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# Design, development and field assessment of a controlled seed metering unit to be used in grain drills for direct seeding of wheat

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A B S T R A C T

A new controlled seed metering unit was designed and mounted on a common grain drill for direct seeding of wheat (DSW). It comprised the following main parts: (a) a variable-rate controlled direct current motor (DCM) as seed metering shaft driver, (b) two digital encoders for sensing the rotational speed of supplemental ground wheel (SGW) and seed metering shaft and (c) a control box to handle and process the data of the unit. According to the considered closed-loop control system, the designed control box regularly checked the revolution per minute (RPM) of seed metering shaft, as operation feedback, using its digital encoder output. The seeding rate was determined based on the calculated error signal and output signal of the digital encoder of the SGW. A field with four different levels of wheat stubble coverage (10%, 30%, 40% and 50%) was selected for evaluation of the fabricated seed metering unit (FSMU). The dynamic tests were conducted to compare the performance of installed FSMU on the grain drill and equipped grain drill with common seed metering unit (CSMU) at three forward speeds of 4, 6 and 8 (Km/h) for DSW. Results of the FSMU assessment demonstrated that an increase in forward speed of grain drill (FSGD) and stubble coverage did not significantly affect the seeding rate in the grain drill for DSW. Using the FSMU reduced the coefficient of variation (CV) by approximately 50%. Consequently, applying the FSMU on the common grain drill led to a desirable seeding rate at different forward speeds of the grain drill and stubble existence.



## 1. Introduction

The main goal of precision agriculture is to control agricultural inputs such as seeds, fertilizers and herbicides to match the necessities of specific soil fertility levels. Moisture content and fertility are the most important soil variables influencing optimum seeding rate in the field. The optimal seeding rate varies depending on variable parameters, soil moisture and fertility. Maximum yield in farmlands notably occurs in the optimum seeding rates [1].

In many farms, direct seeding is carried out through the conservation tillage and maximal stubble on the land.

*Abbreviations:* ANOVA, analysis of variance; CSMU, common seed metering unit; CV, coefficient of variation; DCM, direct current motor; DMRT, Duncan multiple range test; DSW, direct seeding of wheat; FSGD, forward speed of grain drill; FSMU, fabricated seed metering unit; GDDW, grain drill drive wheel; GPS, global positioning system; LCD, liquid crystal display; PATA, parallel advanced technology attachment; PID, proportional-integral-derivative; RPM, revolution per minute; SGW, supplemental ground wheel.

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Researchers announced that the planting machines reduced their efficiency on the farm with stubble and the accuracy of their planting decreased severely [2–5]. It occurs due to the lack of suitable traction between the GDDW and soil which leads to decreased seed planting uniformity. Previous studies have shown that the yield will be decreased, when the seed planting is non-uniform [6–8].

In the recent years, main changes have arisen in the seed metering mechanism of grain drills in specific situation. The general and ordinary forms of the seed metering mechanism of the grain drills have been replaced with the pneumatic metering devices [9–15]. However, the GDDWs have been used as a planting mechanism, being a very traditional form of operating the seed metering device. It worked through the GDDW and its transmission was powered by the GDDW and chain, the GDDW and belt or the gearwheel.

One advantage of application of electronic measurements and control systems in the planters is the elimination of the mechanical friction which occurs within mechanical transmission systems. Several studies have aimed at upgrading the mechanical seed metering device to the electrical [16,17].

White et al. [18] designed and built a grain drill which was able to plant different types of cereals in single or multiple furrows. Switching between type of seeds was controlled by a computer which used GPS as a locator. Their results showed that the average accuracy of 5.5 (m) for switching at the forward speed of 7.2 (Km/h) was obtained for the variation of types.

Jafari et al. [19] statically calculated the time of the response to the applied changes for different seeding rates through installing a DCM on the metering device shaft of grain drill and using GPS. Results of their performance trials indicated that the response time of low-to-high and high-to-low transition seed rates were 7.4 and 5.2 (s), respectively.

Kamgar et al. [20] designed and prepared a mechatronic system to improve the performance of row-planter machines. The system used a main processor, an electromotor and an electronic circuit in order to activate the operation of seed metering unit. According to their findings, the mechatronic system had fewer seeding space errors than the mechanical system.

Jianbo et al. [21] built a control system which used a Hall sensor to measure the working speed of planter and employed a single-chip microcomputer system to calculate the rotational speed of seed metering unit. The system effectively reduced the influence of inhomogeneous sowing caused by the GDDW slip.

According to the practical observations for DSW, the main source of error in precise seeding rate and non-uniformly spacing in the use of grain drills was GDDW skidding. GDDW skidding is the result of lack of required traction between GDDW and soil, land topography and high resistant torque on the GDDW axis. In addition, the stepwise output of seed metering unit transmission of conventional grain drills leads to poor seeding rate control.

To beat this conflict, the planter must be modified in order to overcome the GDDW skidding on the stubble. It can be achieved by increasing the synchronization condition between the wheel rotation and the seed metering rotation in the common grain drills for DSW. This crucial problem may occur due to lack of necessary rotation transfer from the GDDW to seed metering device by mechanical joint.

As it can be found from literature review, there is no attempt to optimize the performance of seed metering unit for direct seeding. Thus, the objectives of the present study were design, fabrication and field performance evaluation of a new controlled seed metering unit useable in grain drills to improve the uniformity of seeding space for DSW.

## 2. Materials and methods

### 2.1. *Design and fabrication of seed metering unit*

Fig. 1 shows the block diagram of CSMU. The rotational speed of GDDW was transferred to gear box of seed metering unit via sprockets and chain. The gear box changed the rotational speed and delivered it to seed metering device via sprockets and chain based on the gears setting of gear box.

The ordinary mechanical transmission system was eliminated from the grain drill and it was replaced with an electronic system and the SGW. The system worked in a way that the RPM of the SGW was measured with an electrical sensor. After processing and applying some sorts of indices on the measured RPM, it was then sent as a voltage to the variable-rate DCM to rotate seed metering shaft of the grain drill. In present study, the steps of changes in the mechanical seed metering unit were performed as follows:

1. Mounting a SGW on the grain drill. The SGW rotated without skidding. There was no mechanical joint between the SGW and seed metering unit of grain drill.
2. Use of the digital shaft encoder as a sensor on the SGW, in order to sense on-the-go rotational speed of the SGW of grain drill.
3. Installing the variable-rate DCM on the seed metering shaft of the grain drill as the drive force supplier.
4. Applying the digital shaft encoder as a sensor on the seed metering shaft, to sense on-the-go rotational speed of the seed metering device.
5. Fabricating the electronic control system to receive rotational speed data from SGW, commanding the variable-rate DCM of the seed metering device and recording some information such as the FSGD and rotational speed of the seed metering shaft.

Fig. 2 presents the block diagram of the designed seed metering unit. Rotational speed changes of the SGW affected the rotational speed of seed metering device directly. Although the rotational speed of seed metering shaft was precisely determined by the variable-rate DCM, the frictional forces among mechanical joints did not allow the seed metering device to rotate expectedly. Therefore, the mounted digital encoder on the seed metering shaft measured the actual rotational speed of seed metering device. It was sent to control box as the error signal. The control box determined the

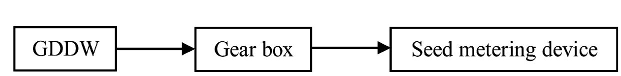


**Fig. 1 – Block diagram of CSMU.**