PRINCIPLES OF CULTIVAR DEVELOPMENT

VOLUME 1

Theory and Technique

Walter R. Fehr

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with the assistance of
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To my wife Elinor, whose numerous contributions to this book and to my life have been of immeasurable value.

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The author wishes to thank the following publishers for permission to adapt or reproduce material in *Principles of Cultivar Development*, Vol. 1.

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Crop Science, Vol. 8, 1968. M. K. Aycock, Jr., and C. P. Wilsie, Fig. 1, p. 484.

Crop Science, Vol. 17, 1977. J. R. Sedcole, Table 1, p. 668.

Crop Science, Vol. 19, 1979. C. S. Schoener and W. R. Fehr, Table 2, p. 187.

The American Society of Agronomy (Publisher)

Agronomy Journal, Vol. 52, 1960. Guy L. Jones, D. F. Matzinger, and W. K. Collins, Table 3, p. 197.

Alfalfa Science and Technology, Agronomy Monograph No. 15, 1972. C. H. Hanson, Ed. Fig. 4, p. 311.

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The American Society of Agronomy and the Crop Science Society of America (Publishers)

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Genetic Contributions to Yield Gains of Five Major Crop Plants, CSSA Special Publ. No. 7, 1984. W. R. Fehr, Ed. Fig. 2-16, p. 32. Fig. 2-25, p. 37. Fig. 4-6, p. 84.

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Journal Heredity, 41:59–67, 1950. M. M. Rhoades. Table 1, p. 58. Published by the American Genetic Association, Washington, D.C.

Soybean Physiology, Agronomy and Utilization, 1978. A. G. Norman, Ed. Chapter by Walter Fehr. Figs. 2, 3, 5, 7, 8, 14, 15, 16, Table II, and p. 134. Published by Academic Press, Inc.

Principles of Plant Breeding, © 1960. R. W. Allard, Table 14-1, p. 152. Reprinted by permission of John Wiley & Sons, Inc., New York.

Preface

The development of superior cultivars of plant species is a challenge that tests the ingenuity, patience, and persistence of an individual. Ingenuity is based on an appreciation of the scientific principles of genetics, agronomy, horticulture, statistics, physiology, and many other disciplines that are an essential part of plant breeding. It involves the ability to evaluate an array of alternative methods for cultivar development, assess the resources that are available, and develop a strategy that is efficient and effective. Patience is required to undertake the development of a cultivar, a process that commonly requires 10 years or more. Persistence is essential in dealing with the numerous obstacles that must be confronted, particularly uncontrollable fluctuations in the weather.

As a university professor, it has been my privilege to teach young women and men who have the ingenuity, patience, and persistence required to be a plant breeder. One of my responsibilities has been to help students understand how cultivar development actually is carried out, sometimes referred to as the nuts and bolts of plant breeding. My colleagues generously shared their experiences with me, which made it possible to develop a set of class notes for distribution to the students. Those class notes became the foundation for this book.

The purpose of the book is to provide some assistance in the decision-making process that every plant breeder encounters. There are not any plant breeding programs that are identical in all respects. Each breeder is faced with unique circumstances for which an appropriate strategy of cultivar development must be developed. The plant species, resources available, expectations of the employer, and demands of the marketplace are a few of the factors that contribute to the circumstances that are encountered. To develop an effective strategy of cultivar development, the breeder must be able to understand the alternative methods that could be used and evaluate the genetic improvement that could be realized from each method. This book is intended to describe in detail the alternative breeding methods and to provide guidelines for the evaluation of their advantages and disadvantages under different circumstances.

The selection and application of plant breeding methods for the genetic improvement of a crop species depends on such factors as the types of cultivars that are grown commercially, the type of parental germplasm available, and the objectives of cultivar improvement. To help students and other interested people understand how plant breeders develop an appropriate strategy of genetic improvement, Volume 2 of *Principles of Cultivar Development* was prepared. In that volume, successful plant breeders describe the step-by-step process of cultivar development for the crop series with which they work, discuss alternative procedures that are available for each step of the process, and provide examples of those methods that have been used most successfully.

There is considerable emphasis in current plant research on the role of cellular and molecular biology in genetic improvement of plant species. The results of the research undoubtedly will improve procedures for cultivar development in the future. The emphasis in this book has been placed on techniques that actually have been used to develop cultivars, however, instead of on future possibilities that have yet to be widely adopted by plant breeders. Future opportunities for the improvement of plant breeding methods are addressed by the authors of individual crop species in Volume 2 of *Principles of Cultivar Development*.

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This book was made possible by the generous support of many people, only a few of whom will be mentioned. Sincere appreciation is expressed to my wife Elinor, who typed the manuscripts for the book, drafted all the figures, and assisted in indexing and proofreading. Thanks are extended to Holly Jessen, who reviewed each chapter, made valuable revisions and additions, and assisted in indexing and proofreading. The technical support of the publication editors, Sarah Greene and Gregory Payne, is gratefully acknowledged. My thanks to Cal Qualset who reviewed the manuscripts for all the chapters, and to all of the students and colleagues who reviewed individual chapters.

WALTER R. FEHR

Contents

CHAPTER THIRTY-SIX

Release and Distribution of Cultivars

The plant breeder has the responsibility to develop and identify cultivars that will enhance commercial production of a crop. The decision to make a cultivar available for widespread use and its actual multiplication and distribution to commercial growers involve many additional persons and agencies. The procedures for release and distribution vary with the type of cultivar, the institution at which it was developed, the procedure for its multiplication and distribution, and the agencies that regulate the distribution process. There also are important differences among countries in the laws that control the release and distribution process. The emphasis in this chapter will be on the procedures commonly used in the United States. To simplify the discussion, the term cultivar will apply to genotypes used for commercial production of a crop or to inbred lines used to produce a commercial hybrid. The term originator will refer to the public institution or private company that developed the cultivar.

THE DECISION-MAKING PROCESS

The decision to release a new cultivar is a stepwise process that usually involves a number of persons, all of whom are responsible for determining if the genotype will be useful for commercial production of a crop. Sufficient performance data must be obtained to convince the breeder and other knowledgeable persons that the genotype merits release. The process is most orderly and efficient when the persons involved have a well-defined procedure to follow. Although exact procedures vary among companies and public institutions, certain principles are common to all.

Role of the Breeder

The breeder is responsible for obtaining the data needed to evaluate the potential of a genotype for commercial use (App. C). It is important that the breeder understand what data are expected by the individuals who ultimately will decide if a genotype will be released. Without that knowledge, the breeder may conduct an inadequate testing program that will prevent the prompt release of a cultivar. In breeding programs of State Agricultural Experiment Stations and the U.S. Department of Agriculture, it may be desirable to release a new cultivar simultaneously in several states. Breeders working in such programs should be aware of the testing requirements of all states that may be interested in release of the cultivar.

The breeder is responsible for coordinating the evaluation of a cultivar with the preparation of breeder seed. Distribution of the cultivar will be most rapid when an adequate supply of breeder seed is available as soon as adequate performance data have been collected. A breeder must work closely with persons responsible for seed multiplication and distribution to ensure that adequate quantities of pure seed are available at the appropriate time.

Role of Persons Other than the Breeder

The final decision to release a cultivar generally is not made by the breeder who developed it (App. C). The persons who make the decision must consider the cultivar's performance relative to that of cultivars currently available and the likelihood that the new cultivar will be readily marketed. As a result, these persons include breeders other than the one who developed the cultivar, agronomists who work closely with farmers, and persons responsible for multiplying and marketing the cultivars. In a private company, an important consideration is the amount of profit that will be realized by use of the new cultivar compared with that obtained with current cultivars.

Although the breeder may not have a vote when the final decision is made, his or her understanding of the factors that are important for release of a new cultivar can directly influence the outcome. Those factors should play a key role in determination of the objectives of a breeding program, development of appropriate sources of genetic variability, and selection and testing of potential cultivars.

Examples of Release Procedures

The principles of the decision-making process that are involved in the release of a genotype will be illustrated by outlining the procedures used by a public

and by a private company. Release of a soybean cultivar will be used in the example for both institutions.

1. Public institution
   The procedures for release and distribution of cultivars by the Iowa Agriculture and Home Economics Experiment Station at Iowa State University are presented in App. C. The procedure described for soybeans will differ in certain details from other crop species, but the principles of the decision-making process will be similar.
   a. First year
      The first replicated test of a line is conducted by the breeder at two locations in Iowa. The lines with the best performance are selected by the breeder without any outside approval.
   b. Second year
      The second replicated test is conducted by the breeder at three locations in Iowa. The breeder selects the best lines without any outside approval.
   c. Third year
      Lines are evaluated in a regional test conducted cooperatively by public breeders in states where the maturity of the line is appropriate. Each breeder who conducts the test recommends whether a line should be discarded or evaluated another year. The final decision on additional testing of lines developed in Iowa is made by the breeder without approval from the Experiment Station.
   d. Fourth year
      Lines are evaluated extensively in the cooperative regional test by all states that are likely to be interested in growing cultivars of that maturity on a commercial scale. All breeders who conduct the test recommend whether lines should be discarded or evaluated again. The final decision for Iowa lines is made by the breeder without approval from the Experiment Station.
   e. Fifth year
      A third year of evaluation in the cooperative regional test is conducted before a line is considered for release. The breeder of a line in Iowa decides if the line warrants consideration for release in that state. If so, a formal request for release must be made to the Agricultural Experiment Station. The Experiment Station requires that a form be prepared by the breeder that documents the attributes of the genotype and the reason for its proposed release (App. D). The request must be approved first by the executive officer of the department to which the breeder is responsible. The executive officer asks the advice and approval of a committee of staff members from the department. The committee consists of plant breeders, extension personnel, and seed production specialists. If the committee approves the request and the

executive officer concurs, the document is signed and forwarded to the Experiment Station.

The associate director of the Experiment Station appoints a review committee of staff from several departments that usually include genetics, agronomy, horticulture, and plant pathology. The breeder who developed the line is not a member of the committee. If approval is given by the review committee and the associate director concurs, the line is released as a cultivar in Iowa. Agricultural Experiment Stations from other states and the USDA are given the opportunity to participate in the release of the cultivar.

2. Private company
   a. First year
      The initial evaluation of soybean lines is conducted in replicated tests at two locations by the breeder. Selection of lines for additional evaluation is done by the breeder without approval from other persons in the company.
   b. Second year
      Lines are evaluated in replicated tests at about five locations. On the basis of the results, the breeder selects lines for additional testing. A form is prepared for each selected line that includes its parentage, morphological characteristics, agronomic performance, and reactions to relevant diseases, nematodes, insects, and soil problems. The breeder decides which lines will be tested the third year.
   c. Third year
      Lines are evaluated at 10 to 15 locations by the breeder who developed them and by breeders at other stations of the company. The breeder uses results of the tests in the third year to select lines that merit additional evaluations and to prepare a detailed description of the performance of each selected line. The decision to test a line the following year must be approved and an appropriate form signed by two other soybean breeders and by the research manager for soybeans. Approval also is required from the manager of the division responsible for production and marketing of a new soybean cultivar.
   d. Fourth year
      A line is extensively evaluated in replicated tests by soybean breeders of the company. It also is evaluated by agronomists of the company in management trials, including row spacing and plant population tests.

      The decision to release a cultivar generally is made after the fourth year of evaluation. The release is based on performance data obtained by the breeders and agronomists. Consideration is given to characteristics important for the production of high-quality seed for sale to farmers. Sales are projected for several years and seed supplies are evaluated. The decision to release a new cultivar must be approved

by the originating breeder, the research manager for soybeans, the person responsible for producing seed of the cultivar, and the manager of the division responsible for production and marketing. Final approval must be given by the president of the company.

DISTRIBUTION PROCEDURES

The distribution of a cultivar to the commercial growers of a crop is a major undertaking. Seed or vegetative propagules must be carefully multiplied and effectively merchandised. The distribution process involves many persons, each with important responsibilities.

Private Companies

Distribution of a cultivar is controlled by the originator or its designated representative. Some private breeding companies maintain direct control over all aspects of multiplication and merchandising. Other companies specialize in plant breeding and obtain a royalty from firms that multiply and merchandise their cultivars. There are companies that specialize in the production and distribution of seed or vegetative propagules to other companies, which in turn make the final multiplication for sale to commercial growers.

Public Institutions

Public institutions that conduct breeding programs include primarily the U.S. Department of Agriculture (USDA) and State Agricultural Experiment Stations. Guidelines for the release and multiplication of cultivars developed by those institutions are described in App. B. Despite these guidelines, there is considerable variation among crops and public institutions in the procedures used to distribute a new cultivar.

A public institution generally is not involved in the direct sale of a cultivar to a commercial grower. The most common strategy is to distribute seed stock of a cultivar to one or more private companies that are responsible for its multiplication and marketing. The originator may permit unrestricted use of the genotype or may regulate its distribution to varying degrees. Some institutions make a cultivar available without charge, and others assess a royalty for its use. This diversity of strategies can be examined by considering independently the philosophies and procedures of the USDA and that of the State Agricultural Experiment Stations.

USDA. A breeder of the Agricultural Research Service (ARS) of the USDA can develop cultivars alone or in cooperation with scientists from State Agricultural Experiment Stations. When the ARS is the sole owner of the cultivar, it has the option of obtaining a plant variety protection certificate or a patent, depending on the species involved. It can grant exclusive rights for distribution of a cultivar to an individual or a company if this is considered necessary to promote use of the cultivar, and can collect a royalty. The revenue would be paid to the U.S. Treasury without any percentage being provided to the ARS or the breeder.

Although the ARS has several options for the distribution of cultivars developed solely by it, the philosophy has been to provide a cultivar to users without remuneration. Plant variety protection has not been obtained for any cultivars, up to the present time.

The most common situation is for the ARS to develop a cultivar in cooperation with scientists from State Agricultural Experiment Stations, including breeders, pathologists, and entomologists. There are no published rules for determining when the ARS is a coowner of a cultivar, but two general principles have been used. ARS is assumed to be a coowner when the ARS scientist is the recognized leader of a cooperative cultivar development program or when the ARS scientist makes decisions that directly influence the development and eventual release of a cultivar.

The ARS and the State Agricultural Experiment Station cooperate as coowners of a cultivar in the decisions concerning its distribution. The ARS will participate in the application for plant variety protection or a patent if initiated by and paid for by the Experiment Station or its designated representative. The details related to seed distribution generally are handled by the Experiment Station.

State Agricultural Experiment Stations. The procedures for distributing cultivars developed by State Agricultural Experiment Stations vary with the type of cultivars involved and the philosophy of the originating institution. In some situations, the distribution is managed by an independent company or corporation that has a contract or mutual understanding with the Experiment Station. The Experiment Station and the breeder may or may not benefit financially from the sale of the genotype. These alternatives will be reviewed by examining procedures used by the Iowa Agriculture and Home Economics Experiment Station at Iowa State University.

Distribution Agencies. The Iowa Agriculture and Home Economics Experiment Station distributes cultivars through two independent corporations closely aligned with the university: the Committee for Agricultural Development and the Iowa State University Research Foundation, Inc. The Committee for Agricultural Development is a nonprofit, nonstock corporation that was formed to assist the Experiment Station in the distribution of new germplasm. As an independent corporation, it can collect, disburse, and invest revenue more readily than the Experiment Station itself. Any revenue received that exceeds the expenses of

the corporation is used to support activities of the Experiment Station. The close relationship between the Committee for Agricultural Development and the Experiment Station is ensured by the makeup of the Board of Directors of the corporation. Four permanent members of the Board are the president of Iowa State University, the dean of the College of Agriculture, the associate director of the Experiment Station, and the head of the Department of Agronomy. Additional members with limited terms on the Board are from outside the University and include farmers and seed producers. The persons employed by the Committee for Agricultural Development to operate the corporation are staff members of Iowa State University.

The Iowa State University Research Foundation is an independent corporation that facilitates the distribution of inventions developed by staff members of Iowa State University. Its Board of Directors include the president and other administrators of the University, and its employees are staff members of the University. Any revenue obtained in excess of expenses is used to support research of the University. It is the policy of the Research Foundation that a percentage of the revenue received from an invention, in excess of the expenses incurred, is given to the inventor. For a patent of a plant cultivar, the inventor would be the breeder who developed it.

Methods of Distribution. *Nonexclusive distribution.* The majority of the cultivars developed by the Experiment Station are distributed by the Committee for Agricultural Development on a nonexclusive basis. A distribution is nonexclusive when seeds or vegetative propagules are sold to a number of individuals or companies that increase and merchandise the cultivars. A royalty could be charged for each unit sold to commercial growers, but that has not been done up to the present time.

Nonexclusive distribution is used for cultivars that can be readily sold by a number of competing individuals or companies. The Committee for Agricultural Development distributes foundation seed of oat and soybean cultivars on a nonexclusive basis. The foundation seed is used to produce certified classes of seed for sale to farmers. Only the Committee for Agricultural Development can distribute foundation seed of oat and soybean cultivars. Therefore, a seed producer who annually produces the registered class of seed must purchase foundation seed from the organization each year.

Inbred lines of maize and sorghum are distributed on a nonexclusive basis by the Committee for Agricultural Development. Individuals and companies can use the inbred lines without restriction for the production of commercial hybrids. They can purify and increase their own seed of the inbred line each year; therefore, they only need to purchase seed of the inbred line from the Committee for Agricultural Development one time.

Committee for Agricultural Development also distributes on a nonexclusive basis germplasm that is intended for use by public and private breeders. This germplasm includes parents for hybridization and populations in which selection could be conducted.

Exclusive distribution. A limited number of cultivars developed by the Experiment Station are distributed exclusively to a single company or corporation by the Iowa State University Research Foundation or the Committee for Agricultural Development. The Foundation manages only the exclusive distribution of cultivars that are patented (App. E). The Foundation obtains a patent for the breeder (inventor) and negotiates a contract with a company for the exclusive distribution of the patented cultivar. Royalties from the company are used by the Foundation to pay for expenses of the patenting process. A percentage of any additional income is shared with the inventor.

Exclusive distribution by the Committee for Agricultural Development has been used for cultivars of forage species that have a limited seed market. A cultivar with a limited market may never be properly distributed on a nonexclusive basis because seed companies could not afford the expense of promoting it in competition with each other. An exclusive distribution was used by the Committee for Agricultural Development for the 'Carroll' cultivar of birdsfoot trefoil. A Memorandum of Understanding was negotiated between the Committee for Agricultural Development (CAD) and a seed company with experience in the distribution of seed of forage species. The Memorandum had the following statement that described the purpose of the exclusive distribution.

> It is the mutual desire of the CAD and the Company to promote the widespread use of Carroll birdsfoot trefoil, a superior variety. Both parties feel that the granting of the exclusive rights for the production, promotion, distribution, and selling of Certified Seed of this variety to the Company is the best means of achieving the goal. It is the belief of the cooperating parties that this promotion will be to their mutual benefit and to the benefit of the people of Iowa.

A royalty was paid to the Committee for Agricultural Development for all certified seed of the cultivar that was sold.

Asexually propagated cultivars that are not patented have been distributed on an exclusive basis by the Committee for Agricultural Development. An agreement was made with the Iowa Nurserymen's Research Corporation for the forsythia cultivar 'Iowa Selection Sunrise.' The Research Corporation is made up of a number of private companies in Iowa that increase and sell plants of asexually propagated cultivars of horticultural species. The Research Corporation agreed to pay a royalty to the Committee for Agricultural Development for each rooted cutting distributed to member nurseries. None of the income from this or any other cultivar distributed by the Committee for Agricultural Development is shared with the breeder who developed it.

LEGAL RIGHT OF OWNERSHIP

In the United States, legal ownership of a new cultivar can be obtained through a plant patent or plant variety protection certificate. The legal owner has the right to control who multiplies and sells the cultivar to commercial growers.

This control provides an opportunity for the originator to profit from its investment in plant breeding.

Plant Patent

A patent can be obtained for asexually propagated plants that are not reproduced by seeds. The cultivar must be distinct from any other cultivar of the species. The commercial value of a cultivar and its performance relative to that of other cultivars are not considerations in granting a patent.

An example of a plant patent is presented in App. E. The person who developed the cultivar is considered the inventor. The assignee is the individual, company, or corporation that has been chosen by the inventor to apply for and administer the patent. The inventor can make the application for a plant patent personally without assigning the responsibility to others.

A plant patent provides the same legal protection as a patent for a machine or design. The inventor or assignee has the legal right to control the multiplication and sale of the cultivar for a specified number of years. Anyone who sells the cultivar without the permission of the patent owner can be prosecuted.

The cost of a plant patent exceeds 1000 dollars. Information about plant patents can be obtained from the Patent and Trademark Office in Washington, D. C.

Plant Variety Protection

Legal ownership of cultivars reproduced sexually by seeds can be obtained by plant variety protection. The inbred lines used to produce a commercial hybrid cultivar can be protected, but not the hybrid per se. The Plant Variety Protection Act was established through Public Law 91-577 approved by the U.S. government on December 24, 1970. Before the law was enacted, it was not possible to obtain legal ownership of seed-propagated cultivars or inbred lines.

The criteria by which a cultivar is evaluated for plant variety protection are novelty, stability, and uniformity. A cultivar must have readily distinguishable characteristics that make it novel from every other cultivar of the species. The novelty statement that describes the distinguishing characteristics is a part of the application form (App. F). After an application is made, the characteristics of the cultivar are compared with those of every other cultivar that has been described for the species, both past and present. If another cultivar is found with the same characteristics, protection will not be granted unless the originator identifies a trait for which they differ. Any qualitative or quantitative character can be used regardless of the commercial value of the trait. A quantitative character, such as yield, can be used only if assurance can be provided that the ranking of a cultivar in comparison with another for that character will not change across environments.

The novelty characteristics of cultivars that have been protected are published quarterly in the *Plant Variety Protection Office Journal* available from the Plant Variety Protection Office; Livestock, Meat, Grain & Seed Division; Agricultural Marketing Service; U.S. Department of Agriculture, National Agricultural Library Building, Beltsville, Maryland 20705. The following examples of novelty were taken from Volume 10, No. 3, July–September 1982.

'Score' cultivar of garden bean developed by Moran Seeds, Inc.

> 'SCORE' is most similar to 'PICKER'; however, the foliage color of 'SCORE' is dark green (Royal Horticultural Society 131B), whereas foliage color of 'PICKER' is yellow-green (RHS 135B). Also, pod color of 'SCORE', is RHS 143C, whereas pod color of 'PICKER' is 143A. Pods of 'SCORE' are borne high on the bush, whereas pods of 'PICKER' are scattered.

'Deltapine 30' cultivar of cotton developed by Delta and Pine Land Co.

> 'DELTAPINE 30' most closely resembles 'DELTAPINE 70'; however, 'DELTAPINE 30' has a higher micronaire reading (5.2 vs 4.8) and weaker fiber (Stl 23.7 vs 24.2 G/Tex) than 'DELTAPINE 70'.

'Southern States 76-30' cultivar of oat developed by Coker's Pedigreed Seed Co.

> 'SOUTHERN STATES 76-30' is most similar to 'COKER 716'; however, 'SOUTHERN STATES 76-30' is 2 or more days earlier and approximately 6 cm taller (100 vs 94 cm) than 'COKER 716'. 'SOUTHERN STATES 76-30' has a hairy lemma dorsal surface, whereas the dorsal surface of lemmas of 'COKER 716' is hairless.

'Orange Cayenne' cultivar of pepper developed by Tommy Bolack.

> 'ORANGE CAYENNE' is most similar to 'CAYENNE LONG RED'; however, 'ORANGE CAYENNE' has bright orange mature fruit, while 'CAYENNE LONG RED' has bright red mature fruits.

'2553' cultivar of common wheat developed by Pioneer Hi-Bred International, Inc.

> '2553' is most similar to 'S76'; however, '2553' is susceptible to Races A, B, C, D, and F of Hessian Fly while 'S76' is resistant. Phenol reaction for '2553' is light brown to brown while the phenol reaction for 'S76' is dark brown to black.

A cultivar is stable that can be reproduced for multiple generations of seed production without changes in its characteristics. It must be uniform to the extent that variants are properly described, predictable, and commercially acceptable.

The originator must specify the role of seed certification in the sale of the cultivar to commercial growers (App. F). One option is to require that all seed be sold by cultivar name only as a class of certified seed. This option prevents anyone from putting a brand name on the seed with the statement "Variety not stated" (App. G). All seed of the cultivar that is sold must have passed the requirements of an official seed certifying agency and the seed container must be labeled accordingly. Another important aspect of the certification option

relates to the prosecution of individuals or companies that merchandise the cultivar without permission of the owner. When the certification option is chosen, the U.S. government has the responsibility to protect the rights of the owner. If an owner believes that someone is selling the cultivar illegally, the U.S. government conducts an investigation and obtains an appropriate settlement, if necessary.

The second option for sale of a cultivar is to permit the sale of either certified or uncertified seed. With this option, the owner can use a brand name and not disclose the cultivar name by use of the statement "Variety not stated." The option to sell certified or uncertified seed makes owners responsible for safeguarding their rights to a protected cultivar. Owners who believe someone is illegally selling seed of their cultivars are responsible for all legal action required to prosecute the offender.

Plant variety protection does not prevent commercial growers from multiplying and planting seed of a cultivar for their own use. Farmers can plant a protected cultivar on their farm and save seed from the harvest to plant the cultivar the next season without paying any money to the owner. A protected cultivar can be used by any individual or company as a parent for hybridization or mutation. It also can be used for research experiments, such as studies on physiology and disease resistance.

Plant variety protection provides an owner with legal rights to a cultivar for 18 years. After that time, the cultivar can be multiplied and sold by anyone as certified or uncertified seed. In emergency situations when the production of food for humans, feed for livestock, or plant material for industry is threatened, the Secretary of Agriculture of the U.S. government can make a protected cultivar available to the public for multiplication and sale.

The application for plant variety protection must be made within a specified time period after the cultivar is commercially available. The fees charged by the Plant Variety Protection Office for protecting a cultivar exceed 1500 dollars. When the initial application is filed, seed of the cultivar may be labeled "Unauthorized propagation prohibited—U.S. Variety Protection applied for." After the application has been examined and a certificate of protection has been issued, seed of the cultivar may be labeled "Unauthorized propagation prohibited—U.S. protected variety."

SEED CERTIFICATION

The seed of cultivars or a planned seed mixture (multiline) of cultivars can be certified for genetic identity and purity by an official seed certifying agency. Each state in the United States independently determines which agency or agencies, if any, will be responsible for seed certification. The agency establishes for the state the requirements that must be met and administers the certification program. Most seed certifying agencies in Canada and the United

States are members of the Association of Official Seed Certifying Agencies (AOSCA).

One of the important activities of AOSCA is to establish minimum standards for genetic purity and identity for the classes of certified seed. No member of the organization may use lower standards for its individual certifying agency, but it may establish higher standards. AOSCA also recommends minimum standards of seed quality, such as germination percentage; however, no member agency is required to include seed quality as a criterion for certification.

Despite the important coordinating role of AOSCA, the voluntary nature of seed certification in the United States makes it difficult to generalize about the system. A company that merchandises seed in several states may encounter different requirements that must be met. All seed certifying agencies must have standards for genetic purity, but the standards for agencies in different states may not be the same. Some agencies require that standards for seed quality must be met for certification. The agencies in some states require that performance data must be obtained by them or their designated representative each year a cultivar or multiline is certified.

To simplify a review of the principles of seed certification, the procedures and standards of AOSCA will be used. Anyone interested in certifying seed in a particular state should become familiar with the procedures and standards used by the appropriate certifying agency.

Cultivars Eligible for Certification

A cultivar or multiline must be approved for certification by at least one certifying agency that is a member of AOSCA or by the National Certified Variety Review Board for the crop. The procedures and requirements of the National Certified Variety Review Boards are representative of those that would be used by individual agencies.

Review boards have been established by AOSCA for alfalfa, grass, small grain, soybean, forage legumes other than alfalfa, and sunflower. Their purpose is to advise member agencies on the eligibility of cultivars for certification. Before the review boards were established, it was necessary for the originator to prepare an application for the agency in each state where the cultivar was to be certified, and each agency had to review the information independently. With the establishment of the review boards, it became possible for an originator to make a single application for eligibility that would apply to more than one state. The member agencies of AOSCA generally accept for certification any cultivar approved by the review board, but are not required to accept the board's decision. If a cultivar is not approved by the review board, the originator may request approval from individual agencies.

The review boards are made up of members from public and private institutions. Organizations represented include AOSCA, American Seed Trade As-

sociation, Crop Science Society of America, National Council of Commercial Plant Breeders, and U.S. Department of Agriculture. The Plant Variety Protection Office is represented by a nonvoting member. The review boards meet at least once annually to review applications.

The application form prepared by the originator is not the same as that used for plant variety protection; however, much of the information requested is similar (App. H). The information includes a statement of the breeding procedures used to develop the cultivar, a description of the cultivar's morphological and physiological characteristics, its reactions to diseases and insects, and procedures for maintenance of seed stocks.

Classes of Certified Seed

The classes of seed in the certification program of the United States are breeder, foundation, registered, and certified (App. I). The originator of the cultivar can specify the number of classes that will be used.

Breeder seed is produced under the direct control of the originator of the cultivar or its designated representative, and is expected to have the highest level of genetic purity of any class of seed. Breeder seed can be used to produce the foundation, registered, or certified classes.

Foundation seed is produced from breeder seed or from foundation seed per se under the control of the originator or its designated representative. Foundation seed can be used to produce the registered or certified classes. In some cases, it is sold to farmers for planting.

Registered seed is produced from breeder or foundation seed. It can be used to produce certified seed, and is commonly used by farmers for commercial planting.

Certified seed is produced from breeder, foundation, or registered seed. It generally is not used to produce additional generations of certified seed, except when foundation seed of an old cultivar is not maintained or in an emergency when supplies of foundation or registered seed are not adequate to plant enough area for certified seed production.

Standards of Genetic Purity

Certification involves inspection of the crop in the field and of samples of the harvested seed. Each field or designated area is considered an independent unit or lot for certification. If seed of a cultivar is produced in 100 separate fields, each field is considered independently for acceptance or rejection. The field and seed inspections are made by employees of the certifying agency.

The requirements that must be met for certification differ for each crop. A field chosen to produce a class of certified seed must meet certain requirements for the types of crops previously grown on it. In general, the land must be free

of volunteer plants of the same species, and no material can be applied to the field before or after planting that may contain seeds or plant parts that would result in the production of off-type plants. The field must be properly isolated from sources of pollen or seed that would cause a reduction in genetic purity.

The percentage of off-type plants that can be present varies with the crop species and the class of seed being produced. The maximum percentages of off-type plants that can be present in rice are 0.01 for foundation, 0.02 for registered, and 0.1 for certified. The maximum percentages for peanuts are 0.1 for foundation, 0.2 for registered, and 0.5 for certified.

Samples of seed are inspected from each field. Standards of genetic purity are established for each crop species and class of seed. The maximum percentages of off-type seeds for cotton are 0.03 for foundation, 0.05 for registered, and 0.1 for certified. The maximum percentages for barley are 0.05 for foundation, 0.1 for registered, and 0.2 for certified.

Seed Conditioning

The cleaning and preparation of seed for distribution, referred to as conditioning, only can be done by individuals or companies that are approved by a certifying agency on an annual basis. Approved conditioners must have facilities that can condition seed without introducing mixtures. They must be able to maintain the identity of seed and keep records on its disposition.

Seed Labeling

The bag or container in which a class of certified seed is sold must have an official certification label attached to it. The labels must meet the specifications of the certifying agency. The colors commonly specified for the classes of seed are white for foundation, light purple for registered, and light blue for certified. The label contains the name of the certifying agency, an identification number for the lot of seed, the cultivar name, the crop, and the class of seed (App. I).

Certification of Cultivar Mixtures or Blends.

Planned seed mixtures (multilines or blends) of cultivars are certified by some agencies. The following are the 1985 requirements of the Iowa Crop Improvement Association.

Certification of Varietal Blends

a. A blend to be certified shall be approved by the Board of Directors.
b. Permission to use a protected or private variety in a blend must be obtained from the breeder or owner of the variety. This evidence must be submitted by the blender to the certifying agency.

c. Each year that a blend is offered for sale, current performance data from tests conducted by or for the Association the previous year shall be available to the purchasers of seed. A blend shall be tested at two or more locations in its area of adaptation in comparison with appropriate check varieties. The fee for testing shall be paid by the breeder, sponsoring organization or institution.

d. A given component of a blend shall be not less than 15 percent of the whole on a weight basis. The sampling tolerance limits of each component shall not exceed plus or minus 10 percent of the whole also on a weight basis. No more than four components (varieties) may be used in a given blend.

e. The components of a blend must have met all field and seed requirements for certification previous to blending.

f. Only Approved Seed Conditioners may blend varieties to be sold as certified seed.

g. The Approved Seed Conditioner shall demonstrate the ability to blend varieties within specified tolerances.

h. The size of a given lot of a given blend shall not exceed 3000 bushels.

i. The components and their proportions within a blend shall be recorded in the files of the Iowa Corp Improvement Association, and this formula shall not vary between lots and between years. Closed formulas will be retained in confidence.

The blendor has the option of stating or not stating the name of the varietal components and proportions on the label provided there is compliance with state and federal laws.

j. Any additional expenses incurred for sampling, testing, etc. in the certification of blends shall be paid for by the Approved Conditioner making the blend.

k. The certification tag shall carry the following information:

(1) *Protected varieties* (as required by owner)

Iowa Certified Seed

Blend and Kind _____

Component A % by wt. _____ % germ. _____

Component B % by wt. _____ % germ. _____

Component C % by wt. _____ % germ. _____

Lot No. _____

Approved Seed Conditioner No. _____ affirms that all the varieties in the blend of seed to which this tag is attached have passed field and seed certification requirements of an official seed certifying agency. Tag Serial No. _____

(2) *Non-protected varieties* or protected varieties where owner does not require listing of components on tag.

Iowa Certified Seed

The Approved Seed Conditioner listed below affirms that the seed to which this tag is attached is a blend of varieties that have passed field and seed certification requirements of an official seed certifying agency. VARIETIES NOT STATED

Blend and Kind _____

Lot Number _____

Approved Seed Conditioner Number _____

Tag Serial No. _____

REGULATORY AGENCIES

The distribution of seed in the United States is controlled by federal and state laws. The general nature of the regulations will be examined by considering those established by the federal government. The information is taken from five pamphlets entitled *Federal Seed Act: Interstate Commerce, Foreign Commerce, and General Regulations; Seed Testing Regulations; Certified Seed Regulations;* and *Rules of Practice*. Copies are available from the Seed Branch, Grain Division, Agricultural Marketing Service, U.S. Department of Agriculture, Washington, D. C. 20250.

The Federal Seed Act was approved on August 9, 1939, and has been amended when necessary by the U.S. Government. The purpose of the Act is to "to regulate interstate and foreign commerce in seeds; to require labeling and to prevent misrepresentation of seeds in interstate commerce; to require certain standards with respect to certain imported seed; and for other purposes."

One important responsibility of the Act is to regulate the information that must be provided about the seed that is being distributed and merchandised in interstate commerce. Each container must have a label with appropriate information, some of which is the following:

1. The name of the crop species and the name of the cultivar for each seed component present in excess of 5 percent of the whole and the percentage by weight of each component. The name of the cultivar can be replaced by the statement "Variety not stated," except when a certificate of plant variety protection specifies that it only can be sold by variety name as a class of certified seed.
2. Location where the seed was produced.
3. Percentage by weight of weed seeds.
4. Percentage by weight of seeds of other crops.
5. Percentage by weight of inert matter.
6. Germination percentages of appropriate components of the seed, and the calendar month and year the test for germination was completed.

State seed laws may vary from that of the Federal Seed Act. For example, the Federal Seed Act permits use of the statement "Variety not stated" as a substitute for the cultivar name, unless prohibited by a certificate of plant variety protection. The seed laws of some states require that the variety name always be stated, and prohibit use of the statement "Variety not stated."

Personnel from an appropriate federal or state agency are responsible for enforcing the seed laws. Periodic checks of seed are made to ensure that the laws are being properly followed. Violation of the laws can prevent the sale of seed and may result in financial penalties.