NEW CROPS: SUCCESSES, FAILURES, AND WHY?

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My specific remarks will be confined to three successful and three unsuccessful new crops that illustrate the factors responsible for success and failure. My general statements and conclusions apply to spermatophyte field crops and may not be appropriate for some ornamentals, succulent fruits, succulent vegetables, fungi, lichens, forest products, or microorganisms.

WHAT ARE NEW CROPS?

New field crops include: 1) new species such as triticale created by agronomic plant breeders, 2) new commodities such as canola created by Canadian agronomists, 3) domesticated wild plants such as crownvetch, and 4) old crops introduced into a new area. The last group, crop introductions, has been the major source of new crops in the twentieth century.

Modification of a crop's morphology, growth habit, chemical composition, pest tolerance, uses, etc. is not new crop development; instead, such modifications represent improvement or expansion of uses for an existing crop. Only when a new species or a new commodity is created should the results of such genetic manipulation be called a new crop. An inclusive term for the four preceding categories of new crops is unconventional crops.

PROMOTION OF UNCONVENTIONAL CROPS

Promotion may be necessary to obtain research funding, to obtain production subsidies, or for market expansion after the crop is successful. But very little promotion is needed to recruit farmers and business entrepreneurs to grow, process, and market a new crop. Although general public interest in new crops is highest in years of agricultural depression such as the 1930's and the 1980's, farmer and entrepreneur interest is continuous. Nonetheless, a fallacy persists that farmers resist change in crops or production practices. History has shown that farmers in the Upper Midwest are informed and flexible, and their choices of crops each year are determined by expected return. Expected return is based on production costs, expected market price, government programs, and/or the differing needs of each individual farm. Consequently, there is no problem in getting farmers to produce new crops if the production appears economically practical.

WHY AREN'T MORE UNCONVENTIONAL CROPS GROWN?

Humankind during the past 3,000 years has selected and improved the best species to grow as crops in the many soils and climates of the earth. There are few, if any, overlooked species that would be suitable field crops. Competent plant breeders do not base their research programs on the rejects of other plant breeders, and new crop programs should not be based on the rejects of 3,000 years of plant breeding. Unconventional crops are unconventional because there is something wrong with them!

BUT CHANGES OCCUR

New varieties, new cultural practices, new farm machinery, new pesticides, or new uses have made production of some previously unsatisfactory crops practical, and these are the successes referred to in the title of my lecture. And continuing change in production technology and market needs may allow more new crop successes in the future.

MAJOR CROPS OF THE PRESENT INCLUDE FAILURES OF THE PAST

The three major crops of the Upper Midwest in 1987 in both acreage and value are corn, soybean, and vegetative cover on land diverted from grain crops by the USDA. Soybean -- the most successful new crop of the twentieth century -- was a failure from the time of its introduction to the United States in the eighteenth century through the early part of the twentieth century.

SOYBEAN

Soybean was a minor forage, oilseed, and pulse (grain legume) crop in the United States until the 1930's, but its great success began in the 1940's. Before World War II, there was little need for soybean oil because cottonseed oil, linseed oil, lard, butter, tallow, and imported vegetable oils satisfied the fat and oil markets. Protein-concentrate needs for livestock production were supplied by skim milk, tankage, meat scraps, cottonseed meal, linseed meal, and other products. Although margarine was acceptable in some areas prior to World War II, it was considered an inferior substitute for butter and lard, particularly in the northern states.

Changes in Market Demands. Butter rationing in World War II, nutritional fears of saturated fats and cholesterol, and rebellion against conservative mores reduced animal fat consumption, and this resulted in greatly increased markets for vegetable oils. Loss of the butter market eliminated the dairy enterprise that previously existed on nearly every farm in the Midwest. With 5 to 20 milk cows and a cream separator, a typical cornbelt farm produced cream as a "cash crop". Every town had a "creamery" that bought cream and manufactured butter. The large volume of skim milk remaining on the farm was the protein-concentrate feed for young pigs (shotes) after weaning. Hogs were a major "cash crop" on most Midwest farms. Without skim milk, these farms needed a protein-concentrate feed. Soybean's time had come! Soybean was the crop that could supply the needed oil and fat for the consumer and the high quality, protein-concentrate feed for the livestock industry. And most important, a major technological change occurred in soybean production!

Technological Changes in Production. The introduction of small 2-row combine-harvesters in the late 1930's made harvesting of soybean seed practical in the cornbelt states.[1] These relatively inexpensive combines were pulled by the

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[1]Large combines had been used since World War I on many cash grain farms in the Great Plains and Pacific Northwest states, but they were not practical on the family farms of the Midwest cornbelt states. On these farms, small grains (and sometimes soybean) were cut and tied into bundles with a binder. The bundles were stored in small shocks and were threshed later when a group of neighboring farmers and a threshing machine came to the farm.

farm tractor. Self-propelled combines did not become common until after World War II.

Soybean became a successful new crop because the technological change to a practical harvesting method occurred just before changes in market needs made soybean the best crop to fill those needs. This success encouraged further technological advances such as herbicides for weed control and improved varieties of higher oil concentration and of earlier maturity which expanded the area of soybean adaptation.

The success of the soybean crop increased efficiency of food production and reduced the cost of food to the consumer, but it has also contributed to the demise of many family farms by replacing "farm-grown" with "factory-processed" protein, fat, and oil. This conference and many statements by scientific and popular writers in recent years are concerned with the potential of returning protein-concentrate production to farms by using grain legumes.

FIELDBEAN[2]

Fieldbean is a successful new crop in Minnesota and the Dakotas, but it was an old crop whose commercial production in those states had almost ceased by the 1950's. In 1849, 12% of Minnesota cropland was devoted to fieldbean and fieldpea, but acreage of fieldbean never exceeded 5,000 until 1923 when 11,000 acres were produced. Minnesota fieldbean acreage stabilized at about 6,000 through 1935. Low fieldbean yields of about 500 pounds per acre and the introduction of soybean reduced plantings to about 2,500 acres per year, whereas soybean occupied 53,000 acres in 1940. Despite a USDA wartime goal of 20,000 acres for Minnesota in 1943, only 8,000 acres of fieldbean were planted. Acreage declined to 1,000 acres in 1947 and remained below 1,000 acres until the 1960's. Since 1980, acreages have been as high as 110,000 in Minnesota and much higher in North Dakota.

Weed Control. Until herbicides became available, production of fieldbean in humid regions and under irrigation in arid regions required supplementation of cultivation with hand labor to control weeds. Consequently, fieldbean production tended to be in states with sugarbeet production because migrant labor was available for both crops. Herbicides liberated fieldbean production from dependence on hand labor and are a major reason that fieldbean became a successful new crop in the Minnesota-Dakota region and a potential new crop for many soybean farmers not presently producing fieldbean.

Varieties, Production Practices, and Conditioning. Although the best new varieties of fieldbean are still inferior to soybean in adaptation to combine-harvest of the standing crop, they usually stand erect and do not require the special bean harvesting machinery that is still used for most of the older fieldbean varieties. Furthermore, fieldbean can now be grown in either cultivated or noncultivated rows of desired spacing. And during the last 15 years, companies that condition the Minnesota-Dakota crop have installed electric eye pickers to remove off-colored seed and thus reduce the number of unsalable seedlots.

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[2]Fieldbean is the inclusive name for all market classes and types of *Phaseolus vulgaris* that are harvested as mature, dry seed.

Technological changes in weed control, varieties, and cultural practices made fieldbean a successful new crop in the Minnesota-Dakota area and have also made fieldbean an alternative crop for soybean growers. Soybean growers can now grow either crop without major changes in machinery or production practices.

CROWNVETCH

Any potential new crop develops many "champions" who promote its development in various ways, and no one individual is particularly important. An exception is crownvetch where agronomist Fred Grau became interested in the species, researched it, produced it, promoted it, and made it a commercial crop 30 to 40 years ago.

Crownvetch uniquely filled the need for a permanent soil cover that controls weeds, does not require mowing, is an attractive roadside plant, and reduces soil erosion on steep roadside banks. It is also used to reseed erosive, abandoned mine lands for cattle pasture and to provide permanent soil cover in corn grown by the no-till method. But crownvetch was not successful until several technological advances occurred: 1) improved varieties (Penngift-Emerald-Chemung), 2) herbicides made farm seed production practical, 3) improvements in harvesting and seed conditioning procedures, 4) improved cultural practices in stand establishment.

RUSSIAN DANDELION

The Russian dandelion crop was a failure. A large, USDA research effort in the 1940's to produce natural rubber included Russian dandelion for Minnesota and guayule for California, and the latter is still a potential new crop. Russian dandelion was researched by a large professional and support staff in St. Paul, and the United States Forest Service was in charge of large scale production. The agronomist breeder increased the latex concentration in the roots from 3% in unimproved germplasm to 10% in his advanced lines.

The agronomist said that lack of weed control was a major reason for failure of large scale plantings. Modern herbicides would probably solve the weed control problem in Russian dandelion. Undoubtedly there are other major problems, but this example illustrates that new technology offers solutions to problems of the past.

CRAMBE

Despite tremendous research input, government subsidies, and attempts at commercial production, crambe has failed. I grew crambe at three locations in Minnesota in 1953. Other than fleabeetle tolerance, it had no agronomic advantage over yellow mustard or oilseed rape. It had the serious disadvantages of seed that retained hulls and no markets. Consequently, we ceased work on crambe until 1959 when we participated in the five-state tests of potential oilseed crops chosen by the USDA Northern Utilization Laboratories at Peoria, IL and coordinated by the USDA Regional Plant Introduction Station at Ames, IA. Crambe performed well in the five midwestern states which led to a one-acre seed increase in 1960 at Rosemount, MN under contract with the Regional Plant Introduction Station. Extensive research and development efforts continued for about 15 years. Additional research and development has occurred in the 1980's.

Crambe's lack of success could be predicted from history. Humankind selected oilseed rape and mustard not crambe for oilseed crops of the Cruciferae family. Only primitive societies retained crambe as a crop. Modern technological advances to solve the toxic meal and hull problem are needed to make crambe successful. Canadian agronomists researched rape instead of crambe and developed canola and high erucic acid varieties of oilseed rape and oilseed turnip rape. The contrast between success with rape and failure with crambe is not to discourage research on crambe but to illustrate that some significant change must occur before a crop discarded by our ancestors can become a successful modern crop.

HEMP

Hemp for Rope and Other Cordage. My parents on a small farm in Iowa were notified in 1942 that their 40-acre field next to a railroad track would be purchased by the federal government for a hemp processing plant. A large concrete building was constructed and hemp production on local farms and processing of the straw began the following year. Returns to farmers were sometimes competitive with corn. Several similar plants were constructed and operated in Iowa, Minnesota, Wisconsin, and perhaps other states. The goal was 300,000 acres in the United States and 60,000 acres in Minnesota. Following World War II, production ceased and the government sold the plants and land for various other purposes. Apparently neither the government nor private entrepreneurs wanted to continue hemp production. Had there been a foreign trade protectionist sentiment or a new crop lobby in 1946, the abandonment of the hemp industry would have created much political discussion.

After hemp production ceased, the crop became a weed that persisted in road ditches and uncropped areas until mowing and herbicides eliminated it as an obvious weed in the 1960's.

Hemp for Birdfeed, Paper, and Cloth. In the early 1960's we learned that researchers in Europe had developed monoecious varieties i.e. each plant had both male and female flowers. This was a major technological achievement because hemp had been a dioecious species i.e. only half the plants produced seed and the other plants produced pollen. Consequently, seed yields of the new monoecious varieties could potentially be 100% higher than seed yields of dioecious varieties. A major objective of my research project at that time was development of birdfeed crops, and devitalized hemp seed was being imported into the United States for birdfeed.

A large flax straw processing plant in southern Minnesota was particularly interested in hemp for paper because they could no longer get enough flax straw in southern Minnesota. The licensing system established in the 1940's for hemp production by farmers and researchers was still viable. Consequently, everything was favorable for speedy development of a new dual purpose fiber and seed crop in Minnesota if the new European varieties proved successful.

The flax company through its affiliates in Europe obtained seed of one monoecious variety from Sweden, two monoecious varieties from France, and two dioecious check varieties from Italy. Seed of the five varieties arrived by airplane from France. A federal narcotics agent met the plane at the Minneapolis airport and acccompanied me to our Agronomy Seedhouse where I agreed to store it in a locked room, away from students, etc.

We grew large plot trials at Rosemount, Lamberton, Morris, and Crookston. From previous experience with hemp, we knew proper cultural practices so all trials were successful. Seed yields of the new monoecious varieties were twice those of the dioecious varieties, and test weights of the seed were 3 to 5 pounds per bushel heavier. Oil concentrations were 33% for all varieties. The monoecious varieties were of uniform height and maturity, whereas the male plants in the dioecious varieties were over 1 foot taller than the female plants. The male plants were dry and brown while the female plants were still green in September. However straw yields of the dioecious varieties were about 0.5 ton per acre more than those of the monoecious varieties.

The straw was processed at the flax plant, and the manager indicated that the crop might be economically competitive with corn. Consequently, an expanded research and pilot production program was planned. Later that winter, the Minnesota manager was told by his New York office to delay further development. Everyone involved with our project called the crop, hemp, but apparently a politician referred to our project and talked about legalizing marihuana in North Dakota. This comment appeared in a 1965 issue of the Wall Street Journal and alarmed the company's board of directors. I waited until 1971 and then phoned the Federal Narcotics Bureau, and they hauled several hundred pounds of seed to an incinerator.

Hemp is a potential dual purpose crop for cordage, paper, cloth, birdfeed, and possibly oil. But its great success as an illegal narcotic crop doomed it to failure as a legal crop.

SUMMARY

Humankind has already selected the best crops to satisfy human needs and that are adapted to the many soils and climates of the world. Consequently, to successfully establish a new crop, there must be a change in market needs, a change in production practices, or a change in the characteristics of the potential crop.

Herbicide development and improved harvesting machinery are the major production changes in the twentieth century that have made previously unconventional crops into successful established crops. Plant breeding to develop new varieties, new commodities, and new species has had major impact on new crop successes and offers the greatest potential for future successes.

I gave a brief history of only three successful and three unsuccessful new crops, but those histories illustrated the factors responsible for success and failure of many other new crops.