RAFI COMMUNIQUE

RURAL ADVANCEMENT FUND INTERNATIONAL

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The Second in a Two Part Series: AGRICULTURAL INPUTS AND BIOTECHNOLOGY

ISSUE: Agricultural inputs (seeds, pesticides and fertilizers) are undergoing major corporate and technological change.
IMPACT: The integration of all agricultural inputs could lead to an increase in the farmers' cost of production; jeopardize the health of agricultural workers; and increase environmental damage and chemical residues in the food chain.
COUNTRIES AFFECTED: All countries, but the economic impact may first be felt in Chile, Mexico, Morocco, New Zealand, Tunisia and Tanzania (major areas for seed multiplication).
WHEN: Early 1990s.
PARTICIPANTS: Monsanto, Du Pont, Ciba-Geigy, ICI, Rohm & Haas, Rhone Poulenc, American Cyanamid, Hoechst, and other leading chemical companies.
ECONOMIC STAKES: Integration of the $50 billion seed, pesticides, and fertilizer industries into the genetics supply industry.[1] Increased market value may equal $12.1 billion by the year 2000.[2]

The last issue of RAFI Communique (November, 1987) examined the industry focus on the development of herbicide tolerant crops, and the recent trend in which two major inputs (seeds and chemicals) are increasingly controlled by one industry.

Part two of our series focuses on other farm inputs which are undergoing major corporate and technological change: artificial seeds (somatic embryogenesis), nitrogen fixation, biopesticides and biofertilizers.

1. Artificial Seeds

A seed is an embryo containing the plant's instructions for reproduction surrounded by starch providing the embryo with food. Through "somatic embryogenesis", this reproductive information can be isolated from any of several parts of a plant and stimulated to grow into a whole plant. The need for seed is thus eliminated. An "artificial" seed

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consisting of a dried or encapsulated embryo is possible. The encapsulated embryo may also be wrapped in nutrients and pesticides making it the perfect market vehicle for fertilizer and pesticide manufacturers.

The following excerpt from BIO/TECHNOLOGY magazine describes the steps needed to someday commercialize artificial seed technology:

> "The delivery of somatic embryos directly to the greenhouse or field as an artificial seed will require an encapsulation matrix pliable enough to cushion and protect the embryos and allow germination, and yet be sufficiently rigid to allow for rough handling of the capsules during manufacture, transportation, and planting. The matrix should be able to contain and deliver sufficient nutrients, growth and developmental control agents, and other chemical or biological components necessary for embryo-to-plant development. Ideally, the capsules could contain plant growth promoting microorganisms and agricultural chemicals specifically chosen for cultivar and environmental conditions. The encapsulation process should also allow for the formation of single-embryo capsules. Furthermore, the encapsulated somatic embryo should be handled and planted using existing seed planting equipment to facilitate acceptance at the farm level."
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> K.Redenbaugh, B.Paasch, J.W.Nichol, M.E.Kossler, P.R.Viss, & K.A.Walker, "Somatic Seeds: Encapsulation of Asexual Plant Embryos," Bio/Technology, Vol. 4 September 1986, p.797

Artificial seeds are being developed for 13 crops by 9 enterprises working in 17 research programmes.

RESEARCH ON ARTIFICIAL SEEDS

TARGET CROP:	CONTRACTING COMPANY:	CONTRACTOR:
Tomato	Atlantic Richfield	Atlantic Richfield
Unspecified	Eureka	Eureka
Grapes	IFAS	IFAS
Orchardgrass	IFAS	IFAS
Carrot	Kemira Oy	Kemira Oy
Alfalfa	Plant Genetics	Plant Genetics
Cauliflower	Plant Genetics	Plant Genetics
Celery	Plant Genetics	Plant Genetics
Barley	Sungene	Sungene
Maize	Sungene	Sungene
Rice	Sungene	Sungene
Sorghum	Sungene	Sungene
Sunflower	Sungene	Sungene
Wheat	Sungene	Sungene
Loblolly pine	UC (Davis)	UC (Davis)
Rice	Univ. Florida	Univ. Florida
Carrot	Univ. Purdue	Univ. Purdue

Benefits:

Current research concentrates on high-value horticultural crops such as celery, carrots, green peppers and tomatoes--but work is also in progress on barley, maize, rice, sorghum and wheat. In theory, the development of artificial seeds could allow more rapid breeding and distribution of crops which are normally propagated vegetatively (i.e. potatoes) since growers would have access to a reliable "seed" whose genetic properties were not in doubt.

Farmers could also reduce their chemical dependence and save money. Encapsulated embryos of tomatoes or peppers, for example, could reduce the use of a fungicide like Apron to one-tenth of one per cent if the fungicide was inserted in the capsule directly. There would also be savings for the environment. Also, in theory, the germination rates of artificial seeds could come close to 100% offering some genuine savings in seed costs and through increased yields per hectare.

Artificial seeds also offer new savings and profits to the genetics supply industry. By producing embryos en masse in laboratories, companies can cut out the "middleman" - the commercial seed grower. Since, occasionally, seed crops are lost in the field through disease or other adverse conditions, this risk is eliminated. The company's need to stockpile seed (and related costs) are also eliminated. Further, companies can reduce their financial risk and inventories by delaying embryo multiplication until just before the growing season.

Concerns:

On the other hand, the genetics supply industry can increase its profitability in at least two ways: First, by exploiting the capsule as a chemicals package and giving farmers no choice but to use more chemical inputs. Secondly, artificial seed technology extends an approach to agriculture which weighs against the use of bin-saved seed and lessens farmer decision-making.

Countries such as Argentina, Chile, Mexico, Morocco, New Zealand, Tanzania and Tunisia, that have specialized in seed multiplication, will also suffer. In Arusha, Tanzania, for example, 11 international companies have seed growing stations and make a marked financial impact on the region[3]. Direct flights connecting Arusha to Amsterdam tie the industry to the Dutch seed trade. This could all end with encapsulated embryos.

RAFI believes that artificial seeds will not become a significant factor in the vegetable seed industry until well into the next decade. Cereal seed production will not be affected until sometime after that. Farmers save and seed growers produce cereal seed with comparative ease and little cost, so it will be difficult for the genetics supply industry to break into this market. Ultimately, however, encapsulated embryos are the logical industry goal for all crops.

LONG-TERM STRATEGIES

Longer-term industry strategies by no means preclude the use of herbicide tolerant genes (see RAFI Communique, November, 1987) or encapsulated embryos. But they do assume a shift away from synthetic crop protection toward biological pest controls and fertilizers. Work is underway in biofungicides, bioherbicides, bioinsecticides and in nitrogen-fixation. Almost all of this work is in the public sector but it can be assumed that at an appropriate time, the genetics supply industry will step in to commercialize this research and develop marketable products. Work in each product area is examined below.

2. Biofertilizers:

Certain plants, like soybeans and other legumes, are able to "fix" nitrogen in the air with the help of special bacteria that live in the plant's roots. This enables the plant to use the nitrogen found in the atmosphere. If biological nitrogen fixation could be extended to other major crops (wheat and corn, for instance) agricultural yields could be increased and farmers would not have to supplement the available nitrogen with chemical fertilizers. Worldwide, farmers now apply 60[4] million metric tons of nitrogen fertilizer annually.

Nitrogen fixation is an extremely complicated process, so research in this area is still in the early stages. In fact, some genetic supply enterprises are scornful of the potential to enhance the nitrogen-fixing capacities of crop plants.

> "I think if you're trying to eliminate things that are peripheral, then eliminate talking about genetically engineering nitrogen fixation. It is the most absurd example that has ever been raised in agricultural biotech and it should be permanently stricken from the vocabulary."
>
> \- Roger Salquist
> Chief Executive Officer,
> CALGENE[5]

Despite the reservations of some industry observers, several universities and a few commercial concerns are engaged in this work. Progress has been made in substantially increasing the capacity of some leguminous plants already. Biotechnica International (Canada) has developed a bacterium that may increase the yield of alfalfa by 17%[6]. Scientists in three US universities have shown that nitrogen fixing genes can be successfully transferred to non-nitrogen fixing crops, opening up the possibility for self-fertilizing cereals[7]. Should nitrogen-fixing genes prove commercially transferable to other crops, the potential reduction in the use of nitrogen fertilizers would be substantial.

While most fertilizer research focuses on nitrogen fixing Rhizobium bacteria, some important work is also underway using algae as a cover crop. Soil Technologies Corp., for example, has created a dry spray of dormant green algae and blue-green algae to reduce soil compaction enhancing both aeration and water retention in the field. The spray costs about $8 an acre and has increased cotton lint production by 200 pounds per acre. Test plot work with soybeans shows an increase of 9.4 bushels per acre[8]. The product is reportedly 30% cheaper than conventional fertilizers.[9]

Some observers are concerned that the improvement of nitrogen-fixing qualities in plants could actually exacerbate groundwater pollution depending on the soil husbandry practices employed by farmers. Sown in areas where nitrogen levels are already adequate, for example, nitrogen-fixing plants could potentially increase the amount of nitrogen runoff from fields into water sources.[10] Recent studies indicate that fertilizers are the leading source of nitrate pollution in groundwater.[11]

It is possible, however, that the research related to nitrogen-fixation will lead to the development of plant varieties capable of utilizing synthetic fertilizers more effectively - or absorbing greater quantities of fertilizers. In this event, farmers may ultimately use more fertilizers than at present. Production costs and environmental damage would increase.

RESEARCH ON BIOFERTILIZERS

TARGET CROP:	CONTRACTING COMPANY:	CONTRACTOR:
Alfalfa	Biotechnica Int'l.	Biotechnica Int'l.
Unspecified	Biotechnica Int'l.	Uniroyal
Soybean	Calgene	Allied
Unspecified	Cyanotech	Pace National
Sugarcane	EMBRAPA	EMBRAPA
Cotton	Soil Technologies	Soil Technologies
Soybean	Soil Technologies	Soil Technologies
Unspecified	UC (Riverside)	UC (Riverside)
Rosaceae	Univ. Oregon; Arizona; NC	Univ. Oregon; Arizona; NC

source: RAFI

3. Biofungicides:

At least seven enterprises are presently engaged in the development of biofungicides through ten research programmes. The work varies from the development of diagnostic kits to detect fungal diseases in lawn grass and golf courses to the development of highly-specific bacteria intended to combat fungus in stone fruit or wheat.

The precision of the biofungicides is both their attraction and their problem. Biofungicides can be much more environmentally sympathetic than their chemical counterparts and target only a very specific pest. However, with many successful broad-spectrum chemical agents on the market, the niches available for biofungicides are limited. For commercial success, companies engaged in this work have two choices: they can either link their product with a standard chemical fungicide or they can opt to broaden the range of pests attacked.

Penwalt has employed the first strategy in developing strains of B. subtillus to be applied along with Benomyl to combat pests in stone fruit. The strategy means not a reduction, but an actual increase in the use of chemicals.

That companies may opt to broaden the target range of biofungicides is a matter for greater concern. The wider the range, the more potent the bacterium and, with extended applications, the greater the danger of uncontrolled mutation. The fact that the fungicide is "natural" rather than "synthetic" (a selling point stressed by those working in this field) is of little comfort. Synthetics don't multiply themselves and mutate in the environment, natural products may.

4. Bioinsecticides:

Commercial research into bioinsecticides has concentrated almost exclusively on the adaptation of Bacillus thuringiensis (B.t.) to diverse crops. B.t. is a protein produced by Bacillus thuringiensis, a naturally-ocurring microbe which lives in the soil. When certain insect pests ingest B.t. the protein is turned into a toxin by enzymes in the insect's stomach, causing paralysis and death. The B.t. protein kills only certain pests, and is considered harmless to people, animals and the environment. Scientists are attempting to engineer crop varieties which will contain the gene for the insecticidal protein B.t.

This work was originally developed at a number of US universities and is now being exploited by private firms--at some risk to the environment. There is already scientific concern that more potent, genetically engineered B.t. strains are creating mutations in insect pests and that a resistance to all B.t. is developing.

Biopesticides, once again, can offer all the problems associated with chemicals as well as the possibility of multiplication and mutation.

> "You hear people suggesting, for example, that if we understood more about allelopathy, we could make plants that produced their own natural herbicides. Well, that's all fine and dandy but we know that some of the allelopathic chemicals are, for example, arsenic and cyanide. Just because its 'natural' doesn't make it 'safe'."
>
> - Robert Goodman, vice president, Calgene[12]

RESEARCH ON BIOINSECTICIDES/BIOPESTICIDES

TARGET CROP:	CONTRACTING COMPANY:	CONTRACTOR:
Cotton	Calgene	Toagosei Chem.
Maize	Calgene	Toagosei Chem.
Maize	Crop Genetics Inst.	Crop Genetics Inst
Cotton	Ecogen	Pru/Tech R&D Partnership
Unspecified	Microbial Resources	Novo Industri
Unspecified	MicroGeneSys	MicroGeneSys
Unspecifide	Mycogen	Lubrizol
Unspecified	Plant Genetic Systems	Plant Genetic Systems
Citrus	Rohm & Haas	Rohm & Haas
Cotton	Rohm & Haas	Rohm & Haas
Maize	Rohm & Haas	Rohm & Haas
Soybean	Rohm & Haas	Rohm & Haas
Tobacco	Rohm & Haas	Rohm & Haas
Tomato	Rohm & Haas	Rohm & Haas
Unspecified	Univ. Clemson	Monsanto
Tobacco	Univ. Durham	Agricultural Genetics
Unspecified	Univ. of Washington	Agrocetus
Unspecified	Univ. of Washington	Agracetus
Unspecified	Abbott	Abbott
Unspecified	Celgene	Hoechst
Maize	Monsanto	Monsanto
Tomato	Native Plant Industries	Native Plant Industries

Source: RAFI

Summary:

Some major world enterprises - such as ICI and Royal Dutch /Shell - have a significant market position in seeds, herbicides and fertilizers. The interrelationship of these three agricultural inputs in light of the new biotechnologies in herbicide tolerance, encapsulated embryos and nitrogen fixation are a cause for concern. The entire inputs industry is undergoing rapid corporate and technological change. The effects of this change will be felt most powerfully among the poor farmers and consumers of the Third World.

Ultimately, new developments in biotechnology are no panacea for agriculture and the growing problem of pesticide resistance. A 1986 study on pesticide resistance conducted by the National Research Council of the National Academy of Sciences (USA) concludes:

> "Pests...can be expected to evolve strains that are resistant to virtually any control agent, including pest-resistant crop varieties. This is likely to hold true whether resistant plant cultivars are developed with the new tools of biotechnology or by traditional genetic methods."[13]

FOOTNOTES

1 George Kidd of L. Wm. Teweles & Co. estimates total seeds and agricultural chemicals market to be $50 billion, but estimates on the commercial value of the global seeds market vary.

2 George Kidd, Senior Market Analyst, L. Wm. Teweles & Co., 1986.

3 World List of Seed Sources, FAO, Rome, AGP/SIDP/82/5, November, 1982, p. 121-122.

4 Of the Earth: Agriculture and the New Biology, Monsanto Company, 1986.

5 Bio/Technology, February, 1987, p.129.

6 Agricultural Genetics Report, August 1987, p.7.

7 "Grafts between N-fixing and non N-fixing shrubs", Agricell Report, July, 1987, p.46.

8 Agricultural Genetics Report, April 1987, p.5.

9 Bioprocessing Technology, December, 1987, p. 9.

10 Robert Grossman, "The Release of Bioproducts for Agriculture: Environmental and Health Risks" paper prepared for Agricultural Bio-Ethics Symposium, November 2-4, 1987, p.5. Iowa State University.

11 Alternative Agricultural News, Vol. 4, No. 11, November, 1986,p.1.

12 Agricultural Biotechnology News, September/October 1987, p.4.

13 Pesticide Resistance: Strategies and Tactics for Management, National Research Council, Board on Agriculture, National Academy Press, 1986, p.13.