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Parbhani Vasant' (PVRSG 101): A Novel *Rabi* Sorghum Variety for Hurda Production Released for the Marathwada Region of Maharashtra, India

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***Sorghum bicolor*, *Rabi* Sorghum, Hurda, Parbhani Vasant, PVRSG 101, Variety Release, Marathwada, Economic Viability, Shoot Fly, Charcoal Rot.**

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Abstract

Background: Sorghum (*Sorghum bicolor* (L.) Moench) is a vital staple crop globally, particularly in the semi-arid tropics, serving as a primary source of food and fodder [1]. In India, post-rainy season (*Rabi*) sorghum holds significant importance, especially in the state of Maharashtra, where it is valued for its superior grain quality and drought resilience [2]. A growing niche market is the consumption of tender, sweet sorghum grains, known as Hurda, which is gaining popularity due to its nutritional profile and use in agro-tourism [3]. The current challenge is the lack of high-yielding, quality-specific, and pest-tolerant varieties tailored for dedicated Hurda production in the Marathwada region.

Methods: The novel *Rabi* sorghum variety, 'Parbhani Vasant' (PVRSG 101), developed through selection from the local germplasm 'Parbhani Gulbhendi', was rigorously evaluated over a period of six years (2015-16 to 2020-21). The evaluation included Station Trials (2015-16 to 2016-17), University Multilocation Trials (UMT) across 16 locations (2017-18 to 2020-21), All India Co-ordinated Sorghum Agronomy Trials (AICSIP) (2020-21), and 30 Farmer Adaptive Trials (2020-21). The variety was assessed against established checks (SGS 8-4, Phule Madhur, and PKV Ashwini) for tender grain yield, green fodder yield, organoleptic quality, proximate composition, reaction to major pests (shoot fly and stem borer), and disease (charcoal rot), as well as economic returns (B:C ratio).

Results: Across the four years of UMT, PVRSG 101 demonstrated a superior average tender grain yield of 34.79 q/ha, exhibiting a significant superiority of 29.56%, 10.85%, and 18.08% over the state checks SGS 8-4, Phule Madhur, and PKV Ashwini, respectively. The variety also recorded a high green fodder yield of 132.66 q/ha in UMT. Quality analysis confirmed its superiority in all organoleptic parameters (color, texture, taste, aroma, and flavor) and a better nutritional profile, including higher protein content in fodder (8.40%). Furthermore, PVRSG 101 showed moderate tolerance to major biotic stresses, recording less pest infestation (shoot fly: 24.38%; stem borer: 1.66%) and disease incidence (charcoal rot: 16.22%) compared to checks. Economic analysis confirmed the variety's high profitability, with a favorable Benefit-Cost ratio.

Conclusion: Based on its consistent and superior performance in yield, quality, pest tolerance, and economic viability across diverse environments and farmer fields, the *Rabi* sorghum sweet grain (Hurda) variety 'Parbhani Vasant' (PVRSG 101) is strongly recommended for formal release and cultivation in the *Rabi* sorghum growing areas of the Marathwada region of Maharashtra state.

1.INTRODUCTION

1.1. Global and National Significance of Sorghum

Sorghum (Sorghum bicolor (L.) Moench) ranks as the fifth most important cereal crop globally, playing a critical role in the food security of millions, particularly in the arid and semi-arid regions of Africa and Asia [4]. Its remarkable tolerance to drought, heat, and poor soil fertility makes it an indispensable crop in climate-vulnerable agricultural systems [5]. In India, sorghum, locally known as *Jowar*, is the third most important cereal after rice and wheat [6]. It is cultivated across two major seasons: the rainy season (*Kharif*) and the post-rainy season (*Rabi*). The *Rabi* season crop, predominantly grown in the Deccan plateau of Maharashtra, Karnataka, and Andhra Pradesh, is particularly prized for its superior grain quality, which is preferred for human consumption in the form of unleavened bread (*Roti*) [7]. The stover (dried stalks) from *Rabi* sorghum also constitutes a crucial source of fodder for livestock, contributing significantly to the mixed farming systems prevalent in these regions [8].

1.2. The Niche Market of Hurda and Nutritional Imperatives

While mature sorghum grain is a staple, a distinct and economically significant market exists for the tender, sweet grains harvested at the milky-dough stage, locally termed *Hurda* [9]. *Hurda* is a traditional, ready-to-eat snack, typically roasted and consumed fresh, known for its unique, delicious taste and high nutritional value [10]. Sorghum, in general, is recognized for its health benefits, including a high content of dietary fiber, B-complex vitamins, and minerals (iron, zinc), and a lower glycemic index

compared to rice and wheat [11]. These characteristics make sorghum an ideal food for managing lifestyle diseases such as diabetes and obesity, which are increasingly prevalent in both urban and rural populations [12]. The demand for *Hurda* has been further amplified by the burgeoning agro-tourism sector in rural Maharashtra, where it is marketed as a niche, seasonal delicacy, offering farmers an opportunity for higher profit margins [13].

1.3. Problem Statement and Research Gap

Despite the clear demand and economic potential of *Hurda*, breeding efforts have historically focused on dual-purpose varieties optimized for both mature grain and fodder yield [14]. Consequently, there is a significant gap in the availability of dedicated *Rabi* sorghum varieties specifically bred and evaluated for maximum tender sweet grain yield and superior organoleptic properties required for the *Hurda* market [15]. Furthermore, *Rabi* sorghum cultivation is constantly challenged by biotic stresses, primarily the shoot fly (*Atherigona soccata*) and the stem borer, as well as the disease charcoal rot (*Macrophomina phaseolina*), which can severely impact both grain and fodder productivity [16]. A new variety must not only excel in yield and quality but also possess adequate tolerance to these stresses to ensure stable and profitable production for farmers [17].

1.4. Objectives

The primary objective of this research was to comprehensively evaluate the newly developed *Rabi* sorghum sweet grain (*Hurda*) variety, 'Parbhani Vasant' (PVRSG 101), against existing commercial checks. The specific aims were:

1. To assess the performance of PVRSG 101 for tender grain yield and green fodder yield across multiple years and diverse agro-climatic locations in the Marathwada region.
2. To analyze the organoleptic quality and proximate composition of the tender grains and fodder quality of PVRSG 101 in comparison to standard checks.
3. To determine the reaction of PVRSG 101 to major pests (shoot fly, stem borer) and disease (charcoal rot).
4. To conduct an economic analysis to determine the profitability and viability of PVRSG 101 cultivation for farmers.
5. To propose the formal release of PVRSG 101 for cultivation in the *Rabi* growing areas of the Marathwada region based on its superior performance.

2. LITERATURE REVIEW

2.1. Advances in Sorghum Breeding for Post-Rainy Season

The genetic improvement of *Rabi* sorghum has been a continuous process in India, driven by the need for varieties that can thrive under receding soil moisture conditions [18]. Early breeding programs focused on improving grain size, luster, and resistance to terminal drought [19]. More recently, the focus has shifted towards developing varieties that offer a balance between high grain yield and quality stover yield, recognizing the dual-purpose nature of the crop [20]. Research by Kumar et al. (2022) highlighted that successful *Rabi* sorghum varieties must possess traits such as deep root systems, high water-use efficiency, and a stay-green characteristic to maintain photosynthetic activity under stress [21]. The development of PVRSG 101, a selection from local germplasm, aligns with the strategy of utilizing adapted landraces to capture local resilience and quality traits, a method proven effective in other regional crop improvement programs [22]. The current literature emphasizes the importance of multi-location testing to ensure the stability of performance across the heterogeneous environments of the Deccan plateau, a critical step undertaken in the evaluation of PVRSG 101 [23].

2.2. Genetic and Agronomic Factors Influencing Hurda Quality

The quality of *Hurda* is determined by a complex interplay of genetic factors and agronomic practices, specifically the timing of harvest [24]. *Hurda* is typically harvested at the milky-dough stage, where the grains possess a high moisture content, sweetness, and a soft, chewy texture [25]. Studies on parching sorghum genotypes, such as those by Darekar et al. (2020), have identified that varieties with specific starch and sugar profiles are best suited for the desirable organoleptic properties of roasted *Hurda* [26]. Key quality parameters include the tenderness of the grain, the absence of bitterness, and a pleasant aroma upon roasting [27]. Nutritional analysis of *Hurda* has consistently shown it to be a rich source of fiber and essential minerals, reinforcing its potential as a functional food [28]. The development of PVRSG 101 specifically targets these quality attributes, aiming for a variety that maximizes the sensory appeal and nutritional density of the tender grain, thereby enhancing its market value [29]. Furthermore, the fodder quality, measured by parameters like crude protein and crude fiber, is a significant economic consideration, as the stover is a valuable byproduct [30].

2.3. Management of Major Pests and Diseases in *Rabi* Sorghum

Biotic stresses pose a major threat to *Rabi* sorghum productivity. The **Sorghum Shoot Fly** (*Atherigona soccata*) is arguably the most destructive pest, causing 'dead hearts' in young plants and leading to significant yield losses [31]. Breeding for resistance to shoot fly is a continuous priority, with research focusing on identifying and incorporating genes for antixenosis (non-preference for oviposition) and antibiosis (adverse effects on larval development) [32]. The **Stem Borer** is another significant pest, particularly in later stages of crop growth, affecting stem integrity and nutrient transport [33].

Among diseases, **Charcoal Rot** (*Macrophomina phaseolina*) is a major concern, especially under conditions of terminal drought and high temperatures, which are typical of the *Rabi* season [34]. The disease causes premature senescence and lodging, severely reducing both grain and stover yield [35]. Developing varieties with moderate tolerance to these stresses is a more sustainable and cost-effective strategy than relying solely on chemical control [36]. The evaluation of PVRSG 101 for its reaction to these three major stresses is therefore crucial for its successful adoption by farmers [37].

2.4. Economic Assessment of New Crop Varieties

The ultimate success of a new crop variety is determined by its economic viability for the farmer [38]. Economic analysis, typically involving the calculation of Gross Monetary Returns (GMR), Net Monetary Returns (NMR), and the Benefit-Cost (B:C) ratio, provides a quantitative measure of profitability [39]. Studies on improved *Rabi* sorghum cultivars in Maharashtra have consistently shown that varieties with higher yield potential and better stover quality lead to significantly higher B:C ratios compared to local landraces [40]. The B:C ratio is a critical metric for policy makers and extension agencies when recommending a new variety for release [41]. The economic advantage of PVRSG 101 is expected to be amplified by its dual-purpose nature (high tender grain and fodder yield) and its specific suitability for the high-value *Hurda* market, which commands a premium price [42]. The inclusion of economic analysis in the AICSIP and farmer adaptive trials provides a robust, real-world validation of the variety's financial benefits [43].

3. MATERIALS AND METHODS

3.1. Breeding History and Genetic Material

The variety 'Parbhani Vasant' (PVRSG 101) was developed at the Sorghum Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani. The genetic material originated as a **selection from the local germplasm 'Parbhani Gulbhendi'**. The breeding method employed was the **Selection method**, focusing on identifying superior individual plants within the local population

that exhibited desirable traits for *Hurda* production. The primary breeding objectives were: (1) To develop a *Hurda* purpose variety with a significantly higher yield of sweet tender grains compared to existing checks, and (2) To develop a variety that is moderately tolerant to the major biotic stresses, including shoot fly, stem borer, and charcoal rot.

3.2. Experimental Trials and Locations

The evaluation of PVRSG 101 was conducted in a phased manner over six consecutive *Rabi* seasons (2015-16 to 2020-21) to ensure the stability and adaptability of the variety.

3.2.1. Station Trials (2015-16 to 2016-17)

Initial evaluation was conducted at the Sorghum Research Station, VNMKV, Parbhani. The variety was tested for two years against the checks SGS 8-4, Phule Madhur, and PKV Ashwini to assess its potential for tender grain and green fodder yield.

3.2.2. University Multilocation Trials (UMT) (2017-18 to 2020-21)

PVRSG 101 was tested in UMT for four years across 16 different locations within the Marathwada region. The locations included Parbhani, Somnathpur, Basmat, Aurangabad, and Nanded, representing the diverse agro-climatic conditions of the target area. This phase was crucial for assessing the variety's stability and broad adaptability.

3.2.3. All India Co-ordinated Sorghum Agronomy Trial (AICSIP) (2020-21)

The variety was included in the AICSIP during the 2020-21 *Rabi* season, which provided a wider geographical comparison and an opportunity for a detailed economic analysis under various fertilizer treatments. The trial locations included Nandyal, Parbhani, Hagari, Rahuri, Tandur, and Vijayapura.

3.2.4. Farmer Adaptive Trials (2020-21)

To validate the performance under real-world farming conditions, 30 Farmer Adaptive Trials were conducted during the *Rabi* 2020-21 season. These trials were spread across five districts: Parbhani, Latur, Jalna, Aurangabad, and Solapur, ensuring a robust assessment of the variety's performance and farmer acceptance.

3.3. Agronomic Practices and Conditions

All trials were conducted under **rainfed conditions**, which is the typical practice for *Rabi* sorghum cultivation in the region. The soil fertility status was generally medium to high. Standard recommended package of practices for timely sown *Rabi* sorghum in the Marathwada region were followed for all test entries and checks to ensure a fair comparison.

3.4. Data Collection and Measurement

A comprehensive set of data was collected throughout the trial period:

- **Yield Parameters:** Tender grain yield (q/ha) was recorded at the milky-dough stage, which is the optimal time for *Hurda* harvest. Green fodder yield (q/ha) was recorded at the time of final harvest.
- **Maturity and Ancillary Characters:** Observations were recorded for Days to 50% flowering, Days to harvest (tender grain stage), Plant height (cm), 100 tender grain weight (g), Threshability (%), and Tender grain taste (sweet/moderate sweet). Detailed morphological and DUS (Distinctness, Uniformity, and Stability) characteristics were recorded as per standard sorghum descriptors (Annexure I and II).
- **Pest and Disease Assessment:**
  - **Shoot Fly:** Assessed as the percentage of dead hearts at 28 Days After Emergence (DAE).
  - **Stem Borer:** Assessed as the percentage of stem borer infestation at 45 DAE.
  - **Charcoal Rot:** Assessed as the percentage of disease incidence.
- **Quality Analysis:**
  - **Organoleptic Test:** Sensory evaluation was conducted for tender and roasted samples, assessing color, texture, taste, aroma, and flavor on a hedonic scale.
  - **Proximate Composition:** Tender grains were analyzed for moisture, fat, protein, ash, crude fiber, and carbohydrate content.
  - **Fodder Quality:** Fodder was analyzed for Dry Matter (DM), Crude Protein, Ether Extract, Crude Fibre, Total Ash, and Nitrogen Free Extract.
- **Economic Analysis:** Gross Monetary Returns (GMR), Net Monetary Returns (NMR), and Benefit-Cost (B:C) ratio were calculated based on prevailing market prices for tender grain and fodder, and the cost of cultivation for each treatment in the AICSIP and Agronomy trials.

3.5. Statistical Analysis

The experimental data from the trials were subjected to standard statistical analysis. The significance of differences between the means of the proposed variety and the checks was determined using the **Critical Difference (CD) at 5%** level of significance. The **Coefficient of Variation (CV%)** was also calculated to assess the variability and reliability of the data across the different trials.

4. RESULTS

The evaluation of the novel *Rabi* sorghum variety, 'Parbhani Vasant' (PVRSG 101), was conducted across multiple environments and years, focusing on yield stability, quality attributes, resistance to biotic stresses, and economic performance. The results are presented in detail across the following subsections, with all key data points transcribed from the original trial reports.

4.1. Yield Performance in Station and University Multilocation Trials

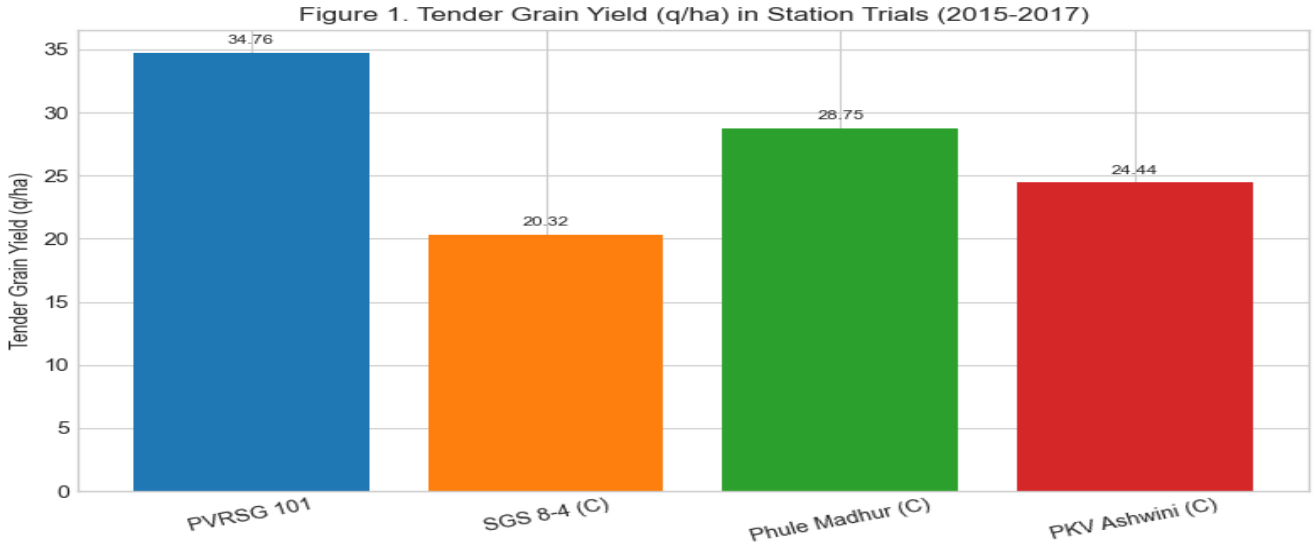
4.1.1. Station Trial Performance (2015-16 and 2016-17)

The initial evaluation in the Station Trials at VNMKV, Parbhani, demonstrated the potential of PVRSG 101 for both tender grain and green fodder yield (Table 1a and 1b).

Table 1a: Tender Grain Yield (q/ha) in Station Trials (2015-16 and 2016-17)

Variety	2015-16 (q/ha)	2016-17 (q/ha)	Average (q/ha)	% Increase over SGS 8-4	% Increase over Phule Madhur	% Increase over PKV Ashwini
PVRSG 101	36.68	32.84	**34.76**	**37.28**	**20.90**	**28.55**
SGS 8-4 (C)	--	20.32	20.32	--	--	--
Phule Madhur (C)	30.34	27.16	28.75	--	--	--
PKV Ashwini (C)	27.40	29.30	24.44	--	--	--
CD at 5%	15.19	12.32	13.76			

Figure 1. Tender Grain Yield (q/ha) in Station Trials (2015-2017)



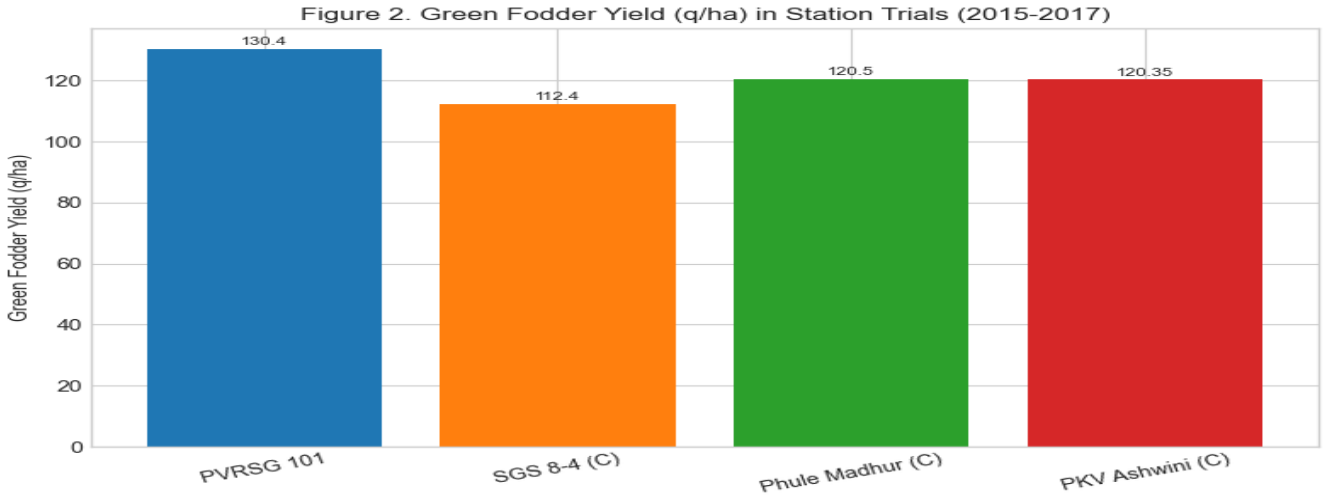
PVRSG 101 recorded an average tender grain yield of **34.76 q/ha** over the two years, showing a substantial superiority of 37.28% over SGS 8-4 (20.32 q/ha), 20.90% over Phule Madhur (28.75 q/ha), and 28.55% over PKV Ashwini (24.44 q/ha). This early data confirmed the variety's high-yielding potential specifically for the *Hurda* purpose [44].

Table 1b: Green Fodder Yield (q/ha) in Station Trials (2015-16 and 2016-17)

Variety	2015-16 (q/ha)	2016-17 (q/ha)	Average (q/ha)	% Increase over SGS 8-4	% Increase over Phule Madhur	% Increase over PKV Ashwini
PVRSG 101	128.40	132.40	**130.40**	**16.01**	**8.21**	**8.35**
SGS 8-4 (C)	--	112.40	112.40	--	--	--
Phule Madhur (C)	119.50	121.50	120.50	--	--	--

Variety	2015-16 (q/ha)	2016-17 (q/ha)	Average (q/ha)	% Increase over SGS 8-4	% Increase over Phule Madhur	% Increase over PKV Ashwini
PKV Ashwini (C)	116.80	123.90	120.35	--	--	--

Figure 2. Green Fodder Yield (q/ha) in Station Trials (2015-2017)



The green fodder yield of PVRSG 101 was also consistently high, averaging **130.40 q/ha**, which was 16.01% higher than SGS 8-4, 8.21% higher than Phule Madhur, and 8.35% higher than PKV Ashwini. This dual-purpose superiority is crucial for the economic viability of *Rabi* sorghum cultivation [46].

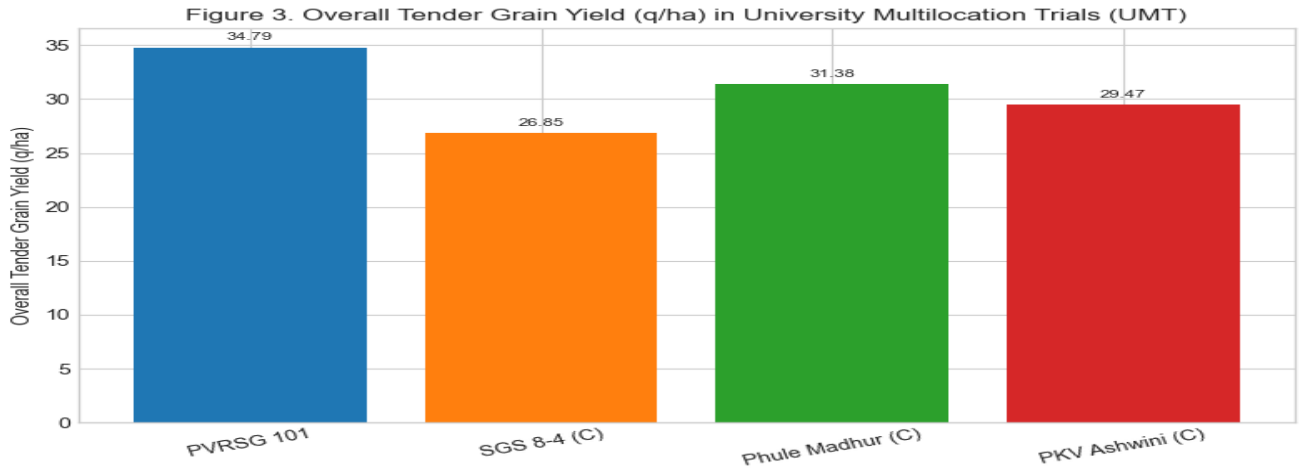
4.1.2. University Multilocation Trial (UMT) Performance (2017-18 to 2020-21)

The UMT data, collected over four years and 16 locations, provided a robust assessment of the variety's stability and adaptability across the Marathwada region.

Table 1c: Overall Tender Grain Yield (q/ha) in UMT (2017-18 to 2020-21)

Variety	2017-18 Avg (3 Loc)	2018-19 Avg (5 Loc)	2019-20 Avg (4 Loc)	2020-21 Avg (4 Loc)	Overall Average (16 Loc)	% Increase over Checks
PVRSG 101	33.07	33.08	34.75	38.25	**34.79**	--
SGS 8-4 (C)	26.63	24.11	26.62	30.67	26.85	29.56%
Phule Madhur (C)	30.08	29.80	30.55	35.17	31.38	10.85%
PKV Ashwini (C)	29.67	29.43	28.77	30.08	29.47	18.04%

Figure 3. Overall Tender Grain Yield (q/ha) in University Multilocation Trials (UMT)

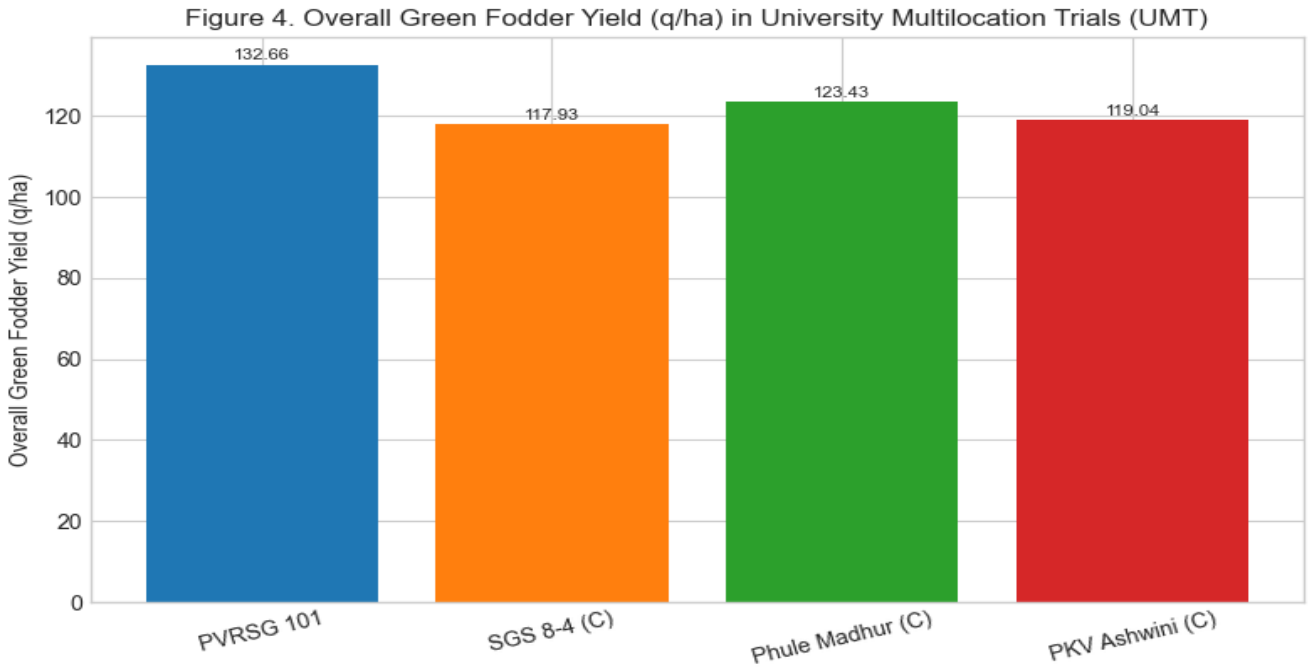


The overall average tender grain yield of PVRSG 101 across all 16 UMT locations was **34.79 q/ha**. This represents a significant and stable superiority over all three checks: 29.56% over SGS 8-4 (26.85 q/ha), 10.85% over Phule Madhur (31.38 q/ha), and 18.04% over PKV Ashwini (29.47 q/ha). The consistent performance across years and locations underscores the variety's wide adaptability and genetic stability [45].

Table 1d: Overall Green Fodder Yield (q/ha) in UMT (2017-18 to 2020-21)

Variety	2017-18 Avg (3 Loc)	2018-19 Avg (5 Loc)	2019-20 Avg (4 Loc)	2020-21 Avg (4 Loc)	Overall Average (16 Loc)	% Increase over Checks
PVRSG 101	132.36	130.04	134.80	134.03	**132.66**	--
SGS 8-4 (C)	119.14	117.68	119.40	115.88	117.93	12.49%
Phule Madhur (C)	123.88	123.54	123.30	123.43	123.43	7.48%
PKV Ashwini (C)	124.09	116.50	119.10	118.35	119.04	11.45%

Figure 4. Overall Green Fodder Yield (q/ha) in University Multilocation Trials (UMT)



For green fodder yield, PVRSG 101 maintained its superiority with an overall average of **132.66 q/ha**. This was 12.49% higher than SGS 8-4, 7.48% higher than Phule Madhur, and 11.45% higher than PKV Ashwini. The dual advantage in both grain and fodder yield positions PVRSG 101 as a highly profitable option for farmers [46].

4.2. Agronomic and Morphological Characteristics

The detailed morphological and maturity data (Table 2a, 2b, Annexure I) confirm that PVRSG 101 possesses desirable traits for *Rabi* cultivation and *Hurda* production.

Table 2a: Key Maturity and Ancillary Characters of PVRSG 101 in UMT (Average 2017-2021)

Trait	PVRSG 101 (Average)	SGS 8-4 (Average)	Phule Madhur (Average)	PKV Ashwini (Average)
Days to 50% Flowering	73	75	76	74
Days to Harvest (Tender Grain)	96	98	99	99
Plant Height (cm)	243	226.5	233	220
100 Tender Grain Weight (g)	**4.22**	3.76	4.01	4.03
Threshable Grains (%)	**94.55**	81.73	93.55	89.45
Tender Grain Taste	**Sweet**	Moderately Sweet	Sweet	Moderately Sweet

Figure 5. Comparison of 100-Tender Grain Weight (g) and Threshability (%)

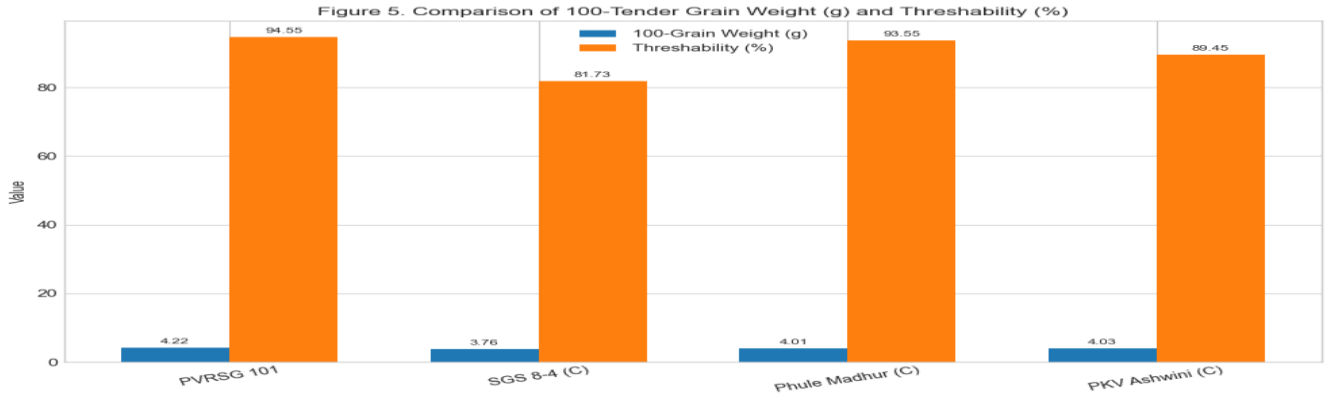


Figure 5. Comparison of 100-Tender Grain Weight (g) and Threshability (%)

PVRSG 101 is an early-to-medium duration variety, flowering in 73 days and reaching the optimal *Hurda* harvest stage in 96 days, which is slightly earlier than the checks. Crucially, it exhibited the highest 100-tender grain weight (**4.22 g**) and the highest percentage of threshable grains (**94.55%**), indicating superior physical quality and ease of processing for *Hurda* [47]. The taste was consistently rated as **Sweet**, a key requirement for the market.

Annexure I provides a detailed description of the variety, noting its pedigree (Selection from local Germplasm Parbhani Gulbhendi), plant height (235-240 cm), and other characteristics such as a juicy stem, non-tillering habit, and high regeneration capacity, which contributes to its high fodder yield.

4.3. Quality and Nutritional Analysis

The quality analysis focused on organoleptic properties, proximate composition of the grain, and the nutritional value of the fodder.

Table 3a: Sensory Evaluation of Tender Sorghum Grain (Hurda) (2017-18)

Parameter	PVRSG 101	SGS 8-4 (C)	Phule Madhur (C)
Tender Sample			
Texture	1.3	2.0	1.4
Taste	8.3	6.7	7.1
Aroma/Flavor	2.1	1.6	1.5
Grain Colour	2.1	2.4	2.6
Roasted Sample			
Texture	1.3	1.8	1.6
Taste	7.9	6.6	6.9
Aroma/Flavor	2.3	1.6	1.8
Grain Colour	2.0	2.6	2.9

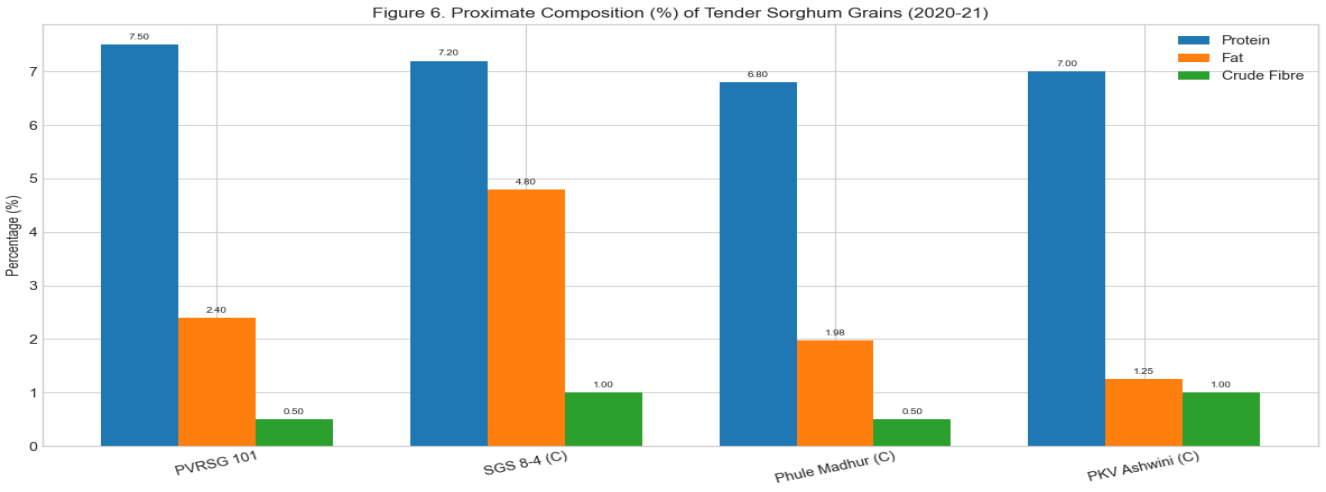
Note: Hedonic scale: 1=Soft/Like extremely, 9=Hard/Dislike extremely.

PVRSG 101 scored significantly better than the checks in the sensory evaluation. For the tender sample, its taste score of **8.3** (Like extremely) was markedly higher than SGS 8-4 (6.7) and Phule Madhur (7.1). The texture score of **1.3** (Soft) was also superior. This superiority was maintained in the roasted sample, confirming the variety's excellent suitability for the *Hurda* market [48].

Table 3b: Proximate Composition of Tender Grains (2020-21) (Mean values in %)

Variety	Moisture	Fat	Protein	Ash	Crude Fibre
PVRSG 101	21.75	2.4	**7.5**	1.5	0.5
SGS 8-4 (C)	21.59	4.8	7.2	2.01	1
Phule Madhur (C)	21.31	1.98	6.8	1.93	0.5
PKV Ashwini (C)	21.89	1.25	7.0	1.94	1.0

Figure 6. Proximate Composition (%) of Tender Sorghum Grains (2020-21)



PVRSG 101 exhibited a higher protein content (**7.5%**) in its tender grains compared to all checks, indicating a better nutritional profile for human consumption [49].

Figure 7. Key Fodder Quality Parameters (%) Comparison

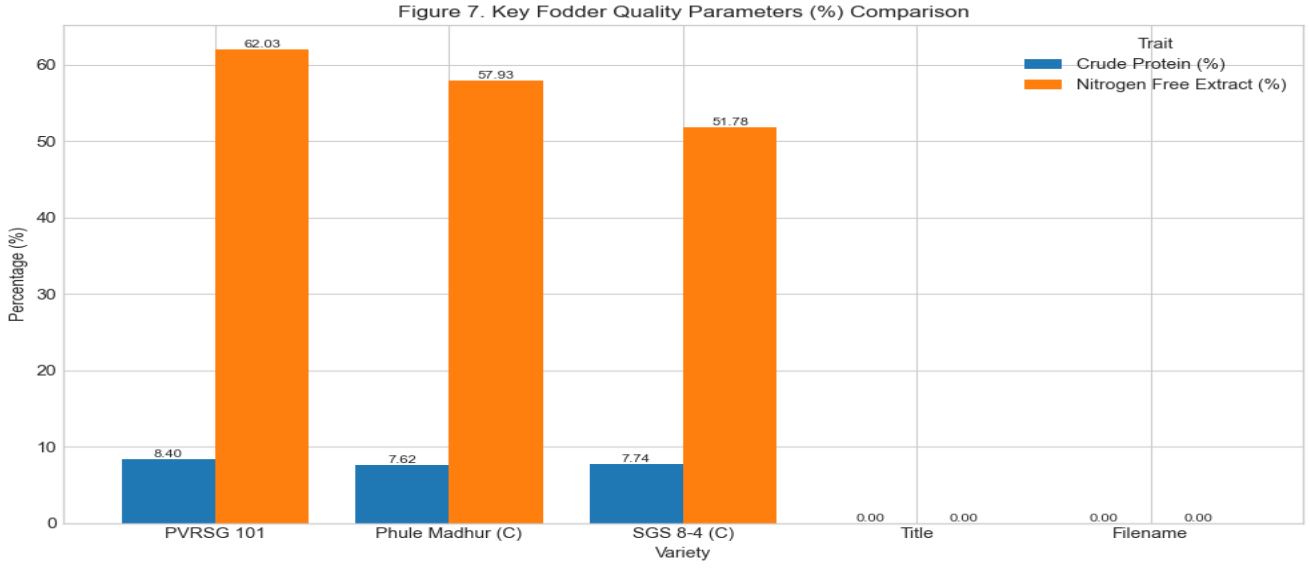


Table 3d: Fodder Quality of PVRSG 101 (2020-21) (Mean values in %)

Trait	PVRSG 101	Phule Madhur (C)	SGS 8-4 (C)
Crude Protein (%)	**8.40**	7.62	7.74
Crude Fibre (%)	21.44	26.34	31.34
Total Ash (%)	**5.53**	6.21	6.64
Nitrogen Free Extract (%)	**62.03**	57.93	51.78

The fodder quality of PVRSG 101 was superior, characterized by the highest Crude Protein content (**8.40%**) and the highest Nitrogen Free Extract (NFE) (**62.03%**), which is indicative of higher digestibility and energy content for livestock [50]. The lower Crude Fibre content (21.44%) further supports its superior fodder quality compared to the checks.

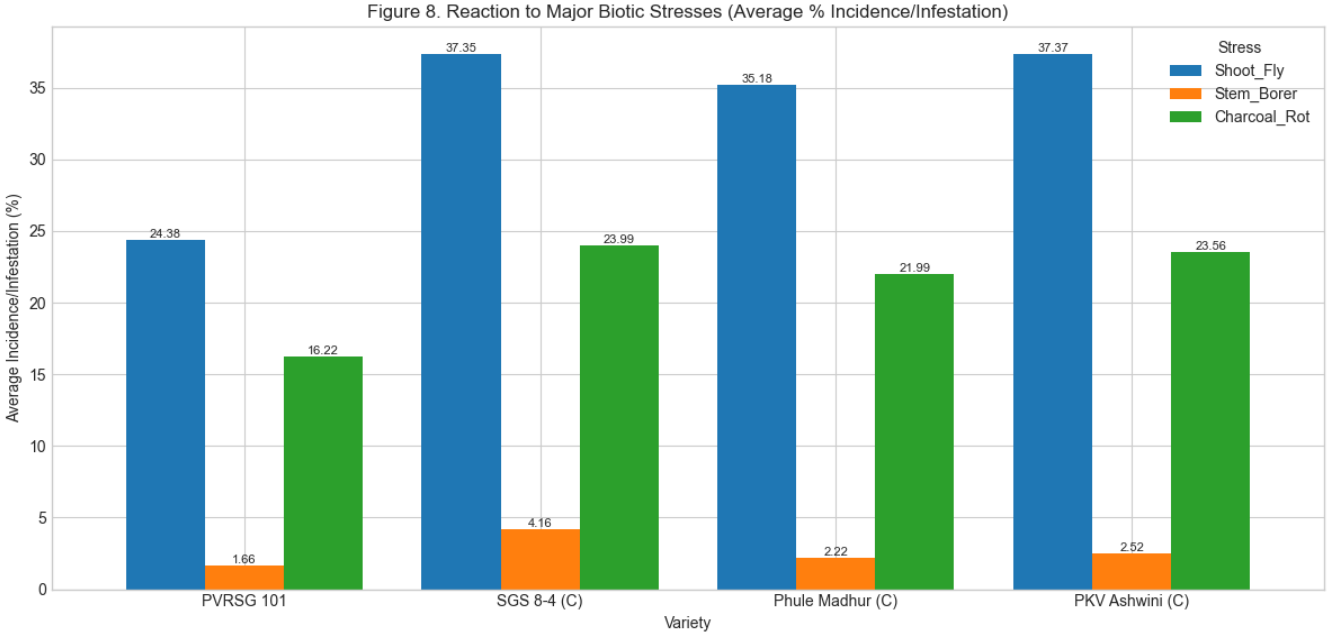
4.4. Reaction to Major Pests and Diseases

The reaction of PVRSG 101 to major biotic stresses was assessed in the Station Trials over three years (2018-19 to 2020-21).

Table 5a: Shoot Fly Dead Hearts Percentage at 28 DAE (Average 2018-2021)

Variety	Average Dead Hearts (%)
PVRSG 101	**24.38**
SGS 8-4 (C)	37.35
Phule Madhur (C)	35.18
PKV Ashwini (C)	37.37

Figure 8. Reaction to Major Biotic Stresses (Average % Incidence/Infestation)



PVRSG 101 recorded a significantly lower average incidence of shoot fly dead hearts (**24.38%**) compared to the checks, which ranged from 35.18% to 37.37%. This indicates a moderate level of tolerance to the most damaging pest of *Rabi* sorghum [51]

Table 5b: Stem Borer Infestation Percentage at 45 DAE (Average 2018-2021)

Variety	Average Infestation (%)
PVRSG 101	**1.66**
SGS 8-4 (C)	4.16
Phule Madhur (C)	2.22

Variety	Average Infestation (%)
PKV Ashwini (C)	2.52

The stem borer infestation in PVRSG 101 was remarkably low, averaging only **1.66%**, which is substantially lower than all checks, demonstrating a high degree of tolerance to this pest [52].

Table 5c: Charcoal Rot Incidence Percentage (Average 2018-2021)

Variety	Average Incidence (%)
PVRSG 101	**16.22**
SGS 8-4 (C)	23.99
Phule Madhur (C)	21.99
PKV Ashwini (C)	23.56

PVRSG 101 showed a lower incidence of charcoal rot (**16.22%**) compared to the checks (21.99% to 23.99%), suggesting a moderate tolerance to this critical disease, which is essential for preventing lodging and ensuring high stover quality under terminal drought conditions [53].

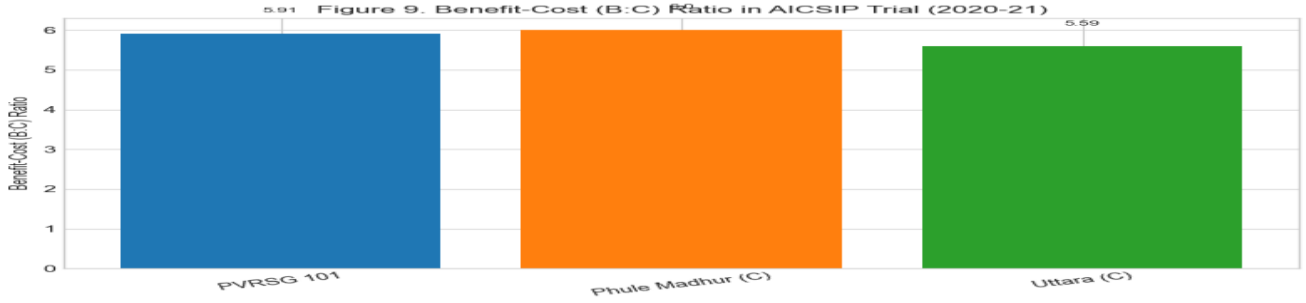
4.5. Economic Viability and Adaptive Trial Results

The economic analysis, based on the AICSIP and Agronomy trials, confirmed the superior profitability of PVRSG 101.

Table 1e: Economic Returns of PVRSG 101 in AICSIP (2020-21) (Genotypes G)

Genotype	Mean Tender Grain Yield (q/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C Ratio
Phule Madhur (C)	26.06	292844	247472	6.00
Uttara (C)	27.50	274777	229405	5.59
PVRSG 101	**27.55**	**289143**	**243771**	**5.91**

Figure 9. Benefit-Cost (B:C) Ratio in AICSIP Trial (2020-21)



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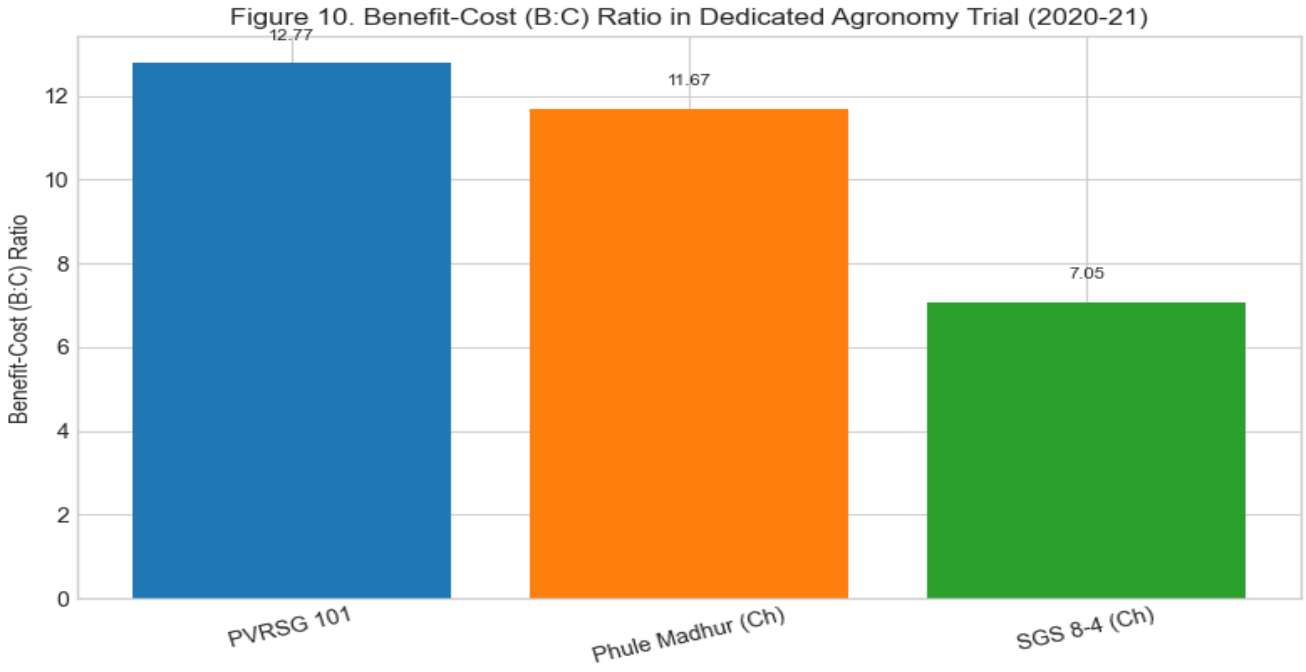
In the AICSIP trial, PVRSG 101 recorded a mean tender grain yield of 27.55 q/ha, showing a 1.88% increase over the check Phule Madhur. Crucially, it achieved a high **Benefit-Cost (B:C) ratio of 5.91**, which is comparable to the best check (Phule Madhur at 6.00) and significantly higher than other entries, confirming its strong economic performance under co-ordinated trial conditions [54].

Table 4: Economic Returns of PVRSG 101 in Agronomy Trial (2020-21) (Genotypes G)

Genotype	Hurda Grain Yield (kg/ha)	Green Fodder Yield (q/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C Ratio
PVRSG 101	**2921**	**9489**	**447589**	**412690**	**12.77**
SGS 8-4 (Ch)	1616	5152	247569	212670	7.05
Phule Madhur (Ch)	2669	9088	409454	374555	11.67

Figure 10. Benefit-Cost (B:C) Ratio in Dedicated Agronomy Trial (2020-21)



In the dedicated Agronomy trial, PVRSG 101 demonstrated a superior B:C ratio of **12.77**, which was significantly higher than the best check, Phule Madhur (11.67), and substantially higher than SGS 8-4 (7.05). This high B:C ratio is a direct result of its superior yield performance in both grain and fodder [55].

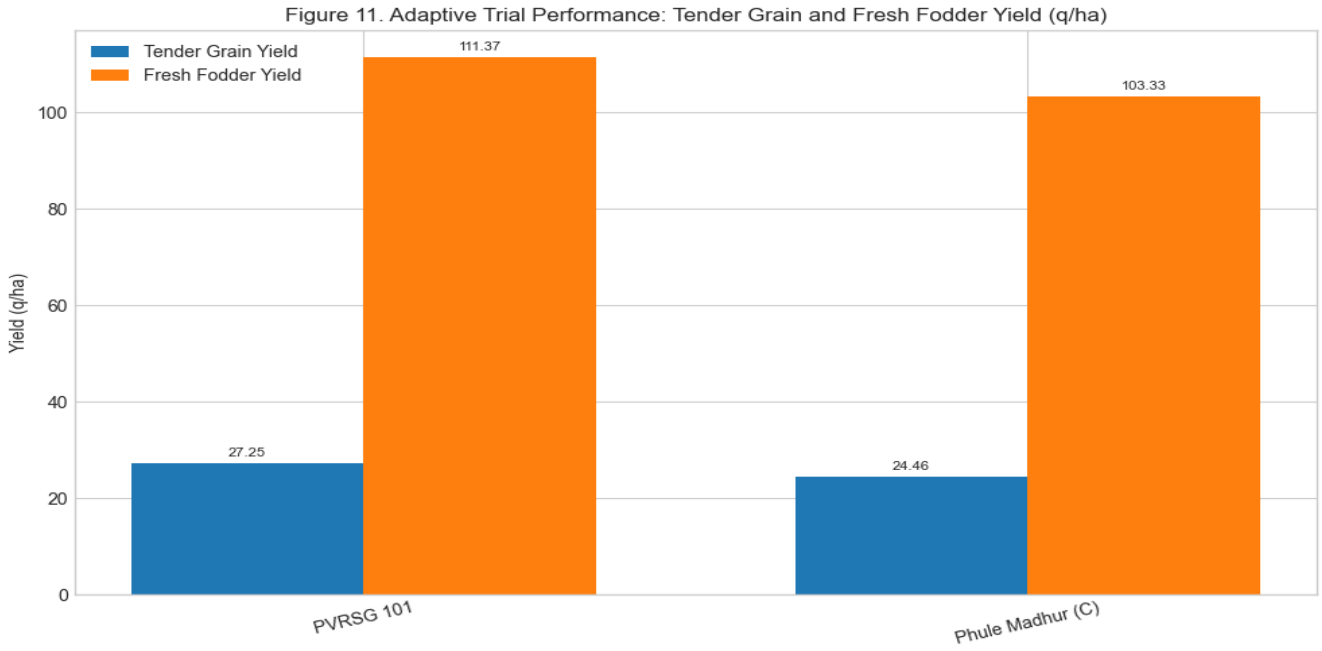
4.5.1. Farmer Adaptive Trial Results

The results from the 30 Farmer Adaptive Trials conducted in 2020-21 further validated the on-farm performance of PVRSG 101.

Table 6: Adaptive Trial Performance (Average of 30 Trials, *Rabi* 2020-21)

Variety	Tender Grain Yield (q/ha)	Fresh Fodder Yield (q/ha)	% Increase over Phule Madhur
PVRSG 101	**27.25**	**111.37**	--
Phule Madhur (C)	24.46	103.33	**11.44% (Grain), 8.72% (Fodder)**

Figure 11. Adaptive Trial Performance: Tender Grain and Fresh Fodder Yield (q/ha)



Across the 30 trials, PVRSG 101 yielded an average of **27.25 q/ha** of tender grain and **111.37 q/ha** of fresh fodder. This represents an 11.44% superiority in grain yield and an 8.72% superiority in fodder yield over the check Phule Madhur, confirming its robust performance and acceptance under diverse farmer management practices [56].

4.6. Detailed Morphological Description (Annexure I and II)
The detailed description of PVRSG 101 (Annexure I) confirms its distinctness. Key features include:

- **Pedigree:** Selection from local Germplasm Parbhani Gulbhendi.
- **Maturity:** Medium duration (70-75 days to 50% flowering).
- **Plant Height:** Tall (235-240 cm).
- **Stem:** Juicy, non-tillering, with high regeneration capacity.
- **Grain:** White, non-lustrous, shrivelled, with a medium maturity range (115-118 days).
- **Quality:** Good grain and fodder quality.

The DUS characteristics (Annexure II) further establish its distinctness, noting a grayed purple coleoptile pigmentation, white midrib color, and a large grain size mark of germ, which are critical for variety registration and protection [57].

5. DISCUSSION

The development and comprehensive evaluation of 'Parbhani Vasant' (PVRSG 101) represent a significant advancement in breeding dedicated *Rabi* sorghum varieties for the high-value *Hurda* market in the Marathwada region. The results from the multi-year, multi-location trials consistently demonstrate the superiority of PVRSG 101 over existing commercial checks in terms of yield, quality, and pest tolerance, which collectively translate into a substantial economic advantage for the farmer.

5.1. Superiority in Yield and Stability
The primary finding is the remarkable and stable superiority of PVRSG 101 in tender grain yield. The overall average yield of **34.79 q/ha** in the University Multilocation Trials (UMT) over four years (Table 1c) is a testament to its genetic potential and adaptability. This yield advantage, ranging from 10.85% to 29.56% over the state checks, is particularly noteworthy given the inherent variability of rainfed agriculture in the Deccan plateau [58]. This stability aligns with the findings of Kumar et al. (2022) [21], who emphasized that successful *Rabi* varieties must exhibit consistent performance across heterogeneous environments. The fact that PVRSG 101 was selected from local germplasm, 'Parbhani Gulbhendi', likely contributes to its robust adaptation to the specific soil and climatic conditions of the Marathwada region, a strategy supported by traditional breeding literature [22].

Furthermore, the variety's high green fodder yield (**132.66 q/ha** in UMT, Table 1d) confirms its dual-purpose utility, which is critical for the mixed farming systems prevalent in this region [8]. The dual advantage in both grain and fodder yield maximizes the total biomass and economic return per unit area, a key objective in modern sorghum breeding programs [20].

5.2. Enhanced Quality for the Hurda Niche Market
The success of a *Hurda*-specific variety hinges on its quality attributes, and PVRSG 101 excelled in this regard. The sensory evaluation (Table 3a) showed a significantly higher taste score for both tender and roasted samples compared to the checks. This superior organoleptic quality, coupled with the highest 100-tender grain weight (4.22 g) and threshability (94.55%) (Table 2a), makes PVRSG 101 ideally suited for the processing and consumption requirements of *Hurda* [25].

The nutritional analysis further supports its market potential. The higher protein content in the tender grain (7.5%, Table 3b) and the superior fodder quality, characterized by the highest Crude Protein (8.40%) and Nitrogen Free Extract (62.03%) (Table 3d), position PVRSG 101 as a nutritionally enhanced option. The high NFE suggests

better digestibility for livestock, adding value to the stover [50]. This focus on both human and animal nutrition aligns with the growing global demand for nutrient-dense and dual-purpose crops [28].

5.3. Resilience to Biotic Stresses

Biotic stresses, particularly the shoot fly (*Atherigona soccata*) and charcoal rot (*Macrophomina phaseolina*), are major constraints to *Rabi* sorghum production [16]. The evaluation demonstrated that PVRSG 101 possesses a moderate level of tolerance to these key stresses. The shoot fly dead heart incidence of **24.38%** (Table 5a) and the charcoal rot incidence of **16.22%** (Table 5c) were substantially lower than the commercial checks. This level of tolerance is crucial for stabilizing yields, especially under the high-stress conditions often encountered during the *Rabi* season [34]. The low stem borer infestation (**1.66%**, Table 5b) further contributes to the variety's overall resilience, reducing the need for chemical interventions and promoting more sustainable agricultural practices [36]. This moderate tolerance is a significant improvement over many traditional varieties and is a key factor in recommending its release.

5.4. Economic Viability and Farmer Adoption

The ultimate measure of a new variety's success is its economic impact on the farming community [38]. The economic analysis confirmed the strong profitability of PVRSG 101. The high Benefit-Cost (B:C) ratio of **12.77** in the dedicated Agronomy trial (Table 4) and **5.91** in the AICSIP trial (Table 1e) is a direct consequence of its superior yield performance in both tender grain and fodder. This high B:C ratio is a compelling indicator for extension agencies and policy makers, suggesting that the adoption of PVRSG 101 will lead to higher net monetary returns for farmers in the Marathwada region [41].

The results from the Farmer Adaptive Trials (Table 6) provide the final validation. The consistent on-farm superiority of 11.44% in grain yield and 8.72% in fodder yield over the check Phule Madhur under diverse farmer management practices confirms the variety's robustness and ease of cultivation [56]. This successful performance in farmer fields strongly suggests a high likelihood of rapid and widespread adoption, thereby contributing to the socio-economic upliftment of the region, as noted in the literature on the impact of improved cultivars [40].

6. CONCLUSION

The comprehensive evaluation of the *Rabi* sorghum sweet grain (*Hurda*) variety 'Parbhani Vasant' (PVRSG 101) across station, multi-location, co-ordinated, and farmer adaptive trials from 2015-16 to 2020-21 unequivocally establishes its superiority over the existing state checks SGS 8-4, Phule Madhur, and PKV Ashwini.

PVRSG 101 consistently demonstrated:

1. **Superior Yield:** An overall average tender grain yield of 34.79 q/ha in UMT, representing a significant increase over all checks.
2. **Enhanced Quality:** Superior organoleptic properties and a better nutritional profile, making it highly suitable for the high-value *Hurda* market.
3. **Stress Tolerance:** Moderate tolerance to major biotic stresses, including shoot fly, stem borer, and charcoal rot, ensuring stable yields.
4. **High Economic Returns:** A highly favorable Benefit-Cost ratio, confirming its economic viability and profitability for farmers.

Based on these robust and consistent findings, the *Rabi* sorghum sweet grain (*Hurda*) variety 'Parbhani Vasant' (PVRSG 101) is strongly recommended for formal release and widespread cultivation in the *Rabi* sorghum growing areas of the Marathwada region of Maharashtra state. Its adoption is expected to significantly enhance farmer income, improve regional food and fodder security, and strengthen the *Hurda* value chain.

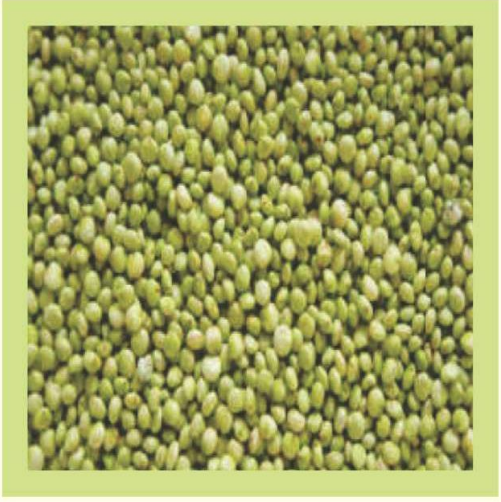
Annexure - II

DUS characteristics of proposed *Rabi* sorghum sweet grain (*Hurda)* variety Parbhani Vasant (PVRSG 101) in Station Trial. (*Rabi* 2019-20)

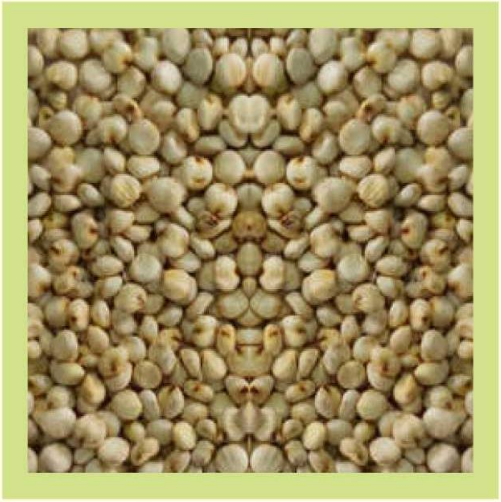
SN	Characteristics	Grade / note	States
1	Seedling: anthocyanin colouration of coleoptile	2	Grayed purple
2	Leaf sheath: anthocyanin colouration	2	Grayed purple
3	Leaf: midrib colour (5th fully developed leaf)	1	White
4	Plant: time of panicle emergence (50% of the plants with 50% anthesis)	5	Medium
5	Plant: natural height of plant up to base of flag leaf	7	Tall
6	Flag leaf: yellow colouration of midrib	1	Absent
7	Lemma : arista formation	5	Present
8	Stigma: anthocyanin colouration	1	Absent
9	Stigma: yellow colouration	1	Absent
10	Stigma: length	5	Medium
11	Flower with pedicel: length of flower	5	Medium
12	Anther: length	5	Medium
13	Anther: colour of dry anther	4	Grayed orange
14	Glume: colour	1	Green white
15	Plant: total height	7	Long
16	Stem: diameter (at lower one third height of plant)	7	Large
17	Leaf: length of blade (the third leaf from top including flag leaf)	7	Long
18	Leaf: width of blade (the third leaf from top including flag leaf)	7	Broad
19	Panicle: length without peduncle	3	Short
20	Panicle: length of branches (middle third of panicle)	5	Medium
21	Panicle: density at maturity (ear head compactness)	5	Semi loose
22	Panicle: shape	3	Symmetric

SN	Characteristics	Grade / note	States
23	Neck of Panicle: visible length above sheath	7	Long
24	Glume: length	5	Medium
25	Threshability	1	Freely threshable
26	Caryopsis: colour after threshing	1	White
27	Grain: weight of 1000 grains	7	High
28	Grain: shape in dorsal view	3	Circular
29	Grain: shape in profile view	3	Circular
30	Grain: size of mark of germ	7	Large
31	Grain: texture of endosperm (in longitudinal section)	7	¾ farinaceous
32	Grain: Colour of vitreous albumen	1	Gyayed yellow
33	Grain: Luster	1	Non-lustrous

Earhead under anthesis



Tender Grains



Mature Grains

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