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Seeding Depth Regulation Controlled by Independent Furrow Openers for Zero Tillage Systems*

— Part 2: Control System of Independent Furrow Openers —

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Abstract

Incorrect seeding depth causes poor seed germination, low seedling emergence and poor crop yields. To address this, a control system employing a unique method of regulating seeding depth via an independent furrow opener was designed and built. This study evaluates the performance of this system. Actual soybean seeding showed significant differences in seeding depth between the controlled and uncontrolled rows in the zero tillage treatments and conventional tillage treatments where the plow and rotary tiller were used. The control system effectively placed seeds at the correct depth and seedling emergence was positively improved.

[Keywords] control systems, precision farming, furrow opener, sensors, tillage, seedling emergence

I Introduction

The main purpose of seeding is to place the seeds at a certain distance and depth in the seedbed (Karayel *et al*., 2004). The operator must not seed too shallow to avoid predation and seed drying, and not too deep to avoid seeds from consuming their stored nutrients before they reach the soil surface during germination (Ozmerzi *et al*., 2002). Correct seeding depth plays a crucial role in increasing the success rates on seedling emergence, stand count, and crop yields.

Several studies (Siemens *et al*., 2007; Bowers *et al*., 2006; Tasaka *et al*, 2004; Tessier *et al*., 1997) have been conducted in controlling seeding depth. Most of these studies control seeding depth by adjusting the position of the gauge wheels of the seeder or by elevating the implement frame. They are mostly tested on conventional tillage (CT) fields where soils are soft and with smooth soil profiles. However, with zero tillage (ZT) fields, achieving correct seeding depth becomes a challenge. The soils are hard to penetrate, the soil profiles are rough and the moisture content varies within the field. Moreover, modifying a Japanese seeder for precise zero tillage seeding on Andosols (high clay content soils) posed a great technical challenge.

As discussed in Part 1 of this study, the first control system had high hydraulic power requirements, poor response times due to the weight of the whole seeder unit, and required enhancements to properly perform. A new hydraulics-based control system that directly adjusts the depth of an isolated furrow opener based on the current soil profile to regulate the seeding depth is presented in this study. The furrow opener was selected in the first part of this study (Burce *et al*., 2012a).

The objectives of this study are to develop a prototype of the new control system and to evaluate its seeding performance based on seeding depth and seedling emergence.

II Materials and Methods

1. Prototypical control system

A tractor propelled Japanese seeder (Tabata TJEV-4LR,), commonly used for conventional tillage seeding, was the seeder selected for testing (Fig. 1). It has four independent seeder units equipped for dual-band seeding and fertilization. Fig. 2 (a) shows the original setup of the seeder unit with the fertilizer unit and some parts omitted.

The seeder unit ❶ is attached to the mainframe ❷ via its arm link system ❸. The mainframe maintains a relative fixed height from the ground via two gauge wheels ❹. The metering system ❺ dispenses the seeds ❻ at the target seeding depth (z_{seed}). The target seeding depth is strongly

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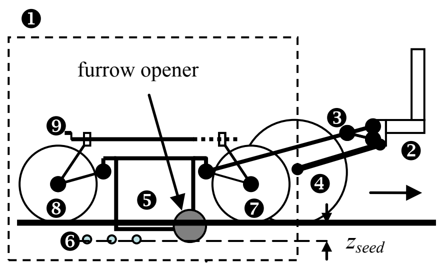
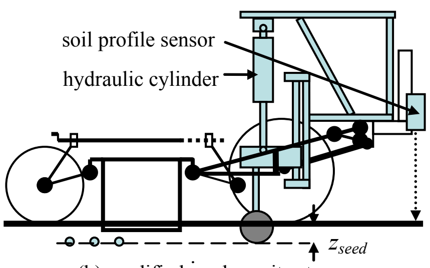
influenced by the working depth of the disc furrow opener attached to the metering system. The front presswheel ❼ and rear presswheel ❽ follows the soil profile to maintain uniform seeding depth as the tractor moves forward. The adjustment lever ❾ lowers and raises the furrow opener via the presswheels to set manually the target seeding depth.

The first control system (Burce *et al*., 2012b) automatically lowered and raised the whole seeder unit. The seeding performance of the control system was penalized by the weight of the seeder unit that resulted to poor response time and high hydraulic power requirements. To address the problem, the furrow opener attached to the metering system was detached and directly controlled by the control system. This is shown in Fig. 2 (b). The hydraulic load could be decreased with only the furrow opener to control, thus allowing multiple seeder units to be controlled and increasing the cylinder response time.

Fig. 1 Tested Japanese seeder



(a) original seeder unit setup



(b) modified seeder unit setup

Fig. 2 Modification with new control system

The tested seeder was then modified and installed with a double acting hydraulic cylinder (Ace System AS0404, 145 mm stroke) held by a cylinder frame. The cylinder frame was attached to the mainframe of the seeder to position the cylinder above the independent furrow opener. A linear rail guide (Misumi SX2WTLZ42-440 and SRZL42-440) stabilized the vertical movement of the furrow opener.

The cylinder lowered and raised the furrow opener based on the current soil profile monitored by a look-ahead soil profile sensor (Keyence UD320, 1 mm resolution) and an amplifier (Keyence UD300). The soil profile sensor was attached on the mainframe, in front of the seeder unit, and in-line to where the seeds are dropped. The soil profile sensor measured the relative distance (height) from the sensor head to the surface of the soil profile. An electro-hydraulic valve (Ace System TSB-2339) acted as a bi-directional switch that controlled the flow of the hydraulic fluids from the tractor auxiliary port to the cylinder and vice versa. A stroke sensor (Ace System AS0801, 145 mm stroke) measured the linear displacement of the cylinder stroke. Fig. 3 shows the developed control system.

Fig. 3 Major components of new control system