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Development and Evaluation of Weeding Cum Earthing up Equipment for Cotton

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Abstract

The arduous operation of weeding is usually performed manually with the use of traditional hand tools in upright bending posture, inducing back pain for majority of the weeder-laborers. This situation necessitates the introduction of a suitable machine for weeding operations. The unit developed consists of an inter-cultivator-cum earthing up equipment fitted to a standard tractor-drawn ridger. Three sweep type blades of 45 cm width are affixed to the ridger frame with 120° approach angle and 15° lift angle for accomplishing the weeding operation in between standing rows of crops. Three ridger bottoms, which were fitted behind the sweep blade, work on the loosened soil mass and aid in earthing up by forming ridges and furrows. The unit was evaluated for its performance with the available weeders and the conventional method of weeding. Manual weeding using hand hoe registered the maximum efficiency of 82.56% (wet basis) and 82.4% (dry basis). The weeding efficiency of the tractor-drawn weeding-cum earthing up implement was 60.24 (wet basis) and 61.62 (dry basis). The savings in cost of weeding operation with bullock drawn junior hoe, self-propelled power weeder and tractor-drawn weeding-cum earthing up implement when compared to the manual weeding were 78.7, 79.8 and 68.7 per cent respectively. The savings in time of weeding operation using the with bullock-drawn junior hoe, self-propelled power weeder and tractor-drawn weeding-cum earthing up implement when compared to the manual weeding was 96.5, 96.6 and 98.9 per cent, respectively.

Introduction

Crop intensification, timeliness in farm operations and efficient use of production resources will be critical inputs in increasing the productivity of agriculture sector. A decrease in the availability of farm labor is a direct consequence of migration of farm laborers to the industrial sector due to development of the market economy and rural industries. One-third of the cost of cultivation is spent on weeding alone when carried out with manual labour. The arduous operation of weeding is usually performed manually with the use of traditional hand tools in upright bending posture, inducing back pain for majority of the laborers. This situation necessitates the introduction of a suitable machine for weeding operations in cotton production.

Review of Literature

The yield of cotton was reduced by 41.46% when the weeds were allowed to grow unchecked. The treatments of weeding alone, interculture and weeding together however, did not differ significantly. In the row crops of the cotton crop after the 50^{th} day of sowing without or with application of weedicide, the bullock-drawn junior hoe is used for inter-cultivation. After 2 or 3 inter-cultivations using the junior hoe, urea or nitrogen application was done to the crop with the help

Table 1. Comparative Performance of Weeders

Name of the weeder	Weeding efficiency (%)	Plant damage (%)	Man-hrs/ ha	Cost of weeding Rs./ha
Blade harrow	76.8	12.16	6.63	15.15
Three tyne cultivator	67.4	9.7	6.94	17.35

Table 2. Specification of Weeding Cum Earthing up Implement

Particulars	Value
Over all dimensions (L x B x W), mm	2100 x 630 x 1500
Weight, kg	242
Number of rows	3
Number of weeding blades	3
Number of ridger bottoms	3
Shape of the weeding blade	V shaped sweep bottom
Width of sweep blade, mm	450
Approach angle, deg	120
Lift angle	15
Row spacing, cm	Adjustable(60,75,90 cm)
Source of power	35-45 hp tractor
Depth of operation, cm	15

Fig.1 Tractor drawn weeding cum earthing up implement.

of a ridger. The bullock-drawn blade harrow gave better performance when compared to the bullock-drawn three-tyne cultivator as seen from **Table 1**. The tractor-drawn high clearance cultivator using full and a half sweeps has given good results. The bullock-drawn lister plough may be used during the later stages of plant growth (Bahl *et al.* 1988).

The ridger should be used between the rows for inter-row cultivation and for collecting soil around the crop rows. The tractor-drawn, high-clearance cultivators using full and one-half sweeps has given good results. The bullock-drawn lister plough may be used at later stages of plant growth. The ridger may be used between the rows for inter-row cultivation and for collecting the soil around the crop rows.

Materials and Methods

Development of Tractor-drawn Weeding-cum Earthing up Equipment

The unit developed consisted of an inter-cultivator-cum earthing up equipment fitted to a standard tractor-drawn ridger. Three sweep type blades of 45 cm width were affixed to the ridger frame with 120° approach angle and 15° lift angle for accomplishing the weeding operation in between standing rows of cotton crop. The operational view of the unit in between the rows of cotton crop as shown in **Fig. 1**. Three ridger bottoms which were fitted behind the sweep blade, work on the loosened soil mass and aid in earthing up by forming ridges and furrows. The specifications of the unit are shown in **Table 2**.

The salient features of the unit are: the weeding and earthing up operations were simultaneously performed in a single pass; row to row distance between the sweep blades and the ridger bottoms which were adjustable (60, 75 and 90 cm); the cost of the unit was Rs.12,000; and the capacity was 1.6 ha per day.

Existing Models of Weeders for Cotton Crop

The available models of weeders which can be used for weeding in a cotton crop were:

Self-propelled power weeder (TNAU model) and b. Bullock-drawn junior hoe the descriptions of which follow:

The description of the above mentioned implements and their specification are furnished below.

Self-propelled Power Weeder (TNAU model)

The weeder was operated by a 3-hp petrol start kerosene-run engine. The engine power was transmitted to the ground wheels through a V belt-pulley and sprocket - chain mechanism. At the back of the machine was a fixed replaceable sweep blade (**Fig. 2**). Sweep blades of different widths can be fitted to the machine depending on the row-to-row spacing of the crop. A tail wheel was provided at the rear to maintain the operating depth. The sweep blade could be raised or lowered so as to have the desired operating depth. A rotary weeding attachment to the power weeder was developed. The rotary tiller consisted of three rows of discs mounted with 6 curved blades in opposite directions alternatively in each disc. These blades when rotating enabled cutting off and applying mulch to the soil. The width of coverage of the rotary tiller was 350 mm and the depth of operation could be adjusted to weed and apply mulch to the soil in the cropped field. In addition to the rotary tiller and sweep type blades, the ridger or cultivator could be fitted to the unit, in the place of rotary tiller easily by the operator of the weeder. The cost of the machine was Rs. 53,000 (Rs. 35,000/- excluding the prime mover). The capacity was 0.75 ha per day. The salient features of the unit are; useful for weeding between rows of crops like tapioca, cotton, sugarcane, maize, tomato and pulses whose rows spacing is

Fig.2 Self propelled power weeder.

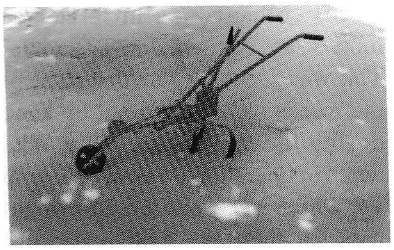


Fig.3 Bullock drawn junior hoe.

more than 45 cm. The specifications of the power weeder are shown in **Table 3**.

Bullock-drawn junior hoe

This intercultural implement is used primarily for weeding in between the rows of standing crops. It consists of reversible shovels with curved tynes attached to framework with hinge arrangement. A handle and beam are fixed to the framework for guiding and attaching the unit to the yoke (**Fig. 3**). The spacing between the shovel could be adjusted according to the row spacing of the crop. The cost of the unit was Rs.1500.

Conventional Method of Weeding

In the conventional method of weeding a cotton crop the operation is performed by women laborers using a hand hoe (**Fig. 4**). The hand hoe consists of a triangular shaped mild steel-weeding blade of 75 mm width that is attached to a short wooden handle of 450 mm long. The weeding operation is carried out in an upright bending posture.

Table 3. Specification of Power Weeder (TNAU model)

Particulars	Value
Over all dimensions (L x B x H), mm	2400 x 1750 x 1100
Weight, kg	300
Source of Power	3.5hp petrol start kerosene engine
Number of blades	Sweep blade-1; Shovel-5
Nominal working width, mm	2250 (Adjustable depending on row spacing)
Depth of operation, mm	30 (adjustable)

Treatments Selected for the investigation

The treatments selected for the investigation were:

T_1-Operation with junior hoe

T_2-Operation with self-propelled power weeder (TNAU model)

T_3-Operation with tractor-drawn inter-cultivator

T_4-Control(Manual using hand hoe)

The developed tractor-drawn weeding-cum earthing up implement was evaluated for its performance in terms of weeding efficiency (wet and dry bases), depth of operation and per cent breakage of the cotton plant. The moisture content of the soil during evaluation was 14.48 per cent on dry basis.

Weeding Efficiency and Per Cent Breakage

The weeding efficiency (wet basis) was computed by using the following expression:

$$\eta_{ww}\ \% = \frac{Wr}{Wr + Wu} \times 100$$

Where,

η_{ww}-Weeding efficiency (wet basis), per cent

Wr-Wet weight of weeds removed by the implement/m^2

Wu -Weight of weeds left in the field after the weeding operation/m^2

The weeding efficiency (dry basis) was computed by using the following expression:

Where,

$$\eta_{wd}\ \% = \frac{Wr}{Wr + Wu} \times 100$$

η_{wd}-Weeding efficiency (dry basis), per cent

Wr-Weight of oven dried weeds removed by the implement/m^2

Wu-Weight of oven dried weeds left in the field after the weeding/m^2

The percent breakage of cotton stalks was computed by using the following expression:

$$\eta_{b},\ \% = \frac{P_b}{P_t} \times 100$$

Where,

P_b-Number of plants broken in the row

P_t - Total number of plants in the row

The cost of weeding using the tractor-drawn weeding-cum earthing up implement was compared with the weeding using the power weeder, junior hoe and manual method of weeding. The cost and time saved by the tractor-drawn weeding cum earthing up implement against other methods were compared.

Results and Discussion

During the field trials, it was observed that the power weeder (TNAU model) could not be operated in between the standing rows of cotton crop. One of the ground wheels had to be necessarily run on the ridge, resulting in overturning of the unit. As a result the plant was damaged. Hence the power weeder was used in the plot sown by pneumatic planter and cultivator seeder where there was no ridge between the rows of cotton crop and the performance was com-

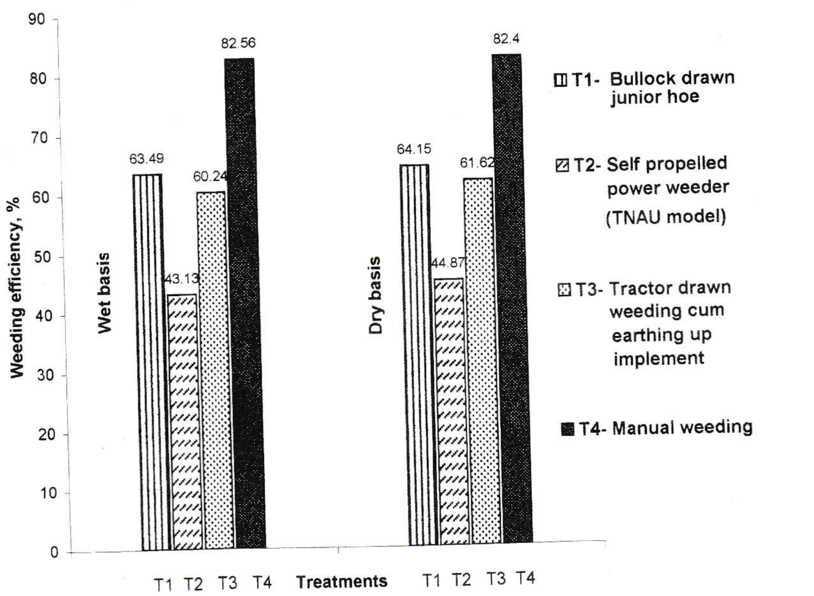


Fig.4 Efficiency of weeders evaluated in cotton crop.

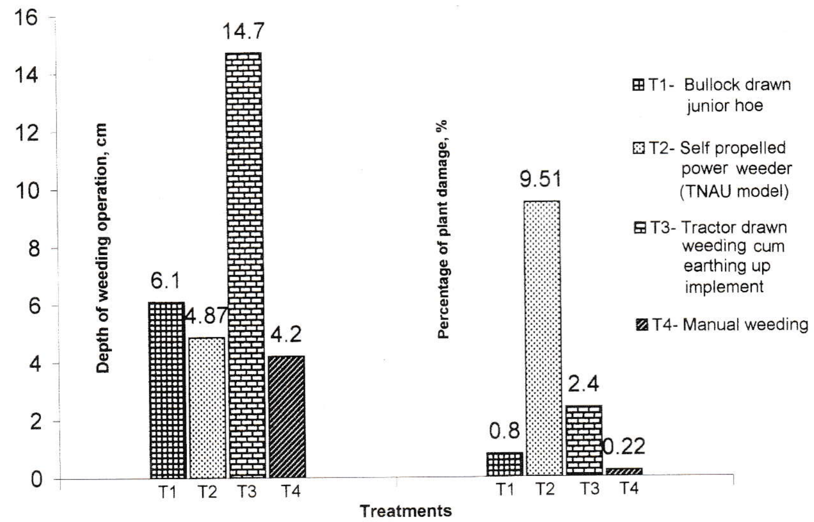


Fig.5 Depth of operation of weeders and percentage of plant damage in cotton fielg.

pared.

The performance evaluation of the weeders in the cotton crop is shown in **Table 4**. It is noticed that the weight of the weeds collected in the treatment T_3 was maximum when compared with those T_1, T_2 and T_4. The high weight of weeds collected was due to the complete up rooting of the weeds with roots by the tractor-drawn weeding-cum earthing up implement.

The weeding efficiency for all the selected treatments is shown in **Fig. 5**. It is observed that there was no significant variation between the weeding efficiency on wet basis and weeding efficiency on dry basis in all the treatments. Among the treatments, the T_4 registered the maximum efficiency of 82.56% (wet basis) and 82.4% (dry basis). The efficiency of T_1 and T_3 are comparable. T_2 had the lowest efficiency of 43.13% (wet basis) and 44.5% (dry basis) among the treatments.

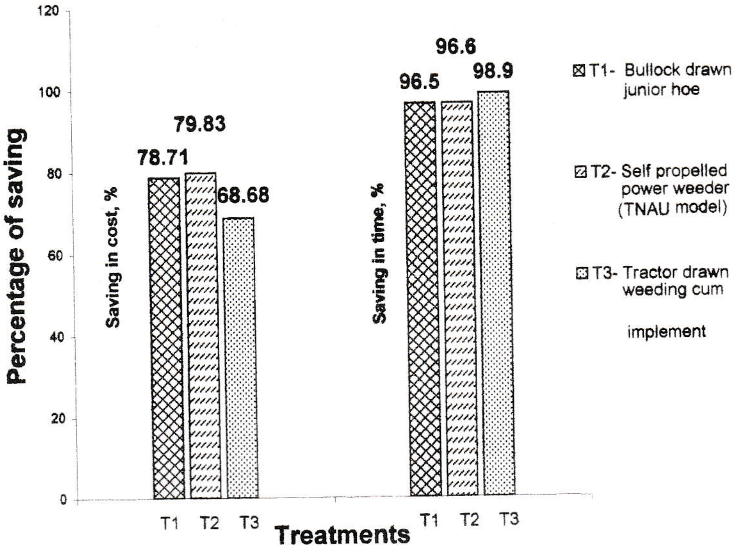
The depths of operation in weeding for all the treatments are shown in **Fig. 5**. It was inferred that the depth of operation was highest in T_3. Owing to this maximum depth of operation the weeds were completely uprooted and the weight of the weeds collected per unit area was also maximum in T_3 as seen from the observations recorded in **Table 4**.

The depth of operation was the minimum in T_4. But the weight of weeds collected per m^2 area was more when compared to T_1 and T_2. This was due to the fact that some of the weeds were pulled out by hand during the manual weeding. The depth of operation was low in T_1 and T_2, which necessitated additional passes in these two treatments.

The percentage of plant damaged in the trial field during the operation of the weeders is shown in **Fig. 6**. The percentage of plant damaged was greater in T_2 followed by T_3. This is due to the fact that the wheels and the blade caused damage to the plants while passing the irrigation channels and while turning of the weeder at headland. With sufficient head land and training in the operation of the units in between the rows of cotton crop the percent of plant damage can be minimized.

The results of the trial for weeding operation in cotton crop with the selected treatments are presented in **Table 5**.

The savings in cost and time of weeding operation using the bullock-drawn junior hoe, self-propelled power weeder and tractor-drawn weeding cum earthing up implement are shown in **Fig 6**. It is clearly reflected from the figure that all the treatments T_1, T_2 and T_3 were positive except T_4. Among the T_1, T_2 and T_3, T_2 recorded the highest percent saving in cost, followed by T_1 and T_3. The high initial cost of the tractor and weeding unit increased the cost of weeding operation in T_3 and hence the lowest. There was not much difference in savings in time among the treatments T_1, T_2 and T_3.



Fig, 6 Saving in cost and time when compared to conventional method.

Table 4. Results of the Performance Evaluation of the Weeder in Cotton Crop

Particulars	T_1	T_2	T_3	T_4
Wet weight of weeds collected after weeding operation, gm/m^2	139.3	160.0	324.9	429.9
Wet weight of weeds left in the field after weeding operation, gm/m^2	80.09	211.02	214.4	91.02
Total wet weight of weeds , gm/m^2	219.39	371.02	539.4	520.9
Weeding efficiency, %	63.49	43.13	60.24	82.56
Dry weight of weeds collected after weeding operation, gm/m^2	72.12	68.15	148.7	245.4
Dry weight of weeds left in the field after weeding operation, gm/m^2	40.31	83.73	91.99	51.86
Total dry weight of weeds , gm/m^2	112.3	151.88	240.7	297.2
Weeding efficiency, %	64.15	44.87	61.62	82.40
No. of plants for 30 m long	162.6	150	167	155.3
No. of damaged plants	1.33	14	4	0.33
Percentage of damage	0.80	9.51	2.40	0.22
Depth of operation, cm	6.1	4.87	14.7	-

Table 5. Results of the Evaluation Trail for Weeding Operation in Cotton Crop

particulars	T_1	T_2	T_3	T_4
Width of operation,m	0.45	0.75	2.25	-
Length of the field,m	46	46	46.0	-
Time taken to travel,sec	65.6	60.54	100.3	-
Forward speed of operation,kph	2.53	2.75	1.66	-
Theoretical field capacity,ha/hr	0.114	0.207	0.373	-
size of the field,m^2			46x11.5=1890m^2	-
Time taken, in 1st pass, min	27.9	29.7	16.0	-
Time taken, in 2nd pass, min	27.0	24.6	-	-
Total time taken, min	54.9	51.4	16.0	450 women hrs/ha
Actual field capacity, ha/hr	0.058	0.06	0.198	-
Field efficiency, %	50.9	50.0	52.6	-
Cost of operation, Rs/hr	50	55	250	9.0
Cost of weeding, Rs/ha	862.07	887.1	1268.63	4050.00
Saving in cost when compared to conventional method, %	78.71	79.3	68.68	-
Saving in time when compared to conventional method, %	96.5	96.6	98.9	-

Conclusions

Based on the analysis of the results the following conclusions are drawn:

1. An inter-cultivator cum-earthing up implement fitted to a standard-tractor drawn ridger was developed.
2. The developed unit was evaluated for its performance in comparison with the existing models of weeders and conventional method of weeding.
3. Manual weeding using the hand hoe registered the maximum efficiency of 82.56% (wet basis) and 82.4% (dry basis). The weeding efficiency of the tractor-drawn weeding-cum earthing up implement was 60.24 (wet basis) and 61.62 (dry basis).
4. The savings in cost for weeding operation using the bullock-drawn junior hoe, self-propelled power weeder and tractor-drawn weeding-cum earthing up implement when compared to manual weeding was 78.7, 79.8 and 68.7 per cent, respectively.
5. The savings in time for weeding operation using the bullock-drawn junior hoe, self-propelled power weeder and tractor-drawn weeding-cum earthing up implement when compared to manual weeding was 96.5, 96.6 and 98.9 per cent, respectively.

REFERENCES

Bahl, V.P., M.K. Garg, and M.L. Jain, Role of improved farm machinery in increasing cotton productivity. J Agric., Engg. ISAE, 20(4): 9-10.

Bahl, V.P., D.N. Sharma, and M.L. Jain, 1988. Cotton Cultivation in Haryana State, India. Agricultural Mechanization in Asia, Africa and Latin America, Japan, 19(4) : 63-67.

Design Parameters for Cocoa Pod Breaker

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Abstract

This work centered on the fracture characteristics of whole cocoa pods under dynamic loading that are relevant to the development of machinery for primary processing. The moisture content and some physical properties of cocoa bean were determined. The impact and uni-axial compression tests were carried out on F_3 Amazon (hybrid) whole cocoa pods in lateral and longitudinal axes.

The mean values of the minimum impact load and rupture energy were 2.27kN and 5.14kJ for loading in the lateral axis, and 2.42kN and 8.01kJ in the longitudinal axis. The mean values of maximum compression rupture load and toughness are 1.38kN and 5.44J for compression in the lateral axis and 1.95kN and 24.23 J in the longitudinal axis. The average stiffness modulus was 124.5kN/m.

The average moisture content of the fresh cocoa pods used was 77.9% wet basis, with an average length and diameter of 15.37cm and 7.60cm, respectively. The average thickness at the furrow was 0.92cm and ridge, 1.22cm.

Introduction

Cocoa (Theobroma cacao L) is strictly a tropical tree crop which is cultivated in the tropical forests of West Africa, Latin America and South East Asia (Opeke, 1987). In Nigeria, it is commonly grown in the western part of the country especially in Osun and Ondo States. Processed cocoa beans are used in the manufacture of chocolate-based products and cocoa butter. The residual cocoa powder is used in cakes, biscuits, cocoa food, soft drinks, ice-cream, baking, and other confectioneries such as bournvita, cacao, pronto etc. The dry pod husk can be utilized as a livestock feed constituent (Adeyanju et. al., 1975a, Opeke, 1987; Atuahene et. al. 1984). Locally, crude spirit known as illicit liquor can be made from its liquid.

The economic importance of cocoa notwithstanding, its processing has been restricted to manual operations. Breaking of the cocoa pod has been one of the most difficult tasks during its processing. There is, therefore, need to consider ways of breaking the pods mechanically.

In view of this, a detailed knowledge of mechanical characteristics of cocoa pod will lead to the understanding of the characteristics of materials and general behavior under applied loads. A study of these properties is very fundamental in relation to research work on the design and development of machines for handling and processing of agricultural products. The structure of the pod is believed to be important in relation to the pod breaking behaviour (Maduako and Faborode, 1990). Therefore, it is necessary to first characterize the pods breaking behaviour by carrying out impact and compression tests (ASAE, 1990). This is with a view to reducing the pod into small particles. Faborode and Oladosu, (1991) observed that the reduction involved in pod breaking is not the same as for homogeneous materials.

Some of the mechanical properties affecting the breaking behaviour of agricultural materials are defined as hardness, toughness, elasticity or rigidity of the material (Sitkei, 1986).

There has been some work on mechanical pod breaker, though none of the machines is in the market today. Few examples of such machines are the Zinke breaker and cocoa pod processor.

Materials and Methods

Cocoa pods of a commercially grown variety of Nigerian cocoa, F_3 Amazon, were harvested from the Cocoa Research Institute of Nigeria (CRIN), Idi-Ayunre, Ibadan. The moisture content was determined using the oven method at 3, 24, 48, 72, 96, 120 hours after harvest.

The parameters for the physical characteristics were measured before the pods were subjected to tests for mechanical failure. The experimental tests on all cocoa pods were carried out within five days after harvest using only ripe healthy pods.

The length, diameter and thickness of (20) whole cocoa pods were measured using vernier calipers.

Ten whole cocoa pods of different sizes were used for the uni-axial compression tests in both lateral and longitudinal directions of the pod, using a tensiometer. By prop-