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Performance Evaluation of Mechanical and Manual Harvesting of Sugarcane

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A B S T R A C T

India is one of the most sugarcane producing countries in the world which covers 18.52% area and contributes 18.45% sugarcane production of the world. Medak is the leading producer of sugarcane in Telangana. With a goal to establish performance measures for sugarcane harvesting, four field trials were conducted in the sugarcane crop fields of Kohir Mandal, Medak district. The height of cut of canes above the ground by sugarcane harvester was observed to be at an average of 4.1 cm whereas by manual harvesting, it was at an average of 10.8 cm. The total time taken to harvest one acre by sugarcane harvester was 3 hours whereas by manual harvesting was about 9 hours. The field capacity obtained for mechanical harvesting was 0.141 ha/h whereas for manual harvesting, it was 0.045 ha/h. From the present study in four different field trials, total harvesting cost per ton was calculated to be Rs.841 and Rs.1500 for mechanical harvesting and manual harvesting respectively. Wider row spacing with mechanized harvesting would prove to be profitable in terms of cane yield and harvesting cost rather than adopting narrow spacing with manual harvesting means.

Introduction

Sugarcane is one of the several species of tall perennial true grasses of the genus *Saccharum*, tribe *Andropogoneae*, native to the warm temperate to tropical regions of South Asia and Melanesia used for sugar production. It has stout jointed fibrous stalks that are rich in the sugar sucrose which accumulates in the stalk internodes. The plant is 2 to 6 meters (6 to 19 feet) tall. All sugar cane species interbreed and the major commercial cultivars are complex hybrids. Sugarcane is a tropical crop and its maximum growth takes place under hot, humid and sunny conditions. The importance of sugarcane in the agrarian economics of the world needs no emphasis because of its higher value as a cash crop, a major source of sugar and as a source of basic raw material for various Agro-Based industries.

It is a long duration crop and requires 10 to 15 and even 18 months to mature, depending upon the geographical conditions. It requires hot and humid climate with average

temperature of 21°-27°C and 75-150 cm rainfall. India is one of the most sugarcane producing countries in the world which covers 18.52 % area and contributes 18.45 % sugarcane production of the world. Largest sugarcane producing state of India is Uttar Pradesh which has 38.61 % share in overall sugarcane production as per 2013-14 statistics (J.V. Mande and B.M. Thombre, 2009).

The second and third largest states are Maharashtra and Karnataka. Other main sugarcane producing states of India include Bihar, Assam, Haryana, Gujarat, Andhra Pradesh and Tamil Nadu.

Sugarcane cultivation in India is a labour intensive process. Farmers depend mainly on human power and it requires continuous engagement of labour throughout the crop cycle. Scarcity of labour is often felt in the agricultural sector. For want of sufficient labour at reasonable wages, most of the cultural operations are delayed or not taken up at all, resulting in low production and productivity. It is estimated that, 134 man hours are required per metric ton of sugar produced. Of this, one third is required for production whereas remaining two third is utilized for harvesting, cleaning and loading. Hence mechanization of sugarcane harvesting is essential not only for reducing the production cost but also for reducing drudgery involved in manual harvesting operations and also to ensure quality produce. Shortage of labour is one of the reasons why many farmers have walked away from this promising crop. Mechanization is considered as an alternative to solve the problem of labour shortage.

Rajula shanthy and Muthusamy (2012) stated that wide row spacing of 120 cm gave a difference in cane yield of 5.70-41.59 t/ha when compared with farmers conventional practice of 90 cm narrow spacing and manual harvesting costs incurred for narrow row spacing and wider row spacing are Rs. 39,379 per hectare and Rs. 42,500 per hectare respectively.

Materials and Methods

Medak is the leading producer of sugarcane in Telangana. Harvesting operation is the most tedious activity in sugarcane cultivation as it involves huge input energy. In Medak, harvesting methods followed are primitively manual means and the mechanical means are stacking up. Evaluation study was conducted at Kohir, a town and Mandal headquarters in the Medak district of Telangana, India. Kohir is located at 17.6000^0N 77.7167^0E. It has an average elevation of 627 metres (2060 ft.).

Manual harvesting

For most of the sugarcane crops in Medak, harvesting operation is done manually using locally made small hand tools such as knives. The farmers generally use old design sickles and knives made of iron for harvesting sugarcane. Sugarcane harvesting operation involves the unit operations such as cutting the sugarcane, detrashing the cane, detopping and transporting to sugarcane factory for further processing. These operations are very much drudgery prone and cause fatal damages to human in the reality, so the workers need to be skilled to perform the operations safely.

Mechanical harvesting

In a normal sugarcane harvesting operation, the harvester first severs cane tops and spreads them to the side of operating rows. Then the topped cane plants are gathered by crop dividers and arranged in the longitudinal orientation (parallel to feeding direction) to be fed into machine. Next, stalks are cut at their bases about 30 mm above the ground using a cutting mechanism. Stalks are then conveyed by feeding rollers to cane choppers for

chopping them into 15-30 cm billets. Chopped billets are transported up the discharge elevator, where the primary and secondary extractor fans remove residual leafy materials prior to discharging billets into the collection bins.

Determination of height of cut above the ground

The four different fields of sugarcane after harvesting operation where inspected for determining height of cut. Ten cut stalks left after harvest in both mechanical and manual harvested fields respectively were chosen randomly in different rows. Height of cuts was noted by placing the scale along the left over cut stalks in both mechanical and manual harvested fields as shown in Fig. 1. These heights of cuts of machine harvested fields were compared with manual harvested fields to evaluate its performance.

Determination of time taken to harvest

The harvesting operation was made to start in both mechanical and manual harvested fields and the time of start of harvest was noted using a stopwatch. Additionally, the machine operational time of single row was noted for about five rows and also the total time taken to harvest one acre was noted by using a stopwatch. The noted mechanical and manual time readings were compared to evaluate the harvester performance.

Determination of height and diameter of canes

Five canes are selected randomly from different rows of both mechanical and manually harvested fields respectively. Height of canes is measured by placing the tape along the length of cane as shown in Fig. 2. Diameters of canes are measured by using scale.

Determination of field capacity

Field capacity is the total area covered in an operation to the total time taken to complete the operation. The total area covered in each of the four field trials was taken as one acre to make a standard. The total time taken to harvest was noted already during both mechanical and manual harvesting trials. The field capacity was obtained by dividing area covered in harvesting operation with the total time taken to harvest in both mechanical and manual trials.

$$\text{Field capacity (ha/h)} = \frac{\text{Area covered (ha)}}{\text{Total time taken to harvest (h)}}$$

Calculation of the total harvesting cost

The total harvesting cost is calculated for custom hiring harvester and self-owned harvester by farmer.

Calculation of the total harvesting cost (custom hiring)

The total harvesting cost on custom hiring basis in mechanical harvest includes hire cost of machine, labour cost and costs incurred in transporting the cane billets to nearby sugarcane industries for further processing. The total harvesting costs in manual harvest includes labour costs for harvesting operation, loading and transporting the cane billets to industries nearby. The transport cost may vary with the distance of field from the industry.

Total harvesting cost on custom hiring (Rs/t) = Hire cost of harvester + Labour cost + Transport cost

Calculation of Labour cost in Rs/ton (custom hiring)

Labour cost = Rs/day

Field capacity = ha/day

$\frac{\text{Labour cost(Rs/day)}}{\text{Field capacity(ha/day)}}$ = Labour cost (Rs/ha)

Yield = t/ha

$\frac{\text{Labour cost (Rs/ha)}}{\text{Yield (t/ha)}}$ = labour cost (Rs/t)

Calculation of the total harvesting cost (Harvester owned by farmer)

Fixed Cost

D (Rs/h) = $\frac{C-S}{L\times H}$S = 10% of initial cost

I (Rs/h) = $\frac{C+S}{2}\times\frac{i}{H}$I = 10% per year

Housing cost per hour (Rs/h) = 1% of initial cost of the machine

Insurance cost (Rs /h) = 1% of initial cost of the machine

Taxes (Rs /h) = 1% of initial cost of the machine

Total fixed cost (Rs /h) = Depreciation + Interest + Housing cost + Insurance cost + Taxes

Operating cost

Fuel cost (Rs/h) = Fuel consumption (litres/hr) × Cost of fuel (Rs/litre)

Cost of lubricant (Rs/h) = 30% of fuel cost

Repair and maintenance cost (Rs/h) = 6% of capital cost per year

Wages for operator (Rs/h)

Total operating cost (Rs/h) = Fuel cost + Cost of lubricant + Repair and maintenance cost + Wages of operator

Total cost (Rs/h) = Fixed cost + Operating cost.

Results and Discussion

Height of cut above the ground

As described in subsection 3.4.1, there were ten left over stalks chosen randomly in different rows of four mechanical and manual harvested field trials respectively.

The mechanical and manual harvested height of cuts in field trial 1 was 5.15 cm and 10.25 cm respectively, in field trial 2, 3.85 cm and 10.08 cm respectively, in field trial 3, 4.5 cm and 12.71 cm respectively and in field trial 4, 2.92 cm and 10.38 cm respectively as shown in Fig. 3.

The mechanical harvested field height of cut is lower than manual harvested field height of cut. This difference in height of cut may be due to the following two reasons. In case of manual harvest, labour may cut the canes six inch above the ground level to avoid the strike of knife with soil.

In case of mechanical harvest, the base cutter is arranged as close to the ground as possible so that there is lower height of cut. It is to be noted that, the maximum sugar content is present at the bottom of the cane (Rohith J. Masute, *et al.*, 2014).

Time taken to harvest

The total time taken to harvest one acre in mechanical and manual harvested fields of field trial 1 was 2 hours 40 minutes and 8 hours respectively, in field trial 2 it was 2 hours 35 minutes and 8 hours respectively, in field trial 3 it was 3 hours 25 minutes and 10 hours respectively and in field trial 4 it was 2 hours 50 minutes and 10 hours respectively as shown in Fig. 4.

Fig.1 Determination of height of cut above ground

Fig.2 Determination of height of cane

Fig.3 Comparison of height of cuts for manual and mechanical harvesting

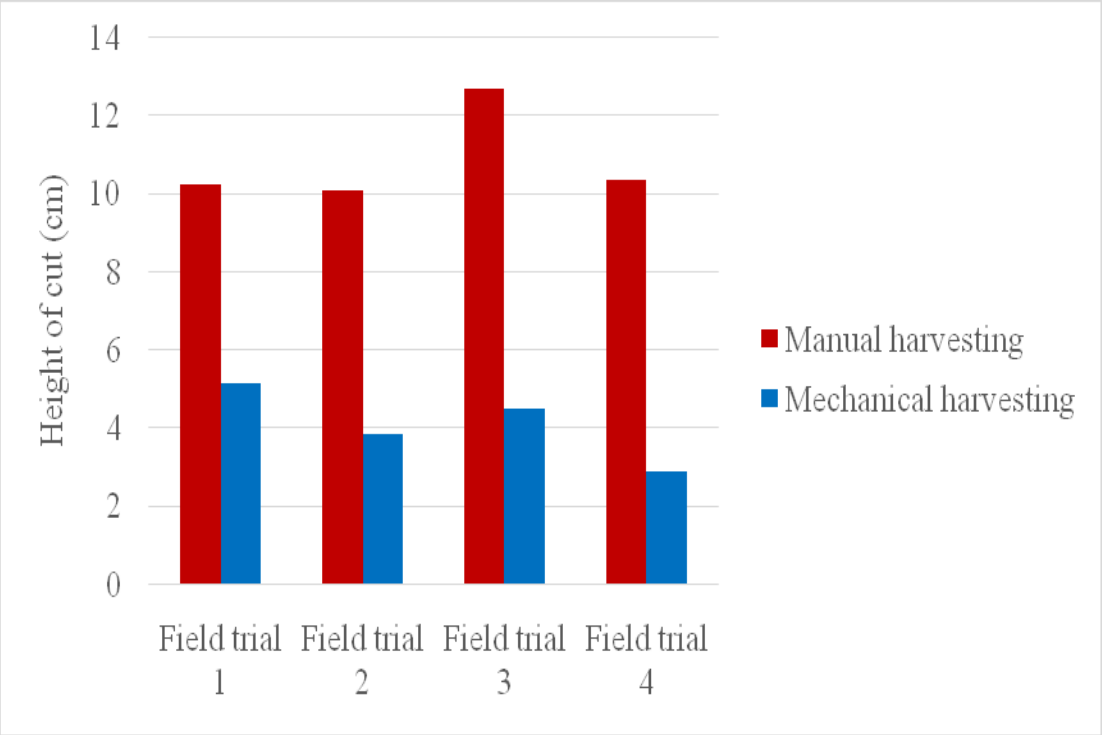


Fig.4 Comparison of time taken to harvest in manual and mechanical harvesting

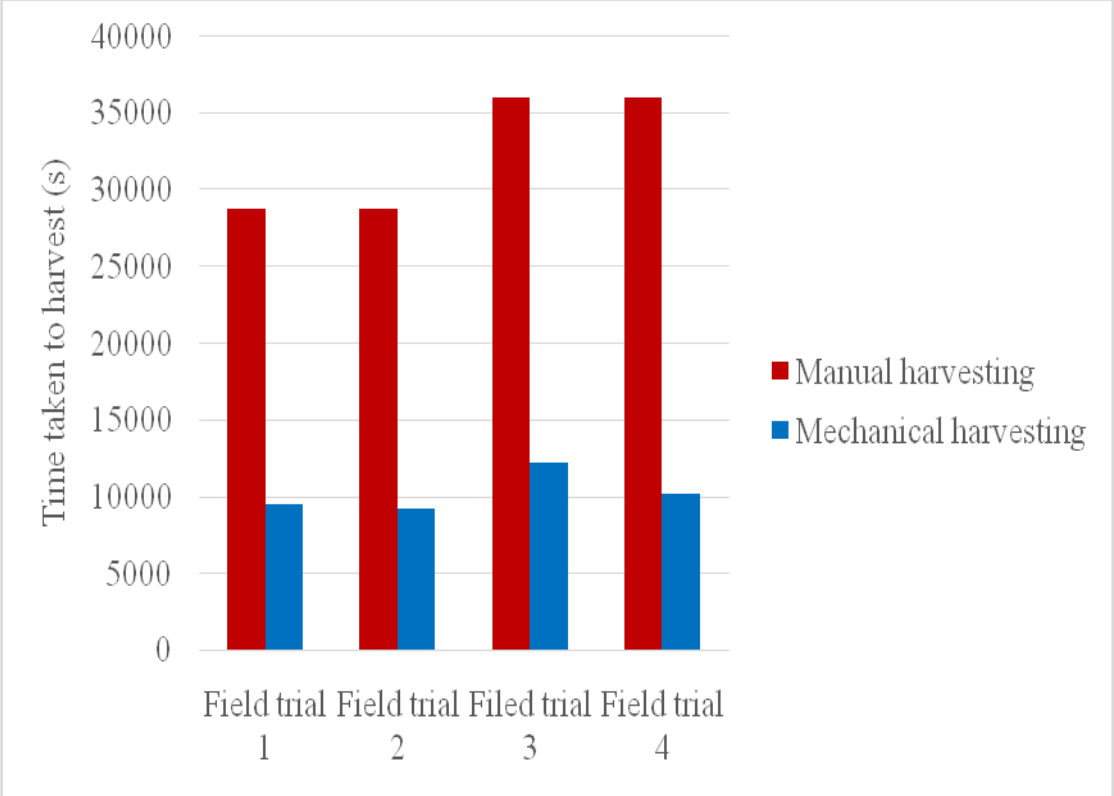


Fig.5 Comparison of field capacity of manual and mechanical harvesting

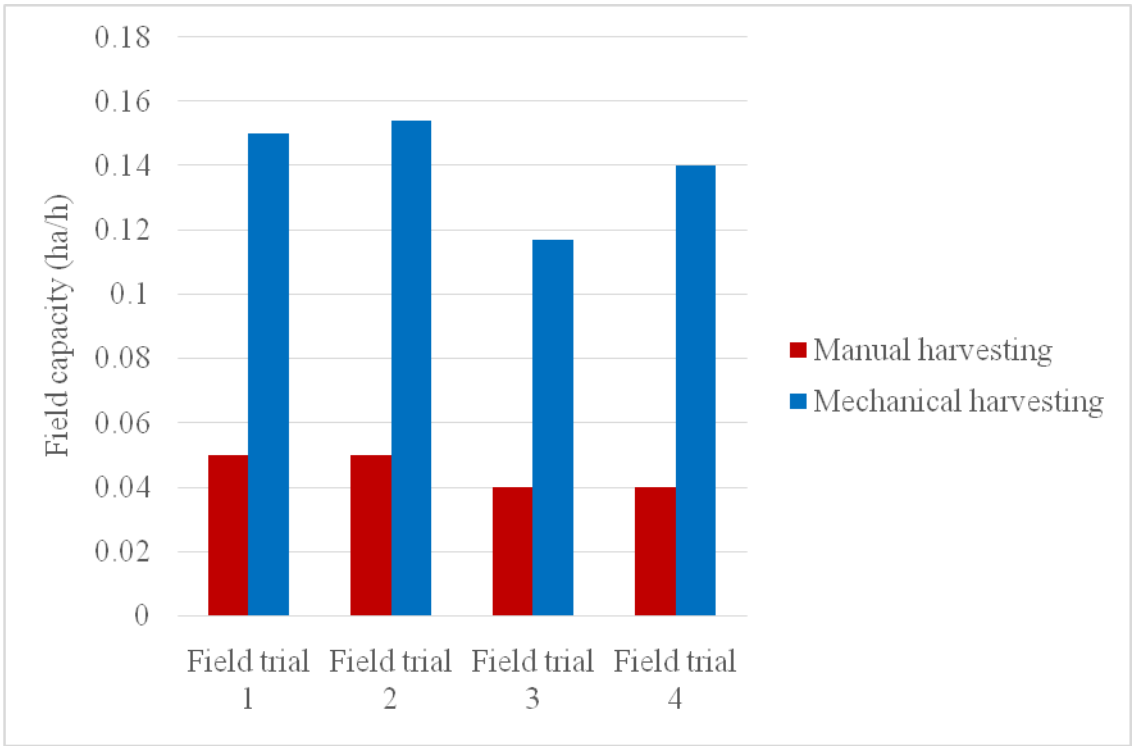
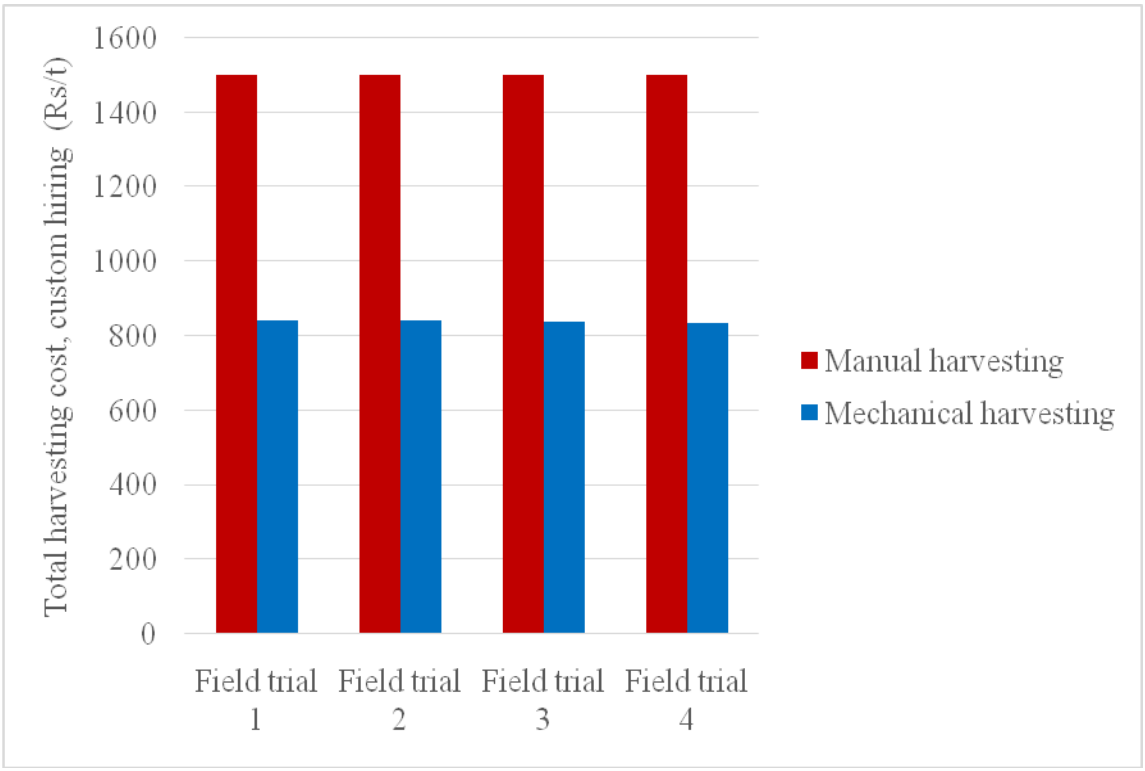


Fig.6 Comparison of total harvesting cost of manual and mechanical harvesting custom hiring)



Field capacity

The field capacity of mechanical and manual harvest of field trial 1 was 0.15 ha/h and 0.05 ha/h respectively, in field trial 2 it was 0.154 ha/h and 0.05 ha/h respectively, in field trial 3 it was 0.117 ha/h and 0.04 ha/h respectively and in field trial 4 it was 0.14 ha/h and 0.044 ha/h respectively as shown in Fig. 5.

Total harvesting cost

The total harvesting cost on custom hiring in mechanical harvest includes hire cost of machine, labour cost and costs incurred in transporting the cane billets to nearby sugarcane industries for further processing as mentioned in subsection 3.4.5. The labour cost in mechanical harvest of field trial 1, field trial 2, field trial 3 and field trial 4 were Rs. 5 per ton, Rs. 5 per ton, Rs. 10 per ton and Rs. 5 per ton respectively. The hire cost in mechanical harvest of field trial 1, field trial 2, field trial 3 and field trial 4 were Rs. 520 per ton, Rs. 520 per ton, Rs. 450 per ton and Rs. 450 per ton respectively.

The transport cost in mechanical harvest of field trial 1, field trial 2, field trial 3 and field trial 4 were Rs. 320 per ton, Rs. 320 per ton, Rs. 380 per ton and Rs. 380 per ton respectively. The total harvesting cost in mechanical harvesting of field trial 1 was Rs. 845 per ton, in field trial 2 it was Rs. 845 per ton, in field trial 3 it was Rs. 840 per ton and in field trial 4 it was Rs. 835 per ton. The total harvesting costs in manual harvest includes labour cost for harvesting operation, loading and transporting the cane billets to industries nearby. The manual harvesting labour cost to cover one acre in field trial 1 was Rs. 10,000, in field trial 2 was Rs. 10,500, in field trial 3 was Rs. 8000 and in field trial 4 was Rs. 12,000. The total harvesting cost in manual harvesting of the four field trials were same i.e., Rs. 1500 per ton as shown in Fig. 6.

Mechanization of sugarcane harvesting is essential not only for reducing the production cost but also for reducing drudgery involved in manual harvesting operations, and also to ensure quality produce.

The evaluation study was carried out in Medak district of Telangana. The existing methods of manual and mechanical harvesting were evaluated to know its performance. The study is concluded in terms of height of cut, time taken to harvest, field capacity and total cost of harvesting as follows.

In field trials, the height of cut of sugarcane above the ground using harvester has an average value of 4.1 cm whereas manual harvesting has an average value of 10.8 cm above the ground. The harvester takes an average time of 7.5 h whereas manual harvesting takes an average time of 22.5 h to harvest one hectare. The field capacity obtained for mechanical harvesting has an average value of 0.141 ha/h whereas manual harvesting has an average value of 0.045 ha/h. From the present study, the cost of harvesting is calculated from four different field trials for sugarcane harvester on custom hiring which has an average of Rs. 841 per ton and in manual harvesting has an average of Rs. 1500 per ton.

From this study it was observed that the cost of harvesting by mechanical method of harvesting and manual harvesting are Rs. 63,433/ha and Rs. 16,667/ha. So, in order to reduce the cost of harvesting by machine, the harvester should work for more hours to cover maximum area.

The only possible way to sustain sugarcane farming is through mechanization as it is a labour, drudgery and energy intensive crop. For any tractor drawn implements, increased row spacing is a pre-requisite. Farmers have started realizing this crude reality and a

considerable area is practiced under wider row spacing. Wide row spaced cultivation has its own advantages over narrow spacing. Wider row spacing with mechanization would prove to be profitable in terms of cane yield and harvesting cost than narrow spacing.

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