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Development of a Mechanical Harvester for Mehandi

Amogh Sharma,Dr. D.P. Darmora, Dr. Dhiraj Singh

[a]Junior Research Fellow, Jaipur [b]Professor, VGU, Jaipur[c]Associate Professor, VIT

Abstract: A mechanical mehandi harvester was developed to address the harvesting problem associated with mehandi crop. The developed mehandi harvester has a field capacity of 1.4ha/day against 0.1 ha/day field capacity of sickle which is used traditionally to harvest the mehandi crop.

The harvester consisted of a prime mover, a rotary disc type cutter assembly, a crop windrowing system and two pneumatic ground wheels to support the harvester components and forward movement of the harvester.

The harvester equipped with a 35.8cc, 4 stroke petrol engine as prime mover was found effective to harvest the mehandi crop in levelled field. A more powerful engine of 47.9cc was, however required as prime mover to harvest the mehandi crop transplanted 15-20 years ago as field turned undulated during long time span of 15-20 years due to irregular stem base development and disturbed row to row spacing. The harvester saved about 80% harvesting cost against traditional harvesting with sickle.

Keywords: Harvesting, field capacity, fuel consumption rate, windrowing.

I. INTRODUCTION

Mehandi is an important crop of Sojat area in Pali district of Rajasthan. About 90% farmers of the region grow this crop as other crop cannot be grown due to non-availability of irrigation water and the production cost of mehandi is comparatively low, it is an excellent dye crop and foreign exchange is generated through export of 40% production of the crop to about 130 countries.

Harvesting of the crop is however, done with the sickle having very low field capacity of 0.1ha/day. Labours also do not become available during peak harvesting season. It delays the harvesting of the crop resulting in deterioration of about 29% mehandi leaves causing a considerable loss to mehandi grower. A mechanical harvester of higher field capacity was thus developed in the Department of Agriculture, VGU Jaipur under a TDP project sponsored by DST.

II. DEVELOPMENT OF THE HARVESTER

2.1 Determination of the size of the mechanical mehandi harvester

The size of the mehandi harvester can be decided on the basis of the average land holding of the mehandi growing farmers and the optimum period available for mehandi harvesting before deterioration in quality of mehandi leaves starts.

A field survey of 3 randomly selected mehandi growing villages in Sojat area was conducted to know the average land holding of mehandi grower and also to know the total available time of mehandi harvesting before its leaves get deteriorated. The available harvesting time of 13 days and average land holding of 1.83 ha was found from the study.

Assuming one mechanical harvester among 10 mehandi growers, the minimum field capacity of the harvester was determined as (1.83*10)/13 = 1.4 ha/day (say 1.4 ha/day).This machine has the capability and the economic value for fulfilling the needs of farmers having small land holdings (less than 2 acres) [1].

A mechanical harvester, having a field capacity of 1.4 ha/day was thus developed to address the problem in traditional harvesting. It consists of a prime mover (a 4-stroke petrol engine) a cutting mechanism equipped with a rotary disc cutter and

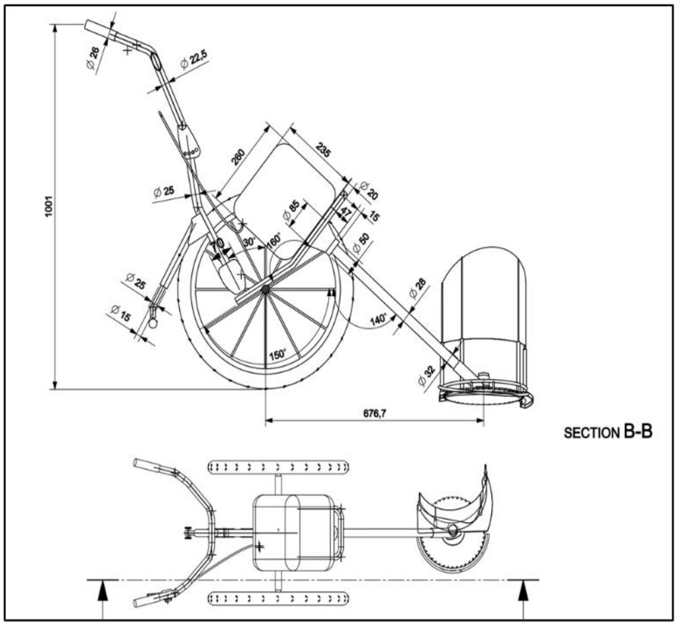

Fig 1: 2-D View of harvester with 35.8cc Engine

2.2 Selection of prime mover

windrowing mechanism to lay down the cut crops in a straight row on the field and the movement system supporting the weight of the machine (Fig 1).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 [2].

Electric power supply is not available near farmer's field in Sojat area thus; an IC engine was preferred over an electric motor as a prime mover for the harvester. As the mehandi growers in the area have low land holding, and cannot afford to buy a large size harvester needing more than 1 Kw Engine, a small size petrol engine having 35.8 cc swept volume was selected as a prime mover. Diesel engine of less than 1 kw are not commercially available, Further, a four-stroke petrol engine has advantages of higher fuel and volumetric efficiencies, it creates less noise, pollution and vibration and also results in low tear and wear of the engine as compared to a 2- stroke petrol engine. **In view of above a four-stroke petrol engine of 35.8cc (Swept volume) was selected as a prime mover for the harvester.**

2.3 Selection of cutter

A rotary stainless-steel cutter was selected for the harvester in view of its suitability for the small HP engines. The design parameters of the rotary cutter (diameter, number of teeth, rake angle and rotational speed) were optimized by conducting different field experiments in VGU campus, where mehandi plants have been grown in 3-4 rows along the boundary walls.Rotary cutter blades are very sharp, can be sharpened, and are available in different sizes [3].

The effect of these design parameters (independent variable) was studied on harvesting quality of mehandi (number of plants cleanly cut per minute) in 3 replications and average of the 3 was worked out for comparison.

2.3.1 Effect of diameter of rotary cutter on harvesting performance

Four sizes of the rotary cutter (6'', 7", 8" and 10" with 80 teeth each) were selected for the study and their effect on harvesting performance was investigated (Fig 2). The experiment was conducted in 3 replications with 5° rake angle. Maximum numbers of plants harvested per minute (41) were observed with 10" diameter cutter followed by 8" (39), 7" (36) and 6" (32). 10" diameter rotary cutter was thus selected based on best harvesting performance.

2.3.2 Effect of number of teeth on harvesting performance

Two 10" diameter rotary blades one having 60 teeth and another 80 teeth were selected for the study. The experiment was conducted in 3 replications with 5° rake angle. The Rotary blades having 80 number of teeth was found better based on harvesting quality (number of plants harvested per minute: 42 with 80 teeth compared to 38 with 60 teeth).

2.3.3 Effect of rake angle of the rotary cutter on harvesting performance

Effect of 3 rake angles (5°, 10°, 15°) of a 10" rotary blade having 80 teeth was studied on harvesting performance with 3 replications. Harvesting performance was best (45 plant/min) with 10° rake angle followed by 41 plants/min each with 5° and 15° rake angle.

2.3.4 Effect of rotational speed of rotary cutter on harvesting performance

Two positions of the throttle lever corresponding to 3000 rpm and 4500 rpm were marked to see the effect of rotational speed of the cutter on harvesting performance. The experiment was conducted in 3 replications with two rotational speed of the cutter (3000 rpm and 4500 rpm). Harvesting performance was not found satisfactory with lower rotational speed of 3000 rpm as harvesting reduced down to the level of 18 plants/min. **Rotational speed of 4500 rpm gave the best performance.**

A rotary type stainless steel cutter of 10" diameter having 80 teeth with rake angle of 10° was thus selected for harvesting of mehandi based on the results of field experiments.

Fig 2: Different sizes of stainless- steel rotary blades

2.4 Selection of windrowing system

A concave semi cylindrical vertical guard made of 24-gauge G.I sheet was provided just above the rotating cutter behind the cutting edge at certain angle in order to lay down the harvested plants of mehandi on the ground in a straight line. The height, radius of curvature and horizontal angle of the guard with direction of forward movement were varied in different field experiments in order to optimize these parameters for clean windrowing of harvested mehandi plants on the field surface.

Fig 3: Different sizes and shapes of Crop Guard

2.4.1 Effect of radius of curvature of the guard on windrowing quality

Three radii of curvature (13.5, 14.5, and 15.5 cm) of the guard were selected to investigate the effect of the guard concavity on windrowing quality in a field experiment in three replications. (Fig 3) Radius of curvature of 13.5 cm was found optimum as a clean and straight windrowing was achieved with this concavity.

2.4.2 Effect of guard height on the windrowing quality

Three height of the guard (18, 26 and 33 cm) were selected to investigate the effect of the guard height on windrowing quality in a field experiment with three replications.

A guard height of 33 cm was found optimum as best windrowing quality was observed with this height.

2.4.3 Effect of horizontal angle of guard with direction of forward motion on windrowing quality

Three horizontal angles of the guard with the direction of motion (0°, 5°, and 10°) were selected to investigate the effect of this angle on windrowing quality in a field experiment in three replications. A horizontal angle of the guard of 0° was found optimum on the basis of best windrowing quality.

Based on above field experiments, a G.I. made guard of 33 cm height with 13.5 cm radius of curvature and0° horizontal angle with direction of forward movement was found most suitable in order to get the best windrowing of the harvested mehandi.

2.5 Selections of ground wheels for forward movement and transverse movement of cutting arm

The harvester has to move forward and simultaneously the cutting arm, equipped with rotary cutter at its forward edge, has to cut the plants from right to left, grown in 3 rows. Following two mechanisms were experimented to achieve the forward movement of the machine and simultaneously transverse movement of the cutting arm in order to cut the plants from right to left from 3 rows.

(a) Nylon castor wheels can firmly support the engine and perform both the movements. Two types of nylon castor wheels were investigated for achieving forward movement of the machine as well as right to left movement of the cutting arm simultaneously in order to harvest the plants from 3 rows.

(i) Single castor wheel (4” and 8” diameter)

(ii) Double castor wheel (4” and 8” diameter)

During experimentation it was observed that the performance of the 8” diameter double caster wheel was better than 4” and 8” diameter single caster wheels as well as 4” double caster wheel. Even 8” diameter double caster wheel was not found suitable as it was difficult to balance the machine during forward movement and transverse movement of the

cutting arm simultaneously (Fig 4).

Fig 4: Different types and sizes of Wheels

(b) Two pneumatic rubber wheels can support the engine in a trolley through a bush bearing to enable right to left movement of the cutting edge along with the engine as well as forward movement. A trolley supporting the engine through bush bearing and mounted on two pneumatic 20” diameter wheels was thus investigated. The two pneumatic rubber wheels were used for the forward movement of the harvester whereas the engine mounted on a hinge (bush bearing) enabled right to left movement of the cutting arm for harvesting mehandi plants from three rows.

In view of above a frame supporting the engine (equipped with cutting arm through bush bearing and mounted on the pneumatic 10” diameter rubber wheels were selected for the harvester).The machine is a walk behind type of harvester which can be used for harvesting [4] mehandi.

III. PROTOTYPE DEVELOPMENT

The prototype of the mechanical mehandi harvester was thus developed on the basis of results of various field experiments conducted. It has the following components:

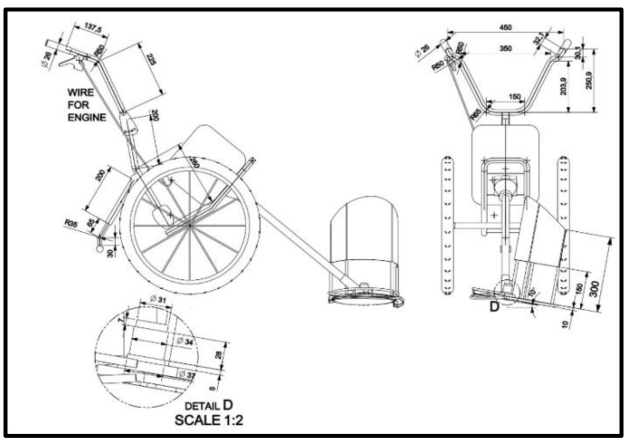

Fig 5: 2-D View of harvester with 35.8cc Engine

1. Prime mover: A 35.8 cc four-stroke petrol engine.

2. A 10” diameter stainless steel rotary cutter having 80 teeth attached at one end of the cutting arm through a bevel gear unit and the other end attached to the engine output shaft.

3. A G.I. made semicircular guard (33 cm height, 13.5 cm radius of curvature) set at 0° horizontal angle with direction of forward movement for windrowing of harvested mehandi.

4. A prime mover and crop cutting assembly supported on two 20” diameter pneumatic rubber wheels on which the petrol engine is mounted through a bush bearing.

This machine is made of locally sourced materials which is easy to maintain or repair and also cost effective [5].

IV. PERFORMANCE EVALUATION

The developed mehandi harvester was tested in farmers field near Sojat (Fig 6). The test results revealed the following:

(i) The harvester performed satisfactorily in case of levelled field however in case of old transplanted fields, row spacing got disturbed bovver the 15-20years time span and the irregular thick stem growth at the 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 the cut crops also deteriorated under undulated field

condition.

Fig 6: Field Testing of Harvester with 35.8cc Engine

Fig7: Field Testing of Harvester with 47.9cc Engine

(ii) A more powerful engine of 47.9 cc was thus selected to overcome difficulties incurred in undulated fields. Field test with the engine revealed its suitability under undulated field conditions (Fig 7).

V. CONCLUSION

(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.

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