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"DESIGN AND DEVELOPMENT OF MANUALLY OPERATED DISC WEEDER FOR GARLIC CROP"

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Abstract

Weeding is an important operation for increasing the productivity of farm. For small land holdings and considering economic condition of Indian farmer, manual operated weeder is most suitable. The major Garlic producing states of India are Madhya Pradesh, Gujarat, Uttar Pradesh, and Rajasthan which produce 80% of the country's garlic. In garlic weeding operation is done manually by khurpi and wheel hoe. Manual weeding is precise but requires about 900-1200 man-hours/hectare. Due to acute shortage of labour in peak seasons, weeding operation is difficult to carry out within short stipulated. With regard to this, a manually operated weeder was developed and tested. The weeding disc was made from iron plate and circular with a diameter of 30mm outer diameter. The desired height of the handle from ground surface is obtained with the adjusting and fixed with nuts & bolt at 0.961m height. The developed garlic disc weeder was tested under different moisture % present in soil <5%, 5-10%, 10-15%, 15-20% respectively. Avg. speed at different moisture % is 1.9 Km/hr, 1.7 Km/hr, 1.5K/hr, 1.4Km/hr. The developed weeder can work higher up to 2.5cm depth. The higher avg. field capacity of developed weeder was obtained to be 0.0183 ha/hr and field efficiency 91.41% at <5% of moisture content. Higher avg. weeding efficiency was obtained (i.e. up to 90.17%) at 5-10% moisture content. The overall performance of the disc weeder found satisfactory.

Keywords: Garlic, Disc weeder, Weeding.

INTRODUCTION:

In India, the annual loss due to weeds in food grains is about 82 million tonnes and commercial crops are about 52 million tonnes (P.K. Singh, 2013). Weeding is a time-consuming and labor-intensive operation that accounts for approximately 25% of total labor required (900-1200 man-hours/hectare) (Yadav and Pund, 2007). Weed is an unwanted plant

that grows in the agriculture field and extracts the nutrients which is essential for the main crops. These plants are harmful as they are not required in the field. The two common weeds found in India are Amaranthus and Chenopodium.The quality and quantity of crops yield depends upon effective and timeliness of weed removal from the field. As far as Indian scenario is concerned, more than 75% of farmers belong to small and marginal land holdings. Because average Indian farmers' economic conditions are poor, they cannot afford large-scale automatic labor-free mechanization of their farms. In India, weeding operation is mostly performed manually with a khurpi or trench hoe, which requires higher labour input and is also a very tedious and time-consuming process. This is a crucial need to design and development of manually operated disc weeder for farmer operators in order to improve overall ease of use, safety and successful incorporation of man and women in farming system. Foundation (NHRDF), India‟s garlic area, production, and productivity were 3.16 lakh ha, 1.61 MT, and 5.08 t/ha in 2017–2018 (NHRDF, 2020). As per the Directorate of Onion and Garlic Research (DOGR), there is a need to increase garlic production to 1.79 million tones and the productivity of garlic in India.

The major garlic producing states in India are Madhya Pradesh, Gujarat, Uttar Pradesh, and Rajasthan, which produce about 80 percent of the country‟s garlic. The major garlic producing states in India were Madhya Pradesh (60,000 ha), Rajasthan (45,000 ha), and Uttar Pradesh (37,200 ha). However, the highest productivity was shown by Punjab (12.16 t/ha), followed by West Bengal (11.94 t/ha) and Maharashtra (11.43 t/ha). The highest production was recorded for Madhya Pradesh (270,000 t), followed by Gujarat (250,000 t) and Rajasthan (218,400 t) (NHB, 2015; (Malik et al., 2017). Selected cloves are planted plant to plant spacing of 10 cm and a row to row spacing of 15 cm. Control of weeds at the initial growth stages is essential for getting a high quality bulb yield. Within the first month after planting garlic, two manual and one chemical weeding are typically performed. The manual weeding is highly labor-intensive and draderous due to the clove-to-clove distance.

In India, this garlic is grown on 164860 hectares. In the present situation, 62.96% of farmers have less than a four-hectare plot. This implies that these farmers are unable to purchase costly power-operated machinery, and this is uneconomical too. Hence, low-cost and manual

or animal-operated machines have future scope (Mahajan and Gupta, 2011). Weed is an unwanted plant that grows in the agriculture field and extracts the nutrients which is essential for the main crops. These plants are harmful as they are not required in the field. The two common weeds found in India are Amaranthus and Chenopodium.

In India, the annual loss due to weeds in food grains is about 82 million tonnes and commercial crops are about 52 million tonnes (P.K. Singh, 2013). Weeding is a time-consuming and labor-intensive operation that accounts for approximately 25% of total labor required (900- 1200 man-hours/hectare) (Yadav and Pund, 2007). As far as Indian scenario is concerned, more than 75% of farmers belong to small and marginal land holdings. Because average Indian farmers' economic conditions are poor, they cannot afford large-scale automatic labor-free mechanization of their farms. In this agriculture sector, out of the different field operations, weeding is an important operation to be performed by the farmer to protect cultivated crops from weeds and unwanted plant. The growing concern to control agricultural products is increasing speedily in many developing countries like India.

The quality and quantity of crops yield depends upon effective and timeliness of weed removal from the field. Weeds causes highest annual yield loss of about 45% compared to dieses (20%), insects (30%) and pests (5%) (Gupta et al., 2014). Depending on weed intensity 20-30 % loss in yield quite usual, if crop management practices are not followed properly (Gill and Kollar, 1981). Weeds are unwanted and undesired plants, which compete with the main crop in the field for space, water & plant nutrients and adversely affect the micro-climate around the plant and removes 30-40% of applied nutrients (Behera et al., 1996; Rao, 1999; Nojavan, 2001).

In India, weeding operation is mostly performed manually with a khurpi or trench hoe, which requires higher labour input and is also a 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 the efficiency of the worker. Weeds compete with crop plants for nutrients and other growth factors, removing 30 to 40% of applied nutrients in the absence of an effective control measure, resulting in significant yield

reduction (Goel et al., 2008). There is an increasing concern over the intra-row weeder because of environmental degradation and the growing demand for food. Today, the agriculture sector requires non-chemical weed control that ensures food safety. Consumers demand high quality food products and pay special attention to food safety.

Weeding has been reported as one of the most laborious activities with a drudgery scale value of 2.01 followed by agriculture operation as professed by women (Gupta et al, 2002). Out of total man hours involved in crop production 15% - 20% are taken away by weeding alone (Nag, 2004). Drudgery is a term used to donate the intolerable incidents that restrain work performance in any activity (Technical module, 2009). It can be reduced by using appropriate farm tools and equipments. In fact, drudgery is termed for hard work, monotony, time consuming, use of traditional tools with inappropriate working posture in field (Sridhar et al., 2015).

Manual weeding can give hygienic weeding but if a strenuous is process (Biswas, 1990). Hand weeding requires more energy and more time which may ultimately lead to higher cost of weeding. For hand weeding the normal man-hour requirement as per estimates is around 400-600 per hectare which amounts to Rs 2200 per hectare. This estimate depends upon used infestation. The other major issue in hand weeding is the availability of labor (Vivek et al., 2013). Weeding is mostly done by women. Greater part of the farm women does weeding control using hand tool like sickle, khurpi, and so on. Even through traditional method of hand weeding was found effective because it covers 98% weed mortality, it requires more number of workers and is totally of drudgery. During these activities women adopt bending and squatting body posture due to which their physiological workload increases and also, they face many types of musculoskeletal problems. The efficiency of women to work decreases to a great extent as a result of their ill health (Sharma, 1999). On an average per hectare 45 man days were required for weeding by khurpi and their amounts of Rs 6750 hectare. Weed infestation is a most important factor that influences cost of weeding. The estimate agricultural work force is 9.2 million. This figure accounts for 40% of the entire agriculture workers in the country (Sing et. al, 2007).

Ergonomics involve fitting the job to human being. Ergonomics deals with human behavior, capabilities, limitation, and other characteristics to the design of tools, machine, systems, for effective human use (Chapanis, 1985). (Relationship between the worker, farm and the farm task environment involves ergonomics. The design features of the total and work methods add to ergonomic problem. Ergonomically designed implements exhibit potential and encouraging results by lifting up the operating competence, without compromising on their health and safety. The consideration of ergonomic principle in the design of agriculture implements has been not there.

Therefore, working with these tools increase the chances of injury due to excessive force demanded by the task or many lead to a tasking working posture and high load. Further the tools are physically demanding and they are difficult to use at case for particular task. This is a crucial need to design and development of manually operated disc weeder for farmer operators in order to improve overall ease of use, safety and successful incorporation of man and women in farming system. There is need for development of effective manually operated weeding machine for small and marginal farmers to overcome the problems which are faced by the farmers both men & women which is discussed above and also for increasing the productivity. In order to overcome these difficulties, I have proposed a push type weeder, it is a suitable device and no need of any fuel to operate, which is easy to move & also remove weeds through disc.

MATERIALS AND METHODS:

This chapter deals with the study of project entitled ‘Design and Development of manually operated disc weeder for Garic crop’ carried out at Department of farm machinery and power engineering, Sam Higginbottom university of Agriculture, Technology and Sciences, Prayagraj (U.P) during the year 2020-22. The various factors involved such as collection of anthropometric dimension of agricultural workers, design, development and conducting experiments regarding weeding operation in field. The weeder were tested from mechanical point of view. The developed weeder was tested under different moisture conditions. The materials and methods about the development and testing of Disc weeder are discussed in this paper.

Experimental site

The study was conducted in SHUATS, situated at 25.4137^{o} North latitude and 81.8491^{o} East longitude with an altitude of 95.097 meter above mean sea level. This district lies in the southern part of the state in the genetic plain and adjoining Vindhyan Plateau of India. The operational field meant for study was selected from the demonstration/research field of faculty.

Climate and weather conditions

The climate is typical version of a humid subtropical climate that is common to cities in north-central India. Prayagraj experiences three seasons: hot dry summer, cool dry winter and warm humid monsoon. The summer seasons lasts from April to June with the maximum temperatures ranging from 40^{o}C (104^{o} F) to 45^{o}C (113^{o} F). Monsoon begins in early July and lasts till September. The winter season lasts from December to February. The average rainfall of the district is 960 mm and the monsoon season is spread between July-September.

Soil Type

The soil of the Prayagraj region is broadly classified as vertisol as per the norms of U.S. classification by krishi vigyan Kendra prayagraj are as follows:

Table of Types of soil in Prayagraj and classification

S. No.	AES	Situation	Soil type	Area in % / × 1000ha	Block
1.	AES 1	Black & coarse grayland (jamunapar)	Clay loam toSandy loam	48%/230.1	Shankargarh, Koraon, manda, Meja
2.	AES 2	Jamuna khaddar & alluvial (jamunapar)	Loam & Sandy Loam	10%/51.1	Jasra, karchhana Chaka, kaundhiara
3.	AES 3	Ganga low land %sodic (Gangapar)	Sandy loam toSodic	15%/92	Pratappur, handia, phulpur

4.	AES 4	Ganga plane (Gangapar)	Sandy loam &Clay	27%/138.1	Phulpur, Saidabad, soraon

Description of design and Fabrication

Design of Frame

Mild steel hollow square pipes were used to build the base frame. The handle, roller, and weeding disc are all supported by the base. The base frame was joined to the handle, wheel, and disc using supporting M.S. plates, rod, nuts, and bolts. The wheel moves in tandem with the disc as the operator pushes the weeder between the row crops. The weeds are sliced and uprooted by the disc at the location. The way weeding operation is done.

Factor of Safety = $Limit\ stress$

$Safe\ stess$ ……..

Maximum bending moment (M) = Pv x length of the square pipe

Where,

Pv = vertical force acting while pressing

Maximum bending stress = F× Z

Where,

F = bending strength

Z = Section modulus (bt sq./t)

b = width of the square pipe, t = thickness

3.4.2 Design of Wheel

Wheel is made up of mild steel material use because it is more durable and high wearing strength. Roller is type of cylinder that rotates about central axis and used in various machines and devices to move flatten & easily move on soil.

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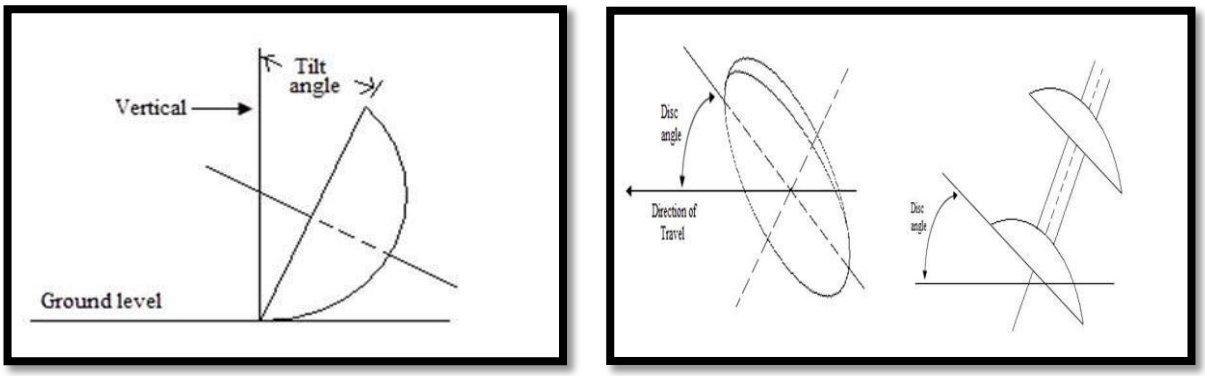
Design of Disc

For designing of disc is the ratio of disc harrow such as thickness, diameter, angle, curvature. It is the main part of my weeder through this uproot, invert soil and cutting of weeds done. It is circular, concave revolving steel plate. Disc angle – at which the plane of cutting edge of the disc is inclined to the direction travel. And tilt angle at which the plane of the cutting edge of disc is inclined to a vertical to the vertical plane. The tilt angle in machine is not considered. Principle – Double action disc harrow but instead of digging and pulverizing soil.



It removes weed.

Fig.of Disc angle and Tilt angle

3.4.4 Design of handle

A laboratory study was carried out for a push-pull type manually operated. 95th percentile middle finger palm grip diameter of male workers was the lower limit and 5th percentile grip diameter (inside) of the female worker was the upper limit considered in determining the grip of handle. To accommodate both male and female workers, 5th percentile, acromial height of male workers was considered. Therefore, the handle height was adjusted b/w 0.93 – 1.15m.

Table. Selected anthropometric and strength data of Indian agriculture workers.

S. No.	Parameters	Male (N=236)			Female (N=236)		
		Mean	Percentile Value		Mean	Percentile Value	
			5^{th}	95^{th}		5^{th}	95^{th}
	Anthropometric data						
1.	Age, years	29.7	19.0	50.0	33.5	20	50
2.	Weight, kg	51.6	42.0	63.0	45.6	35.5	59.3
3.	Stature, cm	164.6	155.3	174.6	151.3	142.7	159.7
4.	Eye height, cm	154.9	144.8	164.7	141.2	132.4	149.7

5.	Acromial height, cm	137.2	128.4	146.2	126.2	118.2	133.9
6.	Elbow height, cm	104.7	97.5	111.4	96.0	89.9	102.3
7.	Lliocrystale height, cm	97.7	90.3	105.0	91.3	84.2	98.3
8.	Metacarpal III height, cm	70.2	64.5	76.2	65.3	60.1	71.0
9.	Grip diameter(inside), cm	5.3	4.6	6.0	4.8	4.3	5.4
	Strength data						
10.	Hand grip strength(right) N	416.9	254.1	588.6	226.6	98.1	342.4
11.	Push strength (both hands)	256.0	172.7	351.2	183.4	126.5	246.2
12.	Leg strength (height) sitting, N	395.3	267.8	559.2	258.0	165.8	361.0
13.	Torque strength both hands (standing), N	208.0	154.0	265.9	166.8	115.8	220.7

Design of shaft

It is a rotating machine element, which is circular in cross-section, which is used to transmit power from one part to another which is useful to move roller and disc of weeder machine.

Design of bearing

It is a machine element that constrains relative motion to only the desired motion and reduces friction b/w moving parts. The design of the bearing may, for example, provide for free rotation around a fixed axis; or it may present a motion by controlling the vectors of normal forces that bear on the moving parts. His size of sealed ball bearing for supporting typical radial loads. Its chrome steel construction makes it durable and resistant to deformity under heavy loads. The rubber seals on both sides of the bearing keep lubricant in and contaminants out, and it come pre-lubricated from the manufacturer so that no additional lubrication is required. This single row sealed ball bearing is for use in applications that involve combined radial and axial loads and a need for high running accuracy at high rotational speeds.

Field Test-
Field parameter

The test condition of the field were considered like type of field, length and width of the field, area of the field , soil moisture content and soil type . The condition of weed is also taken into consideration in terms of type of weed, root zone, depth of weed, and density of weed. The condition of crop is also considered in terms of variety, row spacing, plant population per meter square of area and height of plant.

Speed of operation

To determine the travel speed of the machines during weeding operation, the time required for covering 10m row length was recorded. Data were recorded in each plot at different place at different level of moisture content in soil and average value was taken. A digital stop watch was used to record the time in seconds to cover 10m distance by weeder. **(RNAM procedure).**

Depth of weeding

The depth of cut of the weeder was measured in the field by measuring the depth of soil layer tilled by the weeder in a row. The depth of the weeding was measured by measuring scalein different rows at different places. Average of observations was taken as depth of weeding.

Performance evaluation of fabricated machine

Study on the field performance was carried out to obtain actual data on over all machine performance and work capacity in the actual field conditions. The weeding operation was carried out in row. Sown garlic at row - row spacing of 15cm. The plant and weed population was counted before and after the operation. The machine performance parameters such as weeding efficiency, Plant damage, Actual field capacity, Theoretical field capacity, field efficiency of the weeder were determined as follows.

Theoretical field capacity

Theoretical field capacity of the weeder is the rate of field coverage that would be obtained if the weeder was performing its function 100% of the time at the rated forward speed and cover 100% of its rated width. It is expressed as hectare per hour and determined as follows **(Kepner *et al.*, 1978).**ed, km/h

Main components of manually operated disc weeder:

Main Frame: Main frame of the machine is designed and develop as per required strength and space. The main frame is made of mild steel (MS) hallow square pipe of length 355 mm & width of the frame 140 mm. The handle, roller, and weeding disc are all supported by the main frame. The frame was joined to the handle, wheel, and disc using supporting mild steel plates, rod, nuts, and bolts. The wheel moves in tandem with the disc as the operator pushes

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the weeder between the row crops. The weeds are sliced and uprooted by the disc at the location. The way weeding operation is done.

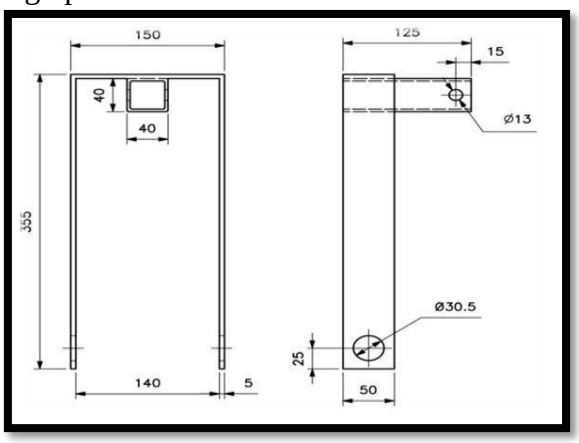

Fig 1: Orthographic view of Frame

Wheel: Wheel is made up of mild steel material which is more durable and high wearing strength. The diameter is 150 mm & the width is 100 mm.

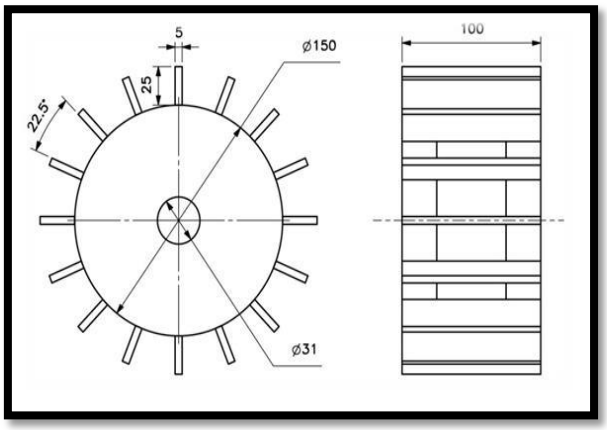

Fig 2: Orthographic view of Wheel

Handle: The handle was made of hollow Galvanized iron pipe material having length 1000 mm & diameter of hollow pipe 30 mm. A laboratory study was carried out for optimum handle height for a push – pull type manually operated. The handle height was adjustable b/w 0.93 – 1.15 m. The handle was fixed at 0.961m height.

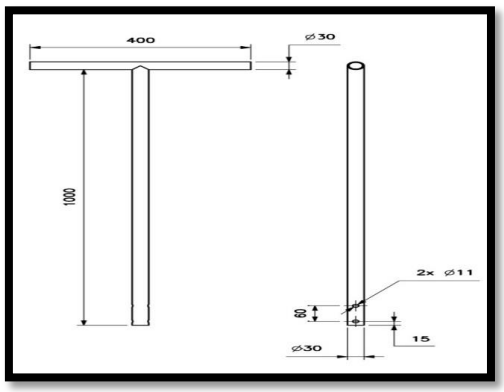

Fig 3: Orthographic view of Handle

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Disc: For designing of disc is the ratio of disc harrow such as thickness, diameter, angle, curvature. It is the main part of my weeder through this uproot, invert soil and cutting of weeds done. It is circular, concave revolving steel plate. Disc angle – at which the plane of cutting edge of the disc is inclined to the direction travel. And tilt angle at which the plane of the cutting edge of disc is inclined to a vertical to the vertical plane. The tilt angle in machine is not considered. Principle – Double action disc harrow but instead of digging and pulverizing soil. It removes weed. It is a circular, concave revolving iron plate used for cutting the weeds and inverting soil. The spacing of between two discs is 25 mm & diameter of disc 130 mm.

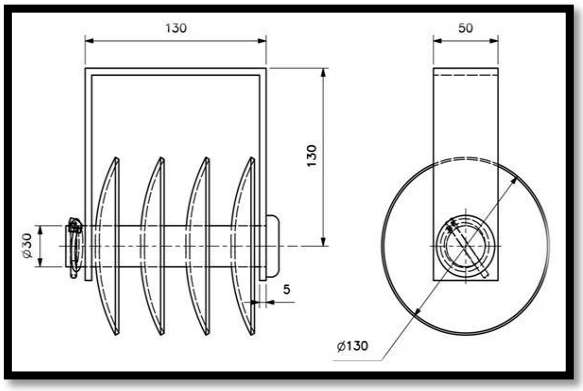

Fig 4: Orthographic view of Disc

Bearing: It is a machine element that constrains relative motion to only the desired motion and reduces friction between moving parts. Ball bearing is used in manually operated disc weeder made of Alloy steel of size 6001RS (28 × 12 × 8 mm sealed ball bearing).

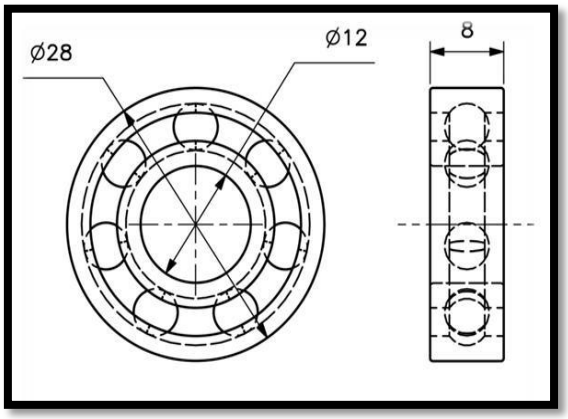

Fig 5: Orthographic view of Bearing

Shaft: It is made up of mild steel (MS). Diameter of shaft is 10 mm & length of shaft 150 mm. It is a rotating machine element, which is circular in cross-section, which is used to transmit power from one part to another which is useful to move roller and disc of weeder machine.

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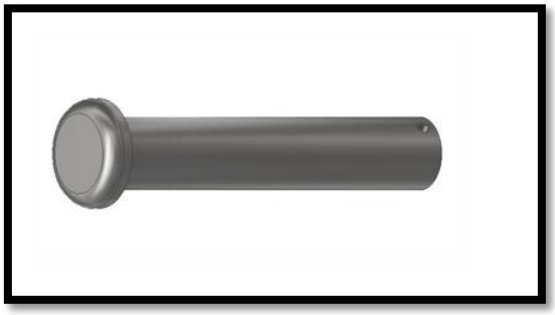

Fig 6: Isometric view of shaft

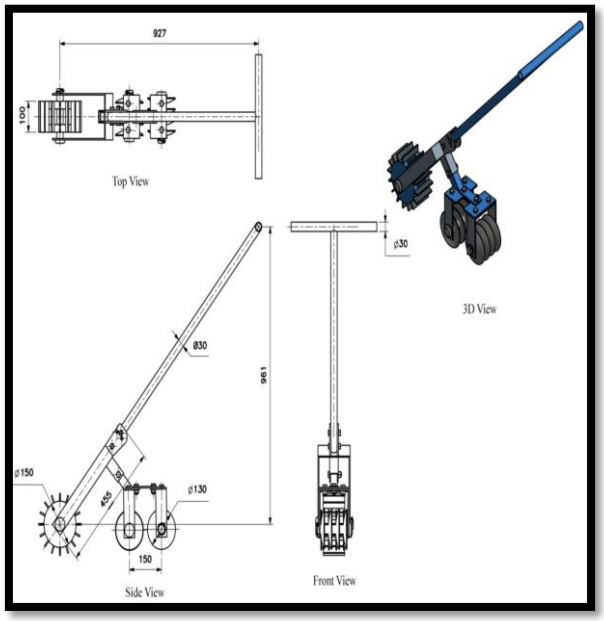

Fig 7: Orthographic view of Disc weeder

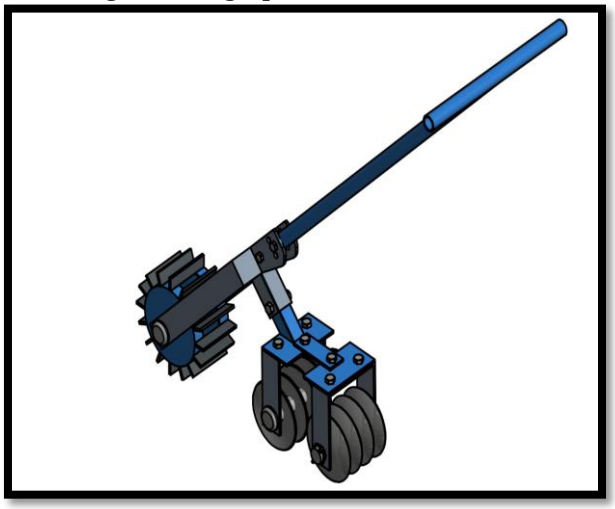

Fig 8: Isometric view

Table 1: Brief specification disc weeder :

S. No.	Details	Particulars

1.	Overall dimension (L x B x H), (mm)	927 × 100 × 961
2.	Weight in (kg)	12
3.	Width of roller (mm)	100
4.	Diameter of roller (mm)	150
5.	Height of handle from ground (mm)	950
6.	Length of handle (mm)	1000
7.	Diameter of disc (mm)	127
8.	No. of disc	8
9.	Space between disc (mm)	25
10.	No. of bearing	6
11.	Dimension of bearing 6001RS (mm)	12 × 28 × 8
12.	Diameter of shaft (mm)	10
13.	Length of shaft (mm)	160

Fig 9: Developed Manual Disc weeder

Experimental Procedure: -In the experimental study the test condition of the field were considered like type of field, length and width of the field, area of the field, soil moisture content and soil type. The condition of weed is also taken into consideration in terms of type of weed, root zone, depth of weed, and density of weed. The condition of crop is also considered in terms of variety, row spacing, plant population per meter square of area and height of plant.

Speed of operation: -To determine the travel speed of the machines during weeding operation, the time required for covering 10 m row length was recorded. Data were recorded in each plot at different place at different level of moisture content in soil and average value was taken. A digital stop watch was used to record the time in seconds to cover 10m distance by weeder. (RNAM procedure)

Speed (km/h) = (Distance (m)) / (time (s))× 3.6 ….. (1)

Depth of weeding: - The depth of cut of the weeder was measured in the field by measuring the depth of soil layer tilled by the weeder in a row. The depth of the weeding was measured by measuring scale in different rows at different places. Average of observations was taken as depth of weeding.

Performance Evaluation of Fabricated Machine:-Study on the field performance was carried out to obtain actual data on over all machine performance and work capacity in the actual field conditions. The weeding operation was carried out in row. Sown garlic at row-row spacing of 15 cm. The plant and weed population was counted before and after the operation. The machine performance parameters such as Theoretical field capacity, Actual field capacity, field efficiency, Weeding efficiency, Plant damage, of the weeder were determined as follows.

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

Theoretical field capacity (ha /h) = $\frac{S \times W}{10}$ **……. (2)**

Where,

S= Speed, km/h

W= Theoretical width, m

Actual field capacity: The weeder was continuously operated in the field for the specific time period. Actual field capacity is the actual average rate of work coverage by the weeder, 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. Actual field capacity is usually expressed as hectare per hour **(Kepner *et al.*, 1978).**

Actual field capacity (ha /h) = $\frac{A}{T_p+T_n}$ **……. (3)**

Where,

A= area covered, ha

Tp= productive time, h

Tn= non-productive time, h

Field efficiency of the weeder: It was calculated by using formula. **(Dubey, 2001)**

Field efficiency= $\frac{\text{Actual Field Capacity}}{\text{Theorectical field capacity}} \times 100$ **….(4)**

Weeding efficiency: It is the ratio between the numbers of weeds removed by the weeder to the number of weeds present in a unit area and is expressed as a percentage. The samplings were done by quadrant method, purposively selected of spots by a square quadrant of square meter **(Tajuddin, 2006).**

Weeding Efficiency (%) = $\frac{W1 - W2}{W1} \times 100$ **…… (5)**

Where,

W_1= Number of weeds $1m^2$ before weeding.

W_2= Number of weeds $1m^2$ after weeding.

Plant damage: Plant damage percentage is measured using the following formula equation**. (Yadav and Pund, 2007).**

$Q = \left(1 - \frac{q}{p}\right) \times 100$ **……. (6)**

Where,

Q= Plant damage

q= Number of plant in a 10m row after weeding.

p= Number of plant in a 10m row before weeding.

Soil moisture percentage: Soil moisture content on dry weight basis was determined randomly before field preparation. The soil samples were taken from the experimental plots, at a depth 15cm, with the help of an auger. The soil moisture analysis was done by oven drying method. Moisture content was found out on dry weight basis. Soil samples were collected at different places. The weight of the soil sample was measured and then the soil sample was put in an oven at 105^{o}C for 24 hours and then the weight of dry sample was measured. The following formula was used for calculating the soil moisture content **(Javadi and Hajiahamad, 2006).**

$$MC\ (db) = \frac{Ww - Wd}{Wd} \times 100 \qquad \text{…….. (7)}$$

Where,

Mc (db) = Moisture content dry basis (%)

Ww = Weight of undried soil (g)

Wd = Weight of oven dried soil (g)

RESULTS AND DISCUSSION

This chapter deals with the results and discussion for design development and performance evaluation of the developed manually operated disc weeder with from mechanical point of view. A testing was conducted at the Department of farm machinery and power engineering, SHUATS Prayagraj (U.P).

Mechanical study:

Working depth:

Depth of working is different at different moisture content % in soil. The average depth of cut of weeder at less than 5%, 5-10 %, 10-15 %, 15-20% moisture content is 1.8 cm, 1.9 cm, 2 cm, 2.5 cm.

Weed height: Plant height at different place the avg. max height is 10 - 15cm and avg. minimum plant height 3- 5cm.

Fig10: Pictorial view of working depth

Fig 11: Pictorial view of Weed height

Working width: Theoretical width of cut is 10 cm and average Actual width of cut is 9.80 cm.

Operational speed: The operational speed of weeder is different at different moisture content. The average operational speed of weeder at less than 5%, 5-10 %, 10-15 %, 15-20% moisture content is 1.9 km/h, 1.7 km/h, 1.5 km/h, 1.4 km/h.

Field capacity and field efficiency: The result of actual field capacity and field efficiency in four treatments at different moisture contents presented in tabular form as shown in table given below and also graphical representation is shown in figure.

Fig 12: Pictorial view before weeding

Fig 13: Pictorial view after weeding

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Fig. Before Weeding (1m × 1m) **Fig.No.After Weeding (1m × 1m)**

Table : Field capacity and field efficiency of disc weeder (at <5% and 5-10% moisture content)

S. No.	Replication	At <5% moisture content			At 5-10% moisture content		
		TFC (ha/h)	EFC (ha/h)	FE %	TFC (ha/h)	EFC (ha/h)	FE %
1.	R1	0.02	0.0185	92.36	0.02	0.0167	83.60
2.	R2	0.02	0.0181	90.46	0.02	0.0166	82.88
R_{avg}		0.02	0.0183	91.41	0.02	0.0167	83.24

Table : Field capacity and field efficiency of disc weeder (at 10-15% and 15-20% moisture content)

S. No.	Replication	At <10-15% moisture content			At 15-20% moisture content		
		TFC (ha/h)	EFC (ha/h)	FE %	TFC (ha/h)	EFC (ha/h)	FE %
1.	R1	0.02	0.0150	75.06	0.02	0.0141	70.56
2.	R2	0.02	0.0148	73.94	0.02	0.0138	69.07
R_{avg}		0.02	0.0149	74.50	0.02	0.0140	69.82

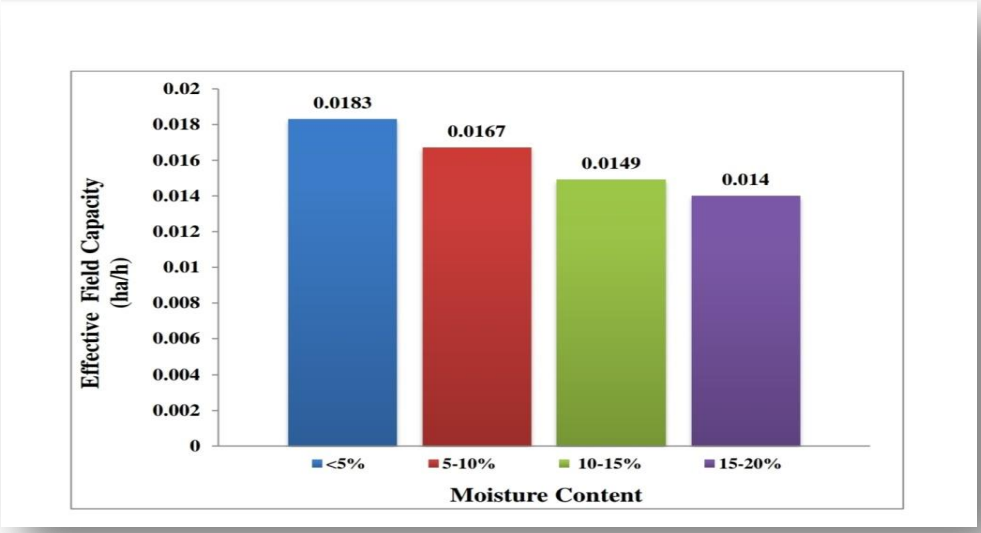

Fig 14: Effective field capacity (at <5%, 5-10%, 10-15% and 15-20%moisture content)

Table 4: Weeding efficiency of disc weeder (at<5% and 5-10% moisture content)

S.No.	Replication	At <5% moisture content	At 5-10% moisture content
		Weeding Efficiency (%)	Weeding Efficiency (%)
1.	R1	89.33	90.67
2.	R2	88.39	89.66
R_{avg}		88.86	90.17

Table 5: Weeding efficiency of disc weeder (at 10-15% and 15-20% moisture content)

S.No.	Replication	At 10-15% moisture content	At 15-20% moisture content
		Weeding Efficiency (%)	Weeding Efficiency (%)
1.	R3	87.50	82.86
2.	R4	85.88	80.56
R_{avg}		86.69	81.71

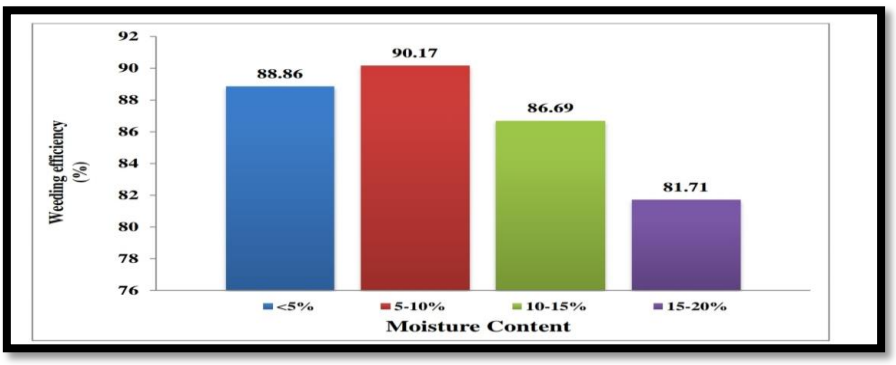

Fig 18: Weeding Efficiency (at <5%, 5-10%, 10-15% and 15-20%moisture content

CONCLUSION:

With regard indicated a clear view for adopting this design of manually operated disc weeder for garlic crop, because it is easy to operate and outcome of weeding efficiency is also satisfactory. It is suitable to use at 15 -20 days of crop age in between about 15 cm. The higher disc weeder could work upto 2.5 cm depth. The average weeding efficiency was obtained (i.e. up to 90.17%) at 5-10% of moisture content. The average field capacity of the disc weeder was found to be 0.0183 ha/hr and average field efficiency 91.41 % at <5% of moisture content. No plant damage was occurred during weeding operation with disc weeder. This manually operated disc weeder is also useful for 15cm above wide row crops.Weeding with this machine reduces human drudgery, reduces labour, reduce time etc. It is most economical and effective for marginal farmer. The overall performance of weeder was satisfactory.

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