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[F] PhD Extended Abstract Form *(Please select the Calibri 10 typeface)*

FULL PhD THESIS TITLE … DESIGN, DEVELOPMENT AND EVALUATION OF A VARIABLE RATE APPLICATOR FOR REAL TIME APPLICATION OF FERTILIZER

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Extended Abstract

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Chapter 1; Introduction

Nitrogen fertilizer is a major chemical fertilizer which is used by farmers to achieve more yield. Intensive agricultural production requires judicious use of nitrogen-based fertilizers to avoid excessive exposure of human and animals to increasing nitrate levels in food. Technologies like variable rate application (VRA) of various inputs have been used to optimize the use of fertilizers and to raise both the production and the quality of agricultural yield. Variable rate of fertilizer can be applied with the help of Leaf Colour Chart (LCC), Green Seeker, Chlorophyll meter etc. especially for small fields. Punjab Agricultural University has recently recommended use of Green Seeker through the package of practices for the farmers of state.

Traditionally, soil test based fertilizer application is done in the field by the farmers but it only could apply in the field as uniform application, Therefore, it was required to use VRT to apply fertilizer as per plant requirement. Through variable rate technology machines, the dosage and the spot of use could be specified exactly as per requirement of crops. The input cost in agriculture will reduce by need based application which helps to create better environment and sustainability in agriculture. It will also maximize the productivity of crop output and the quality of farm produce. In the light of above facts, a study was conducted to design and develop a variable rate fertilizer applicator to detect real time deficiency of nitrogen in the field and applying it as per requirement, with following objectives; (1) To design and develop a system to vary the rate of fertilizer for variable rate applicator, (2) To evaluate the performance of developed variable rate fertilizer applicator in field conditions.

Chapter 2; Materials and Methods

To design and develop variable rate applicator, fluted roller type metering mechanism was selected due to having more uniformity than spinner disc type applicator. Suitable nitrogen (N) sensor i.e. Greenseeker was selected on the basis of literatures reviewed. The microcontroller system was developed and integrated with the N sensor and mechanical part through hydraulic system. PWM valve was used to vary the rotational speed of hydraulic motor resulting variation in the rotation of metering mechanism shaft. Field performance of the developed machine was conducted at four levels of nitrogen (kg/ha), three levels of height (cm) of sensor from the crop canopy and three levels of crop growth stages. The selected dependent variables were response time and amount of N fertilizer applied by variable rate applicator.

Integration of different systems of variable rate applicator

Mechanical, hydraulic and sensing systems were integrated to communicate with each other for the development of variable rate applicator for fertilizer. The microcontroller was used as a combined circuit which was housed within each component that to accomplished the required operations and that could accomplish a control on pulse width modulation valve in order to operate the hydraulic control system routinely without necessitating manual operation. The Greenseeker directly sends NDVI values to the Raspberry Pi 3 board which processes the received data based on an algorithm to extract only the useful values. It then transmits the data to the Arduino Uno which process the values and decides PWM command to be sent to the valve control circuit based on a coded algorithm. The valve control unit receives the PWM command and regulates the current supply to the oil flow valve with the help of a MOSFET accordingly. Varying the current supply to the oil flow valve control the opening and closing of the valve which in turn controls the hydraulic motor to dispense fertilizer. Integration of different systems developed for variable rate applicator are shown in Fig 2.1.

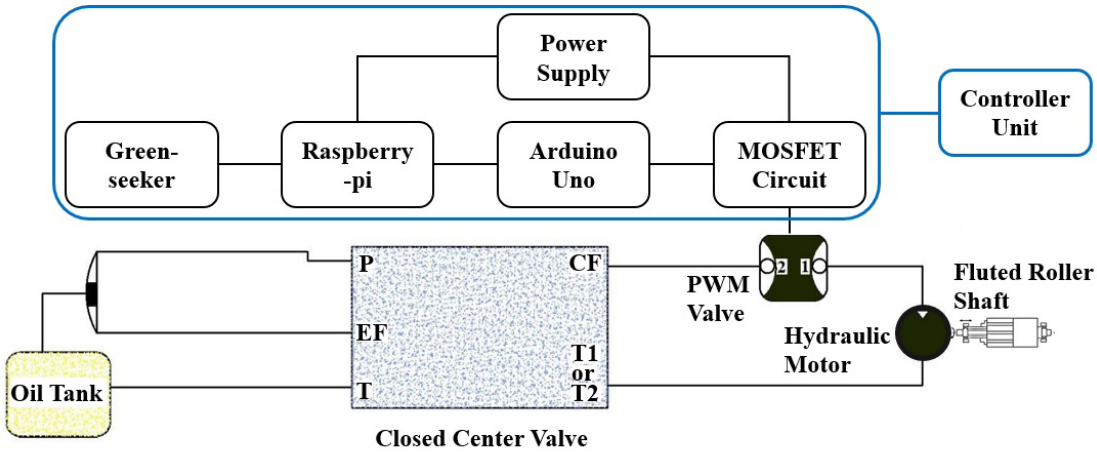

Fig 2.1 Integration of various systems developed for variable rate applicator

Chapter 3; Results and Discussion

In this chapter the experimental data collected during field evaluation of variable rate applicator was statistically analyzed and presented. The result from the present study on 'Design, development and evaluation of a variable rate real time fertilizer applicator' are summarized as following:

1. Data showed that the effect of fluted roller metering mechanism speed (rpm) on fertilizer discharged rate was linear and CV of fertilizer discharge for different tubes was ranging from 2.36 to 4.28%.
2. Fertilizer rate at 10 rpm of metering mechanism shaft was minimum i.e. 15.18 kg/ha and was maximum 54.38 kg/ha at 40 rpm of the shaft speed. This fulfills the requirement of variable rate applicator developed to change the fertilizer rate with the change in the speed of the shaft of the metering mechanism.
3. To check the uniformity of fertilizer application in the field, maximum CV i.e. 8.06% was obtained at 10 rpm and minimum CV i.e. 6.06% was at 40 rpm of the fluted roller type metering mechanism shaft. This has been proved that due to the reason fluted roller type mechanism was selected having lesser variation (CV ranging from 6.0 to 8.0 percent) in fertilizer rate applied as compared to the spinner disc type fertilizer applicator having CV ranging from 20.0-50.0 %.
4. Speed of shaft of metering mechanism changed from 0 to 40 rpm when NDVI was changing from 0.75 to 0.35. It means when NDVI is higher (Max NDVI is 0.75), crop is healthier and no fertilizer (Min rpm is 0) is needed by the crop and when NDVI is lesser (Min NDVI is 0.35), crop required more fertilizer (max rpm 40).
5. At first crop growth stage (40 DAT), average values of NDVI for fertilizer rate N1 and N2 were same i.e. 0.5. But it was 0.53 and 0.54 for fertilizer rate N3 and N4 respectively. At the second crop growth stage (60 DAT), average values of NDVI were 0.51, 0.55, 0.61, and 0.66 for fertilizer rate N1, N2, N3 and N4 respectively. Similarly, at third crop growth stage (80 DAT), average values of NDVI were 0.50, 0.55, 0.62, and 0.69 for fertilizer rate N1, N2, N3 and N4 respectively. The effect of different fertilizer rate at different N levels on NDVI at 5 percent level of significance was significant at all growth stages of the crop.
6. The effect of height on NDVI at 5 percent level of significance was non-significant, which means that the Greenseeker could be mounted on tractor at any suitable height between 40 to 100 cm from the crop canopy.
7. The response time of the control system to apply fertilizer in the field was within the range of 6.45 to 7.81 s. Therefore, for efficient working of on-the-go fertilizer adjustment, the speed of tractor should be 2.0 km/h instead of 3 km/h.
8. Applied fertilizer by using developed variable rate applicator at different growth stages of the rice crop at 40, 60 and 80 DAT indicated that when fertilizer rate is increasing from N1 to N4, NDVI is increasing from 0.49 to 0.69. Hence, shaft speed is decreasing from 27 to 7 rpm to apply the fertilizer rate 35.47 to 9.00 kg/ha respectively.
9. Likewise, in wheat crop before second irrigation (60 DAS) When fertilizer rate is increasing from N1 to N4, NDVI is increasing from 0.54 to 0.79. Hence, shaft speed is decreasing from 21 to 0 rpm to apply the fertilizer rate 39.50 to 0.00 kg/ha respectively.
10. In the plot with N4 level, total fertilizer applied by variable rate applicator was 122.32 kg/ha instead of 225 kg/ha as

recommended by the university resulting 45% saving in fertilizer application by developed variable rate applicator.

Chapter 4; Summary (Abstract)

… There is a strong need to avoid use of excessive N as it is unlikely to be effective in increasing crop yields because of its diminishing returns. Therefore, a study was conducted to design and develop a variable rate fertilizer applicator to detect real time deficiency of nitrogen in the field and applying it as per requirement of the crop. To design and develop variable rate applicator, fluted roller type metering mechanism was selected due to having more uniformity than spinner disc type applicator. Suitable nitrogen (N) sensor i.e. Greenseeker was selected for the development of applicator. The microcontroller system was developed and PWM valve was used to vary the rotational speed of hydraulic motor resulting variation in the rotation of metering mechanism shaft. Field performance of the developed machine was measured at different levels of nitrogen (kg/ha), height (cm) of sensor from the crop canopy and at different growth stages of the crop. Fluted roller type metering mechanism was selected having lesser variation (CV ranging from 6.0 to 8.0 %) in fertilizer rate applied as compared to the spinner disc type fertilizer applicator having CV ranging from 20.0-50.0 %. Fertilizer rate at 10 rpm of metering mechanism shaft was minimum i.e. 15.18 kg/ha and was maximum 54.38 kg/ha at 40 rpm of the shaft speed. Speed of shaft of metering mechanism changed from 0 to 40 rpm when NDVI was changing from 0.75 to 0.35. The response time of the control system to apply fertilizer in the field was within the range of 6.45 to 7.81 s. Applied fertilizer by using developed variable rate applicator at different growth stages of the rice crop at 40, 60 and 80 DAT indicated that when fertilizer rate is increasing from N1 to N4, NDVI is increasing from 0.49 to 0.69. Hence, shaft speed is decreasing from 27 to 7 rpm to apply the fertilizer rate 35.47 to 9.00 kg/ha respectively. Total fertilizer applied by variable rate applicator was 122.32 kg/ha instead of 225 kg/ha as recommended by the university resulting 45% saving in fertilizer by using developed variable rate applicator.

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Final remarks concerning the competition benchmarks and strength points

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