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Development of power weeder for mound-cassava in hilly terrain

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ABSTRACT

A power-weeder has been developed to address the weeding requirement of the cassava planted in mound pattern in hilly terrains. Although there are many commercial makes available for weeding of cassava planted in flat method as well as ridges and furrows method, it seems that there is no suitable weeder presently available in the country to address the weeding requirement of mound cassava of hilly terrains. The power weeder developed consists of petrol-engine, main weeding rotor, offset weeding rotor, depth control lever, ground-wheels, transmission assembly, frame and handle. The main weeding rotor removes the weeds on the furrow while the offset weeding rotor removes the weeds on mounds without damaging the tuber grown under mounds. It is economically viable with fuel consumption limited to 27 L/ha. The machine proved its capability of weeding between the rows on both directions with acceptable weeding efficiency of 92.8% with negligible percentage (0.7) of damage to rhizome, field capacity of 0.16 ha/day, and field efficiency of 79.0%. It was also found that the operators did not observe any difficulty due to side thrust since the sideways thrust might have been transferred by the method of attaching the lateral rotor at 20mm ahead to the line joining central axis to the lateral axis. The power-weeder was recommended as an ideal machine for medium cassava farms of India.

Key words: Cassava weeding, Mound-planting, Power weeder, Weeding efficiency, Weeding index

Cassava grows poorly in weedy farms and produces fewer and smaller storage roots. However, the presence of weed plants in the farm does not always mean that they will cause severe losses in food and income from the farm. Weeds become a problem in growing cassava because of a number of reasons. Weeds harm cassava mainly when they are abundant in the farm. They will cover the ground almost completely and increase the time spend on weeding. When they are abundant, they also use up lots of nutrients and water from the soil making these materials unavailable for cassava plant growth (Ali 2014, Buhler 2014, Evan *et al*. 2012, Fermont *et al* 2009, Finch *et al* 2014). Weeds grow more rapidly than cassava and this enables them to choke cassava farms very quickly. For example the giant sensitive weed, *Mimosa invisa*, rapidly occupies the spaces between cassava plants; Siam weed, *Chromolaena odorata*, chokes cassava farms in a similar manner. By their rapid growth, weeds also shade cassava plants from sunlight. Weeds are difficult to remove for a number of reasons. For example, if the thorns of the giant sensitive weed, *Mimosa invisa*, hook into young cassava stems, it will be difficult to remove the weed without breaking the stems. Similarly, the parasitic weed dodder, *Cuscuta australis*, which climbs and wraps tightly on cassava plants, causes breakage of cassava shoot tips during hand weeding. Weeds can also be difficult to remove if they injure people. For example, it is difficult to remove *Mimosa invisa* by hand-weeding or hoeing because its thorns scratch and cause wounds to people. Weeds which reproduce by rhizomes, stolons, and tubers are difficult to remove from the soil. They break easily into pieces during hand or hoe weeding. The pieces remain in the soil and sprout later. Weeds with these structures will therefore be ‘stubborn’ in the farm. Certain weeds grow and feed directly on cassava stems. For example dodder, *Cuscuta australis*, attaches itself tightly to cassava stems and sucks water and nutrients from the plant. Cassava pests and diseases can multiply on weeds and later move on to cassava. For example, immature stages of the variegated grasshopper, *Zonocerus variegatus*, gather on bushes of *Chromolaena odorata* and then move on to cassava plants as they become mature grasshoppers.The emerging shoots of spear grass, *Imperata cylindrica*, sometimes pierce and destroy cassava storage roots (Kartika *et al*. 2014, Kerstin and Valerie 2002, Preston 2014, Rowan 2014, Soroush *et al.* 2014).

Cassava is produced by 102 countries globally with the average productivity of 11.0 tonnes/ha. India accounts

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for 3.8% of world's production of cassava and stands highest productivity (27.9 tonnes/ha) in the world. Kerala, Andhra Pradhesh, Assam, Meghalaya, Maharashtra, Gujarat and Tamil Nadu are the major cassava growing states in the country. Planting Season are March-April; September-October, June-July. It is practiced either mono crop or inter crop.

Weed control is one of the most expensive operations in Indian crop production. Majority of Indian farmers uses hand-hoe for weeding which requires 40-60 manual labourers for one hectare. It consumes 19.7 man-days in low land and 21.3 man-days in upland cropping system (Tewari *et al*. 2014). Timing and frequency of weeding were important in influencing root number and root yield in cassava production, and delayed weed control depressed both attributes. In Kerala two weedings are recommended along with earthing up operation and top dressing for mound-cassava during 45th day and 75th day respectively.

All the commercial makes available are suitable for flat method of planting which are found unsuitable for mound pattern practiced in hilly terrains (Alan *et al*. 2007, Cordill, 2011, Dirk and Kurstjens 2007, Gobor *et al*. 2013, Van der Linden *et al*. 2008). Existing makes of commercial weeders are not suitable for the existing crop varieties as breakage of roots as well as damage of branches occurred during the operation of the weeders. This might be due the fact that farmers practicing narrow spacing (60 cm × 60 cm) in view of more yields.

The objective of this study is to develop and evaluate the performance of a power weeder. The machine is conceived to meet the needs of small farm holders.

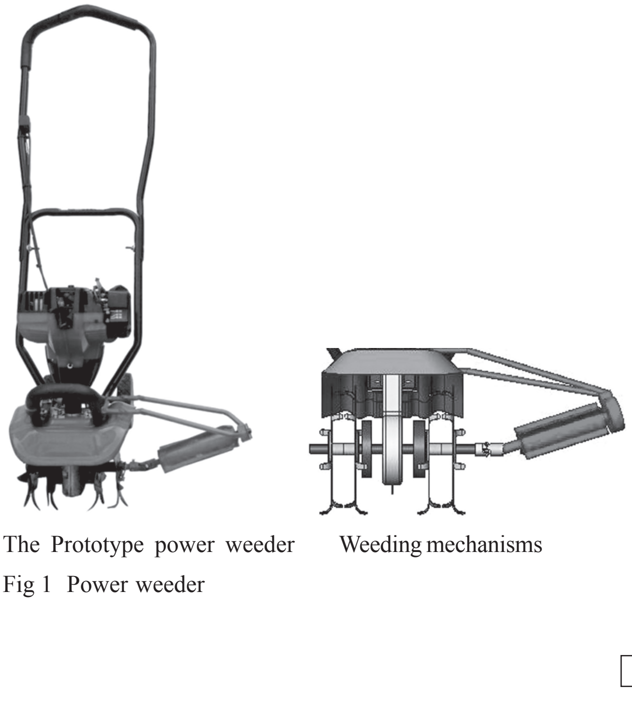
MATERIALS AND METHODS

A commercial make was improvised to suit weeding of mounds. An offset weeding rotor was attached to remove the weeds on mounds. The drive for offset rotor was tapped through main rotor since the offset rotor was attached with the axis of the main rotor. The weeder consists of the following components; a 1 hp-petrol engine (26.2 cc), main weeding rotor, offset weeding rotor, depth control lever, two ground wheels (pneumatic), tool assembly, frame and handle.

The weeder is pushed manually and the power to the rotary hoe is supplied from the engine through shaft. The weeding tines on a shaft were arranged radialy. Each tine was made of steel rod of 12 mm diameter. The rotary power weeder is to be powered by a 1-hp internal combustion engine. Gear arrangement was adopted for transmission of power. The ideal speed of the engine was 3000-3600 rpm fixed with the shaft carrying the rotary tines. The various components of the machine were constructed while other standard components, such as prime mover and transmission elements were sourced locally and the parts were assembled (Gobor *et al*. 2014).

The performance evaluation of the constructed power weeder was conducted on the experimental fields of Central Tuber Crops Research Institute, Tiruvanathapuram, Kerala. The performance evaluations were conducted to investigate the effect of weed density (Fogelberg and Kritz 2014). The experimental area was infested mostly with weeds like bermuda grass *(Cynodon dactylon)*, feathery pennisetum *(Pennisetum polystachion)*, Guinea grass *(Panicum maximum)*, purple nutsedge *(Cyperus rotundus)*, waterleaf *(Talinum triangulare)*, tropical spiderwort *(Commelina benghalensis)*, tridax *(Tridax procumbens)*, waterleaf *(Talinum triangulare)*, wild poinsettia *(Euphorbia heterophylla)*, giant sensitive weed *(Mimosa invisa)*, goat weed *(Ageratum conyzoides)*.Prior to each weeding schedule, weed density in each experimental unit was determined by laying-out a squared grid (0.3m × 0.3m) in the plot and weeds in the grid were counted (Pullen and Cowell 2006). Three such determinations were made for each experimental unit. The performance indicators used for this experiment includes the following.

Weeding index: Weeding index is a ratio between the number of weeds removed by a weeder and the number



The Prototype power weeder Weeding mechanisms

Fig 1 Power weeder

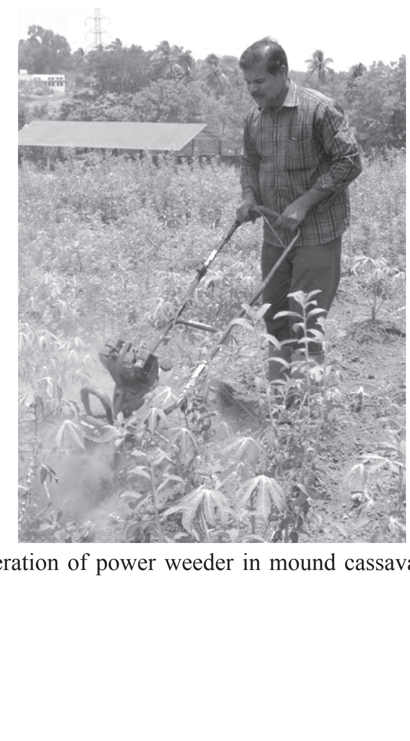


Fig 2 Operation of power weeder in mound cassava plot

present in a unit area and is expressed as a percentage (Rangasamy *et al.* 1993). Nine plots of 27m × 2m each were marked out of the main plot for sampling. Weeds in each plot were counted before and after weeding using the constructed rotary weeder. The time taken to perform this operation were noted.

Weeding index was calculated by using the following formula (Anon 1985).

$$e = [(w_1 - w_2)/w_1] \times 100 \quad (1)$$

where, e = weeding index (%), w_1= number of weeds/m^2 before weeding, and w_2= number of weeds/m^2 after weeding.

Field capacity: The weeder was tested on the same plots to determine the field capacity of each of them. Field capacity is the amount of area that a weeding tool can cover per unit time as shown in equation.

$$\text{Field capacity (ha/h)} = a/t \quad (2)$$

where, a= area covered (ha) and t = time (h).

Side thrust: The offset weeding rotor was attached as the core part of the machine to remove the weeds on mounds. Due to its cantilevering effect, side thrust was expected to act upon the lateral weeding rotor during operation of the machine. To balance the side thrust, the lateral rotor was attached 20 mm forward to the line joining central axis to the lateral axis (Bosai *et al.* 1956). By this method, the sideways thrust has been transferred. To validate the concept, twelve operators were interviewed in this direction.

Based on the materials used and labour requirement for the fabrication of the weeder, the material cost and fabrication cost of the unit were calculated. The cost of operation per unit time of the weeder was worked out using the procedure recommended by RNAM test codes (Anon. 1995). The cost of the commercial model of the machine was estimated. The economic viability of the machine with respect to fuel consumption was also determined. This cost was also compared with the cost of operation of the same by conventional method. The time and cost saved by using the power weeder against conventional weeding was compared based on the field capacity, field efficiency, and fuel consumption. Break-even point for utility of this machine and pay-back period were determined for recommendation of the machine.

RESULTS AND DISCUSSION

Performance of machine

The weeding index which was determined by counting the number of weeds before and after using the weeder developed, on the five blocks (replicated thrice). Detail records are presented in Table 1. The weeding efficiency of the weeder was found to be 92.8% with the field capacity of 0.16 ha/day. Fuel consumption of the machine works out 0.555 l/h (27.1 l/ha).

From the Table 1, it was found that there is no significant difference among the stage of weeding with respect to weeding index, field capacity, field efficiency, rhizome damage, and fuel consumption of the machine.

Table 1 Performance of power weeder

Variety	Stage of weeding	Weeding index (%)	Field capacity (ha/day)	Damage to rhizome (%)	Fuel consumption (l/ha)	Field efficiency (%)
Variety 1	45th day	93.2	0.17	0.9	26.3	76.5
	75th day	92.9	0.16	1.8	29.2	79.0
Variety 2	45th day	94.2	0.16	1.3	28.3	80.3
	75th day	94.5	0.14	0.7	28.5	77.2
Variety 3	45th day	92.5	0.18	0.5	25.7	82.7
	75th day	97.1	0.16	0.6	26.2	81.0
Variety 4	45th day	88.7	0.17	0.0	26.6	74.7
	75th day	88.8	0.15	0.2	26.4	77.9
Variety 5	45th day	90.8	0.15	0.5	26.4	81.7
	75th day	94.2	0.18	0.0	26.9	79.5

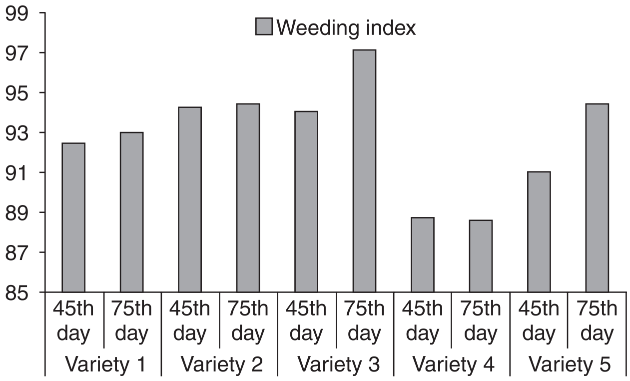


Fig 3 Weeding index of the power-weeder

Side thrust: To determine the difficulties due to side thrust, twelve operators were interviewed for subjective response. It was found that all the operators did not observe any difficulty due to side thrust. It might be due to the sideways thrust that has been transferred by the method of attaching the lateral rotor at 20 mm ahead to the line joining central axis to the lateral axis (Bosai *et al.* 1956, Kouwenhoven 1997).

Cost economics

Based on the materials used and labour requirement for the fabrication of the weeder, the material cost and fabrication cost of the unit was calculated. The cost of operation per hour of the weeder was worked out using the procedure recommended by RNAM test codes (Anon. 1995). The cost of the commercial model of the machine was estimated at ₹ 18 000. It is economically viable with fuel consumption limited to 27 l/ha. This cost was compared with the cost of operation of the same by conventional method. The time and cost saved by using the power weeder against conventional weeding was compared. The machine capacity was 0.16 ha/day, while only 148 m^2 can be covered by a labourer in conventional method. Cost of weeding by machine works out ₹ 6 123/ha while that of manual method was ₹ 25 000/ha which denotes 75.5% of cost-saving, 90.9% of time-saving and 95.5% of energy-saving through machine-weeding compared to manual-weeding. Break-even point for utility of this machine was 50 ha/annum and pay-back period is 0.7 year. The machine is recommended for medium cassava farmers around the nation since the machine can provide weeding solution for mound method of planting.

a) The weeder was found suitable to address the weeding requirement of mound cassava of hilly terrains with mean weeding index of 91.9% in the all the varieties studied.
b) Cost of weeding by machine works out ₹ 6 123/ha while that of manual method was ₹ 25 000/ha which denotes 75.5% of cost-saving, 90.9% of time-saving and 95.5% of energy-saving through machine-weeding compared to manual-weeding. Break-even point for utility of this machine was 50 ha/annum and pay-back period is 0.7 year. It is also economically viable with fuel consumption limited to 27 l/ha.
c) The machine proved its capability for weeding between the rows on both directions with acceptable weeding efficiency of 92.8% with negligible percentage (0.7%) of damage to rhizome, field capacity of 0.16 ha/day, and field efficiency of 79%.
d) The power-weeder was recommended as an ideal machine for medium cassava farms of India.

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