ABSTRACT

Weeding is the important operation in agriculture to minimize crop competition and enhance crop production and productivity. Unmanaged weeds lead to yield losses of up to 33%. Conventional methods of weeding are energy and cost intensive either demanding huge labour or are environment-destructive for excessive chemical usages. Mechanical methods are high throughput but are majorly available for managing weeds in the inter-row region. Limited intra-row weeding techniques have been developed but are conducted independently that lead to double energy, fuel, and cost consumptions. This thesis is focussed on design and development of a tractor driven sensor-based integrated inter- and intra-row weeding system for row crops. The hypothesis is that the system could ensure weeding in both inter and intra-row region within single pass of the prime mover (tractor). This would ensure a higher weeding efficiency and lower energy expenses. The intra row weeding prototype was integrated with a four-bar mechanical linkage and actuator system, electronic sensing, and control systems. The mechanical linkage consists of vertical axis rotors (R_{VA}), four-bar linkage (FBL) cranking mechanism, the electronic components consist of ultrasonic sensors, pulse width modulation operated (PWM) DC motors, and control system consists of motor controllers and microcontrollers. The crank of FBL mechanism actuates R_{VA} which comprises of a ring that mounted the weeding tools. The R_{VA} shifts laterally when the ultrasonic sensors detect crop plants else continues to operate within the crop row for weeding. The decision making for lateral shift was based on fuzzy logic algorithm. The developed system was evaluated and refined in a soil bin for response, delay and actuation time based on various soil, plant and operating conditions.

Pertinent to laboratory evaluations, cone index (CI), depth of operation (DO), forward speed (FS), plant spacing (PS) and their interactions had a significant effect on the plant damage that ranged from 0.7–8.7% for all evaluation configurations. The integrated system was field evaluated for green chilli plantation. Weeding efficiency of 87.56 % (±2.88 %), yield critical plant damage of 4.45%, and superficial plant damage of 11.11% was observed. The draft, toque and lateral shift force recorded were 1020 N (±20.43 N), 112.97 Nm (SE: ± 10.58 Nm) and 65.05 N (± 2.23 N), respectively at the FS of 2.25 km/h and DO of 40 mm. The operational delay was significantly influenced by FS and were recorded as 161.33 (±6.11 ms) and 117.5 ms (±5.91 ms) at FSs of 1.3 and 2.25 km/h, respectively. Actual field capacity was observed in the ranges of 0.16–0.27 ha/h at the FSs of 1.3 and 2.25 km/h, respectively. Mean fuel consumption rates ranged from 2.95 to 3.70 l/h at FS range of 1.3 to 2.25 km/h. The work capacities of the integrated weeder were 6.02 and 3.76 h/ha at FSs of 1.3 and 2.25 km/h, respectively. Based on the observations, an integrated inter- and intra-row weeding system can be a highly efficient and cost-effective system for weeding in the field row crops accounting for advantages of both inter- and intra-row weeding in one go with minimum fuel and energy expenses.

Key words: Inter and intra-row weed control, mechatronics, time-of-flight sensing, agricultural automation, microcontroller, fuzzy logic