A cassette air seeder for cereal breeder plots

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The design, construction, and operational assessment of a cassette air seeder for cereal breeder plots has been completed by the Swift Current Research Centre (SCRC) of Agriculture and Agri-Food Canada’s Research Branch. The seeder was designed to automate the planting of small cereal plots used in the evaluation of breeder seed lines, allowing the evaluation program to expand through more efficient use of labour. Seed placement accuracy and sample integrity has been maintained or improved over the conventional envelope or former cassette seeding system.

La Station de recherche de Swift Current, qui relève de la Direction de la recherche d’Agriculture et Agroalimentaire Canada, vient de terminer la conception, la construction et l’évaluation du fonctionnement d’un semoir pneumatique à casier alvéolé. Avec un tel appareil, l’automatication du semis des petits lots servant à évaluer les lignées de semences de grains permettra d’accroître le volume des activités, grâce à l’utilisation plus efficace de la main-d’œuvre. La régularité du semis et l’intégrité des échantillons sont égales ou supérieures à celles obtenues au moyen de l’ancien semoir à casier ou des pochettes habituelles.

INTRODUCTION

Increasing cost of labour and shrinking government budgets for research in Canada provide constant pressure for design engineers to improve the efficiency of plot operations. Plant breeders and agronomists have, however, sought to enlarge the number of breeding lines to be evaluated while simultaneously reducing costs and maintaining or improving seed placement accuracy.

Plot seeding equipment at the Swift Current Research Centre (SCRC) has tended to be self-propelled (Dyck 1972). Three point hitch seeders for specialized purposes have been constructed for forage and cereal use as well (Bjornestad and Lauer 1991). The design chosen for the new cassette air seeder was a conventional pull-type due to the small size of the desired tractor and the need for sufficient seeder weight for four zero-till openers to penetrate the soil. The cassette seeder is used in many phases of cereal breeding agronomy, physiology studies, specialized nurseries, breeder seed increase, and cereal pathology trials. See Fig. 1 for an overall view of the cassette air seeder and Fig. 2 which shows critical elements of the seeder in schematic.

OBJECTIVES

Cereal breeders and field crew at the SCRC approached the design staff to develop a cereal plot seeder with the following objectives. The seeder should be able to:

1) efficiently handle a large number of plantings of different seed lines in a replicated experimental design, with seed placement in rows or hills (or nests) spaced 450 mm apart,

2) seed in row lengths from 1.5 to 7.5 m,

3) seed in three different row spacings: 225, 300, and 450 mm,

4) simultaneously interseed spring cereals with winter cereals for material separation between plots,

5) accommodate a wide variety of seed sizes from rape-seed and flax to durum wheat and oats,

6) operate in zero, minimum, or conventional tillage conditions,

7) change simply and quickly from row to hill planting, one row length to another, and one row spacing to another, and

8) be constructed inexpensively.

DESCRIPTION

Cassette seed system

The seeder designed by the SCRC was based on the use of two different sizes of seed cassettes supplied by Precision Machine (Lincoln, NE). The small cell cassette can contain up to 100 durum wheat seeds and is suited to hill planting or rows up to 1.5 m in length. The large cell cassette holds up to 300 durum seeds and is used when row lengths greater than 1.5 m are required. See Fig. 3 for an illustration of the two cassette formats employed. The cassettes offer several advantages over envelope seed systems to cereal breeders. Each envelope is the equivalent of an individual cell and must be filled and emptied individually by the technician. Experimental designs can be laid out in the cassettes prior to seeding when labour is more readily available. Inoculation of seed for bunt or other diseases borne on the seed surface can be easily done by technicians, a task made more difficult and time consuming by the envelopes used to hold individual seed samples. The seed is protected from wind by the cassette and lid assembly; therefore a cab is not required on the seeder, reducing seeder cost. Accuracy of seed placement is readily assured by the semi-automatic placement of seed as controlled by the electronic controls. Seed placement in hills is much faster from the cassettes due to the nature of the seeder design since stopping is not required. The major disadvantage of the
The cassette is indexed to its proper position by a cam and roller operated microswitch. The 12 VDC indexing motor is easily reversed to remove jammed cassettes or relocate a cassette to a specific seed row. There are two centre sections provided with the seeder, one for each cassette format. See Fig. 4 for a photograph of the seed distributor.

The seed samples are exposed to an airstream provided by a low volume, high pressure, hydraulically driven fan and are transported to cyclones for air/seed separation. The hydraulically driven fan is a Cincinnati model PB10A with a 320 mm radial wheel and an output of approximately 9 m³/min at 14 kPa static pressure. Fan speed is typically 3200 rpm for small seeds (flax, canola, and mustard) and 3500 rpm for coarse cereals. Exhaust air from the cyclones is collected into the fan intake with a variable bleed valve regulating the amount of air allowed to enter the otherwise closed system. This technique regulates the negative or positive pressure on the trap doors of the cyclones and can help the speed of seed delivery when hill planting.

Four cyclones are required (one per seed row) for air/seed separation. The barrels of the cyclones measure 130 mm in diameter and are constructed with a 180° spiral in the barrel to deflect incoming material and air downwards. The cone section is designed with a vertical fin located on the periphery and angled 45° to the side wall. This fin reduces the time required for the seed to spin down and drop onto the trapdoor at the bottom of the cyclone. Electric solenoids connected to trap doors at the bottom of the cyclones control the timing of the seed drop onto the seed cones or directly to the openers for hill planting. Hill planting is accomplished by shifting the cyclones forward and installing hoses which connect the cyclones to the openers directly. The cyclones are mounted on a rack and slide assembly with two detent positions to ensure accurate cyclone location and ease of changing between row and hill planting.

**Seeder controls**

An electronic control panel monitors the fan speed, coordinates the automatic indexing of the cassette to the next sample, and the opening of the cyclone trap doors. The operator manually initiates the indexing cycle for row plant-

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**Fig. 1. Swift Current Cassette Air Seeder.**

**Fig. 2. Seeder schematic.**

cassettes is that a large plot trial can be easily spoiled if a mishap occurs while transferring the loaded cassettes.

The automated seed distributor was designed so that the cassette could be left in an upright position, with the lid remaining on during the entire seeding operation. The distributor is constructed of three sections, an infeed section where a full cassette with a lid is placed, a centre section consisting of the seed collection tubes, drive motor and rotors, and an outfeed section which automatically ejects empty cassettes into a holding bin for removal when convenient.
Fig. 3. Cassette formats.

by pressing and releasing the ‘PULSE’ button, while hill planting is indexed automatically. The indexing motor and solenoids are interlocked so that the solenoids must be closed before cassette indexing can occur. This interlock can be manually overridden by the ‘MOTOR’ and ‘SOLENOID’ push button switches. A row/hill switch allows either manual indexing and cyclone operation, or automatic operation during hill planting. Hill spacing requires a cam and microswitch operated by the main seeder drive.

Row length is adjusted by changing sprockets driving a SCRC zero-max (infinitely variable speed drive) or by adjusting the SCRC zero-max. This allows the operator to quickly change the seed cone drive ratios from row lengths of 1.5 m to 7.5 m. During hill planting, the cones are not required and a clutch lockout latch is engaged to save unnecessary cone wear. The clutch operates the cone drive when the openers are in the soil, disengaging when the openers are raised.

Seed placement

The cones used for seed spacing during row planting are the SCRC belt cones (McLauflin and Dyck 1986) which provide a relatively uniform seed spacing without the expense of precision space planting equipment. The opener is a SCRC design incorporating a zero-till style disc opener and a choice of two different packer systems which also provide depth control for more precise seed placement. Depth is determined by the position of the packer retaining arm. A simple spring and clevis pin pair make this change easy to perform. Zero-till operation requires the use of a 300 mm diameter, 22 mm wide packer (John Deere part no. AA33297). Conventional tilled operation requires the use of a 330 mm diameter, 50 mm wide packer (Dutch Industries, Regina, SK).

Winter wheat interseeding between rows of spring wheat requires the use of the seed box located at the front of the seeder and a second set of five openers operated from a separate hydraulic lift and rockshaft. These openers are similar in design to those used for breeder seed placement. A clutch is provided on the winter wheat drive so that it can be easily disengaged when not required. The winter wheat openers are easily removed from the toolbar and the hydraulic ram and rockshaft are easily moved to allow seed row spacings other than 450 mm.

The winter wheat and breeder seed openers are clamped onto a 50 mm square steel tube (6.4 mm wall thickness). The frame width of the seeder is designed to allow different combinations of opener spacings including the three considered essential for SCRC operations: 225 mm, 300 mm, and 450 mm. The main seeder frame is constructed of 50 mm wide, 76 mm deep rectangular steel tubing (4.8 mm wall thickness) and is suspended on two small tractor grip tires on hubs that are easily adjusted to prevent interference with seed rows.

Tractor requirements

The seeder is designed to connect to a Ford 1510 or equivalent tractor with either a hydrostatic or gear type transmission. Protective check valves in the hydraulic lines ensure proper flow direction and fan operation. A minimum of 23 L/min hydraulic flow at 12 MPa at rated engine speed is required for proper seeder operation. Another check valve has been placed in the fan motor loop to allow the fan motor
to spin down should the tractor hydraulics be interrupted in any way. The seed distributor and electronic panel require 12 VDC from the tractor electrical system. A cable connecting the tractor battery and the seeder controls was furnished with a standard 110 VAC - 3 prong connector to provide breakaway protection and low cost convenience.

OPERATION AND PERFORMANCE

The design group now has four seasons of operational experience with the cassette air seeder. The design has evolved from a prototype to two final versions, one with hoe openers and the other described here. A nursery in California was planted in October by the seeder with hoe openers, with an average of 120,000 samples planted in a combination of 1.5 m, 3 m, and 6 m rows and hills containing from one to 25 seeds. Problems with seed cassette variability have virtually been eliminated. A small amount of flax may carry over due to the occasional seed being ejected from the cyclone slide slot. However, mixing of seed samples including flax, canola, and mustard has not been reported as a problem, with breeding staff satisfied with the final plot establishment results. The use of seed envelopes is accommodated by the removal of the exhaust hoses from the tops of the cyclones and the insertion of funnels to aid in pouring accuracy. Bridging of large seeds, such as field pea, can be a concern. The cyclone trap diameter has been enlarged from 18 mm to 22 mm to alleviate this problem.

Failures of trap door solenoids have been experienced infrequently, but accelerated failures have occurred when the solenoid duty cycle was improperly set. The microswitch on the indexing motor has been replaced by one with a higher current rating and has not failed since replacement. Hydraulic fan operation on both hoe and disc opener seeders has proven reliable under field conditions. Fully automatic row planting operation has been attempted. An electronic distance counter operated by the seeder drive wheels has been used to determine row length and cassette index position, but repeatability has been a concern with some cereal breeding staff. This option may be reconsidered for zero-till field operations where field marking in advance of seeding may pose problems.

The seeder has proven very versatile and adaptable. Row spacing (facilitated by marks scribed on the toolbar), cassette size, and packer changes require approximately 25 minutes each by a single individual. Changing the distributor centre section for each cassette size is easier and faster when done by two individuals. Difficulties with proper positioning of the cassettes within the distributor can occur when tray thickness or environmental conditions (temperature and humidity) vary significantly, requiring operator time and attention.

The seeder requires little regular maintenance. Grease fittings on the toolbar bushings, openers, and clutch assembly require lubrication once per week. The cyclone slide assemblies require graphite to be sprayed on them once per season.

ACCESSORIES

Field markers are provided to aid plot seeding accuracy. These markers consist of spring-loaded packer wheels similar to the zero-till packers used with the seed openers. The markers are mounted on toolbar extensions that are easily removed for transport. A separate three point hitch mounted plot marker has been constructed to create marks in breeder seed plots on 2.4 m centres or multiples of 2.4 m up to 7.2 m centres. The wings of this unit are designed to be raised independently by the use of an inexpensive hydraulic splitter valve served by a single hydraulic spool from a small (Ford 1210) field tractor. The marker is easily dismantled into sections small enough to fit inside a standard full size pickup truck box.

CONCLUSIONS

The Swift Current Research Centre Design Group has successfully designed and constructed a cassette air seeder for use on cereal breeder plots. An example of the engineering success of this design is that the use of the seeder has allowed cereal breeders to quadruple the size and number of seedings in a winter nursery with no additional labour. The quality of the harvested samples has improved, indicating that the cassette seeder maintains a high degree of seed sample purity. The unit has also been successfully used to plant canola and flax.

Therefore, the design objectives set out in the INTRODUCTION section of this paper have largely been met. The seeder has not been tested under zero-till conditions, so potential problems with opener penetration and drive wheel slippage have not been assessed. Engineering work is continuing to improve the ease of operation, especially during distributor changeover and ease of manufacture. The latter is especially important if the design is to be successfully commercialized.

REFERENCES


Note: Mention of brand names does not imply product endorsement.