Chapter 57
Appropriate and Sustainable Plant Biotechnology Applications for Food Security in Developing Economies

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ABSTRACT

Appropriate plant biotechnology applications could be a major tool in the fight against hunger and poverty, especially in developing economies. Some promising results have already been reported through a range of biotechnology applications, for example the mass propagation of plants through in vitro clonal propagation, use of molecular markers and marker assisted breeding to improve plant breeding, use of bio-products and the application of molecular techniques for quick and accurate diagnosis of plant diseases. Thus, biotechnology may have the potential to deliver solutions to some of the shortcomings of the green revolution such as the limitations of conventional breeding, poor quality and insufficient quantity of planting materials available to farmers and the negative environmental consequences of high usage of inorganic pesticides and fertilizers. This chapter will elaborate the successful application of these technologies for sustainable agriculture and food security in developing economies. It is envisaged that through partnership between developing and developed economies, and assistance from international organizations and governments, capacity can be developed for developing economies to achieve the full potential of biotechnology and sustainability.

INTRODUCTION

The world population may total 8.8 billion by 2050 with 90% of this growth occurring in developing countries (Botella-Rodriguez, 2011). Today, almost a billion people (more than 16% of world's population) live in absolute poverty and suffer from chronic hunger. From the developing economies, most of this population comprises farmers and their families, whose living conditions depend on small plots

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of poor lands that are mainly affected by drought, salinity, pest and diseases thus resulting in low crop yields (Botella-Rodriguez, 2011). In contrast, there exists an over production of many major crop species and a revolution in biotechnology and associated information technology which aim to improve health and welfare in general in developing economies (Cooper, Spillane, & Hodgkin, 2011). In the future, this food security gap will be even greater taking into account the population growth pattern in both regions. While it is expected that the population in developed countries will not change, in developing countries it will increase to almost 40%. Such was the case during the last century, where green revolution technologies contributed to avoidance of generalized food crisises.E,g., maize cultivation led the modernization process. In 1940, farmers in the United States of America (USA), produced 56 million tons of maize on roughly 31 million hectares, with an average yield of 1.8 t/ha. In 1999, USA farmers produced 240 million tons of maize on roughly 29 million hectares, with an average yield of 8.4 t/ha. This more than four-fold yield increase was due to the impact of modern hybrid seed-fertilizer-weed control technology, promoted as components of the green revolution technological packages.

The green revolution which took place in the late 50s and 60s, was a combination of genetics and technology, the genetics being breeding and the technology the application and availability of petroleum based pesticides and fertilizers and crops that were compatible with these inputs. This resulted in a huge increase in production, but also brought a huge amount of ecological problems (such as eutrophication, high level of water contamination and high amounts of nitrogen oxide) coupled with negative impacts on human health (Pretty, 2008; Tilman, 1999). Of course, this approach is not the sustainable way needed to advance in the future. Just as the food requirements of today's population of 6 billion people could not have been met by the technologies available before the "green revolution", we cannot assume that current practices will feed the increased population of the next 20-30 years. While conventional plant breeding has made some contributions to agriculture it was a slow process with technical limitations. Any further increases in food production should also be based on a sustainable approach. This new sustainable agriculture intensificationcannot depend on a further input from petroleum based products because of the damage that is caused by the applications of these products in terms of contamination of the environment (Brethour & Weersink, 2001) and their negative effects on human health. Thus, it should be almost entirely genetic and using mainly inputs of biological origin (Tilman, 1999). Hence, a major goal will be to redress the ecological imbalance of earlier efforts, by developing genetically diverse new crop varieties, minimizing chemical use with an integrated pest management approach and improving on-farm water efficiency and nutrient management. Diversity of the genetic base of the new plants, the reduction of chemical inputs and the integrated soil, nutrient and water management on-farms are the three pillars of any new sustainable agriculture intensification effort. This can be addressed through biotechnology.

Biotechnology can be defined as any technique that utilizes living organisms or substances derived from organisms to make or modify a product, improve plants or animals or develop microorganisms for specific uses (Fagwalawa, Kutama, & Yakasai, 2013). Too often, the term 'modern biotechnology' refers to transgenic technologies such as with genetically modified crops. However, for the developing world other applications of biotechnology are extremely important. The range includes: the development of new bio-products with better formulation and known action mechanisms (Chandler et al., 2011); mass plant propagation based on tissue culture techniques for rapid multiplication of plants; marker assisted selection to improve the efficacy of plant breeding programs (Cardena, Oropeza, & Zizumbo, 1998) and use of molecular technologies for the diagnosis of plant diseases (Miller & Martin, 1988). From the