

Original papers

Development of an electro-mechanic control system for seed-metering unit of single seed corn planters Part I: Design and laboratory simulation



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ABSTRACT

The performance of precision planters is very important for attaining uniform seed spacing. While a planter is on work, undesired situations such as spinning and slipping on ground wheel, vibration, seizing and jamming on the chain-sprocket systems may occur during the transfer of the motion from the ground wheel to the seed-metering unit especially at high operating speeds. In order to overcome these problems, it was aimed to develop an electro-mechanic drive system (EMDS) for seed metering units of a classic single seed planter. The performances of the EMDS and the classic drive system (CDS) were tested at three different operating speeds (v_f) (5, 7.5, 10 km/h) and ten different seed spacing (z_c) from 6 to 29.3 cm at laboratory. Both systems were compared regarding to the seed spacing uniformity. When the EMDS was used, the quality of feed index (I_{qf}), multiple index (I_{mult}), miss index (I_{miss}) and precision index (I_p) were ranged as such: 2.91–95.36%, 0–1.73%, 4.45–97.09% and 8.79–22.14%, respectively. At the test of the CDS, the performance indices varied as such: I_{qf} 2.09–98.55%, I_{mult} 0–0.36% and I_{miss} 1.09–97.91%, I_p 5.79–20.92%. Seed spacing uniformities were found as “good” and “moderate” for both systems. Average seed spacing values obtained from the EMDS were found to be closer to the theoretical seed spacing values compared with that obtained from the CDS. EMDS enabled the suggested optimum seeding rate, a quick and simple setting possibility, synchronization and real-time control, the ability to work under higher speeds, individual movement and control for each metering unit. However, EMDS should be tested to determine the success of the system in practice. Therefore, the field performance of EMDS with respect to plant spacing uniformity and operational parameters (variation among rows, fuel consumption and negative slippage) were examined in the following part of this study (Part II: Field Performance).

1. Introduction

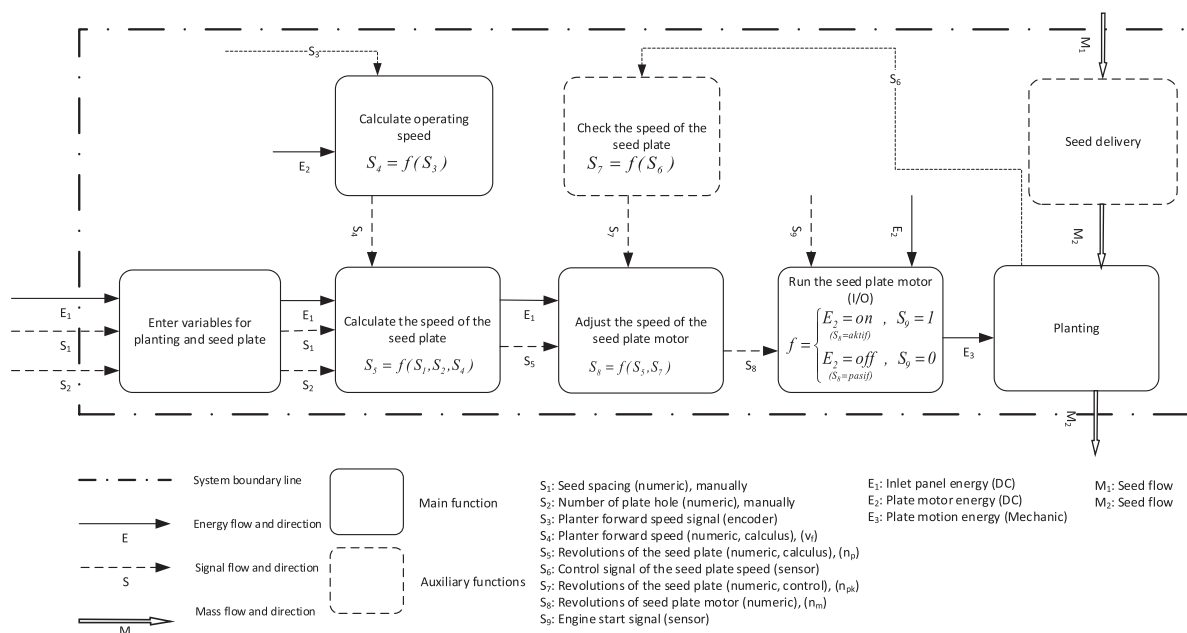
It is very important to equally distribute the moisture and plant nutrients in the soil among the plants during the growth period. In addition, uniform plant spacing in the field has direct effects on grain yield per unit area (Liang et al., 2015; Miller et al., 2012; Zhan et al., 2010). In other words, another means to decrease yield loss, competition between plants and production cost is to plant the seeds at a uniform spacing. This can only be possible by using precision planters (Karayel, 2009; Ozmerzi et al., 2002). The performance of precision planters during planting is very important for attaining uniform seed spacing. The most important component that directly affects the performance of precision planter is seed metering unit (Karayel et al., 2006; Miller et al., 2012; Navid et al., 2011; Yazgi and Degirmencioglu, 2014). Seed metering unit has generally been the component that has been worked the most during the development period of precision planters. Studies have been carried out mostly on the constructional properties of the seed planter drum, its position (horizontal or vertical),

hole shape and size as well as vacuum pressure (Singh et al., 2005; St Jack et al., 2013).

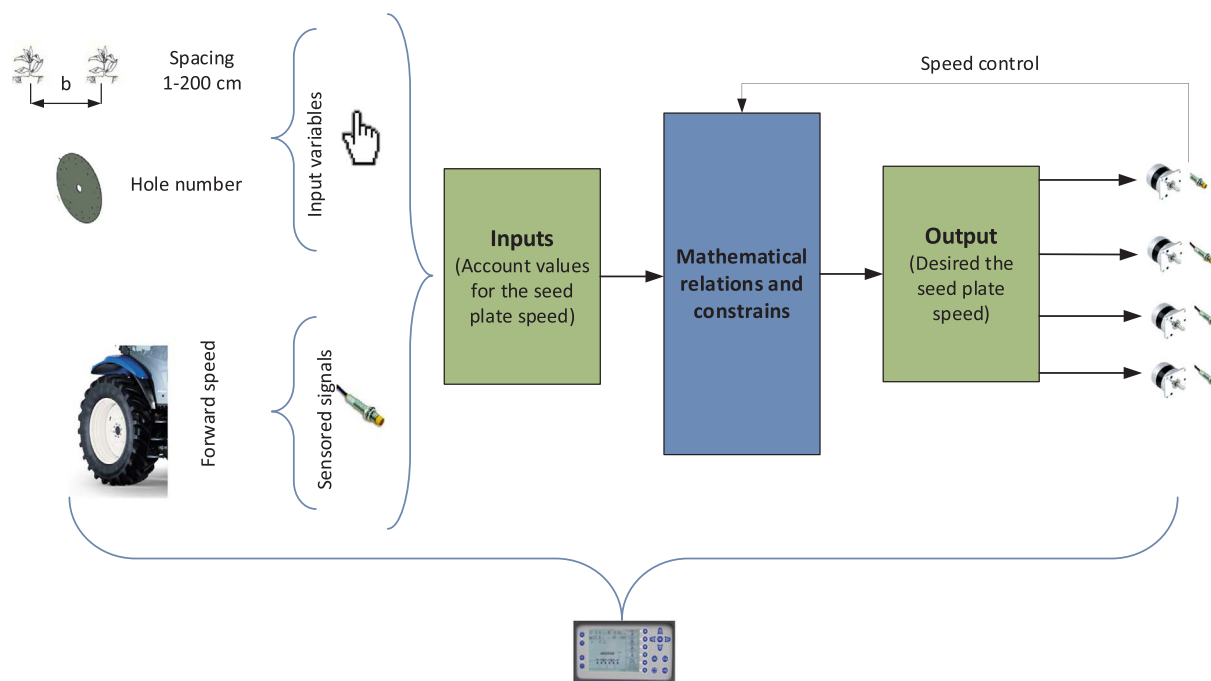
The motion obtained from ground wheel in precision planters is changed by way of mechanical drive components such as chain-sprocket, gear box and shafts. Thus, the speed of the seed plate is adjusted for reaching the desired seed spacing. These machines are frequently used presently and even though they are accepted to have the sufficient performance, they still have many shortcomings. Undesired situations may occur especially during the transfer of the motion from the ground wheel to the seed metering unit at high speeds such as spinning and slipping on ground wheel, vibration, seizing and jamming on the chain-sprocket systems (Iacomi and Popescu, 2015; Liang et al., 2015). For example, studies conducted using different precision planters pointed out to a negative slippage between 6.08% and 8.77% and expressed the necessity to improve the transmission components of planters (Aykas et al., 2013; Yalçın et al., 2013). These negativities limit the operating speed. Another important subject is planting the optimum number of seeds in per area, shown in the seed manufacturing

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(a)



(b)

Fig. 1. Functional (a) and schematic (b) design of the electro-mechanical drive system.

companies' catalogues that is suggested from the adaptation studies, in order to obtain maximum yield.

In planters with mechanical transmission systems, seed spacing can be adjusted by changing the limited and stepped transmission rate allowed by the gearbox. Furthermore, the number of holes on the seed plate is another element that indirectly limits the transmission rate and

the desired seed spacing. Therefore, less or more than the required number of seeds may be planted in a unit area, and it changes the yield and increases the operating costs.

In order to overcome the negativities mentioned above, there have been recent efforts for developing hydraulic and electronic controlled driving systems to drive the seed metering units more precisely without

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