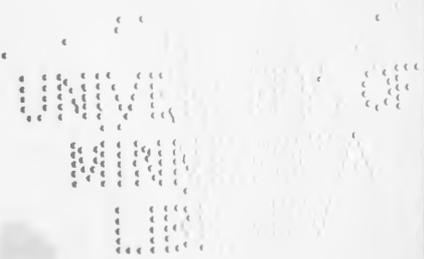


THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report
of
Committee on Thesis



The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Harold Lamont Borst for the degree of Master of Science.

They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science.

Alamy

Chairman

C. O. Rosendahl

E. M. Arman

June 2nd 1920

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report
of
Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given Harold Lamont Borst final oral examination for the degree of Master of Science . We recommend that the degree of Master of Science be conferred upon the candidate.

Minneapolis, Minnesota

June 9th 1920

Almy
Chairman

C. O. Rosendahl

E. M. Freeman

SEED CERTIFICATION AND REGISTRATION

A THESIS

**Presented to the Faculty of the Graduate
School of the University of Minnesota in
Partial Fulfillment of the Requirements
For the Degree of
MASTER OF SCIENCE**

By

Harold Lamont Borst

June

1920

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INTRODUCTION

The criteria of crop improvement are two, viz., increased production and increased quality. Production may be increased mainly by four different means, viz., (1) by improvement in soil fertility, (2) by improvement in cultural methods, (3) by combating insects and plant diseases, (4) by improving and raising the standard of seed used. Since the matter of disease and even some insect control is linked up with the seed, it cannot be overestimated as a point on which to focus further effort.

It may be justly said that the value of good seed was not realized, if it is properly now, nearly as early as attention was given to soil, rotations and other factors contributing to increased production. Cato recognized the value of crop rotations, yet even today, to a large number of farmers seed is merely seed. Variety, to be sure, is recognized to some extent, imperfectly, however, since many varieties are not grown under their real names. Purity and viability are also recognized to a certain extent, but the importance of maintaining a high standard in seed as is attempted, for instance, in livestock is only now beginning to be realized.

The question: Has the same steady, progressive improvement occurred in crop varieties as has been accomplished in livestock? may legitimately be asked. The cases are not entirely parallel, but the same underlying principles of livestock improvement fit also improvement of farm crops. The answer is undoubtedly

in the negative for it is necessary only to glance over some representative grain field, look over the reports of samples in a seed laboratory, or examine what is being sown to realize that not only are there too many "scrub" varieties, but that the good varieties deteriorate rapidly.

No little effort has been put forth in recent years to bring and keep crop seeds up to an efficient standard. Seed and weed laws have been passed, seed laboratories established and disease control measures worked out, but these efforts have not been sufficiently correlated or united to combat deterioration in all respects at once. Seed deteriorates and becomes inferior mainly from six different causes, viz.,

1. By mixing with aberrant types of the same variety.
2. By mixing with other varieties or crops.
3. By mixing with foul seed and foreign matter.
4. By becoming diseased.
5. By natural crossing.
6. By losing capacity to germinate.

Numbers 1 and 5 of these causes are very important since they have to do with varietal purity. It is in respect to varietal purity that the least work has been done and, therefore, the most remains to be done.

The value of varietal purity is really self-evident. It is only logical that if a variety possesses inherent superior qualities warranting its origin and subsequent production these should be perpetuated by keeping the variety in a reasonably pure state, at least until a better variety is brought forth to take its place.

A striking example of deterioration in this respect is that of Marquis wheat in Minnesota. Introduced six years ago, it is now estimated by experts to be no more than 80% pure. Newman of Canada (26)* says: "Were all the seed of new and superior varieties or strains distributed direct to the grower without the exercise of any control whatever over it or its progeny in succeeding generations, the greater part of it would quickly lose its identity and eventually be either ruined by lack of proper care in maintaining purity or completely lost". This is exactly what has been happening in the United States. In 1912, one bushel of Rosen rye(38) sent out by the Michigan Experiment Station. Five years later, in 1917, the production in the state had reached 15,000 acres. However, it is stated that only 5% of this production was 99% pure at this time. Cross-fertilization in rye makes it exceedingly difficult to maintain absolute purity. However, with the proper system of control a much higher state of purity could be maintained. Some agent is plainly needed to hold up the standard of seed in this respect.

The question may occur in this connection, however, as to whether or not varietal purity of superior and selected varieties is important enough to warrant great efforts in perpetuating it. Much evidence is available on the superiority of selected varieties over commercial or common varieties. Figures on a few such varieties are submitted in the following tables showing their yields. Yield, however, it should be understood, is only one of the qualities that a superior variety may possess.

* number refers to bibliography.

Results from University Farm, Minnesota Experiment Station (53)

Haynes Bluestem 169 - Av. yield 1895-1904	27.3 bu. per A
" " original Av. yield 1895-1904	23.1 " " "
Gain of selected variety over parent variety	<u>4.2</u> " " "
Manchuria Barley Minn. 184 - 3 yr. average	43.9 " " "
" " " 105 - 3 " "	38.9 " " "
Gain of selected variety over parent variety	<u>5.0</u> " " "

Results from the Ohio Experiment Station (47)

Pure line selections of wheat were tested.

Variety	: 18 yr.av.of : parent var. : 1898-1915	: 8 yr. av. : of both	: Increase of : favor of : selected var.
Gladden (selection)	:	37.62	:
Gypsy (parent)	31.27	33.99	3.63
Trumbul (selection)	:	37.06	:
Fultz (parent)	29.60	34.63	2.43
Portage (selection)	:	39.79	:
Poole (parent)	31.44	36.06	3.73

In addition to their ability to produce higher yields, these selected varieties also possess superior qualities such as bread-making qualities and stiffness of straw.

Iowa 103 and 105 oats sent out by the State Experiment Station to 100 farmers were reported to yield practically 5 bushels per acre over the old varieties in a period of 3 years. Sixteen varieties at the Missouri Station (24) gave a 5 bushel increase over the commercial varieties from which they were selected.

From these reports it is seen that these selected and pure bred varieties are superior to the commercial variety from which they were obtained and that the superiority is sufficient to warrant an effort to preserve them in a high state of purity.

Deterioration from diseases for which control measures have been worked out is very important. Not only do these diseases affect the seed directly but they indirectly affect the crop coming from this seed in that the seed furnishes a source of transmission for some of these diseases. Much good work has been done in working out control measures and in education, but it remains to make control measures obligatory in the production of the best seed.

Deterioration of seed from mixture with other crop and weed seed, and through loss of viability is being combatted in several states at present, by seed laws and seed laboratories. However, definite standards in all these respects, especially in respect to varietal purity, should be established for seed and these standards should have recognition. The question which now logically arises is: What agency accomplishes the maintenance of a high standard in seed in all these various respects simultaneously?

A system of seed registration and certification is the answer. A system which will maintain varietal purity by the proper cultural methods and by registration of the seed. A system which will set standards of excellence in all qualities of good

of good seed and recognize their achievement by certification.

Give growers definite standards and assurance that these standards will be recognized and give them also a definite, scientifically well-founded program for meeting these standards in seed production and a great step is taken in seed improvement.

The purpose of this paper is to review the efforts that have been put forth in this direction, and in the light of what has been done, to propose a system for the production and registry of certified seed accomplishing the maintenance of a high standard in seed in the respects already mentioned. By registry is meant recording the ancestry, variety and generation, and by certification assurance that the seed has fulfilled certain requirements of purity, viability, quality and freedom from disease.

HISTORICAL REVIEW

Maintaining an efficient standard in seed by means of certification and registration is a comparative recent line of effort. Work of similar nature, however, has been in vogue in Europe for some time. A very important step toward seed improvement was taken when E. Möller-Holst founded, as a private enterprise, the Danish Seed Testing Station in Denmark in 1871. Two years previous to this, however, the first Seed Testing Station in the world had been founded in Tharand Saxony by Geheimerat Nobbe (20). As this station no longer exists, the Danish Station is the oldest of the 200 stations thruout the world. In 1891 (20) the state recognized the value of the work and took over the station. Subsequent to this date, so-called Seed Control Stations have been established in the principal countries of Europe as they existed before the late war. These stations are very similar in their work.

They are essentially only seed testing stations, but are important in this connection since they test for varietal purity and disease.

In Denmark all the important seed firms of the realm guarantee their seed and contract with Control Stations binding themselves to furnish to the Stations names of all persons to whom they sell "guaranteed" seed. The Station then obtains, or at least is able to obtain from the purchaser, samples of these for testing.

All "guaranteed" seed is guaranteed to be pure or genuine as to variety in addition to the following points: place of origin, total germination, germinative power, purity as regards foreign seed, weed seed and foreign matter. In these respects, which are the most important points of consideration, this guaranteed seed is certified. It cannot be called registered, however, because no record of planting is kept. Providing the standards are high enough, and provided the genuineness of variety can be determined with sufficient accuracy, this method of control would have nearly the same results as registration. The genuineness of variety, if it can not be determined in the laboratory, is made in the field by sowing 25,000 plants and observing them until maturity. During this period of growth the plants are also inspected for disease. "Number 1 guaranteed" seed is also guaranteed to be free from diseased seed.

At the Control Station at Hamburg (20) the work is done in much the same manner with the difference that not as much attention is paid to determining variety identity.

At Wageningen, Holland (20) the work is practically the same as in Germany. The scope of the work of the station is broader taking in inspection of feed and giving advice upon seed production and the like.

The Zurich Station in Switzerland (20) is patterned after that of Denmark and the work is very similar. Much attention is paid to disease in seed, however, and efforts are being made

toward setting a high standard in freedom from disease.

The control station at Budapest (20) is worth mention for having brought about the passage of a law making it a misdemeanor to sell seed containing any dodder. The variety of the seed must be guaranteed if the amount is over 22 pounds. Most of the merchants operating under this law sells seeds which have been examined and "sealed" by an official of the Control Station.

At Vienna in Austria (20) practically the same control work is carried on as in Denmark and Switzerland.

Commendable efforts are made by seed houses in Europe in addition to their "contracts" with control stations in producing pedigreed seed (13). Limited quantities of seed, pure especially as to variety, are produced with the utmost care by the seed house. This is called "mother seed" and is supplied to a reliable grower under contract with the house who increases this for the house on a commercial scale.

In England and Ireland (13, 52) seed laboratories have been established but practically nothing has been accomplished in keeping up standards and varietal purity by certification and registration.

The work of the above-mentioned control stations, while very important in raising the standard of seed on the continent, cannot be classed as certification or registration in itself. The stations do furnish evidence even as to variety and disease upon which a merchant may and does certify, but they do not supervise directly the production of seed nor make any attempt, as far as the writer has been able to ascertain, to register crops for the purpose of keeping up varietal purity.

The stations are of interest in connection with this

subject in being a means of raising seed standards, and in being a means thru which seeds are certified by merchants in respect to certain standards, especially in regard to variety.

Probably the most far-reaching work toward seed improvement and standardization that has been done at any time, and surely the most important as pioneer work is that which has been done at Svalöf, Sweden, by the Swedish Seed Association. (26, 44, 49). In view of the fact that this work has led to important developments along the same line all over the world, it merits more than a cursory review.

The Swedish Seed Association was established in 1886 by farmers and seed growers on the initiative of one, Birger Welinder, a progressive farmer living near Svalöf.

The original aim of the Association was to experiment in order to obtain suitable varieties, to breed new varieties, to produce quantities of good stock seed and distribute it, and to push good seed propaganda generally. The underlying aim was to develop the raising of small grain and perhaps other seed as a national business in order to compete with the importations to Europe of American grain. Later two other seed associations were organized in different parts of the country, but these were soon amalgamated with the original one making one large association of national scope.

The membership of the association is composed of honorary, life members and annual members. The fee for annual membership is five kronor (approximately \$1.35). The members receive the association publication and advice from the association. No actual work is required of members since practically all the work is done at the grounds of the association by the staff, either at Svalöf or at the Branch Stations, while the production is carried

on by the general Swedish Seed Company under the supervision of the Association. The affairs of the association are administered by the following officers:

(a) An Executive Council consisting of not more than twelve or less than seven members and in addition three vice-presidents.

(b) A Board of Directors consisting of the honorary members of the association, all the members of the Executive Council, and a representative from each Agricultural Society which contributes towards the up-keep of the association. Those societies which contribute more than 500 kronor can elect one representative for each 500 kronor contributed.

The revenue of the association is derived from membership fees, government grants, contributions from the Agricultural Societies, fees from the Swedish Seed Company on account of stock seed sold to the company and for the inspection and control by the association of the Company's commercial seed.

It was not till 1891 that the certification and registration of seed, as the terms are understood in this paper, was begun by the Association. At this time, realizing that their efforts in producing strains of high yielding and other desirable qualities would be lost unless the result of their efforts be transferred to the grower in fairly large quantities, and apparently realizing also that their staff of trained technicians were not the men to handle the increase and sale of this seed, the Association promoted the General Swedish Seed Company (49).

The administration and staff of the two institutions are quite distinct and separate, but the company is under control of the scientific association and also of the government.

The entire business of the Company is subject to the strictest supervision by the Association from the very first till the merchandise is ready to be dispatched.

Wallden describes the working (44) out of the arrangement. The agreement between the two institutions is to the effect that the "General Swedish Seed Company alone has the right under supervision of the Swedish Seed Association to carry out the breeding of Svalöf strains and to sell the original seeds to consumers". This agreement has received the sanction of the Royal Board of Agriculture and among others the following rules have been laid down:

"Art. 8. The company undertakes to obey the directions of the management of the Seed Association with respect to the cultivation of the seeds and maintaining the purity and quality of the same".

"Art. 9. The company shall, in regard to the breeding and sale of the seed stock taken over, conform to the guidance of the management of the Seed Association both in the field and in the granaries".

In pursuance of these fundamental provisions the control may be briefly put thus:

The control or supervision is intended first, to carefully observe the conditions of the producing fields and the quality of the threshed seeds, and secondly to make sure that in dispatching the seeds the delivery is up to the conditions of the guarantee.

The Association keeps an exact register of all stock carried, also of the perfected seeds, the original ones as well as the regenerated strains, which are continuously being placed on the

market to replace older sorts.

The Association carries forward this register into a Stock Book, listing seeds in practical use, so that the office knows exactly the derivation, breeding and producing record of all seeds suitable for production or sale.

The first increases from original strains produced by the Association are as a rule carried out in the fields of the company in order that the breeders of the Association may more easily observe and criticize the same where grown relatively on a large scale. Subsequent increases are not produced here but in different localities as a sort of variety test. These larger fields are also inspected by the staff of the Association while the crop is growing, and in all inspections of any generation the following points are noted: condition of seed, purity of strain, liability to plant diseases, especially those which may be communicated by the seed to the crop. At inspection of the crops are either passed immediately or are passed subject to sufficient improvement by roguing out aberrant forms or foreign types to bring them up to standard, or else they are entirely rejected.

The second task of the Association is to superintend the cleaning, sorting and other warehouse treatment of seeds. Every delivery, upon reaching the warehouse, is examined by officers of the Seed Association. All cleaning, sorting and treating is supervised by these officers. Even some hand picking is required. After the seed is thus prepared, purity and germination tests are made.

The third duty of the Association is to supervise the sending out of the seeds. Every package containing seeds to be sent out as such must be marked with the seal of the Association and must bear under the seal, on the outside, a certificate or label of

in addition to the one in the package. This certificate shows the most important analytical results; the weight of 1,000 seeds, percent of purity, percentage of foreign matter, the germination percent and number of noxious weed seeds.

No set standard of guarantee is adopted save in general, for each lot is guaranteed to be of the standard indicated by the analysis.

A word should be said regarding the original production of these varieties by the Association for, if not produced according to sound plant breeding principles, they would not stand up subsequently.

Their starting point since 1891 in producing a new strain has been a single plant or the selection of single plants following crosses. The method of originating a new variety by the selection of a single plant, which is really the isolation of a pure line, was discovered by Nilsson in 1891. Nilsson did not understand, however, the theory upon which he was working till some ten years later when Johannsen (3, 15) established his pure line theory with his work with beans. New varieties are tested for years before they are put on the market and even afterward to thoroughly try them out.

In Sweden is found the production of true certified and registered seed upon a large enough scale to be of commercial importance. The Association first originates the variety and subsequently controls its production by supervision and registry so that its efficiency is kept up. The General Seed Company is merely the laborer and dealer.

This system, once established, is very good for pure seed production, especially for Sweden. It may be criticized, however, as an agent for general seed improvement, in being narrow,

As merely a source of good seed the system is excellent. It is capable of supplying a fairly large quantity of very high grade seed directly to the grower, but it does not furnish any program or means of encouraging or enabling the grower to produce seed of the same high grade. Even the members of the Association are not direct producers. If the Shorthorn Breeders Association of America were to undertake the production of all the pure Shorthorns on its own responsibility, with the idea of distributing the animals produced to stockmen and thus improve the stock of the country, the situation would be somewhat analogous. That this would not be a wise procedure in the United States is self-evident. The system in use in Sweden would not be applicable to United States conditions because increasing it in size to meet national conditions here would probably make the arrangement cumbersome and unwieldy to the point of failure.

The question of the applicability of the system to Minnesota conditions, or to any state, would be answered largely by the consideration mentioned above. The chief objection is that the grower himself would not be educated and encouraged sufficiently toward the upholding of the standard of his seed.

Probably the most far-reaching and important effort in the line of seed certification and registration in America, has been made by the Canadian Seed Growers Association (25, 27).

This organization is an outgrowth of the McDonald Seed Grain Competition, a movement started in 1900 on the initiative of Dr. Robertson to interest boys and girls on Canada farms in the matter of seed selection. The plan outlined took the form of a competition which was to last 3 years in which each competitor was to operate a seed plot of some grain and make mass selection of

of desirable heads. Later the parents of these competitors were organized into the McDonald-Robertson Seed Growers Association, and in 1904 this name was changed to the Canadian Seed Growers Association.

Altho this organization is modeled upon the Swedish Association, it is quite different in many respects; and, since it has furnished a model for much work that has been done in the United States, it also will bear reviewing in some detail.

The aim of the organization as set forth in their literature is "the conserving of all that is good and useful in stock seed together with its judicious increase and distribution on an extensive scale and under efficient control".

This is done by:-

1. "Making regulations respecting the growing, selecting and preserving of seed of various farm crops for the guidance of its members".
2. "Causing to be kept records of the history of seeds produced by members".
3. "Fixing standards for seeds that may be eligible for registration".
4. "Publishing information as to standards".
5. "Issuing certificates of registration to members by which hand selected seed or the product thereof may be distinguished from other seed".
6. "Such other means as may be expedient from time to time".

The officers of the organization are a president, a secretary-treasurer, three vice-presidents, and nineteen directors. The president and ten directors are elected each year by the members of the Association. Nine of the directors are appointed by the Provincial Departments of Agriculture, one from each Province. The three vice-presidents are elected from and by the completed Board of Directors, i.e. the officers and the directors. The secretary-treasurer is appointed by the Board of Directors. An Executive Council is made up of the president, the secretary-treasurer and five directors elected by the Board of Directors.

The membership consists of honorary and active members. The active members are chiefly growers of seed, who follow to the satisfaction of the Association as a whole its methods of "producing, under expert direction seed of known origin, purity, and of high quality, for their own or for the trade, or both".

Applicants for membership are elected by vote at any meeting of the Association or Executive Council.

The honorary membership consists of persons directly or indirectly interested in agriculture in Canada, but who do not produce seed. Such members have the privileges of active members. The total active membership in 1918 was approximately 400. At this time there was a large waiting list of applicants which together with growers failing to qualify, made a total of over 1,400 affiliated with the Association.

The Association is supported by an appropriation of approximately \$8,000 granted yearly by the Dominion Government and by revenue from small fees charged the members for final inspection. The head office of the Association is at Ottawa, Ontario. Here all

records are kept and principal business transacted. Each Province, or its District representative, assumes responsibility for the initiative, and supervision of the work of growing Registered seed including inspection of fields. While the field inspections are made by the Provincial officers, the final inspection of seed in sacks offered for sale is made by officers appointed at and under direct supervision of the head office.

Unlike the Swedish Seed Association the Canadian Association is an Agricultural Extension Agent, in that it promotes the production of standardized seed by the growers over the country who are not under contract with the Association.

Naturally the work of supervising the production of guaranteed seed on hundreds of farms over thousands of miles of territory is a different matter than supervising, as the Swedish Association does, the production on the concentrated areas of the Swedish Seed Company.

In order to get a clear idea of how the Association accomplishes its work and to bring out more clearly just what work is, it is necessary to outline the method of procedure followed in the production of registered seed.

Three grades of seed are recognized by the Canadian Seed Growers Association. These are:

1. Elite seed.
2. Registered seed.
3. Improved seed.

Elite seed is seed that has been selected by hand from a mature crop grown on a special seed plot, and of a variety endorsed by the officers of the Association.

Registered seed is seed that is not more than three

generations removed from Elite seed and grown according to rules laid down.

Improved seed is either seed of the same origin as Registered seed and which, while superior to commercial seed, has failed to qualify as Registered seed or seed which has not yet received public recognition. The method of producing these classes of seed by the grower, as outlined and stipulated by the Association is in brief as follows:

The system varies with the certain classes into which crops are grouped according to the way they are propagated and fertilized as, largely self-fertilized crops as wheat, oats and barley, peas and beans; largely cross-fertilized crops as corn; plants needing cross-fertilization as grasses, clovers and alfalfa; and finally those crops produced vegetatively as potatoes.

For the first group, cereals, the method is to obtain Elite seed from a grower already producing or from some Experiment Station, or produce it by hand selection from a special seed plot of one-fourth acre. Keep this pure by selecting from this plot, each year, enough heads or pods to sow the plot next year. All other seed from the plot may be sown to produce first generation registerable seed.

For corn the ear-to-row test is used. In fact two modifications of this are used. The first is briefly this: Choose an isolated seed plot. Plant 50 rows of 50 hills from 50 ears. Plant three and one-half feet apart and thin to three plants in a hill. Detassel all undesirable plants. Mark a few of the best rows based on vigor and productiveness. Select 50 ears from these rows and from these select 20 for next year's plot.

The second is the remnant method. One half of each

of the ears chosen for the plot is planted in a separate row. The 25 best of these ears is determined by the yield of each row. These superior ears, thus determined, are planted in a seed plot the following year, the ears producing the highest yield are put in alternate rows and are considered pollinating rows. All other rows are detasseled. From this plot the best ears are selected for the seed plot the following year and the bulk of the desirable seed is put into the increase field. Every fourth year the ear-to-row test is repeated.

The program for plants naturally cross-fertilizing, as grasses and clovers, is as follows: The grower obtains a superior strain or selects it from his field. If the crop is clover or alfalfa, this seed is planted in an isolated seed plot. Elite seed is grown by sowing the crop in drills and carefully roguing all weeds, foreign crops or inferior plants. The seed from this plot is sown next year in an isolated increase plot or sold as select seed. In perennial crops a new seed plot need not be started every year.

The production of Elite grass seed is not attempted by the members of the Association. They, instead are advised to obtain high quality seed from an Experiment Station or a specialist and using this as Elite seed continue it as is outlined for clovers and alfalfas.

All fields are inspected while the crop is growing as near harvest time as possible by an expert under direction of the District or Provincial Representatives of the Dominion Seed Branch, a Bureau of the Dominion Department of Agriculture.

The points considered in inspection are -

1. Stand of crop.
2. Vigor.
3. Type.
4. Freedom from weeds.
5. Freedom from disease.
6. Freedom from other varieties.
7. Plumpness and uniformity of grain.

After the seed is harvested, threshed and prepared for sale, a sample of 1 quart in the case of cereals is sent to the head office at Ottawa for inspection and analysis. If this sample is found to be up to standard in all particulars, an inspector from the head office retaining part of this sample goes out to the stock of the grower and inspects it, at the same time comparing the portion of the sample sent in with the bulk of the seed. If the seed passes this inspection successfully, the inspector seals the containers and tags them with a metal tag bearing the seal of the Association, and a label.

The label attached bears the following information: Kind of seed, variety, quantity in the sack or container, grower's certificate, signature of grower, of inspector and statement of transfer. A certificate is issued the grower certifying the seed to be of the variety named, generation, quantity and to have been produced under the rules and regulations of the Association.

An important amendment to the regulations of the Association was passed in 1918 (31). This allows that the immediate progeny of first or second generation seed, no matter by whom it is produced, if the crop has been properly inspected, may be registered. Also the immediate progeny of Registered seed produced by recognized experts may be registered. In other words this amendment allows any grower, whether member of the Association or not, to purchase Elite or Registered seed of first or second generations and from it produce Registered seed provided his crop is properly inspected and is up to standard. Also, pedigreed seed produced by experts at Experiment Stations is recognized as Elite seed and may be used as such. This amendment increases the number of growers and consequently the amount of good seed produced. Recognizing seed produced by experts as Elite seed, increases the supply of this seed which will also increase the production of Registered seed.

Professor John Bracken (36) of the Saskatchewan University proposes that the Experiment Station cooperate with the Seed Growers and distribute enough pure bred seed every year to sow 20 acres. This would add to the output of the Association by increasing the supply of Elite seed.

The Canadian system, unlike the Swedish system, acts as an Agricultural Extension of education agent and accomplishes improved seed production by the grower as well as for him. The Canadian system also accomplishes at the same time the production of large amounts of seed over a large area of country with a comparatively small staff actually engaged in the control and registering work.

There are a few minor points in which the Canadian system may be criticized. In the past the obligatory hand selection of so-called Elite seed has limited production. Also the regulation that only members could register seed was disadvantageous since many growers not members were capable of producing good seed. Both of these faults, however, have been corrected by recent amendments.

The method of producing Elite corn by the old ear-to-row method can yet be criticized since it is not founded on sound scientific principles. On the whole, the system is excellent since it has a national scope and backing, and since it has such close touch with the different experiment stations and with the Department of Agriculture. Without these and without the prestige and importance obtained from its national standing, the system would be much weaker.

The first important step toward standardization of seed by certification or registration in the United States was taken in 1901 by the Wisconsin Experiment Station thru the initiative of

Professor R. A. Moore, in organizing the Wisconsin Experiment Association (23).

This Association is modelled after the Canadian Association in general. It differs, however, in being promoted by and operated in close touch with the State Experiment Station and in requiring that its members be former students of the State Agricultural College or some similar approved institution. It differs also in its aim and scope. Its aim is to promote generally the agricultural interests of the State, and to bring about cooperation between the farmer and the Agricultural College in all enterprises as well as in crop improvement by good seed production.

At present the Association has a membership of over 2,000, and in addition there is the membership of so-called orders which brings the total to about 5,000. The orders are suborganizations in special localities or growing special crops. The most important of these are the hemp and the alfalfa orders.

The Association is supported by dues and inspection fees paid by the members. The secretary and his assistant being on the college staff, receive their salaries from that source and thus the Association is relieved of this financial responsibility.

The general plan is that the members obtain their original seed from the Agronomy Department of the University and each member is entitled to an amount of pedigreed seed sufficient to plant a trial plot. Thus each member is supposed to become a pure seed center for his neighborhood. Some experimental work for the members is planned by the Agronomy Department each year. Members are supplied with new varieties put out by the Experiment Station. These they test out and, if they find them satisfactory, continue these productions. The wisdom of this practice is questionable

since it is doubtful if the average grower is capable of making tests sufficiently accurate to be valuable in deciding upon varieties to be propagated for further distribution. Proper technique in such tests is essential. This practice also complicates the work of the grower and detracts from the time he can give to registered seed production.

A system of inspection is in vogue in the Association of both the growing crops and the seed in the bin. However, since the organization is so large and its scope so broad all crops cannot be inspected every year. In this event, growers who have a good reputation do not have their crops and seed inspected every year.

The organization on the whole is commendable, but it may be criticized for attempting so much that, as an agent for maintaining varietal purity and its attendant superior qualities, its program and regulations and standards are scarcely adequate. Inspections are not always made. Hence standards cannot be high and registration cannot mean what it should.

In 1904 at the Minnesota Station was organized the Minnesota Seed Growers Association (10) with a general aim somewhat similar to that of the Wisconsin Association. The name of this organization was later changed in 1912 to the Minnesota Crop Improvement Association which it still holds.

The object of the Association at first, as set forth in the Constitution, was "to collect and disseminate information concerning growing, handling, harvesting and storing of the seed of the staple field crops and by selection and breeding to improve this seed." No registry or certification was made at first. In 1918 crop inspection and registry regulations practically identical to those used by the Canadian Seed Growers Association were laid down. Some fields were inspected and registered by the Secretary of the

Association. In 1919 crop inspections were made as well as bin inspections. As the seed sown to produce these crops was of known origin, the seed produced was registered and certified if it came up to the standard. Production of pure seed by head selection from a seed plot was also begun in 1919.

Since the organization of the Minnesota Field Crop Breeders Association, and principally during the last five years, organizations for the improvement and distribution of seed have sprung up in Michigan (33), Arizona (12), Georgia (11), Idaho (35), Illinois (37), Kansas (46), Montana (16), Maryland (21), Oregon (19), Ohio (17), Oklahoma (41), Maine (32) and North Dakota (34).

All of these, with the exception of that in Maine, are the usual organization of growers promoted by the State Agricultural College and have remained in touch with the institution by retaining as a secretary a college-staff man.

Altho they are very similar in organization, they differ considerably in the work done. In general the organizations in Kansas, Idaho, Oregon, Oklahoma, Ohio and Maryland may be put in the same class since, in addition to being promoted by the State Agricultural College, they only inspect and certify crops. As yet they pay no attention to the ancestry of the crop and no registry is made of such. These, then, are certifying and distributing agencies but no registrying agencies.

Very good work in crop improvement is done by these, especially those having strict rules and high standards, as the Ohio, Kansas, Oregon, but in order to do the most good, strains and varieties should be registered. This is being done in Michigan, Montana and Georgia.

The Michigan Crop Improvement Association (33) has

reached a high state of efficiency in both certification and registration. Almost without exception the registrable varieties are those put out by the State Experiment Station. A criticism may partly be made of the number and names of the grades of seed registered. These are:

1. Pedigreed Seed.
2. Improved Seed.
3. Approved Seed.
4. Registered Seed.

The number of grades and the similarity of the terms approved and improved is apt to be confusing to the grower..

The Association also asks its members to run variety tests of crops put out by the Experiment Station in a manner similar to that in the plan of the Wisconsin Association. This complicates the work of the grower and detracts from the time he might give to his seed plots.

The Montana (16) Seed Growers Association makes no regulation that the seed come from the Experiment Station as does the Michigan Association. However, it does require that all registered seed date from hand selected pure seed which is registered by the Association.

In Georgia (11) the work is carried on by the Georgia Breeders Association consisting of breeders of both stock and crops. Careful registry is made of all seed passing inspection and the ancestry of the seed, i.e., "original selection", is recognized as essential in registering. Stringent standards have not yet been instituted.

In Illinois (38) is found the Illinois Seed Corn Breeders Association consisting entirely of growers which is

commendable in recognizing only seven varieties of corn and in being an organization separate from any institution. As yet this association does no registering.

In the systems in vogue in the United States reviewed so far, some form of association is the agency carrying on the work. Many of these systems have points where improvement could be made in detail of procedure as has already been brought out, such as the lax inspection in the work of the Wisconsin Association, or the too numerous grades of seed of the Michigan Association. It remains, however, to criticize the Association agency as a type.

The most serious objection to the association, especially where it is connected with the State Agricultural College, is that the secretary is the association. The brunt of the work, as well as the life of the association itself, devolves upon this one man. This accounts to no little degree for the difference in the success of the systems in different states. Theoretically the association has a Board of Directors or similar body, but the responsibility of keeping the machinery in motion falls upon the secretary because he is a public official.

The second objection follows this very closely since the public official really has many duties. It is, that many times, the association is merely a side line. The secretary having other duties often has not sufficient time to devote to the work to put it on a sound basis.

The third objection to the association, when connected with the Experiment Station, is that it is somewhat out of place since its work is largely regulatory. The modern tendency of Experiment Stations is to divorce regulatory work and stand frankly on its own feet regarding its function. This gives the farmer a

much clearer and sometimes healthier conception of what the Experiment Station is trying to accomplish.

The fourth objection is that work carried on by an association, even when connected with the State Experiment Station, has not the backing or prestige that it might have if carried on by an agency whose entire and sole business is the registration and certification of seed.

The fifth objection, perhaps not quite so important as the others, is that one secretary and even other officers of the association would be influenced by personal acquaintance with the members and by petty politics.

It must not be gathered, however, that the growers association or like organization has no function. It has a very important one in encouraging crop improvement, the introduction of new crops and like lines of effort. Also it is the logical agent to initiate and stimulate the production of certified and registered seed. It is only from the standpoint of a registering and certifying agent that it has been criticized.

An innovation in seed registration was started in 1912 by Professor Bolley in North Dakota (5,6,8). The work was an innovation in that it gets away from the association idea and established the matter of seed registration by law. In all the states considered so far, the association idea is dominant. States recently starting the work have mostly followed the beaten path and adopted some sort of organization of growers which at first usually amounts to little more than a seed-listing agency since the regulations regarding origin of seed, cultural and breeding methods and standards for inspection are weak or entirely lacking.

North Dakota, however, has established seed registration

by law on much the same basis as seed inspection. As this system is the only one thus established so far, a rather full review is warranted.

The system was established (←) by an amendment to the State Pure Seed Law in 1913 (5). This law puts the work in the charge of the State Seed Commissioner, who is appointed by the Director of the State Experiment Station. The Seed Commissioner has the power to cause to be examined the crop or seed of any one growing or claiming to grow pedigreed seed, or any improved variety of agricultural or garden seed. Further contents of the law and methods of working it are summed up in the following:

1. A record is kept of all growers.
2. List of these growers published before March each year.
3. Three grades of seed listed.
 - (a) Pedigreed seed, one variety dating to a selected individual.
 - (b) Improved seed - one variety.
 - (c) Bulk seed - common seed of high quality.
4. Seed is certified as to variety and seed law requirements.
5. The Seed Commissioner lays down rules for issuing certificates.
6. All labels must conform to state seed law.
7. Commissioner may revoke certificate for one year.
8. Two dollars is paid for certificates.
9. Seed commissioner and assistants appointed by head of station and salaries fixed by trustees of Experiment Station.
10. All certified seed must bear laboratory label with

serial number and stamp of authority and sealed with a lead seal. Bin inspections and sealing is done by the assistants to the Commissioner.

The following rules have been adopted:

1. Grower applying for certification shall have obtained a pure variety. If said variety is not obtained from Experiment Station a letter showing origin of seed must accompany application.
2. No seed is certified after the first of March each year.
3. All certificates void after July 1st each year.
4. No seed is sealed after it has changed hands.

Field inspection so far has not been required in every case and in this respect the regulations are lax. Stricter rules might also be enforced as to the origin of the seed.

The idea of establishing seed certification by law as done in North Dakota is very good. It puts the matter on an official and indisputable basis. Linking it up with the Seed Laboratory work puts it in a regulatory field also which is a good thing. However, having it in connection with the Agricultural College at all may be criticized since it is the modern trend to isolate all regulatory work from Experiment Stations. Putting the matter in the entire charge of one man is not in accordance with best practice altho this is what virtually happens in the association. A board comprising growers and scientific men would secure greater efficiency and be more in accordance with the latest ideas.

Progress in a somewhat similar direction as that taken in North Dakota has occurred in potato certification in some states, especially in Minnesota (42) and in both potato and crop seed

certification in Maine (32).

In Minnesota the work of potato certification is handled by the Minnesota Board for Potato Seed Inspection and Certification. The board and its work are established by a law "creating a board for seed potato inspection for the violation of such provisions". The law also stipulates the personnel of the board, their pay and duties, and takes up the matter of fees, eligibility of applicants, and also makes it a misdemeanor for any inspector to falsely label potatoes inspected.

The board with the aid of the Chief Inspector, whom they employ to take charge of the work, have laid out rules and regulations governing the work.

Two inspections of the crop are made and the following points noted:

1. Varieties - only 8 standard varieties are recognized.
2. Varietal purity.
3. Constitutional vigor.
4. Type.
5. Size.
6. Freedom from disease.

No bin inspection is made, but seals and tags are attached to the container at the time of shipment by the Chief Inspector, Deputy or otherwise authorized person.

A certificate is issued the grower when the seed is certified.

This method of carrying on the work is very good in principle at least. It puts certified seed on a basis recognized by state law. It relieves the Experiment Station of any unpleasant-

ness in carrying on the inspection work necessary, and in fact of all the regulatory work which does not rightly come within the scope of Experiment Station work.

The work of this nature at Maine is not established by law but is handled by a Bureau of Seed Improvement which is a section of the State Department of Agriculture. Both certification of cereal and grass crops and of potatoes are handled by the same machinery. For potatoes there are two field inspections and inspection at sealing in the container. All certified potato seed must pass stringent inspections and be sealed. The program for crops has not been as well developed as that for potatoes. If, however, it develops to be as efficient as the potato certification, as it should with the same machinery, it will be of value. Much depends here, as in all of this work, on the personnel in charge and the thoroughness of inspection and enforcement of rules and the indications are that the Maine enforcements have not been any too strict. However, this is a matter which can be remedied.

The method of handling the work at Maine (32) is commendable. Attention should be called to the fact, however, that the responsibility and much of the success of the system devolves upon one man,

At present there are twelve states certifying potatoes.

That no little interest is being taken in the establishment of more definite standards for crop seed and more rigid inspection is evidenced by some literature of propagandic nature.

Bolley (9) writes in this vein advocating "official" field crop inspection" under compulsion by law. He brings out the failure under present cultural methods to hold varieties up to a

standard of purity. He states that cereal crop varieties are not handled with the same intelligence and care that is used with our fruit varieties. He indicates few of our cereal varieties remain reasonably pure after the third generation and often drop out of existence after a decade and brings out, also, that there is no basis for holding a crop to standard of purity and as a result the work of many crop improvers die with them.

To improve this situation he proposes a law authorizing field crop inspection, seed certification, seed standardization and seed sales list. He calls attention to the fact that the seed inspection law does much good in preventing the sale of much non-viable and impure seed, but that it has not assured crop improvement and that the inspection must go back to the producing field. "The seed merchant can sell only that which he buys and he cannot buy better than the farmer grows." To go further than seed inspection, he proposes a scheme of crop inspection to be carried on by the Experiment Station on the fields of any man growing seed for commercial production.

Moore (23) calls attention to the fact that animal breeders have been working for centuries consistently along the line of animal improvement, and have demonstrated what can be done and states that there is no such continuity of effort in grain breeding and that our farmers are raising hundreds of "scrub" varieties. He also describes in this connection the Wisconsin Experiment Union.

Temple (41) cites the work already done in potato certification and suggests the same be done in vegetables and cereals. He states that certification is the only logical means of disease control in vegetables.

Cockayne (13) outlines an efficient method of producing

pure seed as a war measure. In ordinary times New Zealand could not compete with cheapness of production in Germany and England. The plan would include the contracting and production of pure seed in certain licenced areas. He also describes production of pure seed on the continent.

In England pure seed production as a means of increasing production has also been recognized (49). The increase from pure varieties is clearly understood, and a method of production similar to that in vogue at Svalöf was suggested.

Winters (26) describes and advocates a method of improving cotton in North Carolina by registering the seed and standardizing varieties.

The matter of registering varieties (51) was considered in 1911 by the American Society of Agronomy. A committee was appointed who recommended first the more definite classification of varieties and then registering them in a herd book. This would be an important step toward seed standardization. The work, however, has not been finished as yet.

Spragg (36) criticizes the system in vogue in North Dakota. He is of the opinion that an association is needed to handle the marketing end of the work. He also gives data showing the efficiency of seed registration in Michigan.

Summary of Review.

After the foregoing review it is of advantage to sum up briefly the various methods and means of carrying on seed improvement work.

(1) The Seed Control Stations of continental Europe, while doing a very important work, are interesting from the standpoint of certification and registration only in that they

are agencies working for seed improvement, by furnishing a basis thru their tests for certification of seed in certain respects the most important of which is varietal purity. They bring about indirectly, virtual certification by merchants. They do not, however, attempt to control cultural or production methods nor to keep varietal purity by registration.

(2) The Swedish system accomplishes very well all that it sets out to do. It is very successful as a source of pure seed for growers. As an agency for the purpose of supervising, inspecting, certifying and registering crops produced by farmers and growers thruout the realm it accomplishes nothing, for this it does not attempt to do. It is a centralized method of producing Registered seed.

(3) The Canadian system, unlike the Swedish system, promotes and supervises the production of seed by growers themselves. In this way it acts as a powerful agency toward seed improvement by the grower and farmer. This being the case, its influence is very broad and the amount of seed produced very large in proportion to the staff employed. Since the association is an entity in itself whose sole purpose is to inspect, certify and register seed, it has gained national standing and hence represents an almost ideal agency for the purpose. Minor details of procedure may be criticised, i.e. the selection plot for the production of Elite corn. This procedure is founded on an unscientific basis and should be changed.

(4) The systems in vogue in the United States are, as a whole, modeled upon the Canadian system in form of organization. They differ in most instances, however, in being connected with some State Agricultural College or Experiment Station upon which they

lean rather heavily. Good work is done by these associations in states where the rules and procedure are wisely planned, and where actual registry is done as in Michigan and Montana. Cognizance is also taken of ancestry in Georgia and Wisconsin, but in the former state not sufficiently definite regulations have been worked out, and in the latter inspections are apt to be lax on account of shortage of inspectors.

(5) The modern tendency seems to be to put the work on an official basis by establishing it by law or making it a part of the work of the State Department of Agriculture, as has been done in North Dakota and Maine respectively. Good work can be done by these agencies if they do not, as associations are apt to, become a one-man proposition.

GENERAL CONSIDERATION

To be of practical value a system of seed certification and registration should accomplish improvement in seed, or at least the maintenance of a high standard in seed in respect to the causes of deterioration already mentioned viz., (1) mixture with other crops, (2) with aberrant types, (3) with foul seed and dirt, (4) by natural crossing, (5) by becoming diseased, (6) by losing viability. Not only must the system accomplish this but it must do it simply, efficiently, impersonally, thoroughly, and without regard for politics.

To be efficient, proper methods of culture, supervision, inspection, standards of product and stringent rules must be adopted. Also the agency carrying on the work should be established for the sole purpose of carrying on the work unhindered by obligations to the members of an association or one group of growers, or by connections with any institution where the work does not logically belong. This agency should be backed by both growers and experts

but not dominated by either. The lack of effectiveness in the systems reviewed has been due to a variety of reasons. In the proposed system that follows, an attempt has been made to obviate most of these faults and to include, at the same time, the strong points of the systems reviewed.

PRINCIPLES OF CROP IMPROVEMENT

Before taking up the proposal of a system, it is necessary to take up briefly some of the fundamental facts and principles of crop improvement which are now recognized and upon which the production phase of certified seed is based. It is absolutely essential that these principles be recognized for, upon some of them at least, depend the success of keeping varieties pure.

Perhaps the first thing to consider is the fact that plants differ in their method of reproduction. On this score they may be classed into four groups thus:

1. Plants with limited cross-fertilization as wheat, oats, peas, beans, flax.
2. Plants naturally crossing as corn, rye.
3. Plants in which cross-fertilization is necessary as red clover.
4. Plants vegetatively produced as potatoes and sugar cane.
5. In addition to this it is necessary to review briefly the methods of plant improvement now accepted and in vogue. These are (1) mass selection, (2) isolation of pure lines, and (3) hybridization and subsequent selection of pure lines.

Mass selection consists of picking out choice plants

from the main crop and sowing the seed from them en masse (3). In a cross-fertilized crop, or with a variety which is not homozygous, i.e. all of one strain or a pure line, improvement can be brought about by mass selection. It is usually found necessary to continue selection in order to maintain the improvement gained. However, in a variety which is a pure line, mass selection can only maintain a standard of purity and can accomplish no improvement. This method has long been used with small grains and other crops as well. One of the earliest breeders to use this method was Vilmorin, a French investigator, who began work on carrots about 1830. This method became popular and was the chief method in Germany, and in Sweden also till 1891. In the United States, R. J. Leaming originated the Leaming variety of corn by this method, beginning his selections in 1825. The same method was used in originating Rieds Yellow Dent. This method is the most practical for the farmer. By this means purity and desirable qualities may be kept up with the least possible effort. Improvement in a variety may even be accomplished if the variety is one naturally crossing or if it is not a pure line.

The second method, i.e. the isolation of pure lines will not be clear till an idea of the nature and importance of a pure line is obtained.

Johannsen, (16) who first used the term defines a pure line as the progeny of a self-fertilized individual of homogeneous individual. The important facts about a pure line are these: That unless mutation takes place, none of the descendants of the self-fertilized homozygous individual can differ from the parent in genetic factors, and since this is true (3) selection within a pure line is of no avail. It is interesting that this principle was discovered in 1891 by Nilsson-Ehle at Svalöf, Sweden (16). It had been used long since by Lacouteur, (16)

Shirreff (16), and Hays (16). None of these men understood the principles, however, till Johannsen established it in 1908.

The third method of plant improvement (3) is hybridization followed by selection. This method consists of crossing varieties or strains, or even species. In so doing, there is not only a possibility of combining desirable qualities of the parents but also of obtaining increased vigor in the progeny, for a time at least. This method, presenting the greatest possibilities to the expert plant breeder, is not at all practical for use by the farmer.

THE PROPOSED SYSTEM

The method of producing and registering certified seed as proposed in this paper is not put forth as being ideal or unimpeachable. The writer has endeavored, however, to group together the most successful modern ideas into a system which overcomes the majority of objections found in the various systems in use at the present time, and which is based upon sound scientific principles with which different phases of the work are related.

The system and its work is presented in outline so that it may be more easily grasped as a whole.

OUTLINE OF PROPOSED SYSTEM

- I. Seed Certification and Registration established by law.
- II. Law, known as the Seed Certification and Registration Law, authorizes work and establishes an agency to carry on same.
- III. Agency for carrying on work.
 - A. Seed Certification and Registration Board.
 - B. Membership of Board.
 1. Director of State Experiment Station.
 2. Farm Crops Specialist at Experiment Station.
 3. Three growers, appointed by the governor, one of whom is the president of the local growers association, or like organization if there be such.

C. Duties of the Board.

1. Organize.
2. Appoint and employ a Seed Commissioner whose sole official duty it shall be to carry out the work under the direction of the Board.
3. With Commissioner outline a sound plan of seed production.
4. Lay down essential rules regarding production, inspection and all regulatory work.

D. Duties of the Seed Commissioner.

1. Institute and operate machinery for all regulatory work.
2. Cause to be inspected standing crops and threshed seed of growers.
3. Publish annually before March 15th a list of growers having certified seed for sale.
4. Perform any other duty which may come within his jurisdiction which will make for better seed.

E. Finances of Agency.

1. Sources of Revenue.

a. Legislative appropriation to suit needs.

b. Fees.

- (1) Field inspection fee of \$2.00 for first five acres or less, fifty cents per acre over five acres.

(2) Sealing fee of 5 cents per bushel.

2. Expenditures.

- a. Salaries of Commissioner and other employees.
- b. Expense of Board while serving.
- c. Expense of work in general.

IV. Penalties.

- A. Any unauthorized person labeling seed as Registered will be guilty of misdemeanor and subject to punishment for such.
- B. Any inspector or deputy tagging and sealing seed which does not meet requirements will be guilty of misdemeanor.

V. Work of the Agency.

A. Production phase.

- 1. Classes of seed recognized with main requirements.

- a. "Select Seed"

- (1) Small grains.

- (a) Recognized variety.

- (b) First year increases from seed selected by hand from standing crop on special seed plot.

- (c) Practically pure as to variety.

- (d) Grown from disease treated seed.
- (e) Meeting germination standard adopted for year.
- (f) Plump, good color, standard weight.
- (g) Practically free from bunt.

(2) Corn

- (a) Recognized variety.
- (b) First year increases from seed selected by hand from standing crop on special seed plot.
- (c) Showing no evidence of crossing with other varieties.
- (d) Mature and meeting germination standard.

(3) Clovers and Grasses.

- (a) Harvested by hand from a hand-rogued seed plot $\frac{1}{4}$ acre.
- (b) Containing less than .5% of other variety. Practically no weed seed and less than .5% foreign matter. (Latter would vary from light seeds as red top, blue grass, etc.)
- (c) Must meet germination standard adopted for year.
- (d) Be of standard weight, plump and of good color.

4' Up to germination standard.

5' Mature and of good color.

(b) Class II.

1' All of the requirements for Class I but slightly inferior in color, plumpness or maturity.

(3) Clovers and grasses.

(a) Class I.

1' The first, second and third generations from Select seed, inclusive.

2' Up to germination standard of year.

3' Practically pure as to noxious and all weed seed as defined in the State seed law.

4' Containing less than .5% foreign matter.

(b) Class II.

1' May differ from Class I in having 1.5% foreign matter.

2' Slightly less plump or slightly inferior in color.

3. Improved Seed - all crops.

(1) Not registerable but listed.

(2) Higher in standard than common run of farm seed but failing to qualify as registered seed because the variety is not

accepted as standard, or because of
lack of sufficient purity of variety.

2. Program of Production.

a. Small Grains.

(1) Select Seed.

(a) Seed to be used.

- 1' Pedigreed seed of accepted variety from some Experiment Station.
- 2' Select seed, own or from other growers.
- 3' Registered Seed, own or other grower.
- 4' Any other recognized source.

(b) Method.

- 1' Sow on carefully chosen plot of $\frac{1}{4}$ acre.
- 2' Leave alleys 2' wide every 10 ft. or less to facilitate roguing.
- 3' Cultivate alleys or sow to grass, preferably the former.
- 4' If rye, plot should be separated from other fields by 20 rods or natural barrier.
- 5' Rogue of all weeds, aberrant types, foreign varieties and plants diseased by all smut.

b. Registered Seed.

(1) Small Grains.

(a) Class I

- 1' The first, second, and third generations from Select seed, inclusive.
- 2' Grown from disease treated seed.
- 3' Must contain less than .5% other variety or type.
- 4' Practically pure as to weed seed and foreign matter.
- 5' Plump, good color and of standard weight.

(b) Class II.

- 1' All requirements same as for Class I save slight inferiority in plumpness, weight or color.

(2) Corn.

(a) Class I.

- 1' The first generation increase from Select seed.
- 2' Exhibit no crossing with other varieties.
- 3' Fairly true to type.

- 6' Harvest by hand selection of heads sufficient seed from this plot to sow special plot next year.
- 7' If plot passes inspection and pedigreed or select seed was used, the bulk of the seed in plot is classed as select and increased to Registered seed the next year.
- 8' If first or second generation registered seed was used, bulk will be the generation following that sown.
- 9' All seed should be carefully harvested and stored in a dry well ventilated place protected from rodents and insects.

(2) Registered Seed - small grains.

(a) First generation

- 1' Seed used; Select, produced or purchased.
- 2' Sow on clean, well prepared land.
- 3' If wheat, corn should not be preceding crop in order to obviate scab.

4' If rye, field should be isolated as for Select seed production.

5' Rogue for weeds, aberrant types and foreign varieties.

(b) Second and third generations.

1' Increase on clean fertile land.

2' Isolate rye as for Select Seed production.

3' Wheat should not follow corn to obviate scab.

b. Corn.

(1) Select Seed.

(a) Method I. Bar-to-Row followed by selection.

1' Source of seed Select or Registered.

2' Use 100 ears, plant one-half of each ear in separate row, retaining remnants.

3' Determine superior ears by checking yields of rows.

4' Mix seed from remnants of 25 best ears as determined by test, and plant in special seed plot next year.

- 5' From this plot gather number of ears desired from vigorous plants of full stand hills. •
- 6' After discarding malformed ears, seed gathered may be used for planting Select plot, for increasing to Registered seed, or for sale.
- 7' Plots and fields should be located 40 rods, or separated by natural barrier, such as woods or hills, from corn fields of other varieties.
- 8' Gather seed ears at a time when plants which mature too late can be avoided.

(b) Method II. Selection only.

- 1' Source of seed, pedigreed or Select, only.
- 2' Plant special seed plot one to two acres annually.
- 3' Thin to even stand.
- 4' From this plot gather number of seed ears desired from vigorous plants in full stand hills.

5' After discarding malformed ears, seed gathered may be used for planting Select plot, for increasing to Registered seed, or for sale.

6' Gather at a time when plants which mature too late can be avoided.

(2) Registered Seed Corn.

(a) Plant Select seed.

(b) Locate fields 40 rods from corn of other varieties unless separated by natural barrier as woods or hills.

(c) Gather seed ears from vigorous plants which mature too late can be avoided.

C. Clovers, Alfalfas and Grasses.

(1) Select Seed.

(a) May be produced or purchased.

1' Production advised in alfalfa, red clover and timothy.

(b) Method.

1' Sources of seed, Pedigreed, Select seed or a recognized commercial variety.

2' Sow without nurse crop on clean well prepared land.

- 3' Sow in drills 24"-30" apart and cultivate.
- 4' Locate plots 30 rods from other field of same crop unless separated by natural barrier of woods or hills.
- 5' Rogue out all inferior and off type plants and all weeds.
- 6' Thresh by hand or with special separator.

(2) Registered Seed.

- (a) Program of production the same for all generations as follows:
- (b) Sow Select seed with nurse crop in fields $\frac{1}{4}$ mile from, or separated from other fields of same crop by woods or hills.
- (c) Rogue carefully all weeds and aberrant types or mixtures.

B. Regulatory Phase.

1. Growers make application before March 15th on blanks furnished by Commissioner. Application will show following data:

Date _____

Name of applicant _____

Town _____ County _____ State _____

Varieties to be grown	Acres	Grade	Generation	Origin of seed
1.	:	:	:	:
2.	:	:	:	:
3.	:	:	:	:
4.	:	:	:	:
5.	:	:	:	:

2. If applicant is a beginning grower, and seed to be sown has been purchased, application must be accompanied by transfer tag, if not already filed with the Commissioner, or other evidence showing source of seed.
3. A grower may begin the production of Registered seed with a commercial variety if recognized, or any generation or grade of Registered seed, i.e. with Select seed or first, second or third generation Registered seed.

4. All fields will be inspected by Seed Commissioner or deputy within 3 weeks prior to harvest.
5. All Select plots and first generation fields must be rogued prior to inspection. No field inspected a second time nor passed subsequent to inspection upon promise to rogue.
6. Mixture of other types and varieties, weeds, presence of disease, and location to prevent crossing of plots are the chief points of field inspection.
7. Mixture and percentage of disease are determined by actual count of representative measured spaces in the fields.
8. If standing crop passes inspection, the seed is harvested and carefully threshed or husked, cleaned, graded and sacked or crated for inspection before January 1st.
9. Sample of seed thus prepared is sent to Seed Commissioner for inspection before January 1st.
10. Size of sample,- for cereals 1 quart, corn 10 ears; for clovers $\frac{1}{2}$ pound, for grasses $\frac{1}{2}$ pound.
11. A sufficient portion of this is sent to the State Seed Laboratory for purity and germination reports.

12. Remainder of sample is examined by the Commissioner or his assistants in regard to (1) purity of variety, (2) disease, (3) plumpness, (4) color, and (5) weight.
13. If submitted sample is found satisfactory, the Commissioner or deputy visits the grower and compares submitted sample with bulk of seed in containers. Final inspection is made before February 15th. Notification will be given of time when inspector will be in certain sections.
14. If this comparison is satisfactory, the containers of seed are sealed and tagged by the Commissioner or authorized deputy.
15. The seal is a lead seal impressed by seal of the Board, if such is adopted, or seal of the State.
16. The tag contains the following information in form shown:

Registered Seed

Registered under Seed Registration & Certification Law of State.

Registration No. _____
Kind _____ Variety _____
Amt. in Container _____
Growers Certificate _____
This is to certify that seed in this container has been produced by me in the year 19____ according to rules of Certification Board.

Signature of Grower _____

Signature of Inspector _____

.....
Second Buyer's Transfer Tag
(Note: When seed has been sold or planted, tear this off and to Seed Commissioner.)

Reg. No. _____ Amt. _____
Grower _____
Address _____
Buyer _____
Address _____

.....
First Buyer's Transfer Tag
(Note: When seed has been sold or planted, tear this off and send to Seed Commissioner.)

Reg. No. _____ Amt. _____
Grower _____
Address _____
Buyer _____
Address _____

.....
Grower's Transfer Tag
(Note: When seed has been sold or planted, tear this off and send to Seed Commissioner.)

Reg. No. _____ Amt. _____
Grower _____
Address _____
Buyer _____
Address _____

Purchaser of this seed who wishes to obtain information regarding the production of Registered seed should communicate with the State Seed Commissioner, _____
Town _____ State _____

17. If the seed is sold, the grower detaches, fills out, and sends to Commissioner growers transfer tag where it is filed for the purpose of keeping Commissioner informed as to the amount of seed grower still has for sale. Seed houses who purchase Registered seed for resale are expected to detach, fill out and send first buyer's transfer tag to Commissioner before he can register seed produced from purchased seed. Also, the buyer who plants the seed must file the buyer's transfer with Commissioner before he can register seed produced from purchased seed.
18. After seed is sealed, a certificate of registry is issued the grower as a recognition of effort.

DISCUSSION OF THE SYSTEM

Establishing the work by law follows the modern trend and puts the whole on a permanent and business-like basis which lends importance and prestige to the cause of good seed. The penalties for false certification also mean much more when backed by a law, and, as a result, the term Registered seed means more. The official basis for the work furnished by the law overcomes the objection to many systems, that the work is not put upon a sufficiently firm footing.

The Board is proposed with the idea of overcoming the objectionable and weak features which appear to obtain in the majority of agencies reviewed viz., (1) That the work often devolves too largely upon one man and, since this man often has many pressing duties other than those imposed by the work, the work that should be his main occupation may become a side line. (2) When one man has the majority of the responsibility, the work is too often handled from his view point alone. (3) That influences detrimental to the best interests of the work, may be more easily brought to bear on a single executive than on a Board composed of several members. (4) That the work being largely regulatory does not properly come within the scope of the Experiment Station work.

Since the Board is composed of a number of men, whole sole and special duty as a board is to carry on the work of seed certification and registration, objection one is overcome.

The membership of the Board is chosen with the idea of combining the forces of those interested and obtaining cooperation among them. The director of the Experiment Station is a member since he is interested in all phases of agricultural advancement. The Farm Crops Specialist is especially interested in the increased production by the use of improved methods, and finally the growers, including the president of the local association are especially interested in increased production and increased return. These make an agency capable of uniting the interests of all concerned, and of outlining a plan practicable and suitable for all, and thus the third objection is overcome.

The Board is established independent of the Experiment Station or any organization or association. Its grower members serve without pay for a term of three years and are appointed

by the governor, one each year. These conditions remove the work from a field where it does not properly belong and reduce to the minimum the possibility of the influence of personal acquaintance and petty politics thus meeting objections three and four.

In addition to these points the Board has the advantage that it may for the sake of organization be easily affiliated with the State Department of Agriculture where work of a regulatory nature is centered. The work of the Board, once it is established, is similar to that carried on by the State Department of Agriculture in being largely regulatory. Since this is so, the connection of the two would be an advantage from an organization standpoint.

The Seed Commissioner is employed by the Board to take direct charge in carrying out the work. He devotes his entire time and energy to the work and is responsible for its execution. He must be a man possessing the proper scientific training and executive ability, and be able at the same time to see the growers viewpoint. He will assist the Board in outlining plans for the work and will institute the machinery required for the regulatory work.

The sources of finances at the beginning are appropriations and fees. After becoming well established, however, and a large acreage produced, it is hoped that the work may become self-supporting to a very large extent or entirely.

The penalties are adopted to protect growers and make the term Registered seed significant.

With the idea of simplifying matters for both grower and inspector only two main classes of seed are recognized,

Select and Registered. Since Select seed, except in corn, is produced in comparatively small quantities, Registered seed will be the chief commercial class. To be fair to all growers, however, this class is divided into grades, Classes I and II. Class II includes all seed eligible to registry as far as ancestry and purity of variety is concerned and which fails to qualify as Class I, thru no fault of the grower, but because of climatic or other conditions which cause it to be slightly inferior in color and plumpness and weight. This seed is practically as valuable to sow as Class I but cannot be called first class in every respect.

Improved is seed which while sufficiently above the average being sown to warrant its being listed, is not eligible to registry because of insufficient purity of variety or because the variety has not been recognized. This grade of seed is listed with the idea of giving growers who wish to purchase it an opportunity to obtain at a reasonable price, seed superior to that which they would ordinarily sow. The sale of this seed also enables the grower producing it to reap some compensation for the extra effort he has made to produce it.

In the work that is being done in several states, not sufficient attention is paid to varieties and their sources. Almost any variety from any source is certified if it passes inspection. Not only is this so but often no record is kept of different generations by registry. To make the suggested system efficient in this respect all Registered seed must trace back to selected seed of known origin and recognized variety. This is called select seed.

The Production Phase.

The method of producing Select seed of small grains is adopted in part from the Canadian system. Altho hand selection

of sufficient seed for the seed plot the following year appears to be more arduous than roguing, in the long run it proves to be less so because sowing pure seed would almost entirely obviate, for a time, subsequent roguing of aberrant types and foreign varieties. It is suggested that as many of the varieties of small grains as possible be pure lines. In these no improvement would be looked for, the chief aim of hand selection being to maintain purity of variety and freedom from disease and weeds.

In the subsequent increase of this select seed to registered seed, an effort is made as far as possible to maintain the degree of purity obtained. Roguing is required in the first generation field but after that it would not be feasible.

In corn production some improvement from continuous selection can be expected since the crop is cross fertilized. Two methods of producing select seed are adopted to give the grower some lee-way. These are (1) the ear-to-row test followed by selection and (2) selection only. There is some experimental evidence in favor of the ear-to-row test (48) but it is a question if the busy grower would undertake the production by this method. So the selection only method is suggested also. In either of these methods an understanding of what to select, as far as it may be gleaned from present knowledge, is imperative.

Experiments have shown (48) that former standards for ear selection of seed corn, i.e. covered tips, straight rows, size of ear and shape of ear are of no value as far as production is concerned. This being the case, all that can be said regarding the type of ear to select is that it be fairly representative of the variety and not malformed. Corn sold on the ear would bring more if fairly uniform in size and shape.

More attention should be paid to the plant from which the ear comes. Selection from vigorous plants with strong stalks from full stand hills is advised. Experiments (48) have shown this to be important in that these qualities are transmitted. Also the height of the ear and stalk should be considered since evidence is available (48) showing that ears selected from low-ear stalks produce low-ear stalks and vice-versa. Not only is this true but the low-ear characteristic is correlated with earliness and the high-ear characteristic correlated with lateness. No selection rules can be laid down regarding this because of the difference in aim of different growers.

In increasing Select seed corn, the chief considerations are to keep up varietal purity and maintain, as far as possible, any improvement secured in the Select seed. This is done by preventing crossing as far as possible and by selection.

The production of Select seed in most of the grass crops is not advocated because of the fact that practically no superior varieties have been developed in them, and seed produced by tedious methods of roguing on a seed plot would be little, if any superior to a well cleaned commercial variety.

In clovers, alfalfas and timothy, superior varieties and strains have been developed so that a Select seed plot is advocated. In the production of Select seed of these crops, hand selection is not feasible because of the slowness of the process when applied to these crops. Instead a system of roguing is adopted. The Select plot is sown in drills to facilitate roguing. Once a plot is established with a perennial crop it may be left as long as it is efficient and passes inspection.

In the increasing of the Select seed of all the

crops, i.e. in the production of Registered seed, the object is to maintain the degrees of purity or improvement that has been attained or existed in the Select seed. This is done, as far as possible, by the program of roguing, selection and prevention of crossing.

Thruout the whole program of production an effort is made to combat the causes of deterioration, especially those causing a decrease in varietal purity. Mixtures of aberrant types, other varieties, and weeds are avoided or prevented by hand selection and roguing. Germination standards are kept up by proper harvesting and storing, and by testing and discarding seed of low germinating qualities. Disease, where it can be combatted, is met with regulations regarding seed treatment and sequence of crops. The stipulation that wheat should not follow corn is for the purpose of reducing scab since corn is also a host of this disease.

The Regulatory Phase.

The plan for the control or regulatory work is as simple as it can be and yet be effective. Rigid inspections of fields and threshed grain both are imperative. These are provided for.

The manner of threshing is important, but no definite regulations can be laid down regarding it. Select seed should be threshed by hand or by some machine other than a large separator. Flailing or using a small easily cleaned separator or merely a cylinder driven by a small farm engine are methods which might be used. Registered seed must necessarily be threshed with a large separator. The following program is suggested. The grower should thresh some widely different crop before the seed he wishes to register such as oats before wheat. Then discard all grain for seed coming from the separator while oats appeared in the run.

Should any oats remain in the machine and become mixed with the wheat it can be more successfully separated from the seed than seed of another variety of wheat or rye.

SUMMARY

The need for an agency for the purpose of maintaining an efficient standard is very apparent for, though no little effort has been put forth in this direction, the most efficient method of combating all the causes of poor seed at once has not been worked out. An agency to be successful should do this. A system of seed certification and registration established by law is proposed as being the most efficient agency.

In reviewing the work done toward seed improvement by certification and registration and similar lines of effort the following facts are brought out:

1. The Seed Control Stations of Continental Europe do not certify or register seed, but some of them by making extensive tests as to variety and freedom from disease as well as purity and germination, furnish a basis for certification by seed merchants. They have instituted a program whereby the merchant does the certifying in cooperation with them. They do not supervise production, however, nor register varieties or strains.
2. The work of the Swedish Seed Association and the General Swedish Seed Company amounts to the production of certified and registered seed. They are merely a source of such seed and do not furnish means whereby a grower or farmer may register or certify the seed he produces.
3. The Canadian Seed Growers Association overcomes the objection made above to the system in vogue in Sweden in that it is a

means whereby the grower may produce and register certified seed. In doing this it becomes a great Agricultural Extension Agent. The Association with national scope and standing which it has is almost ideal. It can be criticized in minor points but as a whole it is very successful. On a smaller scale under less efficient supervision it would be open to the criticism that the work has not sufficient backing and importance.

4. Much work has been begun in the United States toward some sort of seed certification or registration. In the majority of cases the work is in the hands of a growers' organization which has been promoted by and retained in connection with the Experiment Station of the state. Some of these are quite efficient. However, they are open to the following criticisms, (1) that the work is often left largely to one man, the secretary, (2) that since this man is connected with the Experiment Station and has many duties the work is apt to be a side line. (3) Also, since one man has charge of the work it is apt to be handled too largely from his viewpoint. (4) Where the man in charge has been elected by an association, or where he has been appointed, he is exposed to personal and political influences. (5) The work is largely regulatory and does not properly come within the scope of Experiment Station work. (6) Not sufficient attention is paid to breeding or to ancestry of the seed. (7) Inspection and regulations are often too lax and in some cases too much is required of the grower.

These objections are largely met by adopting as an agency, a board established by law, whose sole and special duty as a board is to plan and carry on the work of seed certification and registration. The Board chosen as it is, and acting as a

whole minimizes possibility of detrimental personal, factional or political influences. It is composed of both experts and growers whose experience and training enable them to carry on in the best manner for all concerned. The Board is an entity in itself and so is not connected in any way with any institution or organization with which it does not logically belong.

The plan of production is founded upon sound principles of plant improvement as far as known. Breeding and source of varieties are recognized. The program of production is efficient as it can be and yet be practical. The regulatory work also is as simple as it can be and yet be effective.

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