*International Journal of Agricultural Engineering,* Vol. 3 No. 1 (April, 2010) : 161-166

***Research Paper :***

# Performance evaluation of tractor drawn inter-raw rotary weeder

**R.K. RATHOD**, P.A. MUNDE AND R.G. NADRE

**Accepted :** ***April, 2010***

See end of the article for authors' affiliations

Correspondence to:
**R.K. RATHOD**
Department of Farm Power and Machinery, College of Agricultural Engineering and Technology, Marathwada Agricultural University, PARBHANI (M.S.) INDIA

**ABSTRACT**

The tractor drawn rotary weeder was developed with an objective of mechanical means of weeding and keeping in view the crop, soil and machine parameters. Weeding is an important practice to be carried out during the initial stages of crop growth especially for controlling the weeds competing with the crop, stirring the soil for aerating the crop root zones and for burying the weeds into the soil. The developed weeder was evaluated at different test fields for different crops. From the field tests it is seen that, as the moisture content was increased cone index decreased steadily, speed of operation with the depth of operation resulted significant decreases weeding efficiency. The maximum weeding efficiency of 81.39 was obtained at 1.1 km/hr speed and at 13.00 per cent moisture content. While the minimum weeding efficiency of 69.04 was obtained at 1.5 km/hr of speed and at 13.75 moisture content hence the weeding efficiency decreased with increase in speed of operation, weeding efficiency increased with increase in depth of operation

**Key words :** Power performance of tractor operated weeder, Inter row rotary weeder, Weeding parameters

Weed control in Indian farm is a serious concern weeds pose major problem during warm and humid climate especially affecting *Kharif* crops. The problem of weed control is more acute in black soil during *Kharif* season. Weed control is one of the most expensive operations in crop growth. The high cost of weeding can be understood from a comparative study of the loss in the farm due to various causes. Infection of weeds is more in *Kharif* than in *Rabi* season. Often weeding is incomplete or delayed as a result there is significant loss of 20% or more. Weeds increase cost of production and lower the quantity as well as the quality of the crop. Depending on the weed density 20-30% loss in grain yield is quite usual which may increase to 50%, when crop management practices are not properly followed. In production technology plant protection is a key in increasing the productivity of crop. Under plant protection, weed control plays an important role for increasing the yield. Weed alone was found to be reducing the yield of the extent of 58-85%. The yield losses in cotton due to weeds alone was assessed as 13.60 per cent than that of insects and diseases which was about 35.80 per cent, while the losses due to weeds alone was assessed was 33.80 per cent. This shows the necessity of effective weeding operation. Usually tractor mounted cultivators are used for weeding and inter-culturing operations in farm. The rotary type weeder stirs the soil more accurately, disturb the weed root and remove them from the soil. In addition this helps in keeping the soil in loose condition for proper aeration. Especially for the wide row spaced crops like cotton, maize where the tractor can be run in the rows. Looking to the above facts tractor drawn inter-row rotary weeder was developed for widely spaced row crops.

## METHODOLOGY

### *Performance evaluation of the unit:*

The laboratory test and field tests are taken of the rotary weeder. The details about tests are mentioned below, the main objectives of the laboratory test are to study and confirm the specifications and essential components of the unit such test assist in modification and improvement of the machine design.

Some of the items examined by the laboratory test are-

### *Adjustment of working width and depth:*

A inter- row rotary weeder has a operating width of 400 mm which can be adjusted 400 mm to 550 mm and spacing between consequent rotary weeding was240 mm which can adjusted as 240-300 mm. The depth of operation was 40-55 mm.

### *Power transmission system:*

The mechanical power transmission system components were telescopic shaft, safety device, pinion shaft, pinion, crown, transmission shaft, driving gear driven gear and bearings.

A power from the tractor was reduced from 540 rpm to 337 rpm with the help bevel gear arrangement, which was having a gear ratio of 1.6:1. Again power reduction of 1.2:1 was obtained by chain and sprocket.

***Material of blade:***

Spring steel is used for blade after heat treatment.

***Implement specifications:***

| | |
|---|---|
| Make | : M.A.U. |
| Model | : Inter- row rotary weeder |
| Type | : Rotary |
| No. of tynes | : 24 |

***Equipments used :***

*Stop watch:* A stop was used to measure time required for one turn and turning of a tractor. Time measured in and calculated for hours.

*Measuring tape* : measuring tape was used for measuring and marking in the field. A steel foot rule was also used for measuring depth of operation, height of crop, height of weeds.

*Dynamometer* : Draft required to operate the unit in the field was measured by using a dynamometer of 100 kg capacity.

*Cone pentrometer* : To measure penetration resistance of soil or cone index of the soil.

*Tachometer* : Tachometer was used to measure the rpm of shaft.

***Test considerations :***

The inter-row rotary weeder was taken to the field and trials were conducted in black soil, the parameters like soil type, moisture content, cone index, crop parameters were studied, the other factors were taken into considerations were speed of operation, depth of operation, wheel slip, specific fuel consumption, draft. The field tests were conducted as per RNAM test code 1983.

***Condition of field and soil:***

*Area and shape of the test field :*

Three different test were conducted in the fields of size 60 x 30, shape- rectangle , 2) Type of soil - Black soil, 3) Soil moisture content – 13-18.25% for different test conditions.

*Condition of weeds:*

1) Height of weeds – 10 to 20 cm, 2) Type of weeds – Haryali, Lona, Shipi, vinchu, kolsi, Tandulja, Aagada, Doha.

*Condition of crop:*

1)Variety of crop – Cotton PH-348, Soybean M.A.U.S. -81, Sunflower S.C.H-35

2) Planting method – dibbling and sowing

3) Age after seeding and crop height – 35-50 DAS, height 25-40 cm.

4) Row spacing – Field-I 60 cm, Field-II 45 cm, Field-III 60 cm

*Condition of implement:*

1) Type of soil working part : The 'L' type blade of spring steel material of length 250mm, 2) Width of cut for one run = 1200 mm, 3) Traveling speed – 1.1 -1.5 km/hr., 4) Type of power source – A tractor PTO was used as source of power.

**Fig. 1 : Operation of inter-row rotary weeder in row crop**

***Measurements of different parameters:***

*Soil moisture content:*

Soil sample at 10 cm depth in different locations at random were taken. Soil moisture content in per cent has been calculated by following formula:

$$\text{Soil moisture content (\%)} = \frac{\text{Weight of wet soil sample} - \text{Weight of oven dry soil sample}}{\text{Weight of oven dry soil sample}}$$

The mean value was used in the study. Experiments were conducted at three different moisture levels.

*Bulk density:*

The volume of undisturbed soil core from the field during weeding was randomly taken and bulk density was calculated by using the formula:

$$\text{Bulk density (g/cm}^3\text{)} = \frac{\text{Mass of the soil sample}}{\text{Volume of the sample}} \qquad (2)$$

*Cone index :*

Cone index was measured at a depth of 0-10 and 10-20 cm to define the soil condition. The cone index was measured at different places selected randomly. This was measured before and after the weeding at the three moisture levels and mean values in each level were calculated.

***Weeding efficiency test:***

The weeder was operated in the plots of sizes 60 x 30 and the time taken to cover the area was noted. Before operation of the weeder the numbers of weeds in the plot were counted. After the operation the number of weeds left in the plot was also counted. This procedure was repeated at different depth. The forward speed was maintained at constant in all the field tests. Weeding efficiency was calculated by the following expression:

$$E = \frac{W_1 - W_2}{W_1} \quad (3)$$

where, E = weeding efficiency,

$W_1$ = number of weeds counted before operation , per square meter, $W_2$ = number of weeds counted after operation, per square meter

***Draft measurement:***

The draft required to operate the unit in the field was measured by using a hydraulic dynamometer of 1000 kg capacity, mounted in between the test tractor hitched with rotary weeder and hauling tractor (RNAM, 1995). The test tractor with transmission in neutral and the PTO and the hydraulic system fully operational conditions. The dynamometer was hitched to ensure horizontal pull. First the draft required ($F_2$) to pull the test tractor along with rotary weeder in working position was measured, second the draft required ($F_1$) to pull the tractor without any load was measured. Then the draft required to operate the weeder was calculated as below.

$$\text{Draft} = (F_2 - F_1), \text{kg.} \quad (4)$$

***Fuel consumption :***

Fuel consumption was measured by recording the time required and the quantity of fuel consumed for the specified length of run and the fuel consumption was calculated on hourly basis, as follows.

$$W_f = 36 \frac{V_f}{T} \times 10^{-4} \quad (5)$$

where, $W_f$ =Fuel consumed, $m^3$/hr,

$V_f$ =Volume of fuel consumed for a specified run, cc,

T = Time taken to cover specified length of run, s

***Forward speed :***

The forward speed of operation was calculated by observing the distance traveled and the time taken as

$$S = \frac{L}{t} \quad (6)$$

where, S = Forward speed of operation m/s.,

L = Distance traveled m,

t = Time taken s

***Wheel slippage :***

The slip of the tractor was measured by monitoring the number of revolutions of the wheel over a specified distance under load and zero load conditions. The slip was calculated by using the following formula:

$$S^n = \frac{n_1 - n_0}{n_0} \times 100 \quad (7)$$

where, S’ = Wheel slip, per cent ,

$n_1$ = Number of revolution of wheel under load conditions for specified distance,

$n_o$ = Number of revolution of wheel under no load conditions for specified distance.

In most of the cases the tool had no effect on slip at different levels of forward speed. Hence, the measurement of slip was neglected due to the less draft.

***Effective field capacity:***

The rotary weeding machine was operated in the different test fields. The area covered during the test was calculated. The effective field capacity was then calculated by using following formula:

$$\text{Effective field capacity} = \frac{\text{Area covered (ha)}}{\text{Time required (hr)}} \quad (8)$$

***Theoretical field capacity:***

The theoretical field capacity was calculated by using following formula:

$$\text{T.F.C.} = \frac{W_t \times S}{10} \quad (9)$$

where, T.F.C. = Theoretical field capacity ha/hr.,

$W_t$ = Theoretical width of operation m,

S= Speed of operation, km/hr.

***Field efficiency :***

The field efficiency was calculated from theoretical and effective field capacity by using following formula:

$$\text{Field efficiency} = \frac{\text{E.F.C.}}{\text{T.F.C.}} \times 100 \quad (11)$$

where, E.F.C. = Effective field capacity ha/hr,

T.F.C. = Theoretical field capacity ha/hr.

## RESULTS AND DISCUSSION

The performances of the weeding system under different moisture, depth of operation, forward speed are discussed. The field performance and cost economics of the inter-row rotary weeder based on the optimized parameters were discussed.

The performance of the rotary weeder was carried out under different field parameters. The field performance of the inter-row rotary weeder was presented below.

The results of field tests are given in Table 1 which gives the summary of the performance of field tests of the rotary weeder for different fields.

### *Effect of operational parameters on weeding*

*Effect of moisture content on cone index :*

The effect of moisture content on a cone index is presented in Fig. 3 . From the Fig. 3 it is concluded that, as the moisture content increases cone index decreased steadily. There was decrease in cone index from 2.5 to 2 for moisture level 13 to 13.75 in the cotton field ($F_1$).

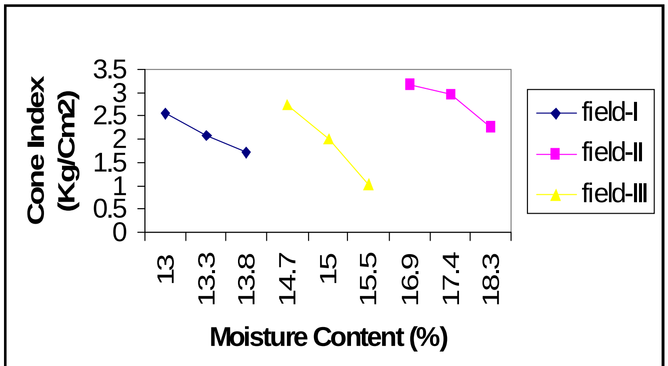


**Fig. 3a : Effect of moisture content on cone index (0-10 cm depth)**

**Fig. 2 : Field observations of rotary weeder in test plot**

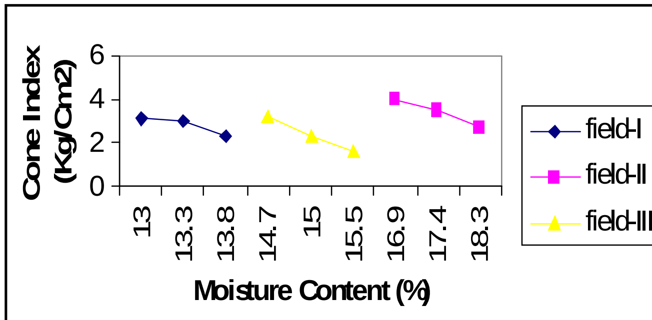


**Fig. 3b : Effect of moisture content on cone index (10-20 cm depth)**

**Table 1 : Results of field tests**

| Sr. No. | Particulars | Field-I | Field-II | Field-III | Mean |
|---|---|---|---|---|---|
| 1. | Plot size | 60x30 | 60x30 | 60x30 | 60x30 |
| 2. | Row spacing (cm) | 60 | 45 | 60 | 55 |
| 3. | Crop height (cm) | 32 | 25 | 29 | 29 |
| 4. | Working width (m) | 1.8 | 1.35 | 1.8 | 1.65 |
| 5. | Speed of operation (km/hr) | 1.27 | 1.27 | 1.27 | 1.27 |
| 6. | Depth of operation (cm) | 50 | 45 | 49 | 48 |
| 7. | Soil moisture (%) | 13.34 | 17.50 | 15.05 | 15.30 |
| 8. | Draft (kg) | 60 | 63.67 | 61 | 63 |
| 9. | Time taken (min) | 44.52 | 60.36 | 44.20 | 49.69 |
| 10. | Time lost in turning (min) | 11.54 | 13.97 | 10.85 | 12.12 |
| 11. | Total time (min) | 56.07 | 74.33 | 55.05 | 61.81 |
| 12. | Effective field capacity (ha/day) | 1.55 | 1.17 | 1.58 | 1.43 |
| 13. | Theoretical field capacity (ha/day) | 1.82 | 1.37 | 1.82 | 1.67 |
| 14. | Field efficiency (%) | 85.65 | 86.17 | 87.21 | 86.34 |
| 15. | No. of weeds before operation in $1m^2$. | 43 | 36 | 34 | 38 |
| 16. | No. of weeds after operation in $1m^2$. | 3 | 4 | 3 | 3 |
| 17. | Weeding efficiency (%) | 92.23 | 92.09 | 93.19 | 92.5 |

*Effect of speed of operation on draft :*

The effect of speed of operation on draft is presented in Fig. 4. It is concluded from Fig. 4 that increase in speed of operation decreases draft. At all moisture content and depth of operation. The interactive change in the depth and moisture level had a significant effect on draft, due to increase in soil resistance as in increase in depth of operation, increased the contact area. Also it concludes that the draft decrease as depth of operation decreased.

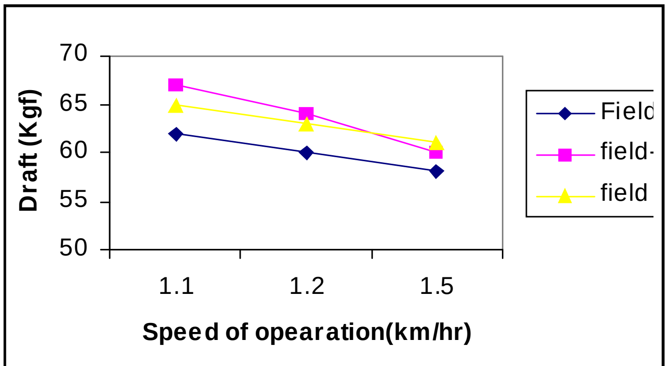


**Fig. 4 : Effect of speed of operation on draft**

*Effect of speed of operation on weeding efficiency:*

Fig. 5, gives the relationship between speed of operation and weeding efficiency, from Fig. 5 it is found that, all three levels of speed of operation with the depth of operation resulting significantly decreases weeding efficiency. The maximum weeding efficiency of 81.39 was obtained at 1.1 km/hr speed and at 13.00 per cent moisture content. While the minimum weeding efficiency of 69.04 was obtained at 1.5 km/hr of speed and at 13.75 moisture content. So it is concluded that the weeding efficiency is decreased with increased in speed of operation.

*Effect of depth of operation on weeding efficiency:*

The effect of depth of operation on weeding efficiency is presented in Fig. 6. From Fig. 6 it is observed that the weeding efficiency increases as depth of operation increases. The weeding efficiency observed at 4.5 cm of depth was 69.04 at 13.75 per cent moisture and that of 5.5 cm of depth was 81.39 per cent moisture level. This means that weeding efficiency increased with increase in depth of operation.

**Conclusion:**

Performance of the inter-row rotary weeder was evaluated in terms of field efficiency, weeding efficiency

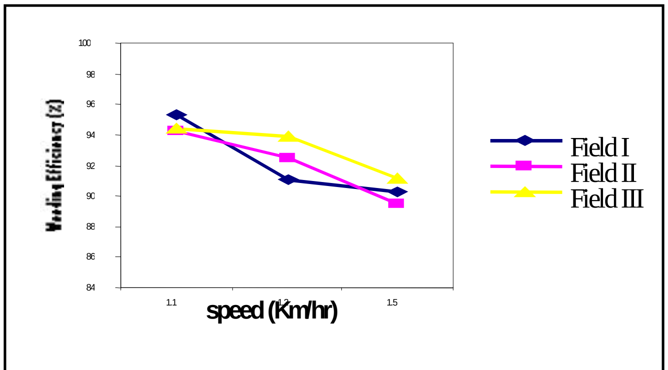


**Fig. 5 : Effect of speed of operation on weeding efficiency**

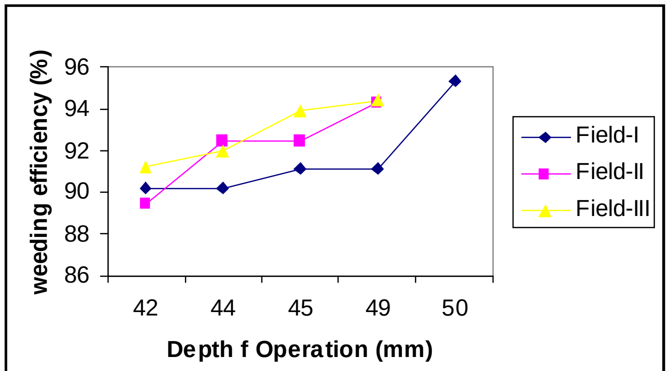


**Fig. 6 : Effect of depth of operation on weeding efficiency**

and cost economics. The experiments were conducted in three different crops with three forward speeds (1.1, 1.2 and 1.5 km/hr) at different moisture content. The field observations were analyzed which give the performance of inter-row rotary weeder. The type of soil was heavy soil where experiments were conducted.

The effective field capacity of inter-row rotary weeder was found to be 1.43 ha/day. The field efficiency and weeding efficiency was found to be 86.34 per cent and 92.23 per cent, respectively. The saving in cost and time were 68.70 per cent and 70 per cent, respectively as compare to conventional method of weeding. The developed tractor drawn inter-row rotary weeder relived the farmer from fatigues work of weeding.

Authors' affiliations:
**P.A. MUNDE AND R.G. NADRE** Department of Farm Machinery and Power , College of Agricultural Engineering and Technology, Marathwada Agricultural University, PARBHANI (M.P.) INDIA

## REFERENCES

**Biswas, H S. (1993)**. Performance evaluation and optimization of straight blades for shallow tillage and weeding in black soils, *Agric. Mech. in Asia, Africa and Latin America*, **24**(4) 19-22.

**Fashina, A.B. and Anumenechi, G. (1991).** A power operated inter-row weeder for the farmers in developing country. *J. Research of Andhra Pradesh Agricultural University*, **19** (1) :17-21.

**Gupta, C.P. and Viswvanathan, R. (1993).** Power requirement of a rotary tiller in saturated soil. *Transactions of ASAE*, **36** (4): 1009-1012.

**Hendrick James, G. and Gill William, R. (1971a).** Rotary – Tiller design parameters – Direction of rotation. *Transactions of ASAE*, 669-674.

**Hendrick James, G. and Gill William, R. (1971b).** Rotary – Tiller design parameters – Depth of tillage. Transactions of ASAE. 675-683.

**Paarlberg, K.R. and Hanna, H.M. (1998).** Cultivation design for inter row weed control in no- till- corn. Transactions of ASAE. Paper No. 95-1131.

**Rajshekhar (2000).** Design and development of inter- row tractor mounted weeder. Tamil Nadu Agricultural University, Coimbatore.

**RNAM (1995).** Test codes and procedure for weeders.

**Victor, V.M. and Ajay Verma (2003).** Design and development of power operated rotary weeder for wetland paddy. *Agricultural Mechanization in Asia, Africa and Latin America*, **34**(4) : 27-29.

——— *** ———