Pushing the YIELD Limits

In an era of little interest in maximum yields—when the very topic seems politically incorrect—Dick Cooper is talking about maximum soybean yields that few can even imagine.

Cooper can talk yields of 100 bushels per acre for soybeans because for the past 24 years he's devoted an acre of land—divided into test plots—to finding the maximum yields possible with soybeans. For these experiments, he isn't concerned with what's practical or economic; he just uses these plots to check on what's possible. Cooper is in the ARS Corn and Soybean Research Unit in Wooster, Ohio.

To get the type of yields only seen occasionally by farmers who win local yield contests, Cooper removes all manageable yield-limiting factors. He gives his plants all the water and fertilizer they need, which might not always be economically feasible in commercial farming. But many of the practices he uses can be—and in some cases have been—adopted by farmers. Practices such as early planting and using semidwarf soybean varieties.

Certainly, practicality is Cooper's bottom line. From that 24-years-and-still-going experiment, he has recently identified a "photothermal barrier" to higher soybean yields. The photothermal barrier theory is that a warm spring season will trigger earlier flowering, resulting in higher yields.

"This brings on the reproductive stage at a time of year when light intensity is greater and the days are longer, extending the length of the reproductive cycle," Cooper says. The theory can be put to practical use by developing full-season soybean varieties with earlier flowering. But until that happens, farmers have to settle for earlier planting.

Cooper also used the maximum yield experiment results to develop a practical system called High Yield System in Place, or HYSIP. HYSIP involves early planting of ARS-developed semidwarf soybean varieties in densely seeded, narrow rows every year. This takes advantage of the ability of the solid-seeded semidwarf soybean system to yield exceptionally high in years with favorable rainfall. He recommends that farmers use semidwarf soybean varieties on productive soils. The first such variety, Elf, was released from Cooper's program in 1977. Subsequently, many new varieties have been released from his program, the most recent being Stout and Strong.

Cooper recommends planting the

Six-thousand-gallon water tanks are used to simulate farm ponds in the recirculating subirrigation/drainage system.

crop between May 1 and 15 in his area, instead of the usual May 15–30, and farmers are doing this.

"We recommend that farmers plant seeds in rows 7 inches apart, instead of the traditional 30-inch row spacing," he says. "Seeds should be planted at a rate of 300,000 per acre for semidwarf varieties. On poorer soils, we recommend staying with traditional varieties, at a rate of 225,000 seeds per acre."

Pipes To Irrigate and Drain

Cooper has merged HYSIP with a subirrigation/drainage system developed at Ohio State University (OSU) in Columbus, Ohio, by ARS soil scientist Norman R. Fausey. Cooper says the idea of merging his and Fausey's systems came when he heard Fausey speak at a 1984 water-management meeting. "This is the first project to merge maximum-yield trials with irrigation-management experiments," Cooper says.

"At the time of that meeting," says Fausey, "people thought of poorly drained areas in terms of having too much water. Spring flooding and soils too wet for planting stood out in their minds. But my research experience showed me another side to the problem: In most years we have yield losses due to not enough water later in the summer. I conceived the idea of saving some of that extra water from spring for use when water gets short in summer."

The irrigation system pumps water into underground drainage pipes during the hottest, driest part of the summer. The idea of irrigating through drainage pipes is to keep the water table constant, so plants never experience drought. Just a few days of drought at critical times in a crop's development can reduce the true yield potential.

The system has now evolved to include recycling irrigation and drainage water. The goal is to develop a system where farmers' drainage water would empty out into a wetland, which would filter out nitrogen and phosphorus. The water would then be stored in a pond or reservoir and later reused to irrigate through the same underground drainage pipes.

To substitute for the ponds, reservoirs, and wetlands in the experiments, Cooper and his colleagues use eighteen 6,000-gallon tanks to store the water for reuse. Cooper works with OSU and Fausey on this. Normally, the drainage water from the underground pipes empties directly into nearby streams, potentially bringing with it excess nitrogen and phosphorus, as well as pesticides. Preliminary data indicate that the recycled water is significantly cleaner than water emptied directly into streams.

PEGGY GREB (K9471-1)

In Wooster, Ohio, technician Tim Mendiola measures plant height of semidwarf varieties grown in the maximum yield studies.

Because of the water quality improvement potential and the value of wetlands, ponds, and reservoirs to wildlife, the U.S. Environmental Protection Agency and the Lake Erie Environmental Protection Fund have been funding three large-scale demonstrations of the recycling water experiment in the Toledo, Ohio, area—near Lake Erie. The funding for the demonstrations was obtained under the leadership of Bernie Czartoski, coordinator of the Maumee Valley Resource, Conservation and Development Council, with collaborators from ARS, Ohio State University Extension, USDA's Natural Resources Conservation Service, and industry.

"We built wetlands and reservoirs to store and recycle water to irrigate corn and soybean fields that are from 7 to 30 acres," Fausey says. "We're seeing an increase in wildlife numbers and diversity at these wetlands and reservoirs—everything from deer and raccoons to birds and frogs, including an increase in numbers of Blanchard cricket frogs, which were thought to be endangered."

The subirrigation/drainage system is not widely used yet because of costs, but Cooper is optimistic it will spread. It requires that drainage pipes be spaced half the usual distance apart, to allow irrigation water to reach midway between pipes, covering all the land. "Because of the improvement in water quality from recycling, the possibility of government subsidy to help cover installation costs could be a significant factor in grower adoption," Cooper says.

"The irrigation stabilizes yields, so farmers in a dry year would have higher yields than they normally would, at a time when prices are high because of drought. It works best for poorly drained soils that are reasonably level, which perfectly describes much of northeast Indiana and northwest Ohio," Cooper says. "And HYSIP puts farmers in a good position to have high yields when there is enough rain. It won't happen every year, but the system gives farmers the potential to have high yields when conditions are right, resulting in higher long-term average yields," he says.

Over his 10-year experiment with HYSIP, Cooper found that without irrigation, there was a substantial yield advantage of 24 percent over the standard system. "The merged systems—HYSIP and subirrigation/drainage—promise consistent annual yields of 70 to 80 bushels per acre for soybeans and 200-plus bushels per acre for corn," Cooper says. "In years with a warm early spring, the experiments have yielded 90 to 100 bushels per acre for soybeans."

"These results demonstrate the value of long-term high yield research. Without the long-term data and the removal of other yield-limiting factors, it is doubtful the delayed flowering barrier to higher soybean yields under normal spring temperatures would have been identified.

"As a result of this new knowledge, I anticipate a major effort will be made by soybean breeders to select for earlier flowering," Cooper says. —By **Don Comis,** ARS.

This research is part of Water Quality and Management, an ARS National Program (#201) described on the World Wide Web at http://www.nps.ars.usda.gov.

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KEN CHAMBERLAIN (K9473-1)

Soybean breeder and production specialist Richard Cooper (left) and soil scientist and water management specialist Norman Fausey have pooled their expertise to develop a subirrigation/drainage, crop management system that consistently provides soybean yields of 70 or more bushels per acre and corn yields of 200 or more bushels per acre.