

**Animal and Plant Health
Inspection Service**

**Planter Equipment Inspection
Training Module**

Authors

**H. Mark Hanna
Extension Agricultural Engineer
Department of Agricultural and
Biosystems Engineering**

**Darren H. Jarboe
Program Manager
Center for Crops Utilization Research**

IOWA STATE UNIVERSITY
Extension and Outreach

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Background

With the advent of field testing in the United States of Federally regulated genetically engineered (GE) plants in 1987, the importance of proper planting equipment clean-out and subsequent government compliance inspection has gained national and international importance. The adventitious presence (AP) of regulated GE plant material or seed, unintentionally introduced through planter equipment, in the Nation's food or feed supplies and channels, would create significant negative domestic use and trade impacts. Such a regulatory calamity could have financial and trade implications measured in the billions of dollars and devastate the long-term survivability of the affected agricultural production sectors. For example, in 2000 the unintentional introduction into human foods of a Federally regulated (Environmental Protection Agency) GE corn line known as StarLink™, which was not approved for human consumption resulted in millions of dollars worth of food products being pulled from the store shelves and dramatic and immediate negative responses by our trading partners.

Animal and Plant Health Inspection Service's (APHIS) experience with high risk GE pharmaceutical-containing plants has demonstrated that a critical point in the prevention of the inadvertent introduction of GE plant material into the environment and the potentially damaging subsequent AP of such material in the food chain and feed supply is crop planting equipment. In order to effectively and efficiently manage this complex regulatory compliance issue, APHIS has contracted Iowa State University (ISU) to produce this valuable training aid. ISU is one of the world's preeminent agricultural universities and a leader in seed identity preservation through proper planter machinery clean-out.

Introduction

With the introduction of value-added traits, identity preservation programs, Federal organic standards, and the advent of field testing of federally regulated genetically modified plants, planter equipment clean-out has become a production, marketing, and regulatory imperative. New federal regulations by United States Department of Agriculture agencies under Marketing and Regulatory Programs, in the areas of certified organic production, plant protection and quarantine, and biotechnology require that planting equipment be cleaned of seed and biomaterial before use, interstate transport, or return-to-service in a growing number of cases.

Traditionally, APHIS has been concerned with plant pest and disease pathway analysis and disease epidemiology related to the rapid spread of plant pests and diseases from one field location to another or to their introduction into the country via equipment. APHIS' regulatory concerns and practices are best exemplified by its quarantine program for Karnal bunt disease of wheat. In order to effectively contain this serious fungal disease and prevent its spread, planters have been cleaned of residue biomaterials, disinfected, and inspected prior to moving to another location.

Currently, APHIS Biotechnology Regulatory Services (BRS) annually issues permits and notifications for field testing of regulated GE crops at over 5,000 domestic field test sites. In the last several growing seasons BRS has seen the appearance of two new classes of GE plants, one class that expresses traits for the synthesis of pharmaceuticals and the second class expresses traits for synthesis of industrial compounds. The Agency's regulation of pharmaceutical or industrial trait expressing plants is more rigorous than traditional GE crops containing agronomic traits such as herbicide or insect resistance. Equipment used to plant these high-risk traits must be dismantled, cleaned and inspected prior to return-to-service for planting of traditionally bred crops. The need for a trained cadre of compliance inspectors with both knowledge and experience in the area of planting equipment clean-out and inspection is an Agency imperative.

Planting machine considerations

A wide range of equipment is used to plant grain, oilseed, and other agronomic crops. To do a good job of inspection, it is important to understand the basic operations of seeding equipment and basic types of planters and seeders. To anticipate where seeds and plant material may reside, an understanding should be developed of seed movement into, through and out of the planter from the point of loading from bulk storage into a hopper to seed placement in the soil. Seed from the hopper must be regulated by some type of metering device to achieve a desired seeding rate per acre or hectare. The more intricate parts of the planter are often associated with seed metering. Inspecting some of these areas may impact calibration of the planter.

Safety considerations include the possibility of falling equipment when inspecting the underside of the planter, sharp edges on seed openers or coulters, possible handling of treated seed, and pinch or crush points around moving parts (figure 1). Safety gear that may be useful during a safety inspection includes safety glasses, leather gloves for handling sharp edges, rubber gloves for handling treated seed, and possibly a hard hat or bump cap if significant time will be spent inspecting lower parts of the planter. Inspecting all areas of planting equipment for fugitive material includes careful perusal of the seed drop area and soil-engaging components on the underside of the planter. Most seed openers are raised hydraulically. When inspecting the underside of planters including seed-openers, closing wheels, etc., with this equipment in the raised position, it is important to make certain this equipment has been mechanically locked or blocked and is not being supported only by hydraulic pressure. A sudden hydraulic leak can result in falling equipment. Reaction time is not nearly quick enough to avoid a serious or fatal accident.



Figure 1. The chain transmission drive on planter is a possible pinch point

An objective of this training module is to show common but not all locations of entrapment for residual seeds and plant material in and around the seeding equipment and safe procedures for inspecting such equipment.

Common areas of planters

Major objectives of seeding equipment are to plant seed at a uniform desired depth and with adequate seed-to-soil contact to assist germination. An additional objective is to achieve uniform spacing of seed within a row or broadcast over the soil surface.

The flow path of seed through the planter can be thought of as: 1) loading seed into storage hopper(s) on the planter, 2) metering seed to achieve a desired application rate, and 3) distributing seed into or onto the soil. Seed is loaded from bulk storage or bags into a seed hopper on the planter. Bulk storage may be a wagon, truck or bag too large to be manually handled. An auger or other conveyor transfers grain into the planter seed hopper. The seed hopper on the planter may be one large storage hopper such as on a grain drill (figure 2) or Case IH with central seed hopper (figure 3). For crops planted into rows wider than about 10 in., most planters use separate small hoppers located above each row planting unit (figure 4). Some larger row-crop planters manufactured since about 2000 use a combination system with a single large central seed hopper to more conveniently fill bulk seed into the planter and smaller hoppers over each row unit that receive seed

conveyed to them from the large hopper.



Figure 2. Grain drill



Figure 3. Central seed hopper on row crop planter



Figure 4. Individual seed hoppers on planter row units

Seed moves from the supply hopper through some type of metering or singulation device. A singulation device separates seed one-by-one so that individual seeds may be metered at a desired application rate for placement into the soil. Metering systems vary, but the mechanism to singulate the seed is often complex enough to include several areas for residual seed to hang up inside the planter. Seed metering units are some of the more intricate, individual, and unique parts of the planter. Several different types are specifically illustrated in the section on common planter types that follows. Some use differential air pressure (vacuum or pressure) to hold seed securely to individual cells of a seed plate or drum as the cells pass through seed from the supply hopper. Others use mechanical devices such as fingers or brushes to pick up individual seed. Those that attempt to singulate seed one-by-one utilize some method to attempt to eliminate “doubles” (i.e. two or more seeds being planted at once). Often a “cut-off brush” is used somewhere near the release point of individual seed into the seed drop tube to attempt to knock out any extra seed beyond the one to be planted. Metering systems as well as other areas inside the hopper, distribution system, and conveying tubes present opportunities for residual seed and plant material to hang up in the planter.

Beyond the metering system, seed is typically moved by gravity through a drop tube or in an air stream within a tube to a distribution device to insert seed into or on the soil. Augers, flight-chain conveyors and other devices also are sometimes used to move seed from one part of the planter to the next. Seed inserted below the surface layer into the soil is usually accomplished by some type of furrow opener (e.g. double-disc (figure 5), runner, hoe, or small sweep) that opens a small furrow. One or more depth-gauging wheels (figure 6), often located adjacent to the furrow opener maintains seed placement at a desired depth. A closing system (e.g. one or two press wheels (figure 7) or closing discs) moves soil back to close the open furrow and help establish seed-to-soil contact. Some types of seeders (e.g. grass) simply drop seed uniformly on the surface below the seeder or broadcast the seed from spinning discs. Later soil incorporation may occur with a secondary implement such as a harrow or roller.



Figure 5. Double-disc seed furrow opener

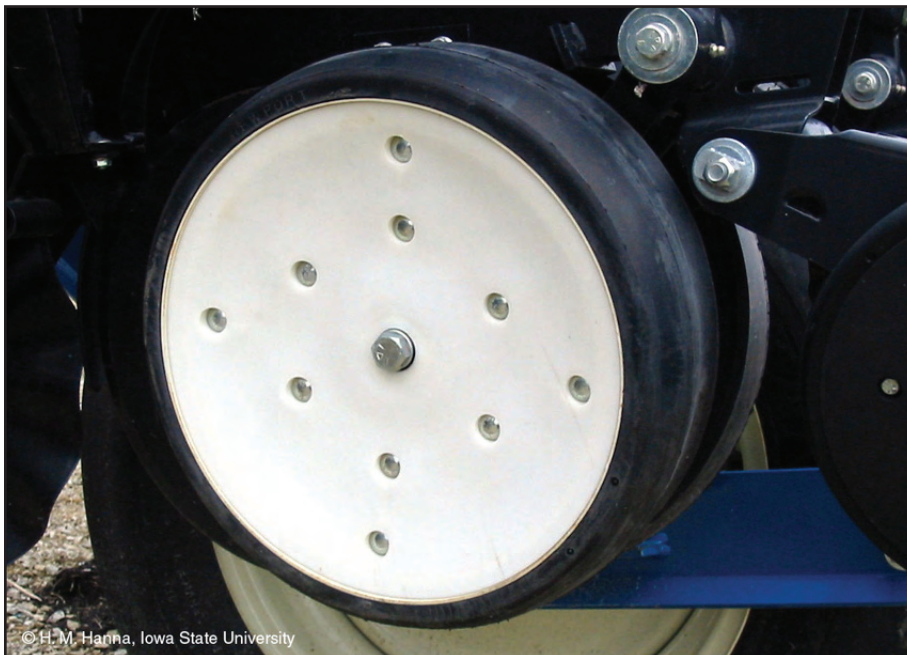


Figure 6. Depth-gauging wheel



Figure 7. Closing wheels

Common planter types

Details of several common planters with different metering systems and how to examine them are described. Trade and company names mentioned are for the benefit of the reader and do not infer endorsement or preferential treatment of the product named.

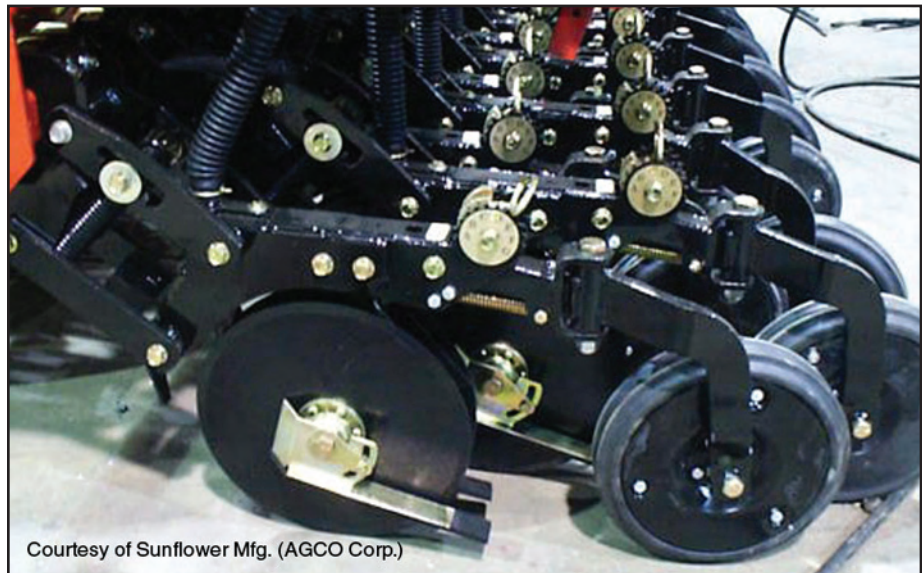
Grain drill

A grain drill is commonly used to plant small grains and in some areas for soybeans. Thoroughly inspect the seed hopper (figure 8), including all ledges and lids. In addition to interior ledges, a ground-driven agitator may be present in the hopper to prevent seed bridging. Seed is typically metered through adjustable orifices in the bottom of the hopper onto fluted metering rolls (figure 9), belts, or seed cups before being dropped through seed tubes (figure 10) to seed furrow openers (figure 11). Fully open seed discharge gates in the metering area. Check for openings at the top of the seed drop tube below the metering area and if present, open for inspection. Carefully rotate the metering rolls at least one full turn inspecting for remaining seed



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Figure 10. Seed drop tube on grain drill between meter and opener



Courtesy of Sunflower Mfg. (AGCO Corp.)

Figure 11. Seed furrow opener and press wheel on grain drill

John Deere row crop vacuum planter

On individual row units, remove the hopper, disconnect the attached vacuum hose (figure 12) and inspect the hopper. Open the seed meter housing door and remove the seed plate (figure 13). Inspect the brush, gasket seal area, and interior ledges. Check the area near the top of the seed drop tube before reassembling after inspection. Make certain seed openers are safely and securely supported in the raised position before inspecting the double-disc seed opener, depth wheels, press wheels, seed drop tube and lower frame. If there is excessive clearance between the depth wheel and seed opener disc

and tolerances are low for plant material, consider having the depth wheel removed to ensure stems, weed seed, or soil are not trapped underneath the depth wheel.



Figure 12. Disconnecting vacuum hose from hopper assembly



Figure 13. Door open showing vacuum seed meter with brush and gasket seal

Case IH planter with individual seed hoppers on row units

On each row unit, disconnect the vacuum hose (figure 14) and remove seed hopper. Inspect the hopper and small trap door discharge area near the base. Locate the seed metering mechanism below the hopper and loosen the clips

to open the metering mechanism. Pull the pin to remove the seed plate (figure 15) and expose the meter (figure 16). Inspect the interior of the meter including ledges and cut-off brush, seed plate and opening to the seed drop tube. Reassemble the metering system and reattach the vacuum hose and seed hopper following inspection. Making sure the seed openers are safely locked in the raised position, check the double-disc seed openers, exit of the seed drop tube, depth wheels, closing discs and planter frame.



Figure 14. Disconnecting vacuum hose



Figure 15. Seed meter with seed plate



Figure 16. Exposed seed meter after seed plate has been removed

Finger-mechanism type planters (John Deere and Kinze)

These types of planters use rotating mechanical fingers to trap individual seeds and carry them on to the release point to the distribution system (figure 17). The distribution system below the finger-type meter consists of a flexible conveyor belt with flights (figure 18) to carry individual seed to a seed tube inserted between double-disc furrow openers that drop seed into the seed furrow.

To inspect individual row units on this type of planter remove the seed hopper after first disengaging the seed drive (figure 19). Loose seeds often cause a rattling noise when the hopper and meter are shaken. Seeds wedged inside the metering mechanism are less likely but will not rattle and so the meter should be partially disassembled to inspect for them. To do this remove the seed meter attached to the lower part of the seed hopper by removing nuts on attachment bolts. Then loosen and remove the nuts holding the cover over the meter (figure 20). Inspect the finger mechanism (figure 17) and other exposed areas such as the cut-off brush near the seed exit to the conveyor belt. Further inspection can be done in the conveyor belt area by removing its cover; however, planter calibration may be affected if the belt becomes misaligned inside the housing during reassembly. There is a lower probability of seeds being caught in this area than in areas above it.

Following inspection, reverse steps to reassemble the meter and hopper row unit. Before reattaching the hopper/meter assembly, check the top of the seed drop tube and upper surfaces in this area around the double-disc seed opener and depth wheels. Either at this time or after all hopper/meter assemblies have been replaced check lower areas of the planter. Make sure openers are mechanically locked in the raised position before checking the underside of the furrow opener, seed drop tube exit, and closing wheels.



Figure 17. Finger-type metering mechanism with cover exposed



Figure 18. Belt conveyor used to deliver seed from meter to seed drop tube



Figure 19. Removing hopper/meter assembly after first disengaging seed drive



Figure 20. Cover over finger-type seed meter mechanism

Seed cup meters (John Deere and Kinze)

Older planters that use a finger-type mechanism for planting corn used a seed cup for some other crops such as soybeans. On an individual row unit, after disengaging the mechanical drive for the meter, remove the seed hopper and meter assembly. Remove two nuts to remove the cover (figure 21) and expose the seed metering cup (figure 22). Inspect the interior of the seed meter, inside of the hopper, and lower entrance of the hopper into the seed meter. Check the area around the top of the seed drop tube before reassembly of the meter and reattachment of the hopper to the planter. The underside of the planter including seed tube exit, bottom of the double-disc furrow opener, and closing wheels should be inspected after the openers have been raised and securely locked up.



Figure 21. Seed cup meter with cover



Figure 22. Seed cup meter after cover is removed

Brush-mechanism type planters (Kinze or John Deere)

A brush mechanism may be used on some planters with mechanical metering drives for gentler seed handling and when seed spacing uniformity is not as rigid (e.g. soybean planting). Seeds are commonly trapped inside brushes so the metering system should be disassembled for inspection.

For each row unit, disengage the seed drive and remove the hopper and meter assembly. Remove the two nuts holding the seed plate on the side of the meter (figure 23) and remove the plate. Inspect the meter interior, brushes (figure 24), and seed hopper. Inspect around the upper entrance of the seed drop tube before reattaching the reassembled meter and hopper assembly to the planter. Make sure the openers are raised and mechanically locked before checking the seed drop tube exit, and area around the bottom of the seed-furrow opener and depth and closing wheels.

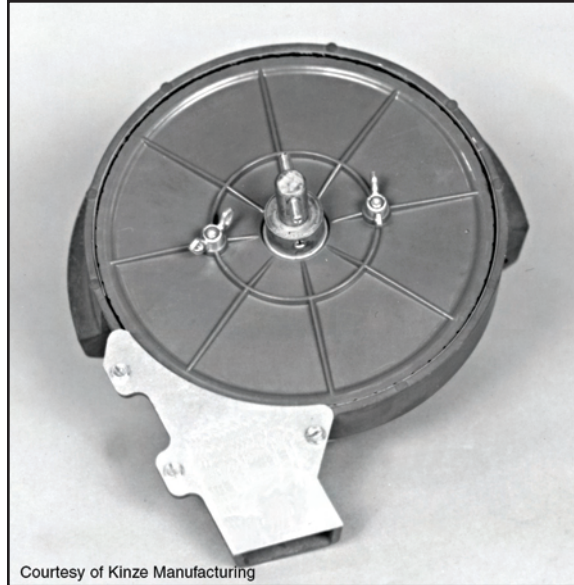


Figure 23. Brush meter with seed plate



Figure 24. Exposed brush meter opened after seed plate is removed

Case IH central seed hopper and metering drum

Older Case IH row crop planters use a large central seed hopper with an attached seed metering drum. Seed moves from the hopper into a metering drum with small cavities with perforated holes to hold individual seeds. The hopper and drum use pressurized air to hold the seeds in the perforated

cavities around the periphery of the drum until reaching a seed delivery tube at the top of the drum. At this point, the differential air pressure is nullified by covering the outer side of the perforated cavity with a rubber wheel. Seed drops into an air tube distribution system to individual double-disc seed furrow openers on each row. Gaskets around the hopper lid and seed drum used to seal the pressurized air from escaping are some of the areas that may hold residual seed or plant material.

To inspect the planter, open the seed hopper lid (figure 25) and remove the attached seed drum (figures 26, 27) from its center bolt mounting. Inside the seed hopper, closely inspect interior ledges including around the seed sensor (figure 28) and where different materials meet. Inspect the top lid and its gasketed seal and the exterior top of the hopper where seeds or material may rest. In the seed drum area to the side of the hopper, inspect ledges including the air intake flange (figure 29), brush, seed tube intakes (figure 30), and gate opening into the main hopper (close and open). Before replacing the seed drum, check around the gasketed seal. Reattach the drum to the side of the hopper and close the hopper lid. If possible, attach a tractor to the planter and re-pressurize the metering system to blow out seed tube lines. Make certain the planter furrow openers are locked in the raised position before inspecting seed tube exit, double-disc furrow opener, depth wheels, closing discs, and press wheels on each row unit.



Figure 25. Seed hopper with open lid (note gasket seal)



Figure 26. Seed drum on side of central hopper



Figure 27. Seed metering area after removal of seed drum



Figure 28. Seed sensor in bottom of seed hopper



Figure 29. Air intake flange underneath seed drum



Figure 30. Seed exits into air tubes underneath seed drum

White air planter

On each row unit, remove the hopper lid and also the end cap on the seed removal tube (figure 31) near the base of the hopper above the metering system. To remove the seed plate on the side of the metering system, remove its center attachment bolt (figure 32). Make sure the gate allowing seed to move from the hopper into the meter (figure 33) is open. Newer models don't use a seed removal tube, but instead place a funnel (figure 34) over the meter to collect seed when removing the seed plate. Carefully inspect the interior of the hopper and meter before reassembly. With the furrow openers securely locked in the raised position, inspect the underside of each row unit including the seed tube exit, double-disc furrow opener, depth wheels, and closing wheels. Manually rotate the discs of the furrow opener (use leather gloves for sharp coulter edges) and depth wheels to ensure seed falling from the meter area during prior clean-out was not trapped in these lower areas. If the planter toolbar frame has wings that fold for transport, remove and inspect inside tubes supplying air to seed meters on the left wing. When folded, seed may have fallen from the meter into these tubes.

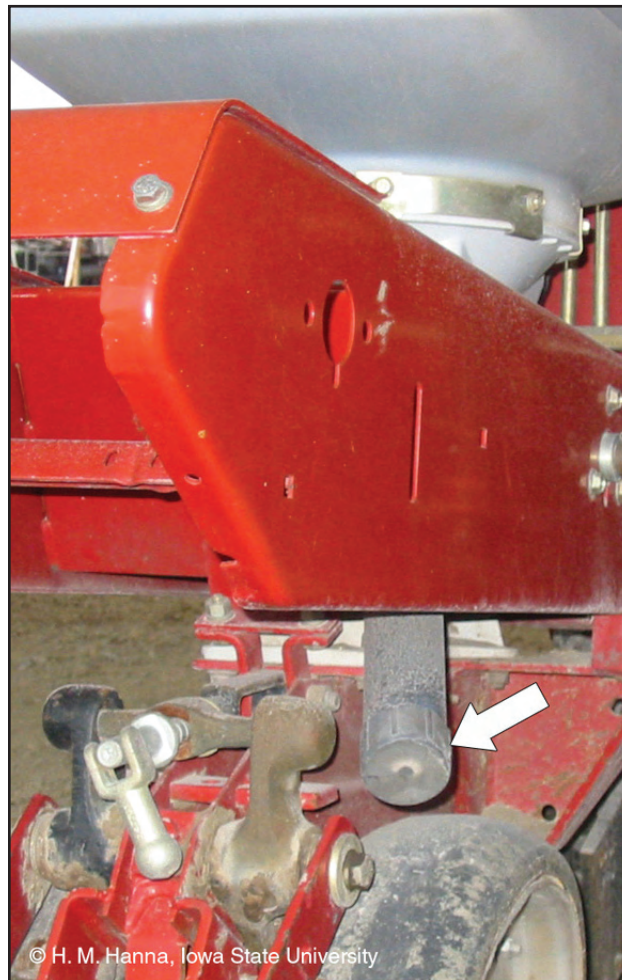
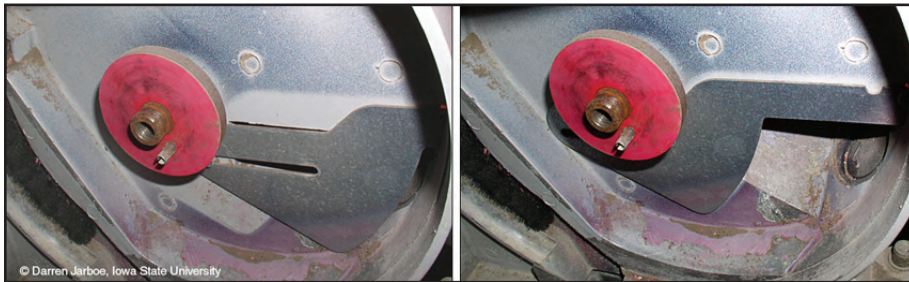


Figure 31. End cap on seed removal tube at base of hopper



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Figure 32. Seed plate fastened by center attachment bolt



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Figure 33. Gate from hopper into seed meter — (left) closed, (right) open



Courtesy of White Plains (AGCO Corp.)

Figure 34. Seed funnel used on side of meter on newer models

Air drill

An air drill (figure 35) is another alternative seeder for small grains and soybeans. Its name comes from using pressurized air to blow seeds from the

hopper and meter to the soil-engaging components to insert seed into the soil. Major parts of the drill are a large single hopper for the seed and a tillage implement frame usually with small sweeps attached. Seed is often simply metered by a conveyor into air distribution tubes. Each tube blows the seed to an exit behind the soil-engaging sweep which acts as the seed furrow opener.

Inspection steps are similar to those of a grain drill in the seed hopper area. At the meter, open any access gates and turn the metering mechanism if required to inspect seed holding cavities. Inspect the entrance of air tubes. Power the air supply if possible and observe any material blown from the tubes. Check around the air tube exits and soil-engaging components of the furrow opening devices making sure they are mechanically locked in the raised position before inspection.



Figure 35. Air drill

Closing inspection items

Final inspection steps for row-crop planters and grain drills with a gravity drop to the seed opener includes close inspection of the planter frame, transport wheels and virtually anyplace seed could land during planter operation and stick to equipment. Seed may adhere on soil that is built up just inside the seed tube exit (figure 36) or on any of the wheels touching the soil or soil engaging components. Seed may also adhere to exposed lubricating grease near bearings (figure 37). Inspection of the lower parts of the planter requires the seed openers to be raised. Be sure these units are mechanically locked in the raised position before inspecting the underside of equipment. During inspection in these areas, attempt to view equipment as often as possible from the side without being directly underneath it. Flex a few of the depth gauge wheels up and down while looking for biomaterial. If tolerances are low and significant material is found or if much space exists for material to be wedged between a depth wheel and adjacent coulter consider having some or all the depth wheels removed to inspect for material behind them (figure 38). In cases of very low tolerance, it may be desirable to disassemble the double-disc seed openers and inspect for any soil, plant material, or seed that may be trapped between the discs.



Figure 36. Seed tube exit

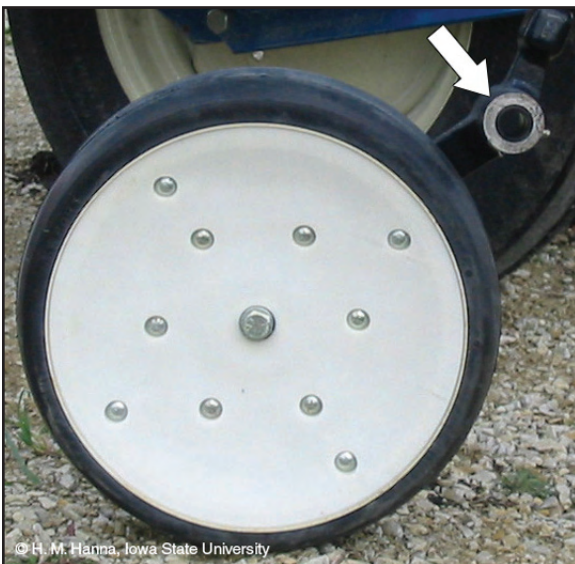


Figure 37. Bearing on support arm of depth gauge wheel



Figure 38. Depth wheel removed exposing disc on one side of double-disc seed opener

Plot planters

Seed companies need to build up supplies of desirable varieties and also compare yields and other traits among varieties in controlled tests over a range of soil and climatic conditions. Small plots are used for this purpose. Because a major objective is to keep varieties segregated during planting, plot planting equipment is much more frequently cleaned than planting equipment used on bulk commercial fields. Still, inspection is critical to avoid contamination by planting unwanted seed or exposing seed to other diseased plant material.

Since only a small number of seeds are planted in each plot, a supply hopper may not be present. Instead seeds are directly poured from a height through one or more gravity drop tubes onto the meter. Research work requires a unique metering mechanism that can uniformly distribute a specific number of seeds across a plot, allowing controlled comparisons between varieties. To do this, a certain number of seeds must be reliably singulated one-by-one. A common method for doing this is to drop seed onto the point of a cone-shaped meter with a specific number of seed cells around the base perimeter of the cone. The cone is relatively open and visible (figure 39) so that the operator may check to see that each seed cell cavity is filled. Once the seed cells are loaded, planting can proceed with the cone rotating individual cells over the seed drop tube behind the seed furrow opener. The mechanics of this lower distribution system to place individual seed into the soil are similar to those described for commercial planters.

Begin inspection at the top of the planter where seed is loaded (figure 40) above the metering mechanism. If gravity drop tubes are present, inspect around the entrances. A random splitter or divider may be used inside the tube to help distribute seed to different parts of the meter. If seed has been spilled during loading, it may have bounced almost anywhere on the planter frame (figure 41). Although the objective of keeping seed segregated in each plot implies that all seed should have been previously picked up and accounted for, spend some time checking surfaces, particularly anywhere an errant seed could have fallen and wedged.

If a cone-type meter (figure 39) is used, it will be generally open for visual inspection. If the meter is enclosed (such as a rotating seed plate filled by means of differential air pressure, similar to some commercial planter meters) it should be opened and inspected. Inspection of the distribution device to insert seed into or onto the soil follows procedures described for the corresponding commercial mechanism. Again, be sure that seed openers are mechanically locked in the raised position before inspection of these lower planter areas.



Figure 39. Seed metering cone on plot planter



Figure 40. Seed loading area on plot planter



Figure 41. Plot Planter