

## SORGHUM-2011: A NEW DUAL PURPOSE SORGHUM BICOLOR CULTIVAR FOR AGRO-CLIMATIC CONDITIONS OF PAKISTAN

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### ABSTRACT

A new *Sorghum bicolor* cultivar Sorghum-2011 was developed at Fodder Research Sub-Station, Ayub Agricultural Research Institute, Faisalabad, Pakistan from a cross Sugrorib (local) × Australian No.7 (exotic). It was selected through pedigree breeding method during the year 1998-99. Homozygous progenies of pedigree No. F6-6019 was bulked in 2001-02 for yield evaluation. Its fodder yield potential alongwith grain yield was assessed in station, zonal, micro and national uniform fodder yield trials during the year 2002-03 to 2009-10. Sorghum-2011 performed better in all these trials than existing cultivars (Hegari, JS-263 and JS-2002). Its maximum fodder yield potential (75.46 tons/ha) was attained in 2007-08 in NUFYT at Agricultural Research Institute, Dera Ismail Khan. It is a dual purpose variety that produces high tonnage with good grain yield, high water use efficiency, less fertility requirements, excellent nutritional quality, robust cover crop and green chop fresh fodder. In addition, it contains one percent more sugar content contributing 130 kg sugar per hectare than existing varieties without any additional cost of production. It has a wide adaptability in targeted production areas of Pakistan. The variety Sorghum-2011 is superior in morphological characters i.e. plant height (255cm), number of leaves per plant (16) and maximum length × breadth (339 cm<sup>2</sup>) giving higher forage yield (70 t/ha) and grain yield (2.94 t/ha) as compared to commercial check varieties JS-263 and JS-2002. It has 2.11 and 13.98 percent low HCN content than JS-2002 and popular sweet variety Hegari, respectively. It has potential to fill the gap in supply and demand for summer fodders and also may be helpful in reducing export of sorghum seed in Pakistan. Due to these remarkable features, the new strain F-9917 named as Sorghum-2011 was released during the year 2011 for general cultivation in Pakistan.

**KEYWORDS:** *Sorghum bicolor*, new cultivar; hydrocyanic acid; sucrose content; agronomic characters; Pakistan.

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## INTRODUCTION

Sorghum is an important summer annual grass (19) and ranks fifth among cereal crops in the world. Sorghum plant is unique in stature and can grow in adverse environments. It has a very large and extensive tap root system that enables it to obtain water and nutrients from soil depth of over five feet. *Sorghum bicolor* is usually cultivated for its high stem juice, vegetative biomass (forage yield) and grain yield that reveals its diverse utility. Demand of green fodder and grain yield for rapidly growing livestock and poultry industry in Pakistan, is increasing day by day. Sorghum can be grown successfully throughout Pakistan both under irrigated and rainfed conditions. It is cultivated for forage and grain purpose on an estimated area of 0.41 million hectares with 6.31 metric tons green fodder production (4). Moreover, it fulfills more than 50 percent requirement of rainfed region of the country. In rainfed areas it is also stored in the fields or sheds to feed livestock even in winter fodder scarcity period. In Pakistan, there are two lean periods for fodder scarcity, first in May-June during summer and second in October-November during winter. Due to stay green trait, sorghum improvement for yield and quality characters can greatly reduce the risk of inadequate forage production during summer.

Sorghum has a significant role in livestock production in the tropical zone where feed stuffs could not meet animal requirements due to soil biotic and abiotic factors (23).

Breeding programmes aiming at evolving varieties and hybrids with high sugar and grain yields have produced very promising varieties (17). The yield per unit area may be increased substantially through evolution of genotypes, possessing good combination of all yield components (25). Pedigree breeding method is utilized in developing high yielding and disease resistant varieties (5). Chohan *et al.* (8) reported that sorghum plant traits like plant height, number of leaves and leaf area were significantly and positively correlated with high vegetative biomass. Chughtai *et al.* (9) emphasized the need for on-farm verification of appropriate germplasms and newly developed varieties of sorghum adaptable to Pakistan conditions. Hussain *et al.* (13) concluded that sorghum cultivars No. 94 and 95 provided a better green fodder and dry matter yield and crude protein contents. Breeding efforts to produce dual-purpose sorghum have been successful (18). Progenies derived from both sweet x sweet and sweet x non-sweet crosses contain significantly higher sugar content than their parents (17, 21). Al-Sultan (2) and Srinivasa *et al.* (27) reported high HCN content in early growth stage gradually decreased with plant maturity. Sorghum is economically the

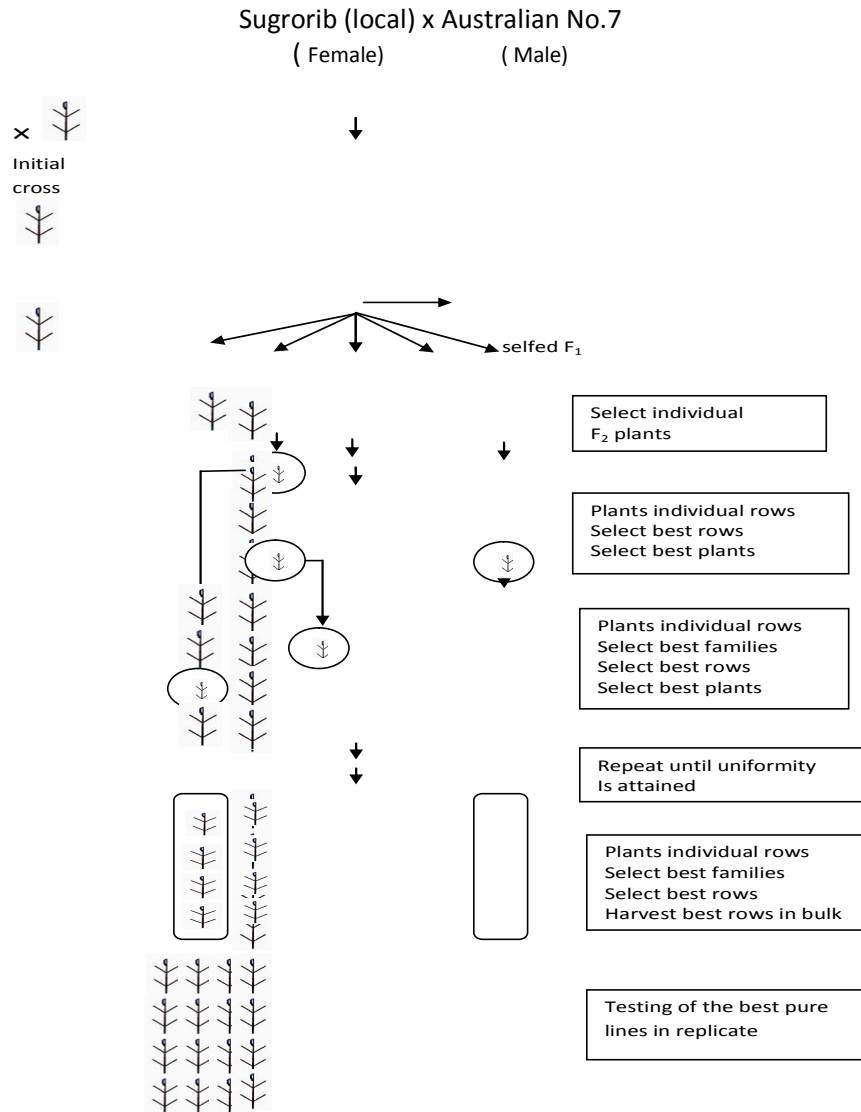
most important kharif fodder crop. It provides palatable green fodder over a longer period than maize and millet. Its green fodder contains 12 percent protein, 70 percent carbohydrates, minerals, nitrogen free extract and crude fat. The existing sorghum cultivars i.e. Hegari, JS-263 and JS-2002 do not cater to the demand of livestock enterprise due to disease susceptibility, early maturing, low seed and fodder yield. The fodder production is hardly enough to meet about 30 to 50 percent of the total national fodder requirement (3). The commercial variety JS-263 is susceptible to long smut (*Tolyposporium chrenberigic*) and grain smut (*Sphaecelotheca sroghi*).

The present study was undertaken to develop a new high value nutritional green sorghum cultivar having stay green gene with low HCN content, better grain yield and resistance to biotic and abiotic stresses.

### **MATERIALS AND METHODS**

Variety Sorghum-2011 was developed at Fodder Research Sub-Station, Ayub Agricultural Research Institute Faisalabad, Pakistan. Two diverse lines with desirable characteristics i.e. Sugrorib (local) and Australian No.7 (exotic) were hybridized in the experimental field. In order to prevent cross pollination, sorghum heads were bagged during blooming period and manual emasculation and plastic bag techniques were employed to produce cross. When stigma became exposed, pollen from desired male parent was dusted with camel hair brush and panicle was covered with paper bag to avoid contamination. The pedigree method of selection was adopted and their filial generations from F<sub>1</sub>-F<sub>7</sub> were maintained (Fig. 1). Selection of pure lines from outstanding plants in the field was applied to the crop. Single plant selection was made on the basis of plant height, sweetness, juiciness, number of leaves, strong stem, HCN level and high fodder tonnage. These plants were sown in head to rows progeny in F<sub>2</sub> to F<sub>7</sub> generations and seed of head to row progeny was bulked after achieving maximum uniformity. Variety MR sorghum-2011 was assessed in the field at various agro-climatic conditions for various morpho-chemical distinct traits alongwith standard varieties.

F<sub>2</sub> generation provided first opportunity for pedigree selection in which more emphasis was given on the elimination of individuals carrying undesirable major genes. In subsequent generations hybridization gave way to pure breeding as a result of natural self-pollination, and families derived from different F<sub>2</sub> plants began to demonstrate their unique characters. Usually one or two superior plants are selected within each superior family in these generations. By F<sub>5</sub> generation, homozygosity is extensive and emphasis



**Fig. 1. Pedigree breeding method employed for development of Sorghum-2011 variety.**

shifted almost entirely to selection between families. The pedigree record is useful in making these eliminations. At this stage each selected family is usually harvested in mass to obtain larger amounts of seed needed to evaluate families for quantitative characters. This evaluation is usually carried

out in plots grown under conditions that stimulate commercial planting practice as closely as possible. When the number of families is reduced to manageable proportions by visual selection, usually by F<sub>7</sub>, precise evaluation for performance and quality begins. After attaining uniformity, single head rows were bulked in F<sub>7</sub>.

The final evaluation of Sorghum-2011 was undertaken during the year 2002-03 to 2009-10 in preliminary, regular, advanced, adaptation and national uniform yield trials at stations and out stations for forage and grain yields alongwith commercial check varieties Hegari, JS-263 and JS-2002. The design of trials was RCBD with three replications. Each plot consisted of 6 meter long and 30 cm apart ten rows having a plot size of 18 m<sup>2</sup>. Seed @ 75kg per hectare and fertilizer @ 60-60-00 kg NPK per hectare were applied. Three irrigations were applied during the entire period of crop growth. Furadan granules were applied @ 15 kg per hectare at the time of sowing to control shoot fly and at six-leaf stage to control stem borer. All above mentioned recommended practices were applied at all experimental locations except environment. Data from ten randomly competitive plants were recorded on plant height (cm), stem thickness (cm), number of leaves per plant, green fodder yield (t/ha) and grain yield (t/ha). Some morphological and chemical parameters were also measured as given below:-

#### **Ear leaf area (cm<sup>2</sup>)**

Leaf area was measured as the product of ear length from base to tip and maximum breadth in the center by using the formula suggested by McKee (18).

$$\text{Leaf area} = \text{Leaf length (cm)} \times \text{leaf width (cm)} \times 0.73$$

#### **Leaf stem ratio**

Leaf blades were separated from stem of each plant and then dried the separated leaves and stem. Leaf-stem ratio was calculated by the formula:

$$\text{Leaf stem ratio} = \text{Dried leaf weigh (g)} / \text{dried stem weight (g)}$$

#### **Hydrocyanic acid (HCN) (ppm)**

Quantitative analysis of HCN in the sample was carried out by picrate paper test as proposed by Hogg and Ahlgren (12). Two gram chopped green fodder

was put into the test tube and moistened by adding few drops of distilled water followed few drops of chloroform . The freshly prepared sodium picrate strips (dipping Whatmann No. 1 filter paper strip into 1% picric acid and 10% sodium carbonate solution) were inserted in the test tube in hanging position without touching sides or sample. The test tubes were rubber corked tightly. Colour development of strips was began after five minutes. Then tube having content was put at room temperature for minimum six hours, paper changed its colour from yellow to brick red according to level of hydrocyanic acid.

### **Sugar content (%)**

Glucose was analyzed by DNS method and total sugar measurement was done by Anthrone method (11).

### **Chemical composition**

Quality traits were evaluated with proximate analysis (1).

### **Data analysis**

The data recorded were statistically analyzed using the analysis of variance technique and least significant differences at 5 percent probability (26).

## **RESULTS AND DISCUSSION**

Significant differences were observed among three varieties at various locations for plant height, ear leaf area, number of leaves per plant, stem thickness, leaf-stem ratio, green fodder yield and grain yield. The data (Table 1) revealed that variety Sorghum-2011 ranked top in fodder yield potential (67 to 71 t/ha) in all yield trials during years 2003 to 2010 against check varieties JS-263 (53-57 t/ha) and JS-2002 (63-65 t/ha). On an average basis, this new variety produced 15 and 6.2 tons per hectare more fodder yield than JS-263 and JS-2002, respectively. These findings are in line with some earlier workers (8, 13). Performance of new sorghum variety in different trials is discussed below:-

### **Preliminary yield trials**

Variety Sorghum-2011 was evaluated consecutively for two years in these trials. The data (Table 1) depicted that variety Sorghum-2011 gave maximum fodder yield potential (71 t/ha) as compared to standard varieties JS-263 (57.0 t/ha) and JS-2002 (64 t/ha) in preliminary yield trials. This variety also

excelled in grain yield (3 t/ha) than JS-263 (1.7 t/ha) and JS-2002 (0.55 t/ha). Regarding morphological traits, this variety showed superiority over both checks with more plant height (256 cm), ear leaf area (339 cm<sup>2</sup>), and stem thickness (1.7 cm) and less leaf stem ratio (2.63). Similar results have been reported earlier (7, 8).

**Table 1. Comparison of mean values of morphological and yield related traits of MR Sorghum-2011 to check varieties, JS-263 and JS-2002 at stations and out stations field trials.**

Traits studies	1 Year (2001)	2 Year (2002)	3 Year (2003)	4 Year (2004)	5 Year (2004- 2007)	Avg.	LSD at 5%
<b>Sorghum-2011</b>							
Plant height(cm)	256	254	257	253	255	255	
Ear leaf area (cm <sup>2</sup> )	339	338	341	337	340	339	
No. of leaves/plant	14	12	15	13	16	14	
Stem thickness (cm)	1.7	1.9	2.0	1.8	1.6	1.8	
Leaf-stem ratio	2.63	2.64	2.70	2.66	2.61	2.65	
Green fodder yield (t/ha)	71.0	72.0	71.0	69.0	67.0	70	
Grain yield (t/ha)	3.0	3.2	3.1	2.9	2.5	2.94	
<b>JS-263</b>							
Plant height(cm)	171	174	173	172	170	172	
Ear leaf area (cm <sup>2</sup> )	290	289	291	292	293	291	
No. of leaves/plant	10	9	10	11	11	10	
Stem thickness (cm)	1.2	1.1	1.0	1.3	1.0	1.12	
Leaf-stem ratio	2.83	2.84	2.87	2.86	2.82	2.84	
Green fodder yield (t/ha)	57.0	56.0	55.0	54.0	53.0	55	
Grain yield (t/ha)	1.7	1.8	1.4	1.9	1.8	1.72	
<b>JS-2002</b>							
Plant height(cm)	232	234	233	235	231	233	4.81
Ear leaf area (cm <sup>2</sup> )	330	333	331	329	334	331	8.75
No. of leaves/plant	14	12	11	13	11	12	1.42
Stem thickness (cm)	1.5	1.4	1.6	1.3	1.5	1.46	0.25
Leaf-stem ratio	3.02	3.01	2.99	3.03	3.05	3.02	1.04
Green fodder yield (t/ha)	64.0	63.0	65.0	64.0	63.0	63.8	3.89
Grain yield (t/ha)	0.55	0.56	0.59	0.56	0.56	0.56	5.63

1 = Preliminary Yield Trial, 2 = Regular Yield Trial, 3 = Advanced Yield Trial, 4 = Adaptation Yield Trial, 5 = National Uniform Fodder Yield Trial.

### Regular yield trials

Variety Sorghum-2011 also produced higher fodder yield (72 t/ha) than check varieties JS-2002 (63 t/ha) and JS-263 (56 t/ha) in regular yield trials. Regarding seed yield, Sorghum-2011 ranked first (3.2 t/ha) as compared to JS-263 (1.8 t/ha) and JS-2002 (0.56 t/ha). This variety also revealed better plant height (254 cm), ear leaf area (338 cm<sup>2</sup>), leaves per plant (12), stem thickness (1.9 cm) and leaf-stem ratio (2.64) having a remarkable variation

as compared to check varieties. These results agree to the findings of earlier researchers (13, 14).

### Advanced yield trials

In advanced yield trials also Sorghum-2011 produced higher fodder (71 t/ha) and grain yield (3.1 t/ha) than both checks (Table 1). For morphological traits Sorghum 2011 proved as superior to check varieties in plant height (357 cm), ear leaf area (341 cm), leaves per plant (15), stem thickness (2.0 cm) and leaf-stem ratio (2.70). Earlier workers (24, 28) have also reported similar findings.

### Adaptation yield trials

The data (Table 1) showed that variety Sorghum-2011 also excelled in fodder (69 t/ha) and grain yield (2.9 t/ha) in these trials. This variety was found as superior in all morphological traits i.e. plant height (253 cm), ear leaf area (337 cm), leaves per plant (13), stem thickness (1.8 cm) and leaf-stem ratio (2.66). Earlier researchers (7, 8, 9, 26) also made similar observations.

### National uniform yield trials

Also in national uniform yield trials (Table 1) Sorghum-2011 produced maximum green fodder (67 t/ha) and seed yield (2.5 t/ha) as compared to standard varieties JS-263 (53.0 t/ha) and JS-2002 (63.0 t/ha). Significant differences were observed in new variety for plant height (255 cm), ear leaf area (340 cm), leaves per plant (16), stem thickness (1.6 cm) and leaf-stem ratio (2.61). These results are in accordance with previous work (15, 16).

### Quality parameters

The data (Table 2) depicted that variety Sorghum-2011 showed its superiority in quality over both check varieties JS-2002 and JS-263. These results are in agreement with earlier researchers (3, 17, 21). Due to its high profile in quality traits and fodder yield potential, it can be considered for general cultivation to the farmers throughout Pakistan.

**Table 2. Proximate analysis of sorghum genotypes.**

Variety/Line	C.P (%)	C.F (%)	E.E (%)	Ash (%)	Palatability (%)	Digestibility (%)	HCN (ppm)	Sugar (%)
Sorghum-2011	7.01	35.78	1.78	9.28	78.95	63.1	348.71	0.78
JS-2002	4.92	36.34	1.77	8.86	70.00	55.7	376.22	0.48
JS-263	4.00	37.09	1.67	8.67	68.33	52.4	381.15	0.44
Hegari	4.50	37.40	1.60	9.03	78.40	62.9	405.39	6.2
LSD%	3.02	NS	NS	NS	2.14	5.26	6.18	1.01

C.P= Crude protein; C.F=Crude fiber; E.E= Ether extract; HCN= Hydrocyanic acid

There is variation in HCN content at the same stage in different varieties. Variety JS-263 and JS-2002 had higher HCN content i.e. 376.22 and 381.15 ppm, respectively than Sorghum-2011 (348.71 ppm). Similar variation have also been reported by Patel *et al.* (22) who observed high variation in the HCN content in range of 5.28 (S-1049) to 75.36 mg% (JS-3) in different varieties of sorghum at one month after sowing. Higher HCN content was recorded in hybrid varieties as compared to local variety Malavan. Similar findings of genotypic differences for HCN in sorghum were also reported earlier by EL Obeid *et al.* (10) and Mohanraj *et al.* (20). Blood and Henderson (6) reported that hybrid of Johnson grass (*S.halepense*), Sudan grass (*S.sudanese*) and sorghum (*Sorghum bicolor*) were more toxic than pure species.

Sorghum-2011 also showed its superiority over the check varieties JS-2002, Hegari and JS-263 having more crude protein (7.01%), ether extract (1.78%) and less crude fibre (35.78%). Similarly this variety has more palatability (78.95%) and digestibility (63.1%) than other varieties. This new variety also contains more sugar contents (0.78%) than latest approved variety JS-2002 (0.48%).

#### **Description of variety Sorghum-2011**

Sorghum-2011 variety having high green fodder and grain yield is a dual purpose variety. It has more crude protein, sugar, palatability, digestibility, ashes and ether extract with less crude fibre and HCN. It is a medium

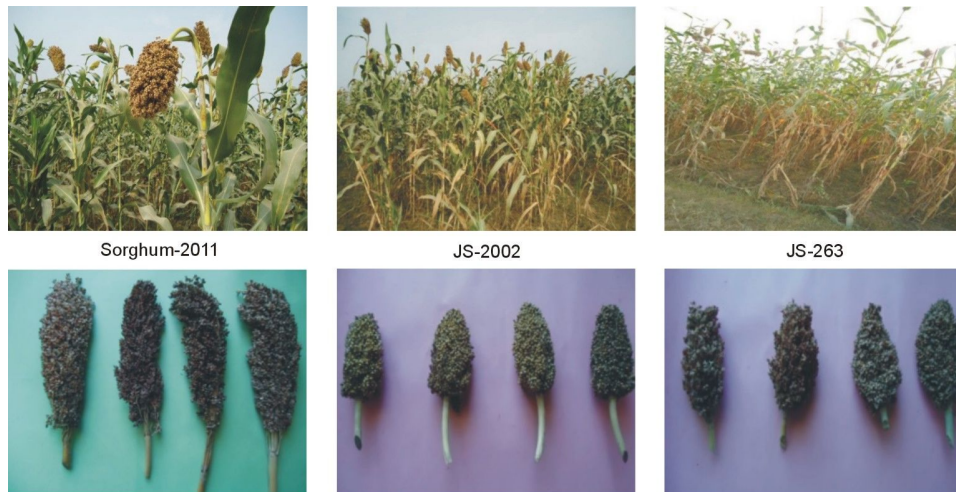


Fig. 2. Pictorial comparison of forage plant biomass and panicle shape of various sorghum cultivars. duration variety with stay green character and tall growing habit. Its stalk and leaves remain green and succulent even after maturity. Its midrib colour is dark. It has triangular auricle with flat margin shape. It has compact and large panicle with straight peduncle. Its grain colour is brown. It has wider adaptability under both irrigated and rainfed conditions. It has no specific agronomic requirements and can successfully be planted adapting prevalent agronomic practices. This variety will provide a base for further improvement in fodder quality and yield. The adoption of this approved variety will certainly help the farmers in increasing their green fodder and grain yields resulting in more milk and meat production in the country. Due to its high seed yield potential than existing approved varieties, it will also lessen the import of sorghum seed.

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