Research Institute Washington, D.C.
7. Lobell DB, Field CB (2007) Global scale climate-crop yield relationships and the impact of recent warming. Environ Res Letters 2:1-7.
8. Rane J, Shoran J, Nagarajan S (2000) Heat stress environments and impact on wheat productivity in India: Guestimate of losses. Indian Wheat News Letter 6: 5-6.
9. Kosina P, Reynolds MP, Dixon J, Joshi A (2007) Stakeholder perception of wheat production constraints, capacity building needs and research partnerships in developing countries. Euphytica 157: 475-483.
10. Mohammadi M (2012) Effects of kernel weight and source-limitation on wheat grain yield under heat stress. African Journal of Biotechnology 11: 2931-2937.
11. James C (2003) Global review of commercialized transgenic crops. Curr Sci 84: 303-309.
12. Lorz H, Leckband G (1998) Transformation and expression of a stilbene synthase gene of Vitis vinifera L. in barley and wheat for increased fungal resistance. Theor Appl Genet 96: 1004-1012.
13. Zupan JR, Zambryski P (1995) Transfer of T-DNA from Agrobacterium to the plant cell. Plant Physiology 107: 1041-1047.
14. Yao Q, Cong L, Chang JL, Li KX, Yang GX, et al. (2006) Low copy number gene transfer and stable expression in a commercial wheat cultivar via particle bombardment. Journal of Experimental Botany 57: 3737-3746.
15. Anand A, Zhou T, Trick HN, Gill BS, Bockus WW, et al. (2003) Greenhouse and field testing of transgenic wheat plants stably expressing genes for thaumatin-like protein, chitinase and glucanase against Fusarium graminearum. J Exp Bot 54: 1101-1111.
16. Han Y, Jin XL, Wu FB, Zhang GP (2011) Genotypic differences in callus induction and plant regeneration from mature embryos of barley (Hordeum vulgare L.). J Zhejiang Univ Sci B 12: 399-407.
17. Kasirajan L, Kovilpillai B, Bansal KC (2013) Optimization of genetic transformation protocol mediated by biolistic method in some elite genotypes of wheat (Triticum aestivum L.). Afr J Biotechnol 12: 531-538.
18. Hu T, Metz S, Chay C, Zhou HP, Biest N, et al. (2003) Agrobacterium-mediated large-scale transformation of wheat (Triticum aestivum L.) using glyphosate selection. Plant Cell Rep 21: 1010-1019.
19. Sparks CA, Jones HD (2009) Biolistic transformation of wheat. Methods Mol Biol 478:71-92.
20. Redway FA, Vasil V, Lu D, Vasil IK (1990) Identification of callus types for long-term maintenance and regeneration from commercial cultivars of wheat (Triticum aestivum L.). Theor Appl Genet 79: 609-617.
21. Fennel S, Bohorova N, Ginkel M, Crossa J, Hoisington DA (1996) Plant regeneration from immature embryos of 48 elite CIMMYT bread wheats. Theor Appl Genet 92: 163-169.
22. Sharma VK, Rao A, Varshney A, Kothari SL (1995) Comparison of developmental stages of inflorescence for high frequency plant regeneration in *Triticum aestivum* L. and *Triticum durum* L. Desf. Plant Cell Rep 15: 227-231.
23. Supartana P, Shimizu T, Shioiri H, Nogawa M, Nozue M, et al. (2005) Development of simple and efficient in planta transformation method for rice (*Oryza sativa* L.) using *Agrobacterium tumefaciens.* J Biosci Bioeng 100: 391-397.
24. Kojima M, Arai Y, Iwase N, Shiratori K, Shioiriet H, et al. (2000) Development of a simple and efficient method for transformation of buckwheat plants (*Fugopyrum esculentum*) using *Agrobacterium tumefaciens*, Biosci Biotechnol Biochem 64: 845-847.
25. Bratic AM, Majic DB, Miljus-Djukic JD, Jovanovic ZS, Maksimovic VR (2007) In planta transformation of Buckwheat (*Fagopyrum esculuntum moench.).* Arch Biol 59: 135-138.
26. Chugh A, Vikrant S, Mahalakshmi A, Khurana A (2012) A Novel approach for Agrobacterium-mediated germ line transformation of Indian Bread wheat (Triticum aestivum) and Pasta wheat (Triticum durum). J Phytol 4: 22-29.
27. Zhou H, Arrowsmith JW, Fromm ME, Hironaka CM, Taylor ML, et al. (1995) Glyphosate-tolerant CP_4 and GOX genes as a selectable marker in wheat transformation. Plant Cell Rep 15: 159-163.
28. GMO Compass (2016) Wheat [http://www.gmo-compass.org/eng/database/plants/78.wheat.html] Accessed on: March 9, 2016.
29. Abdul R, Ishfaq AH, Imran M, Azhar H (2011) Development of *in planta* transformation protocol for wheat. African Journal of Biotechnology 10: 740-750.