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Development of a portable mechanized maize sheller for sustainable improvement of farm women's workload efficiency in maize production

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ABSTRACT

This study introduces and evaluates the work performance of a portable mechanized maize sheller as a solution to address challenges such as labor scarcity, high labor wages, and drudgery in maize production. Through multi-location testing and comparative analyses, the mechanized sheller demonstrates superior performance in terms of output capacity, reduced man-days, cost-effectiveness, and decreased drudgery experienced by farm women. Feedback from farmers confirms the practicality and acceptance of the technology, making it a viable option for enhancing maize production efficiency, particularly for small and marginal farmers. However, the study faced challenges related to variability in maize varieties, moisture content, and differing field conditions across locations, which influenced shelling efficiency and operational performance. Limited access to consistent power sources and initial resistance to mechanization among some farmers also posed constraints during evaluation. Despite these challenges, the study significantly contributes by providing empirical evidence on the technical and economic advantages of portable mechanized maize shellers, highlighting their potential to reduce labor drudgery, improve productivity, and promote mechanization among resource-poor farmers.

Keywords: Drudgery reduction, Mechanized maize sheller, Labor efficiency, Cost-effectiveness, Small and marginal farmer.

Introduction

In India, a substantial proportion of women are actively engaged in the agricultural sector, participating in activities ranging from land preparation to post-harvest operations. Most of these tasks are labour-intensive, repetitive, and monotonous, leading to significant physical and mental strain. Traditional tools commonly used by women often require bending or squatting postures, resulting in high levels of drudgery and health problems such as back pain, knee pain, fatigue, and occupational injuries (Khadatkar et al., 2014).

Women play a vital role in the national economy, with their workforce in agriculture and allied sectors estimated at around 92 million, accounting for nearly 40 per cent of the total rural workforce in India (Singh et al., 2007). Despite their significant contribution, women continue to face disproportionate physical burdens due to limited access to gender-friendly and mechanized tools.

The farming community is currently confronted with serious challenges, including labour shortages, escalating labour wages, and increased drudgery, especially in post-harvest operations such as maize shelling. Manual maize shelling is particularly strenuous, time-consuming, and physically demanding for women. To address these constraints, the development of affordable and portable mechanized tools is essential. In this context, the present study focuses on the development of a portable mechanized maize sheller aimed at reducing drudgery,

improving labour efficiency, and lowering operational costs. The study evaluates the performance of the developed sheller in comparison with traditional and hand-operated methods and assesses its impact on workload reduction, productivity enhancement, and economic feasibility.

Methodology

Locale of the study: Rayapur, Uppinabetageri, Managalgatti and Mulamuttala villages of Dharwad taluk, Karnataka State, India.

Sample Size

a) Ergonomic study: An ergonomic assessment was carried out to analyze perceived drudgery and the nature of participation of farm women in the maize production system, with a sample size of 30 farm women.

b) Large-scale testing: Large-scale field testing of the developed technology was conducted with 9 farmers/farm women.

1. Observations

Drudgery score was calculated using six parameters measured on a five-point scale (1–5), namely:

- Rating on work Demand: very demanding (5), demanding (4), moderate (3), less demanding (2)
- Rating on Feeling of Exhaustion: very exhausted (5), exhausted (4), moderately exhausted (3), mildly exhausted (2), no exhaustion (1)
- Rating on Posture assumed in work: very difficult (5), difficult (4), moderately difficult (3), easy (2), very easy (1)
- Rating on Manual Loads Operatives: very painful (5), painful (4), moderately painful (3), mild pain (2), no pain (1)

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- Rating on Difficulty perception: very heavy (5), heavy (4), moderately heavy (3), light (2), very light (1)
- Rating on work Load Perception : very heavy loads (5), heavy loads (4), moderately heavy loads (3), light loads (2), no loads (1)

2. Work performance parameters: labour / man days, time, output capacity and cost of operation*

*Cost of operation : Total fixed cost + Total variable cost

Total fixed cost : Depreciation + Interest+Tax+Insurance+Housing tax

Total variable cost : Cost of fuel + Cost of lubricant + Cost of repair and maintenance + Cost of operator.

c. Seed germination test

The methodology involved the design and development of the mechanized maize sheller, incorporating components such as a hooper, drum, mesh, rigid frame, petrol engine, pulley, bearing, and chain. Multi-location testing was conducted to evaluate the sheller's performance across different farming contexts. Comparative analyses were carried out on parameters including output capacity, man-days required, cost of operation, and drudgery experienced by farm women. Seed germination tests were also performed to assess the impact of the shelling process on seed quality. Feedback from farmers who participated in large-scale testing was collected to gauge the practicality and acceptance of the technology.

Result and Discussion

Table 1. Gender participation and technology usage in Maize production system

Activity	Gender participation					Technology usage
	WE	WD	ME	MD	EP	
Removal of stalks and stubbles	03 (10.00)	10(33.33)	-	02(6.66)	15(50.00)	
Dibbling	20 (66.66)	08(26.66)	01(3.33)	01(3.33)	-	
Top dressing of fertilizer	22 (73.33)	07(23.33)	-	01(3.33)	-	
Weeding	18(60.00)	09(30.00)	03(10.00)	-	-	
Cob removing	08 (26.66)	12(40.00)	-	07(23.33)	03(10.00)	

Figure in the parenthesis indicates percentage

WE - Women Exclusive only ,WD - Women Dominated and supported by men , ME - Men Exclusive only, MD - Men Dominated and supported by women, EP - Equal Participation by men and women

Gender participation in maize production activities reveals a predominance of women in tasks like dibbling and top dressing of fertilizer, while men are more involved in cob removing. Equal participation is observed in activities such as the removal of stalks and stubble. These findings highlight the need for gender-inclusive approaches in technology development to address labour disparities and promote equitable participation in agricultural activities.

Table 2: Comparison of drudgery experience by women while performing under Maize Production system

Sl. No	Drudgery factor	Maize production system			n=30
		Weeding	Cob removing	Maize shelling by hand	
1	Rating on work Demand	3.00	3.00	3.60	
2	Rating on Feeling of Exhaustion	2.50	3.10	3.20	
3	Rating on Posture assumed in work	3.10	3.00	3.50	
4	Rating on Manual Loads Operatives	3.00	2.89	3.80	
5	Rating on Difficulty perception	3.00	2.90	3.50	
6	Rating on work Load Perception	3.21	3.00	3.45	
7	Rating of perceived exertion	3.50	2.87	3.60	
8	Human power used	3.20	3.50	3.50	
	Total drudgery score	24.50	24.26	28.15	
	Average drudgery score	3.06	3.03	3.51	

The comparison of drudgery experience among women in different maize production activities reveals that maize shelling by hand is associated with the highest average drudgery score (3.51), followed by cob removing (3.03) and weeding (3.06). This suggests that maize shelling by hand imposes the greatest physical strain and discomfort on women compared to other tasks. These findings underscore the importance of developing and implementing mechanized solutions to reduce drudgery and improve the well-being of female farmers in maize production.



1	-	Hooper (Funnel)
2	-	Drum
3	-	Mesh
4	-	Rigid Frame
5	-	Tray (saddler)
6	-	Petrol Engine
7	-	Pulley
8	-	Bearing
9	-	Chain
10	-	Frame

Development of Technology: Portable Mechanized Maize sheller

Salient features

- Petrol engine with 3.5 HP, 1500 RPM
- Shaft, side tray, cube tray, two pulleys with belt and barrel with metal chain
- Labour&time saving, gender friendly
- Higher output capacity (3 Q/hour)

- Shelling efficiency : 96 %
- Cleaning efficiency : 96 %
- Cost effective technology (Rs. 102 /- per Q) as compared to other methods
- SuiTable for shelling of dehusked cobs
- Minimum seed damage (< 2 %)
- Recommended for small and marginal farmers and researchers

Table 3. Comparison between different maize shelling methods for work performance with the developed technology (Portable Mechanized Maize Sheller)**a. Out Put Capacity**

Output capacity	Portable Mechanized maize sheller	Traditional Method	Hand operated maize sheller
Kg/hr	300	6.54	11.47
Q/day	15	0.52	0.92
Superiority (Q) of Mechanized maize sheller over			
Traditional method	14.48		
Hand operated maize sheller	14.08		

Machine runs for 5 hrs / day The output capacity with portable mechanized maize Sheller is higher (300 Kg/hr) than traditional (6.54 Kg/hr) and hand-operated maize sheller(11.47 Kg /hr). The output capacity of portable mechanized maize sheller is superior to the tune of 14.48 Q/day over the traditional method and hand operated maize sheller 14.08 Q/day

b. Man days

Particulars	Portable Mechanized maize sheller	Traditional method	Hand operated maize sheller
Man days (no. /Q)	0.04 (20 min)	1.87 (15 hr)	1.12 (9hr)
Reduction in man days with the use of mechanized maize sheller over			
Traditional method	1.83 (14 hrs 38 min)(98 %)		
Hand operated maize sheller	1.08 (8hrs 38 min)(96 %)		

The man days required for maize shelling with portable mechanized maize sheller is lesser (0.04 man days/Q) as compared to traditional (1.87 man days/Q) and hand operated maize sheller (1.12 man days/Q)

c. Cost of operation: Labour wages + fuel cost

Particulars	Portable Mechanized maize sheller	Traditional method	Hand operated maize sheller	Large scale maize thresher
Cost of operation (Rs./Q)	87 (65+22)	975	585	136 (Rs. 120 /- per Q+Rs. 16/-)
Saving in cost of operation (Rs. /Q) with the use of portable mechanized maize sheller over				
Traditional method	888 (91%)			
Hand operated maize sheller	498 (85 %)			
Large scale maize thresher	49 (36%)			

Labour wages/day:Rs 519-

Labour wages: 3 labours / 20 min/Q =Rs. 65/-

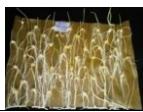
Cost of operation:Rs. 120/Q + 3min/Q/5 labour (Rs. 17/-)

Fuel consumption : 700ml/hr

Machine runs for 5 hrs / day
Petrol cost: Rs 93/-liter

The cost of operation for maize shelling is lesser with portable mechanized maize sheller (Rs. 87 /Q) as compared to large scale maize thresher (Rs.136 /Q) and hand operated maize sheller (Rs.585/Q). The savings in cost of operation with portable mechanized maize sheller over large scale maize thresher is Rs.49 /Q and Rs.498/Q over hand operated maize sheller

Table 5. Deshelled maize seeds germination test from developed technology

Maize variety	Moisture content (%)	Germination percentage (%)	
MTK RI-6	13.20	96.00	
MTK RII-1	12.50	98.00	
MTK -RII-2	13.40	97.00	
MTK -RII-6A	13.30	96.00	
MTK- RII-1A	12.60	97.00	

The germination test results of seeds deshelled with the Portable Mechanised Maize Sheller show high germination percentages (ranging from 96% to 98%) across different maize varieties. This indicates that the shelling process does not adversely affect seed viability, affirming the effectiveness of the portable mechanised sheller in preserving seed quality and ensuring successful crop establishment.

Table 6. Multiplication/large scale testing of portable mechanized maize sheller

Name of the village/Location	Name of the farmer / farm women	Output Capacity (Q/day)		Farmers feed back
		Hand operated maize sheller	Portable Mechanized maize sheller	
UAS, Dharwad	1. Chetan Reddy (BSc Agri student)	0.89	15	Low cost technology
UASD	2. Dept. of GPB	0.90	15	SuiTable for small & marginal farmers
Mulamuttal	3. ShantammaBiradar	0.88	15	Accepted
	4. ManjulaNekar	0.87	14	SuiTable for small & marginal farmers
	5. ShamkrevvaMukashi	0.90	16	Accepted
Rayapur	6. GourammaHubballi	0.98	16	Accepted
Uppinabtageri	7. KamalavvaBudri	0.97	14	Accepted
	8. BhimavvaSankoji	0.89	16	Low cost technology
Managalgatti	9. MallammaEligar	0.89	16	Accepted
Average		0.91	15.22	
Superiority (Q/ day)		14.31		

The large-scale testing of the portable mechanized maize sheller demonstrates favorable feedback from farmers, with an average output capacity of 15.22 Q/day. Farmers highlight its suitability for small and marginal farmers, as well as its affordability, indicating its potential to address labor constraints and enhance productivity in maize production. These results underscore the practicality and acceptance of the mechanized sheller among farming communities.

Discussion

Farm women perceived significantly lower levels of drudgery while operating the portable mechanized maize sheller, with a drudgery score of 6.25, compared to the traditional manual shelling method (drudgery score: 23.83) and the hand-operated maize sheller (drudgery score: 14.26). The substantial reduction in drudgery clearly indicates that the developed technology is ergonomically superior and effectively minimizes physical strain, fatigue, and discomfort among women engaged in maize shelling. This improvement can be attributed to the mechanized operation, reduced manual handling, and elimination of prolonged bending or repetitive hand movements, making the technology women-friendly and suitable for sustained use.

In addition to reducing drudgery, the portable mechanized maize sheller proved to be a highly labour- and time-saving technology. The labour requirement for shelling maize using the mechanized sheller was only 0.04 man-days per quintal, which is drastically lower compared to the traditional method requiring 1.87 man-days per quintal and the hand-operated sheller requiring 1.12 man-days per quintal. This substantial reduction in labour demand highlights the efficiency of the developed sheller in addressing labour scarcity and reducing dependency on manual labour during peak agricultural seasons.

Economic analysis further demonstrated the cost-effectiveness of the portable mechanized maize sheller. The cost of operation for maize shelling using the developed technology was only Rs. 87 per quintal, which is considerably lower than that of the large-scale maize thresher (Rs. 136 per quintal) and the hand-operated maize sheller (Rs. 585 per quintal). The savings in operational cost amounted to Rs. 49 per quintal when compared to the large-scale maize thresher and Rs. 498 per quintal when compared to the hand-operated sheller. These findings confirm that the portable mechanized maize sheller is economically viable and particularly advantageous for small and marginal farmers who may not afford large-scale machinery.

The results of the present study are in agreement with the findings of Amare et al. (2017), who reported that the threshing performance of a hand-held maize sheller was more than two times higher than that of traditional shelling practices.

In their study, shelling efficiency reached up to 100 per cent, indicating the technical superiority of mechanized shelling methods over conventional practices. Similar trends were observed in the present study, where the mechanized sheller demonstrated high shelling efficiency while ensuring minimal grain damage.

Furthermore, comparative economic analysis using partial budgeting techniques revealed the clear advantage of motorized threshers over traditional and cylindrical manual threshing methods. For threshing quantities of 21 quintals of maize and 20 quintals of sorghum, the motorized thresher proved more efficient based on trampling capacity. Assuming 90 working days per year with 6 hours of operation per day, the motorized thresher, with an estimated service life of 10 years and an initial cost of 50,700 ETB, was found to be economically superior to traditional methods. These findings reinforce the potential of mechanized technologies in improving productivity, reducing labour costs, and enhancing profitability in post-harvest operations.

Overall, the study establishes that the portable mechanized maize sheller is a drudgery-reducing, cost-effective, and labour-efficient technology that not only improves work efficiency for farm women but also offers substantial economic benefits, thereby supporting sustainable mechanization in smallholder farming systems.

Conclusion

The portable mechanized maize sheller developed in this study demonstrated significantly higher output capacity, reduced labour requirement, and lower cost of operation compared to traditional and hand-operated shelling methods. The technology effectively reduced drudgery among farm women and proved to be a labour- and time-saving, cost-effective solution. High levels of farmer acceptance indicate its suitability for small and marginal farming communities, thereby supporting sustainable mechanization and improved work efficiency in maize production.

Future Scope

1 The present study demonstrates the technical feasibility and socio-economic benefits of a portable mechanized maize sheller; however, further scope exists for refinement and wider application.

2 Future research may focus on optimizing the design to operate with alternative power sources such as electric motors or solar energy to enhance accessibility in power-scarce regions.

3 Long-term field evaluations across different agro-climatic zones and maize varieties can provide deeper insights into durability, adaptability, and performance consistency.

4 Additionally, integration of safety features and ergonomic enhancements may further reduce physical strain on farm women. Scaling up production and conducting impact assessments on income generation and livelihood improvement will support policy-level promotion of the technology among small and marginal farmers.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this research article. The study was conducted solely for academic and extension purposes, without any commercial or financial influence.

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