"Vital Role of Sweeper Weeder Mechanism in Agriculture"

[1]Dhiraj V. Astonkar, [2]Komal P. Chinchamalatpure, [3]Dr. Prashant N. Pawade, [4]Dr. Sanjay M. Kherde
[1]Assistant Professor, [2]Research Scholar, [3]Associate Professor & Head, [4]Professor & Principal
[, 4] Department of Mechanical Engineering, [2, 3] Department of Botany
[1]Dr. Sau. Kamaltai Gawai Institute of Engineering and Technology, Darapur,Tq. Daryapur, Dist. Amravati, Maharashtra 444814,
[2,3] Arts, Commerce & Science College, Kiran Nagar, Amravati, Tq. Amravati, Dist. Amravati, Maharashtra 444606.
[4] P. R. Pote Patil Institute of Engineering and Research, Amravati, Tq. Amravati, Dist. Amravati, Maharashtra 444603.

Abstract: Weed control is the one of the most important problem that will reduce the farmer interest to continue cultivation. Modern agriculture depends heavily on engineering, technology and the biological and physical sciences. Irrigation, drainage, conservation and channeling are all important fields to guarantee success in agriculture and require the expertise of agricultural engineers. The aim of the work is to construct and develop the powered weed to provide the best opportunity for the crop to establish itself after planting and to grow vigorously up to the time of harvesting. The weeder driven by man to move in forward direction and the blade is attached at rear end is placed at the roots of weeds, once wheel get rotated then the blade starts cutting the weeds and once the operation is completed the weeder is shifted next row, like this the complete land of cultivation is made as weed free. Main advantage is reducing labor cost by reducing the number of labors, less time consumption. The operation is made to be simple that even any can handle, by handling it without any stress.

***IndexTerms* – Sweeper Weeder, Mechanism, Agriculture**

I. INTRODUCTION

Modern agriculture depends heavily on engineering, technology and the biological and physical sciences. Irrigation, drainage, conservation and channeling are all important fields to guarantee success in agriculture and require the expertise of agricultural engineers. Agricultural chemistry deals with other issues vital to agriculture, such as the use of fertilizers, insecticides and fungicides, soil structure, analysis of agricultural products and the nutritional needs of farm animals. Plant breeding and genetics represents an invaluable contribution to agricultural productivity. Genetics has also introduced a scientific basis in animal husbandry. Hydroponics, a method in which plants thrive without soil by chemical nutrient solutions can solve other additional agricultural problems. The packaging, processing and marketing are closely related activities also influenced by the development of science. The methods of rapid freezing and dehydration have increased the markets for agricultural products.

Mechanization, the outstanding feature of agriculture in the late nineteenth and twentieth century has relieved much the work of the farmer. Even more significantly, mechanization has increased efficiency and productivity of farms. Planes and helicopters are used for agriculture purposes, such as planting, transportation of perishable goods and fighting forest fires and crop fumigant to control insect pests and diseases. The radio and television transmit vital weather data and other information of interest to farmers.

Objective of Study:

- To understand the most common damaging weeds and observe the yield.
- To determine the abundance and distribution of weeds of validate the existence of common weeds and others.
- Estimate the range of loss due to lower population and increased the cost.
- Determine at what stage is the most competition during growing cycle between the crop and weeds.
- To understand the conditions under which the weed competition could be more severe.

Scope of Study:

- The approach of treating crop and soil selectively according to their needs by small autonomous machines is the natural next step in the development of precision farming.
- By taking a system approach, we can develop a new mechanization system that collectively deals with all crops agronomic needs in a better way.
- The agricultural chemical revolution has the ability to selectively manage weeds in cropping system with chemical design to kill on contact or movement within the plant.

Benefits from Study:

- Weeding maintained the yield by removing the unwanted grass from the yield.
- By maintaining the yield it reduces the cost of weed control as well as it reduces the pollution.
- It breaks the soil crust and covers the large area in less time. It also gives nearly complete weed control.

II. OVERVIEW OF PROJECT

Conventional Weeding Concepts:

figure 1: conventional weeding

Weeding is the removal of unwanted plants in the field crops. Weeding control is done by mechanical weeding, thermal weeding, flaming, biological control, chemical control, and by farming pattern. It has always been a problem to successfully and completely remove weeds and other innocuous plants. Invariably, weeds always grow where they are not wanted. Weeding with the use of tools like cutlass and hoe requires high labor force in a commercial farming system. Weeder demands less body effort as compared to operation by bullocks. The bullock implements require the hand and body pressure to achieve depth and alignment of the implement in use, whereas weeder the implements are mostly self guided. This reduces human drudgery to a great extent.

The comparative higher output of operation by the weeder as compared to bullocks reduces the operational time and achieves timeliness in operation. The maintenance of the weeder is easy. It is ideally suited for mechanizing small farm holdings which account for 80 % of the farm holdings of the country. Cost wise weeder should be an obvious choice of smaller farmers, if they are intending to have a mechanical power source for farm-operation. Weeder reduces the drudgery of collecting the waste grass between crops in the field during operations as compared to operations by bullocks. Weeder makes the manual of that wastage grass by cutting it in small piece and thoroughly mixed with soil during operation. Mechanical weed control is very effective as it helps to reduce drudgery involved in manual weeding, it kills the weeds and also keeps the soil surface loose ensuring soil aeration and water intake capacity. Weeding is an important but equally labor intensive agricultural unit operation.

There is an increasing interest in the use of mechanical intra- row welders because of concern over environmental degradation and a growing demand for organically produced food. Today the agricultural sector requires non-chemical weed control that ensures food safety. Consumers demand high quality food products and pay special attention to food safety. Through the technical development of mechanisms for physical weed control, such as precise inter-and intra-row welders, it might be possible to control weeds in a way that meets consumer and environmental demands. These mechanisms contribute significantly to safe food production. Weeds are a major problem in Groundnut cultivation. Herbicides are usually used for weed controlling despite the fact that herbicides have many negative effects due to environmental contamination. It has been understood that mechanized weeding significantly improves weeding efficiency as well as the quality of weeding.

However, it may consume non-renewable petroleum for operations; however, operational difficulties and slow weeding rate have been identified as major drawbacks of this weeder, particularly in large-scale cultivation. The weeder is one of the main farm mechanization in promoting soil weeder especially considering the fact that the majority of farmers are having small land. It reduces human effort. The implements are mostly self- guided. Working of the project is based on engine and chain sprocket mechanism which drives the wheels. It is a great saver of time and expenses on field operations. Thus it will have very effective uses on the farm field for weeding. Development of high capacity energy efficient versatile machines and combination machinery for increased labor productivity, reduced unit cost of operation, improved timeliness of operation and suitable for custom hiring. Thus it will have very effective uses on the farm field either for seeding as well as for weeding. Because of smaller size, two wheels and limited constructional arrangements; the soil weeder becomes one of the lightest yet most effective farm power sources.

Now the project has mainly concentrated on this difficulty, and hence a suitable weed removal machine is developed. In this project the engine with petrol starts and shaft with the help of chain sprocket mechanism and gears drives two wheels an operator generally has to walk behind the weeder to guide the direction of travel for various operations. Hence mechanical weeder is necessary to reduce the labor force. Environmental degradation and pollution caused by chemical is reduced by the use of Mechanical weeder. Low effective operation, low work effort and high time requirement for different types of hoe or cutlass, can be overcome with the use of mechanical weeder.

Layout of Soya Bean:

- Agro-climatic conditions for soybean farming:

Soybean thrives well in warm and moist climate. A temperature of 26 to 32°C appears to be the ideal for most of the varieties of soybean. Soil temperatures of 16°C or above support rapid germination and vigorous seedling growth in soybean farming.A lower temperature may cause to delay the flowering. Day length is the key factor in the soybean varieties as they are short day plants.

figure 2: soya bean farm

- Best season to grow Soybean:

Best season to plant soybean from 3rd week of June to mid of July.

- Soil requirement in Soybean Farming:

Soybean requires well drained and fertile loamy soils with a pH range between 6.0 and 7.5 are most favorable for its cultivation. Saline soils and sodic inhibit germination of Soybean seeds. Water logging damages the crop, so it is mandatory to have good soil drainage in rainy season.

- Seed Rate in Soybean Farming**:**

Depending on the variety, On average, the seed rate varies from 16kg/acre. Seed rate also depends on seed size, germination percentage, and sowing time.

- Crop Rotation in Soybean Farming:

In Soybean farming, mixed cropping mandua, sesamum& maize has been found feasible and fetching more returns. In inter cultivation; plant row spacing of maize should be at 100 cm keeping plant to plant distance 10 cm and 3 rows of soybean in between maize rows. Soybean has excellent scope as an intercrop in cotton, arhar, and upland rice in north India. In south part of the India, soybean can be cultivated as intercrop in cotton, sorghum, arhar, sugarcane, and groundnut.Land selection and Its preparation in Soybean Farming:- Land selection is very important in soybean farming as this will impact the overall production of soybean. The main land must not have been sown with soybean crop in the previous season to avoid volunteer plants that cause admixture. Land continuously cultivated with soybean may harbour wilt pathogen. So these kind of fields must be avoided. By following the crop rotation, endemic pathogen can be reduced. A soil with high organic matter defiantly helps in leading production of vigorous seed. The field should be made into ridges & furrows of 1feet wide or beds & channels of 4 feet x 6feet depending on cultivation practices followed.

- Seed selection in Soybean Farming:

Soybean seeds used for sowing must be from an authentic source. Genetic purity is an important factor in selecting sowing seeds. Avoid diseased, immature, hard, damaged, shrunken seeds. Seeds selected for sowing should also be vigorous for a good field stand.

- Line diagram for soya bean:

According to our study fig. shows the general layout of soya bean. As per the standard size and dimensions of the soya bean farm we design the blade. The distance between the two rows soya bean plant is approximately 16 inch to 18 inch. In between that the unwanted trash is present, so we required the accurate size of the blade that we design.Our vehicle is such a design that maximum three rows are to be covered. Generally, in conventional weeding only one row can be completed at same time but our vehicle will complete the three rows at same time.

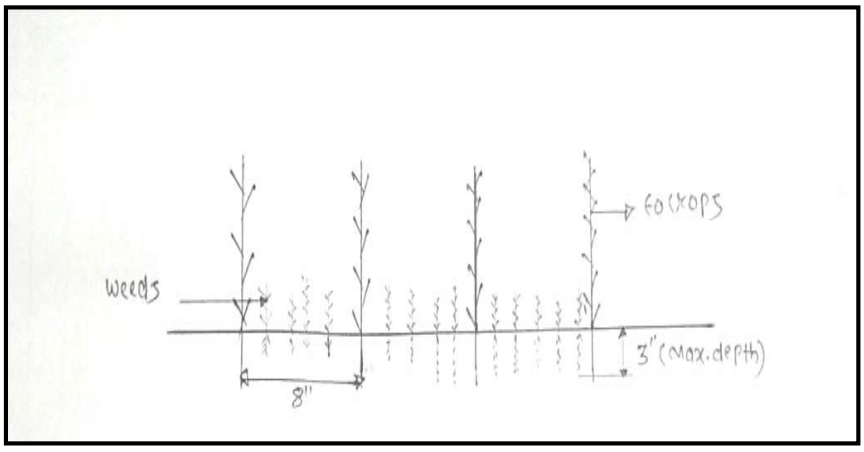

figure 3: line diagram for soya bean

Our vehicle is such a design that maximum three rows are to be covered. Generally, in conventional weeding only one row can be completed at same time but our vehicle will complete the three rows at same time. In conventional there is no relaxation to the human but in our project there is a comfort to the human. The major advantage of our project we completely reduce the animal power. In conventional weeding maximum 3 – 4 acres are covered. In our project maximum 5 – 6 acres are to be covered.

Damages or Losses Caused by Weeds:

- Reduction in crop yield:

Weeds compete for water, nutrients & light. Being hardy & vigorous in growth habit, they soon outgrow the crops & consume large amounts of water & nutrients, thus causing heavy losses in yield. E.g.: 40% reduction in yield of groundnut & 66% reduction in yield of chili. The loss of N through weeds is about 150 kg/ha..

- Increase in the cost of cultivation:

One of the objects of tillage is to control weed on which 30% expenditure is incurred and this may increase more in heavy infested areas & also cost on weed control by weeding or chemical control. Hence, reduce margin of net profit.

- Quality of field produce is reduced**:**

Weed seeds get harvested & threshed along the crop produce which lowers the quality. Such produce fetches fewer prices in the market. E.g.: Leafy vegetables, grain crop.

- Reduction in quality of livestock produce:

Weeds impart an undesirable flavor to the milk (Ghaneri), impair quality of wool of sheep (Gokhuru, Aghada), and cause death of animals due to poisonous nature of seed (Dhatura).

- Harbour insect-pests & disease pathogens:

Weeds either give shelter to various insect pests & disease pathogens or serve as alternate hosts & thus helps in perpetuating the menace from pests & diseases. E.g. Gall fly of paddy, midge fly of Jowar, leaf minor of soybean & Groundnut, rust of Wheat, tikka of Groundnut, Black rust of wheat,Downey mildew (Saccharumspontaneum).Weeds compete for water, nutrients & light. Being hardy & vigorous in growth habit, they soon outgrow the crops & consume large amounts of water & nutrients, thus causing heavy losses in yield.

- Check the flow of water in irrigation channels:

Weeds block drainage & check the flow of water in irrigation canals & field channels thereby increasing the seepage losses as well as losses through over through over flowing, so reduce the irrigation efficiency.

- Secretions are harmful:

Heavy growth of certain weeds like quack grass (Agropyonrepens) or lavala lowers the germination & reduces the growth of many crop plants due to presence of certainphytotoxins secreted by weeds.

- Harmful to human beings and animals:

Weeds cause irritation of skin allergy & poisoning to human beings, also death of castles.

- Cause quicker wear & tear of farm implements:

Being hardy & deep rooted; the tillage implements get worn out early & cannot work efficiently unless they are properly sharpened or mended.

- Reduce value of the lands:

Heavily infested lands with perennial weeds fetch less price as require heavy expenditure to brought under cultivation.

III. SYSTEM DESIGN OF WEEDER:

Design of project:

Our design provides simple and less expensive construction related to the all existing machines of weeding operation. According to the market survey and hurdles of complexity and economy, the design of our product is simple in operation and partially automated. Product life and cost effectiveness can be increased by selection of proper materials. By studying and evaluating of all the parameters of farming we created our design in pro-e software. The actual model is given below

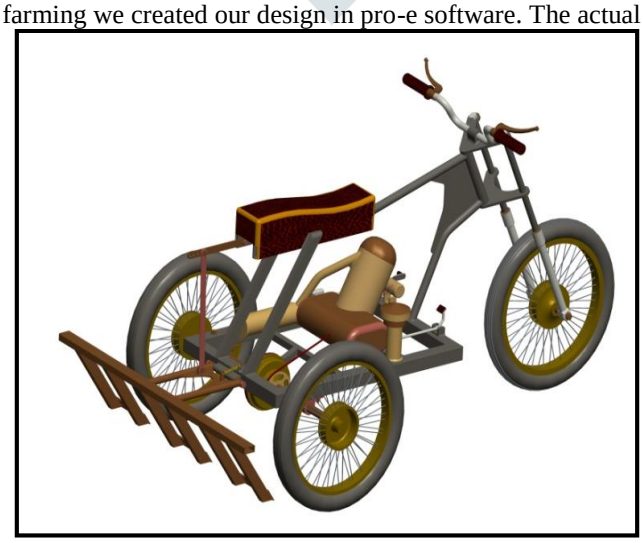

figure 4: CAD model of weeder mechanism

Since the design is differs than existing machines design of weeding machines which consist of engine, weeding blades, seating arrangements etc. which gives higher efficiency and human comfort.

Characteristics of Blades:

- The interaction between soil and machines takes place at the blades thus by improving their geometry the power required and the size of machine will reduce.
- Blades are attached to a flange mounted on a rotating shaft usually by nuts & bolts.

Types of Blades:

- L-shaped Blades
- C-Shaped Blades
- J- Shaped Blades

Selection of shape of blade:

- Weeding efficiency of l blade is 91 , c is 87& j is 84 %
- Cost of operation of j blade is rs.550,c is rs.580 & for l is rs.429 rs per hector.
- L shaped blade is economical & efficient as it saves 10.88 % of weeding cost & reduces plant damage n achieve weeding efficiency upto 91%.
- So we are going to use L shaped blade.

table no.1: characteristics of various type blade.

Characteristics	C Type Blade	J Type Blade	Sweep Type Blade
Cost of operation (for fuel & labour charges Rs/ha)	580	429	550
Weeding efficiency (%)	87	91	84
Plant damage (%)	3.4	5.1	1.2
Actual Field capacity (ha/hr)	0.068	0.059	0.12
Performance Index	114.30	169.84	153.23

Design Calculation of Weeder Blade:

- To develop and design the power weeder blade, functional requirement and consideration were:
- Blade should be able to cut the soil properly without causing unnecessary damage to the sharpening edge.
- The blades should be preferably designed, so that they do not enter the soil at the same time, but gradually (this helps in reducing the impact of the blades on the soil).
- The speed of the blade and forward speed of machine should be adjusted to cut sufficient uniform part every time with considering that the bottom uniformity of the furrow is more or less. So, locally manufactured vertical type blades were used in the study and mounted on a circular rotating element on its horizontal side. The available types of blades in markets were mostly rotary blades that can be fixed around the main rotating shaft periphery in rotary weeders. Therefore, the shape and dimensions of blades were determined as modified L-shape with angled cutting edge. Different parameters used in the study and have been in consideration to give safe strength and bending values for manufactured blades during weeding operation.

figure 5: CAD model of weeder blade

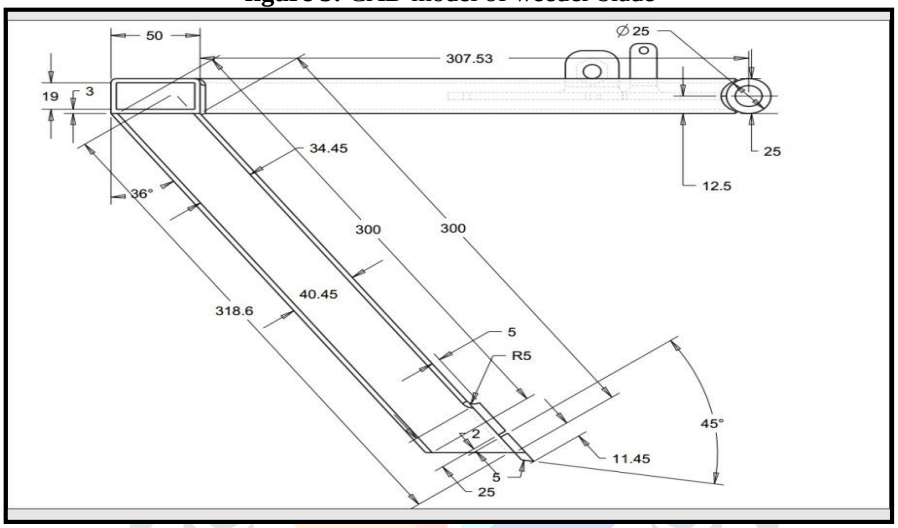

figure 6: line diagram of the blade.

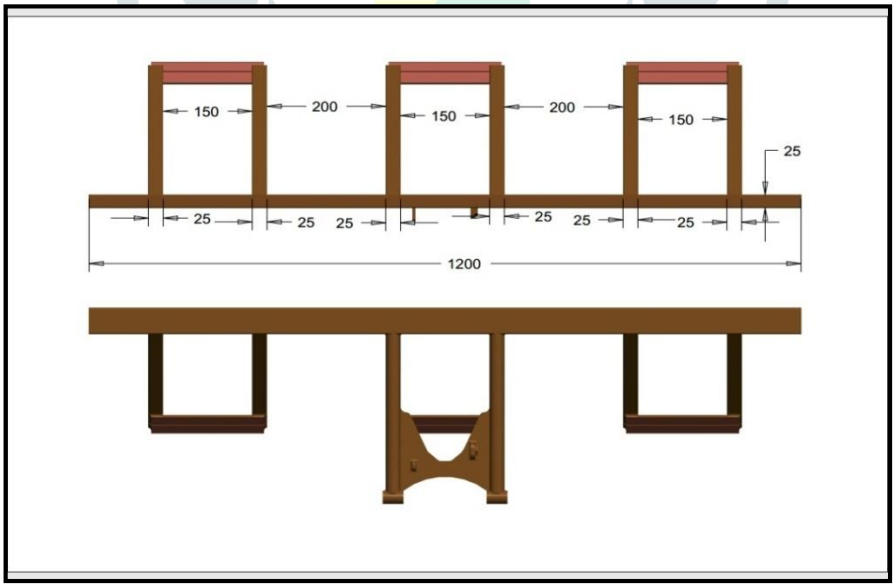

figure 7: CAD model of weeder bar

The calculation and assumptions are based on standard handbook of machine design were followed. Assumption was made as follows; Number of blades in one working set = 3; Length of blade = 6 cm; Width of blade = 5 cm. to calculate the design strength of blade, we considered; revolution per minute as engine output (N) = 1500 r.p.m; radius of engine output rotor (R) = 0.017 m. Therefore, speed of engine output (u) will be:

$u = 2 \pi R N = 2 \pi \times 0.017 \times 1200 = 128.2$ m/min……. (1) Moreover, expected Length of soil slice, L …... (2) Where; V = Average forward speed of the machine (35 m/min); U = Peripheral velocity provided by engine (128.2 m/min at 1200 rpm); R =

50 mm as a maximum required depth of cut; and Z = Number of blades so, L will be: Maximum force required to cut the soil for each blade (P); P = p A = 0.57 ×2.2 × 6 = 7.524 kg / each blade …… (3)

Where; P = Specific resistance of soil = 0.57 kg/cm2 (for medium firm soil); A = Area to be disturbed, A= a × length of soil slice; and a = Z Rπ2 U VAssumed edge length of the blade. If we have maximum four blades but only one can cut and disturb the soil, and 3 sets in the power rotor, so the maximum force required to cut the soil by the weeder.

P max = 7.524 × 3 = 22.57 kg

Cutting force per unit length of blade:
(pa) =6 22.57= 3.76 kg/cm length of blade.
Taking this as beam (cantilever) with uniformly distributed load, both maximum bending load and moment of inertia can be calculates as below:
Maximum bending load and Moment of inertia = 4 7.29cm
Where; d is assumed width of blade edge, 0.05 m; and e is assumed maximum thickness of blade edge, 0.007 m. To check for bending;
Where; E = 2.1 × 106 kg /cm2 for high carbon steel. The value will be:
Deflection = 101.06cm
It is almost negligible and for safe design deflection should be < a/1200 (1.06 × 10-4 < 5 × 10-3), so, it is safe.

IV. EXPERIMENTAL SETUP FOR WEEDER

Parameter Selection:

- The condition of the crop and weed population.
- Soil characteristics.
- The characteristics of the interface between soil and the soil acting.
- Weeder design parameters.
- Weeder needs to have built-in adjustability to change the width of working.
- It should have some arrangement to avoid mud getting stuck between the teeth/blades and needs to be fitted with a guard.
- It should be simple in design also work in all season weather.
- It can be manufactured locally and sold at an affordable price.
- Needs to have built-in adjustability to change the width of working.
- Should have some arrangement to avoid mud getting stuck between the teeth/blades.
- Needs to be fitted with a guard.
- Should be simple in design so that it can be manufactured locally and sold at an affordable price.
- In the particular case of animal-drawn weeders, the implement draft and the capacity of the animals to provide the required power will also affect performance, as will ergonomic considerations related to the comfort of the operator.

Soil Parameters:

When soil-acting mechanical weed-control implements are used, the soil is subjected to cutting or shear forces which cause it to fail and disintegrate. The parameters which influence a soil's resistance to this failure are:

- Its cohesion.
- Its internal friction, described by the angle of internal friction.

Test results for samples obtained at different depths are described according to the project benchmark, which was established at an arbitrary elevation of 100.00 feet. The actual elevation of the benchmark is unknown, but judging from the USGS Radford North quadrangle map, it is approximately 1700 feet above mean sea level. The ground surface in the area of the test foundations was relatively flat. The average surface elevation, after stripping the topsoil, was 97.5 ft.

The soil conditions at the site, which covers an area about 100 feet by 50 feet, are quite uniform. The soil profile revealed by six borings and two test pits was as follows:

table no.2: soil parameter

Elevation (ft)	Soil Description
97.5 to 94.0	Brown silty sand and sandy lean clay with fine sands and frequent small roots.
94.0 to 88.5	Dark brown, moist sandy lean clay with occasional gravel.
88.5 to 84.5	Brown moist sandy silt with lenses of silty sand.
84.5 to 80.5	Brown, moist sandy silt and silty sand.
80.5 to 77.5	Light brown sandy lean clay and sandy silt with trace of gravel.

Independent and Dependent Variables of Soil:

It has been understood that mechanized weeding significantly improves weeding efficiency as well as the quality of weeding. However, it may consume non-renewable petroleum for operations; however, operational difficulties and slow weeding rate have been identified as major drawbacks of this weeder, particularly in large-scale cultivation. The weeder is one of the main farm mechanization in promoting soil weeder especially considering the fact that the majority of farmers are having small land. It reduces human effort. The implements are mostly self- guided. Working of the project is based on engine and chain sprocket

mechanism which drives the wheels. It is a great saver of time and expenses on field operations. Thus it will have very effective uses on the farm field for weeding. Development of high capacity energy efficient versatile machines and combination machinery for increased labor productivity, reduced unit cost of operation, improved timeliness of operation and suitable for custom hiring. Thus it will have very effective uses on the farm field either for seeding as well as for weeding. Because of smaller size, two wheels and limited constructional arrangements; the soil weeder becomes one of the lightest yet most effective farm power sources.

table no. 3: independent and dependant variables

Independent variables and their levels	
Soil moisture content	7.73, 12.28 and 16.18, % (dry basis)
Blades arrangement for each unit	Two and four vertical blades
Forward speed	1.8, 2.1 and 2.4, km/h.
Depth of operation	From 0 to 20 mm and from 20 to 40
mm Dependent Variables:	
Fuel consumption	Weeding Index
Plant damage	Effective field capacity
Field efficiency	Total cost
Energy required per agricultural unit area	-

Weed Control Strategy:

There are few circumstances where there will be no requirement for weed control, but deciding on what your strategy will be, and how intensive it should be, is based on a number of factors.

- Type of tree chosen and area into which it is planted. Trees planted into more fertile land, for example well-restored brown field sites, are likely to need more intensive weed control measures than trees planted in infertile areas.This is because the land is likely to contain a large weed seed bank and repeated application of herbicides or a combination of several methods may be needed to gain full control of the weeds during the establishment phase.
- Environmental factors need to be evaluated as all weed control methods, whether cultural or chemical, will have both positive and negative environmental effects.
- Timing of weed control is important. It is often better to control weeds pre- emptively rather than to try to deal with a weed problem retrospectively after the situation has become severe. Avoiding a problem is better than taking remedial action.

table no. 4: weed control strategy

Modified Proctor	**Unscalped**	**Scalped**
maximum dry density	147.4	146.1
optimum water content Standard Proctor	4.9 %	5.1 %
maximum dry density	135.7	-
optimum water content	7.6	-

- The land is likely to contain a large weed seed bank and repeated application of herbicides or a combination of several methods may be needed to gain full control of the weeds during the establishment phase.
- It is often better to control weeds pre-emptively rather than to try to deal with a weed problem retrospectively after the situation has become severe. Avoiding a problem is better than taking remedial action.

V. RESULT AND CONCLUSION

Result:

This Paper consist of the engine operated weeder, it provides the better solution over conventional weeding operation. This engine operated weeder used in the farm for removing the trash at better cost. This is used in any kind of farm that is whether it may be tough soil or loose soil This provides better comfort to the farmer. At least 4 to 5 acres can be covered by using this than conventional. The average of the vehicle is 20kmpl on road and 11kmpl on field.

Conclusion:

This product was designed and developed on the existing manual weeder by implementing Petrol engine, sprockets, shaft, chain and gears with few modifications on the mainframe. Overall weight of the device is about 70Kgs which can be easily handled by a person in the field. Handle is made such a way that, to adjust person's height. Handle grip is provided to hold the device in appropriate position and easy to operate. Electrical cut-off switch is fixed at the left side of the handle to stop the engine.

The device is designed for ergonomically consideration for its operation only to push in the forward direction such a way that the front wheel rotates and the blades uproots the trash from the soil. The device moves forward direction due to the engine shaft rotation and by manual pushing action.

VI. REFERENCES

[1] R. Yadav and S. Pund "Development and Ergonomic Evaluation of Manual Weeder".Agricultural Engineering International: the CIGR Ejournal. Manuscript PM 07 022. Vol. IX. October, 2007.

[2] G.SELVAKUMAR *et.al* ," Design and Fabrication of Manually Operated Double Wheel Weeder", International Journal of Innovative Research in Science,Engineering and Technology, Vol. 6, Issue 3, March 2017,PP 4562-4566.

[3] D. D. Bombe *et.al* ," Design and Fabrication of Power Weeder, International Journal for Research in Engineering Application & Management (IJREAM) Special Issue – ICRTET-2018 ISSN : 2454-*9150*,2018,pp 549-551.

[4] S. A. Deshmukh et al. 2017. "Fabrication of Engine Operated Weeder" Volume 5 Issue IV,April 2017 IC Value: 45.98 ISSN: 2321-9653 .

[5] M. Rajshekhar et al. 2014. "Simulation and analysis of low cost weeder". International Journal of Research in Engineering and Technology, e-ISSN: 2319-1163, p-ISSN: 2321-7308

[6] Bernacki, H., Haman, J. and Kanafojski, Cz. 1972. Agricultural machines, theory and construction. Vol. I, Scientific publication, Central Institute of Scientific, Technical and Economic Information, Warsaw, Poland: 426- 428.

[7] Garg B K and Devnani RS, 1983. Animal- drawn multipurpose tool carries. Technical Bulletin CIAE/83/41. Central Institute of Agricultural Engineering (CIAE), Bhopal, India.

[8] Asit Dhawale *et.al* ," Modification of Sweeper Weed Cutter Machine Into Multipurpose Agriculture Machine", IJSART - Volume 5 Issue 2 –FEBRUARY 2019, PP 145-148.

[9] A. Hari Kumar, V. Deepanjali "Design & Analysis of Automobile Chassis" International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 5,Issue 1, January 2016.

[10] Dhatchanamoorthy.N, Arunkumar.J, Dinesh Kumar.P,Jagadeesh.K, Madhavan.P, "Design and Fabrication of Multipurpose Agriculture Vehicle", IJESC, Volume 8 Issue No.5 2018.