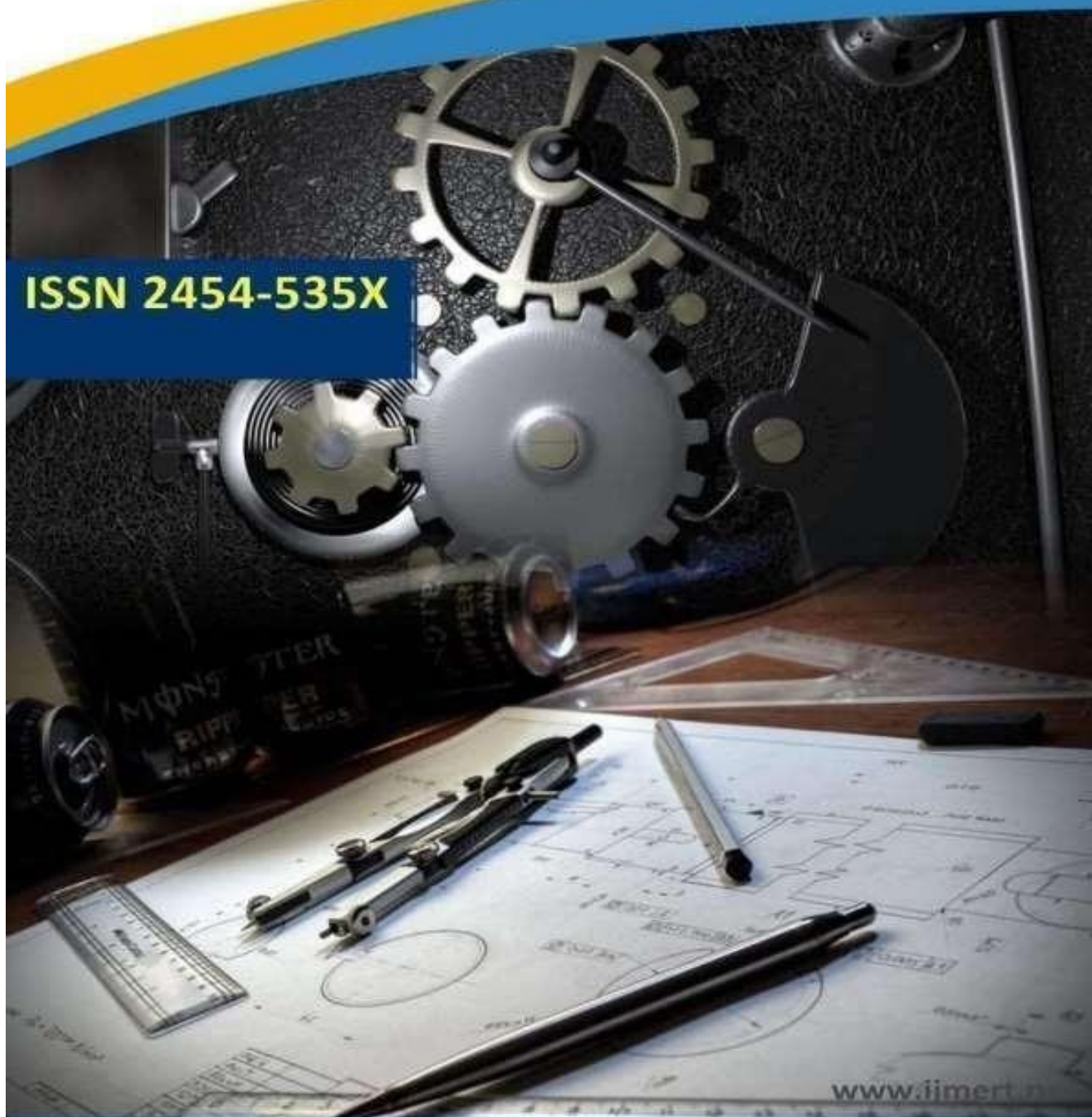




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A Crop Cutter for Pearl Millet Made with the Help of the Scotch Yoke Mechanism

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ABSTRACT

This study outlines the proposed design of a crop cutter for pearl millet that makes use of the Scotch Yoke mechanism for accurate and efficient cutting. To slice millet stalks with ease and consistency, the Scotch Yoke mechanism transforms rotating action into reciprocating motion. To achieve efficient cutting with little energy input, the design optimizes critical variables such as blade curvature, bevel angle, and material selection. An affordable and practical alternative for small-scale millet harvesting, the design prioritizes simplicity, cost-effectiveness, and ergonomic usage. With any luck, this effort will help mechanize millet harvesting, which will increase productivity while decreasing the need for human labor.

Scotch Yolk Mechanism, Millet Cutter

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I. INTRODUCTION

Pearl millet, or bajra (*Pennisetum glaucum*), is a vital crop in dry and semi-arid climates throughout the globe, including India. For millions of people, especially in rural regions, this drought-tolerant grain is an essential source of food and livestock, and it also helps keep economies stable. Bajra grows well in arid climates and is hence mostly grown in states like Gujarat, Uttar Pradesh, Rajasthan, and Maharashtra. A major participant in the food and agricultural sectors, the crop is essential for human consumption and also plays a significant role as a feed for cattle. Despite its significance, bajra harvesting poses a number of obstacles, prompting research into more efficient and economical ways of cutting the crop. Manual labor is a major component of traditional bajra cutting procedures. Workers use sickles to manually cut the mature plants. Though successful, this labor-intensive procedure is becoming more troublesome as a result of growing labor prices, a scarcity of agricultural laborers, and the general physical strain it causes on those engaged in the harvest. Careful handling is required while cutting bajra plants due to their bushy shape and normal height of 3 to 4 feet. Conventional cutting equipment have a hard time navigating the plant's thick, lengthy stems and rough leaves, which causes wasted time and energy. Many small farmers are struggling to keep up with the rising cost of labor, which makes it difficult for them to hire enough people to harvest their crops effectively. This causes harvest delays, which in turn affects the quality and production of their crops.

Mechanization has arisen as a possible answer to these increasing problems. Unfortunately, small-scale farmers cannot use the currently available crop harvesting machinery, including combine harvesters, since they are not built for bajra. These devices are bulky, costly, and often have too much power for the bajra plant's small and bushy stature. The major objective of this study is to address the demand for a cutting machine that is more suitable for bajra crops in terms of accessibility, affordability, and efficiency. We suggest creating a bajra cutting machine that uses a Scotch Yoke mechanism, a device that can transform rotational motion into linear motion, for better control and efficiency. Making a machine that small-scale farmers may afford while simultaneously increasing harvesting efficiency and decreasing reliance on manpower is the main objective. Using sickles or other manual equipment, bajra is traditionally harvested by hand. Although this procedure yields good results, it is very labor-intensive and demands a large number of workers, particularly during the harvest season. The first step is to chop the bajra.

gather the plants at the roots, then stack and bundle the stalks that have been picked. This approach has been around for a long time, but it has a lot of problems that are becoming worse as the price of labor becomes higher and fewer people willing to work in agriculture are available. When cutting bajra, one of the most difficult things is figuring out when to harvest. For the best grain quality, bajra has to be harvested at the correct time of maturity. The grains could fall off the plant and spoil if harvesting is postponed. Also, since the bajra growing season isn't very long, it takes a lot of people working for a short amount of time to harvest the crop. It is common for farmers to have trouble finding enough workers during this critical period, which may cause further delays and crop failure. Physical exertion is an additional obstacle. Bending, kneeling, and wielding sharp sickles are all part of bajra harvesting, which may be physically demanding and risky. This already challenging chore becomes much more so for farmers who are getting on in years or who are short on labor. The first figure depicts a laborer chopping bajra.



Fig A Laborer Cutting Bajra (*Pennisetum glaucum*) Crop Manually

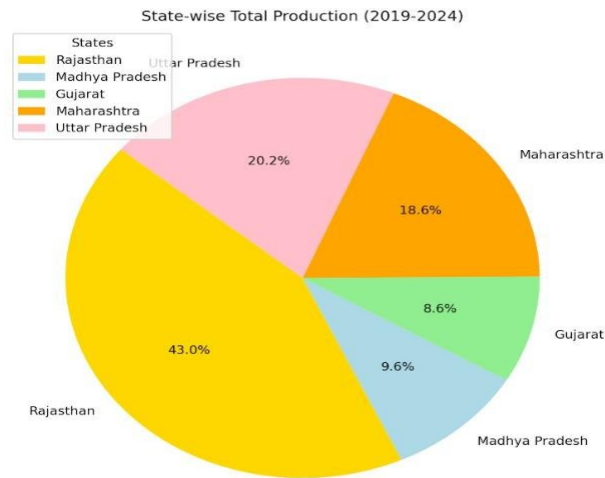


Fig 2. State-Wise Bajar Production in Last 5 Years (In Lakh Tons)

Additionally, with the growing labor shortage, hiring workers has become increasingly expensive. Small farmers often find that the money they spend on labor costs cuts into their overall profits, sometimes leaving them with minimal financial returns after the harvest. In light of these challenges, mechanization offers a potential solution to reduce labor dependence and increase efficiency.

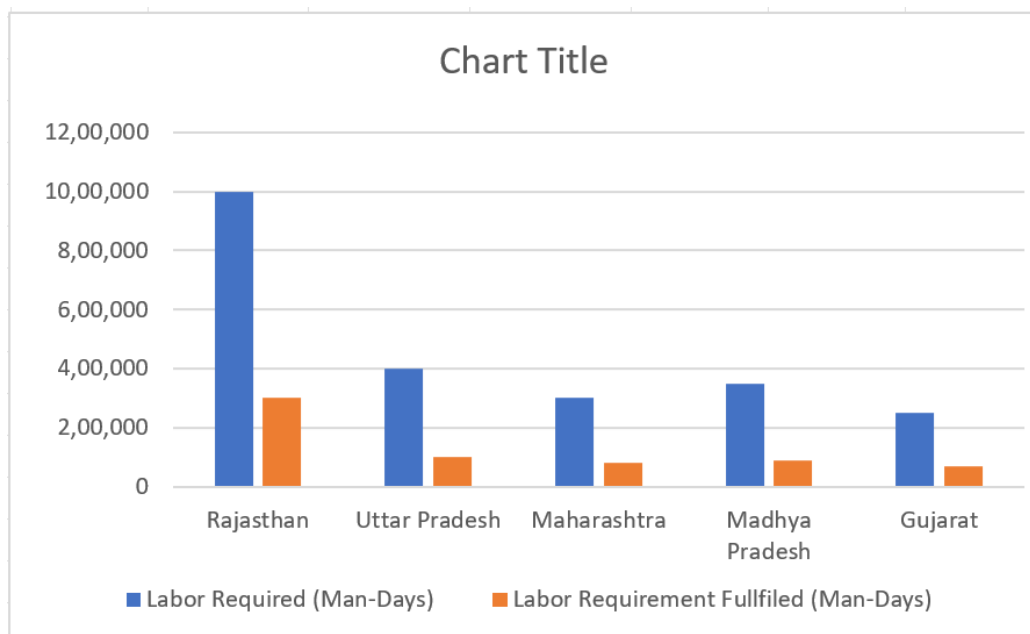


Fig 3. Labor Shortage State-wise In Last 5 Years



But for many small-scale farmers, the prohibitive cost of big gear is a major obstacle. This highlights the obvious need for bajra-specific, smaller, less expensive cutting equipment. Farmers may save time, effort, and money by switching to a bajra cutting machine that uses a simple Scotch Yoke mechanism. This makes harvesting more easier and safer. In order to get a better understanding of the difficulties small-scale bajra farmers have with the present harvesting techniques, a survey was carried out among them in important growing locations. During harvest season, many farmers struggle to locate enough laborers, and labor shortages were mentioned as the top worry by over 70% of farmers. Farmers also said that paying employees took a sizable chunk out of their crop profits due to the high cost of labor. Half or more of those who took the survey said that after paying for labor and other expenditures, their earnings were much lower than expected, making it impossible for them to make a living off of bajra farming. Traditional cutting techniques were also shown to be inefficient in the study; for example, farmers complained that hand harvesting was laborious and taxing on their bodies. More than 60% of those who took the survey would use automated systems if they were feasible and inexpensive for local businesses. When designing a cutting machine for bajra, it is important to take into account the many mechanical forces at work. Cutting bajra stems requires a certain amount of power, which is in turn determined by the plant's material features, such as its height, growth pattern, and stalk thickness and toughness. In order to break the bajra stem without harming the plant's grains or leaves, you need to use enough cutting power. Two main forces, shear and normal, are produced during the cutting procedure. The shear force slices through the bajra stalk, while the normal force gives the blade the pressure it needs to interact with the plant efficiently and operates perpendicular to the cutting surface. Optimizing these forces is greatly influenced by the mechanical advantage of the machine's cutting mechanism, which includes characteristics like blade sharpness, material strength, and the angle of attack. A creative solution is required to address the problems associated with bajra harvesting, which include a lack of available workers, exorbitant prices, and inefficiency. In response to these difficulties, we suggest a bajra cutting machine that will use a Scotch Yoke mechanism to cut bajra more efficiently and cheaply than human hands. This equipment may greatly enhance the harvesting process for small farmers by comprehending the pressures and power needs of bajra cutting and integrating comments from local farmers. In the parts that follow, we'll take a closer look at the suggested machine's architecture and features, as well as its possible advantages,



as well as how it might make bajra cultivation more profitable by cutting down on labor expenses and increasing efficiency.

Table 1 State Wise Agriculture Labor Daily Wages- per day

State/Union Territory	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Andhra Pradesh	216.9	213.3	249.1	269.5	282.0	301.3
Assam	200.6	215.7	229.3	237.5	248.5	252.2
Bihar	198.9	207.1	212.7	223.0	240.3	257.3
Gujarat	160.0	177.6	184.0	187.9	199.3	208.4
Haryana	340.1	352.7	359.3	361.4	391.9	391.8
Himachal Pradesh	308.9	317.3	339.8	368.3	388.6	418.4
Jammu & Kashmir	367.7	394.5	409.8	436.0	443.6	452.9
Karnataka	205.1	228.3	251.9	267.3	288.7	291.8
Kerala	575.1	608.8	644.0	659.8	682.4	700.7
Madhya Pradesh	150.5	160.4	173.1	191.3	196.3	198.1
Maharashtra	196.7	195.9	196.8	207.4	213.7	230.7
Meghalaya	174.7	212.4	221.4	225.0	229.5	231.3
Odisha	180.0	191.3	208.7	222.6	227.4	232.1
Punjab	284.1	305.3	319.3	324.6	337.7	348.7
Rajasthan	269.9	285.2	285.5	287.1	292.9	297.6
Tamil Nadu	334.3	357.0	378.7	385.9	398.7	410.0
Tripura	209.4	209.6	225.0	270.0	270.0	270.0
Uttar Pradesh	191.9	199.6	211.8	229.8	247.1	257.7
West Bengal	216.0	220.2	237.6	255.9	263.1	267.2
All India	224.6	236.9	252.6	267.1	277.4	286.6

Source: Labour Bureau, Government of India.

II. RECENT INVESTIGATIONS IN AGRICULTURAL SECTOR

First, agricultural mechanization has greatly improved harvest efficiency, decreased labor expenses, and increased production; it is now an essential part of contemporary farming operations. The multi-crop cutter, reaper-binder, and reaper have all found extensive use among mechanized farmers because to their versatility and capacity to manage massive harvests in a variety of crop situations. A number of research conducted over the years have helped these machines get better by assessing their performance, improving their design, and finding ways to make them more cost-effective. Other studies, like Kumar et al. (2021) [9] and Tafa et al. (2021) [4], have highlighted the significance of machine modifications for improving operational efficiency and reducing costs. Jun et al. (2023) [1] and Halde et al. (2024) [7] have offered insights into the design and performance of reapers and reaper-binders. In areas where smallholder farmers may reap significant advantages from automation, these endeavors help create a more sustainable and efficient agricultural economy. Research on reaper-binders, which include the harvesting and binding of crops into a single operation, has been an important topic of study. Field research Researchers Tafa et al. (2021) [4] and Kumar et al. (2021) [9] evaluated the efficacy of wheat



harvester-binders and found that they improved operational efficiency and cost-effectiveness. Research in countries like India and Ethiopia has shown that smallholder farmers have benefited greatly from automation, which has reduced their labor needs. By analyzing the fuel consumption and economic feasibility of reaper-binders, Tafa et al. (2021) [4] investigated the possibility of increasing mechanical wheat harvesting in Ethiopia. The use of multi-crop cutters is another significant development in mechanical harvesting. Researchers Pisal et al. (2023) [18] and Halde et al. (2024) [7] sought to develop and manufacture agricultural multi-crop cutters that could harvest millet, wheat, and rice, among other crops. Research like this shows how versatile these devices are in the agricultural sector, where they may boost productivity while cutting down on the requirement for a wide variety of specialist equipment. In a similar vein, Lammari et al. (2022) [16] investigated agricultural cutters that used a four-bar mechanism, shedding light on the best cutting angles and speeds for more efficient harvesting.

Also, reaper-binders' mechanical performance and crop cutting efficiency have been studied at length. In their evaluation of reaper-binders' cutting efficiency, Kumar et al. (2021) [9] discovered that changes to the feed mechanisms and cutting blades had a substantial impact on the overall performance. Cutting speed, fuel efficiency, and residue handling were some of the aspects taken into account in the assessment. Small adjustments, according to their research, might significantly boost harvesting efficiency, particularly in barley and wheat fields. Crop residue management is playing an increasingly essential role in the evolution of agricultural production systems. Global improvements in agricultural residue management equipment were examined by Zhang et al. (2021) [15] and McHugh et al. (2021) [15], highlighting the increasing need to deal the by-products of mechanical harvesting. Based on their findings, reaper-binder machines that include residue management systems improve soil health and reduce field residue, two factors that contribute to sustainable agriculture. The use of mechanical harvesters is also heavily influenced by environmental and economic factors. In their comprehensive analyses of the expenses, fuel consumption, and labor savings related to the use of reaper-binders, Bhatia et al. (2020) [6] and Ghosh et al. (2019) [6] determined that mechanical harvesting systems are economically viable. Labor savings, greater productivity, and decreased post-harvest losses may more than cover the expensive cost of these equipment, according to these research. For example, reaper-binders were shown to save labor expenses by almost half and harvesting time by 30%, according to Kumar et al. (2020) [9], making them a



financially feasible option for farms with medium to large-scale operations. Pearl millet and fodder bajra are two crops that have recently been the subject of extensive study on the effects of nitrogen and cutting management on crop development and output. Two studies that looked at how different amounts of nitrogen and cutting methods affected crop production and quality were Kumawat et al. (2022) [8] and Anoohya et al. (2021) [19]. Improving the total productivity of mechanical harvesting systems may be directly impacted by these research' useful insights into optimizing nitrogen utilization in fodder crops. Maximizing the usefulness of equipment is possible for farmers by boosting crop quality and quantity via improved management procedures.

It is also important to focus on developing portable reapers and multi-purpose agricultural machines. Recent developments in cutting head design have made portable reapers more efficient and versatile, according to research on these equipment conducted by Mohammadi Baneh et al. (2022) [2]. These innovations are particularly relevant to rice harvesting and have the potential to benefit smallholder farmers. In areas where land fragmentation and labor shortages are major problems, these upgrades are crucial. Improvements in efficiency and functionality have been brought about by recent innovations in agricultural technology, especially for crop harvesting. Improvements in crop residue management systems, multi-crop cutters, and reaper-binders have all been created recently. These advancements play a crucial role in changing farming methods, especially in the South of the world. Improving machine performance relies on crucial elements including nitrogen management, lowering efficiency, and finding designs that are cost-effective. The need for environmental sustainability, the increasing demand for automation in food production systems, and workforce shortages are some of the current agricultural difficulties that must be addressed by the continuous progress of these technologies.

III. METHODOLOGY

1) Problem Statement

To design a crop cutter using a Scotch Yoke mechanism with the provided data, considering Factor of Safety (FoS) = 6 and following design failure criteria, we will calculate and dimension each component. Here's the step-by-step solution:



2) Material Selection

- **Material:** High-carbon steel grade EN9 (C45) with a carbon content of 0.8%.
- **Raw Material Form:** Steel sheets or bars are procured in the required thickness (2–5 mm for crop cutter blades).

High Carbon Steel EN9 is a viable material for the construction of blades used in bajra (pearl millet) crop cutting tools. This suitability is primarily attributed to several key properties of EN9 steel:

1. **Hardness:** EN9 exhibits a Rockwell hardness of 20-25 HRC, providing the wear resistance necessary for cutting applications. This hardness ensures that the blade maintains its sharpness and durability during prolonged use in field conditions.
2. **Tensile and Yield Strength:** The material demonstrates a high Ultimate Tensile Strength (UTS) of 600-850 MPa and Yield Strength (YS) of 370-570 MPa. These properties allow the blade to withstand significant mechanical stresses encountered during crop cutting, maintaining structural integrity and performance under demanding conditions.
3. **Toughness:** With good toughness, High Carbon Steel EN9 is capable of withstanding impact and shock forces, which are common during the cutting process. This resilience helps prevent the blade from cracking or breaking under pressure.
4. **Wear Resistance:** Due to its high carbon content, EN9 exhibits excellent wear resistance, making it well-suited to cutting through the tough stalks of bajra. The material's abrasion resistance ensures that the blade remains effective over an extended period.
5. **Edge Retention:** The ability of EN9 to maintain a sharp edge is a crucial characteristic for cutting tools, especially in agricultural settings. This property reduces the frequency of sharpening and improves the efficiency of crop harvesting.

To maximize the performance of EN9 steel in bajra cutting tools, appropriate heat treatment is necessary. Proper heat treatment enhances the steel's hardness and toughness, ensuring that the blade remains durable and effective throughout its service life.

In conclusion, High Carbon Steel EN9 is a suitable material for bajra crop cutting blades, owing to its combination of hardness, strength, toughness, wear resistance, and edge retention.



Table 2. High-carbon steel grade EN9 Property

Property	Value
Density	7.85 g/cm ³
Ultimate Tensile Strength (UTS)	400-550 MPa
Yield Strength (YS)	250-270 MPa
Hardness (Rockwell C)	20-25 HRC
Modulus of Elasticity	210 GPa
Melting Point (MP)	1425-1500°C

3) Mechanism Selection

The Scotch yoke mechanism provides several distinct advantages when integrated into crop cutters, significantly enhancing their performance, efficiency, and durability. This mechanism is primarily valued for its ability to convert rotary motion into reciprocating motion, which is essential for the back-and-forth action required in cutting applications. By efficiently converting rotary motion from the engine or motor into the reciprocating motion needed to operate the cutting blades, the Scotch yoke ensures a smooth and consistent cutting action. This is critical for precision in crop harvesting, optimizing the cutting process and ensuring reliable operation throughout.

The reciprocating motion enabled by the Scotch yoke facilitates a steady, controlled back-and-forth movement of the cutting blades. This consistent cutting rhythm improves the efficiency of the crop cutting process, resulting in cleaner cuts and enhancing the overall precision of the harvest. Such a mechanism helps minimize crop damage, which is crucial for maximizing yield quality. Additionally, the Scotch yoke mechanism is designed to reduce vibration and shock, common challenges in mechanical cutting systems. By smoothly transitioning between rotary and reciprocating motions, it minimizes jerky movements that could damage the blades or other components of the machine. This reduction in vibration not only improves the cutting performance but also decreases wear on the machine, leading to a longer operational life.

The compactness and simplicity of the Scotch yoke mechanism make it an ideal addition to crop cutters. Its design allows it to occupy minimal space within the machine, which is especially important for maintaining the overall compact structure of agricultural machinery.

Furthermore, its simple design makes it easier to maintain and repair, which reduces maintenance costs and improves the overall usability of the equipment. The robust construction of the Scotch yoke also ensures that it can withstand high mechanical stresses, making it durable enough to handle tough conditions, such as cutting through thick or resistant plant stalks. This durability ensures that the mechanism remains effective and reliable over long periods of use.

In addition to its durability, the Scotch yoke mechanism operates with minimal friction, which results in greater energy efficiency. By converting rotary motion to reciprocating motion with minimal energy loss, it leads to better fuel or power utilization. This is particularly beneficial in agricultural settings, where machinery is often used for long hours, as it can significantly reduce operational costs. Moreover, due to its simple design and manufacturing process, the Scotch yoke mechanism is cost-effective. It is less expensive to produce than more complex motion conversion systems, making it an attractive option for farmers, particularly in regions where budget constraints are a consideration.

the Scotch yoke mechanism offers several important benefits when used in crop cutters, including efficient power transmission, improved cutting action, reduced vibration, enhanced durability, and energy efficiency. These advantages contribute to the overall performance, longevity, and cost-effectiveness of the crop cutter. The simplicity and affordability of the mechanism make it a valuable feature for agricultural machinery, especially in the context of crop harvesting, such as for bajra.

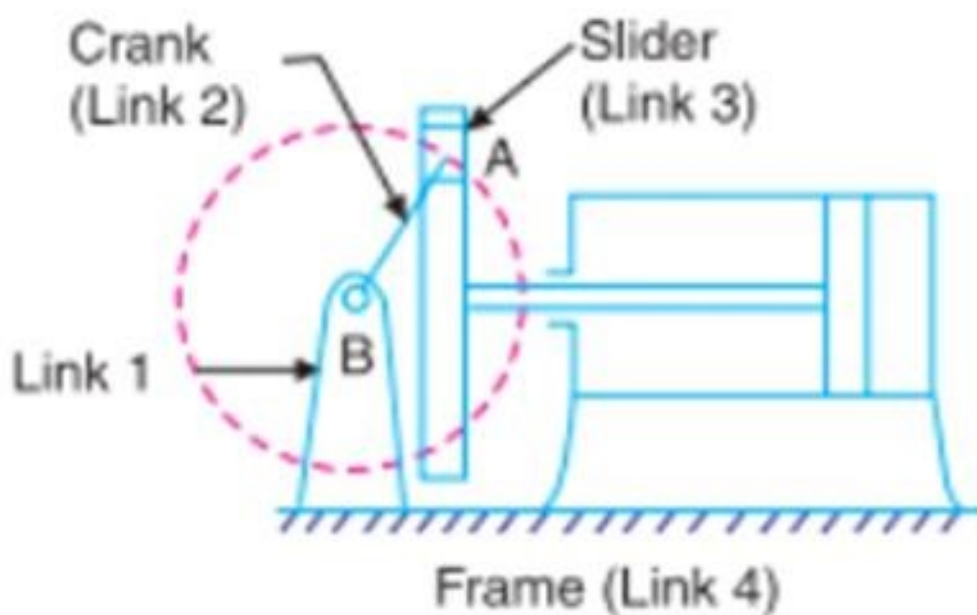


Fig.4 Schematic Scotch yoke mechanism



4) Calculations

Problem Data:

- Cutting Force (F_c) = 100 N
- Reciprocating Speed = 350 strokes/min
- Blade Angle (θ_b) = 35°
- FoS = 6
- Material: High carbon Steel ($\sigma_{\text{yield}}=250$ MPa, $\sigma_{\text{fatigue}}=125$ MPa).
- Mechanism: Scotch Yoke

The mechanism includes:

- 1) Blade
 - 2) Yoke
 - 3) Crank and crank pin
 - 4) Frame or support
- Procedure

Step 1: Stroke Length and Crank Radius

a) Stroke Length

The stroke length is twice the crank radius:

Stroke Length = $2r$.

Practical stroke length of 100 mm for bajra cutting.

$$r = \frac{\text{Stroke Length}}{2} = \frac{100}{2} = 50 \text{ mm}$$

Step 2: Forces on Blade

The force acting on the blade (F_c) at an angle (θ_b) results in components:

1. Normal Force (F_n):

$$F_n = F_c \cdot \cos(\theta_b) = 100 \cdot \cos(35^\circ) \approx 81.9 \text{ N.}$$

2. Shear Force (F_s):

$$F_s = F_c \cdot \sin(\theta_b) = 100 \cdot \sin(35^\circ) \approx 57.4 \text{ N}$$

**Step 3: Allowable Stress with FoS**

The allowable stress is calculated as:

$$\sigma_{allow} = \frac{\sigma_{yield}}{FoS} = 2506 \approx 41.67 \text{ MPa}$$

Step 4: Blade Design**a) Stress Analysis**

The blade is subjected to normal and shear forces. Using **Von Mises Criterion**:

$$\sigma_{vm} = \sqrt{\sigma^2 + 3\tau^2}$$

where:

- $\sigma = \frac{F_n}{A}$ (normal stress)
- $\tau = \frac{F_s}{A}$ (shear stress)

Substituting:

$$\sigma_{vm} = \sqrt{\left(\frac{F_n}{A}\right)^2 + 3 \cdot \left(\frac{F_s}{A}\right)^2}$$

Rearranging for the required area AA:

$$A = \sqrt{\frac{F_n^2 + 3F_s^2}{\sigma_{allow}^2}}$$

Substitute values:

$$A = \sqrt{\frac{81.9^2 + 3(57.4^2)}{41.67^2}}$$

$$A = \sqrt{\frac{6705.61 + 9892.68}{1736.19}}$$

$$A = \sqrt{9.56}$$

$$A = 3.09 \text{ mm}^2$$



b) Blade Cross-Section

Blade thickness $t=5$ mm

$$b = \frac{A}{t} = 3.095 = 0.618 \text{ mm}$$

Step 5: Yoke Design

The yoke is subjected to cyclic forces due to the crank pin. Use **shear stress failure theory** for the yoke slot and body.

a) Dimensions of the Yoke Slot

1. **Crank pin diameter** (d_{pin}) = 20 mm.
2. Adding clearance to avoid binding: Slot Width = $d_{pin} + Clearance = 20+2= 22$ mm

b) Thickness of the Yoke

The yoke experiences a shear force $F_n=81.9$ N

Shear stress is:

$$\tau = \frac{F_n}{A_{yoke}}$$

Assume a yoke thickness of $t_{yoke} = 10$ mm and width of 30mm

$$A_{yoke} = 30 \cdot 10 = 300 \text{ mm}^2$$

$$\tau = \frac{81.9}{300} \approx 0.273 \text{ MPa}$$

Compare with allowable stress:

$$\tau < \sigma_{allow}$$

The design is safe.

Step 6: Crank and Crank Pin Design

The crank pin transmits force F_n to the yoke.

a) Shear Stress in Crank Pin

Shear stress:

$$\tau_{pin} = \frac{F_n}{A_{pin}}$$

Crank pin diameter $d_{pin} = 20$ mm

$$A_{pin} = \frac{\pi}{4} d_{pin}^2 = \frac{\pi}{4} (20)^2 \approx 314.16 \text{ mm}^2$$

$$\tau_{pin} = \frac{81.9}{314.16} \approx 0.261 \text{ MPa}$$



Compare with allowable stress:

$$\tau_{pin} < \sigma_{allow}$$

The crank pin is safe.

b) Torque on Crank

The torque on the crank is:

$$T = F_n \cdot r$$

Substitute $F_n = 81.9 \text{ N}$ and $r = 50 \text{ mm}$

$$T = 81.9 \cdot 0.05 \approx 4.1 \text{ N}$$

Step 7: Power Requirement

Power is given by:

$$P = T \cdot \omega$$

Where:

- $T = 4.1 \text{ Nm}$
- Angular velocity (ω):
- $\omega = \frac{2\pi \cdot \text{RPM}}{60} = \frac{2\pi \cdot 350}{60} \approx 36.65 \frac{\text{rad}}{\text{s}}$

$$P = 4.1 \cdot 36.65 \approx 150.3 \text{ W}$$

Thus, a **150 W motor** is sufficient.

- Final Dimensions
- **Blade:**
 - Width = **0.618 mm** (increase for practical use)
 - Thickness = **5 mm**
- **Yoke:**
 - Slot Width = **22 mm**
 - Thickness = **10 mm**
 - Overall Length = **110 mm**
- **Crank Pin:**
 - Diameter = **20 mm**

- **Crank:**

Radius = **50 mm**

These dimensions ensure safety with a **FoS of 6**. And Material of blade High Carbon Steel EN9.

5. Design of Blades and Mechanism

For Blade Design a highly curved blade ensures an efficient slicing action, reducing the force required during cutting. For millet, a moderate curvature with a radius of 8–14 cm is ideal for maneuverability and effective cutting. Also, the bevel angle determines the sharpness of the blade it is the angle formed between a cut surface and a theoretical plane perpendicular to the surface of the material. For cutting millet, a **bevel angle of 22° to 30°** is recommended.



Fig. 5: Variations of Sickles with a Common Bevel Angle



Fig 6. Cutting Blade

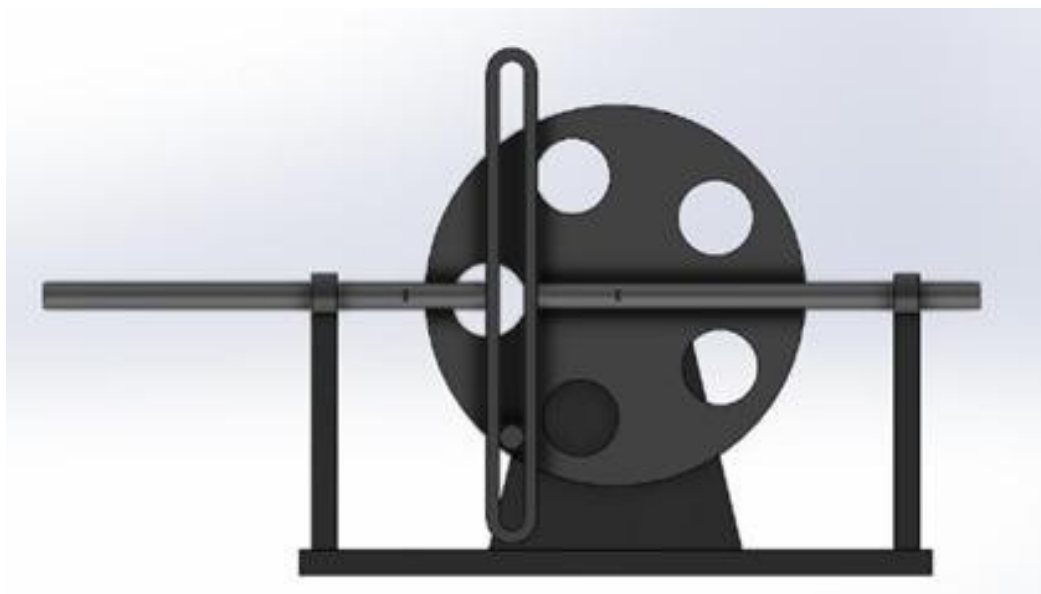


Fig 7. Scotch yoke mechanism

IV. RESULTS AND DISCUSSION



Fig 8 a. Complete Blade

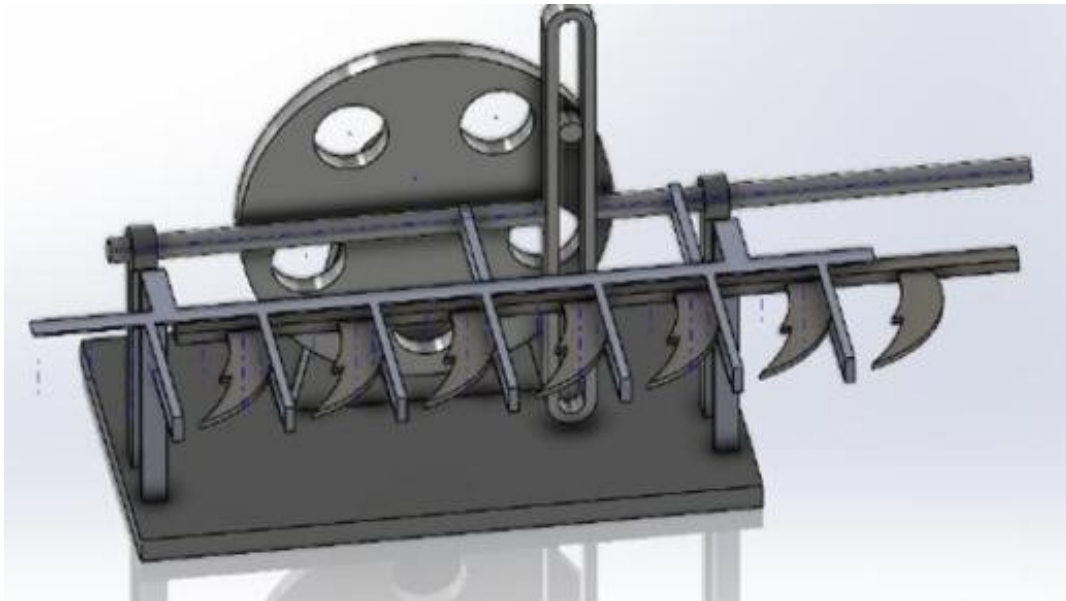


Fig 8 b. Complete Blade and Mechanism Assembly

<i>Parameter</i>	<i>Cutting done by mamal process</i>	Harvesting done by machine
<i>Time required to 6 Day. Cutting bajram the 1-acre farm</i>	<i>6 Days</i>	<i>1 Day</i>
<i>Labour Cost spend to harvesting</i>	<i>Rs 1800</i>	<i>Rs 300</i>
<i>Total cost spending</i>	<i>Rs 1800</i>	<i>Rs 696</i>

Harvesting done by MANUAL process Amount paid to the labor for one day = Rs. 300 per labour Total number of labours required in general to harvest the 1-acre farm in a day = 6 Total amounts paid to the labour = $6 \times 300 = \text{Rs. } 1800$ per acre in one day Therefore, total expenditure in one day is = Rs. 1800

Harvesting done by Machine Quantity of petrol require for 0.25 to 0.3 acre = 1 litre Quantity of petrol require for 1 to 1.2 acre = 3 litre Cost of Petrol per litre Rs 112 Total cost of Petrol for 1 acre farm for a day = $3 \times \text{Rs } 112 = \text{Rs. } 336$ Amount paid to the labour Rs. 300 per



day Total expenditure = Total cost of Petrol + Amount paid to the labour + Maintenance
 $336+300+60$ Rs. 696 Amount saved by using the harvester $1800-696=$ Rs. 1104 per day per acre Saved

The comparison between manual and machine harvesting of pearl millet demonstrates substantial benefits when utilizing a machine, particularly one powered by the Scotch Yolk mechanism. Manual harvesting of 1 acre of pearl millet requires 6 days and involves a labor cost of Rs. 1800 per day for 6 laborers. In contrast, machine harvesting can complete the task in just 1 day. The total cost for machine harvesting, which includes petrol, labor, and maintenance, is Rs. 696 per acre. Of this, Rs. 336 accounts for the petrol cost, Rs. 300 for labor, and Rs. 60 for maintenance.

This leads to a significant cost saving of Rs. 1104 per acre per day when using the machine instead of the manual method. The time reduction is equally remarkable, with the machine cutting the time required for harvesting from 6 days to just 1 day. Furthermore, the labor cost is reduced by over 60%, making the machine-based method a much more cost-effective option.

The use of mechanical harvesters not only reduces time and labor expenses but also improves overall efficiency in terms of fuel consumption and operational speed. These advantages make the Scotch Yolk mechanism-driven harvester a highly promising solution for large-scale pearl millet farming, where maximizing productivity and minimizing costs are essential.

V. CONCLUSION

Scotch Yoke mechanism-powered bajra cutting machine overcomes conventional harvesting's drawbacks, including expensive labor and a lack of available workers. Its low price, long lifespan, and user-friendliness make it ideal for small-scale farmers. The combination of mild steel and an improved blade design guarantee effective cutting, which speeds up harvesting and reduces the need for human labor. Significant savings are achieved by using this equipment, which decreases labor expenses by more than 60% and shortens the harvesting period from six days to one. With machine harvesting, you may save more than Rs. 1100 per acre per day on fuel, labor, and maintenance compared to traditional techniques.



The machine not only helps the economy, but it also promotes sustainable agricultural practices, which are especially important in dry and semi-arid regions. This is because the machine increases production while decreasing operating costs, making farming in these locations more viable in the long run.

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