



## DESIGN AND FABRICATION OF SOLAR AND GASOLINE DUAL-POWERED LAWN MOWER

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### ARTICLE INFORMATION

### ABSTRACT

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The need to improve existing lawnmowers is highly essential, especially when there is availability of alternative and renewable sources of power (solar energy). A readily available two-stroke internal combustion engine and solar panel were used to drive a cutting tool made from a locally available cutlass. The Mechanical power from the internal combustion engine was converted by an alternator to Electrical power and transmitted through the electric motor. The mower's battery is recharged by a 30W solar panel. To avoid completely draining or overcharging the battery, the solar panels were linked in series with an electric charge controller. The lawn mower's cutting blade is fixed to a 12-volt, one-horsepower DC motor, which is powered by two series-connected 12-volt, seventy-five-amp lead accumulators. Through the use of solar energy captured by the solar panels, the DC batteries (lead accumulators) are replenished. The hybrid powered lawn's intricate design was developed and the performance demonstrated the field efficiency of 83% and 87% when powered with solar and combustion engines respectively. The blade height is adjusted for the desired height of the cut. The battery which takes approximately 2 days to recharge mows a total area of 455m<sup>2</sup> of lawn. The mower showed neat mowing of the grasses with ease of operation.

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### 1.0 Introduction

The use of solar power as an alternative source of energy has been in existence long before now but has not well been utilized for diverse applications due to its intermittent characteristics and the use of other sources of energy. In recent times, solar technologies have been used as an alternative or backup power supply for homes and appliances (Amin *et al.*, 2021; Qazi, 2017). In a country like Nigeria, with a high dependency on fossil fuel for energy generation, taking a shift from the dependency on fossil fuel will go a long way in providing better and cleaner sustainable alternative means of power generation and usage. But recently, awareness of fossil fuel pollution and its contribution to global warming (Valavanidis, 2022) and the fact that fuel energy is non-renewable and unsustainable thereby awakening applications and research in renewable energy generation technologies like solar.

There is a dire need for the environment to be always kept tidy and clean. This is very crucial, especially in the physical environment in which man lives. In such environments mostly gardens, parks, institutional settings or estates, it is common to see manual labourers with the use of hand tools to cut grasses. These tools include machete, hoes, cutlasses, rakes, etc. But because of its discomfort for large lawns and time-wasting man developed what is known as a mechanical machine. Nowadays, mechanical machines such as lawnmowers are becoming more and more common in society, most especially in urban areas. The working principle of lawnmowers is mainly to provide high-speed rotation to the blades, which aids in cutting the grass through generated kinetic energy. The blades may be powered either by pushing the mower forward to operate the mechanical blades by an electric motor, by solar power or by a small internal combustion engine to spin the

blades. Regarding the current literature availability, many variations of lawn mower exist in the global markets, which may not fulfil the performance and operational cost criteria (Dutta *et al.*, 2016).

The hybrid power lawn mower can be described as the application of different power sources such as solar energy or electrical energy to power an electric motor which in turn rotates a blade which does the moving and trimming of the lawn to suit desired needs or convenience. The use of solar energy or electrical energy in this sense is employed to charge the battery which supplies the current needed by the motor and in turn enables the rotation of the blade (Patel, 2022). Therefore, the main objective of this study is to improve existing lawn mowers through the design and fabrication of an efficient and cost-effective dual-powered lawn mower (that is powered by solar and gasoline) from locally sourced materials thereby reducing the problem of carbon dioxide emission and increasing reliability.

## 2. Materials and Method

This work involved the systematic design, fabrication, and evaluation of a hybrid lawn mower. The design consideration include the material selection, functionality or usability, material availability, cost and manufacturability are the factors considered in the design and fabrication of the hybrid lawn mower. The performance testing was carried out to arrive at a more effective and efficient final product that could handle cutting of grasses of different height combining two energy sources. As such, to complete the process of design and fabrication of the hybrid lawn mower, careful consideration and calculations of parts were followed. These include the material and shape of the blade, speed of rotation of the motor, power ratings of the solar system and combustible engine and the sizing of the deck.

### 2.1 Blade Design

Lawnmower blades can be made from different materials but the most suitable blade for fabrication is Steel. Stainless steel was considered in the design due to its lightweight and corrosion resistance. The light weight of stainless steel could also have a positive impact on the consumption of power during the operation of the mower. The shape of the blade was also taken into consideration. There are different blades ranging from tapered blades, mulching blades, gator blades, and high lift blades. A mulching blade is chosen (see Figure 1) due to its high efficiency on both dry and damp surfaces and any type of soil. Rotating shafts of the blades have a high mass; thus, a mulching blade is selected to have an increased cutting edge (Akinoyemi and Damilare, 2020).

Blade length, width and thickness were taken to be  $300 \times 30 \times 2 \text{ mm}$ . The blade density was taken as  $7500 \text{ kg/m}^3$  since the material is made of stainless steel (Quaranta and Davies, 2022).

Therefore, volume, mass and weight were calculated using the expressions below.

$$\text{Volume of blade} = \text{area} \times \text{thickness} \quad 1$$

$$\text{Mass} = \text{Density} \times \text{volume} \quad 2$$

$$\text{Weight of the blade} = \text{Mass} \times \text{acceleration due to gravity} \quad 3$$

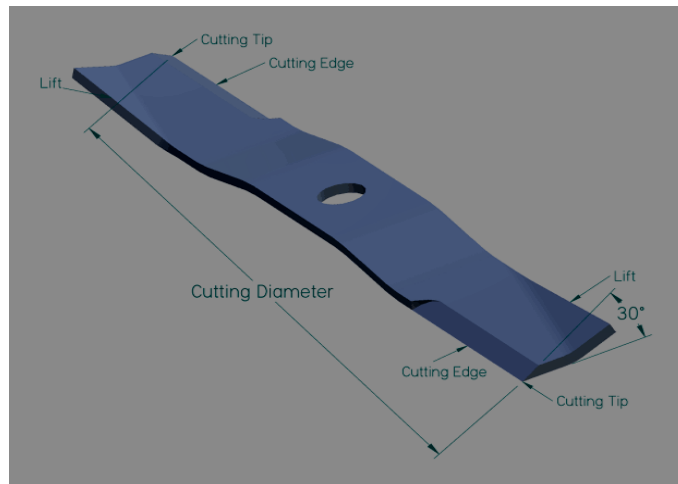
Also, the torque of the cutting blade, angular velocity of the blade and power generated by the blade were calculated using equations 4 to 6.

$$\text{Torque} = \text{Weight} \times \text{radius} \quad 4$$

$$\text{Angular velocity} = 2 \pi N/60 \text{ (taking } N \text{ as the speed of rotating of the blade in rpm)} \quad 5$$

$$\text{Power } P = \text{torque } t \times \text{angular velocity } \omega \quad 6$$

The power generated at the blade is 155.49 Watt, which is approximately 0.21 Hp.



**Figure 1: Cutting blade of the lawn mower**

The edge of the cutting blade is tilted at an angle of  $30^\circ$ , this is done to increase the cutting edge and also allows the blade to cut the grass and bring it back to the deck where it will be cut into smaller pieces before falling back to the lawn (Dange et al., 2011)

## 2.2 Handle of the lawnmower

The load of the machine is centralized and to accommodate the length of the solar panel, a length of 920 mm at an angle of  $60^\circ$  was selected. To determine the maximum bending moment ( $M_{max}$ ), equation 7 (Khurmi and Gupta, 2005) was utilized. The handle of the lawn mower is shown in Figure 2.

$$M_{max} = \frac{\sigma I}{y} \quad (7)$$

Where  $\sigma$  is the stress,  $I$  is the moment of inertia and  $y$  is with respect to the length taken as  $y = x \cos \theta$

To determine the stress exerted on the system, equation 8 was used.

$$\sigma = \frac{F}{A} \quad (8)$$

Where  $F$  is force (N) and  $A$  is the Cross-sectional area  $m^2$

However, the area of the frame is  $152 m^2$

Force is 45 N (Where the total weight of the machine is 10 N and the battery is 35 N)

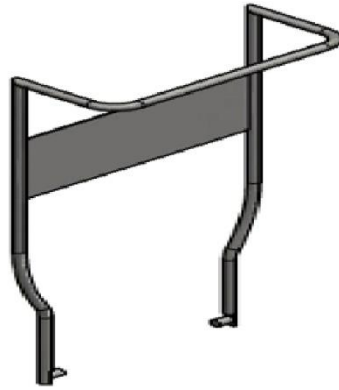
Therefore,

$$\sigma = \frac{45}{152} = 0.296 N/m^2$$

Where  $I$  is the moment of inertia, given as:

$$I = \frac{\pi (D^4 - d^4)}{64} \quad (9)$$

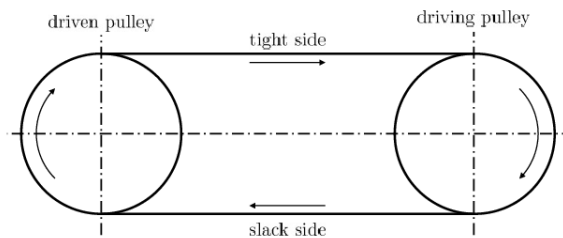
and  $y$  with respect to the length is taken as  $y = x \cos \theta$



**Figure 2:** Handle of lawn mower (Akinyemi and Damilare 2020)

### 2.3 Design of the Pulley System

The design of the pulley system as shown in Figure 3 was based on the design equation of Khurmi (2005).



**Figure 3:** Pulley design

$$\text{Pulley diameter/speed ratio} = \frac{D_1}{D_2} = \frac{N_2}{N_1}$$

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Where,

$D_1$  = Diameter of the Motor Pulley, 100mm

$D_2$  = Diameter of blade shaft pulley

$N_1$  = speed of motor pulley = 1500 rev/min

$N_2$  = Desired blade shaft speed,  $\geq 3000$  rev/min

Finally,  $D_2$  is calculated to be 50 mm.

### 2.4 Efficiency of the Combustion Lawn Mower

The efficiency of the machine is considered based on the total area covered and time taken. To calculate the forward velocity,

For the forward distance of 38m, the time taken was 120s.

$$\text{Therefore, the average forward velocity} = \frac{38}{120} = 0.32 \text{ m/s}$$

To obtain the field efficiency,

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Theoretical Field Capacity (TFC) = forward speed x Theoretical width 11

The theoretical width of the blade = 0.30m

$$\text{TFC} = 0.32 \times 0.30 = 0.095 \text{ m}^2/\text{s}$$

Effective field capacity (EFC) = total area covered/total time taken 12

$$= 40 \text{ m}^2 / 481 \text{ sec} = 0.083 \text{ m}^2/\text{s}$$

Therefore, the field efficiency =  $(0.083 / 0.095) \times 100 = 87\%$

## 2.5 Solar Panel Selection

Solar energy is a time-dependent energy that occurs at irregular intervals. Therefore, energy must be stored so it can be readily available for use when there is no further supply of the sun's energy. In Nigeria, the peak sunny hours per day is approximately 5 to 6 hours daily (Sinha and Marthur, 2020). Selection of the solar panel requires other considerations apart from the average sunlight per day. The battery capacity, current drawn by the mower and operation of the mower are also taken into consideration.

## 2.6 Battery Sizing

To charge the battery, a solar panel is expected to tap the solar energy from the sun and convert it to electric energy that will be put away in the battery connected to it. A charge regulator that will be wired between the solar board and the battery is likewise required. The reason for the controller is to prevent the battery from the solar panel when there is no insulation or production of electricity. It likewise prevents excessive charging when the battery gets fully charged and controls the voltage getting to the battery.

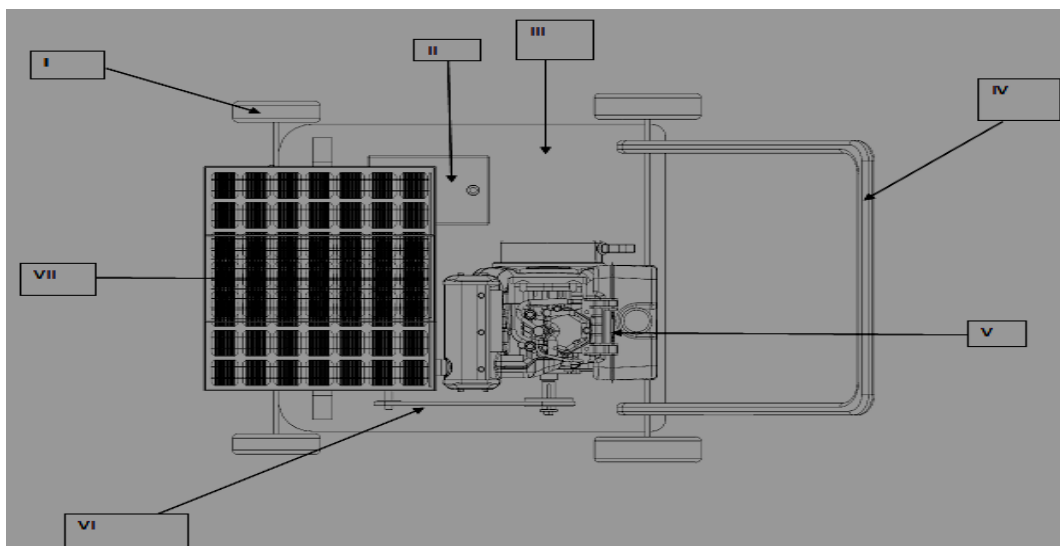
## 2.7 Solar Sizing Design

The solar panel selected is 2.5 Amps rated at 30 Watts

$$\text{Average battery charged per day} = 2.5 \text{ A} \times 6 \text{ h} = 15 \text{ Ah}$$

The battery will be fully charged in (charging rate) =  $75\text{Ah} / 19\text{A} = 3.95$  hours.

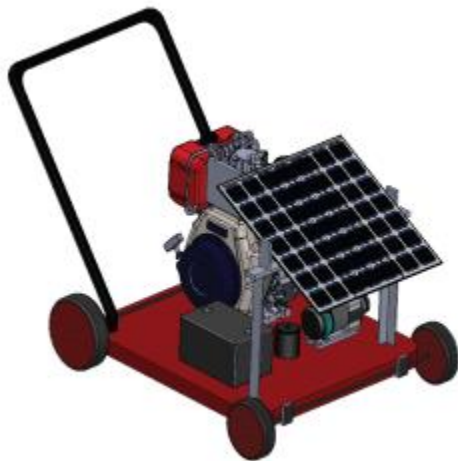
Figure 4 and 5, Table I and plate I, give a detailed description of the lawn mower and its component parts.



**Figures 4:** Top view and part name of the proposed lawn mower

**Table I:** Detailed Description of the Lawn Mower and its Component Parts

S/N	Part Names
I	Tyre
II	Battery
III	Frame
IV	Handle
V	Internal Combustion Engine
VI	Belt
VII	Solar Panel



**Figure 5:** Rendered view of the proposed lawn mower



**Plate I:** Side view of the hybrid lawn mower

### 3. Results and Discussion

The hybrid-powered lawn mower was fabricated and tested. During the machine operation, solar power from the battery is transmitted to the blade to achieve cutting. Also, the machine using its hybrid system through its alternator (convert mechanical energy to electrical energy) was able to perform cutting operations. The electric circuit ensured that power was transferred from the battery to run the DC motor, while the solar panel continuously charged the battery during operation. The blade generated power from the DC motor at a speed of 1500rpm.

When the switch is on, the electrical energy from the battery powers the motor which in turn drives the blade. The solar panel generates current to recharge the battery, thereby compensating for battery discharge. The rotating blade continuously cuts the grass as the mower is being propelled. During the operation, it was convenient to cut grasses at different heights using an adjustable lever mechanism attached to the deck area of the machine.

For the combustible operation of the lawn mower, the prime mover was connected to the alternator through a pulley belt which transfers mechanical energy to electrical energy to the DC motor that is responsible for driving the blade during the cutting process. The alternator is also responsible for charging the battery.

Table 2 shows the results obtained from mowing different types of grasses using the solar power of the hybrid mower. Table 3 shows the results obtained from mowing different types of grass using the combustible engine. The two systems were made to cut different grasses of the same coverage area (16 m<sup>2</sup>) over specific time intervals after which the grass height of the cut grasses was then measured. Figure 6 shows the battery drop and fuel level as it relates to the information provided in Table 1 and Table 3.

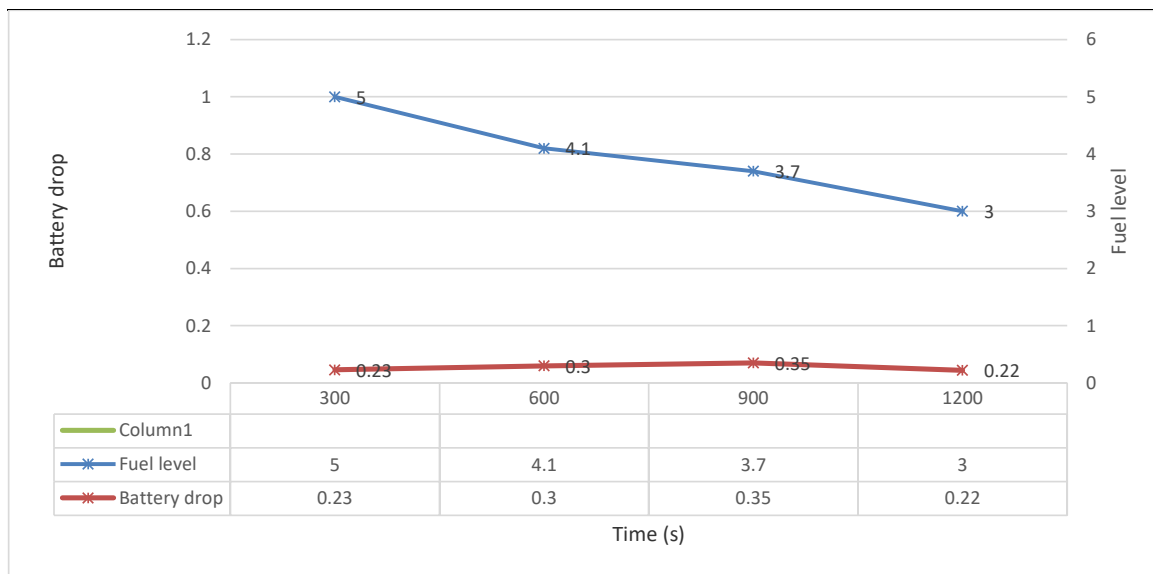
The result outcomes revealed a similar trend with both systems showing that spear grass has the lowest heights of 130 mm and 120 mm in using solar and combustible engines respectively. While stubborn grass has the highest heights of 600 mm and 650 mm using solar and combustible engines respectively.

**Table 2:** Results for Mowing Different Types of Grass Using Solar

S/N	Sample Plot	Coverage Area (m <sup>2</sup> )	Battery Drop (V)	Time (s)	Grass Height (mm)
1	Carpet grass	16	0.23	300	470
2	Spear grass	16	0.3	600	130
3	Stubborn grass	16	0.35	900	600
4	Soft grass	16	0.22	1200	400
<b>Total</b>				3000	

**Table 3:** Results for Mowing Different Types of Grass Using Combustion Engine

S/N	Sample Plot	Coverage Area (m <sup>2</sup> )	Fuel Level (L)	Time (s)	Grass Height (mm)
1	Carpet grass	16	5.0	300	450
2	Spear grass	16	4.1	600	120
3	Stubborn grass	16	3.7	900	650
4	Soft grass	16	3.0	1200	420
<b>Total</b>				3000	



**Figure 6:** Battery drop and fuel level of the lawn mower after testing

It can be observed in Figure 6 that the fuel consumption drops over the time the mower was in operation and the change in the battery voltage over time does not change as the solar panel continues to receive solar energy to charge the battery. Also, with the use of a charge controller, the charging regulation was achieved.

The efficiency of the solar lawn mower designed and developed is 87% which is well above average and this is due to the power output of the electric motor which drives the blade attached to the shaft of the motor. The 100W solar panel can adequately charge the battery (40Ah), for approximately 5 hours, which is being regulated by the charge controller, however, the speed of the motor which is 3000rpm rotates the blade causing it to cut the grass until the battery completely discharges.



In comparison to work done by Akinyemi and Damilare (2020), Soyoye (2021), Tanimola et al. (2014), Madhav and Bhaskar (2015) and Mil'shtein et al. (2002), the cutting efficiency for different grasses were obtained as 85%, 70.50% to 84.10%, 93%, 64%, 81-84% respectively. The results of the present study have shown that the produced lawn mower is more efficient, with lower noise and with lower energy cost. And when is solar powered, no air pollution was caused as gasoline mowers produced a lot of noise and affected the environment.

#### 4. Conclusion

The development and performance evaluation of the hybrid-powered lawn mower highlight its effectiveness and environmental benefits. Powered by a 12-volt, one-horsepower DC motor connected to lead-acid batteries replenished via solar energy, the mower demonstrated commendable field efficiencies of 83% and 87% when operating on solar energy and a combustion engine. The result of this study has shown that combining two energy sources to cut grasses of different heights can be more effective and efficient. It also provides the option of choice in powering the mower when compared to the normal lawn mower powered by combustion engine only. Furthermore, it shows the advantage of switching between power sources when one is unavailable. This study affirms the viability of hybrid power systems in enhancing energy efficiency and reducing environmental impact, paving the way for further innovations in sustainable lawn care technologies.

#### References

- Amin, SB., Chowdhury, MI., Ehsan, SA. and Iqbal, SZ., 2021. Solar energy sustainability in Bangladesh: tackling the management challenges. In *Design, Analysis, and Applications of Renewable Energy Systems*, 705-734. Academic Press. <https://doi.org/https://doi.org/10.1016/B978-0-12-824555-2.00034-4>
- Dutta, PP., Baruah, A. and Konwar, A., 2016. A technical review of lawn mower technology. *ADB Journal of Engineering Technology*, 4.
- Qazi, S., 2017. PV systems affordability, community solar, and solar microgrids. *Standalone photovoltaic (PV) systems for disaster relief and remote areas*, 177-202. <https://doi.org/https://doi.org/10.1016/B978-0-12-803022-6.00008-3>
- Valavanidis, A., 2022. Global warming and climate change. Fossil fuels and anthropogenic activities have warmed the earth's atmosphere, oceans, and land. Hoboken, New Jersey, United States: Environmental Toxicology and Chemistry (ET&C) aligned with John Wiley & Sons. 1-42. [https://www.researchgate.net/publication/358498680\\_Global\\_Warming\\_and\\_Climate\\_Change\\_Fossil\\_fuels\\_and\\_anthropogenic\\_activities\\_have\\_warmed\\_the\\_Earth's\\_atmosphere\\_oceans\\_and\\_land](https://www.researchgate.net/publication/358498680_Global_Warming_and_Climate_Change_Fossil_fuels_and_anthropogenic_activities_have_warmed_the_Earth's_atmosphere_oceans_and_land)
- Patel, S., 2022. *Production of Multipurpose Agricultural Vehicle* (Doctoral dissertation, Rajasthan Technical University).
- Akinyemi, AO. and Damilare, AS., 2020. Design and fabrication of a solar operated lawnmower. *International Journal of Innovative Science and Research Technology (IJISRT)*, 5(10).
- Quaranta, E. and Davies, P., 2022. Emerging and innovative materials for hydropower engineering applications: Turbines, bearings, sealing, dams and waterways, and ocean power. *Engineering*, 8: 148-158.
- Dange, AR., Thakare, SK. and Rao, IB., 2011. Cutting energy and force as required for Pigeon pea stems. *Journal of Agricultural Technology*, 7(6): 1485-1493.
- Khurmi, RS., & Gupta, J.K. (2005). *A textbook of machine design*. S. Chand publishing.
- Akinyemi, SA., Adebayo, OF., Nyakuma, BB., Adegoke, AK., Aturamu, OA., OlaOlorun, OA., Adetunji, A., Hower, J.C., Hood, MM. and Jauro, A., 2020. Petrology, physicochemical and thermal analyses of selected cretaceous coals from the Benue Trough Basin in Nigeria. *International Journal of Coal Science & Technology*, 7: 26-42.



Sinha, Y. and Mathur, SM., 2020. Development and performance evaluation of solar powered lawn mower. *International Journal of Current Microbiology and Applied Sciences*, 9(5): 3378-3384.

Venkatesh, K., Priyanka, K., Sridhar, R. and Sakthivel, A., 2015. Fabrication and Analysis of Lawn Mower. *International Journal of Innovative Research in Science, Engineering and Technology*, 4(6): 606.

Soyoye, B., 2021. Development and performance evaluation of a solar powered lawn mower. *Turkish Journal of Agricultural Engineering Research*, 2(2): 348-362.

Mil'shtein, S., Teynor, W., Paquin, B., Deloge, T., Tran, Y. and Snoonian, R., 2002. *Solar-electric powered lawnmower with electronic minimization of energy consumption*. U.S. Patent Application 09/783,454.

Tanimola, OA., Diabana, PD. and Bankole, YO., 2014. Design and development of a solar powered lawn mower. *International Journal of Scientific & Engineering Research*, 5(6): 215-220.

Madhav, PH. and Bhaskar, HB., 2015. Development of Environment Friendly Manually Operated Rotary Lawn Mower. *International Journal of Engineering and Management Research (IJEMR)*, 5(1): 217-219.