RESEARCH PAPER ANALYSIS

ENGINEERED SOYBEAN BECOMES A REALITY

Advances
in Science...

The two papers—from research groups at Monsanto Co. (St. Louis, MO) and Agracetus (Middleton, WI)—appearing in this month's *Bio/Technology* mark a milestone in the application of plant genetic engineering to crops of major agricultural importance.

Because the germplasm of soybean grown in the United States is extremely narrow—the majority of soybean cultivars are derived from less than ten parental lines—it represents a prime target for improvement via recombinant-gene technologies. And while this goal has been pursued for some time, it has taken more than three years to progress from the first introduction of foreign genes into soybean tissue (Facciotti et al., *Bio/Technology* 3:247, Mar. '85), to the successful production of the genetically modified soybean plants reported here. The Agracetus and Monsanto researchers have paved the way to rapid soybean crop improvements such as herbicide resistance, insect and disease tolerance, improved nutritional quality, and possibly even yield *per se*.

Although achieving the same end, the two groups used quite different approaches, each with its own advantages. The Agracetus team utilized a direct DNA- delivery system based on DNA-coated gold particles fired at the plant cells by electric discharge particle acceleration. Their targets were the primary and axillary meristems of soybean embryos, and their heterologous genes were neomycin phosphotransferase (NPTII) and β -glucuronidase (GUS). NPTII expression confers kanamycin resistance—used as a selectable marker; GUS expression, which can be easily visualized, was used to quickly identify transformed shoots and chimeric tissue. With this technique, the scientists were able to deliver foreign DNA into existing meristem tissue (and possibly into benzyladenine-induced buds) to obtain chimeric, and upon occasion, completely transformed regenerating shoots.

The Monsanto researchers used *Agrobacterium*-mediated gene transfer; their regeneration system was excised cotyledons from freshly germinated seeds. This procedure takes advantage of benzyladenine-induced

adventitious bud formation at the juncture of cotyledon base and embryonic axis node. With this system, Maude Hinchee and her colleagues were able to incorporate NPTII, GUS, and a glyphosate-tolerance gene into regenerated soybean: they report the stable inheritance of these foreign genes in the progeny of the initially transformed plants.

Although producing an impressive recovery frequency of six percent, the *Agrobacterium* transformation system appears to depend on a specialized regeneration protocol, and may be restricted by the limited number of cultivars that, to date, are known to be susceptible to *Agrobacterium* in-

fection.

Direct DNA delivery, on the other hand, offers the possibility of reducing or even eliminating the need for sophisticated regeneration systems. Indeed, it would appear that micro-propagation methodology is all that is required. And while the frequency with which transformed plants are recovered is low (two percent or less), the technology should be applicable to all soybean varieties and—in principle—to all plants.

—Michael G. Carnes
and Martha Wright

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...Impact on Agribusiness

As the Midwestern soybean crop sears in the heat of the drought of '88, many in the seed industry pray for both rain and future crop improvements—especially the sort of seed improvements that have eluded conventional plant breeders since the

cause of the plant's complex oil- and protein-synthetic machinery, and the attendant complexities of altering them. Data reported in this issue of *Bio/Technology* by Maude Hinchee et al. (Monsanto Co., St. Louis, MO) and Paul Christou and his colleagues at Agracetus (Middleton, WI), however, are a clear, first, and major step to streamlining conventional soybean improvement.

The economic importance of soybeans is undeniable. Approximately 126 million acres of soybeans are planted annually world-wide. In the U.S., about 65 million acres produce over 2 billion bushels (60 million tons). Over one billion bushels are crushed to produce 11 billion pounds of oil and 50 billion pounds of meal. The oil is the primary ingredient in margarine, cooking oils, and salad dressings, and the meal is formulated as animal feed or is extruded to produce textured vegetable protein.

The first likely outlet for the technologies described by the Agracetus and Monsanto scientists is soybean seed. Approximately \$400 million of this seed is sold in the United States with about half being purchased from seed companies. The objective of soybean breeders and molecular biologists alike is to add features to the seed that encourage more farmers to purchase their seed from commercial concerns. The successes of the two groups reduce to reality the possibility of recombinant or hybridized soybean. Either would expand the commercial soybean seed trade.

—George H. Kidd

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REASONS

Cinderella crop of soybeans blossomed in the United States in the 1960s.

Since research objectives are set 7–10 years before the soybean seed is planted in the farmer's field, conventional soybean breeders are at a particular disadvantage. Many critical objectives—such as resistance to environmental stress, water conservation, lodging, and disease resistance—have been addressed only on a piecemeal basis because of the extended times required for breeding and testing new seeds. Some even believe that soybean yields may soon plateau be-