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Review

Genetically modified sunflower release: Opportunities and risks

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Abstract

Sunflower (*Helianthus annuus* L.) is a crop native to North America for which there are no genetically modified commercial varieties. Some of the transgenic traits incorporated in other crops have already been subjected to research and experimentation in sunflower. Several new traits have also been noted, with the most relevant of these being the aim to increase latex production. GM sunflower release would modify crop management through improved mineral nutrition, weed control, insect and disease resistance, and product quality. In this research, the traits investigated were reviewed and analyzed in connection with main crop constraints. These characters could potentially influence agro-ecosystem components and produce a significant environmental impact. In regions where sunflower coexists with wild relatives this situation could affect germplasm resources, with this being especially important at the centre of origin and where *Helianthus* populations established in Africa, Asia, and Europe.

Keywords: Sunflower; Biotechnology; GM crops; Environmental impact; Herbicide tolerance; Pest control

Contents

1. Introduction

Sunflower is the fifth most important source of edible oil after soybean, rapeseed, cotton, and peanut. The total world production of 25.8 million tonnes of sunflower seed go almost exclusively to oil extraction, providing 8.2% of total world volume, estimated at around 107 million tonnes. The sunflower crop is important in several Eastern European countries and also in Argentina, which provides more than 10% of world production. Sunflower is considered good quality oil, but does not command the high prices of other edible oils, for which there is greater demand in the most select markets. The mean price of sunflower on the Rotterdam market over the last decade was US$ 663 per tonne, exceeding those of soybean, palm, and coconut oils (FAS, 2005).

Biotechnology can speed up plant breeding, with many of the techniques complementing rather than substituting con-

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ventional methods (FAO, 2005a) and some biotechnological products have had a strong impact upon production systems because they have also facilitated crop management. This has led to a major increase in the total area devoted to genetically modified (GM) maize, soybean, cotton, and rapeseed production, which now exceeds 90 million ha, most of which are distributed amongst the 14 countries in which these crops have been authorized (James, 2005).

GM soybean constitutes a particularly significant case. Since its release as a commercial crop in Argentina 10 years ago, there have been increases in acreage, yield, and total production of 12.5%, 10.6%, and 25%, respectively (SAGPyA, 2002). This trend is still continuing and may, at least in part, be associated with RR (Roundup Ready®) soybean tolerance to glyphosate herbicide (Monsanto, 2002). This simplifies its cultivation under no-till systems immediately after wheat harvest, and greatly facilitates weed control. Moreover, it helps to reduce production costs, making the crop profitable in otherwise marginal areas of Paraguay, Brazil, and Bolivia. These facts help to explain the major increase in production observed in South America during the last 10 years (FAS, 2005). Sunflower and peanut are the only major vegetable oil yielding crops that have no GM varieties authorized for commercial use. This does not imply that versions of these products are not available through research; their use has been discouraged for other reasons. In the case of sunflower, the release of genetically modified organisms (GMO) must be carefully considered because of the agro-ecological implications of a possible transgene escape. This is an open-pollinated crop native to North America (Heiser et al., 1969; Harter et al., 2004) which has now wild relatives throughout the world's crop regions, Europe (Faure et al., 2002), Australia (Dry and Burdon, 1986), Africa (Quagliaro et al., 2001; Ribeiro et al., 2001), and Argentina (Poverene et al., 2002). Diffusion to these areas can be addressed to human activity. Crop-wild gene exchange allows transgene escape via gene flow in sunflowers (Whitton et al., 1997; Linder et al., 1998; Rieseberg et al., 1999; Burke et al., 2002). Transgenes from the crop could potentially disperse into wild or weedy populations enhancing their fitness and modifying their ecological interactions (Burke and Rieseberg, 2003; Snow et al., 2003). Conversely, wild or weedy sunflowers and volunteers can invade and interfere crop, and may modify traits, such as oil composition, via pollen flow (Faure et al., 2002; Bervillé et al., 2004). Furthermore, the impact of GMO release on edible oil marketing could be negative, because of the well known consumer resistance to GM products. So far, these circumstances have delayed the development of GM sunflower for commercial uses. The goal of this work was therefore to analyze the likely impact of the use of transgenic sunflower on agronomic crop management and to consider the possible consequences of authorization being granted for the commercialization of such products.

2. Registered GM crops

The level of adoption of GM crops in the USA is the highest in the world, with 49.8 million ha (James, 2005). Their diffusion was preceded by intense research and development activity. At present, more than a hundred different GM products have been authorized for commercialization: 13 of these are crops, including maize, soybean, rapeseed, flax, and rice (Table 1). The products authorized for farming and industrial uses mainly facilitate weed, pests and/or virus control, and seek to improve quality and facilitate hybrid seed production. These commercial products represent the successful end products from just a few of more than 20,000 authorized trials undertaken with several dozen species.

The GM products available to farmers in Argentina have traits which facilitate crop management, such as herbicide tolerance and insect resistance. Only the soybean, maize, and cotton harbouring modifications of these traits have been authorized for commercial use (Table 1). In Argentina, the studied events include a smaller number of traits than in the USA. From the beginning of the biotechnological registrations in 1991, more than 800 cases have been authorized for research. Only about 10% of these cases involve sunflower, including modifications aimed at increasing the capacity for nitrogen assimilation and disease resistance. Even so, insect resistance and herbicide tolerance account for more than 80% of the release permits.

Australia, a country also actively involved in biotechnology, adds other traits to its GM products (Table 1). It has authorized the commercialization of transgenic maize, soybean, potato, and sugar beet, and an improved quality GM product, the high oleic soybean, is also now available. Authorized events for controlled research include metabolic transformation in photosynthesis, resistance to salinity, synthesis of new products (alkaloids) and modified quality in grapes, wheat, sugar cane, cotton, and flowers (carnation).

In spite of resistance to the use and consumption of GM products in Europe, a number of crops have already been authorized, and/or are currently under evaluation (Table 1). At present, commercial authorizations have been granted for the production and/or consumption of GM maize, rapeseed, endive, soybean, and flowers. The genetic modifications confer upon them similar traits to those previously detailed for the USA, Australia, and Argentina. Among products pending approval there is a variety of potato with modified starch content for industrial use. Amongst European states, Spain stands out as a major producer of transgenic crops, with over 100,000 ha of transgenic maize (James, 2005).

Although transgenic sunflower varieties have already been obtained, they remain the subject of ongoing research in both the USA and Argentina. Fig. 1 shows that the interest in GM sunflower research has decreased in the 21st Century, probably because official control bureaus have imposed restrictions in the face of ecological concerns. Although it is impossible to accurately assess the present extent of private research, public registrations on this crop include the traits detailed in Table 2. The main impacts upon crop management can be analyzed as follows.