Abstract

Fertilization is one of the most crucial and effective approaches for improving soil characteristics, boosting crop production, and enhancing yields. The quality and quantity of cotton depend greatly on the fertilization. Desired dose of fertilizer should be applied to the crop, as it is a costly input and adversely affects the human, environment and soil health, if overused. Conventionally, broadcasting and placement are the two commonly employed methods to apply microgranular fertilizers in cotton crop. In the broadcasting method, fertilizer is spread over an entire field; hence, it introduces several operational challenges, such as increased growth of weeds, and an uneven distribution of fertilizer that leads to its inefficient use. Manual placement of fertilizer is good for effective application but it is labor-intensive, time-consuming, and leads to create posture-related problems for laborers such as back muscle pain. The majority of microgranular fertilizer applicators utilize the broadcasting method of fertilization, while placement method-based applicators are operated intermittently rather than continuously. Undoubtedly, conventional fertilizer applicators are often attributed to non-uniformity in distribution, labor and time intensiveness, high discharge rate, wastage of input, and fostering weed proliferation. To address these challenges, there is a need for precisely placing granular fertilizer in the cotton field; leading to design and development of such an applicator that can do such task with precision and effectiveness in order to reduce wastage of fertilizer, offers time-saving, and reduces the overall cost of fertilizer application. This research was carried out to design and develop a precise fertilizer applicator, especially to cotton field. The developed applicator comprised: a) *plant recognition system* to capture and predict presence (or absence) of cotton plants using the YoloV5 recognition model via Raspberry Pi, and relay them to a microcontroller; b) an *embedded system* to control motor as per received cotton-detection signal from the plant recognition system; and c) *fertilizer metering system* that delivers precisely-metered granular fertilizer to the targeted cotton plant when corresponding motor is triggered by the microcontroller. Precision, recall, F1 score, and mean average precision (mAP) of the plant recognition model are determined as 1.00 at 0.696 confidence, 097 at 0.000 confidence, 0.87 at 0.151 confidence, and 0.879 at 0.5 confidence, respectively. The test results showed the mean absolute percent error (MAPE) 6.71% and 8.5%, mean absolute deviation (MAD) 0.74 g/plant and 0.92 g/plant, on application of Urea and DAP, respectively. The statistical analysis showed no significant effect of forward speed of the conveying unit on fertilizer application rate [$p > 0.05$], and hence, offering a uniform application throughout the field without being dependent on forward speed. The developed fertilizer applicator enhances precision in site-specific application, minimizes fertilizer wastage, and reduces labor requirements. Eventually, precise fertilizer placement results in lowering weeds growth, and delivering fertilizer as per the recommended dosage.

Keywords: Crop detection, Deep learning, Embedded system, Placement method, Micro-granular fertilizer