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Design and Fabrication of Fertiliser Spreading Machine

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Abstract: Sugarcane is most widely grown crop in India due to rapid development in sugar industry in India. Sugarcane is grown on around 2.8% of gross cropped area of India. To achieve good yield of sugarcane crop use of fertilizers is obvious. Fertilizers provide plants with the essential chemical elements needed for growth particularly nitrogen, phosphorus and potassium. Solid chemical fertilizers are one of important sources for plant nutrition they provide the plant with important nutrients needed for growth during the periods of its growing life, and also it works to improve the properties of soil (soil structure and the degree of acidity).

The objective of this invention is to provide a simple and inexpensive fertilizer spreader, in a form of a 'walk-behind' device which may be easily and quickly pushed by the farmers for spreading solid fertilizers like urea. This is a type of spreader which can be operated manually for spreading granular materials in farms especially for solid fertilizers like urea. When the vehicle is pushed, motion is transferred from rear axle wheels which in turn transmits rotational motion through sprocket (mounted on rear axle) and chain mechanism which in turn rotates second sprocket connected to a shaft having screw conveyor at both the ends. This rotation of screw conveyor will discharge the fertilizer which is supplied through a hopper acting as storage tank.

Keywords: Sugarcane, Cultivation, Fertilizer spreading, Sugarcane plantation, Fertilizer mechanism, Screw conveyor, Ridge and furrow.

I. INTRODUCTION

From years ago the majority of Indian population depends on agriculture. Even today around 61.5% of rural Indian population depends on agriculture for their bread and butter. Agriculture always play an important contribution in the GDP of India (currently 17.9% of GDP).

Tropical region shared about 45% and 55% of the total sugarcane area and production in the country, respectively along with the average productivity of 77 t/ha (2011-12). Sub-tropical region accounted for about 55% and 45% of total area and production of sugarcane with an average productivity about 63 t/ha (2011-12). The tropical sugarcane region consists of sugarcane agro climatic zone 4 (Peninsular zone) and 5(Coastal zone) which includes the states of Maharashtra, Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Madhya Pradesh, Goa, Pondicherry and Kerala.

Sugarcane is most widely grown crop in India due to rapid development in sugar industry in India. Sugarcane is grown on around 2.8% of gross cropped area of India. India produced around 350 million tons of sugar in 2013-14. To achieve good yield of sugarcane crop use of fertilizers is required. Fertilizers provide plants with the essential chemical elements needed for growth particularly nitrogen, phosphorus and potassium. Solid chemical fertilizers are one of important sources for plant nutrition, due to its low price compared to liquid chemical fertilizers, they provide the plant with important nutrients needed for growth during the periods of its growing life, and also it works to improve the properties of soil (soil structure and the degree of acidity). Especially in poor soil, need of fertilizer application to save main elements for increasing yield and quantity of crops is high.

Nutrient concentration in soil (for sugarcane)		
Sr. No.	Nutrient	Critical levels (ppm)
1	Fe (non-calcareous soil)	4.2
2	Fe (calcareous soil)	6.3
3	Zn (Loamy soils)	1.2
4	Zn (Clay soils)	2.0
5	Mn	2.0
6	Cu	1.2
7	Hot water soluble-B	0.44

Fertilizer spreader is the technology with an updated system of spreading fertilizer for best results. While the traditional method of spreading fertilizer with hands eases more laborious, time consuming and health hazardous, this modern method designed by us is less time consuming and more comfortable and also it does not present any threat to health.

II. DIFFERENT TYPES OF FERTILIZER SPREADER

There are different types of spreaders we can utilize to fertilize the farm. Some of them are as follows:

A. Handheld spreaders
B. Drop Spreaders
C. Rotary Fertilizer Spreader
D. Liquid Fertilizer Spreader

III. LITERATURE REVIEW

There are different researchers who invented different types of fertilizer spreading machines. They publish their papers and the papers published are given below:

Chaudhari et. al [1] studied the sugarcane plantation in India and need of an alternative to the traditional as well as tractor operated fertilizer spreading machine. In India near about 70% people of our country are farmers. Due to these reasons the author developed the machine which has minimal capital cost compared to traditional fertilizing equipment. Laghari et. al. [2] focuses on beneficial uses of fertilizer in agriculture. Soil contains various micro and macro elements which are essential for plant growth and yield. It is necessary to save important nutrient elements like nitrogen, phosphorus and potassium by application of chemical fertilizers. For certain situations broadcast applications can be an inefficient method of application because there is much greater soil to fertilizer contact in more fixation or tie-up of nutrient. Narode R. R et al. [3] have generated a method to spread the fertilizer uniformly over a fallow land by dropping the fertilizer over the impeller disc. The system consists of a three wheels, two at the front and one at the back. These two wheels at the front are used to impel the fertilizer. The two hoppers are used to store the fertilizer; these hoppers are placed at some height from the wheel axle so that the fertilizer falls on to the impeller. The hopper is provided with flow control mechanism. In fertilization, the flow maintenance is necessary. Generally, every crop should get sufficient amount of fertilizer. This condition is satisfied by Spring Mechanism.

Kweon & Grift [4] have proposed a method which employs control of the drop location of fertilizer particles on a spinner disc to optimize the spread pattern uniformity. The system contained an optical sensor as a feedback mechanism, which measured discharge velocity and location, as well as particle diameters to predict a spread pattern of a single disc. Das et al. [5] have done a review of different fertilizer and pesticide spreaders. Author has sought attention towards growing population in India which is projected to be 1.6 billion in next few years. He also emphasizes that 73% of population is in Agricultural sector and out of that 65% farmers are small land and marginal farmers. In this he has discussed various types of spreaders and pesticides like Backpack sprayer, Lite-Trac, Motorcycle Driven Multi-Purpose Farming Device, Aerial Sprayer and their advantages & disadvantages. Joshua et.al [6] have worked on solar operated pesticide sprayer. Most of the increase in the area of irrigated land in the world has been through the increasing use of engine-driven pumps. However, the increasing price of oil-based fuel has reduced the margin to be gained by farmers from irrigation, since food prices have generally been prevented from rising in line with energy costs.

Adamade et al. [7] worked on mechanization is recognized as the necessary major means needed to accelerate agricultural production and create a period of surplus in Nigeria. Indeed, food sufficiency can only be attained in Nigeria by encouraging and promoting local designs and manufacture of implements and equipment at low cost. We have taken the useful data from this research paper. Kishore et al. [8] described various machineries present in sugarcane farming such as Mechanized land preparation in which animal or power driven vehicles or tractors are used. Kshirsagar et.al [9] have created a Multifunctional Agricultural vehicle which can perform many operations such as seed bowing, fertilizer spraying and grass eruption from roots. Small-size farms are a huge issue in mechanization because it is against of the “economics of scale”. These problems are classified into technological constraints, financial and economic problems, and environmental issues. Focuses on the basic problems faced by fellow farmers i.e. Seed sowing, fertilizers spraying and grass eruption.

Mada et.al [10] have mentioned importance of mechanization in agricultural by giving examples. The conclusion from the paper was need of a cheap and simple vehicle for ease of different processes in farm. Vignesh et.al [11] have draws attention towards incredible changes that have arisen in conservative methods of agriculture like seed plantation, irrigation system, pesticides and spray castoff. For emerging our monetary condition, it is obligatory to upsurge our agricultural production and superiority also.

Bhojane et. al [12] have designed a manually operated machine for fertilizer spreading by taking into consideration the user group & their needs. The project design divided in to three level, top level, middle level, bottom level. Top level consists a hopper. Middle level consist a gear arrangement, chain drive and spreader disc. The bottom level consists wheel. they have taken help of this to understand how mechanization can solve the problem and what can be done more so that mechanization is possible for every farmer.

IV. PROBLEM IDENTIFICATION

There is an urgent need to mechanize the agricultural operations (use machines to carry out basic agricultural practices like irrigation, weeding, fertilizing etc.) as it increases the production and decreases the wastage of labor force.
Present machineries available are costly and not useful for small scale farmers.

V. THEORY AND DESIGN

A. Introduction

It includes design of hopper for different farm sizes, design of different components such as bearing, screw conveyor and shaft. We calculated amount of fertilizer required for a single furrow and designed the capacity of hopper for a complete travel of machine. Also found out different forces acting on chassis and designed rear axle accordingly.

B. Flowchart

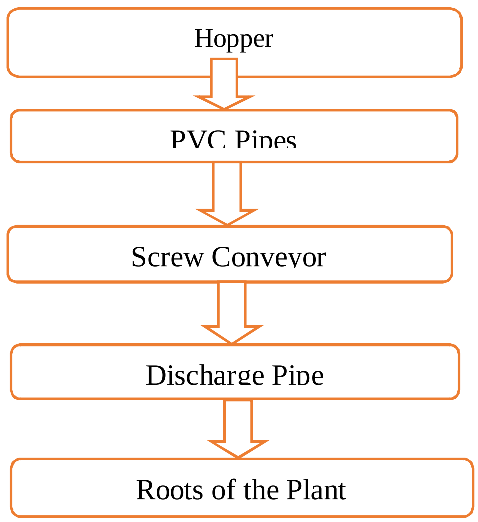

Figure 3.1 Flowchart of Flow of Fertilizer

Hopper has capacity to store 20kg of fertilizer. Urea or any other solid fertilizer is stored in hopper. When vehicle is pushed, the fertilizer will flow through pipes from two holes provided in hopper under gravity. This fertilizer then passes through screw conveyor and two discharge pipes provided. This two pipes can be adjusted so that fertilizer falls at the roots of crops.

VI. DESIGN CALCULATIONS

A. Design of Hopper

Considering 1 acre of land, 1 acre = 4046.85 m^2.
Around 200 kg fertilizer is required for 1 acre of land.
After leaving 2 feet border at left, top and bottom side of land,
1 side is = 206.694 feet, another side = 204.694 feet.
Now, consider 1 division = 4 feet.
Out of which 1 foot consists of sugarcane buds on both the sides and remaining 3 feet is a gap for another row.
Number of divisions = 206.694/4 = 51.67, considering it as 50 divisions.
50 divisions consume 200 kg of fertilizer.
Consumption of fertilizer of 1 division = 200/50 = 4 kg on one side
So, for both the sides it consumes 8 kg of fertilizer.

For one successful to and fro journey of vehicle hopper should contain 16 kg of fertilizer. So, hopper should at least contain 16 kg of fertilizer. Hence, designing hopper for 20 kg.

Density of fertilizer = 1335 kg/m^3. Mass = 20 kg.

Volume = mass / density = 20/1335= 0.01 m^3.

∴ Volume of hopper = ½× (a+b) ×h ×l

By trial and error method we get the dimensions as

a = 0.25 m, b = 0.20 m, h = 0.20 m, l = 0.30 m.

∴ Volume of hopper = ½× (0.25+0.20) ×0.20×0.30 = 0.01 m^3

∴ We choose the above dimensions for hopper.

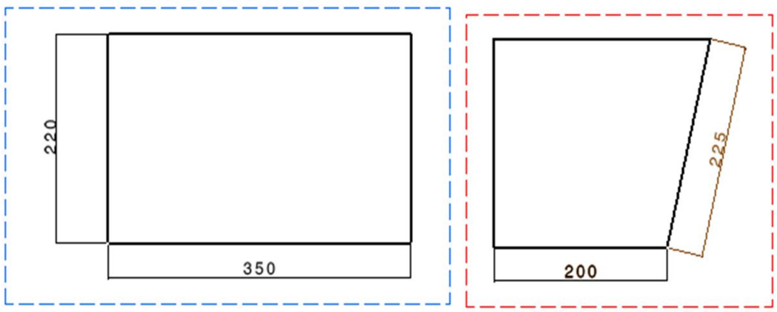

Fig. 3.2 Draft Drawing of Hopper

B. Design of Rear axle

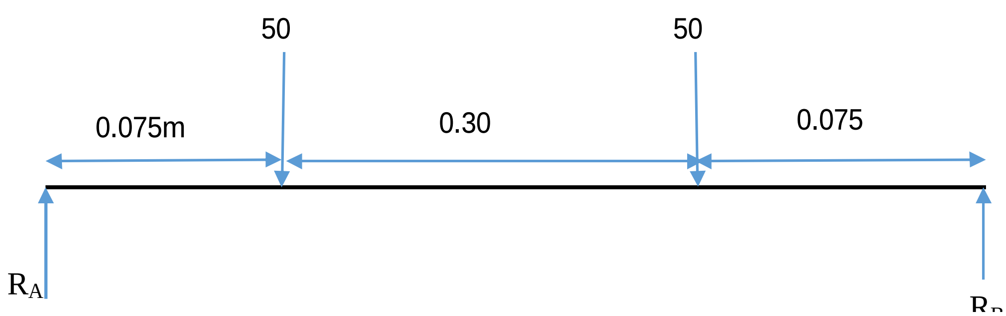

Fig. 3.3 Load Diagram

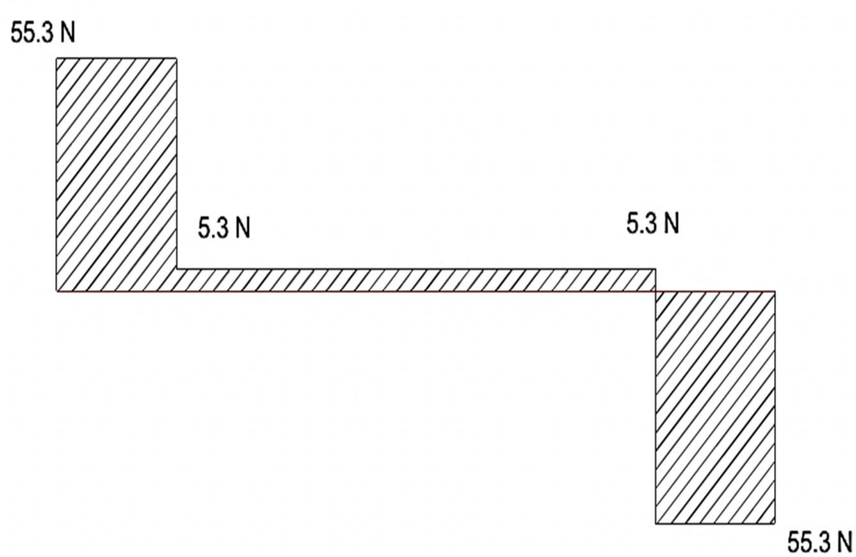

Fig. 3.4 Shear Force Diagram

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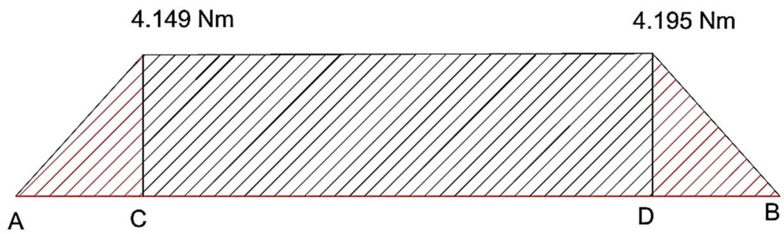

Fig. 3.5 Bending Moment Diagram

B.M. at point A = 0 Nm
B.M. at point C = 4.149 Nm
B.M. at point D = 4.195 Nm
B.M. at point B = 0 Nm
Max. Bending moment = 4.195 Nm
$T_{max} = 0.30\ S_{yt}$
$T_{max} = 0.18\ S_{ut}$
Considering medium carbon steel 30C8 (S_{yt} = 400 N/mm^2)

τ_{max} = 0.30 ×400 = 120 N/mm^2 = 120×10^6 N/m^2 (kb=1.5 & kt=1)

$$\tau_{max} = \frac{16}{\pi d^3} \times \sqrt{[k_b \times M_b]^2 - [k_t \times M_t]^2}$$

∴ d = 0.013 m
Taking factor of safety = 2, d = 0.026 m
Power = f × v = 40 × 9.81 × 0.81 = 0.317 kw
Torque = f × r = 40 × 9.81 × (0.35/2)
Torque = 68.67 Nm
P = (2π N_1 T)/ (60×1000)

N_1 = [P×60×1000]/ [2π ×T]
= [0.317×60×1000] / [2π ×68.67]
N_1 = 44.13 rpm
Now, i=3
(Z_1 / Z_2) = (N_2 / N_1)
(45 /15) = (N_2 /44.13)
N_2 = 132.598 rpm

C. Discharge from Screw Conveyor

Considering one side of screw conveyor
Capacity of screw is given as,
Q = 60 × (π/4) ×d^2×N×c×ϱ×ψ×s
Where, d = nominal diameter (m)
N = rpm of screw (rpm)
10 = 60×(π/4)×d^2×132.598×0.15×1335×1×0.025
By solving we get,
d = 0.017 m (taking it as 2 cm)
Calculating for full opening of the discharge pipe,
Now, length of 1 division is 206.694 feet = 62.43 m.
Diameter of wheel = 0.35 m.
Distance covered by one rotation of wheel = Circumference of wheel = π×0.35 = 1.099 m.

Discharge from screw conveyor = (π/4) × (D^2-d^2) ×pitch = (π/4) × (0.035^2-0.016^2) ×0.025 = 1.902×10^{-5} m^3/rev of screw conveyor (one side)

Discharge from both sides of screw conveyor = 2×1.902×10^{-5} =$3.804\times10^{-5}$$m^3$/rev of screw conveyor.

But, 1 rotation of wheel = 3 rotations of screw conveyor.

Discharge through screw conveyor for 1 rotation of wheel = 3×3.804×10^{-5}

=$1.14\times10^{-4}$$m^3$/rev of wheel.

∴ Mass flow rate = density × volume = 1335×1.14×10^{-4}

= 0.152 kg/revolution of wheel.

1 rotation of wheel will cover around 1 m.

So, 62 m will be covered in 62 revolutions of wheel.

∴ Fertilizer spread for 1 division = 62×0.152 = 9.424 kg

So considering the fertilizer required is around 10 kg.

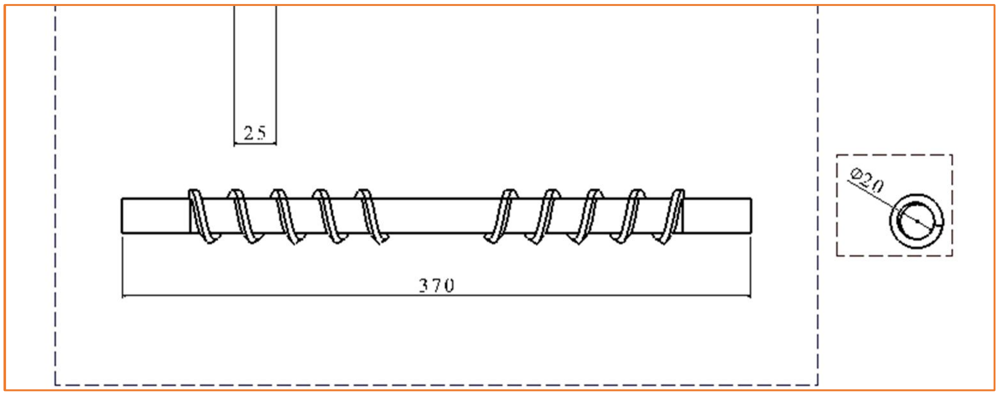

Fig. 3.6 Draft Drawing of Screw Conveyer

D. Design of Chain Drive

Selecting 08B chain number as they are used in bicycles

Now, for 08B

(08/16)×25.4 mm

i.e. P= 12.7mm = 0.0127m

a = center distance between axes of driving and driven sprockets

a = $(v^2 + h^2)^{(1/2)}$ = $(0.292 + 0.30^2)^{(1/2)}$ = 0.4172 m

Assuming, 45 teeth on driving sprocket on rear axle, Z_1 = 45

∴ D_1 = 18.2 cm.

15 teeth on driven sprocket on conveyor shaft, Z_2 = 15

∴ D_2 = 6.5 cm.

Velocity ratio = Z_1 / Z_2 = 45/15 = 3

Now, number of links of chain is given as,

$$L_n = 2(\frac{a}{p}) + [\frac{(Z1 + Z2)}{2}] + [\frac{Z2 - Z1)}{2}]^2 \times (\frac{p}{a})$$

Where,

a = centre distance between axes of driving and driven sprockets

Z_1 = number of teeth on the bigger sprocket

Z_2 = number of teeth on the smaller sprocket

L_n = 2(0.4172/0.0127) + [(45+15)/2] + $[(45-15)/2]^2$ × (0.0127/0.4172) = 102.549

Since number of links for chain should be even.

L_n = 102

a_c = corrected centre distance

$a_c = (p/4) \times \{[L_n - (Z_1 + Z_2)/2] + \{[L_n - (Z_1 + Z_2)/2]^2 - 8\times [(Z_2 - Z_1)/2]^2 \}^{(1/2)} \}$

$= (0.0127/4) \times\{[102 - (45 + 15)/2] + \{[102 - (45 + 15)/2]^2 - 8\times [(15 - 45)/2\pi]^2 \}^{(1/2)}\}$

= 0.4531 m.
L_n = 102 links
Chain length (L) = $L_n \times P = 102 \times 0.0127 = 1.295$ m.

E. Design of Bearings

Radial forces acting on bearing, $F_R = 196.2$ N
The thrust/axial load on the bearing, $F_A = 0$ N
Now, Equivalent Bearing Load (P) = $XVF_R + YF_A$
Where, P = equivalent bearing load
X & Y are radial and thrust factors respectively
Since the load acting on the bearing is purely radial load, hence the equivalent bearing load, $P = F_R = 196.2$ N
The relationship between life in million revolutions and life in working hours is given by,
$L_{10} = (60 \times n \times L_{10h}) / (10^6)$
Where, L_{10h} = Rated bearing life (hours)
n = Speed of revolution (rpm)
$L_{10} = (60 \times 132.598 \times 10000) / (10^6) = 79.55$ million rev.
Dynamic load capacity (C) = $P \times (L_{10})^{1/3}$ …………for all types of ball bearings
$= 196.2 \times (79.55)^{1/3} = 843.843$ N
Based on the above calculations the bearing specification are as follows
Housing number = P204, Bearing number = UC204-12, Shaft size = 20 mm,
Bolt size = M10 3/8 in, Weight = 0.66 kg

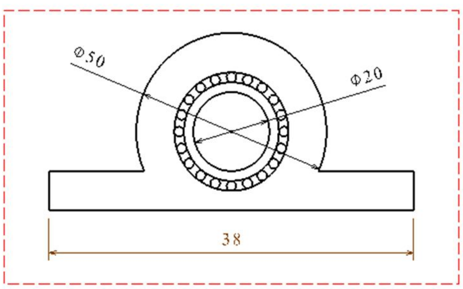

Fig. 3.7 Draft Drawing of Bearing

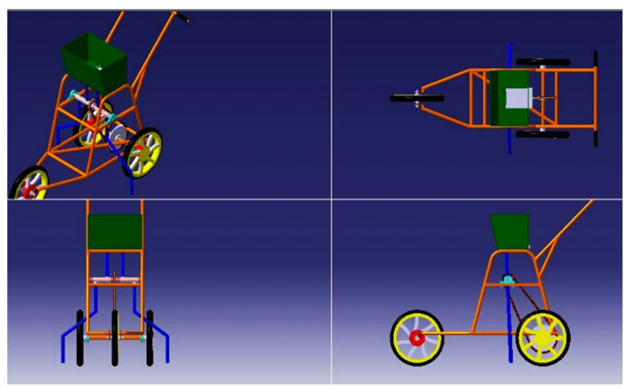

Fig. 4.7 Multi-views of Assembly

VII. RESULTS AND DISCUSSION

Fig. 6.2 Testing of Machine

A. Result

Measuring the discharge of fertilizer,

The spreader tested varied in its shape of hopper drawer opening at different application rates. Considering the square shape of field and 200 kg/ac of fertilizer we got further outcomes.

1) *Full valve opening:* At full valve opening of hole we get discharge of 0.152 kg/rev of wheel.
2) *Half valve opening:* At half valve opening of hole we get discharge of 0.076 kg/rev of wheel.
3) *Quarter valve opening:* At quarter valve opening of hole we get discharge of 0.038 kg/rev of wheel.

B. Discussion

It is important when spreading fertilizer that a spreader can achieve a consistent level of performance at various application rates whilst driving at a specific about width. It is shown from this study that for different capacity we can achieve various discharge rates. With variation in plantation methods, we collected various data. The tested spreader has 50 cm rear width and 82.5 cm length. It can be used for 3 different plantation method. The result obtained from multiple testing varied significantly from above results.

Result shows that for different plantation, discharge of fertilizer required is not the same. There is no consistency between plantation methods, so the product can be used for all methods.

VIII. CONCLUSION

The need of economically weaker farmers will be satisfied by the manually operated fertilizer spreader and they can effectively meet the nutritional requirements of soil with help of this machine. Present project results in the increase in uniformity of fertilizer spreading, good crop yield, and reduction in time required to spread, less human fatigue, minimum use of fertilizers and less waste at less cost as compared to current available machines.

This product is also different from other machines mainly because of its simple design. We have used only screw conveyor for discharge unlike gear assembly used in available machines in market. This has effectively reduced cost and increased efficiency.

IX. FUTURE SCOPE

In the future we can research and develop the project as follows:

A. Better control of discharge of fertilizer can be achieved by using flow control valves such as ball valve, butterfly valve, etc.

B. As of now, it is manually operated, it can be made power driven by attaching a small battery or can be made solar operated.

C. The volume capacity of hopper can be increased so that it covers larger area with minimum refill requirement, without increasing weight of machine.

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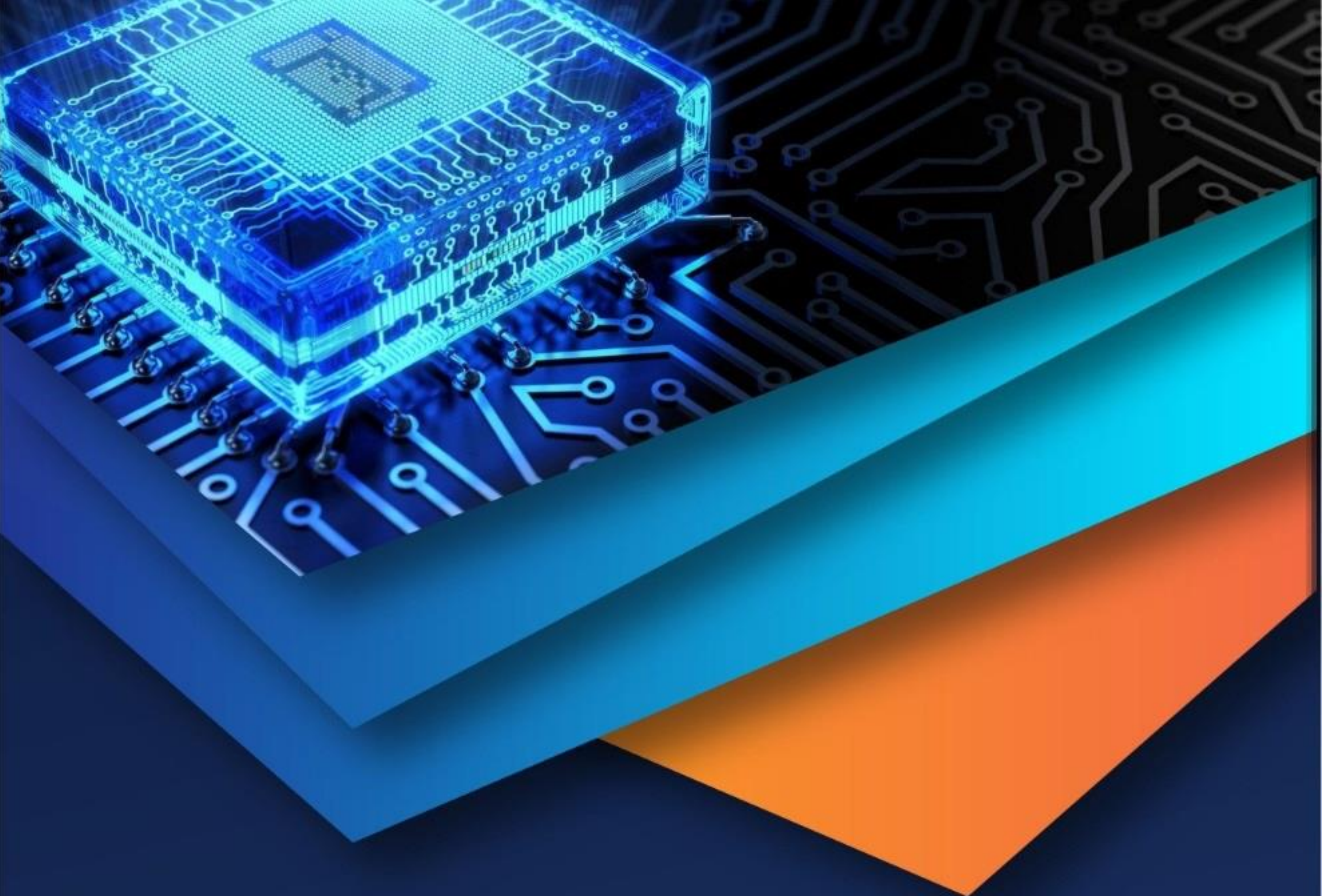

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