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Introduction

Performing diverse field soybean management research in small plots requires a highly adaptable planter. Variable row spacing, in-furrow applications of inoculants and fertilizers, and the ability to plant in no-till as well as using pre-packeted seed or a bulk seed supply are needed. We designed and constructed a 3-point hitch tractor-mounted plot planter that is capable of establishing research plots of various lengths in 38 cm or 76 cm rows and in conventional or no-till systems. Seed can be supplied in small packets for small plots (~23 m²) or in bulk for planting larger areas. Two in-furrow applicator systems can deliver liquid fertilizer or crop protection products and dry pathogen inoculants for disease investigations. A GPS-enabled seed cup tripping system is used to ensure accurate plot length and field position.

Our design objectives for the planter were:

1. Ability to plant soybean [*Glycine max* (L.) Merr.] and corn (*Zea mays* L.)
2. Conventional tillage and no-tillage systems
3. Pre-packeted seed or bulk seed supply
4. 6- 38 cm or 4- 76 cm rows (2.3 m or 3.0 m wide plots)
5. Small plots ranging in length from 4.5 m to 9.0 m or bulk planted plots
6. Application of liquid in-furrow crop protection products or in-furrow pathogen inoculation
7. Tractor guidance using GPS and automatic seed tripping technology
8. A 3-point hitch mounted planter with a maximum width of 2.6 m



Figure 1. Plot planter with tractor



Figure 2. Front of planter showing hitch, frame, drive wheels, and row spacing adjustment mechanism.



Figure 3. Rear view with operator platform, seed box, 76 cm row configuration, and dry inoculator.



Figure 4. Row units with closing wheels in 38 cm configuration.



Figure 5. Drive wheel and John Deere XP row unit with no-till coulter, row cleaner, furrow opening disk blades, and depth wheel.



Figure 6. Liquid in-furrow application system with 3 l bottles, electric valves, and optional 11 l bulk application tank.



Figure 7. Clockwise from top left: row cleaner height adjustment control, Computer-Trac monitor, and tablet computer with SkyTrip plot software.



Figure 8. Bulk seed planting configuration with 55 l hopper.

Future Design Improvements

- Speed proportional, variable speed drive for the dry inoculator

Equipment Description

Frame

15 cm x 0.75 cm thick and 18 cm x 0.75cm thick square tubular steel frame members with hitch points for 3-point tractor attachments. Two 110 cm long x 18 cm square tubes slide over the 15 cm tube to provide a mechanism to shift the planter units to accommodate both 38 and 76 cm row spacing on the same planter. Linear hydraulic actuators move the outer tubes and attached row units 19 cm both left and right to accommodate the two row widths.

Planter units

Six John Deere (Moline, IL) XP row units are each equipped with parallel linkage arms, two furrow-opening disk blades, adjustable down force springs, unit mounted fluted no-till coulters, combination rubber and spike tooth closing wheels, and Yetter (Colchester, IL) air adjustable (Precision Planting, Tremont, IL) row cleaners. Row cleaner height is adjustable using a control valve on the operators station. Seed depth is adjustable by varying the height of the depth wheels. Row units are staggered to improve residue flow.

Tractor

John Deere 6100D, open station, 4-wd, 73.7 kW agricultural tractor. Three point hitch mounting system utilizes a hydraulically adjustable top link for efficient planter leveling.

GPS and seed cup tripping system

John Deere GreenStar 3 system with a 2630 display and RTK equipped receiver and antenna. Auto steer equipped tractor using parallel tracking software on the 2630 display. Almaco (Nevada, IA) SkyTrip seed cup tripping software using GPS signal from John Deere GreenStar system. SkyTrip software runs on a Panasonic (Newark, NJ) ToughPad tablet computer.

Seed divider

Almaco Standard Cone Type Seeder with 31 cm diameter cone and 31 cell divisions. Cone speed (and thus plot length) is adjustable using a Zero-Max (Plymouth, MN) adjustable speed drive. Seed from the cone is dropped into a 4- or 6-port divider for delivery to the seed tubes on the row units.

Drive wheel system

Two rubber tires provide distance-proportional input rotation for the cone seeder and bulk seeding population transmission. The drive wheels and seed transmission were previously used on a John Deere 7300 planter.

Bulk planting

Large size soybean or corn plots can be planted in 38 cm or 76 cm rows using 55 l seed hoppers and a finger pickup seed metering mechanism for corn and a radial bean seed meter for soybean. Population is controlled using the seed transmission. The seeding operation is monitored using a John Deere Computer-Trac 250 population monitor connected to seed tube sensors on each row. Speed input data is provided by the GreenStar GPS system.

In-furrow applicators

Liquid crop protection products or fertilizers can be applied in-furrow using an air pressurized system. Five treatments can be loaded on the planter in 3 l plastic bottles. Pressure and flow rate are adjustable using disk orifices and air pressure. Flow is monitored using a floating ball visible flow monitoring sight glass. Products can be applied through a Schaffert (Indianola, NE) fertilizer tube attached to a seed rebounder, in Totally Tubular (Aberdeen, SD) tubes, or as a spray over the furrow using nozzles placed ahead of the closing wheels. A three way liquid valve is employed on each row unit for fast clean out.

Dry granular inoculants can be delivered to the seed furrow through a Gandy (Owatonna, MN) applicator. Application rates are adjustable using various sprocket combinations from the electric drive motor. Typical uses are applying *F. virguliforme* infested oat (*Avena sativa* L.) or sorghum [*Sorghum bicolor* (L.) Moench] seed while planting soybean plots. Inoculants can be applied to all rows or to 2 of 4 rows to provide a treatment split.