PHYSICAL AND PHYSIOLOGICAL CHARACTERISTICS OF SUBJECTS PARTICIPATED IN EXPERIMENTS ON WEEDING

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***Abstract* – Agriculture plays a vital role in Indian economy. The reason behind reduction in the productivity of agricultural is weeds. Weed removal is serious problem faced by the farmers that will reduce the farmer's interest to continue cultivation. The main objective of this paper is to construct and develop a solar powered weeder to provide the best opportunities for cultivation. Weeder is a mechanical implement used to take away the unwanted plants in the field. Indian agriculture is reliant on human power and also animal power. It is a time-consuming process. The working of this project is dependent on the solar panel. This is motorized equipment driven by the solar energy which moves blades to cut the weeds by chain sprocket mechanism. The design is simple and easy to operate. This equipment is designed to minimize the human effort, to reduce the cost and provide the efficient work output. This weeder will fulfil the requirements of the marginal farmers.**

***Keywords* – Agriculture, Weeds, Solar, Farmers, Weeding**

1. INTRODUCTION

Weed is an everyday term usually to describe a plant considered undesirable. The word weed is commonly applied to unwanted plants in human-controlled settings, such as farm fields, gardens, lawns, and parks. Weeds compete with the beneficial and desired vegetation in crop lands, forests, aquatic systems etc. and poses great problem in non cropped areas like industrial sites, road/rail lines, air fields, landscape plantings, water tanks and water ways etc. Weeds are an important factor in the management of all land and water resources, but its effect is greatest on agriculture. The losses caused by weeds exceed the losses caused by any other category of agricultural pests. It reveals that one third of the cost of cultivation is being spent for weeding alone (Rangaswamy et al., 1993). Weeding is one of the important operations. Various methods are in use for weeding purpose. The mechanical weeding has a wide scope, using implement, tool/machine either operated by human, animal and mechanical power to reduce the cost of labour and energy.

1.1Weeds

Weeds are the undesirable plants which grow with desired crop in the wrong place and in wrong time and doing harm to the desired crops. Weeds compete with the desired crops for water, sunlight, nutrient and available CO2 (Rao, 1999). Weed removal has progressed from a system totally based on the physical efforts of humans through the use of animals, mechanical implements, and chemicals and to some extent biological methods. There are some weeds which have advantages but not when they are growing between the desired crops.

Weeds reduce the productivity, increase the cost of cleaning and overall adversely affect the value of the land and thereby affecting the farmer's energy, time or money. Every year India faces the total loss of 33% of its economy from weeds which accounts an average of 1980 Cr of rupees is wasted due to weeds. The Losses are due to some of the following reasons; total loss of 26% from Crop Diseases, total loss of 20% from Insects and Worms, total loss of 6% from Rats has been surveyed (Sridhar, 2013).

1.2 Types of weed

Fig 1.1 Different types of weed

1.3 Weeding operation

Weeding operation is the process of elimination of unwanted plants so that the regular crops can be grown profitably. The quantitative and qualitative production of crop depends upon the effectiveness and timeliness of weeding operation. Weeds cause 45% of annual yield loss as compared to the disease 20%, insect 30% and pest 5%. Variant losses due to weeds are given as annual monetary loss of Rs. 19800 millions (Mukhopadhyay,1992), in major crops Rs 4200 million (Natarajan, 1987) and in food grain 60 million tonnes (Biswas, 1984). Removal of weeds consumes 25% labour i.e.

900- 1200 man–hour during the cultivation season (Kumar *et al*., 2002). Average weeding cost by traditional method is nearby Rs.945/ha out of the total cost of cultivation Rs. 3000/ ha for agricultural crop (Tajuddin *et al*., 1991). Weeds control method includes viz. mulching, solarization, chemical, flaming, mechanical, sterilization, and crop rotation with its own advantages and disadvantages. Mechanical weeding proved to be better as it keeps the soil surface loose providing better aeration and moisture conservation.

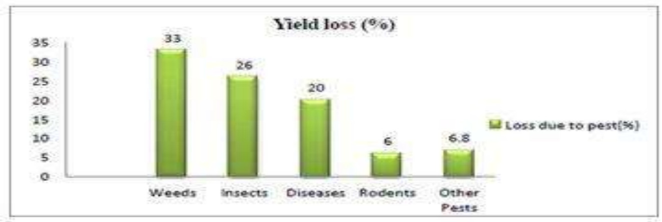

Fig.1.2: Graphical representation of losses due to weeds (Anon., 2016a).

1.4 Weed control methods

The fundamental principles of weed control involve prevention, eradication and control. In India, weed control methods adopted for crops varies through region with approx. 76 per cent of the cultivators having an average land holding size less than 2 ha (Rastogi, 1991). The cultural practices the farmers indulge in depend upon socioeconomic conditions of the farmer.

1.5 Solar control method

California research has turned sunlight to kill weeds by developing a solar powered machine (Bud, 1992). This machine is pulled by hand between rows of crops and concentrates sunshine into a single band of withering light. The solar concentrator known as Fresnel lens is an acrylic sheet made up of an array of tiny lens. The lens works as a part of three- pronged strategy of weed control.

2. LITERATURE REVIEW

Md Taufik Ahmad, degree of MASTER OF SCIENCE Major: Agricultural Engineering Program of Study Committee: Brian L. Steward, Co-major Professor Lie Tang, Co-major Professor Carl J. Bern Robert G. Hartzler

"Development of an automated mechanical intra-row weeder for vegetable crops"

Weed management is one of the tedious operations in vegetable production. Because of labour costs, time and tedium, manual weeding is unfavourable. The introduction of chemical weed control methods has alleviated these undesirable factors. However, the emergence of herbicide-resistant weeds, environmental impact and increasing demand for chemical free foods has led to investigations of alternative methods of weed control. Most implements employing mechanical cultivation cannot perform weed control close to the crops, and existing intra-row weeders have limitations. A mechanical weeding actuation system was designed, and a prototype was constructed. This actuator was developed to mechanically control intra-row weed plants. The mechanical weeding actuator consisted of a belt drive system powered by an integrated servo motor and a rotating tine weeding mechanism powered by a brushless dc motor. One of the major challenges in this project was to properly design the actuator and its weeding mechanism for effective intra-row weed control. A prototype actuator was manufactured and a series of tests was conducted to determine actuator efficacy and the corresponding force and speed requirements of the actuator. The actuator would be combined with a machine vision system for detecting crop plant locations and guiding the weeding actuator to execute mechanical weeding operations without damaging crops.

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"Comparative Analysis of Portable Weeders & Powers Tillers in the Indian Market"

Comparative study for portable weeders and power tillers in the Indian market is discussed. Various methods used for weed removal in crops are also discussed. Main focus of this is to study various equipment used for mechanical weed removal. This study revealed that most of the Indian farmers, majority of which are small scale farmers can afford only portable weeders. These small scale farmers as such don't use mechanical weed control methods. Chemical and manual weeding is predominantly used by these small scale farmers. The literature survey indicated that portable weeders are relatively less expensive in operation and maintenance but are also less versatile. Power tillers are considerably more expensive but are also very much more versatile and can operate in variable soil conditions. Due to these constraints most smaller farmers resort to chemical and manual weeding. These methods are labour intensive and as such a major constraint in crop production. Research has been carried out in many countries to involve technologies such as image analysis, GPS navigation, etc. in mechanical weeding machines. But most these efforts are yet to leave a lasting effect in market place. Hence it is necessary to develop more efficient and cost-effective methods of mechanical weeding so as to lessen the use of chemical and manual weed removal methods.

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"Weed Removing Machine for Agricultural"

The effective design of weed removing machine is to minimize the time taken for removing weed present between the growing plants. The vertical adjustment is to increase and decrease the height of the secondary rotating shaft and the rotary blades. It is mainly focused to increase the growth rate of plants. The horizontal distance can be adjusted by increasing the distance between the individual blades of the machine. The blades are rotated in clockwise direction with respect to the weed elimination. The depth of the removal is controlled by the handle. The power is transmitted from engine to the primary shaft. The primary shaft is connected to secondary shaft. The cam shape of shaft is to transmit the power to the blade by using chain drive. The specification of design is the number of blades, which can be increased and decreased with respect to our requirement. The compact design is very helpful for in the field of agriculture.

3. PHYSICAL AND PHYSIOLOGICAL CHARACTERISTICS OFSUBJECTS

The basic physical and physiological characteristics of 5 subjects (S1, S2, S3, S4 and S5) at different age group (32, 37,42,47and52) participated in the experiment for performance evaluation of different paddy weeders from mechanical and ergonomically point of view for female workers of Jabalpur region were recorded.

Subject	T1	T2	T3	T4
S1	81	125	104	103
S2	89	135	120	105
S3	94	136	122	109
S4	98	141	122	117
S5	103	143	125	120
Avg	**93**	**136**	**119**	**111**
SEm±	1.884	1.698	1.689	2.029
CD	5.649	5.090	5.063	6.083

Table 3.1 Heart rate (beats/min) obtained from five subjects during the weeding operation at 20 days after transplanting (DAT).

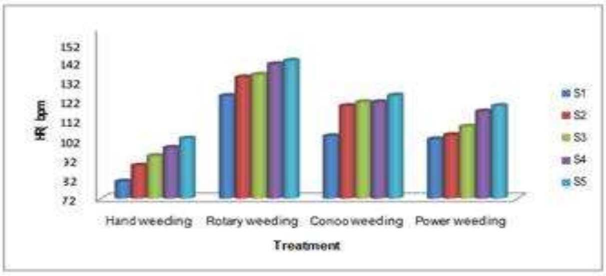

Fig 3.1 Heart rate responses for female subjects

The heart beat responses of workers subject under different weeding operations were observed at 20 DAT. Initial heart rate was different for five different age groups ranging between 80 to 100 beats/ min. For a particular workload the heart rate showed a sudden increase in first few minutes and then it was established throughout the work. After the completion of work the heart rate decreased drastically. Average heart rate of different age groups at different days of work using hand weeding, rotary weeding, cono weeding and power weeding were 93.0, 136.0, 119 and 111 beats/min respectively at 20 DAT . It was found that the minimum heart rate was obtained in T1 93.0 beats per min but it was not economical because of more labour intensive and time consuming. Amongst mechanical weeders the minimum heart rate was obtained in the operation of (T4) power weeder. This means the weeder T4 offer relatively less muscular exertion while pushing through and was liked by all subjects. The maximum heart rate was obtained in T2 136.0 beats/min. It may be due to increase in depth of cut specially designed blades which causes more interaction with soil and proper coverage of uprooted weeds etc increase the workload for rotary weeding. Similar finding were reported by ramesan et al (2007).

Subject	T1	T2	T3	T4
S1	5.02	15.53	10.58	10.21
S2	6.97	17.81	14.30	10.73
S3	8.16	18.15	14.77	11.78
S4	9.16	19.42	14.78	13.62
S5	10.01	19.85	15.72	14.30
Avg.	**7.87**	**18.15**	**14.03**	**12.13**
SEm±	0.475	0.405	0.398	0.483
CD	1.424	1.214	1.194	1.447

Table 3.2 Energy expenditure rate (kJ/min) obtained of five subjects during the weeding operation at 20 days after transplanting.

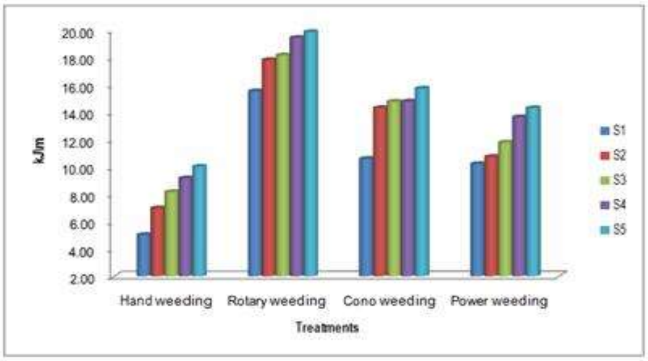

Fig 3.2 Energy expenditure rate responses for female subjects

The Energy expenditure rate responses of female subject under different weeding operations were observed at 20 DAT. Average Energy expenditure rate of different age groups at different days of work using hand weeding, rotary weeding, cono weeding and power weeding were 7.87, 18.15, 14.03 and 12.13 (kJ/min).it was found that the minimum energy expenditure rate was obtained in T1 7.87 (kJ/min). Amongst mechanical weeders the minimum Energy expenditure rate was obtained in the operation of (T4) power weeder. It may be due to the operator has only to guide the weeder and the power to operate rotary blades of power weeder was provided with the help of petrol engine mounted on this weeder. The maximum energy expenditure rate 18.15 kJ/min was obtained in T2. It was concluded that the operation with weeder T2 was relatively more laborious. Similar finding were reported by Kumar et al (2013).

3.1 Field performance of different weeding methods

Details of the performance evaluation conducted for hand weeding (T1), rotary weeder (T2), cono weeder (T3) and power weeder (T4).

3.2 Field capacity and field efficiency

The field capacity and field efficiency in various treatments were analyzed statistically. The result of actual field capacity and field efficiency in various treatments are presented.

Treatments	Field capacity (ha/h)	Field efficiency (%)
T1(control)	ND	ND
T2	0.0096	80.78
T3	0.020	86.87
T4	0.058	91.58
SEm±	0.001	0.925
CD	0.002	3.016

Table 3.3 Field performance of the mechanical and hand weeding methods in paddy field.

Table 3.3 revealed that the mean value of field capacity of T1, T2, T3 and T4 treatments were ND, 0.0096, 0.020 and 0.058 ha/h respectively. Among mechanical weeders, the maximum field capacity (0.058 ha/h) was obtained with T4 treatment followed by T3 which gave field capacity of (0.020 ha/h), and least field capacity obtained in case of treatment T1. In case of power weeder (T4) the operational speed is more than other weeding method. On the other hand, power weeder compared to other tested weeders has more weeding width; therefore its field capacity was higher. In case of rotary weeder the effective cutting width is reduced, the field capacity is also reduced.

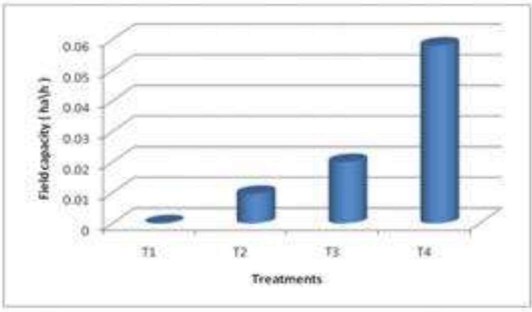

Fig 3.3 Field capacity of weeding methods

The statistical analysis of data revealed that all treatments differ significantly for field efficiency. The mean value of field efficiency of T1, T2, T3 and T4 treatments were ND, 80.78, 86.87 and 91.58 % respectively. The field efficiency, which indicates ratio of useful working to the total working time, was obtained maximum in T4 (91.58%) treatment and minimum in T2 (0.0096%) treatment .similar finding were reported by Parida (2002). Tajuddin (2009), Remesan et al. (2007) and Subudhi, (2004).

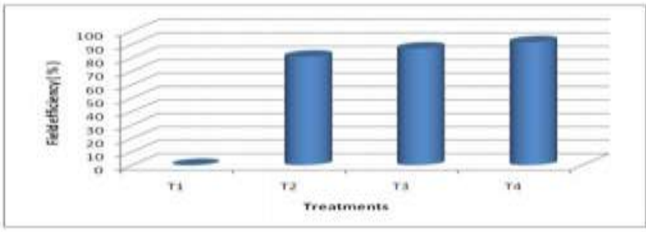

Fig 3.4 Field efficiency of weeding methods

3.3 Operating speed

The operating speed of selected treatments was analyzed statistically. The operating speeds in various treatments are presented.

Treatments	Distance (m)	Avg. Time (sec.)	speed	Operating speed (km/h)
T1	10	ND	ND	ND
T2	10	24.09	0.415	1.49
T3	10	22.92	0.436	1.57
T4	10	17.08	0.585	2.1
SEm±				0.013
CD				0.041

Table 3.4 Comparison of operating speed of the tested weeders in paddy field

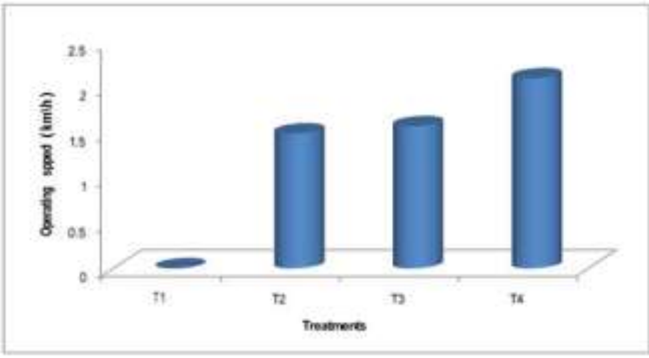

Fig 3.5 Operating speeds of the tested weeders in paddy field

The statistical analysis of data revealed that all treatments differ significantly for operating speed. The mean value of operating speed of T1, T2, T3 and T4 treatments were ND, 1.49, 1.57 and 2.1 (km/h) respectively. Among mechanical weeders, the highest operating speed was found in Power weeder (2.1 km/h) and lowest operating speed in rotary weeder (1.49 km/h). The operating Speed also depends on the parameters such as weight of the operator, height of the operator and physical condition of the operator. In power weeder due to high speed of rotar, the operator has to operate fast therefore the speed of power weeder was more for weeding in paddy crop as compared to the other tested weeder.

3.4 Labour requirement in different weeding methods

Table 4.11 shows that the labour required for different treatments at different weeding stage, and labour saving per hectare as compared to hand weeding method control.

Treatments	Labour required (man-h/ ha)			
	The first weeding (man-h/ ha)	Man (Rs/ h)	Labour cost (Rs ha⁻¹)	Labour saving (%)
T1	137	22.87	3133.19	Base
T2	114	22.87	2607.18	16.78
T3	50	22.87	1143.5	63.50
T4	18	22.87	411.66	86.86

Table 3.5 Labour required in different weed control methods (man-h/a)

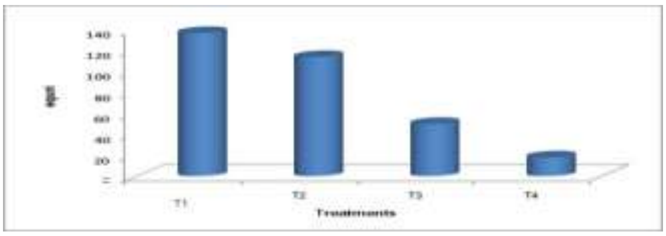

Fig 3.6 Labour required in different weed control method

Table 3.5 revealed that the average hours of performed action for controlling weeds for T1, T2, T3 and T4 were 137, 114, 50 and 18 (man-h/ ha).the minimum time for controlling weeds was 18 (man-h/ ha) for treatment T4 (power weeder) and maximum time for controlling weeds was 137 (man-h/ ha) for treatment T1 (hand weeding). Saving in time for weeding operation T2, T3 and T4 were 16.78, 63.50 and 86.8 %, respectively as compared to hand weeding.

In case of weeding with rotary weeder the labour requirement was comparatively higher than the other weeding methods. The rotary weeder was operated two times in the same row due to less weeding width as compared to other tested weeder. These studies showed that selection of a method for controlling weed has significant role in the reduction of number of labours. Hand weeding method (T1) is costly and labour intensive. limitation of labour at the time of weeding is becoming day by day a major constraint, therefore efficient weeding method should be selected to save time as well as labour.

3.5 Damaged plants

Damaged plant percentages in various treatments at 20 after transplanting are presented in Table 3.6. Number of plant before and after weeding in various treatments was presented

Treatment	Damaged Plant(%)/m^2
T_1(Handweeding)	0.80
T_2 (Rotary weeding)	3.20
T_3(Conoweeding)	3.20
T_4 (Powerweeding)	4.80

Table 3.6 Effect of different weeding methods on damaged plants.

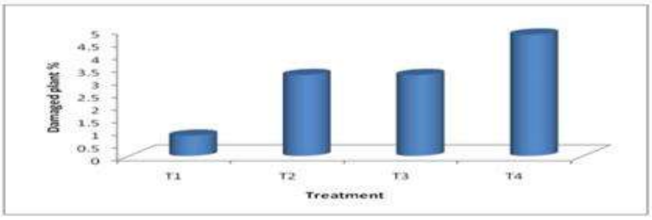

Fig 3.7 Effect of different weeding methods on plant damaged

Figure 3.7 revealed that at 20 DAT minimum percentage of plants damaged was (0.80%) in hand weeding (T1), while the maximum percentage of plant damaged (4.80%) respectively in power weeder (T4). The higher damaged of plant in case of power weeder as compared to mechanical weeders may be due to higher rotating speed of blade as well as higher travel speed. These results are in agreement with finding of Alizadeh M.R. (2011).

4. CONSTRUCTION AND WORKING OF SOLAR WEEDER

4.1 Construction

It consists of frame, which contains three links, translating link, rotary link and guiding link. Rotary link is coupled with dc motor and the translating link is connected to the frame. The translating link is flexible. Weeder setup is made at the end of the guiding link. There are two wheels at the bottom of the frame, so that the whole setup can be moved during the operation. DC motor runs through the battery in which the solar panel is connected.

4.2 Working principle

The battery which runs through the solar power is switched on. The dc motor runs through the battery, make the rotary link to rotate. The translation link which is connected to the guiding link and the rotary link, converts the rotary motion into linear motion. Because of the linear motion, the guiding link which contains the weeder setup, moves back and forth.

5. DESIGN CALCULATION

CHAIN DRIVE

d1 = outer diameter = 6 cm = 60 mm

d2 = inner diameter = 2.5 cm =25 mm

z1 = number of teeth on the sprocket pinion =100

z2 = number of teeth on the sprocket wheel

l = length of the chain = 100 cm

n = speed of rotation =50 rpm to 40 rpm

T = torque = 4 N-m to 18 N-m

i = transmission ratio i = d1/d2 = z1/z2

d1/d2 = 60/25 =2.4 z1/z2 = 2.4 z2 = 100/z1

z2 = 100/2.4 = 42 a = center distance in mm = (30 to 50) p where, p = pitch of chain in mm Assuming, p = 15.875 mm

a = (30 to 50) 15.875 a = 476.25 mm to 793.75 mm

CHAIN TYPE:

Assuming simplex chain, R50 from D.D.B pg: 7.72

Roller diameter, D =10.16 mm Bearing area, A = 0.7 cm2
Weight per metre, w = 1.01 kgf Bearing Load, Q= 2220 kgf

From D.D.B pg:7.77, minimum factor of safety , nmin = 7
From D.D.B pg: 7.78, Actual factor of safety ,[n] = Q / ∑p

∑p = pt+pc+ps Where, pt =Tangential force due to power transmission, kgf pc =Centrifugal tension, kgf

ps =Tension due to sagging of chain, kgf pt = 102 N / v

where, N = power chain velocity =ΠdN/60 = 3.14 *0.06 * 40 /60 = 0.125 m/s

Power, N=2πnT/ 60

=(2*3.14*40*18)/60 =75.398 W

=0.0753 KW pt = (102*0.0753)/0.125

pt =61.193 Kgf pc = w*v2/g

= 1.01 *(0.125)2/9.81 = 1.608 * 10-3 Kgf

ps = K* w* a

= 6*1.01*0.635 = 3.8481 Kgf

[Assuming K=6 for horizontal position] Avg. centre distance, a=635 mm = 0.635 m

∑p= 61.193 + (1.608*10-3) +3.8481 = 65.042 Kgf

[n] = Q /∑p

= 2220/65.042

= 34.13 [n] > nmin Design is safe

Allowable power transmission based on breaking load,

N = Q*V\102*n*Ks From d.d.b. 7.76 K1 =1.25

K2 =1.25 K3 =1 K4 =1 K5 =1.5 K6 =1

Ks = 1,25*1,25*1*1*1.5*1 = 2,34375

N= (2220*0.125)/(102*7*2.34375) Nmax = 0.165 KW

Bearing stress = (pt * Ks) / A

= (61.193 * 2.343)/ (0.7*102) =2.048 kgf/mm2

Design is safe

Length of chain L = Lp*p Lp = 2ap + {(z1 + z2)/2}+{[(z2-z1)/2π]2/ ap}

Where, ap = approximate centre distance in multiples of pitches

ap = a0/p =635/15.875 =40 mm

Lp= (2*40) +{ (100+42)/2} +{[(100-42)/(2*3.14)]2/40}

= (2*40) + 71 + 2.13 =153.13 mm

L = Lp * p

=153.13 * 15.878 L=2430.97 mm

6. CONCLUSION

This project work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between institution and industries.

We are proud that we have completed the work with the limited time successfully. The “SOLAR POWERED WEEDER” is working with satisfactory conditions. We are able to understand the difficulties in maintaining the tolerances and also quality. We have done to our ability and skill making maximum use of available facilities. In conclusion remarks of our project work, let us add a few more lines about our impression project work.

Thus we have developed a “SOLAR POWERED WEEDER” which helps to know how to achieve low cost automation. The operating procedure of this system is very simple, so any person can operate. By using more techniques, they can be modified and developed according to the applications.

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