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Fabrication and evaluation of variable rate fertilizer system

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Introduction: In conventional farming, the soil and crop are considered uniform in different locations of the farm and the fertilizers are applied according to the average of soil needs with an additional percentage for safety (Loghavi, 2003). Non-essential chemical fertilizers in the field have harmful effects and social, economic and environmental concerns will increase. Many fertilizers go into the surface waters and ground waters and cause poisoning and environmental pollution without being absorbed by the plants. In variable rate technology, the soil fertilizer needs a map of all parts of the farm which is prepared with the GIS system. This map is uploaded on the computer before variable rate fertilizer machine starts. The computer continually controls the fertilizing rate for each part of the farm using a fertilizing map and global positioning system. The purpose of this study is to construct and evaluate a map-based variable rate fertilizer system that can be installed on a common fertilizer in Iran to be used as a variable rate system.

Materials and methods: In common variable rate fertilizers, the rotational speed change of the distributor shaft is used to apply fertilizers. In this way, a DC motor is assembled on the main shaft of all distributors, which reduces the fertilizing accuracy. The reason for this is that there is no separation for units along the width of the fertilizer. Therefore, we used one DC motor for each distributor and another motor to rotate the agitator in the tank.

System Set up: To design and select a suitable engine, the required torque for the rotation distributor shaft was measured by a torque meter and the amount of 2.1 Nm was acquired for that. With regard to the maximum rate of nitrogen fertilizer for land and tractor speed at the time of fertilizing, the order of 350 kg per hectare and 8 km per hour, the maximum distributor shaft speed and power required to rotate distributor shaft were calculated to be 55 rpm and 6.9 watts, respectively. The selected motor was rated 27.5 watts, 24 volts and 7.5 amperes (Since there were no 6.9 watts motors in the market, a more powerful motor was selected). According to the gear ratio and motor speed, the speed of the distributor shaft was adjustable in the range of 0 to 65 rpm. To determine the speed and position with respect to the direction, a central encoder (E50S8-600-6-L-5 model manufactured by Autonix Korea) was used on the ground wheel. The encoder had 600 pulses per revolution of the axis.

Performance evaluation of the system: Performance evaluation of the system consists of two parts; static and moving tests. In static tests, the purpose was the determination of the fertilizer loss (in grams), due to changes in distributor speed as well as the accuracy of the electromechanical control system according to the command values sent to the device. Results of this part were used for the calibration of the device.

In motion tests: In motion tests, the assessment of fertilizer loss was due to values set in a given situation and the accuracy of planted fertilizer in place (delay and acceleration) is reviewed. The delay is found by the determination of the distance that the fertilizer was placed after the desired location on the ground and the acceleration is found by the determination of the distance that the fertilizer is placed before the desired location on the ground.

Results and discussion: The distributor flow rate on F0 valve position was measured for different rotation speeds. The correlation (linear regression) between the planted fertilizer and rotation speed of distributor shaft (rpm) were 0.99 for $y=71.636x+75.182$. So, it can be deduced that these two parameters have a good linear correlation. The results achieved from diagrams and regression model were used in the programming of the system control unit. Thus, by reading the distributors motor speed, the amount of fertilizer can be calculated and the amount of used fertilizer according to the need of the farm in each part is controlled. The effect of plot length on the amount of fertilizing on 25% need level was not significant, but it was significant on 50% need level. This is due to stopping and starting fertilizer flow during the test, changes in motors speed and error of these on fertilizer output at a certain amount of fertilizing so that at the 25% need level, the error resulting from these factors had less share on the amount of plant fertilizer and the effect of plot

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length was not significant according to the system default. On the other hand, the effect of forward speed was significant on the 50% need level and insignificant on the 25% need level.
Conclusions: In order to calculate the accuracy of the system, the error from the application amount of fertilizer was measured at different fertilizing rates. The correlation between the adjusted fertilizing rate and the measured fertilizing rate was 0.98 with regression model of y=1.0475x which shows the good accuracy of the system.

Keywords: Intelligent metering device, Fertilizing, Variable rate technology