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A review study on solar powered Weeder

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Abstract
A review on different types of Weeders, solar powered machines and solar powered Weeders was carried out to provide proper knowledge about basic design considerations of weeding mechanism and solar powered system. It had been found that weeding operation involves the soil tool interaction. So, the design of weeding mechanism should consider both weed parameters and soil parameters. From study it had been found that the solar power system should consist of the solar panel, solar charge controller, battery backup, load controller as per designed parameters. The efficiency of the solar system can be improved by application of dc power converters. From the study of developed solar powered Weeders, it was found that different types of Weeders had been developed such as based on artificial intelligence solar powered robot Weeder, solar powered portable power Weeder, solar powered walking type power Weeder etc.

Keywords: Solar, weed, Weeder, solar panel, photovoltaic and energy

1. Introduction
A weed is associate unwanted plant that grows with the seeded crop. It is a plant that competes with the crops for essential demand of water, nutrients and daylight for growth, which ends up in loss of quality and yield of crop production. Globally, actual yield losses due to pests have been estimated approximately 40 per cent of which weeds caused the highest loss of 32 per cent (Rao *et al*., 2007) [27]. Weeds lead to India losing an average of $ 11 billion each year in 10 major crops, shows data from 1581 farm trials in 18 states. If weed management is not proper, it results in massive crop losses as high as 70 per cent (Gharde *et al*., 2018) [10]. Some weeds have useful uses however not typically, once they square measure growing among crops. Weeds decrease the worth of land, significantly perennial weeds that tend to accumulate on long fallows.

Weeding is the operation of removal of weeds from crop field. Weeding is performed to boost the expansion of crops by reducing the competition for availableness of water, nutrient and daylight. Weeding tends to extend the price of crop production because it needs labor for operation. Weeding is a very important and labor intensive agricultural operation and regarding $1/3^{th}$ of the price of cultivation is accounted towards weed operation alone (Rangaswamy *et al.*, 1993) [26].

Weeding can be achieved by using chemical or mechanical methods. Chemically the growth of weeds can be controlled by using weedicides like atrazine, sulfosulfuron, paraquat dichloride etc. Mechanically, the weeds are destroyed by using wheel hand hoe, sweep tyne cultivators, rotary Weeders and other machineries. Mechanical Weeder controls the weed by cutting and uprooting action of Weeders.

The mechanical Weeders can be operated by using animals, humans and engines. For reducing the drudgery on animals and humans, engines are used as a power source. Engine is a machine which converts chemical energy into mechanical energy. In energy conversion process it emits greenhouse gases, which results in air pollution and global warming. For energy conversion petrol, kerosene and diesel are used as a fuel. The fuel prices especially petrol is rising steadily day by day. The cost of weeding by engine operated Weeder is about $1/3^{rd}$ of weeding by manual labors (Tajuddin, 2006) [34]. To overcome these problems, an effort is being made to search for some other alternative sources of energy for machines.

By switching to sources of renewable energy, the impact of the use of fossil fuels can be reduced. The use of renewable sources of energy can cut the risk of environmental pollution as a result improved public health and less global warming, it highly contributes towards the sustainability of the environment (Joshi *et al.*, 2009) [16]. The solar energy is inexhaustible and cleanest resource of energy and its utilization is also ecologically friendly (Akikur *et al*., 2013) [1].

The use of clean energy in weeding machines against petroleum fuels will cut the risk of environmental hazards and reduce dependency on petroleum fuels. By the use of solar energy, the problem of the unavailability of fuels will be resolved. The production capability of Weeder can be conveniently expanded as per need and low maintenance is required due to the absence of any moving parts (Bhattacharya, 2016) [7]. In addition, it will reduce the cost of weeding operation as a result increased income of farmers. To overcome the limitations of petroleum fuels, the solar powered Weeder can be developed.

2. Methodology

Various types of papers had been reviewed on design considerations of solar photovoltaic systems, developed solar powered machines, Weeders and solar powered Weeders. The problem definition of the project is controlling the weeds and application of solar power in the weeding operation. Also, the labor required for weeding is expensive, time consuming and difficult to organize, while the main objective is to build a machine that will overcome the above bottlenecks. In this project we are going to prepare a weed removing machine for agricultural land, to reduce the human effort of weed elimination and to create a machine for low cost using solar energy. Later model design and fabrication will be done.

3. Design considerations of solar powered Weeder

3.1 Design considerations of weeding mechanism

The design of the Weeder mainly depends on various parameters such as depth of weeding, soil properties, width of weeding, height of crop, forward speed of Weeder and type of blade used for weeding. In case of rotary Weeders, the speed of rotary blades is also considered.

The power requirement of the Weeder mainly depends on the depth of weeding, width of weeding, soil resistance, unit draft and speed of rotary blades (Bernacki *et al*., 1972) [6]. Generally, the operation of weeding is performed in the root zone of weeds. The depth of operation is selected as per the growth stage of weeds.

Salam *et al*. (2019) [30] carried out the study, which shows that the weed density decreased with increase in the soil depth. The higher number of weed density observed at 0 to 50 mm depth of soil followed by 50 to 100 mm and 100 to 150 mm depth of soil, respectively. The various types of weeds such as grasses, sedges and broadleaves were found in abundance at 0 to 50 mm than 50 to 100 mm and 100 to 150 mm depth. Annual and perennial weeds were also higher at 0 to 50 mm depth and annual weeds were dominant over perennial weeds at each of the three soil depths. The depth of Weeders can be selected from 0 to 50 mm.

The properties of soil within the operational field are also an important parameter which affects the power requirement and performance of the Weeder such as soil type, soil resistance, bulk density and soil moisture. Soil resistance is the result of cohesive forces between the individual soil particles (Marshall *et al*., 1996) [20]. Soil resistance is strongly influenced by soil texture, soil moisture content and bulk density. The studies shows that soil resistance increases with decrease in bulk density and clay content, while decrease with increase in moisture content (Canarache, 1990; Unger and Jones, 1998; Quraishi and Mouazen, 2010) [8, 36, 24]. The soil resistance of the different soil is given in table 1. For maximum weeding efficiency and better performance of Weeder, the soil moisture and bulk density needs to be in optimum range. The studies shows that the moisture content and bulk density of 9 to 17 per cent and 1.5 to 1.8 gm/cm^3 is found optimum for weeding (Goel *et al*., 2008; Hegazy *et al*., 2014; Mallikajuna, 2017) [12, 15, 19].

Table 1: Soil resistance of different soils

Sr. No.	Type of soil	Soil resistance (kg/cm^2)
1	Sandy soil	0.2
2	Sandy loam	0.3
3	Silt loam	0.35-0.5
4	Clay	0.4-0.56
5	Heavy loam	0.5-0.7
Source: Mallikarjuna [32]		

The width of weeding unit in Weeder is decided on the basis of spacing of the crops and crop canopy. It also affects the power requirement of the Weeder. The spacing of some crops are given in table 2. The forward speed of the Weeder is also an important parameter, which affects the field capacity, field efficiency, weeding efficiency and power consumption of the Weeder. Rathod *et al*. (2010) [29] conducted field tests with inter row rotary Weeder at three forward speeds i.e., 1.1, 1.2 and 1.5 km/hr. The average field efficiency was found to be 92.50 per cent. The field efficiency decreased with increase in speed of operation. The fuel consumption was 2.7 lit/hr and average operating speed of the Weeder was 1.27 km/hr for optimum performance. Hegazy *et al*. (2014) [15] developed a power Weeder for maize crop. The results showed that, the minimum value of fuel consumption was 0.546 l/h and observed at using two blades with 1.8 km/h Weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content of 16.18 per cent.

Table 2: Spacing of different crops

Sr. No.	Crop	Row to row spacing (cm)	Plant to plant spacing (cm)
1	Barley	22.5 (18-20) if delayed	-
2	Bengal gram	30	-
3	Corriander	30	15
4	Cotton	45-60	30-45
5	Fenugreek	15-30	5-8
6	Groundnut	40-45	10-15
7	Maize	60	20
8	Pearl millet	40-45	10-15
9	Sorghum	45-60	10-15
10	Soybean	25-30	4-8
Source: Apni kheti [3]			

Silas *et al*. (2015) [32] evaluated the performance of Weeder in field of okra plant. The weeding efficiency, performance index, depth of operation, field capacity and field efficiency of Weeder was found to be 86.5 per cent, 1108.48, 40 mm, 0.050 ha/h and 87.5 per cent at forward speed of weeding 1.44 km/hr, respectively.

Raosaheb (2017) [28] developed a multi row self-propelled rotary Weeder for narrow spaced crops. The soil type was sandy loam. The Weeder was evaluated on parameters such as blade length, rotary speed and forward speed. The maximum weeding efficiency of 76.70 per cent was observed on blade length of 180 mm, rotary speed of 360 rpm and forward speed of 1.6 km/h, respectively. From above study it can be concluded that for better performance forward speed should be from 1.2 to 1.8 km/hr.

In case of rotary Weeders, it also depends on the speed of the rotary blades. The speed of the rotary blades is optimized on the basis of weeding efficiency. The optimum speed of rotary blades needs to be at least 150 rpm (Chertkiattipol and Niyamapa, 2010) [9].

3.2 Design considerations of solar photovoltaic system

Ali *et al*. (2018) [2] studied the design considerations of solar photovoltaic system and provides the organized approach regarding the designing of solar system. The technical considerations for assessing the load energy demand on daily basis and sizing of the different components of solar system including PV panels, charge controller, battery, inverter and other appurtenances such as cables etc. required for the design configuration and installation of a solar PV system. The output capacity of solar pv system should be enough to charge the battery bank. So, that the load keeps operating. The capacity of battery bank should be sufficient. So, that the load can be operated at low sunshine hours or night (Mohanty and Gujar, 2016) [21].

The output supply from solar panel keeps fluctuating depending on the solar insolation available during sunshine hours. The fluctuating voltage from solar panel results in overcharging and undercharging of the battery (Glaving and Hurley, 2006; Armstrong, 2008) [14, 4]. To control the varying output voltage from solar panel, the solar charge controller of accurate size is used between the solar panel, battery and load (Mohanty *et al*., 2016) [22]. The solar charge controller also prevents the back flow of current towards the solar panel (Ghoto *et al*., 2016; Ali *et al*., 2018) [11, 2].

Baharudin (2017) [5] studies the topologies of dc-dc converter in solar pv applications. There are three types of dc-dc converter given as buck, boost and buck-boost converter that can be integrated with solar pv system. The study conducted on dc-dc converter shows that the basic function of dc-dc converter in pv system is to intermediate power processing, which changes the current and voltage levels such that maximum power can be extracted from the pv array. The application of dc-dc converter in solar pv system for maximum power point tracking (MPPT) feature.

3.3 Development of solar powered Weeder

Goverdhini and Reddy (2017) [13] designed and developed a solar powered multi-crop Weeder as shown in figure 1. The Weeder comprised of solar panel, two electrical dc motors, two batteries and weeding blades. The power transmission was done by chain and sprocket mechanism. The weeding bade used in Weeder was J type. The motor speed can be varied by altering the operating voltage through the speed controller.

Patel *et al*. (2018) [23] designed and developed a solar weeding robot for cotton field as shown in figure 2. The developed weeding robot performs the operation with the help of solar based technology, image processing concepts, weedicide sprayer and rotavator.

Fig 1: Solar powered multi crop Weeder

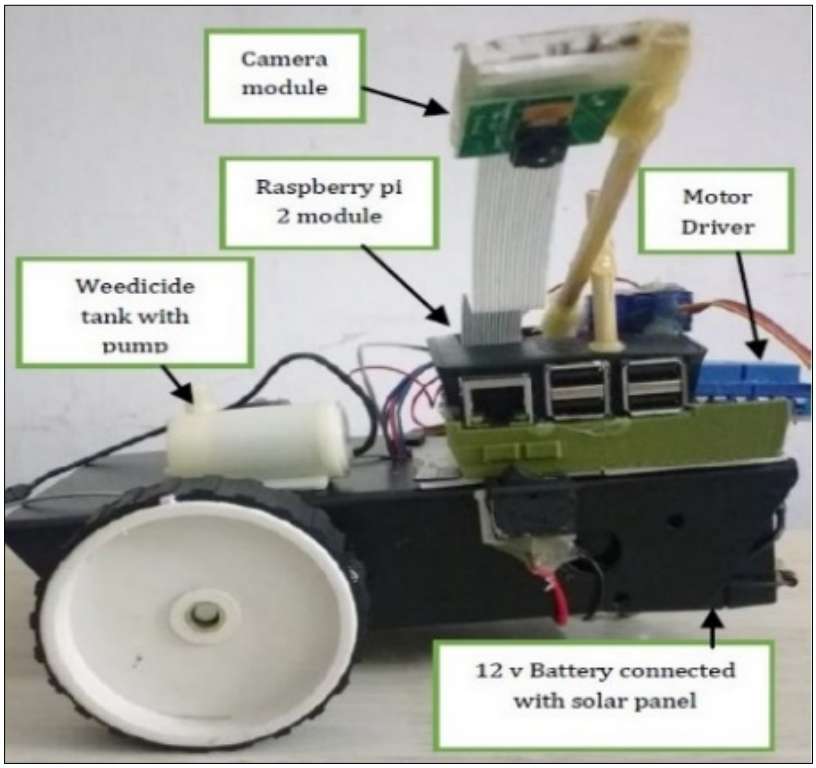

Fig 2: Solar weeding robot

Soni (2018) [33] designed and developed a solar tiller (Fig 3) to break the soil with the help of tilling blades. The solar tiller can also be used for removing weeds with lower depth adjustment than tillage depth. The tiller was developed by integrating the electric hub motor to rotate blades and motor. The power source used for operating Weeder was battery and solar photovoltaic system was used to charge the battery.

Sanjana (2019) [31] had developed a solar operated portable power Weeder figure 4. The Weeder consists of solar panel, dc motor, gearbox and blades. The developed Weeder was directly powered with a solar panel. The solar panel was mounted overhead of Weeder. So, that the solar panel also works as a shadow for worker.

Kachhot *et al.* (2020) [17] developed a solar operated walking type Weeder figure 5. It comprised of a powering system and a blade assembly. The power source included solar photovoltaic panel, solar charge controller, battery, motor charge controller and BLDC motor. The sweep type blade was used, which is mounted behind the main frame and power was given to the rear wheels by 750 W, 48 V BLDC motor using a chain and sprocket drive. Total weight of Weeder is 88 kg and total force required to push the Weeder at 2.5 km/h was 107 kg (730 W). Four batteries each of size 12 V, 12 Ah were used to power the motor. Two solar panels were used to charge the battery, each with a power of 150 W and it takes 2 h to completely charge the battery while Weeder is in steady state. The battery was discharge in 1.3 h in field when solar panel disconnected. With simultaneous charging and discharging of battery, the solar power system could run the Weeder for 7.3 hr.

Thomas (2020) [35] had performed a simulation of solar powered BLDC motor. The study deals with the utilization of solar pv array to drive the BLDC motor for agricultural applications. For extracting maximum power from solar pv array using dc-dc converter and maximum power point tracking algorithm.

Karthikeyan (2021) [18] had proposed a development of a machine that can be used for performing multipurpose operations in agricultural fields such as seed sowing, levelling, pesticide sprayers, Weeding and harvesting the plants. It will reduce the production cost, makes cultivation simpler, more affordable and accessible. The machine was powered with solar energy as primary source and battery as back up supply.

Fig 3(a): Side view of Solar tiller

Fig 3(b): Front view of Solar tiller

Fig 4: Solar operated power Weeder

Fig 5: Solar operated walking type Weeder

4. Conclusion

The main purpose of any Weeder is to control the growth of weeds. So, in first step design of weeding mechanism should be carried out. Then, the design of power system should be done. From the study of developed solar powered Weeder, it had been found that the efficiency of solar system adopted in developed Weeders can be improved by the application of dc power converters. From the above study it had been found that there is a scope of increase in efficiency of developed solar powered rotary Weeder by modifying design of weeding mechanism and electric circuit.

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