“MODIFICATION OF POWER OPERATED SINGLE ROW RICE WEEDER FOR DRY FIELD CONDITION”

M. Tech. (Agril. Engg.) Thesis

by

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“MODIFICATION OF POWER OPERATED SINGLE ROW RICE WEEDER FOR DRY FIELD CONDITION”

Thesis

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Kamlesh Kumar Singh

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CERTIFICATE - I

This is to certify that the thesis entitled **"Modification of power operated single row rice weeder for dry field condition"** submitted in partial fulfillment of the requirements for the degree of **Master of Technology in Agricultural Engineering** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Kamlesh Kumar Singh** under my guidance and supervision. The subject of the thesis has been approved by the Students Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by her.

Chairman

Date: 25/7/17

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member	(Dr. Rajendra Lakhpale)	

CERTIFICATE – II

This is to certify that the thesis entitled **"Modification of power operated single row power weeder under dry field condition"** submitted by **Kamlesh Kumar Singh** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **Master of Technology (Agricultural Engineering)** in the Department of **Farm Machinery and Power Engineering** has been approved by the external examiner and Student's Advisory Committee after oral examination.

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Place: Raipur (Kamlesh Kumar Singh)

Date:

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LIST OF NOTATIONS/SYMBOLS

Notations	Description
%	Per Cent
@	At The Rate
et al.	Et Alibi (And Co-Worker/ And Others)
˚C	Degree Celsius
°	Degree
≈	Approximately Equal To
cm	Centimeter
ha/cm	Hectare Per Centimeter
ha/h	Hectare Per Hour
hp	Horse Power
h/year	Hour Per Year
i.e.	That Is
g	Gram
h	Hour
kg	Kilogram
km/h	Kilometer Per Hour
mm	Millimeter
m	Meter
m^2	Square Meter
m^3	Cubic Meter
q/ha	Quintal Per Hectare
₹	Rupees
₹/qt	Rupees Per Quintal
₹/ha	Rupees Per Hectare
Viz.	Namely
H	Field Efficiency
	Pie
Σ	Standard Deviation
S	Seconds
wt.	Weight
Σ	Sigma

LIST OF ABBREVIATIONS

Abbreviations	Description
Agril. Engg.	Agricultural Engineering
AICRP	All India Coordinated Research Project
ASAE	American Society of Agricultural Engineer
Avg.	Average
C. G.	Chhattisgarh
CIAE	Central Institute of Agricultural Engineering
CV	Coefficient of Variation
d.b.	Dry Basis
DAS	Days after sowing
Dia	Diameter
EFC	Effective Field Capacity
Engg.	Engineering
FAE	Faculty of Agricultural Engineering
Fig.	Figure
FE	Field Efficiency
GMD	Geometrical Mean Diameter
ICAR	Indian Council of Agricultural Research
IGKV	Indira Gandhi Krishi Vishwavidyalaya
kPa	Kilo pascal
m.c.	Moisture Content
M.Tech.	Master of Technology
min.	Minute
MS	Mild steel
Rpm	Revolution per minute
TD	Tractor drawn
TFC	Theoretical Field Capacity
SVCAET&RS	Swami Vivekananda College of Agricultural Engineering and Technology & Research Station
w.b.	Wet Basis

THESIS ABSTRACT

a) Title of the Thesis	:	"Modification of power operated single row rice weeder for dry field condition"
b) Full Name of the Student	:	Kamlesh Kumar Singh
c) Major Subject	:	Farm Machinery and Power Engineering
d) Name and Address of the Major Advisor	:	Dr. A.K. Verma, Professor Department of Farm Machinery and Power Engineering S.V.C.A.E.T & Research Station, I.G. K.V., Raipur
e) Degree to be Awarded	:	Master of Technology in Agricultural Engineering

Signature of the Student

Signature of Major Advisor

Date: 28/7/17

Signature of Head of the Department

Weeding operation is one of the most laborious operations in agricultural farm.. Modified power weeder should have the following features: 2.0 hp, 2-stroke petrol engine. It is compact light low weight equipment, self propelled with accessories of soil working tool as durable floating system. It is centrally driven with worm gear box for transmission. The working width of the developed machine could be adjusted between 150 mm to 250 mm. It is equipped with rotating blades with 176 rpm and is centrally driven. Due to compactness and low weight it is easily maneuverable. Different types of blades were modified and transport wheel was attached to this weeder to perform for dry field condition and another modified part is axle extention shaft for managing the working width and lastly the "C" type blade for better performance in dry field condition. The power transmission from the engine to the blade was done by means of a flexible shaft.

The modified power weeder was tested in the line sown paddy crop at different conditions i.e. dry and wet field condition with various parameters along with

ergonomically evaluation. The average forward speed of modified power weeder varies from 1.55 to 1.66 km/hr. The average time required for weeding operation by this machine for 1 ha was in the range of 30.30 to 33.30 h. Field efficiency was found as 65 to 67 %. Weeding efficiency was found as 62 to 65 %. Two skilled operators were required to operate the weeder continuously. The amplitude of mechanical vibration on various assemblies of power weeder was observed as 150 micron. After 25 h of operation there was loss of 4.7 g in mass of the blade. Initially the mass of blade was 47.4 g. No noticeable difficulty was observed during the operation and adjustment of machine. The operating cost of modified weeder for both condition was Rs. 1800/ha compared to Rs. 1434/ha of wet land weeder. The fuel consumption of modified weeder for dry field condition was 1.03 to 1.09l/ha. The physiological cost was found out and the mean working heart rate of operator was 109 beats /min, the operation was graded as "moderately heavy".

The cardiac mean working heart rate value of the subject was 121.14 beats/min The energy expended during operation of a modified power paddy weeder was 121.14 beats/min for 20 to 25 years, 136.14 beats/min for 30 to 35 years and 128.85 beats/min for 35 to 40 years at 12:00 to 2:00 PM .Same as the oxygen uptake in terms of VO2 max was 1.104 l/min for 20 to 25 years, 1.411 l/min for 30 to 35 years and 1.260 l/min for 35 to 40 years during 12:00 to 2:00 Pm, and then it was decreases to 0.943, 1.270 and 1.144 l/min during 4:00 to 6:00 PM for different age group of worker, respectively. The corresponding energy expenditure was 12.60 kJ/min. Based on the mean energy expenditure, the operation was graded as "Moderately Heavy".

थीसीस अमूर्त

थीसीस का शीर्षक	:	शक्ति चलित एक कतार वीडर का सूखे क्षेत्र के लिए संसोधन
छात्र का पूरा नाम	:	कमलेश कुमार सिंह
प्रमुख विषय	:	फार्म मशीनरी एवं पावर अभियांत्रिकी
प्रमुख सलाहकार का नाम व पता	:	डॉ ए के वर्मा प्राध्यापक (फार्म मशीनरी एवं पावर अभियांत्रिकी विभाग) स्वामी विवेकानंद कृषि अभियांत्रिकी एवं प्रौद्योगिकी महाविद्यालय एवं शोध केंद्र, इं.गां.कृ.वि.वि, रायपुर
डिग्री से सम्मानित किया जाता है।	:	एम. टेक (कृषि अभियांत्रिकी) फार्म मशीनरी एवं पावर अभियांत्रिकी

छात्र के हस्ताक्षर

प्रमुख सलाहकार के हस्ताक्षर

दिनांक : 20/3/17

विभागाध्यक्ष के हस्ताक्षर

अमूर्त

शक्ति चलित एक कतार वीडर का सूखे क्षेत्र के लिए संसोधन

वीडींग ऑपरेशन खेती में एक बहुत ही श्रम साध्य कार्य है। संशोधित धान वीडर में निम्नलिखित विशेषताएं होनी चाहिए: 2.0 एचपी, 2–स्ट्रोक पेट्रोल इंजन। यह कॉम्पैक्ट हल्का कम वजन वाले उपकरण है, जो टिकाऊ अस्थायी प्रणाली के रूप में मिट्टी के काम करने वाले उपकरण के सामान से प्रेरित है। यह केंद्र में संचरण के लिए वर्म गियर बॉक्स से प्रेरित है। विकसित मशीन की कामकाजी चौड़ाई को 150

मिमी से 250 मिमी के बीच समायोजित किया जा सकता है। यह 176 आरपीएम के साथ घूर्णन ब्लेड से लैस है और केन्द्र में संचालित है। कॉम्पैक्ट और कम वजन के कारण यह आसानी से पैंतरेबाजी कर सकता है। सूखे क्षेत्र की स्थिति में बेहतर प्रदर्शन के लिए काम करने की चौड़ाई और अंततः "सी" प्रकार के ब्लेड के प्रबंधन के लिए अलग–अलग प्रकार के ब्लेड संशोधित किए गए थे और इन वीडर में सूखे क्षेत्र के लिए प्रदर्शन करने के लिए एक अन्य संशोधित भाग धुरा विस्तार शाफ्ट था। इंजन से ब्लेड तक पावर ट्रांसमिशन एक लचीली शाफ्ट के माध्यम से किया गया था।

संशोधित पावर वीडर को अलग–अलग परिस्थितियों बोकर फसल परीक्षण किया गया था यानी एरगोनॉमिक मूल्यांकन के साथ विभिन्न मापदंडों के साथ सूखा और गीला क्षेत्र की स्थिति। संशोधित पावर वीडर की औसत अग्रिम गति 1.55 से 1.66 किमी / घंटा तक बदलती है। इस मशीन द्वारा 1 हेक्टेयर के लिए वीडिंग करने के लिए आवश्यक औसत समय 30.30 से 33.30 घंटे की सीमा में था। फील्ड दक्षता 65 से 67% पाया गया था। वीडिंग की दक्षता 62 से 65% के रूप में मिली थी। दो कुशल ऑपरेटर को लगातार वीडर संचालित करने की आवश्यकता थी यांत्रिक वीडर के विभिन्न असेंबली पर यांत्रिक कंपन के आयाम को 150 माइक्रोन के रूप में देखा गया। संचालन के 25 घंटे के बाद ब्लेड के द्रव्यमान में 4.7 ग्राम की कमी आई थी। शुरू में ब्लेड का द्रव्यमान 47.4 ग्राम था। मशीन के संचालन और समायोजन के दौरान कोई स्पष्ट कठिनाई नहीं देखी गई। दोनों स्थितियों के लिए संशोधित वीडर का संचालन लागत रु 1800 / हेक्टेयर था एवं गीला भूमि वीडर की तुलना में 1434 / हेक्टेयर रहा । शुष्क क्षेत्र की स्थिति के लिए संशोधित वीडर की ईंधन की खपत 1.03 से 1.0 9 सधें। शारीरिक मान का पता चला था और ऑपरेटर की हृदय गति 109 बीट्स / मिनट था, ऑपरेशन "मामूली भारी" के रूप में वर्गीकृत किया गया था।

कार्डियक का मतलब काम का दिल की दर का मूल्य 121.14 बीट्स डपद–1 था धान के वीडर के संचालन के दौरान ऊर्जा लागत 20 से 25 वर्ष के लिए 121.14 डपद–1 थी, 136.14 Beats/min 30 से 35 साल और 128.85 डपद–1 35 से 40 साल के बीच 12:00 बजे से दोपहर 2:00। VO2 max के मामले में ऑक्सीजन तेज के रूप में 20 से 25 वर्षों के लिए 1.104 ml/min, 30 से 35 वर्ष के लिए 1.411 ml/min और 1.260 12 से दोपहर 2 बजे के बीच 35 से 40 साल के लिए ml/min, और फिर यह क्रमशः कार्यकर्ता के विभिन्न आयु वर्ग के लिए 4: 00 से

6:00 अपराह्न के दौरान 0.943, 1.270 और ml/min तक कम हो गया। संबंधित ऊर्जा व्यय 12.60 kJ/min रहा मध्य ऊर्जा व्यय के आधार पर, ऑपरेशन को "मध्यम भार " के रूप में वर्गीकृत किया गया ।

CHAPTER- 1
INTRODUCTION

A Weed is essentially any plant which grows where it is unwanted. A weed can be thought of as any plant growing in the wrong place at the wrong time and doing more harm than good. Weed waste excessive proportion of farmer time, there by acting as a brake on development. Weeding is one of the most important farm operations in crop production system. Weeding is an important but equally labor incentive agricultural unit operation. Weeding accounts for about 25% of the total labor requirement (900-1200 man h/ha) during a cultivation season. In India this operation is mostly performed manually with khurpi or trench hoe that requires higher labor input and also very tedious and time consuming process. Moreover, the labor requirements for weeding depend upon on weed flora, weed intensity, time of weeding and efficiency of worker.

Delay and negligence in weeding operation affect the crop yield up to 30 to 60 percent. In India about 4.2 billion rupees are spent every year for controlling weeds in the production of major crops. At least 40 million tones of major food grains are lost due to weed, which were 11.8 % of the total yield in Asia every year. Many research workers have reported a reduction of 5 to 60 per cent of crop yields. Obnoxious weeds like Carthamus oxycantha, Cyperus rotundus, Saccharum spontaneum, Cynodon dactylon, Avena fatua, Phalaris minor, Parthenium hysterophorus, etc are infested in large areas in various states of India. Weeding is the removal of unwanted plants in the field crops. 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. It was revealed that one third of the cost of cultivation is being spent for weeding alone. In India, the weeding operation is carried out with indigenous hand tools like ‘khurpi’ and spade. Recently many improved hand tools have been introduced for weeding by straight blade.

In India this operation is mostly performed manually with khurpi or trench hoe that requires higher labour input and also very tedious and time-consuming process. Moreover, the labour requirement for weeding depends on weed flora, weed intensity, time of weeding and soil moisture at the time of weeding and efficiency of worker. Often several weeding operations are necessary to keep the crop weed free. Reduction in yield due to weed alone is estimated to be 16-42 % depending on crop and location and involves 1/3 rd of the cost of cultivation. Weeding and hoeing is generally done 15-20 days after sowing. The weed should be controlled and eliminated at their early stage. Depending upon the weed density, 20-30 percent loss in grain yield is quite usual which might increase up to 80 per cent if adequate crop management practice is not observed. Rice and groundnut are very sensitive to weed competition in the early stage of growth and failures to control weeds in the first three weeks after seeding reduce the yield by 50 per cent.

Chhattisgarh popularly known as “Rice bowl of India” occupies an area of around 3.7 million hectares with the production of 6.16 million hectares and yield is 1665 kg per hectare of rice in 2010-2011. In the year 2011 – 2012, area under cultivation occupies to 3.77 million hectares with production of 8.58 million hectares and yield was 1597 kg per hectares (Anon., 2012).The prime causes of low productivity of rice in Chhattisgarh are limited irrigation (28%), lack of improved varieties suitable to different ecosystems, low imbalance use of fertilizer and insufficient weed management. Thus production and productivity of the rice can be increased by considering the various factors, among them weed control is one of the main factor.

1.1 Present Study

An existing power operated weeder for wetland condition have been already designed, developed and tested under department of FMPE in the year 2015 and the machine works satisfactorily. But there is also a need to modify this existing paddy weeder by providing some attachments so that it can work under dry land conditions. From this modification of machine, we are able to operate the machine in both dry and wet condition for weeding operation by using this single machine.

In Chhattisgarh, rice is grown by different methods, broadcasting, *biasi*, drilled or line sowing, *lehi* and transplanting depending upon the type of soil, topography of land, availability of water and labours. In order to increase the productivity of direct seeded rice in state, effort have been made through line sowing systems of cultivation, which not only maintain plant population but also offers additive advantages, such as intercultural operations, proper weed control and basal application of fertilizers.

The weed control operations are mainly done by three methods such as *biasi* operation, hand weeding and using of herbicides. In *biasi* operation, weeds are removed by using an indigenous plough after 35-40 DAS by hand weeding, weeds are removed by hand which is more effective but it is expensive, labour intensive as well as time consuming. Nowadays herbicide usage is increasing. In view point of labour shortage circumstances; it is preferred as a quick and effective weed control method without damaging the rice plants. But, it has adverse effects on human health and environment.

In order to assess the possibility of mechanization of the weeding operation, the power operated single row active weeder are proposed to be designed and developed considering the optimum shape, size and location of cutting blades, evaluation of its performance with other weeding methods in field conditions, optimization of dimensions of machine for better performance. The main objective is to design and fabrication of a power weeder, while minimum damages done to rice plants, cost effectiveness, easy manuvelling, low weight and fabrication by using freely available components and easy maintenance are main features of this design. Here comes the relevance of mechanized weeding, which is not a huge time consuming and significantly improves weeding efficiency as well as the quality of weeding.

1.2 Justification

It is imperative to mechanize the weeding process in order to solve or overcome the problem enumerated above. Here comes the relevance of mechanized weeding, which is not a time consuming and significantly improves weeding efficiency as well as the quality of weeding.

A single row power weeder was developed at SVCAET, FAE, IGKV, Raipur (Sirmour *et al*. 2016). This weeder was design and developed for wet field condition hence it could not perform in dry condition due to some design and operational problems. This machine was modified for dry field condition to make it versatile. In view of this, a study was undertaken with the following objectives as

The objective of the present study as:

1. To modify soil working tool of power operated row wet land weeder for dry field condition.
2. To evaluate performance of modified weeder.
3. Ergonomic and economic evaluation of the modified weeder.

CHAPTER-II

REVIEW OF LITERATURE

This chapter deals with the previous research work carried out by different researchers. In this work we make agricultural equipment which is useful for farmer, this equipment is known as power weeder. So we will make power operated single row weeder for wet or dry land. weeder cycles will remove grass between two row. It will remove multiple grasses in less time, so work will more complicated in less time. Therefore less workers and both field are covered for remove grass. The review of research information related to the present study has been arranged under the following headings.

2.1. General:

2.1.1 Weeds:

Weeds may be unwanted for a number of reasons. An important one is that they interfere with food and fiber production in agriculture, wherein they must be controlled in order to prevent lost or diminished crop yields. Other important reasons are that they interfere with other cosmetic, decorative, or recreational goals, such as in lawns, landscape architecture, playing fields, and golf courses. Similarly, they can be of concern for environmental reasons whereby introduced species out-compete for resources or space with desired plants. Weeds have long been a concern, perhaps as long as humans have cultivated plants. For the controlling of weed it is essential to know about the weeds for the experimental study to fulfill the purpose of design and development of friendly weeder.

It is essential to know some basic knowledge of the weeds, for the experimental study to fulfill the purpose of modification of power weeder. Here are some studies and research works carried out by various investigators from India on various aspects of weeds.

2.1.2 Weed flora distribution:

Moorthy and Das (2004) Reported about the problem of weeds in upland rice and gives the weeds and their groups are:\

- Grasses.
- Sedges.
- Broad leaf weeds.

Further it gives the common species in above groups are:

Grasses: In grasses, Jungle rice or owned barnyard grass Echinochlora colona (L.) link; Common barnyard grass or small barnyard grass E.crus-galli (L.) Beauv; Goose grass Eleusine indica (L.) Gaerth; Bermuda grass cynodon dactylon(L.)Pers; Large crab grass Digitaria sang wina(L.);Crow foot grass Dactyloctenium aegyptium (L.) Wild; Yellow foxtail Setaria glauca Intermedia Roem and schult.

Sedges: Purple nut sedge Cyperus rotundus L; Rice sedge cyperus iria L.

Broad leaf weeds: Bristly starbur Acanthopermum hispidum DC; Spiny pig weed Amaranthus spinosus L; Goat weed Ageratum conyzoides L; Dog weed cleome viscosa L; white cock‟ s comb Celosia argentea L; Euphorbia hirta L; Gripe wephyllanthus niruri L; Day flower Commenlina benghalensis L; Wet land amaranth Alteranthera sessilis (L).

2.2. Different Types of Weeds in Paddy

Smith(1964) stated that inter cultivation is an operation that required some kind of tool that stir the surface of the soil to a shallow depth in such a manner that young weeds could be destroyed and crop growth promoted. The primary objectives sought in cultivation of crop are:

1. Retain moisture by
    a. killing weeds
    b. loose mulching on surface
    c. Retaining rainfall
2. Develop plant food

3. Aerate the soil to allow oxygen to penetrate soil.

Promote activity of microorganism

Agrawal and Singh (1968) listed the common weeds of agricultural land with their scientific and common names.

Biswas (1984) reviewed and reported about weeds in Bhopal region. Weeds classified in different ways as per their place of occurrence or habitat, duration of life cycle, plant family etc. As per the occurrence weeds may be classified in two broad group

1. Upland weeds
2. Aquatic weed

Upland weeds may further be classified as:

a) Weeds of agricultural land
b) Weeds of Pasteur land
c) Forests weeds
d) Weeds of wasteland etc.

The aquatic weeds may be classified as:

a) Fresh water weeds
b) Marine water weeds

As per the life cycle, weeds may be classified as:

a) Annual weeds
b) Biennial weeds
c) Perennial weeds

Jana Bishnupada (2016) studied that the major weeds of paddy field in summer and rainy seasons of East Midnapore (Purbo Medinipur) district, West Bengal. The study was based on extensive and intensive fields surveys made during different months of summer & rainy seasons. In Purba Medinipur district 25 blocks are present. In every block the paddy is cultivated. But in Patashpur-I & II, Bhagwanpur-I & II, Ramnagar-I & II blocks the paddy is cultivated in three times in a year. The paddy is cultivated only in rainy season in rest of blocks. During the course the most part of all blocks in this district has been studied in summer and rainy seasons. Frequent field trips were made twice a month in each site for collection of weeds. Some weeds are also used as vegetables such as Marsilea sp. Enhydra sp. Hygrophyllus sp. Oxalis sp. Etc. 87 species of weeds have been identified and they belong to eight monocot families, twenty dicot families and four pteridophyta families.

2.3. Timeliness in weeding

Duff and Oricno (1971) reported that the timing rather than the frequency of weeding was a major determinant of effective weed control for rice. Recommendations have been made for the first weeding to be done 2-3 weeks after sowing , followed by a second weeding three weeks later and if necessary a third one.

2.4. Loses due to weeds

Smith (1961) reported that the weed competition is a serious problem in almost all rainy seasons' crops causing the losses in yield ranging from 9 to 60 percent or more.

Moorthy (1996) reported that the percent yield losses due to weed competition for the first one month, two month and entire crop season were 23.7, 35.4 and 40.8 respectively.

2.5. Methods of weed control:

Weed control is the process of limiting weed infestation so that crops could be growth profitably and other activities of man conducted efficiently. Researchers with varied degree of success have tried many methods of weed control. Knowing the several of weed control and applying some of them systematically, based on the requirements and the situations, the problem of weeds in the agricultural farm may be kept under control.

Agrawal and Singh (1968) study the important methods of weed control.

Biswas (1984) gave the detailed account of various important weed control methods. The study describe the of methods weed control.

2.5.1 Chemical control of weed

Chemical control of weeds is becoming popular day by day in the developing countries.

Fagade (1980) reported that the cost of herbicide application for weed control was half than that of hand weeding.

Singh *et al*., (1982) found that the highest net return was obtained with two weedings at 15 and 30 DAS of rice. When herbicide application was combined with one hand weeding, the highest net return was obtained with thiobencarb at 2 kg a.i./ha followed by butachlor at 2 kg a.i./ha and thiobencarb at 1.5 kg a.i./ha each combined with one hand weeding at 45 DAS.

Chauhan *et al.*, (2014) has reported that, in Asian countries, weedy rice, the unwanted plants of *Oryza sativa* competing with cultivated rice and these plants produce stained grains reduce rice yield from 16% to 74%.

Biswas (1984) though the advanced countries have mostly switched over to chemical control. The use of chemicals in for weed control has been quite low in India. However, a large number of herbicides are now available to control different types of weeds in rice crop. The reasons for limited use herbicides in India have been high cost herbicides, lack of knowledge on the available herbicides and their most of actions. Effective chemical control weed required different herbicides and management practices in various systems of rice cultivation. The work done on some of the important herbicides are presented herewith.

2.5.2 Cultural methods of weed control

Hand weeding is very popular in rice and vegetable crops. In this method the weeds are uprooted by the hands.

Datta *et al.*, (1974) reported that the weeding is traditionally carried out with indigenous hand tools. These involve considerable time and labours.

Ghosh and Singh (1985) found that the hand weeding twice, one at 15 days and other at 30 days gave the highest weed control efficiency and the maximum grain yield.

2.5.3 Mechanical weed control

Biswas (1984) reported that the control of weeds is oldest far method of weed control though it received less scientific attention us compared to the other methods of weed control. The mechanical weed control methods are extensively used and shall be used in many developing countries including India because agricultural s in these countries are cheap and easily available. Mechanical methods of weed control are simple and easily understood by farmers. The tools and implements for mechanical weed control are mostly manual and animal operated. Mechanical control of weeds involves use of weeders operated by human s, animal drawn or tractor drawn weeders, self propelled weeders or power weeders.

Hand tools

Datta *et al* (1974) reported that the weeding is traditionally carried out with indigenous hand tools. These involve considerable time and labours.

Weeders

A mechanical device to remove the weeds from an agricultural land is known as weeder. A weeder may be manual or animal drawn and tractor mounted or power operated.

Considering the importance of the problem of weeding, the Regional Network for Agricultural Machinery (RNAM) of ECAP initiated a sub network activity on testing, evaluation and adoption of weeders during 1978. In the first workshop of RNAM in 1979. The available weeder in the participating countries namely India, Indonesia, Peoples Republic of Korea, Philippines, Shrilanka and Thailand were selected for testing and evaluation.

2.5.3.1 Types of weeders:

Biswas (1984) according to the power sources of weeder, they classified as follows :

1.Manual weeders

a) Small tools or aids

b) Chopping hoes

c) Pull type hoes

d) Push type weeder

e) Push – pull weeder

2.Animal drawn weeders

a) Hoes with triangular and straight blades

b) Cultivators with shovels, sweeps and duck foot sweeps

c) Animal drawn rotary weeders

d) Hoes with rotary tines

3. Power operated weeders (self propelled weeders)

2.5.3.1.1 Manual weeders

These are various types of weeders which can be used for mechanical weeding in line sown rice. Manual and bullock mechanical weeder are friendly to environment, reduced time requirements, reduces human effort, manipulate the crop root zone reducing plant mortality, enhance root and shoot growth. The time saved by use of mechanical weeders may be utilized in better care and management of crop gaining higher yield. The mechanical weeders are also reported to be economical than chemicals and other methods Bhardwaj (2004).

Khan and Diesto (1987) reported that development of push type cono weeder which uproots and buries weeds in a single pass without requiring a back forth movement, specially suitable for rice. Manual weeding of rice in one hectare requires on an average of 120 man hrs. The cono weeder is about twice as for as to operate as that conventional rotary weeder.

Tewari *et al.,* (1993) concluded that the overall performance of a straight flat blade was the best. The field efficiency was highest, physical damage to crop was the least and weed removal per unit area was the greatest. The average power required by push-pull weeder was 21.3 W.

Mishra *et al.,* (1993) conducted field experiments at ZARS, Ambikapur and found that the line sowing of Dhuria rice and weeding by Ambika paddy weeder gave higher yield and economic return compared to chemical weed control.

Shiru (2011) reported that, a push-pull type of mechanical manual weeder was designed and fabricated. The weeder consists of main frame / handle, soil cutter (wedge), spikes, wheel bearing, bicycle chain and sprockets. It was quite simple, effective and the result is immediately observed. Tests result shows a weeding index (e) of 74.53%, efficiency of cutting blades 88% and field capacity of 0.02 ha/h. Small scale farmers can take advantage of the improved weeder to control weeds on their farms.

Muhammad and Attanda (2012) developed a hand push mechanical weeder that consists of two set of cone rotor blades, adjustable main frame and a float. The weeder, of effective field capacity of 0.357 ha/h has 64.87 N draft and overall width and depth of cut of 180 mm and 20mm respectively. With a single run of cut in between the rows on the field at a soil moisture content of 40.8%, the optimum weeding efficiency was 84.5% while weeding efficiency at 10.5% soil moisture content was 53.1%. Consequently, the highest plant damage of 8.33% was recorded at the 10.5% soil moisture content. 0.058 hp is the power required by a single person to push the prototype weeder.

Kumar *et al.* (2013) reported that, two types of manual weeder (cono-weeder and *Mandava* weeder) for shallow water conditions was selected and evaluated for different age group of workers (25 to 30, 30 to 35, and 35 to 40 years) at different day timings (T1 = 8.00 to 11.00 AM, T2 = 12.00 to 2.00 PM, and T3 = 4.00 to 6.00 PM). The weeding operations by different age group of workers at different working hours showed that the heart rates corresponding to cono-weeder and *Mandava* weeder was 154.54 beats/min and 140.17 beats/min, respectively. Oxygen consumption rate was

1.76 l/min and 1.47 l/min respectively. Working during 12:00 to 2:00 PM with both weeders developed maximum heart rate and oxygen consumption rate as compared to 8:00 to 11:00 AM and 4:00 to 6:00 PM. The study also reveals that, agricultural workers of 25 to 30 years age group developed maximum working heart rate and oxygen consumption rate
during weeding operations, which were higher than the age groups of 30 to 35 years and 35 to 40 years.

Gongotchame *et al.* (2014) studied on participatory approaches to examine the suitability of six mechanical weeders (Ring hoe, Fixed-spike weeder, Curved-spike floating weeder, Twisted-spike floating weeder, Straight-spike weeder and 2-Row spike-and-blade weeder) and ranked and compared them in order of preference with weed management practices. The ring hoe had the highest rank with 97 % farmer‟ s preference in the fields of non-ponded water and relatively.

2.5.3.1.2 Power weeders:

Power weeders are self propelled walking type machines used for weeding specially in lowland rice.

Yatsuk, *et al.*, (1982) has reported about use of miniature rototillers for soil working. Rototillers with small cutting width can also be used for light cultivation and weeding the space between the rows of some crops. Manual weeder with a flexible drive shaft and a portable engine earned on the shoulders is one of the types of miniature rototillers. The depth of soil working is regulated by the forward speed of the tiller: the lower the speed, the reater the depth of soil working. Miniature tillers are widely used in England, Japan and Italy.

Tewari (1987) developed a weeder cum herbicide applicating machine at the Agricultural Engineering department of IIT Kharagpur. It had a ground wheel made of MS tlats with 40 cm diameter having MS rod spokes, and a wheel guide extended rearwardly and fixed to a main platform made of angle iron having slots to attach different weeding blades. The unit could be used boths a mechanical
weeder and a herbicide applicator. To enable the machine work as a weeder it could be conveniently attached with various weeding range blades- flat inclined, flat inclined

with serrated edges, four time double and the improved double blade. The applicator mechanism consisted of feed tank, dripping mechanism and applicating mechanism. The herbicides consumption was 100 to 200 L/ha. The mechanical weeder required 8 to 12 man- days /ha.

Singh (1988) used a portable frame and engine of knap sack power sprayer to transmit rotary motion to a serrated disc rotary blade. A flexible shaft was used as means of power transmission. Also an electric motor of 0.5 hp was used as prime mover for operating the same machine set. On testing the man-hour requirement of knapsack sprayer engine and electric motor operated slasher came 57 and 50 respectively. But after some time of operation flexible shaft had broken due to more jerks coming on it. He also developed a front mounted power tiller attached cutter blade to accomplish cutting in small time period. Bearings inside a hollow shaft were used to support a cutting blade rotating in horizontal plane and power transmission was done using a bevel gear set and V-belt. On testing it was found that only 16 man-hour are required to accomplish the cutting of one ha but power of the engine was underutilized thus making wastage of energy.

Ambujam *et al.,* (1993) designed and developed a rotary rice weeder powered by a knapsack type, 1 kW engine. The machine had an operational depth of 70 mm with 80 percent weeding efficiency. The effective field capacity of the machine was 0.022 ha/h with a performance index of 587. The average fuel consumption of the machine was 0.86 L/h. The operational cost of the power weeder was Rs.502.717-compared to Rs.437.5/- for hand weeding.

Rangasammy and Balasubramaniam (1993) developed a power weeder and performance was evaluated and compared with the performance of conventional method of manual weeding with hand hoe and using manually operated dry land weeder. The field capacity of weeder was 0.04 ha/h with weeding of 93 per cent for removing shallow rooted weeds. The performance index of weeder was 453.

Panwar (1999) designed and developed a lightweight, low horsepower engine operated weeder cum seeder for weeding of row crops and single row seeding of different crops. The machine was powered with 1.5 hp petrol start kerosene run engine. The common chasis was designed for reduced rolling resistance and adequate traction ability. The engine power was transmitted to 280 rpm ground wheel through a specially designed reduction gear box and chain and sprocket system. For weeding operation, three types of tools such as hoe blade, sweep and L-blade were attached at the rear of the machine. The weeding tool can be selected based on density of the weed and requirement of the operator. It is a walk behind type of machine with an average ground speed of 2.5 km//2. The field capacity of the machine ranged between 0.5 - 0.6 ha/day for 8 working hours per day. The average fuel consumption was observed in the range of300-350ml/h.

Victor and Verma (2003) designed and developed a power operated rotary weeder for wetland rice cultivation and fabricated at the faculty of agriculture engineering workshop, IGKVV, Raipur, India during 1999-2000 and tested in the experiment field. A 0.5-hp petrol driven engine was used for power weeder with a reduction gear box. The power transmission from engine to traction wheel and to the cutting unit was provided by means of a belt, pulley and chain sprocket. For cutting four L shaped standard blades were used on the hub, and and
in turn fitted on rotary shaft. With 200mm spacing, the field capacity the machine varied between 0.04 to 0.06 ha/h with field efficiency of 71 per cent. The weeding efficiency of the machine was 90.5 per cent. The machine was simple, easy to fabricate by local artesian.

Cloutier *et al*., (2007) stated that mechanical weed control is generally widespread and used by farmers who do not use herbicides and recommendations always come to control weed during the early crop stages because limited tractor and cultivator ground clearance and machine-plant contact may potentially damage the crop foliage at later growth stages**.**

Padole (2007) evaluated the comparison in field performance between rotary power weeder and bullock drawn blade hoe. Rotary power weeder comprises engine, gearbox, clutch, main frame, depth control wheel, V shaped sweep, cutter wheels, handle, controls and transportation wheels. It worked better than bullock drawn blade hoe in respect of working depth 5.67 cm (16.67% more),effective field capacity 0.14

ha/h (40% more), and field efficiency 90%, which is 34.11 % more than that of bullock drawn blade hoe. The cost of operation was found to be 798.46 compare to 894.87 per ha by bullock drawn blade hoe. Hence, it is more economical and effective than bullock drawn blade hoe as it saves 10.77% weeding cost; reduce plant damage up to 54.23%, and achieved weeding efficiency up to 92.76%.

Niyamapa and Chertkiattipol (2010) designed three prototype rotary blades to reduce the tilling torque, impact force and specific tilling energy, and tested in a atory soil bin with flat tilling surface. Experiments with the prototype rotary blades and Japanese C-shaped blade were carried out at forward speeds of 0.069 and 0.142 m/s and at rotational speeds of 150, 218, 278 and 348 rpm (or 3.30, 4.79, 6.11 and 7.65 m/s) by down-cut process in clay soil.

Nkakini *et al.* (2010) designed and fabricated a rotor-weeder powered with 1.4 hp petrol engine and compared the field performance with the traditional manual hand hoe. The weeder consists of main frame, handle, rotary blades, shaft, sprocket and chain, chassis, cutting depth hint rear cutting depth adjuster, wooden engine seating, engine and ground wheel. Theoretical field capacity of the rotor-weeder was 0.47 ha/h with an effective field capacity 0.34 ha/h which was approximately twenty times that of manual weeding. The performance index was 1,700 and fuel consumption was 3.2 l/day. Weeding efficiency of rotor weeder was 71% for removing shallow-rooted weeds.

Ratnaweera *et al.,* (2010) designed and fabricated a power weeder. The weeding ability was optimized by weeding three rows simultaneously. The double-action weeding drum was driven by a small 1.3 kW gasoline engine, which can enable removal of weeds, while facilitating the forward motion of the machine. In addition, the conical shaped weeding drums designed to loose-up soil without harming the rice. A novel row changing mechanism was helpful for operating the machine by single person without destroying rice. A helical shaped toothwas designed in the weeding drums to enhance the shearing effect for weeding while losing up the soil.

Zareiforoush *et al.*, (2010) presented a new theoretical approach to design main tillage components of rotary tillers. In designing the rotary tiller shaft, it was revealed that in addition to the torsional moment, the flexural moment was also effective on the system safety. It was also recognized that in designing a rotary tiller, blades are most subjected to fracture by incoming stresses. The optimal value of rotor diameter considering the values of maximum tangent force was about 39.4 mm.

Olaoye and adekanaye, (2011) studied on the motion of weeding disc at any point on the surface of a rotary tiller. The weeder consists of 5 hp petrol engine, three pneumatic ground wheel, tool assembly, frame and handle. The performance of the weeder was investigated by considering the effects of four (4) weeding tools (Iron rod tine, Cable tine, Line yard tine and Plastic strand tine) and three (3) levels of weeding speeds (1804 rpm, 2435 rpm, 3506 rpm) on the weeding index, weeding efficiency and field capacity. The study resulted that for the forward speeds of 0.4 m/s to 0.5 m/s and engine speeds of 1804 rpm to 2261 rpm the weeding efficiency was 54.98% to 59.05% respectively.

Ojomo *et al.*, (2012) conducted a study on machine performance parameters by developing and evaluating a motorized weeding machine for the effect of moisture content (10%, 13% and 16%) and the type of cutting blades (Flat blade, spike tooth blade and curved blade) on the machine efficiency, quality performance efficiency, percentage of uprooted weeds and percentage of partially uprooted weeds. At 16% soil moisture content, the spike tooth blades gave the best machine efficiency by 94%, quality performance efficiency by 84%, percentage of uprooted weeds by 2.8% and least percentage of partially uprooted weeds by 1.8%.

Olaoye *et al.*, (2012) developed and evaluated a rotary power weeder to reduce the drudgery and ensure a comfortable posture of the operator during weeding and increases production with weeder components parts as frame, rotary hoe (disc), tines, power unit and transmission units. The results of field performance evaluation showed that, field capacity and weeding efficiency of the rotary power weeder were 0.0712 ha/h and 73% respectively. The cost of operation with this weeder was estimated as N 2,700 as against N 12,000 as manual weeding.

Thorat, (2013) was designed and developed for weeding of ridge planted crops. The main working components of the weeder were cutting blades and rotor shaft. Three types of blades (L-type, C-type and Flat-type) were selected having length, width and thickness of 100 mm, 25 mm and 6 mm, respectively, operating with a rotor shaft of 18 mm in diameter. C-type blades were most suitable at gang speed of 200 rpm and 15.26±0.96% (d.b) soil moisture content with weeding efficiency, plant damage, field capacity of 91.37%, 2.66%, and 0.086 ha.h-1, respectively. Time saving with ridge profile power weeder as compared to manual weeding was 92.97 per cent.

Kankal (2013) designed a self- propelled weeder on the basis of agronomic and machine parameters. The main features of prototype self- propelled weeder were, a 4 hp petrol start kerosene run engine, power transmission system, weeding blade (Sweep) and cage wheel. The rated engine speed 3600 rpm was reduced to 23 rpm of the cage wheel by using chain and sprocket mechanism in three steps.

Mahilang *et al.,* (2013) designed, developed and fabricated a power operated rotary weeder. The developed power weeder had a 1.4 hp petrol start/kerosene run engine as prime mover. The power was transmitted by means of belt, pulley from engine to traction wheel and to cutting units. For cutting, standard six L shaped blades were provided on the hub which in turn was fitted on rotary shaft. The weeding efficiency (91%), quality of work (14%), field efficiency (60%) and operational cost was found to be 808.42.

Hegazy *et al*., (2014) developed a power weeder for maize crop with modified vertical blades which were mounted on a circular rotating element on its horizontal side; the motion was transferred to blades units by amended transmission system. The effect of weeder forward speeds, depth of operation, number of blades and soil moisture content on fuel consumption, plant damage, weeding index, effective field capacity, field efficiency, energy required per unit area and total cost were studied. Three levels of soil moisture content (7.73, 12.28 and 16.18%), two blades arrangements (two and four vertical blades for each unit), three weeder forward speeds (1.8, 2.1 and 2.4 km/h) and two depths of operation (from 0 to 20 and from 20 to 40 mm) was chosen. The results showed that, the minimum value of fuel consumption was 0.546 l/h and recorded by using two blades with 1.8 km/h weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content 16.18 %. The highest field efficiency was 89.88% by using two blades with 1.8 km /h weeder forward speed at depth of operation ranged from 0 to 20 mm and soil moisture content 16.18%. The minimum value of effective field capacity was 0.198 fed/h by using four blades, weeder forward speed 1.8 km/h, soil moisture content 7.73% and under depth of operation ranged from 20-40 mm. The lower value of total cost was 55.09 L.E /fed and was obtained by using two blades with 2.4 km/h weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content 16.18 %.

Shravan (2011) stated that modification and performance evaluation of angeru power weeder developed by FIM scheme for paddy under SRI cultivation. It was observed that the machine performance was satisfactory and field capacity of the modified power weeder was found to be 0.0349 ha/h with a field efficiency of 79.74% at an average working depth of 4.8 cm. The field capacity of the cono weeder was found to be 0.0145 ha/h with a field efficiency of 73.03% at an average working depth of 3.1 cm. Fuel consumption of the modified power weeder was 0.6 L/h. Weeding efficiency was 84.58% and 68.97% respectively for power weeder and cono weeder. The increased soil contact and soil inversion capacity of the power weeder add greater values to its higher weeding efficiency. The power weeder gives better performance even in latter stages of weeding. If the weeds are matured the cono weeder just rolls over the weeds with minimum uprooting and inversion. The plant damage was, respectively, 3.61% and 2.03% of the power weeder and cono weeder. The higher percentage damage in the case of power weeder compared to cono weeder was mainly due to the higher effective width of cut of weed rolls. Moreover greater depth of cut and inversion of power weeder cause the uprooting of crop, which are extending to the row spacing.

Jeevarathinam and Velmurugan. (2016) studies on the computer aided engineering analysis and design optimization of rotary tillage tool on the basis of finite element method and simulation method is done by using CAD-software for the structural analysis. In Indian farming, the preparation of seedbeds for deep tillage using additional machinery and tillage tools are increased. Rotary tiller or rotavator is one of the tilling machine most suitable for seedbed preparation. In a Rotary tillage machine, Blades are the critical parts which are engaged with soil to prepare the land and to mix the fertilizer. These blades interact with soil in a different way than normal plows which are subjected to impact that create cyclic forces which result in fatigue failure of the blade. This actually decreases the service life of a blade. Therefore, it is necessary to design and develop a suitable blade. This paper describes the design modification and development of rotavator blade through the (CAD) interrogation method by modifying the design and also by modifying the material properties. Then better design will be compared by comparing the results.

Sam, (2016) stated that Mechanical weed control not only uproots the weeds between the crop rows but also keeps the soil surface loose, ensuring better soil aeration and water intake capacity. Weeding by mechanical devices reduces the cost of labour and also saves time. At present power paddy weeders available in the market were designed to work in two rows at a time. In this study modification was done to attach a cono weeder in line with the float of the power paddy weeder so as to cover the weeding in three rows at a time and ergonomically evaluated. Psychophysical measurement technique was used to quantify the overall discomfort as well as body part discomfort. The physiological cost involved in operation of the three row power paddy weeder was found out and the average working heart rate of the subject was 110 beats min-1. The predicted oxygen consumption rate was 0.971 l min-1 that is 47% of their aerobic capacity (VO2 max) which was above the acceptable limit of 35% of VO2 max. The weeding index was found to be 88%. Area covered by the power paddy weeder was 40 cent/hour while planting 30 cm row spacing. Mean overall discomfort rating on a 10 point visual analogue discomfort scale (0- no discomfort, 10- extreme discomfort) was 4.0 and scaled as "More than light discomfort". If only one worker is engaged for the weeding operation with this equipment, 9 min rest could be provided after 30 min of operation.

Binni, (2016) survey that in Indian agriculture, it's a very difficult task to remove unwanted plants manually as well as using bullock operated equipments which may further lead to damage of main crops. More than 33 percent of the cost incurred in cultivation is diverted to weeding operations there by reducing the profit share of farmers. Every year in India, an average of 1980 Cr of rupees is wasted due to weeds. The country faces the total loss of 33% of its economy from 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. 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. After discovering that tools such as cutlass and hoes require high drudgery, time consuming and high force. This review paper is aim by carrying out the performance evaluation of different weeders such as manually operated and power operated which help to minimize time will consume, working fatigue and to reduce cost.

CHAPTER - III
MATERIALS AND METHODS

The field experiment was conducted to study the modification of power operated single row rice weeder for dry field condition. Testing of the modified power operated single row rice weeder for dry field condition was conducted. The major factors in modification such as rotary blades, axle extention shaft, wheels, mud flap, operational safety, and easiness in fabrication were taken into account for its modification and was made simple so that local artesian can fabricate, repair and operate the machine easily. Details of major system modification, components, designed, development and testing of machine are described below.

3.1 Details of experimental field

3.1.1 Experimental Site

The study was conducted in Swami Vivekananda College of Agricultural Engineering & Technology and Research Station, Faculty of Agricultural Engineering, IGKV, Raipur (CG) situated at 21^{0} 14' 02" N latitude and 81^{0} 43'11" E longitude. The operational field meant for the study was selected from the demonstration / research field of the faculty.

3.1.2 Climate

Raipur has a tropical wet and dry climate, temperature remains moderate throughout the year, except from March to June, which can be extremely hot. The temperature in April–May sometimes rises above 48 °C. These summer month also have dry and hot winds. In summers, the temperature can also go up to 50 °C. The city receives about 1,300 mm of rain, mostly in the monsoon season from late June to early October. Winters last from November to January and are mild (Anon., 2012).

3.2 Description of Power weeder

3.2.1 Existing components before modification

3.2.1.1 Power unit

The power for prime mover used for weeding operation was calculated as 2hp with all major factors taken into account as speed, soil resistance etc. (Sirmour *et al*, 2016) .The power required for weeding condition is about 2 hp per row. The engine to be used for modification of power weeder therefore can cope with the draft requirement for one row. Hence, a single cylinder, 2- stroke petrol engine of 2 hp, with side valve and air cooled engine was used as a prime mover in modified power weeder. The technical specifications of the engine are shown in Table 3.1.

Table 3.1 Technical specification of the Engine

S.No.	Particulars	Specification
1	Type	Air cooled, 2 stroke, Horizontal Spark ignition engine
2	Dimensions, mm	720×520×1030
3	Bore/Stroke, mm	44/33
4	Fuel	Petrol engine
5	Fuel tank capacity, l	1.3
6	Starting	Recoil start
7	Engine weight	17 kg
8	Net power	1.6 kW
9	Recommended speed	6500 rpm
10	Max. Torque	5000 rpm
11	Engine Lubricant	2T oil
12	Transmission lubricant	SAE 90

3.2.1.2 Transmission

A light weight aluminum gear box was connected vertical with the engine. The power from the single central vertical rotor was transmitted to the rotor by means of worm and worm gear arrangement. The rotary wheels were rotated by the power transmission system of the engine. The bottom of the weeder is provided with the wheel. The forward speed of the machine was having a speed ratio of 34:1 from engine to rotor shaft.

3.2.1.3 Rotary blades

In rotary weeders, blades are attached to a flange mounted on a rotating shaft usually by nuts & bolts. Commonly three types of blade geometries are used as blades for weeders and tillers namely, L-shaped blades, C-shaped blades and J-shaped blades. The C-shaped blades have greater curvature, so they are recommended for penetration in hard field and better performance in heavy and wet soils. The J-shaped blades are used for loosening, destroying the soil surface compaction and giving better ventilation to the soil, generally used for tilling hard and wet soils whereas L-shaped blades are the most common widely used for the fields with crop residue, removing weeds (Bernacki *et al.,* 1972 and Khodabakhshi *et al*., 2013). C shaped blades have greater curvature, so they are recommended for penetration in hard field and better performance in heavy and wet soils. J Shaped blades are used for loosening, destroying the soil surface compaction and giving better ventilation to the soil generally used for tilling hard and wet soils.

3.2.1.4 Handle

Handles was made of MS pipe with 19.2 mm, outer diameter 20 mm MS rectangular frame of length 40 mm and width 18 mm with plastic grip fitted at the ends. The overall length of handle 1090 mm with two bends from point of attachment and have a height of 760 mm from ground level. The length of handle cross bar is 570 mm and diameter of handle grip is 25 mm with a length of 105 mm. The handle is attached on main frame at the rear of the machine with help of four pieces of nut and bolts of having diameter 10 mm. With help of handle, the machine can be steered. A throttle lever is provided on right side of the handle to control the engine speed.

3.2.1.5 Mud flap

To avoid throwing of mud and stones towards operator and as a safety, a mud flap is provided covering the upper and rear side of the blades of the rotary cutting units. Upper side is made up of plastic sheet and the rear side is covered by rubber sheet. Both is connected and supported to the inner end of the handle by means of nut and bolt with the help of MS flat.

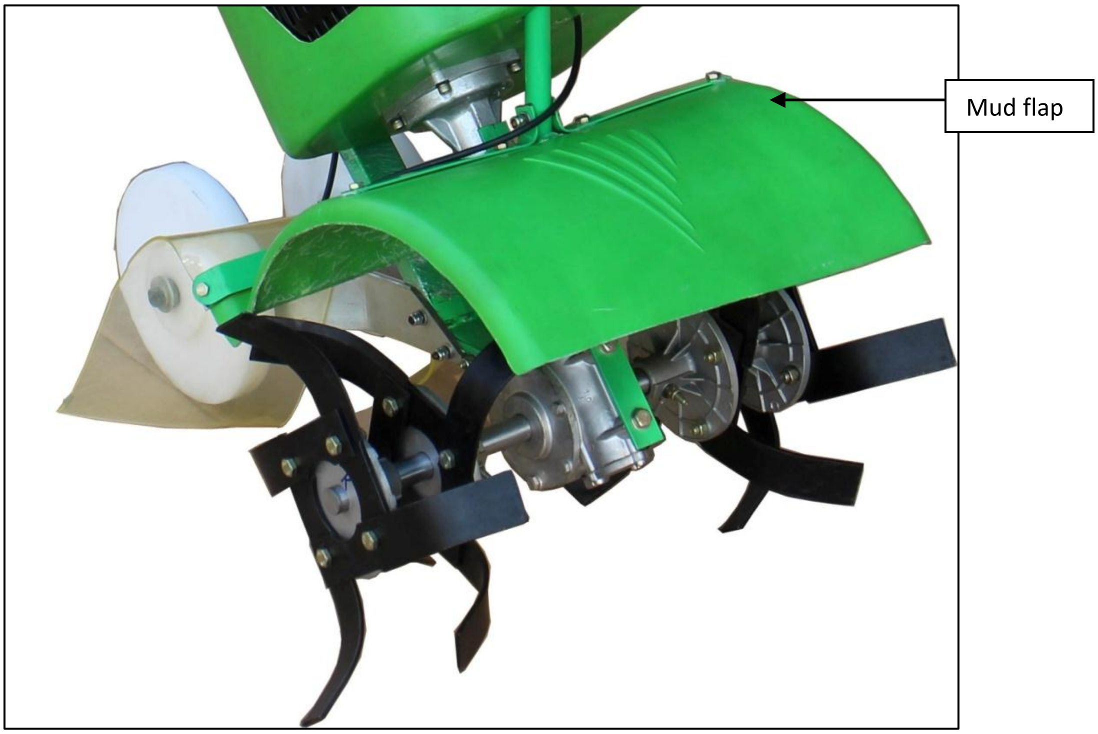

Fig 3.1– Mud flap for the rotary blades

3.2.1.6 Floating mechanism

A particular subset of soil engaging components is the float system, which can be an addition or integrated into the design of the weeder. This component becomes relatively important when the weeder is thought to operate within particular crops or deep-water agriculture systems. In the case of rice cultivation, a float is needed for the machine not to sink in accordance with the different water levels into the soil. The floating mechanism is important part of the machine, as it helps the machine to float in muddy conditions without sinking. The floats reduce the ground reaction due to buoyancy effect. In the present study adjustable float made of plastic control the depth of shearing as required in different ground conditions. The size of float is 860×170 mm and it is made of plastic material with the total weight of float is 1.2 kg. The width and the length of the frame for cutting tool were decided by considering the row to row space for crop and diameter of the rotor. As the row to row crop spacing was in the range of 15 to 24 cm, the width of the frame was kept as 130 mm and 200 mm.

3.2.1.7 Throttle lever

A hand operated throttle lever was provided for controlling the speed of the machine and is attached to right hand side of the handle.

3.2.2 Details of Modified machine components

3.2.2.1 Wheel

In the dry field condition the transport wheel is better for preventing the jerking in undulated fields and smooth field operation, traction wheels were made by using nylon of 180×23 mm diameter as inner and outer ring diameter. It was bolted to rear brackets. The wheel provides better traction and stability during dry field operation.

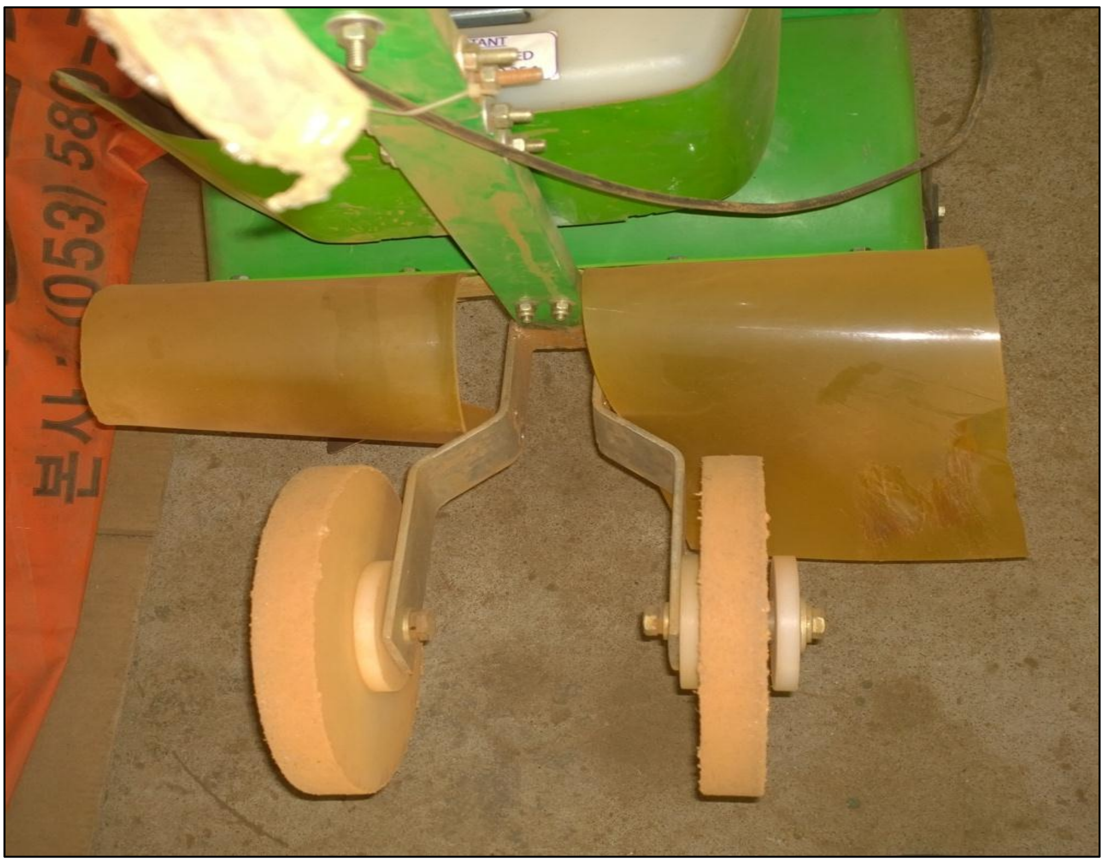

Fig 3.2 Removal of tail wheel along with support plate

3.2.2.2 Rotary blades

The rotary blades work under uneven miscellaneous forces of cyclic loading effect of soil parts at the cutting edge (Jeevarathinam *et al*, 2014). Due to the cyclic loading condition the fatigue strength and life of the blade will be affected. In order to improve the fatigue strength of the blade the design of the blade was modified. There are 8 rotor blades on either sides of rotor flange is bolted on each sides made up of EN 24 APA having thickness of 2.2 mm.

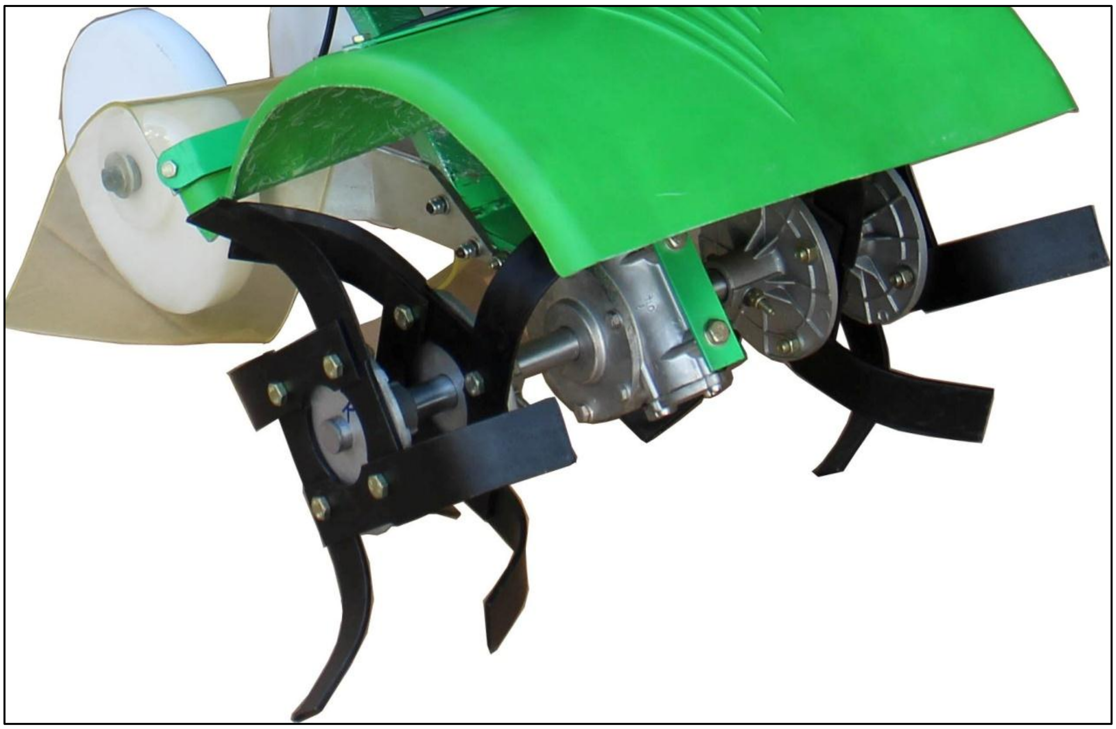

Fig 3.3 Modified rotary blades

3.2.2.3 Axle extention shaft

The removable extention shaft is fixed to the main axle shaft. The two extention shaft are joined on both side by means of nut and bolt for setting of complete cutting unit and are fixed to the rotary shaft as depend upon the field condition and row spacing.

3.3.1 How to change the paddy weeder to dry weeder

The conversion of paddy weeder to dry weeder involves following steps:

- Remove the L type rotary wet disc by opening nut bolt and remove the wet Tyne disc both sides.
- Dismantle the front and rear float supporting bracket from the front gear box, and rear fixing brackets.
- Assemble the plates, connecting gear box and handle bar.
- Assemble the tail wheels along with the brackets.
- Assemble the axle extension shaft both sides.
- Assemble the Tyne disc fixing bolt, and assemble the dry Tyne disc both sides.
- Dry weeder is ready for operation.

3.3.2 How to change the Dry weeder to paddy weeder

The conversion of dry weeder to paddy weeder involves following steps:

- Remove the Tyne disc fixing bolt, use 10-11mm spanner and also remove the dry Tyne disc both sides.
- Remove the axle extension shaft both side.
- Dismantle the tall wheels along with the bracket by using 10-11mm spanner.
- Removes the plates, connecting gear box and handle bar,10-11mm spanner to be also used.
- Assemble the float fixing rear brackets to the gear box and the handle bar and use 10-11mm spanner.
- Assemble the float to the rear fixing brackets and use 10-11mm spanner.
- Assemble the front supporting brackets to the float using the 10-11mm spanner.
- Assemble the front float supporting bracket to the gear box and use 10-11mm spanner.
- Insert the wet Tyne disc to the axle shafts on both sides and lock.

3.4 Testing and Performance evaluation of modified weeder

An experiment was conducted for testing and evaluating the field performance of modified power weeder and it was carried out in Department of Farm Machinery and Power Engineering, SVCAET, IGKV Raipur. The selected plots were weeded by using a different blade arrangement in modified single row power weeder and wet paddy weeder. Relevant observations of each treatment regarding field conditions of each were recorded before and after the weeding operations. The following resultant observations were recorded. Figure 3.4 shows testing and performance evaluation of different treatments.

Fig 3.5(a) Testing and performance evaluation

Fig 3.5(b) Testing and performance evaluation in wet field

3.4.1 Checking and adjustments

Prior to the testing in the field, the machine was checked for its proper functioning in respect of the following:

- Engine system with fuel and oil
- Chain tightness and movement of components for stress – free power transmission to rotary shaft
- Spacing of flange on which weeding blades have been mounted
- Tightness of nuts and bolt and general alignment

Besides the machine was operated idle with required adjustments and settings keeping in view the balancing and stability of the machine during operation.

Table 3.2 Observations of Modified power weeder

S.NO.	Parameter	Specification
1	Average speed of operation (km/h)	1.55 to 1.66
2	Average depth of cut (cm)	4
3	Average width of cut (cm)	30
4	Average area covered (ha/h)	0.030 to 0.033
5	Average time required for 1 ha (h)	30.30 to 33.30
6	Average weeding/field efficiency (%)	62 to 65/ 65 to 67
7	Average fuel consumption (l/ha)	1.03 to 1.09

3.4.3 Observations

3.4.3.1 Bulk density of soil

The bulk density of soil was determined by core cutter method. The core sampler of the soil of known volume was collected and weighed. The soil bulk density was determined as:

$$\rho = \frac{M}{V} \qquad 3.1$$

Bulk density = mass of soil / volume of soil

Where,

ρ = Bulk density, g/cm^3

M = Mass of the soil, g

V = Volume of the soil, cm^3

3.4.3.3 Moisture content of soil

The moisture content of the soil was determined by oven drying method. In this, wet soil sample of known weight was kept in the thermostatically controlled oven at a temperature of 105 ^{0}C for 24 hours. The dried soil is again weighed and the moisture content is determined as:

$$W = \frac{Ww - Wd}{Ww} \qquad 3.2$$

Where,

W = Moisture content, (% db)

W_w = weight of moist soil, g

W_d = weight of dry soil, g

3.4.3.3 Effective working depth

The depth of cut of the machine with different blades was measured in the field by measuring the depth of soil layer tilled by the blade in a row. The depth of the weeding was measured by measuring scale in different rows at different places. Average of five observations was taken as depth of weeding and expressed in cm.

3.4.3.4 Effective working width

The width of cut of the machine with different blades was measured in the field by observing the strip of soil and weeds cut in a row.

3.4.4 Machine performance and evaluation

The machine performance parameters such as weeding efficiency, plant damaged, effective field capacity, theoretical field capacity, field efficiency, and fuel consumption of power weeder were determined for the performance evaluation and are determined as follows.

3.4.4.1 Weeding efficiency

It is the ratio between the numbers of weeds removed by power weeder to the number of weeds present in a unit area and is expressed as a percentage. The samplings were done by quadrant method, by randomly selection of spots by a square quadrant of 1 square meter (Tajuddin, 2006).

$$\text{Weeding efficiency (\%)} = \frac{W_1 - W_2}{W_1} \qquad 3.3$$

Where,

W_1 = Number of weeds counted per unit area before weeding operation

W_2 = Number of weeds counted in same unit area after weeding operation

3.4.4.2 Plant damage

It is the ratio of number of plant damaged after operation in a row to the number of plants present in that row before operation. It is expressed in percentage.

$$\text{Plant damage (\%)} = \left(1 - \frac{q}{p} \right) \times 100 \qquad 3.4$$

Where,

p = Number of plants in a 10 m row length of field before weeding.

q = Number of plants in a 10 m row length of field after weeding.

Fig 3.7 Plant damage by Modified weeder in dry field condition

3.4.4.3 Effective field capacity

Effective field capacity is the actual average rate of coverage by the machine, based upon the total field time. It is a function of the rated width of the machine, the percentage of rated width actually utilized, speed of the travel and the amount of field time lost during the operation. Effective field capacity is usually expressed as hectare per hour (Kepner *et al.*, 1978).

$$EFC = \frac{A}{Tp \, \square \, Ti} \qquad 3.5$$

Where,

EFC = Effective field capacity, ha/h

A = Actual area covered, ha

T_p = Productive time, h

T_i = Non-productive time, h

3.4.4.4 Theoretical field capacity

Theoretical field capacity of the machine is the rate of field coverage that would be obtained if the machine were performing its function 100% of the time at the rated forward speed and always covered 100% of its rated width. It is expressed as hectare per hour and determined as follows (Kepner *et al.*, 1978)

$$TFC = \frac{W \times S}{10} \qquad 3.6$$

Where,

TFC = Theoretical field capacity, a/h

w = Width of cut, m

s = Speed of operation, Km/h

3.4.4.5 Field efficiency

Field efficiency is the ratio of effective field capacity to the theoretical field capacity, expressed as percentage. It includes the effect of time lost in the field and of failure to utilize the full width of the machine.

$$\eta_e = \frac{EFC}{TFC} \times 100 \qquad 3.7$$

Where,

η_e = Field efficiency, %

EFC = Effective field capacity, ha/h

TFC = Theoretical field capacity, ha/h

3.4.4.6 Fuel consumption

The fuel consumption has direct effect the economics of the power weeder. It was measured by top fill method. The fuel tank was filled to full capacity before the testing at leveled surface. After completion of test operation, amount of fuel required to top fill again is the fuel consumption for the test duration. It was expressed in liter per hour or liter per hectare.

3.5 Ergonomic and economic evaluation of the modified machine.

3.5.1 Subjects

Weeding operation is an important field operation, which affects the yield 30 to 60% due to delay and negligence in operation. Drudgery involves in weeding operation increase stress on worker causing increase in heart rate oxygen consumption. The main focus of the study was to evaluate ergonomical and mechanical parameters of power weeder. The estimation of oxygen consumption rate (OCR) by measuring the energy expenditure rate (EER) is fairly accurate and acceptable method. The heart rate of worker varies from 109.47 to 130.66 beats /min by using power weeder. The oxygen consumption rate of worker on using modified power weeder is from 0.873 to 1.302 l/min. The actual field capacity of 114 to 208 man-h/ha was observed for modified power weeder. The following efficiency of efficiency of modified power weeder was observed to 75.25 %.

Ergonomics is the scientific study of relation between man and work environment. This includes ambient condition, tool and materials, methods of work and organization of work. The performance of weeder not only depends on the constructional features but also on the workers who operates them. The performance of man-implement systems may be poor, if ergonomics aspect are not given attention.

Tiwari *et al.*(1991) states that the performance of weeder is interpreted in term of weeding efficiency and the grade of work relates to rating of workload while worker’s comfort is a subjective assessment of operating posture. The physiological cost of work includes the heart (HR) and oxygen consumption rate (OCR). Furth more, severity does not depend on EER; however based on EER severity of work load is classified. Ergonomical evaluation is a tool to evaluate the energy expenditure of work, their physiological cost and suitability of the method for farm workers and how long, they can work continuously without getting fatigue.

3.5.2 Body mass index

Body mass index, also called BMI, is a calculation of a correlation between a person’s height and weight that categorizes him or her as underweight, of normal weight, overweight or obese, assuming a normal body composition. Underweight is considered a BMI of 18.4 or lower. A BMI of normal weight is any number between 18.5 and 24.9. The overweight range is between 25 and 29.9, with anything above that being considered obese.

Regardless of activity level, a minimum level of energy is required to sustain the body's everyday functions. Resting metabolism, the amount of calories needed to supply the body with the minimum level of energy, differs between individuals depending on variables such as age, weight, body composition and energy expenditure.

Body age is based on resting metabolism. Body age is calculated by using weight and body fat percentage to produce a guide to judge whether the body age is above or below the average for actual age. Body age varies according to Body composition and resting metabolism, even if height and weight is the same.

Table 3.3 Physiological characteristics of participants

Variable	S1	S2	S3	S4
Weight, kg	48.5	46	58.5	56
Age, year	29	33	26	22
Fat, %	22.6	19.2	14.8	26.2
RM, kcal	1180	1130	1454	1391
BMI	16.1	18.1	4.0	21.1
Body Age, year	19	30	22	28
Subcantaneous whole body, %	14.5	15.0	10.3	17.5
Subcantaneous trunk,%	12.0	13.2	8.8	15.3
Subcantaneous arms,%	21.3	21.0	16.2	26.2
Subcantaneous legs, %	21.1	18.5	15.2	32.1
Skeletal whole body,%	35.0	37.2	35.9	24.3
Skeletal trunk,%	27.6	26.1	30.5	39.2
Skeletal arms,%	42.0	40.1	40.8	41.2
Skeletal legs,%	52.2	50.5	53.0	49.4

3.5.3 Physiological response

3.5.3.1 Heart rate

The stethoscope was used to measure the average heart rate during the rest and working condition (beats/min.).

3.5.3.2 Oxygen consumption rate (l/min)

The oxygen consumption rate (amount of oxygen consumed by the whole body per unit time) was computed from the heart rate values of the operator and is given by the following equation (Singh *et al*., 2008).

Oxygen consumption rate (l/min) = 0.0114 x HR -0.68

Oxygen consumption rate (kJ)=Oxygen consumption rate x 0.93(1 O_2=20.93kJ)

The physiological responses like heart rate and oxygen consumption rate (OCR) were measured. The work load in term of OCR (OCR as % of $V0_2$ max) was determined. The energy expenditure rate (EER) was determined by multiplying the OCR Work with the calorific value of oxygen as 20.93 kJ/l (Nag and Dutt, 1980). The physiological response of workers was studied during the testing of the weeder. In this experiment the effect of the weeder on pulse rate and systolic and diastolic blood pressure was measured. The energy cost of the subjects thus obtained was graded as per the tentative classification of strains in different types of jobs given in ICMR report as shown in Table 3.4.

Table 3.4 Tentative classification of strains (ICMR) in different types of jobs

Grading	Physiological response		
	Heart rate (bpm)	Oxygen uptake, l/min	Energy expenditure, kcal/min
Very light	<75	<0.35	<1.75
Light	75-100	0.35-0.70	1.75-3.5
Moderately heavy	100-125	0.70-1.05	3.5-5.25
Heavy	125-150	1.05-1.40	5.25-7.00
Very heavy	150-175	1.40-1.75	7.00-8.75
Extremely heavy	>175	>1.75	>8.75

3.5.3.3 Assessment of postural discomfort

Assessment of postural discomfort included overall discomfort rating (ODR) and body part discomfort score (BPDS). The subjects were asked to report at the work site at time have a rest for 30 minutes before starting the trial. After 30 minutes of resting, the subject was asked to operate the power rice weeder for duration of two hours. Sufficient rest period was given for each subject and the second trial should be started after the lunch.

3.5.3.4 Overall discomfort rating (ODR)

For the assessment of ODR, a 10 - point psychophysical rating scale (0 – no discomfort, 10 - extreme discomfort) was used which is an adoption of technique. A scale of 70 cm length was fabricated having 0 to 10 digits marked on it equidistantly. A movable pointer was provided on then scale to indicate the rating. At the ends of each trial subjects were asked to indicate their overall discomfort rating on the scale. The overall discomfort ratings given by each of the four subjects were added and averaged to get the mean rating.

3.5.3.5 Acceptable workload (AWL)

3.5.3.5.1 Pulse rate

Pulse rate is a good index of physical as well as physiological load on the operator. The pulse rate was measured with the help of B P Monitor. The labors were allowed to relax for 10 min before commencement of operation. The pulse rate reading was taken by the B.P Monitor of the operator before and after commencement of operation and in this way the pulse rate per minute was computed. The pulse rate is affected due to force required, working time and operator posture. Increased pulse rate also signifies muscular fatigue of subjects.

3.5.3.5.2 Blood pressure

Blood pressure is the pressure exerted by the blood on the walls of the blood vessels. The pressure of the blood in other vessels is lower than the arterial pressure. The peak pressure in the arteries during the cardiac cycle is the systolic pressure and the lower pressure (at the resting phase of the cardiac cycle) is the diastolic pressure.

3.5.3.6 Work rest cycle

For every strenuous work in any field requires adequate rest to have an optimum work out put. Better performance results can be expected from both the operator and the worker only when proper attention is given for the work rest schedule for different operations. The actual rest time taken for each subject was found from the heart rate response curves of respective operations. The rest time was measured from the cease of the operation till the heart rate of the subject reaches resting level. The rest time taken was averaged to arrive at the mean value for three row power rice weeder. The rest pause to the subject was calculated using the following formula as given by:

$$R = \frac{T(E-A)}{E-B} \qquad 3.8$$

Where,

R = Resting time (min)

T = Total working time/day (min)

E = Energy expenditure during working task (kcal/min)

A = Average level of energy expenditure considered acceptable (kcal/min) B = Energy expenditure during rest (kcal/min)

3.5.4 Instrument used

3.5.4.1 Body fat analyzer

Featuring a full body sensing technology that generates an accurate analysis of the visceral fat level, body fat, body weight, body fat percentage, skeletal muscle percentage and subcutaneous fat percentage, this battery operated fat analyzer comes with a step on analyzer function. It is an ideal device for effective weight management since it displays body mass index to indicate the optimum levels of fat according to the dimensions of the body.

3.5.4.2 Blood pressure monitor

Blood pressure monitor was used to measure the blood pressure and pulse rate simply and quickly. It is a compact and fully automatic blood pressure monitor which works on the oscillometric principle to measure blood pressure and pulse rate without fuss.

3.6 Operational Cost

Cost of weeding operation performed for all treatments was worked out on the basis of the prevailing input and fabrication price of the implements, machinery and rental wages of operator and labors if required. The cost of operation of power weeder is divided into two heads known as fixed cost and operation cost, was fixed cost is independent of operational use while variable cost varies proportionally with the amount of use. (Kamboj *et al*, 2012).

The fixed cost includes depreciation, interest on the capital cost, shelter, insurance and taxes. Operation cost includes, fuel, lubricants, repair and maintenances cost, wages. Cost of weeding operation for power weeder was calculated in Rs./ha. Operation cost of the power weeder was calculated .

3.6.1 Fixed cost

3.6.1.1 Depreciation

It was a measure of the amount by which value of the machine decreased with the passage of the time. According to the Kepner *et al.* (2005), the annual depreciation was calculated as follows:

$$D = \frac{C-S}{L \times H} \qquad 3.9$$

Where,

D = Depreciation per hour

C = Capital investments (Rs.)

S = Salvage value, 10% of capital investment (Rs.)

L = Life of machine in hours or years

3.6.1.2 Interest

Interest is calculated on the average investment of the machine taking into consideration the value of the machine in the first and last year. These are usually calculated on yearly basis. The annual interest on the investment can be calculated as (Kepner *et al.*, 1978).

$$I = \frac{C \times S}{2} \times \frac{i}{H} \qquad 3.10$$

Where

I = Interest per hour

i = 10 % per year

3.6.1.3 Taxes and insurance

Insurance charge is taken based on the actual payment to the insurance, it may be taken as 1% of the initial cost of the machine per year.

3.6.1.4 Housing

Housing cost is calculated on the basis of the prevailing rates of the locality, but roughly, the housing cost may be taken as 1 % of the initial cost of the machine per year.

3.6.2 Operation cost

3.6.2.1 Repair and maintenance cost

The repair and maintenance cost is a product of machine's cost price and repair and maintenance percentage factor (Kepner *et al*., 2005 and Kamboj *et al.*,2012).

RM = 2.5 % × Purchase price or capital investment per year

3.6.2.2 Fuel cost

Fuel cost is calculated based on actual fuel consumption for the operation.

3.6.2.3 Lubricants

It can be determined depending upon the maintenance cost or depending upon oil price or oil consumption. Average lubrication cost is taken as 1.5% of fuel cost in Rs /ha. (Kambhoj *et al.,* 2012)

3.6.2.4 Wages of operator

Wages are calculated based on actual wages of workers per hour.

3.7 Total cost of weeding per hour

The total cost of weeding per hour of the modified power weeder can be calculated by summation of total fixed cost per hour with total variable cost per hour.

Total Cost/h = Fixed Cost per hour + variable Cost per hour

CHAPTER -IV
RESULTS AND DISCUSSION

This chapter contains the result and discussion of the experiment conducted in order to fulfill the objective of the study. The experiments were carried out at the Swami Vivekananda College of Agricultural Engineering Technology and Research Station, Faculty of Agricultural Engineering, IGKV, Raipur (C.G.). The Wet & Modified power weeder was evaluated for its field performance in wet and dry field condition respectively during 2016-17 as per the RNAM 1983 Test codes.

The field performance results are shown and described in this chapter. The wet paddy weeder of weed management practice is compared with modified power weeder for controlling weed. The performance of the modified power weeder and wet paddy weeder weed management practices are expressed in terms of weeding efficiency, plant damaged, field efficiency, fuel consumption. The field test results of developed power weeder are depicted in Appendix-A.

In modified power weeder for dry field condition, the handle, rotary cutting blades (“C” shaped), wheel, axle extention shaft, handle height adjustment for convenient operation, weeding depth adjustments and other accessories such as mud flap and throttle system for engine speed control are the modifications of the available power weeder. Due to these modifications the power weeder worked more economical than previously designed. The designed power weeder is well suited for dry field condition.

4.1 Field test of modified power weeder

For proper weed management in SRI cultivated field and to remove the problems in the operation of wet paddy weeder, an existing power weeder was modified, the machine was tested in the field and it was observed that the machine performance was satisfactory. However there was little problem due to weight of engine and vibration. The machine has been tested in the dry field for evaluation for its effective performance in terms effective field capacity, field efficiency, fuel consumption, weeding efficiency, plant damage, and cost of operation.

4.2 Operational parameter

4.2.1 Moisture content

Before operation of dry weeder, moisture content was measured at different depth of soil level as given in Table 4.1.(a). From the table it was observed that highest moisture content was found 6.1% on dry basis at 4-6 cm depth of soil.

Table 4.1 (a) Soil moisture content

S.No.	Depth cm	Moisture content dry basis, %
1	0-2	5.8
2	2-4	5.9
3	4-6	6.1

4.2.2 Bulk density

The observations related to bulk density were taken before sowing of seeds. It was observed at different depth of soil. The observed bulk density is given in Table 4.1(b). It was taken by core cutter method at different point of field, and it was observed that average bulk density was 1.54g/cc.

Table 4.1 (b) Bulk density, g/cc

S.No.	Bulk density g/cc
1	1.51
2	1.55
3	1.57

4.2.3 Effective working depth

The average working depth of modified power weeder was measured in dry field through a standard scale. The observation value is given in Table no 4.2 where it was observed that maximum depth of cut in 8 blade weeder is 4.5cm while 4.03 and 3.85cm for 6 blade and 4 blade respectively. Maximum depth of cut was observed in 8 blades. When modified weeder was used in wet field, it was observed that maximum depth in 8 blade is 6.8cm while 4.72 cm and 3.75 in 6 and 4 blade respectively.

Table 4.2 Effective working depth of modified weeder

Treatment	Depth of cut, cm	
	(Dry field)	(Wet field)
4 Blade	3.85	3.75
6 Blade	4.03	4.72
8 Blade	4.5	6.8

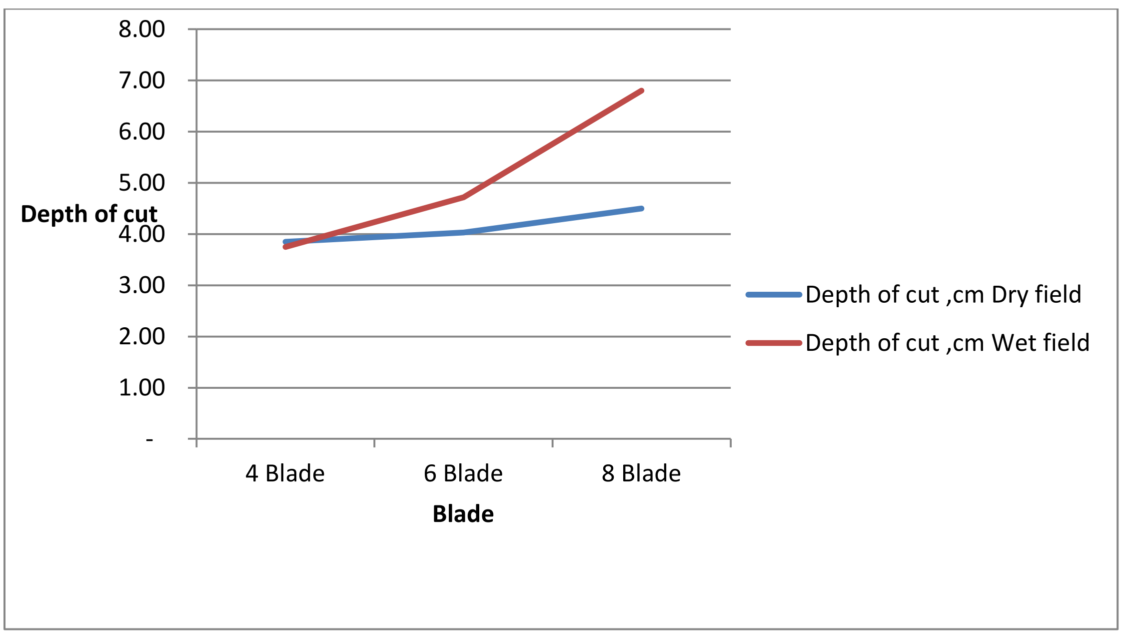

Fig. 4.1 Depth of cut in dry and wet field with different blade

4.3 Machine parameter

4.3.1 Effective field capacity

The effective field capacity of modified power weeder is presented in Table 4.3. The maximum effective field capacity was observed in 8 blade is 0.0357 ha/h followed by 0.033 ha/h and 0.031 ha/h with 6 blade and 4 blade respectively.

Fig. 4.3 Effective field capacity of modified weeder

Treatment	Effective field capacity, ha/h	
	Dry field	Wet field
4 Blade	0.032	0.023
6 Blade	0.031	0.025
8 Blade	0.033	0.027

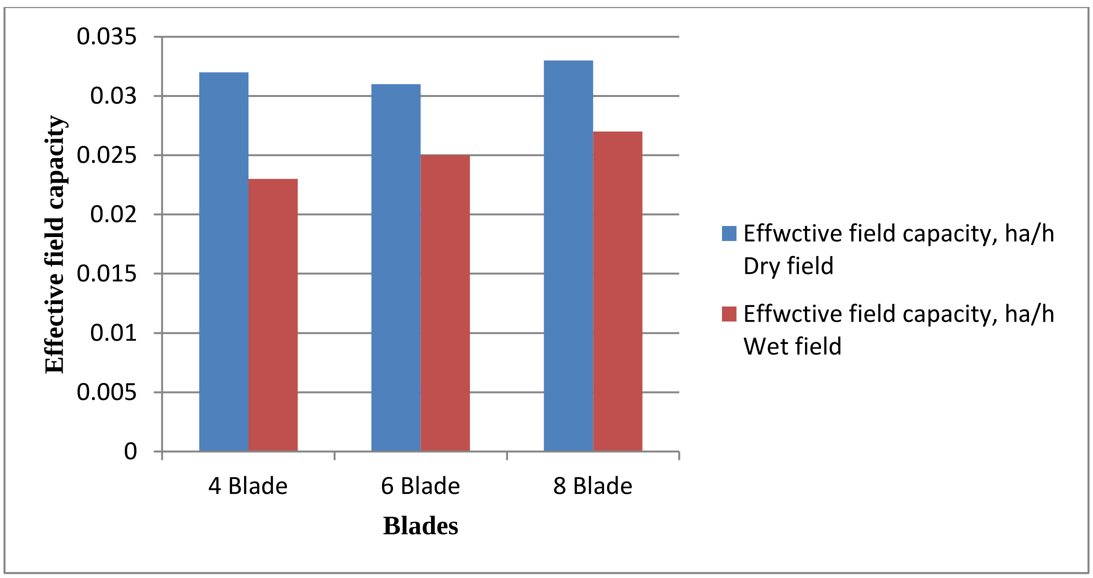

Fig. 4.2 Effective field capacity of modified weeder in dry and wet field with different Blades

4.3.2 Field efficiency

Field efficiency of the modified power weeder was 75.07% at 8 blade followed by 70.35% and 65.15 of 6 blade and 4 blade respectively. At wet field condition, field efficiency was more as compared to dry field condition due to the low resistant force of soil, loose soil, friction in wet field. Maximum field efficiency was observed 85.17 in 8 blade, which followed by 78.42% and 75.32% of 6 blade and blade respectively.

Table 4.4 Field efficiency of modified weeder

Treatment	Field Efficiency, %	
	(Dry field)	(Wet field)
4 Blade	65.15	75.32
6 Blade	70.35	78.42
8 Blade	75.07	85.17

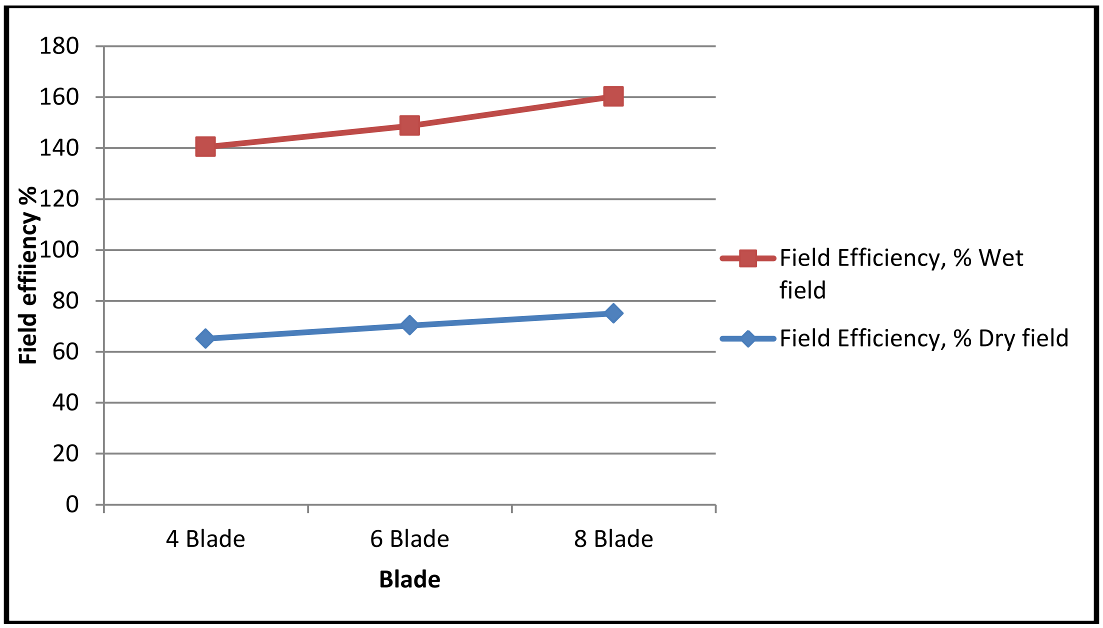

Fig. 4.3 Field efficiency of modified weeder in dry and wet field with different blade

4.3.3 Fuel consumption

Fuel consumption of the modified power weeder was calculated by "topping method". It was observed that maximum fuel consumption in 8 blades with 1.09 l/h while lower fuel consumption was observed in 4 blades with 1.003l/h. It was also observed that in dry field condition fuel is more consumed as compare to wet field condition due to heavy land, high resistant force in dry field, minimum fuel consumed was observed 0.92 l/ha in 4 blade of modify power weeder in wet field.

Table 4.5. Fuel consumption of modified weeder

Treatment	Fuel consumption, l/ha	
	(Dry field)	(Wet field)
4 Blade	0.68	0.55
6 Blade	0.72	0.67
8 Blade	0.78	0.71

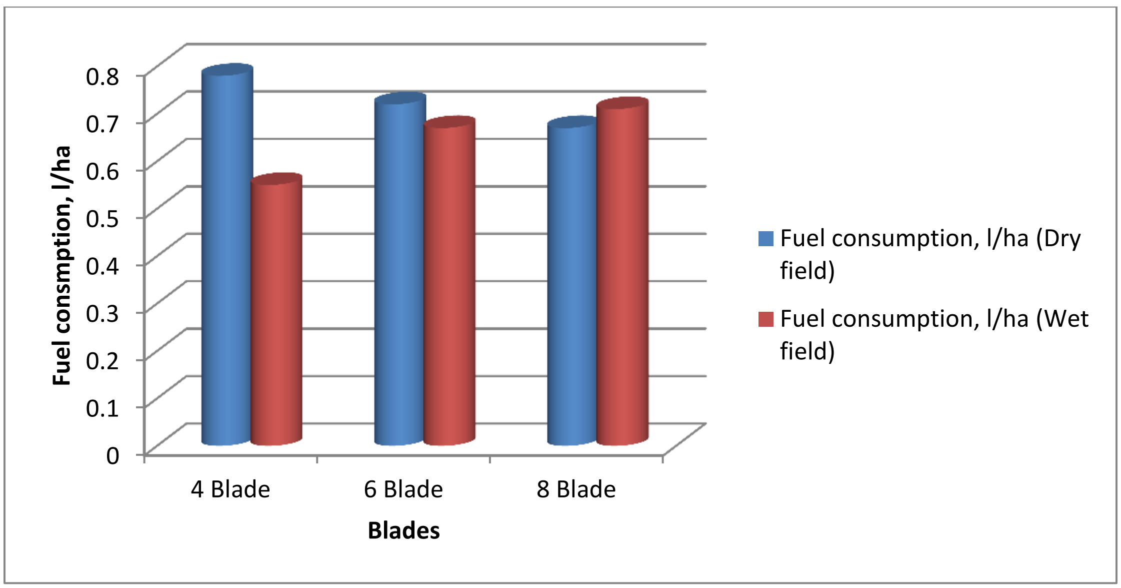

Fig. 4.4 Fuel consumption of modified weeder in dry and wet field with diff. blade

4.3.4 Weeding efficiency

The weeding Efficiency of modify power weeder was maximum in 8 blade with 73.25%, followed by 68.21% and 65.46% with 6 and 4 blade respectively due to large no. of blades the compared to 6 and 4 blade. In wet field condition weeding efficiency was maximum in 8 blade with 70.12%, followed by 66.28% and 62.1% with 6 blade and 4 blade respectively as shown in graph.

Table 4.6 Weeding efficiency of modified weeder

Treatment	Weeding efficiency, %	
	Dry field	Wet field
4 Blade	61.46	70.12
6 Blade	65.21	66.28
8 Blade	73.25	62.12

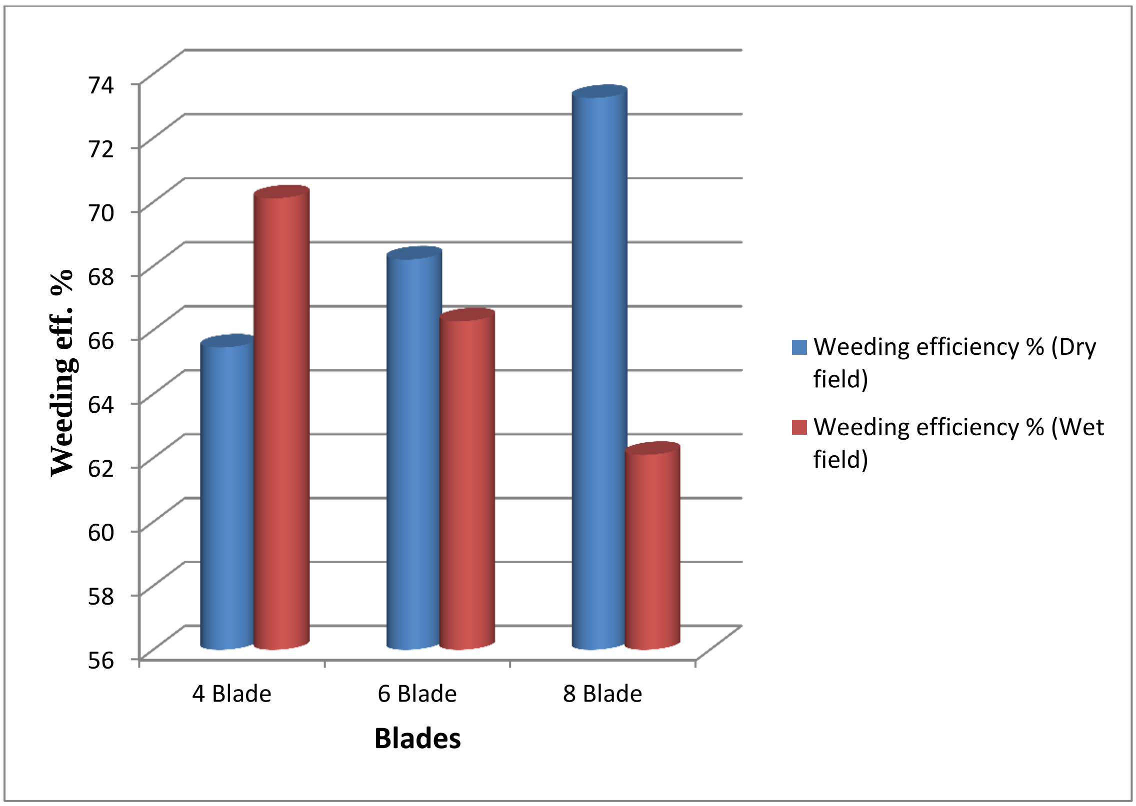

Fig. 4.5 weeding efficiency of modified weeder in dry and wet field

4.3.5 Plant damage

The plant damage caused by the modified power weeder was observed 1.85% in 4 blades while maximum plant damage was 4.74% in 8 blade weeder as given in Table 4.6. In wet field condition maximum plant damage was observed as 6.18% in 8 blades while minimum was 1.65%.

Table 4.7 Plant damage of modified weeder

Treatment	Plant damage, %	
	Dry field	Wet field
4 Blade	1.85	1.65
6 Blade	3.12	3.25
8 Blade	4.74	6.18

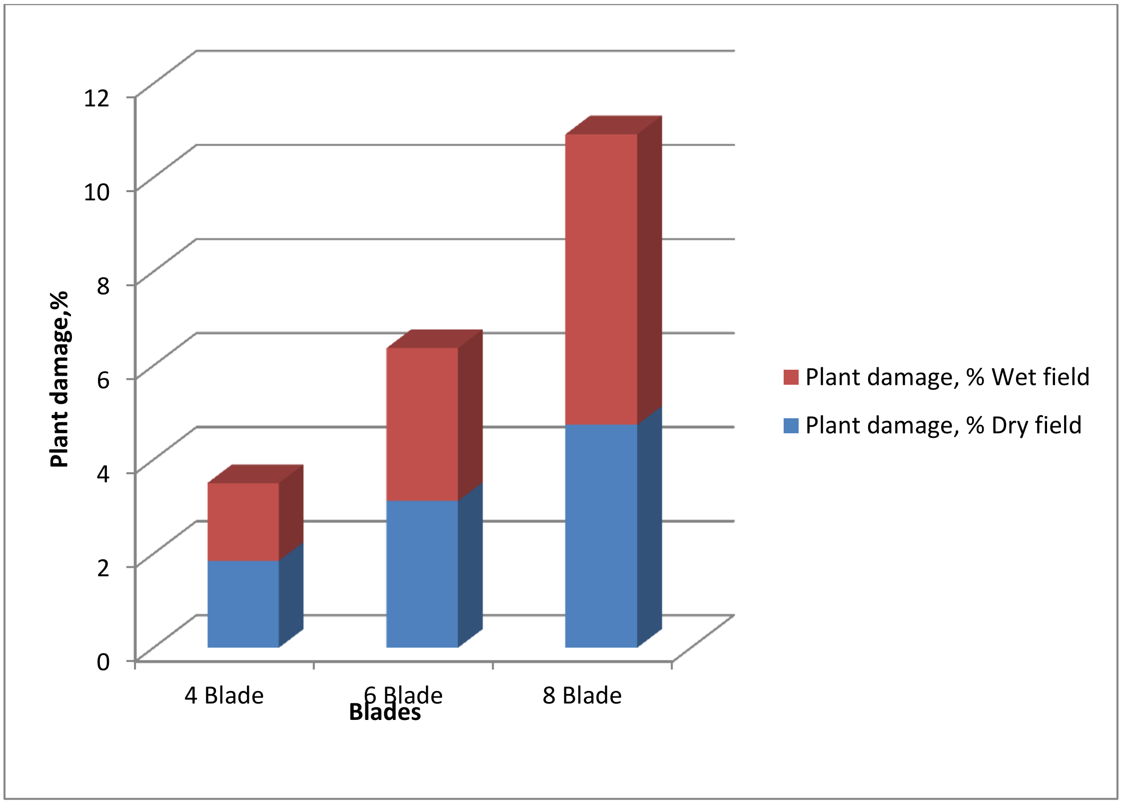

Fig. 4.6 Plant damage of modified weeder in dry and wet field with different blades.

4.4 Ergonomic evaluation of modified weeder

4.4.1 Anthropometric parameters for agriculture worker

In the modification of power weeder for dry field condition, the weeder should be modified to accommodate a reasonable range of individual, usually from 5^{th} to 95^{th} percentiles. The weight of machine 17 kg is realizing a good performance during operation. It is necessary that the movement of the body members are in synchrony, simple and logical motion are made, which can be performed almost automatically by central nervous system. Lower percentile values of handle height should be taken. The mean age, stature and mass of male subjects were 29.8 year, 1649 mm and 51.2 kg respectively while the corresponding parameters for female subjects were 30.22year, 1505.5 mm and 46.3kg. In general the male subjects were heavier and taller than female subjects. The mean lean body mass of male subject was also higher than female subjects. The details anthropometric data of female and male subjects are given in Appendix-B

Fig 4.7 Measurement of body dimension

4.4.2 Heart rate

The heart rate initially was different for three age group and it ranged between 114 to 171 beats/min at 12:00 to 2:00 PM, it decreased to 110 to 160 beats/min at 4:00 to 6:00 PM, which may due to the variation in the environment. The average heart rate for different age group and at different timing using modified power weeder is given in Table 4.7.

Table.4.8 Ergonomic aspect field observation data of power weeder

	Subject S1			Subject S2			Subject S3			Subject S4		
Time	**Heart rate**	**Pulse rate**	**B.P.**	**Heart rate**	**Pulse rate**	**B.P.**	**Heart rate**	**Pulse rate**	**B.P.**	**Heart rate**	**Pulse rate**	**B.P.**
9:00 AM	63	65	120/80	65	63	120/80	63	62	120/80	64	63	120/78
9:30-9:46	101	64	140/90	100	67	130/95	95	65	130/75	97	70	120/90
9:51-10:07	110	65	110/80	117	67	128/80	98	66	128/75	99	69	140/90
10:15-10:31	112	66	118/80	117	67	100/80	103	67	100/65	100	68	110/85
10:35-10:55	114	65	130/90	120	68	100/80	107	66	100/68	100	68	118/85
11:00-11:20	116	64	122/80	115	69	140/85	107	65	140/90	101	67	130/85
11:25-11:43	121	65	120/80	121	68	110/80	110	64	110/80	107	69	122/80
LUNCH												
2:00 PM	65	68	117/80	66	65	117/77	65	63	121/85	66	67	118/82
2:30-2:47	104	67	120/80	105	66	130/80	107	64	112/90	104	66	110/90
2:50-3:22	98	66	120/80	101	65	130/78	105	65	121/72	103	65	110/90
3:30-3:48	97	67	130/80	85	66	138/82	101	64	131/75	89	64	100/80
3:52-4:10	90	68	135/80	81	65	110/77	86	67	116/82	88	66	99/80
4:15-4:30	83	66	130/80	80	65	100/75	82	65	115/80	81	65	115/78

*Subject S1 and S2 are female body

*Subject S3 and S4 are male body

The average heart rate of modified power weeder was 121.14 beats/min for 20 to 25 years, 136.14 beats/min for 30 to 35 years and 128.85 beats/min for 35 to 40 years at 12:00 to 2:00 PM. The heart rate was decreases to 113.00 beats/min for 20 to 25 years, 129.19 beats/min for 30 to 35 years and 123.33 beats/min for 35 to 40 years at 4:00 to 6:00 PM, there for the highest heart rate was recording during 12:00 to 2:00 PM for 30 to 35 years of age group and the lowest heart rate was recording during 4:00 to 6:00 PM for 20 to 25 years of age group. The heart rate was minimum for 20 to 25 years age group and it is maximum for 30 to 35 years age group at all three different timing. The detailed observed data of heart rate, of a particular subject with time duration shown in Table 4.1.

Fig 4.8 Variations of heart rate with time while operating power weeder

4.4.3 Oxygen consumption rate

The oxygen consumption during weeding operation with modified power weeder was 1.104 l/min for 20 to 25 years, 1.411 l/min for 30 to 35 years and 1.260 l/min for 35 to 40 years during 12:00 to 2:00 Pm, and then it was decreases to 0.943, 1.270 and 1.144 l/min during 4:00 to 6:00 PM for different age group of worker, respectively, fig. shows, the oxygen consumption rate was maximum during 12:00 to 2:00 PM for 30 to 35 year and minimum for 20 to 25 years at 4:00 to 6:00 PM. The decreases in oxygen consumption may be due to environmental cool temperature.

4.4.4 Energy cost of operation

The average working heart rate of the operator was 109.55 beats min^{-1} and the corresponding value of oxygen consumption rate was 0.57 l min^{-1}. The corresponding energy expenditure was 12.60 kJ/min. Based on the mean energy expenditure, the operation was graded as "Moderately Heavy". In power rice weeder, the subjects can do the weeding in a standing posture (Fig.3.8). But in hand weeding the subjects were bending over work surfaces for targets which are too low. It may be suggested that pain rather than capacity may often be the limiting factor in such task situations. More weeders have been produced in the case of modified power weeder compared to wet paddy weeder. It is more comfortable to operate modified power weeder. The modified power weeder improves soil aeration and root growth. The disadvantages are starting torque is less and row to row distance should be correct.

4.4.5 Acceptable workload (AWL)

To ascertain whether the operations selected for the trails were within the acceptable workload (AWL), the oxygen uptake in terms of VO_2 max (%) was computed. Saha *et al.* (1979) reported that 35% of maximum oxygen uptake (also called maximum aerobic capacity or VO_2 max) can be taken as the acceptable work load (AWL) for Indian workers which is endorsed by Nag *et al.*, (1979) and Nag and Chatterjee, (1981). The oxygen uptake corresponding to the computed maximum heart rate in the calibration chart gives the maximum aerobic capacity (VO_2 max). Each subject's maximum heart rate was estimated by the following relationship (Bridger, 1995).

Maximum heart rate (beats min^{-1}) = 200 - 0.65 x Age in years

The mean oxygen uptake in terms of maximum aerobic capacity was calculated and it was 45% and the value was above the acceptable limit of 35% of VO2 max indicating that the power rice weeder is could not be operated continuously for 8 hours without frequent rest-pauses.

4.4.6 Overall discomfort rating (ODR)

Mean overall discomfort rating on a 10 point visual analogue discomfort scale (0- no discomfort, 10- extreme discomfort) was 3.0 and scaled as "Light discomfort" during weeding.(rameshan *et al.*,1987)

4.5 Economic evaluation of modified weeder

In modified power weeders, the cost of machine operation is the sum of fixed and variable cost. The total cost of weeding is gained from all machine operation cost and labor cost for weeding whereas in hand weeding the total cost of operation is just related to labor cost. The cost of operation per hectare for weeding methods under various treatments are depicted in the operational cost was 1800/ha

CHAPTER – V
SUMMARY AND CONCLUSION

In 2015, a wet paddy weeder was developed in SVCAET & RS, FAE, IGKV, Raipur, as research study. This machine has shown certain constraints in the effective performance of the operation. Based on these constraints and as a result of its rectification an attempt was done to modify the wet paddy weeder. The modified power weeder was tested in summer season upland gram and vegetable crop to assess the technical and economical performance and compared with wet paddy weeder for weeding operation at 4, 6, 8 blade after sowing. The potential of the power weeder was compared on the basis of weeding efficiency, plant damaged, field efficiency, fuel consumption. The study revealed many meaning full findings, which may provide a magnitude of substitution or replacing the existing methods by modified power weeder.

Thus on the basis of information secured through the study, the following conclusions could be inferred.

1. To modify soil working tool of power operated row wet land weeder for dry field condition.
2. To evaluate performance of modified weeder.
3. Ergonomic and economic evaluation of the modified machine.

The testing of modified power weeder was done on research field of SVCAET & RS, Faculty of Agricultural Engineering, I.G.K.V., Raipur and observed data was analyzed. The testing was carried out to assess the technical and economic performance of the machine. It was tested on the basis of field capacity, field efficiency, weeding efficiency, ergonomics and cost of operation. This study revealed the meaningful findings, which may be developed further. Thus on the basis of the information observed during the study, the following conclusions could be drawn.

Conclusion

1. The average forward speed of modified power weeder varies from 1.55 to 1.66 km/hr.
2. The average time required for weeding operation by this machine for 1 ha was in the range of 30.30 to 33.30 h.
3. Field efficiency was found to be 65.15 to 75.07 %.
4. Weeding efficiency was found as 65.46 to 73.25 %.
5. Two skilled operators were required to operate the weeder continuously.
6. The amplitude of mechanical vibration on various assemblies of power weeder was observed as 150 micron.
7. After 25 h of operation there was loss of 4.7 g in mass of the blade. Initially the mass of blade was 47.4 g.
8. No noticeable difficulty was observed during the operation and adjustment of machine
9. The operation cost of modified weeder for both condition was Rs. 1800/ha compared to Rs. 1434/ha of wet land weeder.
10. The fuel consumption of modified weeder for dry field condition was 1.03 to 1.09l/ha.
11. The physiological cost was found out and the mean working heart rate of operator was 109 beats/min, the operation was graded as “moderately heavy”.

Suggestions for future work

- Blades should be further modified to be carried out on for both wet and dry field condition commonly.
- Studies may be carried out for different field conditions.
- Studies may further studied on the base of energy requirement

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