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Production of High Quality Seed Corn

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Wesley Wilcox [1/]

When I was asked to participate in this "mini course" on corn seed, the suggestions on what to cover were broad. It was suggested that I concentrate on bringing you up-to-date on seed production problems, harvesting and general quality assurance procedures needed to insure hybridization and prevent outcrosses - also, where are we in terms of detasseling and use of male sterility. These constitute a pretty broad subject area, any part of which could be taken and expanded into a meaningful short course itself.

Today there are some 84 million acres of corn planted in the U.S. using hybrid seed. Between 3.6 to 4 acres are planted per 50 lb. unit of seed, so some 23 million 50 pound units are needed to plant these acres. At about $45.00 per unit retail, the corn seed industry grosses about $1 billion per year.

To produce 23 million units of corn seed each year, some 500,000 acres of seed production are needed if we assume an average seed yield per acre of about 45 bushels. The production of high quality seed on these acres is our subject. As I proceed, there are two basic aspects to keep in mind: aspects which we as seedsmen are all aware of but must work hard to fulfill. They are: (1) maximization of the quantity of high quality seed put into the bag; and (2) minimization of costs.

Foundation Seed

The intergrity of the foundation seed supplies used is one of the first places we can encounter the possibility of producing less than optimum quality commercial seed. Because of this a great deal of time, effort and expertise goes into the production of parent stock and the maintenance of the basic inbreds so important to the individuality of each hybrid seed corn company.

A base population of each inbred parent used in experimental and commercial hybrid production is vital. Different companies approach this important job in different ways. But, generally this seed is made

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up of bulked seed from selected ears from several thousand selfed plants in a large population. In other instances each self can be test crossed to the appropriate tester and then only the select selfed ears contributing to a desirable test cross are bulked. Each inbred is an individual in terms of what it contributes to a hybrid combination; thus, it demands special handling. The base populations are carefully increased to desired quantities, then used for foundation production of parent stock.

The production procedures used are the same as the ones I will be covering later for commercial production, with possibly two differences: (1) field sizes for the most part are smaller (1 acre plus); and because of this (2) isolation of the fields from contaminating corn is carefully planned to provide as much distance as is required to insure minimum blow-in contamination from outside the field (See Table 1).

After production an accurate estimate of genetic purity of new crop parent stock is required. Presently, a growout during the winter and/or spring growing season is the primary procedure used.

Planning

The use of a good crystal ball would be very helpful during the time of planning for the production of the commerical seed crop. Plans should be made for an adequate inventory of high quality seed to sell for planting more than 12 months later. This amounts to a seed inventory in the neighborhood of 125-150% of need. The acreage eventually planted will be based on the more or less successful melding together of inputs from marketing on projected sales needs, from Inventory Control and Quality Control in projected carryover, from Seed Production Research on parent characteristics, and also previous experiences on seed yields, etc. The hybrid seed corn industry today is based primarily on the successful production and sale of single cross or modified single cross hybrids. There are, of course, some three way and double crosses produced, but for the most part, commercial production of single crosses is the main thrust.

Once inventory needs are determined, grower selection begins. This is an important job but not the most difficult task confronting production management. Contracts for seed production are premium items to many farmers. From those seeking a production contract, the best growers with top notch land are selected. In this way, we are able to work with the best growers as well as produce the seed on soil types with high productivity indices that have been maintained in a high state of fertility. The growers are also ones who have good knowledge of, and practice the up-to-date agronomics needed to produce maximum seed yields.

Table 1. Typical isolation requirements for hybrid corn seed production.

Type of Production	Isolation From: Yellow Dent		White Dent		Sweet Corn	
	Yards	Meters	Yards	Meters	Yards	Meters
Yellow Dent	220	201	440	402	880	804
White Dent	440	402	220	402	880	804
Waxy	440	402	440	402	880	804
Opaque	440	402	440	402	880	804

Each production year is a new experience. Management wants all the information available. Data are accumulated and made available on each experimental and commercial hybrid parent in parent observation plots located in production areas for such things as:

(1) Days to silking.

(2) Days to pollen shed.

(3) Duration of pollen shed and quantity of pollen shed by parents used as pollinators.

(4) Yield data on new parents.

(5) Ear samples for examination and conditioning data.

Another aspect of seed field inspection is to know the intended cropping of the fields neighboring your seed field. Proper isolation from outside sources of contamination is an absolute necessity to insure a high degree of genetic purity.

It is pretty generally agreed that one of the best ways for insuring good isolation is a perfect nick (seed parent silks emerging when about 10% of the pollinator is starting to shed pollen). Established minimum isolation standards are then followed. These standards and how they are determined for a specific circumstance differ among companies. For the most part variations on the following options are used: (1) distance between seed parent silks and contaminating pollen - 40 rods are a base distance obtained by using soybeans, sterile corn interplanted with pollinator, or meadow; (2) pollen parent barrier rows, to supply a screen of male pollen; and (3) differential flowering dates - a system useful in case space is at a premium as in winter programs. Size of field and pollen shedding capabilities of the pollinator are also important factors in arriving at a decision. We have found the more attention given to the capabilities of the pollinator the better off we are.

Planting

Three additional considerations remain before planting which have a considerable impact on yield and quality of the crops: (1) plant population; (2) planting pattern; and (3) planting time.

Many different planting patterns are used in the seed fields of today: 2:6 at one time was considered to the the standard. As the genotypes of hybrids changed, so did planting patterns for the purposes of getting pollinators closer to all seed rows, and/or more seed rows per acre in order to realize better fill on seed ears and maximizing seed yields (see Table 2). Such patterns as 2:6, still in use, 1:4,

Table 2. Example of information that needs to be obtained for each pollinator (male) parent.

Planting Pattern/ Row Spacing	Seed Parent	% of Plant Flowering	Quantity Pollen*	Height 1st Planting (inches) May 10	Height 2nd Planting (inches) May 22
1:4 38"	Inbred 1	92	4	71	51
Interplanted	Inbred 2	84	4	73	53
1:4 30"	Inbred 1	94	3	77	54
	Inbred 2	98	1	84	62
2:6 30"	Inbred 1	100	3	76	--
	Inbred 2	100	2	--	68

* 1 is good, 9 is poor

1:2:1:4, 1:4 interplant, or 1:4 double plant, etc., are now common sights. 2:6, 1:4, 1:2:1:4 are not too difficult, but when you interplant your pollinator in most cases splitting every 4th and 5th seed row, you are setting up a different environment of high plant populations for the pollinator. However, after the pollinator has been cut out following pollination to avoid seed mixture, there is the advantage of full land utilization for seed production. Under the right conditions this is "great". But the stress of high plant populations coupled with hot and drier weather can cause the pollinator to malfunction to the point of not developing to pollen shed. Double planting a male in a 1:4 pattern is also great if you can lay the 2nd planting in a couple of inches away from the 1st planting without disturbing it too badly. What you gain is a longer period of pollen shed. But, a disadvantage is the lack of uniformity in case rogueing is necessary - so a good clean production field is a necessity.

In order to split date the male and female rows to get a good nick, one must carefully study flowering dates, heat unit data and interrelated morphological characteristics of parents involved. For example:

PARTIAL GUIDE FOR SPLIT DATE PLANTING

Days	Growth	Heat Units
3	¼" Sprout	48
6	Emergence	96
10	1.5 leaves	160
14	2.2 leaves	224

The morphological characteristics are of the first or second planted parent. There are several different split date situations. They are in order of increasing difficulty: (1) female first with a narrow split, (2) male first with a narrow split, (3) female first with a wide split; and, the worse situation, (4) male first with a wide split - here the season gets away from you rather quickly.

Mother Nature is an important contributor to the successful completion of a split date. In case you have found yourself in the past frustrated because of weather and the planting season running out, other methods for making minor (3-4-5 day) adjustments in flowering can be used: (1) variable starter fertilizer rates; (2) variable planting depths between parents; (3) seed coating; (4) clipping and flaming.

Once the seed field is planted and up to stand, it must be carefully watched in order to be ready to react to any problems that might present themselves, insects, weeds, etc. Off-type plants are removed from parents in a timely manner. Here special attention is paid to the pollinator. All off types without fail are to be removed before pollen shed. If you are rushed and cannot get over all the seed parent before detasseling you have another chance at it when you ear harvest and ear sort.

Pollen Control

Various methods of maintaining adequate pollen control to meet standards imposed by Quality Control, seed laws and seed certification agencies have been used or at least investigated. They fall basically into two broad categories: (1) detasseling; and (2) male sterility.

First, detasseling either mannually or in combination with some mechanical device is the most common practice used today. We had a glimpse of "Utopia" when we could cause male sterility in seed parents by using "T" Cytoplasm male steriles and cross in restorers from the male - pretty cozy! - until Southern corn leaf blight (Helminthosporium maydis) mutated and messed up the good deal. We quickly returned to the job of physically removing the tassels and searching for ways to get them off more quickly and at a lesser cost. It is estimated that detasseling contributes 10-15% to the costs of production. Thousands of people are used each season to get this job done either on foot or on personnel carriers, at an estimated cost of $17-20 million per year.

Mechanical detasselers became more and more important to the seed producer as production costs continued to climb. They are varied in design and are used in varied sequences and amounts through the season. There are the "cutters" and "pullers", both mounted on high clearance machines equipped to operate in the worst possible conditions. "Cutters", as implied, are rotating blades that cut or shred the top of the plant. "Pullers" are rotating wheels or rollers that will grab the tassel or top of the plant and pull it out in a manner similar to hand detasseling. The advantages and disadvantages of either depend upon to whom you are talking. The secret to the successful use of either type of machine is a skillful, well-trained operator. If mechanical detasselers are an integrated part of your program and not just for emergency use, chances are the instructions to the operator are to wait as long as possible for maximum tassel extrusion and before silk emergence before starting. In a uniform field it is possible to get a 70% plus "pull" the first time through with a minimum amount of leaf damage (two or two and one-half leaves or less lost.) As a rule of thumb, mechanical detasselers are used a couple of times in a field and then it is cleaned up by hand. Using this system we find we can save some 40% on the detasseling contract rate per acre over it all being done by hand. This, of course, depends upon location, field uniformity, plants per acre of the seed parent, and wage rates for agricultural labor.

Much as been written about the effect of leaf removal incidental to detasseling. Yield reductions we have learned to live with are in the 10-20% range and in some cases more. The variables are: (1) number of leaves removed; (2) genotype - morphology of the plants; and (3) weather conditions.

I have mentioned male sterility as a method of pollen control. There are presently three types either in use or at least being investigated. They are (1) cytoplasmic; (2) genetic; and (3) chemical. Cytoplasmic male sterility has been referred to in relation to Southern corn leaf blight. It is still the most effective method of pollen control. Three primary sources are available to the producer: (1) Texas source; (2) "S" source; and (3) the "C" source. So far, the "S" and "C" sources have not shown adverse side effects (i.e., susceptibility to Helminthosporium maydis Race T) as did the Texas source in the early 1970s. If one or the other of these sources is being used in hybrid seed corn production I would imagine they are used on only a small percentage of the acreage and then thoroughly mixed or blended with seed from detasseled or male fertile sections of the same field, say on a 1:1 or some other predetermined ratio. Over the years it has been found that this procedure will reduce detasseling costs by 30-40% and increase total seed yields at least 5-19% per acre depending on the genotype, the blended ratio and how good the sterile is. If the sterile should break and require immediate attention the cost will go up some $20/acre.

In corn a large number of recessive genes have been identfied that in a homozygous state will cause male sterility. A system has been worked out by Dr. Earl Patterson at the University of Illinois for use of these recessive genes. All I can say about it is that it is complex and expensive to establish and maintain. And, also, a U.S. patent has been awarded Dr Patterson for any eventual use of the system.

Chemical male sterility or the development of an effective male gametocide would be a tremendous break-through for us. If this should ever happen, we would no longer need to introduce into our seed parent germplasm those traits for cytoplasmic of genetic male sterility. Simply by applying the right dosage of the right chemical at the right time on all seed parent plants in the seed field, we would inhibit some stage of pollen development, say meiosis, hopefully 100%. So far I don't believe all of these conditions have been worked out at least for commercial application, but they are vigorously being worked on!

I have talked to some extent on the importance of maintaining the genetic integrity of the hybrids we produce and merchandise. Advantages of one hybrid over another are measured in small increments. To lose that advantage because of some problem in the seed field is a costly error. No one wants this to happen, so in order that we all understand the limits beyond which we cannot go, Quality Control with the support of Management establishes standards and procedures for monitoring and helping maintain genetic purity of all hybrids produced. At this point it is necessary to deal in the seed laws, which are rather specific in their description of what is a hybrid. All production personnel are familiar with the established standards and it is their responsibility to see that they are met or exceeded. In order to help them do this in the seed fields, Quality Control assigns a Seed Field Inspector to a certain number of acres to observe, report and assist in getting the job done on time. The inspector checks and reports only on those facets of the production that have an influence upon successfully producing genetically pure seed. Seed certifying agencies as well as each company have standards to be met. For example, during the season if reports should come in showing at least 5% of the seed parent plants silked and 1% of them shedding pollen on any one inspection or a total of 2% for three inspections, the field or a portion of the field would be suspect because the standards had been violated. But, here again, the matter of how well the pollinator is doing its job is an important consideration.

Estimating genetic purity in some manner is an alternate to, or in many cases an addition to, the work of the Seed Field Inspector. There are several ways this can be done: (1) growouts; (2) electrophoresis; and (3) the green house sand bench. I believe by far the most widely used procedure to date is the growout. Here, an adequate sample of the lot in question is randomly collected. They are then broken into saleable kernel sizes using hand screens or laboratory sizing equipment and sent to winter locations, either Florida or Hawaii, along with appropriate checks for comparison to be planted on clean ground for observation at flowering time and/or when the ears are far enough along to see cob color and kernel characteristics. Adequate populations are planted in order to get as accurate an estimate of purity as is possible. Those lots being checked for reasons of a violation of standards are identity preserved or are placed on "hold" until their fate is determined. Strict standards are maintained.

Electrophoresis is being investigated as a possible alternate procedure to the growout, or at least to work in conjunction with it. It is an accurate biochemical test based on zein heterogeneity. Presently, we find it to be expensive considering the number of tests needed for an accurate estimate of each seed lot and kernel size.

Some companies plant samples in sand benches and identify those seedlings that differ from the check hybrid or, conversely, identify the suspected off type or types.

Harvest

When planning production for one production area, we are careful not to plant lines that will all mature at the same time. Scheduling the harvest of mature high quality seed through the dryers so that as little seed as possible stay in the field longer than necessary is important. We constantly monitor the seed fields to see when they are ready to be brought in. Generally ear harvest can start when the seed is physiologically mature. In seed corn this can pretty well be determined when the water line or maturity line is down or out of sight on the back of the kernels or when the "black layer" is formed on the top of the kernel. It is generally assumed the moisture will be in the neighborhood of 35%. If the seed is to be field shelled then moisture levels should be below 20% to minimize damage. I would stress that these are general comments, because for certain seed parents we want more specific data on harvest moistures in order to maximize high quality through the drier and conditioning equipment.

Seed are usually harvested in the ear and as soon as it is mature in order to: (1) reduce the risk of freeze injury; (2) avoid field losses by the pickers; (3) reduce losses from insect damage - ear worms in particular in some areas; and (4) reduce losses due to ear rots and other diseases. The grower is responsible for harvesting the seed unless other special arrangements have been made. For the most part, harvesting equipment used is of a type that will inflict the least amount of mechanical damage - "New Idea" uniharvesters are very common. Seed ears are delivered to field sorters equipped with husking beds or to in-house sorting systems. Excess husks are removed, diseased and off type ears are also removed as the seed moves on toward the drier.

When field shelling of the seed crop is necessary for whatever reason (emergency, to reduce field shelling loss, to hurry the season along, or shortage of ear dryer space, or no ear dryers at all), there are certain conditions that must be considered in order to maintain the genetic integrity of the seed, the most important being the field must be free of off types because there is no opportunity for ear sorting.

Summary

Quality control including the establishment of standards, timely and thorough inspections, knowledge of the materials under production, and constant vigilance is the key to production of high quality corn seed - or seed of any kind.