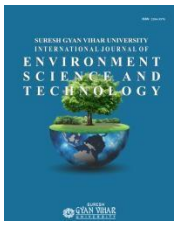

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*Research Article*:

# FIELD TESTING OF A MECHANICAL MEHANDI HARVESTER

**Amogh Sharma[1] and D. P. Darmora[2]**

[1]JRF, Vivekananda Global University, Jaipur, India

[2]Professor, Vivekananda Global University, Jaipur, India

**Keywords**

Harvesting,
Field Capacity,
Windrowing, Mechanical,
Operational Cost

**Abstract**

About 90 percent farmers of villages nearby Sojat (Pali district in Rajasthan) depend upon mehandi farming for their livelihood as its production cost is low and the farmers have no choice for growing other crops because of acute shortage of irrigation water. Timely harvesting of mehandi can generate good income to farmers however, non-availability of sufficient labors at peak harvesting season delays the harvesting operation resulting in deterioration in quality of mehandi leaves and hence a loss to the farmers. A mechanical mehandi harvester, having about 14 times higher field capacity (1.4 ha/day) than traditional harvesting tool sickle was thus developed and tested in farmers' field. The harvester equipped with a 35.8 cc petrol engine was found suitable for levelled mehandi fields. A more powerful engine of 47.9 cc was required for the undulated mehandi fields. A reduction of about 80% in harvesting cost was achieved with the use of the developed mechanical harvester. In addition, timely harvesting with mechanical harvester will also result in good quality of mehandi leaves, fetching a good price in the market.

## Introduction

Mehandi, an export oriented and rainfed dye crop is mainly grown in more than 40,000ha in Pali district of Rajasthan nearby Sojat area as its agro climatic condition is suitable for the crop. It has cosmetic as well as medicinal value. About 90% farmers of the area depend upon this crop for their livelihood as they have no choice for growing other crops because of acute shortage of irrigation water.

The cost of production of the crop is quite low. Once it is planted, it yields continuously for about 25 years and does not require any additional irrigation water, fertilizers and insecticides.

The good quality dried mehandi leaves fetch a good amount from the market. Foreign exchange is also generated from this crop. About 40% produce is exported every year to about 130 countries.

The only problem associated with its cultivation is difficulties in timely harvesting of the crop. Sufficient labours do not become available in peak harvesting season and due to non-availability of a mechanical harvester for mehandi, farmers are forced to engage labours for harvesting of the crop with traditional sickle, which is very slow (field capacity is only 0.1ha /day), very costly in peak harvesting season (labours cost is about Rs 800/day/ person) and cumbersome also. The planting is not done with proper care; hence the crops are strewn with a lot of non-required plants, which grow with the Mehandi [1]. Because of these constraints the farmers generally fail to harvest their crop within the total available harvesting time, which is nearly two weeks from attainment of the crop maturity for harvesting till start of deterioration of mehandi leaves. As a result, the leaves turn grey to black losing their quality and leading to a considerable reduction in its cost in the market.

## Design details of the developed mechanical harvester

A mechanical harvester of about 1.4 ha/day field capacity (14 times higher than that of a sickle) was thus developed under a DST(TDP) sponsored project in Department of Agriculture, Vivekananda Global University, Jaipur to address the harvesting problem associated with mehandi harvesting. This machine has the capability and the economic value for fulfilling the needs of farmers having small land holdings (less than 2 acres) [2]. It consisted of a petrol engine as prime mover, a rotary disc cutter assembly, a handle and a crop windrowing system mounted on a mild steel frame supported by two 20” pneumatic wheels. (Fig.1)

The petrol engine (4- Stroke; 35cc; 0.97 Kw at 7000 rpm) coupled with a rotary disc cutter assembly was mounted on the mild steel

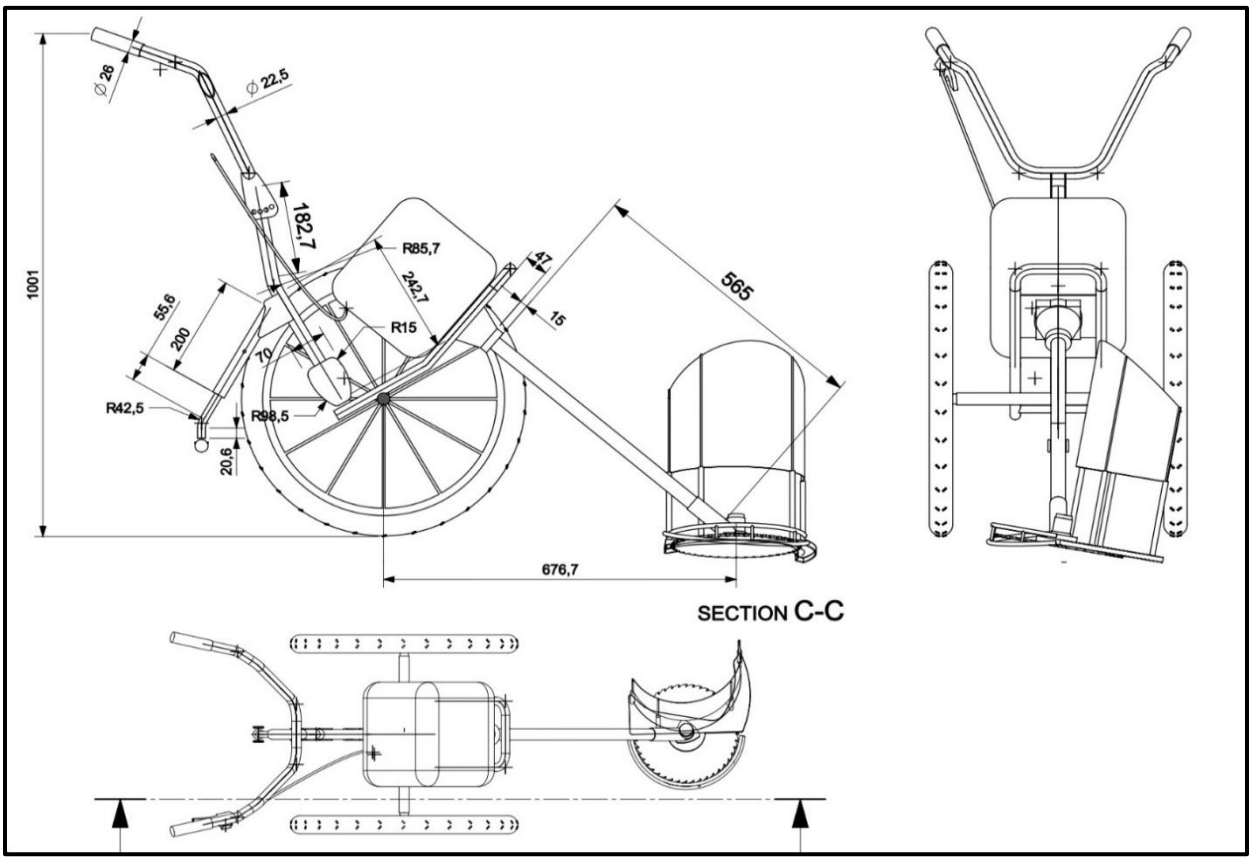


**Fig 1: 2-D View of harvester with 35.8cc Engine**

conduit pipe frame through a bush bearing to enable right to left movement of the cutter arm for cutting the crop of 3 rows in one stretch. The rotary disc cutter assembly consisted of a cutting arm coupled with the engine at its one end and rotary disc cutter of 10" diameter having 80 teeth at its other end. Rotary cutter blades are very sharp, can be sharpened, and are available in different sizes [3]. The crop windrowing system consisting of a 24-gauge G.I. crop guard (semicircular, 33 cm height and 13.5 cm radius of curvature) was fixed at the rotary disc cutter frame opposite to cutting edge. The frame was supported by two 20" pneumatic wheels provided for forward movement of the harvester. The ignition switch and throttle lever were provided at the handle.

The harvester was operated at an optimized engine speed of 4,500 rpm and cutting of crop of 3 rows at one stretch was done at an optimized cutting (rake) angle of 10° by moving the cutting arm right to left while moving forward with the help of the two ground wheels. The machine is a walk behind type of harvester which can be used for harvesting [4] mehandi.

**Preliminary field testing**

The developed mehandi harvester was initially tested in Karmawas maliyan village of Raipur Tehsil near Sojat (about 300km away from VGU campus) on 16th and 17th October, 2021 (Fig. 2). The village has 436 farmers family having a total mehandi cultivation area of 823 ha, the average land holding per family under mehandi cultivation being 1.88 ha. The average crop yield was reported to be 15-16 quintals dry leaves/ha.

The prevailing practice for mehandi harvesting in the village was with traditional sickle having following specifications: Approximate cost= Rs.100, Field Capacity= 0.013 ha/hr. = (0.1 ha/day); Labour requirement = 10-man days/ha (= 80-man hr./ha)

**Fig 2: Preliminary field testing**

**Agroclimatic condition of test field:** Soil class: Sandy loam (83.8 % sand), Average Rainfall: 49 cm; Soil Colour: Medium yellow to brown

**Test Fields and crop condition:**

The developed harvester was tested under two different field conditions (levelled and undulated) belonging to Shri Babu lal. (Table-1).

**Performance evaluation**

The working performance of the developed harvester was evaluated on the basis of following parameters:

- Labour requirement
- Ease of operation
- Effective field capacity
- Fuel consumption
- Windrowing quality

**Labour Requirement**

Only one person was required to complete the harvesting of test fields with the developed harvester. As windrowing of the cut crop was performed simultaneously with the help of crop guard, no separate labour was required to lay down the cut crop in the straight rows.

**Field Capacity**

Total time required to harvest the crop of both the fields was recorded separately. Time loss due to thick stem base obstacles, restarting of engine and engine speed adjustment as well as turning loss were also recorded.

**Table 1: Details of test field and crop condition**

| Field and crop condition | | Field No.1 (levelled) | | Field No. 2 (undulated) | |
|---|---|---|---|---|---|
| **Field** | Field Area | 8 m*5m=0.004 ha | | 80m*20m =0.16 ha | |
| | Field surface condition | Almost levelled (m.c = 6.3%) | | Undulated uneven surface (m.c =5.8%) | |
| | Transplantation Period | 1 Year Old (July, 2020) | | 18-Year-old | |
| | | **Mean Value** | **Standard Deviation** | **Mean Value** | **Standard Deviation** |
| **Crop** | Row to row distance (cm) | 45.2 | 1.8 | 30.8 | 9.1 |
| | Plant to plant distance (cm) | 29.7 | 1.5 | 26.1 | 13.9 |
| | Stem base zone diameter (cm) | 1.9 | 0.3 | 18.7 | 6.9 |
| | Plant height (cm) | 87.8 | 14.2 | 93.8 | 21.4 |

**Fuel consumption determination**

Fuel tank of the engine was filled completely before starting the harvesting operation. The fuel tank was again top-up after completing the harvesting in order to calculate the fuel consumption for harvesting.

**Windrowing quality**

Windrowing of cut crops in a row was achieved with the help of crop guard. In case of levelled field, the laying of cut crops on the ground surface was almost along a straight line however, similar pattern was not observed in case of undulated field condition. Laying of about 30-35 % plants was observed deviated from the straight row as it was difficult to perform the harvesting operations (moving the cutter arm right to left) and to move the harvester forward simultaneously under undulated field condition. The field test results revealed the following:

(i) The harvester performed satisfactory in case of levelled field however in case of old transplanted fields, row to row as well as plant to plant distance got disturbed over the 15- 20 years' time span and the irregular thick stem growth at base created problem in crop cutting as well as movement of the harvester. It not only resulted in lowering down of the speed and the field capacity of the harvester but windrowing quality of cut crops also deteriorated under undulated field condition.

(ii) Difficulty was observed in cutting of plants from 3 rows and forward movement of the harvester simultaneously because of undulated fields resulting due to 18 -20 years old transplantation.

**Table 2: Determination of field Capacity**

| S.No. | Observations | Field-1(levelled) | Field-2 (undulated) |
|---|---|---|---|
| 1. | Area of test field | 8m*5m = 0.004 ha | 80m*20m = 0.16 ha |
| 2. | Total time required to complete harvesting | 1.5 min (0.025hr) | 65 Min (1.08 hr.) |
| 3. | Total time loss due to interruptions | 0.83 min (0.138 hr.) | 12 min (0.2hr) |
| 4. | Theoretical time required to complete harvesting | 1.17 min (0.0195 hr.) | 53 min (0.88 hr.) |
| 5. | Theoretical field capacity | 1.64 ha/day | 1.45ha/day |
| 6. | Effective field capacity | 1.28 ha/day | 1.19ha/day |

**Modifications required for working of the harvester under undulated uneven field conditions.**

Following modifications was thus planned to be incorporated in the design of the developed harvester to overcome above difficulties.

(i) To use a more powerful engine Honda GX 50 having 47.9 cc displacement in place of Green Leaf GX 35 petrol engine having 35.8 cc displacement to meet the higher power requirement under old transplanted field conditions.

(ii) To use a longer cutter arm fixed on a bigger frame made of mild steel conduit pipes through a bush bearing to enable easy cutting of 3 rows by moving the cutter arm right to left with the help of handles.

(iii) To provide a clutch assembly to prevent transverse movement of ground wheel while harvesting the crop by moving the cutter arm left to right to cut the crop of three rows.

A bigger size mechanical harvester was thus developed (Fig 3) after the modifications incorporated in above design to cope up with difficulties associated with the mehandi harvesting in old transplanted fields, where field is undulated and where row to row distance is not uniform due to irregular stem base development.

**Field testing of the modified mehandi harvester suitable for old transplanted undulated field condition:**

The modified mechanical harvester equipped with a 47.9 cc, 4-stroke petrol engine GX50 engine (1.47 kw at 7000 rpm), a 152.4 cm

**Table 3: Determination of fuel consumption**

| S. No. | Particulars | Field -1 (leveled) (0.004 ha area) | Field- 2 (undulated) (0.16 ha area) |
|---|---|---|---|
| 1. | Total fuel required to fill the tank completely | 0.500 lit | 0.500 lit |
| 2. | Fuel required to top up the tank after completing harvesting | 0.015 lit | 0.650 lit |
| 3. | Total fuel consumed | 0.015 lit | 0.650 lit |
| 4. | Specific fuel consumption | 3.75 lit/ha | 4.06 lit/ha |

long cutter arm and a clutch assembly to control the steering action of the ground wheel while cutter shaft moves right to left for cutting the crop of 3 rows at one stretch

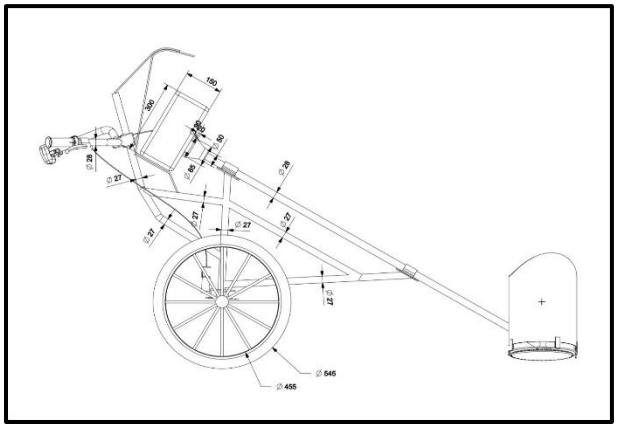

**Fig 3: 2-D View of harvester with 47.9 cc Engine**

was tested in two villages Bagawas and Sojat village area in Pali district of Rajasthan on 23rd & 24th May, 2022 respectively (Fig 4)**.**

**Fig 4: Field testing of modified harvester**

**Test Field and crop conditions**

The modified harvester was tested under undulated field condition in two old transplanted fields belonging to Shri Tara Chand Choudhary of village Bagawas and Shri Bhagwan Singh Charan of Sojat Village.

**Performance evaluation of the modified harvester under undulated field condition**

It was done on the basis of labour requirement, ease of operation, effective field capacity, fuel consumption and windrowing quality.

**Labour requirement**

Only one person was required to complete the harvesting of test fields with the harvester developed for the undulated field condition. As windrowing of the cut crops was performed simultaneously with the help of crop guard, no separate labour was required to lay down the cut crop in the straight rows.

**Ease of operation**

Provision of clutch assembly at ground wheels enabled simultaneous harvesting operation as well as forward motion of the harvester. The engine also did not stop due to obstacles caused by the plant stem base.

**Field Capacity**

Total time required to harvest the crop of both the fields was recorded separately. Time loss because of interruptions like stopping of engine due to thick stem base obstacles, re-starting of engine and engine speed adjustment as well as turning loss were also recorded. Average effective field capacity = 1.39 ha/ day.

**Fuel consumption**

Fuel required to top up the fuel tank at the completion of harvesting was taken as fuel consumed in harvesting. Average specific fuel consumption = 3.78 lit/ ha.

**Table 4: Details of Test fields and crop condition**

| **Field and crop condition** | | **Field No.1 (levelled)** | | **Field No. 2 (undulated)** | |
|---|---|---|---|---|---|
| **Field** | Field Area | 50 m*32m=0.16 ha | | 45m*71m =0.32 ha | |
| | Field surface condition | Undulated uneven surface | | Undulated uneven surface | |
| | Transplantation Period | 18-Year-Old | | 14-Year-old | |
| | | **Mean Value** | **Standard Deviation** | **Mean Value** | **Standard Deviation** |
| **Crop** | Row to row distance (cm) | 43.8 | 8.7 | 44.2 | 6.9 |
| | Plant to plant distance (cm) | 27.3 | 12.6 | 29.5 | 4.8 |
| | Stem base zone diameter (cm) | 17.9 | 5.7 | 13.6 | 3.2 |
| | Plant height (cm) | 71.0 | 8.0 | 74.0 | 5.0 |

**Table 5: Determination of field capacity**

| S.No. | Observations | Field-1(Bagawas) | Field-2(Sojat Village) |
|---|---|---|---|
| 1. | Area of test field | 50m*32m = 0.16 ha | 45m*71m = 0.32 ha |
| 2. | Total time required to complete harvesting | 56 min (0.93hr) | 110 Min (1.83hr) |
| 3. | Total time loss due to interruptions | 4.5 min (0.075hr) | 3.8 min (0.063hr) |
| 4. | Theoretical time required to complete harvesting | 51.1 min (0.86hr) | 106.2 min (1.77hr) |
| 5. | Theoretical field capacity | 1.49 ha/day | 1.45ha/day |
| 6. | Effective field capacity | 1.38 ha/day | 1.40ha/day |

**Windrowing quality**

Laying down of cut crops was observed in rows. Only few cut plants (7-8%) were observed deviated from the straight rows.

**Cost benefit (C- B) analysis**

**(a) cost of manual harvesting with sickle:**

Assuming a field capacity of sickle as 0.1 ha/day = 10-man days/ ha), daily labour wages as Rs. 500, the cost of harvesting will be = Rs. 5000/ha

**(b) Cost of harvesting with mechanical harvester equipped with a 25.8 cc engine, suitable for levelled field:**

Assuming a field capacity of 1.28 ha/ day (Table 2), cost of harvester as Rs. 16,000, life of harvester as 10 years, operation time as 26 days/ year (= 208 hr/yr), fuel consumption of engine as 3.75 lit/ ha (Table 3) and cost of petrol as Rs. 100/lit, the time required to harvest mehandi in 1 ha field = $\frac{8}{1.28}$ = 6.25hr.

(i) Annual depreciation = $\frac{16000}{10}$ = Rs.1600.

(ii) Annual fuel cost = $\frac{3.75*208}{6.25}$ @ Rs.100 = Rs. 12,480

(iii) Annual lubricating and maintenance cost (say one third of fuel cost) = Rs. 4,160

(iv) Annual operator cost @ Rs. 500/day for 26 days = Rs. 13000.

Total annual cost = Rs. 31,240 (or $\frac{31240}{26*8}$ = Rs. 150.19 hourly cost)

Operational cost of harvesting per ha = 150.19 * 6.25 = Rs. 938.7/ ha

Saving due to mechanical harvesting = $\frac{5000-940}{5000}$ = 81.2%

**Cost of harvesting with mechanical harvester equipped with a 47.9 cc Honda petrol engine, suitable for undulated field.**

Assuming a field capacity of 1.39 ha/ day (Table 5), cost of harvester as Rs. 32,000, fuel consumption of engine as 3.78 lit/ ha (Table 6) and cost of petrol as Rs. 100/lit, the time required to harvest mehandi in 1 ha field $= \frac{8}{1.39} = 5.76$hr.

(i) Annual depreciation $= \frac{32000}{10} =$ Rs. 3200.

(ii) Annual fuel cost $= \frac{3.78*208}{5.76}$ @ Rs.100 = Rs. 13,650

(iii) Annual lubricating and maintenance cost (say one third of fuel cost) = Rs. 4,550

(iv) Annual operator cost @ Rs. 500/day for 26 days = Rs. 13000.

Total annual cost = Rs. 34,400 (or $\frac{34400}{26*8} =$ Rs. 165.4 hourly cost)

Operational cost of harvesting per ha = 165.4 * 5.76 = Rs. 952.6/ ha

Saving due to mechanical harvesting = $\frac{5000-953}{5000} = 80.1\%$

In addition, timely sowing with mechanical harvester will result in good quality mehandi leaves, fetching a good price in the market. This machine is made of locally sourced materials which is easy to maintain or repair and also cost effective [5].

**Table 6: Determination of fuel consumption**

| S. No. | Particulars | Field -1 (Bagawas) | Field- 2 (Sojat village) |
|---|---|---|---|
| 1. | Total fuel required to fill up the tank completely | 0.630 lit | 0.630 lit |
| 2. | Fuel required to top up the tank after completing harvesting | 0.610 lit | 1.200 lit |
| 3. | Total fuel consumed | 0.610 lit | 1.200 lit |
| 4. | Specific fuel consumption (lit/ ha) | 3.81 lit/ha | 3.75 lit/ha |

**Conclusions**

(i) The Mechanical mehandi harvester equipped with a 4- stroke, 35.8 cc petrol engine, a rotary type disc cutter of 10" diameter having 80 teeth with 10° cutting angle (rake angle) was found most suitable for mehandi harvesting in a levelled field surface. The field capacity and engine fuel consumption of the harvester were observed as 1.28ha /day and 3.75 lit/ha respectively.

(ii) The developed harvester equipped with a higher power 4- stroke, 47.9 cc Honda petrol engine with a clutch mechanism provided at ground wheel was found suitable

for harvesting of mehandi crop under undulated field condition because of 18–20-year-old transplantation of the crop. The field capacity and the engine fuel consumption of the harvester were observed as 1.39 ha/day and 3.78 lit/ha respectively.

(iii) Two 20" diameter pneumatic ground wheels were found suitable to support the harvester assembly and to move forward under levelled as well as undulated field conditions.

(iv) A G.I. made semi cylindrical crop guard of 33 cm height, 13.5 cm radius of curvature, set at 0° angle with direction of motion was found suitable for desired windrowing of cut crops in straight rows.

(v) The fuel consumption requirement of the harvester equipped with a 35.8 cc and 47.9 cc engines recorded as 3.75 lit/ha and 3.78 lit/ha respectively. Operational cost of the harvester was Rs. 938/ ha and Rs. 952.6 respectively.

(vi) A net operational cost saving of 81.2% and 80.1% was observed in case of harvester with 35.8 cc engine and 47.9 cc engine respectively as compared to traditional harvesting with sickle.