Seeder and Precise Granular Fertilizer Application Control System for Zero-Tillage Crop Cultivation

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Introduction

Zero-tillage cultivation is a type of tillage system where the crops are cultivated in narrow slots or tilled strips leaving an undisturbed soil. Conventional tillage cultivation is the traditional plowing of the field. Compared to conventional tillage cultivation, zero-tillage reduces: soil erosion, air pollution, machine wear, soil compaction, and saves a lot of time and money especially during field preparation. Zero-tillage crop cultivation requires seeding and fertilizing mechanisms to be able to handle residue, penetrate hard soil, regulate seeding depth, cover seeds, and provide sufficient soil-seed contact. Thus, zero-tillage seeder is heavier and stronger than conventional tillage seeders but in some instances conventional tillage seeders can be converted into a zero-tillage seeder.

The objective of this study was to add new functionality to the fertilizer application and seed depth mechanisms of a conventional tillage air seeder so that it is ready for zero-tillage cultivation. Functionality and performance test on the effects made by the converted seeder on crop yields for both the conventional tillage and zero-tillage cultivation of soybean and sugar beet was conducted.

Method

A pneumatic air seeder (TABATA, TJEV-4LR) with granular fertilizer application system was tested in this study. This is a 4 row seeder that is commonly used in Japan. The fertilizer application system was custom-built for flow rate control. An experimental cylindrical hopper, a flow rate sensor, a flow rate actuator, a tractor speed sensor, and a control unit were installed on the fertilizer application system. One of the four seeder units was custom-built to control seeder's position to keep uniform seeding depth. The seeder unit was installed with a hydraulic cylinder, an electro-hydraulic valve, seeding depth sensors, and a control unit. Laboratory and field test were conducted on both control system to test its functionality. For crop cultivation, two experimental silt-clay-loam residue-free fields, one for each crop, each field measuring 162 m × 3 m divided into 9 plots. Three field conditions (1 rotary tilled, 2 un-tilled with high and low soil strength) at three replications each, were prepared randomly on the 9 plots. The crops were cultivated on the field (all applied with similar crop management) for two cultivation seasons (2007-2008) having one controlled row and 3 un-controlled rows. Crop samples and crop yield parameters were monitored and statistically evaluated.

Results and Discussion

Results showed that the developed fertilizer application control system effectively controlled fertilizer application within ±5% error of the target fertilizer application rates above 900 kg/ha at 3 m/s tractor speed. The developed seed depth control system effectively regulated seeding depth at 1 m/s tractor speed at ±75 mm soil surface undulations with 2 m periodic distance. Statistical test on soybean seedling emergence count showed significant difference at $p<0.01$. Statistical results on crop yield parameters for both sugar beet and soybean in 2007 and 2008 showed no significant difference in the yield parameters between the three field conditions applied.

Conclusion

The converted fertilizer and seeder was successfully working. It was demonstrated that residue-free zero-tillage cultivation of soybean and sugar beet can be possibly applied in Hokkaido at minimal effects to original crop yields to help reduce field preparation time.