Protected Agriculture

A Water-Saving Technology

Background

Fresh water is the most limited of the world's natural resources relative to demand,[1] and its scarcity drives debate on water use and practices in the United States and abroad.

One of the biggest water demands in desert regions is for livestock forage production. In the Rio Grande Basin of New Mexico, for example, 75% of surface-water withdrawals and 53% of ground-water withdrawals in 1995 were for irrigated agriculture; a large fraction of that was used to water fields of alfalfa and other forage crops to provide feed for livestock.

Hydroponic forage production (above) can provide nutritional livestock feed, using only seed, water, and light as input.

Protected agriculture is a method of growing crops in a controlled environment, specifically, a greenhouse. The benefits of protected agriculture include the following:

- Significant water saving over traditional field-crop practices
- Consistent high-quality crops
- Less dependence on weather conditions

Protected agriculture has the potential to provide the absolute most 'crop per drop'.

Approach

Most research on water conservation in agriculture offers incremental improvement, such as improved irrigation or water delivery. Sandia National Laboratories, in partnership with 3M, the government of Chihuahua, Mexico, and local small businesses, is pursuing a combination of technologies that have the potential for orders-of-magnitude reductions in water usage.

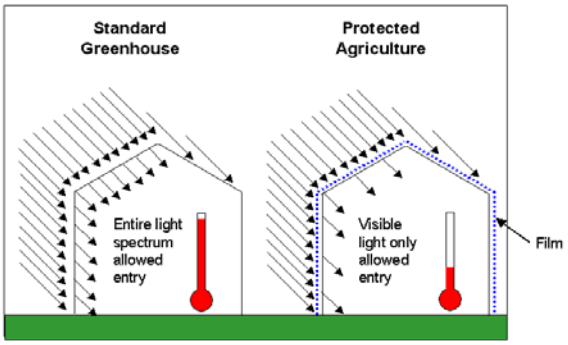
Concepts developed at Sandia, material from 3M, and greenhouse technology developed in Chihuahua could be combined to produce livestock forage using significantly less water. The Chihuahuan government reports that they are able to produce forage for 0.1% of the standard amount of applied water. Their greenhouse technique is labor intensive, but it offers the opportunity to grow forage where water is scarce or conservation is desired. 3M produces a number of specialized films that control the amount and wavelength of light passing through. These films may improve greenhouse efficiency. Sandia

Ten-day-old forage in a protected-agriculture installation in Chihuahua, Mexico, is ready for use.

[1] F. Montaigne, "Water Pressure," National Geographic, September 2002.

National Laboratories has the engineering, analytical, and monitoring expertise to determine how best to use the films in greenhouses to optimize plant production vs. the consumption of water and other resources.

The partnership among Sandia National Laboratories, 3M, and the Chihuahuan government is an opportunity to create a hybrid technology that could allow a significant savings in water usage in the sector that creates the greatest demand – agriculture. Irrigated agriculture has had incremental improvement over the past 6,000 years. Better agricultural usage of water in nations that are not highly industrialized offers the prospect of reducing disputes along many of the world's borders. This cooperative US/Mexico project can be a first step in demonstrating the feasibility of such reductions.



New films on greenhouses would block out infrared and ultraviolet light, reducing cooling costs.

Research and Existing Projects

Sandia has pioneered the use of Dynamic Simulation for modeling the use of resources and the operation of infrastructures. Such modeling has been completed for water use in China, the Estancia basin in New Mexico, and the Middle Rio Grande basin. These models clearly show the effects of agricultural water demands and give a better understanding of the overall water use in a particular region.

Sandia is collaborating with the government of Chihuahua, Mexico, to optimize production using protected agriculture. Preliminary work at Sandia National Laboratories has shown that specialized films applied to the surface of greenhouses can reduce temperatures within the greenhouses, can further reduce water usage, and potentially can even reduce pest problems. The 3M films limit the spectrum of light received by the plants to that required for photosynthesis. Demonstrations are in progress at Ross Gardens in Estancia to validate some of the reported results from Mexico. Experiments will be performed to monitor temperature, water use, nutrient content, and production.

Protected agriculture, particularly forage production, is a technology that could have tremendous impact in the United States; however, further study and research is needed to determine how the technology can be used by and optimized for American producers. These research questions include how to apply and maintain 3M photoselective films to newly constructed greenhouses in Mexico; monitoring water usage and productivity of experimental and control greenhouses; and examining film effects on plant growth rate and large-scale water savings.

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