a lower conductance than more mature roots (Sanderson et al., 1988).

Flow rate measurements for cotton root systems with and without cortex on the cut stem are shown in Fig. 1. Removal of cortex for a short length at the upper part of the root system did not cause a significant decrease in root system conductivity in the nutrient-solution-grown plants but did significantly reduce conductivity of sand-grown root systems at 12, 24, and 36 DAP. Salim and Pitman (1984) found that removal of cortex reduced axial flux of water on sunflower, (*Helianthus annuus* L.), bean (*Phaseolus vulgaris* L.), and tomato (*Lycopersicum esculentum* L.) to a much greater extent than our results with sand-grown cotton. We cannot determine from our data why nutrient-solution-grown roots responded differently from sand-grown roots to removal of cortex.

In conclusion, there were major differences in hydraulic conductivity of cotton root systems that were associated with plant age and with the rooting medium in which the plants were grown. Hydraulic conductivity of young cotton roots was 4 to 10 times greater when the roots were grown in half-strength Hoagland's solution rather than sand.

Hydraulic conductivity of roots grown in either medium was about twice as much at 12 DAP as at 24, 36, and 48 DAP. Errors in measurement of hydraulic conductivity associated with axial flow of water along the cortex were not significant in nutrient-solution-grown plants but were significant in sand-grown root systems.

Large errors will probably occur when hydraulic conductivity values for cotton grown under one root environmental condition are used to model water uptake rates in another root environment.

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RESEARCH PLOT PLANTER FOR FURROW IRRIGATED CROPPING SYSTEMS

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ABSTRACT

Commercially available research plot planters are primarily designed for dryland and/or sprinkler irrigation systems. Research plot establishment in cropping systems involving furrow irrigation requires a planter with an adjustable drive system for diverse furrow spacings. Tool bars should have no interfering support brackets. These features will provide the flexibility needed for a wide range of row and furrow spacings. The planter was designed and constructed for establishing research plots in furrow-irrigated cropping systems. The planter drive wheels provide flexibility for furrow spacings ranging from 0.25 to 2.2 m. Two tool bars with no interfering support brackets allow numerous row spacing arrangements for seed and furrow openers. The planter can be adjusted quickly (approximately 1h) for different furrow systems, and thus, used for research and/or extension demonstration purposes both on- and off-station.

RESEARCH in furrow-irrigated cropping systems presents an investigator with unique plot establishment problems. Furrow spacing affects row spacing and drive wheel position. A small difference in width between the furrow and planter drive wheel will cause the planter to ride up and down along the surface of the furrow resulting in lateral planter travel.

In research plots involving furrow-irrigated cropping systems, a furrow operation must take place either pre-, during, or post-establishment of plots. Field areas that are furrowed before seeding must often be refurrowed because of wheel tracks in tractor turnaround areas. The furrowing operation(s) requires extra time, and if performed following seeding, will often disrupt planted rows, especially in solid-seeded stands. Ideally, experimental plots in furrow-irrigated cropping systems should be seeded and furrowed simultaneously.

Presently, a planter employing one tool bar and a seed opener mounted close to the furrower is used to establish solid-seeded crops. This arrangement often results in accumulation of soil and debris between the furrow and seed openers which results in poor furrow formation and disruption of the seeded rows.

Commercially available and previously described

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research planters have one tool bar and predetermined spacing of drive wheels (1,2,3,4,5,6,7). Adjustment of these planters to accommodate small differences in furrow spacing is difficult. We designed and constructed a three-point hitch tractor-mounted plot planter that features: (i) an adjustable drive system for diverse furrow spacings, and (ii) two tool bars with no interfering support brackets for seed and furrow openers.

Design and Description of the Planter

The lower frame is constructed using two 102- by 2440-mm seamless square steel tubing inserted through square holes in two 152- by 1220- by 19-mm thick pieces of flat metal stock (Fig. 1). The dimension of the lower frame is a 1220- by 2440-mm rectangle. A smaller 51- by 2440-mm square steel tube is inserted through a square hole in the flat iron 101 mm behind each larger bar and used for the tool bars (Fig. 2). The wall thickness of all square tubing is 6 mm.

The upper frame is constructed of 51-mm square tubing and 51- by 51- by 4-mm angle iron (Fig. 1). The angle iron was used in forming the top of the upper frame and bracing. The upper frame is 1650-mm tall by 1370-mm wide by 1370 mm in depth, and it is connected to the lower frame by eight 2.1-mm U-bolts. A three-point hitch tractor-mount assembly provides stability when raising and lowering the planter. Tractor lift arms attach to the front 102-mm square tube of the lower frame. The third link is tied to both upper and lower frames using a yoke and centered support bracket to the rear 102-mm square tube.

The drive system consists of two John Deere[1] (Moline, IL) 381- by 102-mm gauge wheels mounted on the rear 102-mm square tubing of the lower frame (Fig. 3). These wheels provide the drive and depth control for the planter. A screw adjustment is used to move the wheels up or down in a range of 457 mm. Attached to the wheels is a 165-mm by 40-tooth sprocket on which roller chain runs from the wheel sprocket to a 76-mm by 16-tooth sprocket mounted on a 22-mm hex shaft. American National Standards Institute no. 40 roller chain was used throughout the design. Spring chain tighteners are mounted on the axel frame and operate on the slack side of the roller chain. The hex shaft runs the full width of the planter providing ease in changing drive wheel positions. An 89-mm by 17-tooth sprocket on the hex shaft connects by roller chain to an Almaco (Nevada, IA) gear transmission. Ten gears on the transmission provide a range of plot lengths from 1.8 m up to 12.2 m. Longer or shorter plot lengths can be obtained by changing the sprocket on the hex shaft. From the transmission, a 76-mm by 16-tooth sprocket on a 19-mm shaft (Fig. 4) drives a 19-mm shaft running across the

[1] Mention of a trademark, proprietary product or vendor does not constitute a guarantee or warranty of the product by the Univ. of Wyoming and does not imply their approval to the exclusion of other products or vendors that may also be suitable.

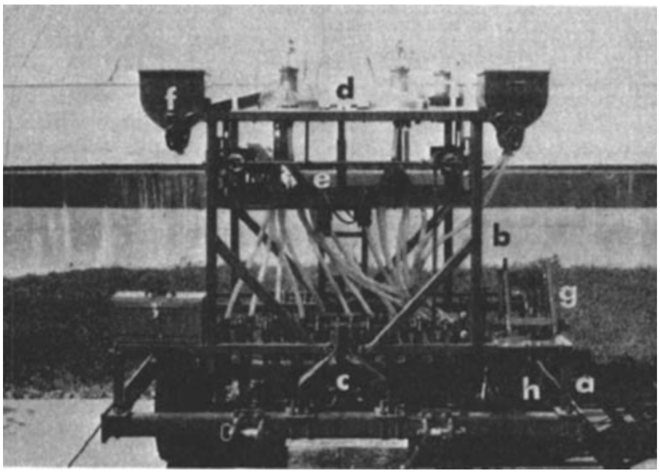

Fig. 1. Front view of planter: a. lower frame, b. upper frame, c. 3-point hitch mount, d. seed dispersion console, e. spinner unit, f. bulk seed box, g. drive system, h. drive and gauge wheel.

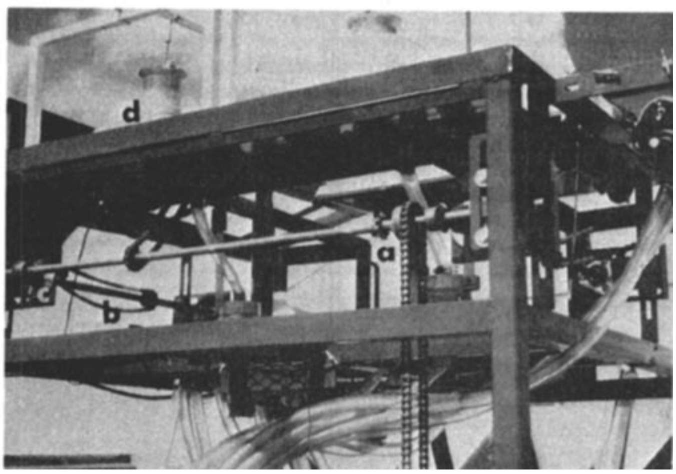

Fig. 2. Side view of planter: a. front tool bars, b. rear tool bars, c. hose receptacles, d. transmission.

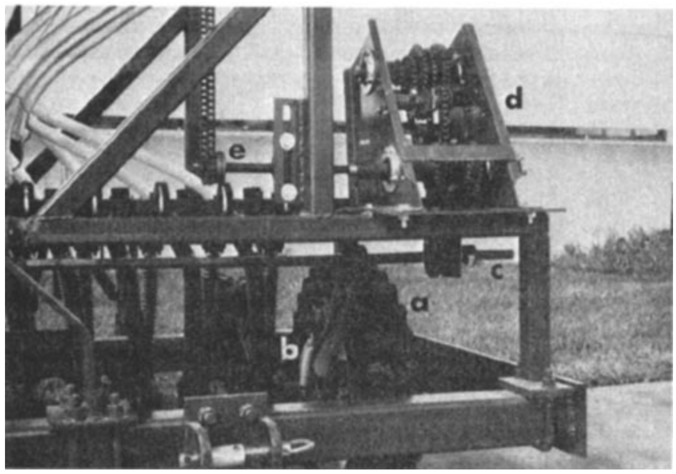

Fig. 3. Planter drive system (lower frame): a. drive wheel, b. chain tightener, c. hex shaft, d. transmission, e. output shaft.

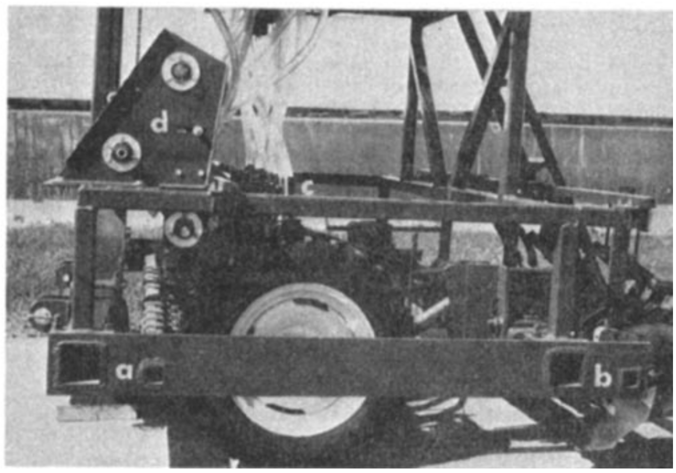

Fig. 4. Planter drive system (upper frame): a. front shaft, b. side shaft, c. bevel gears, d. cone unit.

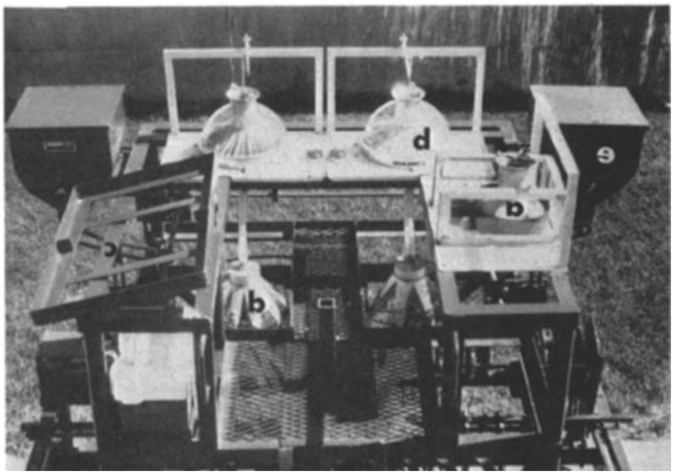

Fig. 5. Seed dispersion console: a. belt cone, b. fluted cone, c. seed tray holder, d. spinner unit, e. bulk seed boxes.

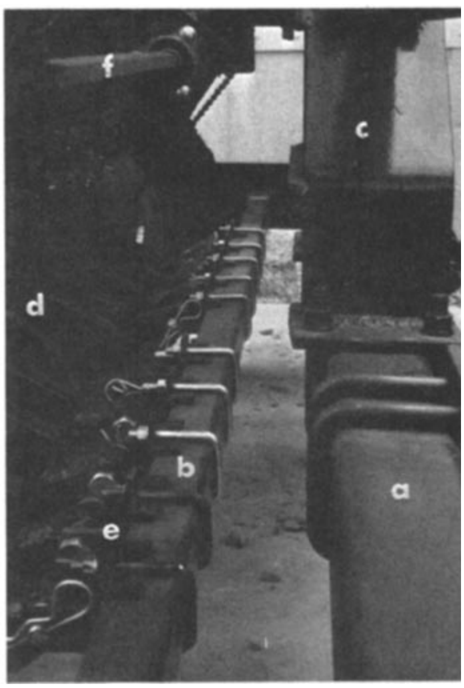

Fig. 6. Front tool bars: a. 102-mm square tube, b. 51-mm square tube, c. third link yoke, d. grain drill double disk openers, e. clamps, f. hex shaft.

front of the upper frame. Two 19-mm shafts on the right and left sides of the upper frame are driven by bevel gears. Seed distribution units are driven by roller chain and 51-mm by 12-tooth sprockets on the front and side 19-mm shafts of the upper frame.

Seed distribution is accomplished by mounting two KEM (Haven, KS) 32-cell fluted cones, a KEM belt cone and two 18-kg Gandy (Owatona, MN) bulk applicator boxes on the top of the upper frame (Fig. 5). These units are funneled into two KEM spinner divider units mounted 0.40 m below the top of the upper frame. The spinner divider units are driven by 12-volt electric motors which can be connected to a slow drain marine battery or the electrical system of the tractor. Sixteen John Deere grain drill double disk flex openers are attached to the front and rear 51-mm square tool bars by a clamp and quick release pin (Fig. 6). These openers can be positioned anywhere on the tool bars. Space is available to run packer wheels behind the openers. Depth control of the individual openers is achieved by the use of John Deere Tru-Vee adjustable depth bands or bolt-on depth bands.

Performance of the Planter

The planter has successfully established plots both on- and off-station using various furrow spacings, and in fields that require simultaneous planting and furrowing operations. Seeding of experiments involving 2-row spacings has been performed in one pass of the planter. Extremely narrow row spacings commonly found in intensively managed cereals have been seeded with this planter. Furrow openers mounted on the rear tool bar reduce the accumulation of soil between seed and furrow openers. The attachment of coulters on the front 51-mm square tube would allow this planter to be used in minimum-till systems.

Seed distribution of many crops is easily accomplished using fluted and belt cones as well as bulk seed boxes funneled through the spinner divider or directly into the seed openers (Fig. 5). Other distribution methods, such as vacuum and pneumatic delivery systems (3), could be mounted on the console.

The front 102-mm square tube has interfering support brackets because of the three-point hitch mount assembly (Fig. 1). The rear 102-mm square tube on which the drive wheels are mounted has one centered support bracket. The two 51-mm square tubes which are used as tool bars have support brackets attached on the outside edge, but no brackets along their 2.4-m length (Fig. 2 and 6). This arrangement allows for numerous row and drive wheel spacings for plot establishment. An improvement would be to position the 51-mm square tubes as diamond tubes thereby increasing their strength.

The planter is easily transported by trailer. The planter is 2.31-m high, 2.44-m wide, and 2.06-m long and weighs 800 kg. The speed of establishing research plots in furrow irrigated cropping systems is approximately 150 plots h^{-1} (6.7-m plot length). The planter drive wheels allow flexibility for planting in furrow spacings ranging from 0.25 to 2.2 m. Furrow spacing adjustments require approximately 1h.

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