Precision Planter Components and Their Effects on Cotton Seed Placement and Emergence

Part 2 – Planning for planting operations; Seed monitoring and delivery; opening and closing systems; and reporting options.

Pedro Andrade-Sanchez, *University of Arizona*; **John Long**, *Oklahoma State University*; **Wesley Porter**, *University of Georgia*; and **Wes Lowe**, *Mississippi State University*

This document discusses precision planting with an emphasis on monitoring and control technology incorporated into planter systems. Part 1 of this paper is available from this link. The value to a cotton grower in implementing a new level of technical sophistication in planting operations is presented, keeping in mind that the fundamental concepts of good planting practices will always apply. Modern precision planting technology can be information-intensive; however, 1) there are many user-friendly options available from different manufacturers for data collection and management; and 2) gains in overall cotton production efficiency can be achieved by improving planting operations. A highlight of this series of papers is the ability for growers to adapt to these new trends by adding technology slowly at steady rates, one season at a time. There is no "one size fits all" in precision planting, there are options for a wide range of users' tolerance to digital technology, financial return on investment scenarios, etc. Precision planting is a flexible option that can potentially fit the conditions of every cotton producer.

Planning for Planting Operations

In the first paper of this series, we reviewed the basic principles of operation and the absolute need to properly set and calibrate all the mechanical components of the planter to ensure optimum performance. In this section, we go one step further in planning the planting operation, starting with checks and diagnostics of the major planter sub-systems to make sure all components are communicating and ready to operate. In many precision planting systems, the in-cab computer display/seed monitor can be used to configure the planter and run diagnostics. Figure 1 illustrates the major actuators used for real-time control in a modern precision planter.

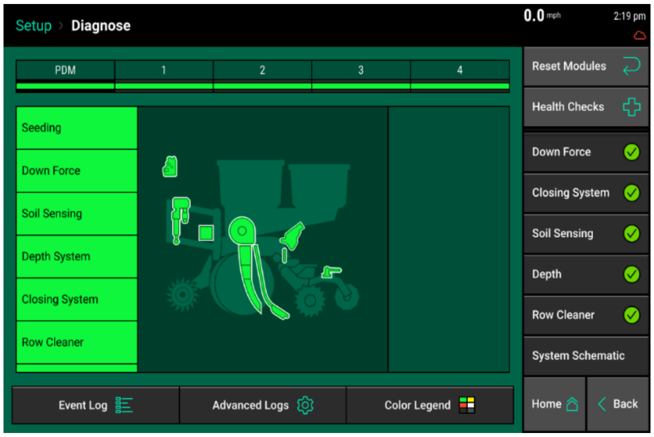

Figure 1. Tractor display illustration of different components for a Precision Planting system.

Another critically important aspect of preparation for planting operations is to provide the precision planter controller with an accurate GPS machine position signal, which can be obtained from the tractor guidance system. GPS signals are digital strings of data that can be used to calculate speed information as well, which is another use of GPS in a precision planter system. In addition to GPS, newer planter controllers use radar speed inputs that update much faster than GPS to improve machine performance, especially at high travel speeds. With the major components properly calibrated and communicating with the controller, the precision planter is ready to be taken to the field and capable of making quick on-the-go adjustments.

Prescription-based Planting

With a fully operational system, growers have the option of programming the planter controller ahead of time to select the desired seeding rates and seed trench depths in a range of values to fit the known variation of soil conditions in the field. These adjustments result from signals generated by the controller and dictate changes in the electric motors driving the seed plates as well as the disc opener depth linkages. Even though this level of functionality is achieved through manipulations at the computer level, current precision planting systems have a user interface with farmer intuition in mind.

Growers have many options when it comes to selecting commercial farm software to plan planting operations. Software packages offer the option to generate prescription maps using a personal computer. Current software versions allow creation of prescription files for plant population and seed trench depth, commonly measured in thousands of seeds per acre and inches, respectively. Note that most of the time seeding depth and trench depth will be equal; however, there can be uncommon circumstances when they are not, such as dry conditions when the side wall of the trench crumble and partially back fill the trench before the seed falls. To generate a prescription map, the user needs to import a digital template of the field, such as a soil survey, previous-year's crop yield, soil electrical conductivity maps, and/or any other spatial layer with soil/crop relevant information. Field boundary layers can be imported from other maps or drawn manually from the software interface. Attributes of these maps are then used in the digital template to draw polygons to delineate zones, which will define field areas with specific plant populations. Trench depth is another operational parameter that can be controlled with prescription maps, and on-going research is evaluating the benefits of adjusting seed trench depth on-the-go in cotton production systems. The created map is then exported as a shape file with instructions that the planter system will interpret. Prescription files are next loaded in the tractor cab display/seed monitor, which relays the information to the controller for real-time actuation while planting. The display screen in Figure 2 illustrates the system capacity to handle simultaneous prescriptions for variable seeding rates and seed trench depths.

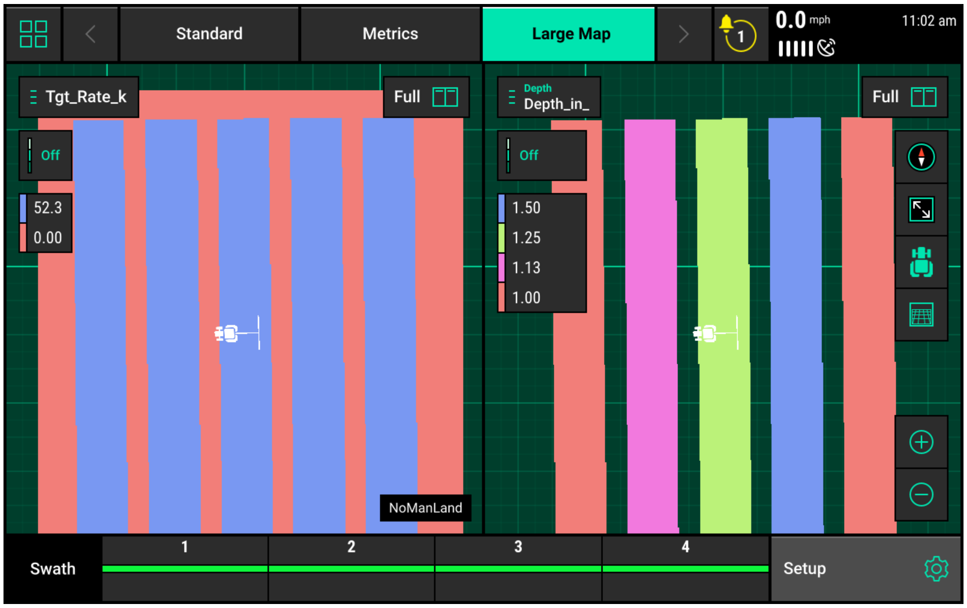

Figure 2. Tractor display screen showing simultaneous implementation of variable seeding rate (zero or 52,300 seeds per acre) and seed trench depth (1, 1-1/8, 1-¼, and 1-½ inches).

In addition to prescribed adjustments in seed trench depth and planting density, precision planters can implement real-time adjustments via soil information from sensor generated data. An example is the adjustment of seed trench depth based on soil moisture measured by instrumented seed firmers. As moisture content declines, seedling depth is increased under the assumption that soil moisture increases at deeper soil layers. The precision planter controller is then programmed to adjust depth within a user-defined range, seeking the right amount of moisture as observed on the tractor display. Therefore, instrumented seed firmers in precision planters perform two functions: one is to apply a mechanical load to firmly lodge the seed within the opened furrow; another function is to generate information on soil conditions such as temperature, moisture content, Cation Exchange Capacity, and organic matter.

Seed Monitoring

Seed monitoring provides information on a per-row basis in real-time to the planter operator. Information can include seeding rate, singulation, vacuum pressure, downforce, furrow quality, seed delivery, and performance of the weight-transfer system. This real-time information allows the operator to monitor these and other planter performance parameters and receive alerts whenever any of these parameters fall outside of their optimum ranges, indicating a problem or issue with the individual row units on the planter. The seed monitoring system can also be connected to a monitor in the tractor cab or guidance system display to spatially capture planter performance data for recordkeeping and further analysis as part of an overall precision agriculture management program.

Seed Delivery

Gravity Drop

Gravity drop tubes are typically the standard seed tubes found on many planters on the market today. Most of them are designed with a rear curvature to account for the forward movement of the tractor during planting. This curvature is typically designed to act much like a slide and change the direction of a falling seed rearward as it moves along the bottom edge of the tube to offset the forward operating speed of a planter. Seed tube bounce during planting can occur and will impact seed placement, uniformity, and spacing. Optical sensors at the middle or near the exit of these drop tubes register the final stage in the seed movement towards the trench. These signals are used by the controller to compute planting parameters such as population, percent singulation, and missing or double seed drops. This information is presented in real-time in the tractor display on a per-row basis to alert the operator of potential problems during planting.

Automated Seed Delivery

Automated seed delivery systems replace traditional gravity drop tubes and deliver seed from the seed meter to the lower point of the row unit and into the seed trench with more control, providing a more precise and uniform placement of seed into the furrow. These seed tubes often rely on a variable-speed belt working in tandem with the seed meter and coordinated with the planter's groundspeed to synchronize the rate at which seed moves to the seed trench to achieve a target planting population. Since seed in this system are regulated as they move through the seed tube assembly and do not rely exclusively on gravity as with traditional seed tubes, movements that tend to cause seed to move off-target, roll, or bounce out of the furrow as it impacts the seed trench is reduced, improving singulation, seed spacing, and stand uniformity. Optical sensors located near the seed tube intake monitor the seed as it enters the power drop delivery system, providing feedback to the controller for adjusting planter performance parameters to regulate seeding population in addition to identifying any skips or multiple seed drops, creating a detailed record of individual seed placement useful for advanced precision agriculture decision-making and analysis.

Seed delivery belts in power drop delivery systems currently in the market utilize two different constructions. Flighted belts, which are belts utilizing evenly spaced individual compartments to carry seed, are utilized in Kinze Manufacturing's TrueSpeed®, Ag Leader Technology's SureSpeed® and Precision Planting's SpeedTube® systems (Figure 3, left). Brush belts, utilized in John Deere ExactEmerge™ planting systems, allow seed to be inserted at any point along its' belt, allowing seed to be evenly spaced and can also accommodate clustered seed delivery as found in hill-drop cotton production systems (Figure 3, right).

Figure 3. Internal views of Ag Leader Technology's SureSpeed® flighted belt (left) and John Deere's ExactEmerge™ brush belt (right) seed delivery systems.

Row Cleaners

In many cotton farming systems, it is very useful to retrofit the planter with tooling designed to remove soil and/or plant residue ahead of the planter row unit. Row cleaners are particularly useful to growers using conservation tillage or no-tillage that by design must deal with large amounts of dead or live vegetation at the time of planting. In irrigated cotton, new research is looking at the possibility of using row cleaning systems to remove the dry layer of soil at the top of the bed, exposing wetter soil for seed placement. In conventional planters, row cleaners are commonly attached to the front of the row unit shanks, creating a mechanical interference with the system of forces and weight transfer whose function is to secure adequate engagement of the disc openers into the soil. Conventional row cleaners are solid fix mounted either to the frame or to the row unit shank. New row cleaner floating designs in precision planters have incorporated two important mechanical improvements. The first is a frame-mounted option to allow row cleaner adjustment to actuate independently of the downforce system of the row unit.

The second is the use of pneumatic or hydraulic actuators to transfer additional downward force to the row cleaner to increase their engagement with the soil and interface of vegetation residue.

Cotton growers have access to a wide variety of row cleaner systems to fit their needs and soil conditions. Figure 4 presents an example of an actuated row cleaning design with independent control of downforce and vertical positioning of row cleaning discs. A variable downward force is automatically controlled on-the-go, while vertical position of discs is a manual adjustment performed at the start of the planting operation. More discussion of row cleaner options for heavy residues is discussed in the paper at this link.

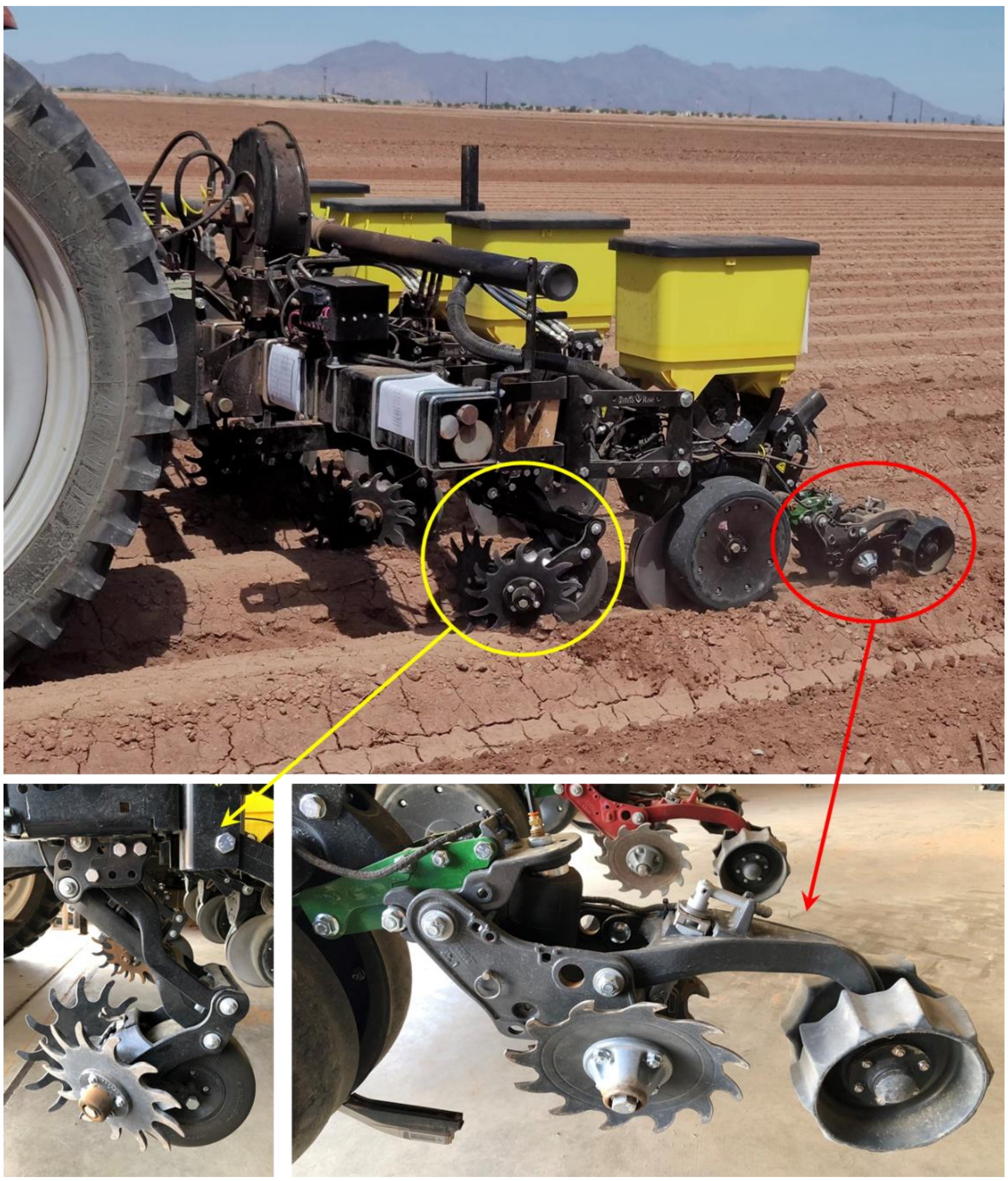

Figure 4. Four-row precision planter used during planting operations in Maricopa, AZ. The yellow circle on the left shows details of front-frame-mounted row cleaner. The red circle on the right shows the details of a two-stage seed trench closing system.

Seed-trench Closing System

With the seed trench open and the seeds delivered, it is time to finalize the planting operation and close the seed trench. The basic principle of closing systems is based on applying an external force to the area just above the walls of the seed trench which causes the walls to collapse and maximize soil contact with the seed. Conventional seed trench closing systems use two spring-loaded wheels or disks, with the spring tension set manually (Figure 5). Other systems rely on two concave disks which pinch the seed furrow and are followed by a trailing semi-pneumatic wheel. Growers can select from a large collection of closing wheels, from solid wheels and disks to designs with spikes and other protrusions designed to break up the walls of the seed trench with examples shown in Figure 5. In conventional closing systems, the type of closing wheel and spring tension are set within each field and must be changed with changes in residue and/or soil moisture. Newer two-stage closing systems offer two features to improve seed trench closing. The first is a pneumatically actuated pair of discs that shatter the soil around the trench walls. The downward force acting on these discs is variable and can be adjusted on-the-go. The second feature is the use of wide wheel tracks that close the trench and press the soil to improve the uniformity of soil around the seeds. Newer options for closing systems include the pneumatically-actuated two-stage closing system previously shown in Figure 4. Compared to conventional closing systems, two-stage closing systems provide additional soil shattering and mixing, leaving the soil on top of the seed in a mechanical state easier to break through during seedling emergence.

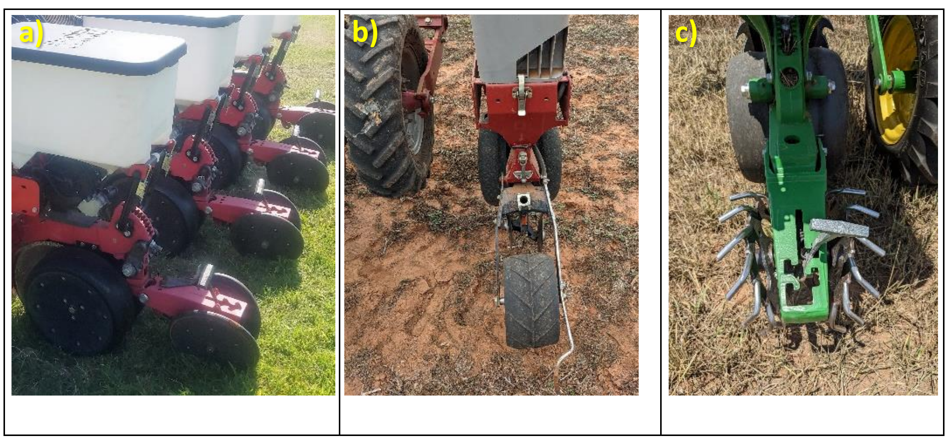

Figure 5. Examples of different types of spring loaded closing wheels: a) two solid wheels for independent action over each trench wall, these wheels are manufactured with different materials such as rubber or steel of similar shape but different weight; b) two concave disks facing each other with a trailing single wide solid wheel for action over the complete seed trenches; and c) spiked wheels for soil shattering of trench walls available in a variety of finger configurations for a range of aggressiveness.

Planting Operation Reports

Most advanced planting controllers provide the option to generate reports containing the values of all the parameters monitored during the planting operation. These reports can be of tabular form and maps that visualize the spatial distribution within the field of these parameters. These reports follow a basic hierarchy of grower-farm-field that is saved separately for every year/season of implementation. Planting operation reports are digital recordkeeping of great value that contain visual information in the form of maps. On the one hand, they provide the grower with raw data to “look back” and identify aspects of soil management and machine operation that deserve more attention to improve planter performance. These data also provide a platform to analyze the variation of the planter parameters in a spatial context within each field, enabling users to “look forward” and implement future strategies for variable-smart management in the form of prescriptions written to adapt to natural variations in soil type.

The current level of machine control achieved in modern precision planters makes it possible to plan and adjust to known soil type variations. However, equally important is the ability to adjust in real-time to small-scale variations in soil conditions. To take advantage of these increased capabilities and to ensure accuracy in system performance, it is important that setup and calibration procedures for each of the system components are performed. Confirm that GPS settings and any equipment offsets are correct, that the downforce system calibration for the row unit and closing system (if equipped) has been performed and conduct static testing for seed meters and automated seed delivery system to confirm that they are operating correctly.

Costs of Precision Planting Upgrades

The benefits of increased accuracy in seed placement and planting speed do come with a cost. Costs to upgrade an existing planter will depend on what components are already in place. For example, most systems will require an in-cab display panel and GPS system that many farmers already have. Some expenses that will be on a per planter basis, such as the control system and other items such as an air compressor. These costs can range from $5,000 to $10,000 per planter. And then other costs will be on a per row unit basis, such as adding automated seed delivery that can range from $1000 to $5000 per row. Thus, the costs to upgrade a 12-row planter can range from approximately $25,000 to $70,000. While this cost is significant, if it allows doubling planting speed while increasing the precision in seed placement, it could eliminate the need for a second planter and reduce labor requirements at planting.

Summary of Benefits from Advance Planting Technologies

The following are potential benefits from implementation of planter technology upgrades.

1. Variable rate seeding allows optimal plant populations based on field variation in soil attributes. For example, it can be possible to compensate for low germination rates with increased planting density when there are parts of the field with non-ideal soil conditions such as a high sand content or elevated soil salinity levels.
2. For fields that are not straight, turn compensation makes sure the planting rate is consistent on the inside and outside rows of the turn.
3. Variable depth seeding, within limits, can optimize seed placement according to soil moisture.
4. Variable weight transfer provides the ability to plant in compacted soil in reduced and no-till systems. Note that weight transfer is of limited value in conventional till systems where seed bed preparation usually results in a non-compacted plant bed.
5. Two-stage trench closing provides an opportunity to break the soil near the seed trench after the seed was delivered, and that is particularly useful in wet planting where the weight of the planter is concentrated in the gauge wheels resulting in compaction. The downward pressure roller is pneumatically actuated to adjust to mechanical state of soil at the point of closing the trench.
6. Row cleaning tines are actuated to adjust the downward pressure as they engage the soil ahead of the row unit that is a very important function in conservation tillage systems.
7. Improved seed singulation results in a more uniform plant stand.

Even more benefits may come as research is exploring the capability to create more complex planting layouts with these technologies. For instance, a gridded plant pattern could enable access to the field in two directions. As precision planting continues to evolve, cotton growers can expect significant improvements in production efficiency in the short to mid-term.

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