Student Voice Report[1]

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This conference's attendance by the members of the private and public sectors, researchers and professors, and students and professionals, exemplified the importance of collaboration amongst disciplines to solving problems related to climate change. It was inspiring to see so many heads together in discussion, and, as students, we had the opportunity to share our ideas.

We offer feedback from our various areas of expertise, as follows.

Plant Science

Plant breeders go between biotechnologists and the needs of growers and consumers. As such, breeders can define technologies that are most needed. This responsibility can be

[1]To increase graduate-student participation at NABC conferences, the *Student Voice at NABC* program was launched ahead of NABC 19. Feedback from those involved was positive, therefore the program was continued for NABC 20 and 21. Grants of up to $750 are offered to graduate students at NABC-member institutions (one per non-host institution) to assist with travel and lodging expenses. Registration fees are waived for the grant winners.

Student Voice delegates are expected to attend all of the plenary sessions as well as the breakout workshops then to meet as a group to identify current and emerging issues relevant to the conference subject matter.

Information on the *Student Voice at NABC 22* will be available in due course at http://nabc.cals.cornell.edu/studentvoice/.

[2]This report on the NABC-21 *Student Voice* discussions was provided by Ms. Sullivan.

met by the "21st-century plant breeder": a plant scientist who is focused on breeding, but who also has the capacity to help develop plant biotechnologies. Grouping breeders with biotechnologists can serve to combat the narrowed focus caused by specialization. Tunnel vision from specialization can be combated through grants that encourage collaboration between biotechnologists and plant breeders.

Plant biotechnologies are not all-encompassing solutions to the problems of adaptation and mitigation of climate change. Instead, many have optimal specific applications. We appreciate this reality and agree that new technologies must be quantitatively evaluated to find their optimal application. This is another responsibility that can be filled by a "21st century plant breeder."

From social and ethical standpoints, maintaining a natural appearance in modified organisms must be acknowledged as a public value. Public education is central to the development of biotechnologies. Communicating how biotechnologies can meet human needs will foster public interest and help remove misconceptions about biotechnology.

Education

Climate change should become a top issue discussed in the classroom, and educators and members of the scientific community need to advocate its inclusion in course curricula. Proper public discourse on climate change requires education on this increasingly important scientific theory. Courses that expose the student to the biotechnology industry, plant breeding, and product development would convey how combining these sectors may contribute to solutions. Future researchers in plant biotechnology must learn how techniques and disciplines can be combined to address climate change from various angles. In addition to scientific approaches to achieving adaptation to, and mitigation of, climate change, lifestyle and behavioral changes, such as responsible consumer choices and sustainable management practices, should be highlighted. If taken early, courses on this subject matter would enable students to place their knowledge in context.

Climate Modeling

Uncertainty causes misinterpretation of climate data, which can confuse and misdirect policymakers. Increased resolution in climate forecasting will help determine biotechnological approaches and performance targets. Accurate models are also imperative in developing appropriate risk-assessment strategies. With a better understanding of future meteorological changes, we can create better risk-management products and insurance plans to protect producers. In addition to changing temperatures, models for future crop zones must take into account growing conditions including water availability, topography, and expected changes in biogeoclimatic zones.

Soil Science

Within the climate-change debate, it is important to view soils as more than a sink for carbon; soils are the basis upon which all biotechnology and plant breeding are possible. To this end, we need to think not only of replacing nutrients removed, but also of conserving soil as a resource and reducing its loss by instituting sustainable management practices.

Efficient use of energy and nutrients go hand-in-hand in combating the effects of climate change; if we focus on nitrogen, carbon will follow. The energy currently needed to create chemical fertilizers is unacceptable, and innovative techniques, based on traditional knowledge for returning organic matter to the soil, need to be adopted.

What potent and affordable practical adjustments can be implemented by farmers? What effects will climate change have on soil microbial communities that are the drivers of nutrient cycling? With increased temperatures and increased microbial activity, what will be the effect on decomposition rates, carbon sequestration and soil fertility? These unanswered questions arose from discussions, reflecting the need for systems approaches for problem solving.

Economics and Policy

As with any public good, it falls to the government to specify the allocation of resources to environmental issues. However, despite their pivotal role, policymakers are often not well-versed in the scientific theory underlying policy formulation. Therefore, scientists, both natural and social, must reach out to policymakers to ensure that they are well informed. By working together, including with consumers, we will create more meaningful policies that benefit the public.

In the climate-change debate, the policy levers most often considered are an emissions tax and a marketable permit system, *i.e.* cap and trade. Each of these mechanisms functions as a price signal to the consumer designed to account for market failures, or externalities. Only through price signals can we hope to change human behavior as a whole. Further, it is essential that the policy mechanism allows for offsets to be provided by industries "outside the cap" to reduce emissions at lower cost.

In the agricultural sector, substantial opportunities exist to increase levels of soil-sequestered carbon and reduce N_2O emissions by improving agricultural practices. Climate-change policy has the potential to promote environmental, social, and economic contributions to society by offering offset payments to farmers who employ these practices. This would introduce a newly shaped form of agricultural subsidy or financial stimulus for using more environmentally responsible farming practices. However, many of these ideas mean new costs, new practices, and new risks for the farmer; policymakers should consider solutions that spread both the benefits and risks of new practices to all stakeholders. Also, soil carbon is impacted by small fluctuations in temperature and moisture, and a large degree of uncertainty surrounds the measurement of N_2O emissions. If the offset market is to include agricultural carbon, it is important that we carefully monitor and regularly document emissions reductions.

Conclusion

Fundamentally, climate change, food security, and, by extension, global stability, hinge upon the ability of the human race to support itself in a sustainable fashion. This will be facilitated by the collaboration of economists and social and natural scientists in a manner that focuses on solutions that are applicable to society. Agriculture is a perfect reflection of society's approach to caring for itself; it is the act of humans cultivating the

Earth upon which we depend. It is clear that agriculture is already, and will continue to be, affected by climate change. With a systems approach we can create life-cycle analyses to fully assess the roles of various disciplines in achieving adaptation to, and mitigation of, climate change.