Pocket K No. 38

Biotech Wheat

Wheat is a member of the grass family that produces modified fruit which is fused with its single seed, forming the grain. The fruits are borne together in a panicle and the edible part of the seed or grain is called kernel. The Middle East is the geographical origin of wheat[1]. Wheat is a staple food that is processed into flour and used for different types of breads, pastries, pastas, and cereals. It is also used for fermentation of alcoholic beverages[2] and biofuels[3]. *Triticum aestivum* L. (bread wheat) and *Triticum durum* (durum or macaroni wheat) are the commonly grown species today[4].

Wheat is the second most-produced cereal crop after maize, with 683.15 million metric tons of global production in 2009[5]. The top three producers of wheat are China, India, and the United States of America. China, the top producer of wheat globally, utilizes its entire wheat yield. India also cultivates for its own consumption. The U.S. produces around 1.3 to 2 billion bushels per year (1 bushel of wheat at 13.5% moisture=27.21kg) but half of it is exported. Canada, Australia and Argentina also export a portion of their wheat production. For the last decade or so, wheat hectarage has consistently declined and failed to meet the target[6].

Maize and soybean are getting ahead of wheat in terms of production because conventional efforts for wheat are not keeping pace with the modernized techniques used to improve maize and soybean[7]. Thus, there is renewed emphasis on utilizing biotechnology approach to produce more wheat, which may solve the problems that conventional breeding methods cannot.

Herbicide Tolerant Wheat

BASF released the first herbicide tolerant wheat in 2007 in Canada commercially known as Clearfield wheat. Clearfield wheat is a product of mutation breeding developed to survive the presence of imidazolinone herbicide which blocks the activity of acetohydroxyacid synthase (AHAS). AHAS is the first enzyme in the biosynthetic pathway of branched amino acids essential for plant growth. Based on the results of the field trials in the U.S., Clearfield is almost similar to the parental line in terms of vigor, time to maturity, seed production (yield), disease resistance, and tendency to weediness[8].

The first herbicide tolerant wheat produced through genetic engineering was developed by Monsanto, the MON 71800 event, commercially known as Roundup Ready™ wheat. A gene from common soil bacterium Agrobacterium tumefaciens strain CP4 was introduced to wheat to produce a glyphosate tolerant wheat line. The gene codes for the production of a novel form of the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) which functions in the shikimate pathway, a biochemical pathway responsible for the synthesis of aromatic amino acids and other aromatic compounds which are vital

for growth and survival. Although studies have proven that this glyphosate tolerant wheat is safe and nutritious, just like the other conventional wheat varieties[9], Monsanto decided not to introduce Roundup Ready™ wheat to the market.

The Future Biotech Wheat

Pest-resistant Wheat

Wheat is affected by a number of fungal diseases such as stem rust (*Puccinia graminis*), *Septoria*, *Fusarium* and common bunt (*Tilletia tritici*) which can easily spread in the wheat fields when the surrounding is moist. Among these fungal pests, *Fusarium* is the worst, causing crown rot and head blight that result to production of small and stunted grains or no grain at all. Some *Fusarium* strains also produce mycotoxins, or poisonous compounds which when ingested by humans or animals may cause nausea, vomiting, hormonal imbalance and other chronic diseases[10]. Syngenta has been working on genetically modified *Fusarium*-resistant wheat but postponed the project in 2007 due to public concern over biotechnology. This could be a candidate for reconsideration with the growing interest for biotech wheat[11]. Syngenta also partnered with CIMMYT to develop stem rust resistant varieties of wheat through marker-assisted breeding[12].

In 2009, researchers from the Institute of Plant Pathology in Zurich and John Innes Center in Britain separately revealed two rust-resistance wheat genes that could be the best solution in eliminating the rust fungus threat[13]. The *Lr34* gene isolated by Zurich researchers could be responsible in fighting off diseases. John Innes Center scientists identified the *Yr36* gene which is found in wild wheat but has been lost during domestication. The scientists infer that *Yr36* recognizes a lipid from a disease and then commands a resistance response.

The Chinese Academy of Agricultural Sciences (CAAS) possibly has the highest investment in the world for biotech wheat. They are developing a wide range of traits such as resistance to yellow mosaic virus, head scab, powdery mildew, and insect. A wheat line with resistance to yellow mosaic virus is expected to be available in the market by 2015[14,15]. The Henan Agricultural University is also developing sprouting-tolerant wheat, to get rid of the 20% loss in production due to early sprouting. This is expected to be commercially available by 2012 or 2013[16].

Salt-tolerant Wheat

CSIRO Plant Industry researchers have already isolated two salt tolerance wheat genes (*Nax1* and *Nax2*), which came from the old wheat relative Triticum monococcum. Both genes inhibit sodium, which can be toxic to plants, by limiting its passage from the roots to the shoots[17]. Based on the field trials conducted in Australia in 2009, the lines with the *Nax2* gene produced 25% more yield than those without the gene in saline conditions.

Biofortified Wheat

Wheat is also being developed to be safe for people with celiac disease, which is caused by the consumption of gluten that leads to damage to the small intestine resulting in obstructed absorption of nutrients from food, and hence malnutrition. Washington State University (WSU) is currently conducting experiments using genetic techniques to remove the celiac-causing gliadins in the wheat grain with improved baking quality traits. The variety is also expected to contain more lysine, an essential amino acid that is usually scarce in wheat[18].

Drought-tolerant Wheat

Drought resistance is an essential trait for wheat because water is a limiting factor especially as the world faces the effects of global climate change[19]. The effect of drought on cereal production can be large enough to affect the economy of wheat-producing countries such as Australia, where 1% subtraction in GDP (from 2002 to 2003) was attributed to drought. In Victoria, the wheat supply decreased by 70% in 2007 due to severe drought conditions, leading to the state's loss of $300 million. In 2007, 30 wheat transgenic lines were tested in Victoria under the project of Professor German Spangenberg of the Department of Primary Industries. Each wheat line contains six different drought tolerance genes from maize (*Zea mays*), thale cress (*Arabidopsis thaliana*), moss (*Physcomitrella patens*) and yeast (*Saccharomyces cerevisiae*). These genes encode proteins that will regulate biochemical pathways to promote normal growth under reduced amounts of water. If the trials are successful, the researchers hope to have the drought-tolerant wheat ready for release in about three years[20]. Similarly, the International Maize and Wheat Improvement Center (CIMMYT) used a gene (DREB1A) from Arabidopsis thaliana to enhance the characteristics of wheat. The genetically engineered wheat exhibited tolerance to drought, low temperature and salinity[21].

The Second Chance of Biotech Wheat

The acceptance for biotech wheat or genetically modified (GM) wheat has changed over the years since crop companies postponed their plans of commercializing the transgenic wheat in 2003 and 2004 due to widespread opposition[22]. A 2009 wheat growers survey conducted by the National Association of Wheat Growers (NAWG) showed that 76% of the respondents are in favor of the petition supporting the commercialization of biotechnology in wheat[23]. The International Food Information Council also conducted "Consumer Perceptions of Food Technology" survey in 2010 in the U.S. and reported that 73% of the respondents said they would likely purchase bread, crackers, cookies, cereal, or pasta made with GM wheat developed to use less water, land and/or pesticides.[24] Nine wheat-related associations from major wheat producers Australia, Canada and the U.S. released a GM Wheat Trilateral Statement, announcing the need for more investment in R&D of GM wheat[25].

Since there is renewed interest for GM wheat, commercialization of biotech wheat could possibly push through. According to the paper released by the Wheat Foods Organization entitled "The Case for Biotech Wheat", biotechnology can make an important

contribution in transforming the competitiveness equation (of wheat, which is declining) and positioning it as a viable production option for producers. If the new technologies available for crops are not used in developing enhanced wheat, then the wheat production sector will continue to decline in acreage and supply[26], leaving farmers with fewer options in the future.

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