

Plant Breeding Coordinating Committee White Paper - Safety and Security

Introduction

The safety and security of our food, fiber, and biomaterials supply underlies the stability of society and is of the utmost importance for the survival of mankind. The constant emergence of new threats to crop production by pests, pathogens, and abiotic stresses, including global climate change, warrant increased diligence in the development of new varieties of plants that can sustainably produce needed yields in this changing environment. In addition to the threats posed by biotic and abiotic stresses, three major trends contribute to the current global food crisis. First, the increasing demand for food from a growing and increasingly affluent world population has strained the world food supply. Second, the use of food commodities to produce biofuels has reduced the world grain stocks to record low levels and record high prices. Third, the increasing costs of oil and other energy sources increases the economic pressures to divert grains to biofuel production while also globally increasing crop production costs, resulting in increasing food and commodity prices. None of these trends are expected to abate in the near future, rather all are expected to increase in magnitude. Securing the supply of food, fiber, and biomaterials in the face of as demand for them increases will require the development of improved plant varieties capable of higher yields under increasing biotic and abiotic stresses, while using less land and energy resources and contributing to consumer and environmental health. The development of these improved varieties is contingent on the existence of trained plant breeders in the future. Currently the pool of trained plant breeders is not adequate to meet national or global needs for improved crops. Rapid action to support research and education in plant breeding is needed to ensure the safety and security of our food and biomaterial supplies.

Problems faced today

Biofuels

The production of biofuels through the use of plant products has the potential to provide cleaner, more environmentally friendly fuels, and to reduce our national dependency on imported oil. A consequence of increasing the use of plant products for biofuels, however, is a reduction in their supply for food consumption. The resulting rise in food and fuel prices has created social unrest around the globe. Furthermore, while biofuels already play an important role in supplementing fossil fuels, current crop yields and biofuel processing methods are insufficient to satisfy more than a small proportion of national energy needs. It is estimated that if all the U.S. corn and soybean production were diverted to biofuel production it would only meet 12% and 6% of the total national demand for ethanol and biodiesel respectively (Hill et al., 2006). Improvements in processes to convert plant cellulose and other fibers to biofuels are being achieved and have the potential to develop perennial crop and tree biomass resources into important energy sources without diverting grain from food supplies (Ragauskas et al., 2006). Whether grains or plant biomass are the source of biofuels, plant breeding is required to develop new varieties with appropriate combinations of traits that will lead to high biomass yield and high fuel conversion efficiency (Bouton, 2007) (Duvick, 2006).

Land and Natural Resources

Urbanization and industrialization are decreasing the arable land available for agricultural production. Cropland area in the United States decreased by 11% between 1950 and 2000 (Brown et al., 2005). Worldwide, the land under cereal production has not increased dramatically since the early 1980's (Khush, 1999). Land use trends in the United States are particularly disturbing because more recent urbanization tends to be "suburban sprawl" that is wasteful of land resources (Lopez and Hynes, 2003). The reduction in available cropland necessitates increases in productivity on the remaining land, which can only be achieved through agricultural intensification and plant breeding (Cassman, 1999). Ongoing crop improvements from plant breeding are needed to maintain a harmonious balance between feeding a growing population and conserving natural resources and biodiversity (Duvick, 2006). Improvements in worldwide grain yields between 1960 and 1995 have been credited with saving wilderness areas equivalent in size to the entire Amazon basin from being developed for agriculture to feed the increasing world population (Ausubel, 1996) (Goklany, 1998). In the future, plant varieties well adapted to agricultural practices that contribute to "ecosystem services" are needed to protect the global natural resources on which human societies depend (Foley et al., 2005).

Water Resources

Water scarcity is a growing problem in many areas around the globe. In Asia, for example, 50% of the total diverted fresh water is used for agricultural production (Tuong et al., 2005). This water is used to grow nearly 75% of the global rice supply grown on just 79 million hectares of land (Tuong et al., 2005). Rockstrom et al. (2007) suggested that there will need to be 50% more water available for agriculture as compared to today to meet the UN Millennium Development Target of halving hunger by 2015. To alleviate hunger by 2050 a two-fold increase in water available for agricultural production is needed if the present water productivity of plants does not increase (Rockstrom et al., 2007). In fact, current and projected future trends are for water to become increasingly limited for agriculture, because of diversion to growing urban populations and industry (Vorosmarty et al., 2000).

Disease

Plant pathogen populations are constantly in flux and are capable of developing new virulences to overcome current resistance genes. The effects of plant pathogens include reduced food quality, yield losses, and in extreme cases, complete loss of large areas of crop yield. Plant disease epidemics include the devastating Irish Potato Famine of the mid-1800's, responsible for about a million deaths (Woodham-Smith, 1962). More recently, the southern corn leaf blight epidemic in the United States in 1970s resulted in an estimated loss of 1 billion bushels of corn, with a current value of 4\$ billion (Strange and Scott, 2005). New diseases and new strains of pathogen species pose a constant threat to the supply of food and biomaterials. Current potential threats to major U.S. crops include asian soybean rust (<http://www.usda.gov/soybeanrust/>) and wheat stem rust race Ug99 (Borlaug, 2008).

Genetic resistance to pests and diseases is often most economical form of control and reduces needs for chemical controls. For example, breeders have incorporated spotted alfalfa aphid resistances and European corn borer resistances into those crops to

reduce the need for insecticide applications. Genetic resistance to Hessian fly and sawfly in wheat have been valued at \$452 million and eliminate the use of about 48 million lbs. of insecticide annually in the USA alone, representing a 300:1 return on investment in breeding and (Tingey and Steffens, 1991). The use of cultivars with resistance to root-knot nematodes increases profits by 30,000 Euros per ha in greenhouse tomatoes (Sorribas et al., 2005). Breeding for leaf rust resistance in wheat increased profits by minimum of ~\$1 million annually in the Yaqui Valley, Sonora, Mexico (Smale et al., 1998). This represents a 27:1 global return on investment in breeding (Marasas et al., 2003).

In addition to directly reducing crop yields, plant diseases are sometimes associated with the production of toxins that pose a threat to human and animal health. Mycotoxins such as DON, aflatoxin, and fumonins, produced by fungi that infect grains, for example, threaten the safety of the food and feed supply. Major progress in breeding wheat cultivars with resistance to *Fusarium* head blight and the DON toxin (vomitoxin) has been achieved in the past decade (Bai and Shaner, 2004). *Aspergillus* and *Fusarium* fungi can infect maize and other species, producing aflatoxin and fumonisin, which are associated with serious human diseases (Richard and Payne, 2003). Varieties with resistance to these diseases are being developed to improve the safety and security of the food supply (Eller et al., 2008; Williams et al., 2005).

Growing Population

Economic Status

Growing economic status in developing countries increases the demand for protein. This increased protein production creates additional demands on the available grain supplies.

Plant breeding opportunities contributing to a securing the food supply

- Increasing Water productivity
- Increasing density tolerance
- Increasing stress tolerance
- Increasing drought tolerance
- Increasing Salt Tolerance
- Extrax system Enhanced Feed, oil and biofuel production
- Increasing Biofuel constituent yield

Consequences of inaction to adequately secure the food supply

- Rising Food costs
- Rising Fuel costs
- Rising unrest (Riots)

News reports from around the world have reported rioting in Mexico in 2007 and most recently in Egypt, Haiti, Bangladesh, Mozambique and Cameroon resulting in injuries and in some cases deaths.

- Increase in hunger and disease
- Environmental degradation of natural resources

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