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Development and performance evaluation of a control system for variable rate granular fertilizer application

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ABSTRACT

A study was conducted to develop a control system for variable rate application (VRA) of granular fertilizers and evaluate its performance. By the use of a microprocessor, a pneumatic cylinder and a rotary shaft encoder, the manual mechanical fertilizer rate adjustment system of a seed drill (SOLA TRISEM 294/R ESP, Model: 37193 TIPO250) was modified and transformed to a real-time automatic control system. Laboratory based tests were conducted to evaluate the developed system performance in automatically applying the predetermined desired application rates at different ground speeds, which were within the range of 3–12 km h^{-1}. Linear regression and ANOVA tests were among the measures used to assess the accuracy of the developed system. Results of this study revealed that the developed system enabled an efficient automatic setting of the desired fertilizer application rate. The investigated operating speeds showed no significant effects on the performance of the system ($P > F = 0.7968$). In addition, the system exhibited an overall application rate error (difference between desired and actual application rate) of ± 2.6%. The response time of the developed system was found to range between 6 and 11 ms for a change of one kilogram in the application rate.

1. Introduction

One of the features of modern agriculture is the investment of scientific and technological feedbacks to improve productivity, both quantitatively and qualitatively; and therefore, enhance the agricultural economic efficiency. A basic goal of the agricultural research in the developed countries, where high-yielding varieties are used with massive use of agricultural chemicals, such as fertilizers, is to protect the environment while farming (Iida et al., 2001). The information age has enhanced the opportunities for integrating the technological evolution into different precision agriculture (PA) applications (Whelan et al., 1997). PA has been defined as being a compilation of operations and tools to estimate the farming needs and apply them exactly in the optimal location at the best time (Dong et al., 2013; Mulla, 2013). Therefore, it is efficiently used to improve the efficacy of agricultural chemical applications by tailoring the application rates to fit the different requirements of different field locations (Robert, 2002; Batte and Arnholt, 2003).

To evaluate the productivity of a particular field, the variability in field soil characteristics influencing the plant growth and health must be studied and comprehended. Understanding the spatial variability of different soil attributes within agricultural fields is the corner stone of successful PA practices and efficient decision-making processes (Adamchuk et al., 2004). It is also considered as an essential part to optimize agricultural management practices and determine the environmental impact due to agricultural activities (Cambardella et al., 1994). Variable rate application (VRA), which refers to the implementation of agricultural inputs in a site-specific manner according to the specific needs of different locations across agricultural fields, is considered as the basis of PA (El Nahry et al., 2011). Maps of different soil characteristics are usually the means that VRA uses to apply different agricultural inputs and practices, such as agricultural chemicals, irrigation water, seeds and soil tillage (Lan et al., 2008). There are two types of VRA, namely, (i) the map-based which is relying on prescription maps and (ii) the sensor-based which is relying on a real-time feedback from onboard sensors (Grisso et al., 2011). It was reported that the map-based VRA was the most commonly used due to the lack of sensors with sufficient precision for monitoring soil and crop conditions (Ess et al., 2001). By nature, VRA can enhance the usage efficiency of inputs for optimum crop production and agricultural economic efficiency. On the other hand, regulating the amounts of agrochemicals applied to agricultural fields can greatly reduce the environment contamination that can be caused by the excessive use of these chemicals.

Various types of variable rate applicators for granular fertilizers

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