RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 13 | Issue 1 | April, 2020 | 121-127

ISSN–0974–2662 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/13.1/121-127**

Design and field performance of power operated paddy weeder

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Received : 21.01.2020; **Revised :** 09.03.2020; **Accepted :** 22.03.2020

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■ **ABSTRACT :** Improper weed control methods can cause about 30–35 per cent reduction in crop yield. The power operated paddy weeder was designed and developed for weeding of paddy crops. In Konkan region, paddy is the major crop cultivated under wet land condition. The hand weeding method using labours is widely adopted at present for paddy. It is costly and drudgerious. Manually operated cono weeders are being used in some of the pockets of Konkan. It's capacity is less (upto 0.12-0.15 ha/day) and its operation is also heavy due to its weight (7.8 kg). Therefore developed power weeder was designed. It was consisted of engine, gear box, propeller shaft, rotor with blade and main frame and float. The reduction gear box (ratio- 32.5:1) was used to reduce the speed to 200 rpm. The two types of rotors were developed *viz.*, L shape blade and hexagonal serrated blade. The serrated blade has resulted into 9.41 per cent higher weeding efficiency than L shape blade. The L shape blade has resulted into 1.02 per cent minimum plant damage than serrated blade. The lowest fuel consumption of power weeder was found with of L shape blade as 0.576 l/h at 40 DAS while the maximum fuel consumption was found on using of serrated blade as 0.68 l/h at 20 DAS. The maximum field capacity was found with L shape blade (0.0266 ha/h) than serrated blade (0.0213 ha/h) at 40DAS which is 30.39 per cent higher.

■ **KEY WORDS :** Paddy weeder, L- shape blade, Serrated blade, Weeding efficiency, Plant damage

■ **HOW TO CITE THIS PAPER :** Shahare, P.U., Jadhav, D. G., Aware, V.V. and Shirsat, N.A. (2020). Design and field performance of power operated paddy weeder. *Internat. J. Agric. Engg.*, **13**(1) : 121-127, **DOI: 10.15740/HAS/IJAE/13.1/121-127.**

Rice (*Oryza sativa* L.) is a staple food of mass population of India and Asia with production of 106.54 mT and 43.90 million ha area under rice cultivation. Maharashtra and Konkan has 1.6 mha and 0.42 mha land under rice cultivation with production of about 3.057 and 1.042 mT, respectively (Anonymous 2015). The most common methods of weed control are mechanical, chemical, thermal, biological and traditional methods.

Nganilwa *et al.* (2003) opined that a farmer using only hand hoe for weeding would find it difficult to escape poverty, since this level of technology tends to perpetuate human drudgery, risk and misery. The mechanical weeding either by hand tools or mechanical weeders are most effective in both dry land and wet land (Nag and Dutt, 1979 and Gite and Yadav, 1990 and 1985). In Konkan region, paddy is the major crop cultivated under wet land condition. The hand weeding method using labours is widely adopted at present for paddy. It is costly and drudgerious. Therefore cost effective and efficient technologies are needed to be adopted by the farmers of Konkan region for getting advantages of agricultural mechanization. Manually operated cono weeders are being used in some of the pockets of Konkan. It's capacity is less (upto 0.12-0.15 ha/day) and its operation is also heavy due to its weight (7- 8.5 kg). If a kind of drive preferably a small portable engine is provided to such weeder, the durdgury involved can be reduced to a greater extent. Its higher capacity can speed up the weeding work and male and female worker can be more comfortable while using such weeder. Hence efforts have been made to develop power operated paddy weeder. It's performance was also evaluated.

METHODOLOGY

Based on agronomic requirement of paddy the power operated paddy weeder was developed. The design and development the individual components were also made. The designs of various components are described below.

Power requirement:

For determining power requirement of the weeder, the soil resistance for silt loam soil was considered to be 0.35 to 0.5 kgf/cm^2 (Basavaraj *et al.*, 2016). Hence the maximum soil resistance was taken as 0.5 kgf/cm^2. The travelling speed of cono weeder (DBSKKV) and developed cono weeder-1 (Double handled), cono weeder-2 (Single handled) were 1.66, 1.71 and 1.69 km/h, respectively (Shirsat *et al.*, 2016). Tayade (2016) was recorded average travel speed of Ambika paddy weeder to be 1.66 km/h. The comfortable working speed in the paddy fields was observed 2.5 km/h (Ratnaweera *et al.*, 2010). The maximum speed of operation of the weeder was considered as 2.5 km/h (0.7 m/s). Total width of coverage of cutting blades (single set) was in the range of 20 to 30 cm. The depth of operation was considered as 4 to 7 cm and transmission efficiency to be 80 per cent. Selection of proper engine was very important while developing the machine. Power requirement for power operated paddy weeder was calculated using following formula (Sahay, 2010).

$$P_d = \frac{S_R \ x\ d\ x\ w\ x\ v}{75}\ hp \qquad \text{..... (1)}$$

where,

P_d = Power requirement, hp

S_R = Soil resistance, kgf/cm^2

d = Depth of cut, cm

w = Effective width of cut, cm

v = Speed of operation, m/s

Hence, power requirement was calculated as 1 hp

Total power required:

The total power required was calculated was

$$P_t = \frac{Power}{\eta} \qquad \text{....(2)}$$

where,

η = Transmission efficiency. (0.80)

$$P_t = \frac{1}{0.80} = 1.25\ hp$$

Considering the overloading factor to be 1.4 the total power = 1.25 × 1.4 = 1.75 hp.

The, premier hawk 1.75 hp @ 6500 rpm petrol engine is selected for the study.

Diameter of the rotor shaft:

For designing the rotor shaft, the maximum tangential force which can be endured by the rotor should be considered. The maximum tangential force occurs at the minimum tangential speed of blades, which was calculated by the following (Bernacki *et al.*, 1972).

$$K_S = \frac{C_S \ x\ 75\ x\ N_c \ x\ \eta_c \ x\ \eta_z}{u} \qquad \text{....(3)}$$

where,

K_s = Maximum tangential force, kg,

C_s = Over load factor (1.5 for non-rocky soils and 2 for rocky soils),

N_c = Power of engine, hp,

η_c = Traction efficiency for the forward rotation of rotor shaft as 0.9,

η_z = Co-efficient of reservation of engine power (0.7-0.8),

u = Minimum tangential speed of blades m/s.

$$K_S = \frac{1.5\ x\ 75\ x\ 1.75\ x\ 0.9\ x\ 0.75}{3.35}$$

K_s = 39.66 kg.

Tangential peripheral speed, u, was calculated using the following equation,

$$u = \frac{2\ x\ \pi\ x\ N\ x\ R}{60} \qquad \text{....(4)}$$

where,

N = Revolution of rotor, rpm, and

R = Radius of rotor, mm.

$$u = \frac{2\ x\ 3.14\ x\ 200\ x\ 0.16}{60} = 3.35\ m/s$$

After substituting values for revolution of rotor shaft (200 rpm) and its radius as 16 cm in eq. (4), tangential peripheral speed was obtained as 3.35 m/s. Using the tangential peripheral speed and other parameters in eq.

(3), the maximum tangential force was determined as 39.66 kg.

The maximum moment on the rotor shaft (T_{max}) was calculated the following equation,

$$T_{max} = K_s \times R \quad \ldots(5)$$

where,

R is the rotor radius (cm).

$$T_{max} = 39.66 \times 16 = 634.54 \ \frac{kg}{cm}$$

The yield stress of rotor made from mild steel was 250 MPa. The allowable stress on the rotor (τ_{all}) was calculated by the following equation (Mott, 1985)

$$\tau_{all} = \frac{0.577 \times k \times \sigma_y}{f} \quad \ldots(6)$$

where,

τ_{all} = Allowable stress on rotor shaft, kg/cm^2,

k = Co-efficient of stress concentration (0.75),

f = Co-efficient of safety (1.5), and

σ_y = Yield stress, 250 MPa

By solving Eq. 6 the allowable stress on rotor shaft were determine as 735.62 kg/cm^2.

The torsional moment being the most important factor that significantly affects the rotor shaft design. Considering the equation for calculating the torsional moment on rotating shafts, the required diameter for the rotor shaft could be obtained as

$$d = \sqrt[3]{\frac{16 \times T_{max}}{\tau_{all} \times \Pi}} \quad ..(7)$$

d=1.6 cm

Considering factor of safety to be 1.2

Therefore, 1.8 cm diameter shaft for rotor was selected.

Design of cutting blades:

In rotary weeder, one-fourth of the blades act simultaneously on the soil. The total power of the machine was distributed between the blades. For cutter blade design, number of blade, cutting width and thickness were important parameters. During cutting, blades would be subjected to shearing as well as bending stresses. (Bernacki *et al.*, 1972 and Khodabakhshi *et al.*, 2013).

Design of rotor with L shape blade:

For the rotor with L shape bade following parameter were considered

– No. of flanges on rotor shaft = 2
– No. of blades on each rotor = 4
– Diameter of flange = 130 mm
– Thickness of the blade =2 mm
– Width of blade = 25 mm
– Length of bend portion of blade (S_s) = 70 mm.
– Blade material - M. S.

The bending stress, shear stress and equivalent stress were calculated and these stresses were compared with bending stress, shear stress and equivalent stress of M.S. material. The higher values of the equivalent stresses of the selected material than calculated stress indicated safe design (Bernacki *et al.*, 1972).

The soil force acting on the blade (K_e) was calculated by the following equation (Bernacki *et al.*, 1972).

$$K_e = \frac{K_s \times C_p}{i \times Z_e \times n_e} \quad ..(8)$$

K_e = 39.66 kg

where,

K_s = Maximum tangential force, kg,

C_p = Co-efficient of tangential force as 2,

i = Number of flanges 2,

Z_e = Number of blades on each side of the flanges (considered as 4)

n_e = Number of blades which act jointly on the soil by total number of blades.

The dimensions of the blades were defined and are presented in Fig. A. The values of b_e, h_e, S_s and S_1 were considered equal to 0.2, 2.5, 7 and 3.5 cm, respectively. (Bernacki *et al.*, 1972).

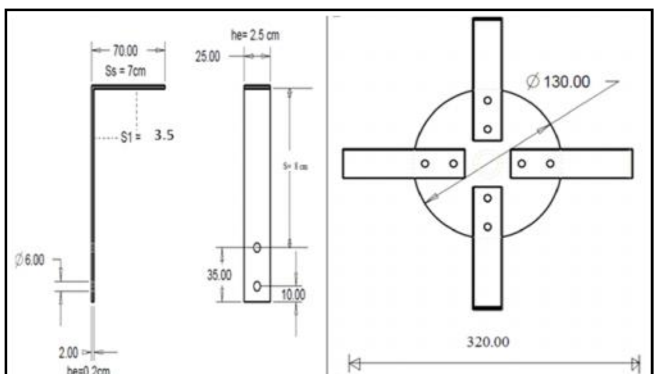

Fig. A : Dimensions of flange and blade

Considering the shape of the blades, the bending stress (σ_{zg}), shear stress (τ_{skt}), and equivalent stress (σ_{zt})

were calculated by the following equations (Bernacki *et al.*, 1972).

$$\text{Bending stress } (\sigma_{zg}) = 6\frac{K_e \times S_s}{b_e \times h_e^2} \quad ...(9)$$

$$\text{Shear stress } (\tau_{skt}) = \frac{3 \times K_e \times S_1}{\left(\frac{h_e}{b_e} - 0.63\right) \times b_e^3} \quad ..(10)$$

$$\text{Equivalent shear stress } \sigma_{zt} = \sqrt{\sigma_{zg}^2 + 4\tau_{skt}^2} \quad ..(11)$$

By solving Eqn. 9, 10 and 11 values of stresses were bending stress to 1332.57 kg/cm^2, shear stress to 877.06 kg/cm^2 and equivalent stress of 2202.88 kg/cm^2. For M.S. the allowable bending, shear and equivalent stresses are 1580.56 kg/cm^2, 1172 kg/cm^2 and 2828.21 kg/cm^2, respectively. The obtained value of equivalent stress is less than allowable equivalent stress of M.S. material. Therefore design was safe. Hence, the dimensions of the blade were confirmed and final designed dimensions are shown in Fig. A.

Design of rotor with serrated blades:

The another blade was developed considering same load on depth of operation, working width were same. The same rotor shaft was used as L shape blade. The serrated blade was developed to reduce contact area and to resolve the problem of soil mass sticking over the blades. The geometry of the blades affects the draft as well as vertical and lateral components of soil forces (Kepner *et al.*, 1978). The 15-20 cm width of cut was the most appropriate within human limitation (Tiwari and Dutta, 1985). As the paddy weeder was planned to work in the paddy crop transplanted at 20 to 25 cm, the width of blade was selected as 150 mm.

The total weight of the machine was supported on the rotor. By taking total weight of machine as 24 kg, the load acting on one blade is 24/2 *i.e.* 12 kg. Considering the unit draft of light to medium soil in Konkan region as 0.35 kg/cm^2, and width of blade 150 mm. The depth of blade was calculated by following equation (Sharma and Mukesh, 2010).

$$\frac{W}{2} \times d \times \text{unit draft} = \text{Load on blade (kg)} \quad ..(12)$$

where,

d is the depth of blade.

Therefore,

$$\frac{15}{2} \times d \times 0.35 = 12$$

d = 4.5 cm

Total six blades were fitted on the rotor shaft

The design dimensions of the serrated blades is shown in Fig. B.

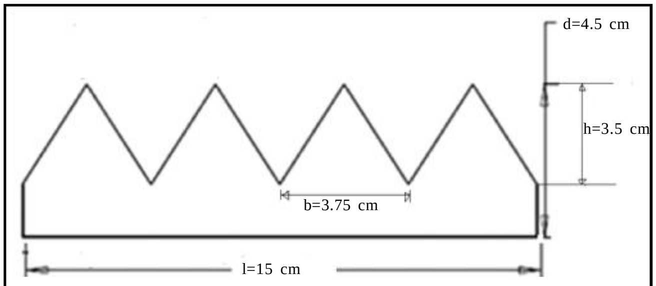

Fig. B : Dimensions of serrated blade

Description of developed paddy weeder:

The developed paddy weeder consists of engine, gear box, propeller shaft, rotor with blade and main frame and float. A petrol engine of 1.75 hp @ 6500 rpm (make-Premier Hawk, 2 Stroke) selected as prime mover for the developed weeder. The reduction gear box (ratio-32.5:1) was used to reduce the speed to 200 rpm. The same speed was given to rotor of the machine. The rotor

Table A : Technical specifications of the developed paddy weeder

Sr. No.	Descriptions	Values / specifications
1.	Engine	Premier Hawk, 2 Stroke
2.	Power	1.75 hp @ 6500 rpm
3.	Fuel	Petrol
4.	Dimensions, mm	1300 × 700 × 1000
5.	Gear Box	Oil lubricated, worm
6.	Speed ratio	(32.5:1)
7.	Blades	L-shape blade, serrated blade
8	No. of blade rotor	2
	With L shape blade	4 blades
	With Serrated blade	6 blades
9.	Types of blade	
	L shape blade	Weeding width 150 mm
	Serrated blade	Weeding width 150 mm
10.	Float Size, mm	840 × 140 × 70
11.	Mudguard	
	Shape	C shape (semi-circular)
	Size	Length - 370 mm
		Width – 180 mm
12.	Shaft	Length- 500 mm

has two blades viz. L shape and Hexagonal serrated blade. The bottom of the weeder was provided with the float. Total working width of the weeder was 300 mm having rotor shaft of length of 500 mm. Total 4 blades were provided with rotor having L shape blade. To avoid throwing of mud and stones towards operator a mud flap is provided covering the upper and rear side of the blades of the rotary cutting units. Total 6 serrated blades were provided for the hexagonal rotor. The specifications of developed power weeder for paddy in Konkan region is as given in Table A. The performance of the developed weeder for the both the blades was studied independently.

Field Performance of paddy weeder:

The performance of developed paddy weeder was measured in terms of weeding efficiency, plant damage, field capacity, field efficiency, fuel consumption (Fig. C).

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.

$$\text{Wedding efficiency (\%)} = \frac{W_1 - W_2}{W_1} \quad ..(13)$$

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.

Plant damage:

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

$$\text{Plant damage (\%)} = 1 - \frac{q}{p} \quad ..(14)$$

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.

Effective field capacity:

Field capacity ($ha.h^{-1}$) was computed by recording the area weeded during each trial run in a given time interval. With the help of stopwatch, time was recorded for respective trial run along with area covered.

Theoretical field efficiency:

Theoretical field capacity of the machine is the rate of field coverage that would be obtained if the machine was performing its function 100 per cent of the time at the rated forward speed and always covered 100 per cent of its rated width.

Fig. C : Field testing of developed paddy weeder in paddy field

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.

$$\text{Field efficiency (\%)} = \frac{\text{Effective field capacity}\left(\frac{ha}{h}\right)}{\text{Theoretical field capacity}\left(\frac{ha}{h}\right)} \times 100 \quad ..(15)$$

Fuel consumption:

The fuel consumption has direct effect the economics of the power weeder. It was measured by top fill method. It was expressed in liter per hour.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Comparative performance of developed paddy weeder with different blade:

The developed weeder with L shape and serrated blade was operated for weeding in paddy field under low land condition. The weeding operation was performed

Table 1 : Field performance of developed paddy weeder with different blade at different time

Sr. No.	Particulars	Serrated blade			L- Shape Blade		
		20DAT	30DAT	40DAT	20DAT	30DAT	40DAT
1.	Weeding efficiency, %	82.11	84.74	87.37	77.25	77.11	79.85
2.	Plant damage, %	0.98	1.64	2.33	0.97	1.61	1.85
3.	Field capacity, ha/hr	0.0189	0.0197	0.0213	0.0237	0.0265	0.0266
4.	Field efficiency, %	75.72	80.11	81.06	78.37	83.07	84.82
5.	Fuel consumption, lit/hr	0.680	0.655	0.646	0.586	0.581	0.576

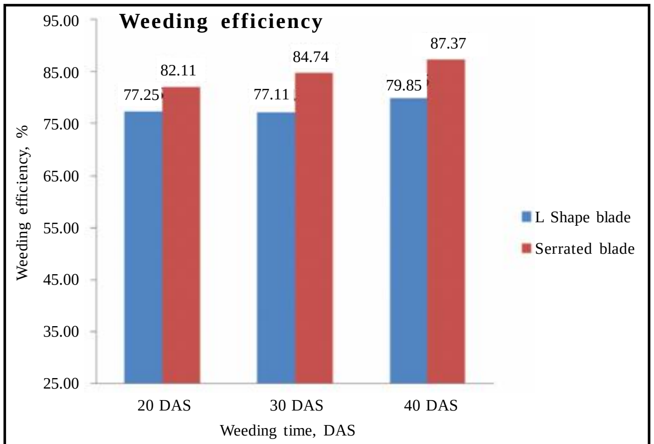

Fig. 1 : Weeding efficiency of power weeder using different blades at different weeding time

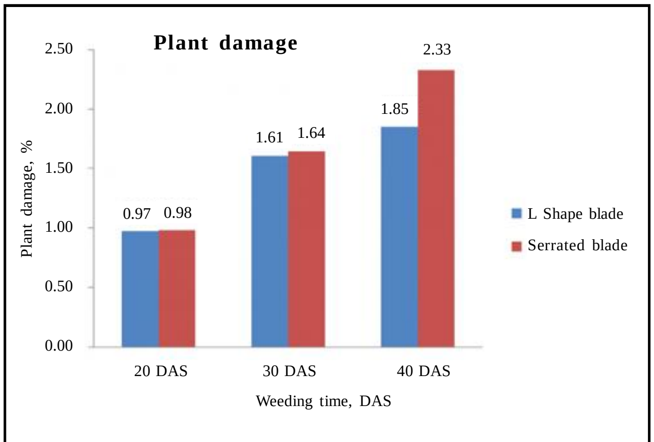

Fig. 2 : Plant damage by power weeder using different blades at different weeding time

at 20 DAT, 30 DAT and 40 DAT after transplanting. The comparative performance of the weeder with different blades is explained through (Fig. 1-2).

Conclusion:

The weeding efficiency were found with serrated blade 87.37 per cent whereas L shape blade has given weeding efficiency as 79.85 per cent at 40 DAT. The serrated blade has resulted into 9.41 per cent higher weeding efficiency than L shape blade. The minimum plant damage were found with L shape blade 0.97 per cent at 20 DAT whereas serrated shape blade has given minimum plant damage as 0.98 per cent at 20 DAT. The L shape blade resulted in to 1.02 per cent minimum plant damage than serrated blade. The maximum field capacity were found with L shape blade (0.0266 ha/h) than serrated blade (0.0204 ha/h) at 40 DAT which was 30.39% higher. The minimum fuel consumption of 0.576 lit/hr found with L shape blade at 40 DAT whereas serrated blade has given minimum fuel consumption as 0.646 lit/hr at 40 DAT which is 10.83 per cent less over serrated blades. For weeding point of view the weeder with serrated blade performed better in field.

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■ REFERENCES

Anonymous (2015). Director of Agriculture Pune, rice production, rice productivity of India.2014-2015.

Basavaraj, Surendrakumar A. and Divaker Durairaj C. (2016). Study of agronomical and soil parameters in paddy field for development of paddy weeder *Internat. J. Agric. Sci.*, **8** (30): 1627-1631.

Bernacki, H., Haman, J. and Kanafojski, Cz. (1972). *Text book of Agricultural machines, theory and construction. Vol. I*, Scientific publication, Central Institute of Scientific,Technical and Economic Information, Warsaw, Poland.pp. 426- 428.

Gite, L.P. and Yadav, B.G. (1985). Ergonomic consideration in the design of mechanical weeders. Proceedings on Design Course of Agricultural machines Central Institute of Agricultural Engineering, Bhopal, India.

Gite, L.P. and Yadav, B.G. (1990). Optimum handle height for a push pull type manually operated dry land weeder, Ergonomics, 33.

Kepner, R. A., Bainer, R. and Barger, E. L. (1978). *Text book of Principles of farm machinery, 3rd edition,* AVI Publication Co., INC., Westport, Connecticut.

Khodabakhshi, A., Kalantari, D and Mousavi, S.R. (2013). Effects of design parameters of rotary tillers on unevenness of the bottom of the furrows. *Internat. J. Agron. & Plant Production,* **4**(5):1060-1065.

Mott, R. (1985). Machine elements in mechanical design. Merill Publishing Company, Columbus, Ohio.

Nag, P.K. and Dutt, P. (1979). Effectives of some simple agricultural weeders with reference to physiological responses. *J. Human Ergonomics,* **8** :13-21.

Nganilwa, Z.M., Makungu, P.J. and Mpanduji, S.M. (2003). Development and Assessment of an Engine Powered Hand Held Weeder in Tanzania. International Conference on Industrial Design Engineering, UDSM, Dares Salam.

Ratnaweera, A.C., Rajapakse, N.N., Ranasinghe, C.J., Thennakoon, T.M.S., Kumara, R.S., Balasooriya, C.P. and Bandara, M.A. (2010). Design of power weeder for low land rice cultivation. International conference on sustainable built environment (ICSBE), Kandy, 13- 14, December, 2010. pp. 468-475.

Sahay, Jagdishwar (2010). *Text book of Element of Agricultural Engineering. 4th Edition* A. K. Jain standard publications distributors New Delhi. pp 80.

Sharma, D.N. and Mukesh, S. (2010). *Text book of Farm Machinery Design, Principles and Problems, 2nd Edition. pp 15.*

Shirsat, N. A., Chavan, S.S., Aware, V.V., Shahare, P.U., Dhande, K.G. and Aware, Seema V. (2016). Cono weeder: An economic hand tool for women labour in paddy field. *Agric. Update,* **11** (2) : 154-157.

Tayade, N.H. (2016). Performance evaluation of Ambika paddy weeder for paddy in farmer's field. *J. Crop & Weed,* **12**(3): 178-179.

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