Cultural Practices for Optimizing Maize Seed Yield and Quality in Production Fields

Peter .R. Thomison[1]

Abstract

Successful maize seed production requires a much higher level of management skill and is far more labor and time consuming than maize grain production. In commercial maize seed production fields, up to 12 trips across a field in a single season, to plant the seed parents and apply fertilizers, insecticides, and post emergent herbicides, in addition to the detasseling operations, are not uncommon. The "best" management practices recommended for use in normal crop production become especially important in seed production. In commodity grain production, not following recommended practices may result in lower grain yield, but in seed production it can jeopardize grain quality, in addition to yield. The introduction of trangenic traits and development of GMO hybrids has increased the need for planning and sound technical knowledge to ensure successful seed production. The recent Starlink incident demonstrates the problems that can occur when dealing with the new GMO technology. This paper will review key cultural practices required for optimal seed yield and quality.

Introduction

The cultural practices used in commercial hybrid seed production are similar to those followed in producing commodity grain maize. The major difference between seed and grain production is the need to follow management practices that will 1) preserve the purity and identity of the seed from planting through storage, and 2) reduce crop risk from environmental stress and pest problems. The latter is an important consideration since most seed parents are more vulnerable to environmental stress and pests than conventional hybrids.

The "best" management practices recommended for use in normal crop production become especially important in seed production. In commodity grain production, not following recommended practices may result in lower grain yield, but in seed production it can jeopardize grain quality, in addition to yield. The introduction of transgenic traits has increased the need for planning and sound technical knowledge to ensure successful seed production. The recent Starlink incident demonstrates potential

[1] Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210-1086; Salaries and research support provided in part by State and Federal funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University. Email: thomison.1@osu.edu

for problems occurring when a new technology is not well understood. Growers should follow recommended agronomic practices, including the maintenance of good soil fertility and good control of weeds and other pests, to minimize stress and maximize yield potential.

Successful seed production requires a much higher level of management skill and is far more labor and time consuming than grain production. Up to 12 trips across a field in a single season, to plant the seed parents, followed by additional trips to apply fertilizers, insecticides, and post emergent herbicides in addition to the detasseling operations are not uncommon (Stuever, 2001). While agricultural colleges and Extension at U.S. land grant universities have played a major role in developing guidelines for successful grain production using hybrids, seed companies and other private commercial concerns have, for the most part, developed seed production technologies. This may be in part due to the proprietary nature of the inbreds used in seed production as well as the contract grower system and the more limited geographic region where seed production is concentrated compared with hybrid grain production. This paper focuses primarily on key cultural practices required to optimize seed yields and quality and draws heavily on past overviews of hybrid seed production, including those by Wych (1988), Jugeheimer (1985) and Zuber and Darrah (1987).

Select field sites with high yield potential.

Establish seed production fields on the most fertile, well drained soils to reduce stress and maximize yield potential and grain quality. Avoid droughty soils as well as poorly drained soil conditions. Good soil structure and tilth are important in order to avoid the adverse effects of poor drainage and crusting on inbred stands (Wych, 1988).

Plant seed fields early

The recommended time for planting maize in northern Ohio is April 15 to May 10 and in southern Ohio, April 10 to May 10 (OSUE, 1995). The minimum soil temperature for growth of maize is 10 degrees C. Many agronomists believe that the optimum time for planting maize is as soon as maize at the 5-cm depth reaches that temperature. Soil moisture and potential for compaction must also be taken into account (Wych, 1988). Yield reductions resulting from "mudding the seed in" may be much greater than those resulting from a slight planting delay. In the eastern US Corn Belt, during the 2 to 3 weeks of optimal maize planting time, there is on the average about 1 out of 3 days when fieldwork can occur. Early planted maize may reduce the exposure to various late insect and disease pest problems, such as European corn borer and gray leaf spot.

Adjust seeding depth according to soil conditions

Plant between 1 ½ to 2 inches deep to provide for frost protection and adequate root development (OSUE, 1995). In April, when the soil is usually moist and evaporation rate is low, seed should be planted shallower - no deeper than 1 ½ inches. One risk associated with shallow planting depths is the possibility of poor development of the permanent (or secondary) root system - if the crown is at or near the soil surface, some of the permanent roots may not grow under hot, dry conditions (resulting in the “rootless” and “floppy” maize syndromes). Another potential risk from planting less than 1 ½ inches is shoot uptake of soil-applied herbicides.

Adjust seeding rates to produce the maximum yields of high purity seed of saleable kernel size.

The appropriate seeding rate will be determined by the specific seed parents being used, the average rainfall in the production area or irrigation availability, and local labor supply. Although hybrid response to seeding rate has been the subject of considerable research, much less has been published on inbreds. However, seed companies conduct in-house research to evaluate yield and kernel sizeout response to increasing plant density (Wych, 1988). Higher seeding rates are recommended for sites with high yield potential with high soil fertility levels and water holding capacity. In Ohio, seed growers using irrigation may use plant densities up to 64000 plants/ha whereas a grower relying exclusively on rainfall, may use 54000/ha. With inbred male parents especially those that shed limited pollen, higher plant densities of male parent rows are used to help with isolation by increasing pollen "load" as well as to ensure adequate pollen, especially with inbred males that shed limited pollen.

Choose isolation methods that will assure a high degree of genetic purity.

Minimum standards for isolation of seed maize fields have been established by the Association of Official Seed Certifying Agencies (1971). When zero or one male pollinator border row is present, minimum distances ranging from 125 to 201 m are typically required between the female parent of the hybrid being produced and any other maize of the same seed color, maturity, or endosperm type. Where the possible contaminant maize may have different kernel color or endosperm type, a 201 m minimal distance is specified. Additional distance is needed in situations where the contaminant maize may have different pollen shedding capacity and where wind velocities may be high (Wych, 1987). Minimum isolation distance requirements can be modified (i.e. reduced) by using additional border rows and the size of the field and production block (Jones and Brooks, 1950). In some states, effective natural barriers and differential flowering dates are allowed to "substitute" for some isolation distance. However, natural barriers may not as effective as border rows of maize in providing isolation (Jones and Brooks, 1952). Differential flowering times between seed maize production and neighboring hybrid maize can also be effective if silks of the of female seed parents are not receptive when pollen other than the male pollinator is present (Wych, 1988)

Select the appropriate planting pattern for the production environment and grain parents

Growing conditions (moisture availability) and grain parent genetic background should be considered when determining planting patterns (Jugenheimer, 1985). Common planting patterns include 4:1 (four rows of female parent to one row of male parent), 4:2, 4:1:4:2, 6:2, and solid male parent with inter-planted male parent. With the 4:1 and 4:2 patterns, one-half of the female parents are adjacent to a male parent; with the 4:1:4:2 pattern two thirds of the female grain parents are next to male parents. With the 6:2 pattern only one third of the female grain parent rows are adjacent to male parents. According to Wych (1988), use of the 6:2 pattern is generally restricted to male parents that shed an abundant supply of pollen. Some Ohio operations utilize solid planting of female parents in 76 cm to 102 cm row spacings with every other or every fourth row spacing interplanted with the male parent. This approach allows full utilization of land area for female production (an important consideration when land or irrigation is limited) and placement of the male parent closer to the female parent rows.

Wych (1988) notes that solid plantings are typically limited to female parents that will not out compete the male parent and thereby delay pollen release. After pollination is complete destroying the male parent prevent grain formation in the male rows and eliminates the risk of seed contamination at harvest. It may also reduce competition with the developing female parent for nutrients and available soil moisture.

Use split date plantings of grain parents to ensure timely "nick"

Split date plantings of seed parents refers to the planting of the female and male parents on different dates. This practice is employed to optimize the synchronization of pollen shed and silking of the two seed parents, so parents of differing maturity "nick" or reach the flowering stage concurrently (Wych, 1988). Male parents are often planted on two dates to extend the pollen-shedding period by the inbred male. Plantings are timed so that peak pollen shed coincides with the maximum exposure of silks by the female parent, e.g. Some Ohio growers will plant their first inbred as soon as the female grain parents (planted earlier) reach the V1 stage (1-leaf collar) and then establish a second planting of male pollinators 1-2 week later, sometimes in the same row with earlier male pollinator planting but using different seeding rate densities on each planting date. Other methods utilized to alter flowering dates to bring parents of differing maturities together for timely nick include clipping or flaming to delay crop development, variable planting depths, and variable fertilizer rates (Wych, 1987). The methods are not used widely because they can reduce seed yields.

Improve stand establishment

Uneven plant spacing and emergence can reduce yield potential (OSUE, 1995). Seed should be spaced as uniformly as possible within the row to ensure maximum yields and optimal crop performance - regardless of plant population and planting date. Maize plants next to a gap in the row may produce a larger ear or additional ears (if the hybrid has a prolific tendency), compensating to some extent for missing plants. Although skips (resulting from missing plants) cause greater yield losses than doubles, under stress conditions, crowding may result in barren plants or ears too small to be harvested (nubbins), as well as stalk lodging and ear disease problems. Reduced plant stands will yield better if plants are spaced uniformly than if there are large gaps in the row. As a general guideline in grain production, yields are reduced an additional 5 percent if there are gaps of 4 to 6 feet in the row and an additional 2 percent for gaps of 1 to 3 feet. Recent studies suggest that maize growers could improve grain yield from 4 to 12 bushels per acre if within-row spacing were improved to the best possible uniformity (depending on the unevenness of the initial spacing variability).

Uneven emergence affects crop performance because competition from larger, early emerging plants decreases the yield from smaller, later emerging plants. If the delay in emergence is less than 2 weeks, replanting increases yields less than 5 percent, regardless of the pattern of unevenness. However, if one-half or more of the plants in the stand emerge 3 weeks late or later, then replanting may increase yields up to 10 percent. To decide whether to replant in this situation, growers should compare the expected economic return of the increased yield with both their replanting costs and the risk of emergence problems with the replanted stand.
To improve planter accuracy and enhance uniformity of emergence consider the following:
Keep the planting speed within the range specified in the planter's manual.

Match the seed grade with the planter plate.
Check planters with finger pickups for wear on the back plate and brush (use a feeler gauge to check tension on the fingers, then tighten them correctly).
Check for wear on double-disc openers and seed tubes.
Make sure the sprocket settings on the planter transmission are correct.
Check for worn chains, stiff chain links, and improper tire pressure.
Make sure seed drop tubes are clean and clear of any obstructions.
Clean seed tube sensors if a planter monitor is being used.
Make sure coulters and disc openers are aligned.
Match the air pressure to the weight of the seed being planted.

Perform tillage operations only when necessary and under the proper soil conditions

Deep tillage should only be used when a compacted zone has been identified and soil is relatively dry. Late summer and fall are the best times of year for deep tillage. Avoid working wet soil and reduce secondary tillage passes. Perform secondary tillage operations only when necessary to prepare an adequate seedbed. Shallow compaction created by excessive secondary tillage can reduce crop yields. Cloddy seedbeds and soil compaction contribute to uneven stands.

Take advantage of rotational benefits

Maize grown following soybeans will typically yield 10-15% higher than maize grown following maize. Rotation benefits are most pronounced following legumes such as soybean or alfalfa, especially in reduced tillage systems on poorly drained soils.

Benefits from growing maize in rotation with soybeans include 1) better weed control in both crops, 2) fewer difficult to control weeds, 3) the opportunity to rotate herbicides as crops are rotated (which means that it is less likely that certain weed species will develop resistance to specific herbicides), 4) less opportunity for an increase in insect pests and disease inoculum (Cash costs are reduced because rootworm insecticide is not needed for first year maize), and 5) lower fertilizer nitrogen use is possible without lowering maize yields. The spread of gray leaf spot across the U.S. Corn Belt in recent years can be directly related to continuous no-till maize production. Given the limited genetic resistance available in most maize hybrids, rotation must be used to effectively manage this disease. Tillage to bury disease inoculum may help reduce the onset of disease but it carries the risk of greater soil erosion.

Manage potential pest problems throughout the growing season

Controlling weeds, insect pests, and diseases has become an integral part of seed production (Jugenheimer, 1985). Since inbreds are less competitive than hybrid maize with broad leaf weeds and grasses, seed growers rely heavily on herbicide applications to minimize weed pressure. Above and belowground insecticide applications (seed, pre-, and post-application) are regarded as a necessity by many producers. To address environmental concerns regarding excess pesticide application as well as cut unnecessary expenditures, some companies are using integrated pest management principles and use scouting to determine if and when pesticide treatment of seed fields is needed.

Timely harvest is critical to ensure grain quality

Ears are usually picked just before seeds approach physiological maturity, the stage at which maximum dry matter accumulation occurs (Zuber and Darrah, 1987). According to Wych (1988), target moisture levels will be determined a number of factors including, the female grain parent, environment, weather forecasts, production volume, and finally plant capacity. The moisture content at which kernels achieve physiological maturity is affected by environment and genetic background. Timely harvest is necessary to minimize the risk of freeze damage, field losses from mechanical pickers, risks of harvest delays due to adverse weather conditions, seed quality deterioration caused by insect damage, ear molds, and stalk rots (Zuber and Darrah, 1985; Wych, 1988)**.** The loss of one normal-sized ear per 100 feet of row translates into a loss of more than one bu/A. An average harvest loss of 2 kernels per square foot is about 1 bu/A (OSUE, 1995).

Scout fields throughout the growing season

To observe crop conditions and diagnose potential problems as they develop. Such scouting and troubleshooting are critical steps in identifying yield limiting factors which need to be determined before crop management alternatives and remedies can be considered. For more information on dealing with various field problems that occur during the growing season, consult extension or commercial newsletters. In Ohio, the *Ohio State University Crop Observation and Recommendation Network Newsletter* available online at http://www.ag.ohio-state.edu/~corn/agcrops.html. Such newsletters are typically published weekly during the growing season and can also be obtained from local county extension offices.

Know the nutrient needs of the crop

Inbreds may be subject to more nutrient deficiencies since they have less extensive and vigorous root systems than hybrids (Wych, 1988). Some contract growers over fertilize to ensure against possible fertility deficiencies. Lower commodity prices (upon which contract prices are based) have led some growers to evaluate and monitor nutrient needs more closely. Moreover as concerns about ground water contamination growers are being encouraged to soil test regularly and apply fertilizers only as needed (Wych, 1988). Nitrogen (N), phosphorus (P) and potassium (K) recommendations should be based on yield potential and inbred response. Thus a realistic yield goal is the first critical step in nutrient management. For N, credits should be given for previous crops and manure. If the previous crop was soybeans, an N credit of 30 lbs/A may be taken. Depending on population density, perennial legumes, established more than one year, may have an N credit between 40 and 140 lbs/acre. Manure credits may be taken depending upon application method and time of application.

A split application of N (at planting and sidedress) is the most efficient and environmentally sound method for N management. This system allows later adjustments to nitrogen rates depending on the growing season. Phosphorus (P) and potassium (K) are relatively immobile in the soil (what a crop has not removed will generally accumulate for future crops). A soil test is the best way to estimate if P and K levels are in excess, adequate, or deficient. Soil P levels above 40 ppm (80 lbs/acre) are in excess and should not need additional amounts. Phosphorus applications should match crop removal if soil levels are 15 to 30 ppm (30 to 60 lbs/acre). Crop removal rates equal the yield goal multiplied by 0.35. Between 30 to 40 ppm, amounts less than crop removal would be recommended depending on yield goals. If P soil levels are below 15 ppm, then applications would include crop removal and a build up program.

Potassium recommendations follow the same philosophy as P except consideration is given for soil cation exchange capacity (CEC). Since applied K may be held more tightly by soils with high CEC, rates increase as the soil CEC increases. Regardless of CEC and yield goals, yields would not respond to additional K at soil levels above 200 ppm (400 lbs/acre). Maize grown on soils that have a CEC < 10 would not respond to additional K when the soil test level > 150 ppm (300 lbs/acre). Tables in the *Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat and Alfalfa* guide (Bulletin E-25) published jointly by the land grant universities in Ohio, Indiana, and Michigan provide K rates at various yield goals and soil CEC. These fertilizer recommendations are available online at: http://ohioline.ag.ohio-state.edu/e2567/index.html.

Future Developments to Consider

With the introduction of new GMO traits, greater attention will need to be given to ensuring maximum genetic purity. With the potential for the genetic “stacking” of GMO traits, plus the continued demand for non-GMO seed, this trend will require even more rigorous methods to prevent contamination. There is a small, but rapidly growing acreage of maize in the U.S. that is produced organically The increase in organic maize grain production has been associated with a demand for organically produced seed. To accommodate this new market, seed producers will need to consider alternative non-conventional management practices.

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