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Factors affecting production, consumption and marketed surplus of sorghum in Maharashtra

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Abstract
Sorghum (*Sorghum bicolor* L.) is a key cereal crop in Maharashtra's semi-arid regions, valued for its drought tolerance, low input requirements and nutritional richness. Despite its importance for food security and rural livelihoods, sorghum cultivation has been declining due to reduced acreage, stagnating yields, market volatility and climate variability. This study examines the factors affecting production, household consumption and marketed surplus of sorghum in Solapur district, using primary data from 60 farm households classified into small, medium and large categories. Multiple regression models were employed to identify significant determinants.

Results indicated that sorghum production was significantly influenced by machine labour, manure and irrigation across all farm sizes while fertilizers had a positive effect in medium and large farms. Seed cost had no significant impact. Consumption was positively associated with family size, education, price and awareness of sorghum's nutritional value, suggesting that knowledge dissemination could enhance demand. Marketed surplus was determined primarily by production level, farm size, financial obligations, price and market accessibility. Higher output and better infrastructure were linked to greater market participation, while seed and feed requirements showed mixed effects. The findings highlighted the need for targeted interventions to enhance sorghum's economic viability. Strengthening farm mechanization, improving irrigation facilities, ensuring timely access to inputs, developing market infrastructure and promoting awareness of nutritional benefits can improve productivity, increase consumption and boost marketed surplus. Such measures would make sorghum cultivation more sustainable, profitable and resilient, contributing to livelihood security in Maharashtra's dryland farming systems.

Keywords: Sorghum, factors, production, consumption and marketed surplus

Introduction

Sorghum (*Sorghum bicolor* L.) is one of the most important cereal crops grown in semi-arid and arid regions of the world, valued for its remarkable adaptability to drought, resilience under high-temperature conditions, low input requirements and high nutritional profile. It is a vital source of carbohydrates, proteins, minerals and dietary fiber and serves as both a staple food for humans and a key component of livestock feed. In Maharashtra, sorghum holds strategic importance in ensuring food security, providing livelihood opportunities and sustaining rural economies, particularly in dryland farming systems where climatic and resource constraints limit the cultivation of other cereals.

Despite its significance, sorghum cultivation in the state has been declining over the past few decades, largely due to shrinking acreage, stagnating yields, changing dietary preferences toward rice and wheat and the shift in agricultural priorities following the Green Revolution. Price volatility, limited market infrastructure, inadequate post-harvest handling facilities and low profitability have further discouraged farmers from investing in sorghum production. Climate variability, erratic rainfall patterns and soil degradation have also exacerbated the challenges faced by sorghum growers.

Understanding the factors that influence sorghum production, household consumption and marketed surplus is therefore critical for formulating strategies to revitalize the crop's economic viability. Production efficiency is influenced by the judicious use of key inputs such as human labour, machine labour, seeds, organic and inorganic fertilizers, manure and irrigation facilities. Consumption patterns, on the other hand, are determined by household size, demographic

composition, educational status, price dynamics, taste preferences and awareness of the crop's nutritional and health benefits. The marketed surplus is shaped by production levels, farm size, seed and feed requirements, financial obligations, prevailing market prices and accessibility to marketing channels. Given these dynamics, there is a pressing need for empirical research to identify and quantify the determinants of sorghum production, consumption and marketed surplus. Such insights can guide policymakers, researchers, and extension agencies in designing targeted interventions, ranging from promoting improved production technologies and enhancing market infrastructure to implementing nutritional awareness campaigns that can improve productivity, increase demand and ensure better price realization for farmers.

Materials and Methods

The study is based on the primary data. Solapur district of Maharashtra was selected for their highest area under sorghum cultivation. Two tehsils with the highest sorghum production area were chosen. Two villages from each tehsil were randomly selected, resulting in 4 villages. Sorghum growing households were classified as small (0.01–1.00 ha), medium (1.01–2.00 ha) and large (2.01 ha and above) based on operational landholding, using the cumulative frequency square root technique. From each village, 15 households were randomly chosen proportionate to their category share, giving a total sample size of 60 households.

To identify the effect of these factors on production, consumption and marketed surplus multiple regression technique was employed (Degefa *et al.* 2023) [1]. The functional model used to analyze the factor's affecting production of sorghum is,

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + u$$

Where,
Y = Total output (₹/ha)
X_1 = Seed (₹/ha)
X_2 = Machine labour (₹/ha)
X_3 = Human labour (₹/ha)
X_4 = Manures (₹/ha)
X_5 = Fertilizer (₹/ha)
X_6 = Irrigation charges (₹/ha)
u = Error term
a = Intercept
bi's = Regression coefficients

The functional model used to analyze the factor's affecting consumption of sorghum is,

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + u$$

Where,
Y = Total consumption (kg/ha)
X_1 = Family Size (No.)
X_2 = Gender (Male =1, Otherwise = 0)
X_3 = Age (Years)
X_4 = Education (Educated = 1, Otherwise = 0)
X_5 = Awareness about nutritional value of millet crop (Yes = 1, Otherwise = 0)
X_6 = Taste preference (Good = 1, Otherwise = 0)
X_7= Price of the commodity (₹/q)
u = Error term
a = Intercept
bi's = Regression coefficients

The functional model used to analyze the factor's affecting marketed surplus of sorghum is,

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + u$$

Where,
Y = Total marketed surplus (q/ha)
X_1 = Family Size (No.)
X_2 = Farm size (ha.)
X_3 = Production level (q/ha)
X_4 = Seed and feed requirement (q/ha)
X_5 = Financial obligation (Yes = 1, Otherwise = 0)
X_6 = Price of the commodity (₹/q)
X_7= Accessibility to the market (Good = 1, Otherwise = 0)
u = Error term
a = Intercept
bi's = Regression coefficients

Results and Discussion

Factors Affecting Production of Sorghum

The results of a multiple linear regression analysis to identify the factors affecting sorghum production across different farm sizes: small, medium, large and overall have been highlighted in Table 1. The regression analysis includes variables such as human labour, machine labour, seed, manure, fertilizer and irrigation charges with the aim of understanding their influence on sorghum yield.

Table 1: Factors affecting the Production of Sorghum

Sr. No.	Particulars	Small	Medium	Large	Overall
1	Intercept	0.15 (0.13)	-0.15 (0.16)	0.89 (0.65)	0.86 (0.78)
2	Seed (₹/ha)	0.36 (0.35)	-0.47 (0.32)	0.33 (0.33)	-0.79 (0.47)
3	Human labour (₹/ha)	-0.24 (0.37)	0.24 (0.36)	-0.36 (0.28)	-0.39 (0.30)
4	Machine labour (₹/ha)	0.47 (0.45)	0.36*** (0.09)	0.47*** (0.08)	0.36*** (0.09)
5	Manure (₹/ha)	0.41*** (0.08)	0.27** (0.10)	0.20** (0.09)	0.52*** (0.09)
6	Fertilizer (₹/ha)	0.23 (0.47)	0.33*** (0.08)	0.36*** (0.08)	0.24 (0.80)
7	Irrigation Charges (₹/ha)	0.38*** (0.09)	0.36*** (0.08)	0.22 (0.76)	0.39*** (0.07)
8	R^2	0.71	0.75	0.78	0.75

Figures in the parenthesis are the standard errors of the respective regression coefficient
Note: *** and ** indicate that 1 and 5 per cent level of significance, respectively

Human labour shows mixed results. It was negatively associated with sorghum production in small and large farms, though not significant. This may suggest overuse or inefficiency of labour in these groups. Machine labour shows a highly significant and

positive effect on sorghum production across all categories specially for medium, large and overall farms at the 1 per cent level of significance. This suggested that increased use of machinery helps improve productivity. Manure also had a consistently positive and significant influence in all size groups. It was significant at 1 per cent level for small and overall farms and at 5 per cent for medium and large farms, indicated that organic inputs like manure were beneficial for sorghum growth.

Irrigation charges have a strong positive impact on production in small, medium and overall farm groups, all significant at the 1 per cent level. This means that better irrigation facilities enhance yield. However, for large farms, the coefficient was positive but not statistically significant, suggested variability in irrigation effectiveness in that group. Fertilizer use was significant and positive only in medium and large farms, highlighted its importance in those categories. The results are consistent with the findings of Jerop *et al.* (2020) [3], who reported that fertilizers and manure had a positive and significant effect on finger millet yield. On the other hand, the effect of seed cost was not significant across any farm group and its coefficient was even negative for medium farms, indicated either inefficient seed use or that other factors were more influential. The overall model fits well with R-squared values ranging from 0.71 to 0.78, indicated that the included variables explain a high proportion of the variation in sorghum production.

The results indicated that investment in machine labour, manure and irrigation plays a crucial role in enhancing sorghum productivity. Policymakers and farmers may consider prioritizing these inputs to improve yield efficiency.

Factors Affecting Consumption of Sorghum

The regression analysis in Table 2 helps us to understand the major factors that influence the consumption of sorghum across small, medium and large farm households as well as overall. The results showed that family size had a strong and significant positive impact on sorghum consumption in all categories. This means that as the number of family members increases, the quantity of sorghum consumed also increases, likely because more people require more food.

Education also shows a positive effect, especially in medium and large farm households. This suggested that educated people were more likely to include sorghum in their diet, possibly because they were more aware of its health benefits. Similarly, awareness about the nutritional value of sorghum had a significant and positive effect across all groups. This highlighted that when people understand the health benefits of sorghum, they were more likely to consume it.

The price of the commodity also plays an important role. For small and medium farmers, a higher price was associated with more consumption, which may reflect that they were producers and benefit from higher prices. However, in large farms, the relationship was not strongly significant. Variables like gender, age and taste preference show mixed results and were mostly not statistically significant, meaning they did not have a consistent or strong impact on sorghum consumption in this study. Vahini *et al.* (2023) [13] highlighted that age, gender, awareness, taste perception and perceived nutritional value are key factors significantly influencing millet consumption.

Table 2: Factors Affecting the Consumption of Sorghum

Sr. No.	Particulars	Small	Medium	Large	Overall
1	Intercept	-0.36 (0.47)	0.31 (0.68)	0.47 (0.70)	0.52 (0.03)
2	Family Size (No.)	0.45*** (0.05)	0.31*** (0.06)	0.61*** (0.10)	0.23*** (0.03)
3	Gender	0.63 (0.51)	-0.43 (0.69)	0.23** (0.08)	0.47 (0.26)
4	Age (years)	0.54 (0.63)	0.84 (0.62)	-0.34 (0.83)	-0.36 (0.69)
5	Education	-0.32 (0.82)	0.49*** (0.10)	0.25** (0.09)	0.11*** (0.02)
6	Awareness about nutritional value	0.23** (0.08)	0.33*** (0.08)	0.35*** (0.08)	0.21*** (0.05)
7	Taste preference	0.35*** (0.09)	0.58 (0.51)	0.28 (0.38)	0.32 (0.21)
8	Price of the commodity (₹/q)	0.45*** (0.10)	0.32*** (0.09)	0.85 (0.50)	0.29*** (0.04)
9	R^2	0.69	0.73	0.78	0.79

Figures in the parenthesis are the standard errors of the respective regression coefficient

Note: *** and ** indicate that 1 and 5 per cent level of significance, respectively

The model overall was statistically strong, with high R-squared values (69% to 79%), meaning it explains most of the variation in sorghum consumption. It was summarized that sorghum consumption was mainly influenced by family size, education, price and awareness of its health benefits. These findings suggested that policies aiming to increase awareness and nutritional education could positively influence the demand for sorghum in rural households.

Factors Affecting Marketed Surplus of Sorghum

The results of a regression analysis conducted to identify the major factors influencing the marketed surplus of sorghum across different size groups of farmers, along with the overall sample has been demonstrated in Table 3. The model was statistically reliable, as indicated by the high R-Square values ranging from 0.80 to 0.84. Among the explanatory variables, production level (q/ha) showed a consistently positive and significant impact across all categories. This suggests that higher production leads to more surplus available for marketing, which was expected. Similarly, financial obligation was positively significant in most cases, especially for small and medium farmers, indicated that those with debts or financial commitments tend to sell more to meet their obligations. Farm size was also positively and significantly related to marketed surplus for large and overall farmers. This implies that larger landholdings contribute to higher marketable quantities. Seed and feed requirement had mixed effects. It was significant and positive in small and medium groups, but not in large farms.

Table 3: Factors Affecting the Marketed Surplus of Sorghum

Sr. No.	Particulars	Small	Medium	Large	Overall
1	Intercept	-0.43 (0.66)	0.31 (0.28)	0.37** (0.15)	0.13 (0.06)
2	Family Size (No.)	0.47 (0.89)	0.45*** (0.09)	-0.36 (0.44)	0.22 (0.16)
3	Farm Size (ha)	-0.32 (0.63)	0.53 (0.27)	0.41*** (0.07)	0.33** (0.11)
4	Production Level(q/ha)	0.27*** (0.07)	0.36** (0.12)	0.32*** (0.07)	0.41*** (0.09)
5	Seed and Feed requirement (q/ha)	0.13** (0.05)	0.51** (0.23)	-0.13 (0.14)	-0.33 (0.17)
6	Financial Obligation	0.41*** (0.05)	0.31** (0.10)	0.13 (0.12)	0.22*** (0.04)
7	Price of the Commodity (₹/q)	-0.40 (0.70)	0.47 (0.78)	0.41*** (0.08)	0.42** (0.17)
8	Accessibility to the market	0.15 (0.12)	0.52 (0.40)	0.14*** (0.04)	0.22*** (0.06)
9	R^2	0.82	0.80	0.83	0.84

Figures in the parenthesis are the standard errors of the respective regression coefficient
Note: *** and ** indicate that 1 and 5 per cent level of significance, respectively

The price of the commodity was significant for large farmers and in the overall sample, suggested that higher prices encourage more marketing. Market accessibility was positively significant in large and overall groups, highlighted the importance of infrastructure. Priya *et al.* (2020) [10], reported that area under cultivation, production level, financial obligations and current market prices were positively associated with the marketed surplus of the paddy crop. It was seen that production level, farm size, financial obligations, market price and market access were the key drivers of sorghum marketed surplus. Strategies focused on improving production, price realization and market access can enhance marketed surplus among farmers.

It was summarized that sorghum production and consumption were influenced by factors like machine labour, manure, irrigation and awareness of nutritional value. Education and family size also play key roles. Production levels, farm size and financial obligations significantly impact marketed surplus. While seed and gender show mixed results, overall model fit was strong, confirming the reliability of findings across farm sizes.

Conclusion

The study found that sorghum production was strongly influenced by machine labour, manure and irrigation with fertilizers benefiting medium and large farms. Seed cost had no significant effect, indicated a need for better seed use. Consumption was mainly driven by family size, education, price and nutritional awareness, suggested that promoting health awareness could boost demand.

Marketed surplus was determined by production level, farm size, financial obligations, price and market accessibility with higher output and better linkages leading to more sales. Strengthening farm mechanization, irrigation, input access and market infrastructure, along with improving awareness of sorghum's nutritional value, can enhance productivity, consumption and marketed surplus, making sorghum cultivation more sustainable and profitable in Maharashtra.

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