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Development of portable knapsack power weeder

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ABSTRACT : Weed management is an ever-present challenge to crop production. Presence of weeds in general reduces crop yield by 31.5 per cent (22.7 % in *Rabi* season and 36.5 per cent in *Kharif* and summer season). Yield losses due to weeds were about 65 per cent depending on the crop, degree of weed infestation, weed species and management practices. Presently available weeder mostly run by tractor or power tiller, these are large in size, cannot work for low inter row spaced crops.To over come these problems, portable knapsack power weeder was developed for low inter row spaced crops with width of cut was 25 cm. The main working components of power weeder were flexible drive shaft, worm gear box, rotor shaft, flanges and blades. The" L" type blade was selected having length, width and thickness of 130 mm, 30 mm and 5 mm, respectively, operating with a rotor shaft of 20 mm in diameter. Maize and chilli was tested with number of blades per flange (2, 4 and 6).

KEY WORDS : Engine, Flexible drive shaft, Worm gear box, Rotor shaft, Flanges, Blades

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India is a vast country with 329 million hectares of geographical area with agriculture still as a main occupation of 70 per cent of Indian population (Anonymous, 2011).The scenario of agricultural mechanization has been increasing during last four decades. The application of machinery in Indian agriculture has assumed importance for increasing agricultural production, productivity and profitability by timely farm operations, labour saving, as well as maximizing input efficiency by effective and proper utilization. Weeds are always associated with human endeavors and cause huge reductions in crop yields, increase cost of cultivation, reduce input efficiency, interfere with agricultural operations, impair quality, act as alternate hosts for several insect pests, diseases and nematodes.

At a conservative estimate, an amount of Rs.100 billion is spent on weed management annually in India, in arable agriculture alone (Anonymous, 2011). A recent study undertaken at Directorate of Weed Science Research (DWSR) suggests that proper weed management technologies, if adopted, can result in an additional income of Rs.1.5 lakh crores per annum (Anonymous, 2007). Presence of weeds in general reduces crop yield by 31.5 per cent (22.7 % in *Rabi* season and 36.5 % in *Kharif* and summer season). The potential yield losses due to weeds can be as high as about 65 per cent depending on the crop, degree of weed infestation, weed species and management practices (Yaduraju, 2006).

One third of the cost of cultivation is spent on weeding alone when carried out with the manual labour. Manual weeding requires huge labour force and accounts for about 25 per cent of the total labour requirement

(900-1200 man-hours/hectare) (Nag and Dutt, 1979). In India this operation is mostly performed manually with the use of traditional hand tools (*Khurpi* or trench hoe) in upright bending posture including back pain for majority of labours. Manual weeding requires higher labour input and also very tedious and time consuming process.

In India, farmers mainly follow the weeding with small hand tools though chemical weeding is slowly becoming popular, in spite of it being costly. Use of herbicides will have residual effect and change in quality of soil and the chemicals used in weed killers cause damage to the environment and to the health of people who come into contact with them. Tractor operated weeding implements can save about 75 per cent time and 20 per cent cost as compared to bullock drawn methods. But there is uncovered headland and tractor hiring charges will be crucial input cost which may vary according to the season.

The rotary type weeder stirs the soil more accurately, disturb the weed root and remove them from soil. In addition this helps in keeping the soil in loose condition for proper aeration. The major advantage of rotary power weeder is power being used for rotary weeder blades requires less draft and improved field performance. Several weeders are available which run by tractor or power tiller, these are large in size cannot work for low inter row spaced crops.

■ METHODOLOGY

A manually operated portable knapsack power weeder was developed for low inter row spaced crops. From design point of view the rotor shaft and cutting blades were the two important components of power weeder.

Theoretical calculations while selecting machine parts:

Determination of tangential force:

For designing the rotor shaft, the maximum tangential force which can be endured by the rotor was considered. The maximum tangential force occurred at the minimum tangential speed of blades, which was calculated by using the following equation (Bernacki *et al.*, 1972).

$$K_t = C_s \frac{75\ N_c M_c M_z}{U_{min}}$$

$$K_t = 1.5\ \frac{75 \times 1.67 \times 0.9 \times 0.75}{2.13} = 59.537\,\text{kg}$$

where,

K_t = Maximum tangential force, kg,

C_s = Reliability factor 1.5 for non-rocky soils and 2 for rocky soils,

N_c = Power of engine, 1.67 hp,

M_c = Traction efficiency that its value for forward rotation of the rotor shaft as 0.9,

M_z = Co-efficient of reservation of engine power (0.7-0.8),

U_{min} = Minimum tangential speed of blades, m/s,

Tangential peripheral speed, (U_{min}) can be calculated by using the following Eq.:

$$U_{min} = \frac{2\,\pi\,N\,R}{60}$$

$$U_{min} = \frac{2 \times \pi \times 185 \times 0.11}{60} = 2.13\,\text{m/s}$$

where,

N = Revolution of rotor shaft, 185 rpm,

R = Tangential distance, 0.11 m,

Determination of soil force :

In rotary weeder, one-fourth of the blades act simultaneously on the soil. The total power of the machine was distributed between the blades. The soil force acting on each of the blades (K_s) was calculated by using following equation (Bernacki *et al.*, 1972).

$$K_s = \frac{K_t\,C_p}{I z_e\,n_e}$$

$$K_s = \frac{59.537 \times 2}{2 \times 3 \times 1/4} = 79.382\,\text{kg}$$

where,

K_s = Soil force, kg,

K_t = Maximum tangential force, 59.53 kg,

C_p = Co-efficient of tangential force (1.5 for non-rocky soil and 2 for rocky soils)

I = Number of flanges, 2

z_e = Number of blades on each side of the flange,3

n_e = The number of blades which act jointly on the soil divided by the total number of blades, (1/4).

Determination of torque :

The maximum moment on the rotor shaft was calculated by the following equation (Sharma and Mukesh, 2013).

$$T = K_t \times R$$

$$T = 59.537 \times 0.11 = 6.54\ \text{kg-m}$$

where,

T= Torque, kg-m

K_t = Tangential force, 59.53 kg,

R= Tangential distance, 0.11 m.

Design of rotor shaft :

Diameter of rotor shaft was calculated by using following equation (Sharma and Mukesh, 2013).

$$T = \frac{x\ d^3\ x\ F_s}{16}$$

$$6.54 = \frac{\pi\ x\ d^3\ x\ 1000\ x\ 10000}{16} = 15\ mm$$

where,

T = Torque on rotor shaft, 6.54 kg-m

d = Diameter of rotor shaft, m

F_S = Allowable shear stress of material, 1000×10^4 kg/m^2 (Sharma and Mukesh, 2013).

In order to take account fluctuating load during the operation, diameter of the rotor shaft was selected higher than the calculated value as 20 mm.

Determination of power :

Power was calculated by using following formula (Sahay, 2013).

P = Speed (m/s) × Tangential force (kg)

P = 2.13 (m/s) × 59.537 (kg) × 9.8

P = 1242.775 Nm/s.

P =1.25 Kw.

Components of weeder :

The portable knapsack power weeder consists of following components.They are engine, Flexible drive shaft, handle, worm gear box, rotor shaft, flanges, blades, blade cover, and transportation wheels.

Engine :

It was the prime mower of the machine works as heart for the developed power weeder. The engine was used for development of portable knapsack power weeder. Hence, a, single cylinder, 2-stroke air cooled petrol engine with 42.7 cc displacement and 6500 rpm (1.25 kW) was used. Power head contained various components like engine, clutch, fuel system and ignition system and recoil starter (Fig. A).

Fig. A : . . . . . .

Flexible drive shaft :

Flexible drive shaft was used to transmit power from engine to the worm gear box. Flexible drive shaft upper end connected clutch case of engine and bottom end connected to worm gear box. The rubber outer sheath and steel inner cable (shaft).

Handle:

The shape of the handle type was D, this can be adjusted according to comfort and convince of the operator (Fig. B).

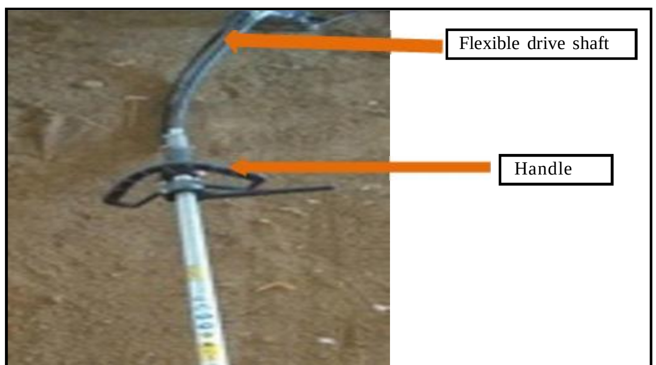

Fig. B : Handle

Worm gear box:

A light weight gear box was used to reduce at

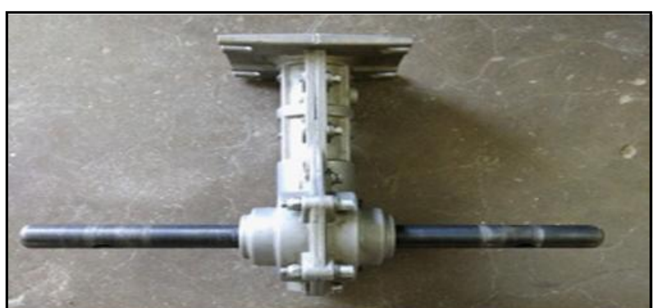

Fig. C : Worm gear box with rotor shaft

desired rpm level. The power comes from the engine to worm gear box with help of flexible drive shaft.The flanges were rotated by rotor shaft. The RPM was reduced with a speed ratio of 35:1 from engine to rotor shaft (Fig C).

Rotor shaft:

The rotor shaft was used to mount the flanges with 'L' shaped blades. Rotor shaft made up of mild steel. The diameter and length of rotor shaft was 20 mm and 250 mm (Fig. D).

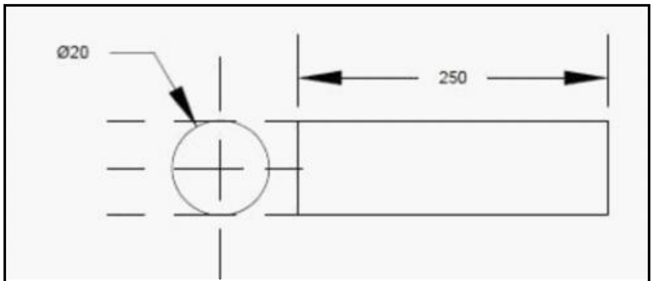

Fig. D : Rotor shaft

Flanges:

Flanges are used for structural component for the cutting blades. In order to mount blades, flanges were used. Flanges were made up of 8 mm thickness with mild steel sheet. Outer and inner diameter of flanges was 120 mm and 20 mm. A pair of flanges with cutting blades were fabricated and mounted on a rotor shaft (Fig. E).

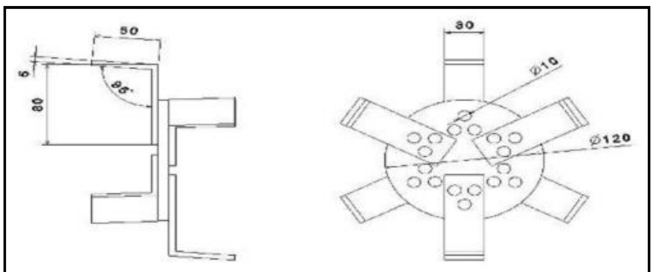

Fig. E : Flange with blades

Cutting blades

In rotary weeders, blades are attached to a flange mounted on a rotating shaft usually by nut and bolts. 'L' Shaped rotary blades are most common widely used for fields with crop residue, removing weeds (Bernacki *et al.*, 1972 and Khodabakhshi *et al.*, 2013). The cutting blades were made up of spring steel. The spring steel are bending from one end to form 'L' shape to satisfy cutting length of 5 cm and fixed to rotary flange of 120 mm diameter by using nut and bolt of diameter 10 mm (Fig. F).

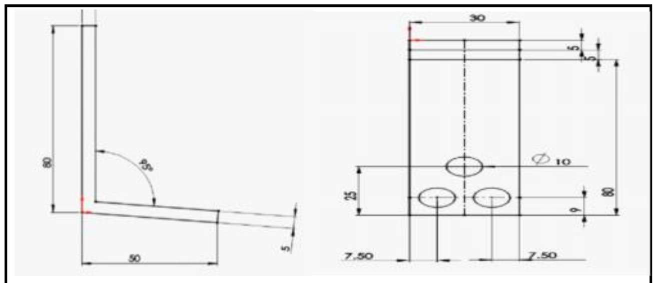

Fig. F : Cutting blade

Fig. G : Flange with 6 blades

Blade cover:

The blade cover was made up of 3 mm thickness of mild steel sheet. It covers the rotary blade assembly and gives protection to the operator from the soil thrown during operation (Fig. H).

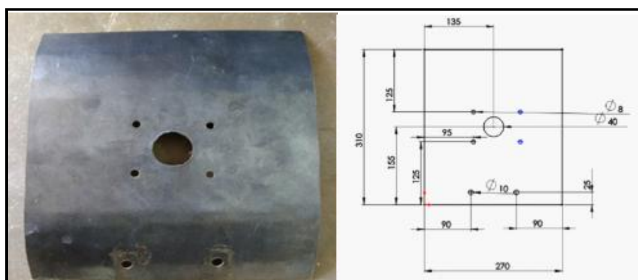

Fig. H : Blade cover

Transportation wheels:

For transportation two rubber wheels were used. Wheel is 10 cm in diameter and 3 cm width fitted on backside bottom of the blade cover (Fig. I).

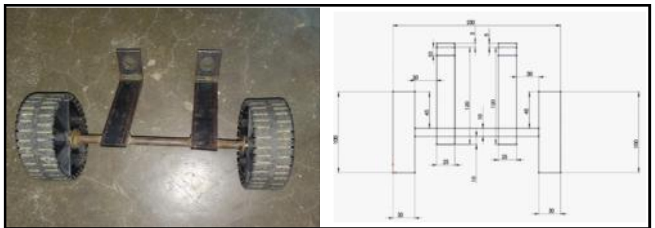

Fig. I : Transportation wheels

Performance evaluation of developed weeder:

The field experiment was conducted in different crops such as maize and chillieach blade (2, 4 and 6 blades per flange) combination. During the field evaluation effective field capacity, field efficiency, weeding efficiency, plant damage, performance index, fuel consumption were measured.

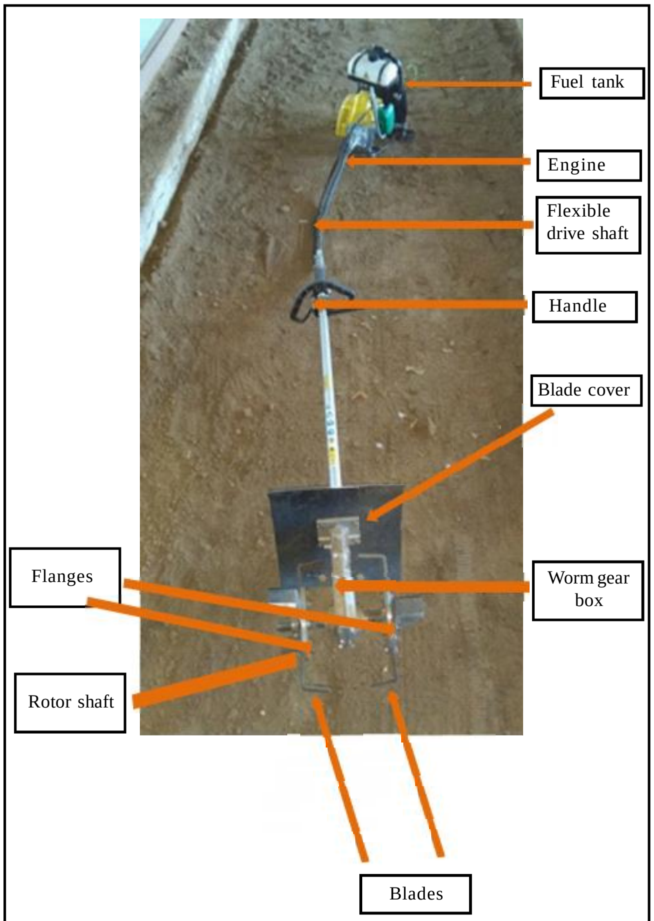

Fig. J : Portable knapsack power weeder

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Actual field capacity:

The actual field capacity of the weeder with different blades in different crops was determined. Maximum and minimum actual field capacity of weeder for maize crop was 0.028 ha/h with 2 blades and 0.023 ha/h with 6 blades. Similarly maximum and minimum actual field capacity of weeder for chilli crop was 0.029 ha/h with 2 blades and 0.025 ha/h with 6 blades.

Field efficiency:

The data reveal that the maximum and minimum field efficiency of weeder for maize crop was 74.6 per cent with 2 blades and 61.3 per cent with 6 blades. Similarly, maximum and minimum field efficiency of weeder for chilli crop was 77.3 per cent with 2 blades and 66.6 per cent with 6 blades, respectively.

Weeding efficiency:

The weeding efficiency for maize and chilli crop was measured in the field by different blade combination. It was observed that the maximum and minimum weeding efficiency of weeder for maize crop was 89.3 per cent with 6 blades and 84.7 per cent with 2 blades. Similarly, maximum and minimum weeding efficiency of weeder for chilli crop was 85.2 per cent with 6 blades and 79.9 per cent with 2 blades.

Plant damage:

The plant damage for maize and chilli cropwas measured in the field with blade combination. The test result shows that maximum and minimum plant damage of weeder for maize crop was 4.28 per cent with 2 blades and 2.4 per cent with 6 blades. Similarly, maximum and minimum plant damage of weeder for chilli crop was 5.03 per cent with 2 blades and 3.30 per cent with 6 blades.

Fuel consumption:

Fuel consumption of the power weeder was calculated by topping method. It was observed that the maximum and minimum fuel consumption of weeder for maize crop is 0.70 l/h with 6 blades and 0.61 l/h with 2 blades.Similarly, maximum and minimum fuel consumption for chilli crop was 0.76 l/h with 6 blades and 0.64 l/h with 2 blades.

Conclusion:

Test result indicates a clear view for adopting this development of portable knapsack power weeder because it is easy to operate and outcome of weeding efficiency is also satisfactory. The developed weeder can work upto 5.0 cm depth of operation with field capacity of 0.025 ha/h. higher weeding efficiency was obtained (*i.e.* upto 89.30%) and plant damage was 2.4 per cent. The performance index of the developed weeder was obtained 132. Fuel consumption was 0.76 l/ h.

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