Results and Discussion

• 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.
• The effect of height on NDVI at 5 percent level of significance was significant at all growth stages of the crop.

Field evaluation: With the intention of evaluating the machine properly, the research field was divided three replications and each replication divided to four plots. The rate of fertilizer for these four plots varied from N1 = 75 kg/ha, N2 = 125 kg/ha, N3 = 175 kg/ha, N4 = 225 kg/ha for paddy, and N1 = 0, N2 = 90 kg/ha, N3 = 180 kg/ha, N4 = 270 kg/ha.

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. The developed applicator varied the fertilizer dosage as per crop health status indicated by NDVI. For crop health monitoring, greenseeker due to cost effectiveness and comparative accuracy was most suitable sensor for integration with variable rate applicator.

Variation in fertilizer discharge among different delivery tubes was observed less with fluted roller type metering mechanism (CV ranging from 6.0 to 8.0 percent) as compared to the spinner disc type fertilizer applicator (having CV ranging from 20.0-50.0 %).

The developed microcontroller system through PWM valve precisely controlled the speed of fertilizer metering mechanism via hydraulic motor.

The response time of the control system to apply fertilizer in the field was within the range of 6.42 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.

• 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.
• 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 9.00 kg/ha respectively.
• In the plot with N4 level, total fertilizer applied by variable rate fertilizer applicator was 122.32 kg/ha as recommended by the university resulting 45% saving in fertilizer application by developed variable rate applicator.

Conclusions

Design approach
• There should be sensing unit to record the plant health. The plant health needs to correlated with crop N status.
• The system should recognize the N requirement of plant based on its health status.
• A mechanism to vary fertilizer rate discharged by the applicator.
• Control unit (microcontroller) to receive the data from the sensor, process the data and send a signal to vary the fertilizer rate.
• It should precisely apply N for different field areas based on N requirement.

Functional components

• The developed microcontroller system through PWM valve precisely controlled the speed of fertilizer metering mechanism via hydraulic motor.

Methodology

• The high clearance tractor with narrow rear tyre width (20 cm) was used as prime mover for mounting of Greenseeker in front of the tractor, Fig 1.
• To select a suitable sensor for measurement of available nitrogen in the crop, information on different nitrogen measuring sensors was reviewed from literature followed by their performance comparison through different reported studies. Suitable nitrogen (N) sensor i.e. Greenseeker was selected on the basis of comparative analysis.
• The sensor was evaluated for NDVI value at heights of 40, 60, 80 and 100 cm from the crop canopy.
• For developing NDVI based variable rate applicator, fluted roller of existing seed drills was selected for converting it into variable rate applicator. The fluted roller fixed in the applicator had 11 flutes.
• For variable rate fertilizer application microcontroller was incorporated for controlling the speed of fluted roller metering system and to vary the fertilizer discharge based on the NDVI readings on-the-go.
• The rate of fertilizer was varied by varying the speed of fluted shaft via hydraulic motor which was fixed at the end of one side of the fluted roller shaft to rotate it.
• The fluted metering roller regulated the amount of fertilizer based upon its rotation controlled by hydraulic system.
• The PWM valve was used to control the rotational speed of hydraulic motor resulting variation in the rotation of metering mechanism shaft.
• The total operating width of the developed machine was 2.2 m and the spacing between two rows was 0.2 m.
• The machine was evaluated under lab and field conditions. Experimental data collected during field evaluation of variable rate applicator. The machine was statistically analyzed for significance.

References