



## Fakhar E Punjab (YSH-95): A high-yielding dual-purpose indigenous sorghum hybrid

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### Abstract

In Pakistan, milk and meat production potential remains limited despite the country's good ranking. Sorghum is a good substitute for maize and other crops used for poultry feed and livestock fodder, owing to its high carbohydrate and protein concentration. Hybrids have higher potential than varieties, but because of the lack of suitable indigenous hybrids, a new hybrid, YSH-95, was developed with high grain and stalk yields, high brix, and high tolerance to foliar diseases. This hybrid was submitted to the national expert subcommittee and approved with the name Fakhar e Punjab. The hybrid was constituted from a CMS line and restorer lines received from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India, in Kharif (spring sowing season) 2000 and planted at the Maize and Millet Research Institute (MMRI), Yusafwala, Sahiwal, Pakistan. This sorghum hybrid has a potential grain yield of 6500 kg/ha, which is higher than the local check variety YS-16 and the Lasani commercial check hybrid. Fakhar e Punjab performed better in varietal yield trials, and in adaptability and national uniform yield trials during 2015, 2016, 2017 and 2018. Fakhar e Punjab also proved superior in stalk yield to the local check and the commercial check in varietal yield trials. Fakhar e Punjab has an intermediate maturity time (118 to 123 days), which is shorter than the local check YS-16, and is suitable for medium soil. Fakhar e Punjab is currently the best-performing hybrid recommended by the Punjab Seed Council owing to its medium height, sweetness, high grain and stalk yield, and ability to stay green at maturity.

**Keywords:** brix%, days to anthesis, grain yield, NUYT, stalk yield

### Introduction

Pakistan ranks highly in milk and meat production, but there remains a large potential gap, as is also the case for poultry and egg production (Zia *et al.*, 2011) [31]. An increase of up to 100% in production can be achieved with better-quality fodder and feed. Livestock and poultry production are increasing steadily in Pakistan: in 2018-19 both increased by 4%. But due to urbanization, the land area for crop cultivation is decreasing, and this is a major hurdle in the production of quality seed. As a result Pakistan is facing a shortage of quality fodder and poultry feed (Govt. of Pakistan, 2018-19).

The area under fodder crops was 2.04 million hectares in Pakistan in 2018-19. The share of sorghum crops (*Sorghum bicolor*) in this area was 0.255 million hectares, with a total production of 0.153 million metric tons, accounting for 12.50% of the total fodder crop production in Pakistan. These figures make sorghum the second largest fodder crop after berseem (43.54%) (Pakistan Bureau of Statistics, 2016). Because the availability of berseem is limited during lean periods, i.e. in December, January, June and July, sorghum can be considered an attractive alternative fodder crop in Pakistan. Moreover, the high brix value of sorghum makes it desirable as livestock fodder. Sorghum is also a major ingredient in poultry feed, with a recommended proportion of sorghum of 15% to 20% (Pakistan Agriculture Research Council, 2019).

As a coarse grain plant, sorghum is an important dual-purpose crop for both grain and fodder, and can be cultivated in both irrigated and rain-fed conditions throughout the country (Bibi *et al.*, 2010; Akram *et al.*,

2011) [5, 1]. It is considered the fifth most important cereal crop worldwide after wheat, rice, maize and barley (Motlhaodi *et al.*, 2014; Ritter *et al.*, 2007) [16, 26]. Its importance is increasing with the expansion of the poultry industry; in addition, it is gaining importance as a source of starch for textile industries, and is used in gum manufacture (FAOSTAT, 2016) [9]. It is also a good source of carbohydrates and protein (Selle *et al.*, 2014) [27]. The quality components of sorghum are compared with other major crops in Table 1 (Khalil *et al.*, 1984; Ambreen *et al.*, 2006; Sramkova *et al.* 2009; Nkongolo *et al.* 2010; Stevanovic *et al.*, 2012) [15, 2, 28, 20, 30].

The Maize and Millet Research Institute (MMRI) in Yusafwala-Sahawal has been a front-line provider of sorghum varieties, but unfortunately has not succeeded in developing any indigenous hybrids. Among the advantage of hybrids are not only higher yield but also uniformity in maturity and height, which is why they are preferred by farmers because farmers are very conscious to yield of the crop (Awal *et al.*, 2007; Mumtaz *et al.*, 2017) [4, 17]. To date all hybrids have been imported, at a heavy economic burden. Variety YS-16, released during 2016 for general cultivation, has good grain yield potential but is still unable to compete with exotic hybrids. Accordingly, a new hybrid named Fakhar e Punjab (YSH-95) has been developed with high yields as grain and fodder, a high brix value, and good tolerance to foliar diseases.

### Material and Methods

The YSH-95 hybrid was constituted from a cytoplasmic male sterile (CMS) line and restorer lines received from the

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India during the Kharif 2000 growing season and planted at the MMRI, Yusafwala, Sahiwal. The Kharif season crops were sown in June, July, August and harvested on October, November every year. Before hybrid constitution, the lines were planted and evaluated for adaptation, acclimatization, uniformity and resistance to insects and diseases. After these evaluations, hybrids were obtained from the CMS lines with different restorer lines during Kharif 2014. The procedure is described in detail below.

Crop breeders cultivated imported lines at research centers for adaptation, acclimatization and screening for insect and disease resistance. After acclimatization, the CMS lines were crossed with different restorers and the constituted hybrids were planted in the following season for evaluation in hybrid yield trials. Breeders were aware of the variation that can occur because of genotype–environmental interaction. To overcome this phenomena, zonal trials were widely conducted in the area of adaptability, usually in cooperation with enlightened growers and on government farms. When a breeder confirmed a hybrid on the basis of a wide range of tests and considered it to have sufficient merit, he submitted seed samples to the National Seed Registration Department to determine the distinctness, uniformity and stability (DUS) characteristics for description and registration purposes (Jones *et al.*, 2003)<sup>[14]</sup>. Simultaneously, seed samples were also provided to the Variety Evaluation Committees of Pakistan Agriculture Research Council (PARC) for crops. Both these organizations evaluated the candidate varieties and hybrids for value and cultivation use (VCU). Varieties or hybrids that met the VCU and DUS requirements were then accepted for registration and release as defined in the Seed Act: a released variety/hybrid is a registered variety/hybrid having agricultural value for cultivation and approved by the National or Provincial Seed Council (PARC, 2018)<sup>[22]</sup>. To fulfill these requirements and develop a hybrid, continuous selection among lines remains in progress to attain uniformity in different traits (Poehlman, 2006)<sup>[23]</sup>. The parental lines of hybrid YSH-95 have been evaluated for many years (during Kharif 2000 to 2014) and then used to constitute the new Fakhar e Punjab hybrid, which was then evaluated for yield and other important traits from 2015 to 2018 at MMRI Yusafwala-Sahiwal. The data were analyzed with the Fisher analysis of variance technique for a least significant difference (LSD) of 5% to compare differences among treatment means (Steel *et al.*, 1997)<sup>[29]</sup>. Quality analysis of Fakhar e Punjab was carried out with proximate analysis as described below.

#### **Determination of moisture, ash and crude fiber contents**

The samples were kept in an oven overnight at 100–110 °C and then cooled in a desiccator to determine moisture, which was calculated as the weight loss. Then, to determine ash content the samples were heated in a muffle furnace at 550 °C until the ash turned white or grayish white, and total ash was weighed directly. Crude fiber was measured by treating samples with 1.25% H<sub>2</sub>SO<sub>4</sub>, 1.25% NaOH and then 1% HNO<sub>3</sub>, with filtering and washing with hot water after each step. The residue was oven-dried at 130 °C and ashed at 550 °C in a furnace. The weight loss on ignition was expressed as crude fiber content (AOAC, 2000)<sup>[3]</sup>.

#### **Determination of lipid, protein and carbohydrate contents**

Total lipid was extracted from the sample with petroleum ether (60–80 °C) in a Soxhelt apparatus for about 6–8 h. The residual solvent was evaporated in a preweighed beaker, and the increase in weight of the beaker was recorded as total lipid content (AOAC, 2000)<sup>[3]</sup>.

Nitrogen content in the sample was estimated with the micro-Kjeldahl method, and crude protein was calculated by multiplying the nitrogen value by 6.25. Total carbohydrate was determined as 100 – (percentage of ash + percentage of total lipid + percentage of protein + percentage of crude fiber) (AOAC, 2000)<sup>[3]</sup>. The calorific value was calculated by multiplying the values for total carbohydrate, lipid and protein by the factors 4, 9 and 4 respectively, summing the products, and expressing the result in kilocalories (Guil-Guerrero *et al.*, 1997)<sup>[12]</sup>.

#### **Results**

Hybrid YSH-95 was tested in Punjab under different agro-climatic zones, and the results of yield trials are reported below.

##### **Sorghum hybrid yield trials**

Hybrid YSH-95 was evaluated in yield trials against local check YS-16 and compared with the commercial Lasani hybrid at two sites – MMRI in Yusafwala and the Sub-Station in DG Khan – from 2015 to 2017 (Table 2). The results presented in Table 2 show that according to average yield data for 3 years at both the locations, the proposed YSH-95 hybrid out-yielded the check variety (YS-16) and commercial Lasani hybrid by 34.72% and 24.24%, respectively.

##### **Adaptability sorghum yield trials**

The proposed hybrid was evaluated by the Maize, Sorghum and Millet (MSM) Coordinator at the National Agricultural Research Centre (NARC), Islamabad during 2016 and 2018 along with 3 other varieties/hybrids in National/Uniform Sorghum Yield Trials (NUSYT), which were replicated in 4 locations

##### **National uniform sorghum yield trial 2016**

The results presented in Table 3 show that according to average yield data at all four locations during 2016, the proposed YSH-95 hybrid out-yielded the check variety (YS-16) by 3.67%.

##### **National uniform sorghum yield trial 2018**

The results presented in Table 4 show that according to average yield data at all four locations during 2018, the proposed hybrid out-yielded the check variety by 7.59%.

##### **Overall summary of grain yield performance**

The summary of tall grain yield trials conducted at research stations and farmers' fields (Table 5) shows that according to overall average grain yield, the proposed hybrid out-yielded the check variety YS-16 by 17%.00%.

##### **Stalk yield performance**

Stalk yield of the proposed hybrid was evaluated in sorghum hybrid trials at MMRI in Yusafwala and the Sorghum

Research Sub-Station in DG Khan. The data in Table 6 indicate that the new YSH-95 hybrid was superior to the check variety YS-16 (14.03% greater yield) and the commercial Lasani hybrid (28.84% greater yield) based on mean values at both locations.

### Agronomic studies

#### Fertilizer trials

These trials were conducted to determine the most suitable level of NPK fertilizer for maximum grain yield in hybrid YSH-95. According to the results shown in Table 7, maximum grain yield (3056 kg/ha) was obtained at a fertilizer dose of 225-112-50 NPK kg/ha.

#### Plant population trials

Kharif 2015

As shown in Table 8, the maximum grain yield of 3757 kg/ha was obtained with T<sub>1</sub> (P-P = 15 cm), whereas T<sub>4</sub> (P-P = 22.5 cm) produced the lowest yield (3257 kg/ha) during Kharif 2015.

Kharif 2016

The data in Table 9 show that the maximum grain yield of 2467 kg/ha was obtained with T<sub>2</sub> (15cm, 88,888 plants/ha), whereas T<sub>1</sub> (17.5 cm, 10666 plants/ha) produced the lowest yield (1937 kg/ha) during Kharif 2016.

Kharif 2017

The data in Table 10 show that the maximum grain yield of 2467 kg/ha was obtained with (15 cm), whereas 20 cm produced the lowest yield (3575 kg/ha) during Kharif 2017. Standard recommendations regarding irrigation, seeding rate, plant population and other agronomic practices for this variety are given in Table 11.

#### Disease reaction

The resistance of YSH-95 and YS-16 against leaf diseases (*Helminthosporium maydis* and *Helminthosporium turcicum*) was compared under natural conditions (Table 12). The new candidate hybrid YSH-95 clearly showed better tolerance (46%) to leaf diseases than the check variety YS-16.

#### Entomological measures

Sorghum crops are susceptible to shoot fly, stem borer and aphids. Attacks by these insects can be managed by the timely application of 1) seed treatments, 2) appropriate insecticide spraying, and 3) granules.

#### Quality parameters

The quality parameters were estimated by proximate analysis at the Agriculture Biochemistry Section, Ayub Agricultural Research Institute, Faisalabad. The YSH-95 hybrid was better in all parameters (crude protein %, crude fat %, crude fiber % and carbohydrates) than the local check hybrid YS-16 and the commercial Lasani hybrid (Table 13).

#### Discussion

Sorghum hybrid YSH-95 performed better in terms of grain yield (34.72% higher than the local check, and 24.24% higher than the commercial check) in hybrid yield trials at two locations (MMRI in Yusufwala, Sahiwal and the Sorghum Research Sub-Station in DG Khan) for three consecutive years (2015, 2016 and 2017). Hussain *et al.*, (2019) [10] reported an average yield of 4100 kg/ha in an

approved variety (33% lower than the check). Mumtaz *et al.*, (2018) [18] observed a yield of 4100 kg/ha in different sorghum varieties, and more recently these authors reported grain yields in different sorghum hybrids ranging from 2858 to 5266 kg/ha (Mumtaz *et al.*, 2019) [19]. Moreover, hybrid YSH-95 out-yielded YS-16 (local check) and Lasani (commercial check) in Adaptability/National Uniform Yield Trials conducted by the National Agriculture Research Institute, Islamabad in comparisons at four locations across country in 2016 and 2018. Hussain *et al.*, (2019) [10] found 33% higher yield for the approved variety compared to the check in Adaptability/National Uniform Yield Trials. Hybrid YSH-95 also proved better in stalk yield than YS-16 (local check) and Lasani (commercial check), with a mean difference of 14.03% and 28.84% respectively in hybrid yield trials at both locations. Mumtaz *et al.*, (2018) [18] observed stalk yields in different sorghum hybrids ranging from 28663 to 45667 kg/ha. Hussain *et al.*, (2019) [10] found a 37.06% greater stalk yield for the approved variety of sorghum (YS-16) at two locations. A similar procedure to develop maize hybrids was used by Rafique *et al.*, (2018a) [24], Rafique *et al.*, (2018b) [25] and Ghani *et al.*, (2017) [10]. For the development and approval of a sorghum variety, a similar procedure was also followed by Brocke *et al.*, (2010) [6], Charyulu *et al.*, (2013) [7], Ezeaku and Gupta (2004) [8], Nkongolo *et al.*, (2008) [20] and Hussain *et al.*, (2019) [10].

Hybrid YSH-95 is a medium tall hybrid with an intermediate time to maturity (118 to 123 days), which is faster than both checks used in the present study. Its stalk is more palatable to milch animals due to its high sugar content (brix 12–14%) than the commercial check Lasani (10–12%). Mumtaz *et al.*, (2019) [19] observed brix values ranging from 8% to 18% in different sorghum hybrids. Hybrid YSH-95 is adaptable to all parts of the Punjab except hilly areas. Maximum grain yield of variety YSH-95 can be obtained with a fertilizer dose of 225-112-50 NPK kg/ha. The best sowing time is from 20 July to 8 August for irrigated areas, and from 21 June to 31 July for rain-fed areas. The recommended seeding rate is 12–15 kg/ha (5–6 kg/acre). A total of 6 irrigations are required during the whole season. This new hybrid is suitable for medium soil, and is tolerant to leaf diseases. Hussain *et al.*, (2019) [10] also recommended a similar dose of fertilizer, sowing date, irrigations and soil type for sorghum variety YS-16.

Hence hybrid YSH-95, the first indigenous hybrid recommended by the Punjab Seed Council, shows optimal characteristics due to its medium height, intermediate time to maturity, higher grain and fodder yield, resistance to lodging, sweetness, and capacity to remain green at maturity

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**Table 1:** Comparison of sorghum quality components with other major crops

Components	Percentage				
	Sorghum	Maize	Wheat	Rice	Bajra
Carbohydrates	74	71	69.9	67.9	68.3
Protein	10.4	9.8	13.2	7.9	10.4
Oil content	1.9	4.3	1.9	1.8	3.9
Fiber content	1.8	1.9	2.6	6.5	2.9
Minerals	1.3	1.5	1.9	5.2	-

**Table 2:** Comparative grain yield performance of Fakhar e Punjab (YSH-95) with checks

Year	Name of trial	Grain yield (kg/ha)									% Increase over checks	
		Fakhar e Punjab (YSH-95) (Candidate)					YS-16 (Local check)			Lasani (Commercial check)		
		Mmri	DG Khan	AVG.	Mmri	DG Khan	AVG.	MMRI	DG Khan	AVG.		Local
Kharif 2015	Sorghum Hybrid Yield Trial	2667	4267	3467	2269	3733	3001	-	-	-	+15.53	-
Kharif 2016	Sorghum Hybrid Yield Trial	4278	4089	4184	2725	3289	3007	2364	4333	3349	+39.13	+24.94
Kharif 2017	Sorghum Hybrid Yield Trial	3617	4756	4187	2311	3289	2800	2733	4045	3389	+49.52	+23.53
Mean		3521	4371	3946	2435	3437	2936	2549	4189	3369	+34.72	+24.24

**Table 3:** National Uniform Sorghum Yield Trial (Kharif 2016) Grain yield (kg/ha)

Entries	Name	MMRI Y. Wala	NARC Islamabad	Sahiwal Pioneer	Dadu Sindh	Average	% Increase
(1)	W-3535	1813	1356	1149	3333	1913	+3.13
2	R-3636	406	1343	582	3333	1416	-23.67
3	Fakhar e Punjab (YSH-95)	2319	1667	396	3311	1923	+3.67
4	YS-16(C)	1986	1361	695	3378	1855	
	CV%	47.86	17.55	4.05	4.41	11.88	
	LSD (0.05%)	NS	NS	57.02	NS	NS	

**Table 4:** National Uniform Sorghum Yield Trial (Kharif 2018) (All locations) Grain yield (kg/ha)

Entries	Name	MMRI Y. Wala	RARI, BWP	D.G. Khan	DADU	Average	% Increase
1	W-3535	2641	2957	1667	3370	2659	-15.53
2	R-3636	2208	2624	1759	2850	2360	-25.03
3	S-22, RARI	2455	2541	1914	3150	2515	-20.11
4	Fakhar e Punjab (YSH-95)	3435	3568	2222	4323	3387	+7.59
5	YS-16(C)	2997	3790	2006	3797	3148	
6	YSS-42	2467	3457	1450	4360	3184	+1.14
	CV%	19.33	10.08	-	18.28		
	LSD (0.05%)	NS	578.6	-	NS		

**Table 5:** Overall summary of grain yield performance of Fakhar e Punjab (YSH-95) in national trials

Year	Name of trial	Fakhar e Punjab (YSH-95)			YS-16 (Check)			% Increase over checks
		MMRI	SRSS, DG Khan	Av.	MMRI	SRSS, DG Khan	Av.	
Kharif 2015	Sorghum Hybrid Yield Trial	2667	4267	3467	2269	3733	3001	+6.1
Kharif 2016	Sorghum Hybrid Yield Trial	4278	4089	4184	2725	3289	3007	+22.8
Kharif 2017	Sorghum Hybrid Yield Trial	3617	4756	4187	2311	3289	2800	+18.9
Kharif 2016	NUYT		1358			1341		+1.3
Kharif 2018	NUYT		3075			2931		+5.0
	Average		3179			2781.57		+17.00

**Table 6:** Stalk yield performance of Fakhar e Punjab (YSH-95) in comparison to checks

Year	Name of trial	Stalk yield (kg/ha)										% increase over checks
		Fakhar e Punjab (YSH-95) (Candidate)			YS-16 (Local check)			Lasani (Commercial check)				
		MMRI	DG Khan	AVG.	MMRI	DG Khan	AVG.	MMRI	DG Khan	AVG.	Local	Commercial
Kharif 2015	Sorghum Hybrid Yield Trial	28889	43667	36278	27111	36667	31889	-	-	-	13.76	-
Kharif 2016	Sorghum Hybrid Yield Trial	39445	37556	38501	38889	33444	36167	34445	30000	32223	6.45	19.48
Kharif 2017	Sorghum Hybrid Yield Trial	25556	35333	30445	20000	28445	24223	21667	22778	22223	25.69	37.00
Mean		31297	38852	35074	28667	32852	30759	28056	26389	27223	14.03	28.84

**Table 7:** Results for effect of different fertilizer doses on grain yield of new sorghum hybrids (KHARIF 2015)

Sr. No.	Treatments (kg/ha)			Grain yield (kg/ha)	Stand count	Days to 50% Silking	Plant height (cm)
	N	P	K				
1	0	0	0	1300	80	86	174
2	125	62	50	2200	81	84	189
3	150	74	50	2433	81	84	192
4	175	87	50	2800	81	83	193
5	200	100	50	2756	81	82	200
6	225	112	50	3056	80	82	199
	CV %			6.40	2.47	0.75	2.17
	LSD %			126.69	N.S	1.134	7.532

**Table 8:** Determination of optimum plant spacing for sorghum hybrid Fakhar e Punjab (YSH-95) in Kharif 2016

Sr. No	Plant densities (R-R=75 cm)	Actual/Required plants	Grain yield (kg/ha)	Day to 50% anthesis	Plant height (cm)
1	T1= 88888 (15 cm)	56/66	3757 a	88	233
2	T2= 76190 (17.5 cm)	45/56	3437 b	89	233
3	T3= 66666 (20 cm)	35/50	3270 b	90	233
4	T4= 59276 (22.5 cm)	30/44	3257 b	90	235
	CV%	5.54	4.74	0.66	1.43
	LSD @ 5%	3.65	260	0.93	NS

**Table 9:** Determination of optimum plant spacing for sorghum hybrid Fakhar e Punjab (YSH-95) in Kharif 2017

Sr. No	Plant densities (R-R=75cm)	Actual/Required plants	Grain yield (kg/ha)	Day to 50% anthesis	Plant height (cm)
1	T1= 106666 (12.5 cm)	72/80	1937 b	81	219
2	T2= 88888 (15 cm)	59/66	2467 a	80	227
	T3= 76190 (17.5 cm)	52/56	2092 b	81	228
4	T4= 66666 (20 cm)	46/50	2075 b	80	233
5	T5=59276 (22.5 cm)	41/44	1957 b	79	234
	CV%	4.39	7.28	1.12	1.36
	Cd1	3.66	243.74	1.38	4.78

**Table 10:** Determination of optimum plant spacing for Fakhar e Punjab (YSH-95) sorghum hybrid in Kharif 2017

Treatment	Stand count (6 m <sup>2</sup> )	Plant height (cm)	Days to anthesis	No. of heads	Total head weight	Grain yield (kg acre <sup>-1</sup> )
5 inches (12.5 cm)	86667	173.5	71.250	52500	5908	4321 bc
6 inches (15 cm)	71250	183.5	70.500	56250	7579	5404 a
7 inches (17.5 cm)	58750	188.8	70.500	51250	6231	4671 b
8 inches (20 cm)	53333	186.5	72.500	47083	6267	3575 d
9 inches (22.5 cm)	47500	177.3	72.500	47917	6327	4179 c
LSD <sub>0.05</sub>	7467.9	8.32	NS	4872	329.57	358

**Table 11:** Recommended production technology for sorghum hybrid Fakhar e Punjab (YSH-95)

Agronomic recommendations	Irrigated areas	Rain-fed areas
Sowing time	20 July to 8 August	21 June to 31 July
Sowing method	Line/bed sowing	Line sowing
Seed rate (kg/ha)	12 to 15	15 to 20
Row spacing (cm)	75	60
Plant spacing (cm)	15	20
Irrigations	5-6	-
Fertilizer application	225-112-50	200-100-50

**Table 12:** Disease reaction score of Fakhar e Punjab (YSH-95) in 2016 and 2017

Entry	2016	2017	Mean	% Tolerance
Fakhar e Punjab (YSH-95) (Candidate hybrid)	1.00	1.00	1.00	+46
YS-16 (Check)	2.00	1.67	1.84	
Mean	1.5	1.34	1.42	

**Table 13:** Comparison of quality parameters in hybrids Fakhar e Punjab, Lasani and YS-16

Genotype	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	Carbohydrates
Fakhar e Punjab (YSH-95)	9.48	2.81	1.80	1.30	84.60
Lasani (Commercial check)	9.46	2.65	1.68	1.95	84.25
YS-16 (Local check)	9.48	2.71	1.77	1.54	84.50

## References

- Akram Z, Khan MM, Shabbir G, Nasir F. Assessment of genetic variability in sorghum genotypes for drought tolerance based on RAPD analysis. *Journal of Agricultural Research*. 2011; 49(4):455-464.
- Ambreen N, Hanif NQ, Khatoon S. Chemical composition of rice polishing from different sources. *Pakistan Veterinary Journal*. 2006; 26(4):190-192.
- AOAC. Association of Official Analytical Chemists. Official Method of Analysis. 13<sup>th</sup> edition. Washington DC, 2000.
- Awal MA, Habib AKMA, Hossain MA. A study on comparative performances of hybrid and conventional rice varieties in Aman season. *Journal of Agriculture and Rural Development*. 5(1&2):13-16.
- Bibi A, Sadaqat HA, Akram HM, Mohammed MI. Physiological markers for screening sorghum (*Sorghum bicolor*) germplasm under water stress condition. *International Journal of Agriculture and Biology*. 2010; 12(3):451-455.
- Brocke KV, Trouche G, Weltzien E, Kondombo CPB, Goze E, Chantreau J, *et al.* Participatory variety development for sorghum in Burkina Faso: Farmers' selection and farmers' criteria. *Field Crops Research*, 2010; 119:183-194.
- Charyulu DK, Bantilan MCS, Nedumaran S, Deb UK. Development and Diffusion of Improved Sorghum Cultivars in India: Impact on Growth and Variability in Yield. 5th-8th February 2013. 57th AARES Annual Conference Sydney, New South Wales, 2013.
- Ezeaku IE, Gupta SC. Development of sorghum populations for resistance to *Striga hermonthica* in the Nigerian Sudan Savanna. *African Journal of Biotechnology*. 2004; 3(6):324-329.
- FAOSTAT. Sorghum. Food and Agriculture, Organization. United Nations, Rome, Italy, 2018. Available from <http://www.fao.org/land-water/databases-and-software/crop-information/sorghum/en>.
- Ghani A, Yousaf MI, Arshad M, Hussain K, Hussain S, Mukhtar MT, *et al.* YH-1898: New High Yielding, High Temperature Tolerant Local Yellow Maize (*Zea Mays L*) Hybrid. *International Journal of Biology and Biotechnology*. 2017; 14(3):441-449.
- Govt. of Pakistan. Economic Survey of Pakistan. Finance Division, Economic Advisory Wing, Islamabad. Pakistan, 2018, 19.
- Guil-Guerrero J, Rodriguez-Garcia I, Torija E. Nutritional and toxic factors in selected wild edible plants. *Plant Foods for Human Nutrition*. 1997; 51(2):99-107.
- Hussain D, Mumtaz A, Saeed M, Arshad M, Ihsanullah, Yousaf MI, Ghani A, *et al.* YS-16: A high yielding dual purpose sorghum variety. *Agrica*. 2019. 8:45-56.
- Jones H, Jarman RJ, Austin L, White J, Cooke RJ. The management of variety reference collections in distinctness, uniformity and stability testing of wheat. *Euphytica*, 2003; 132:175-184.
- Khalil JK, Sawaya WN, Safi WJ, Mohammad HMA. Chemical composition and nutritional quality of sorghum flour and bread. *Plant Foods for Human Nutrition*. 1984; 34(2):141-150.
- Motlhaodi T, Geleta M, Bryngersson T, Fatih N, Chite S, Ortiz R, *et al.* Genetic diversity in ex-situ conserved sorghum accessions of Botswana as estimated by: microsatellite markers," *Australian Journal of Crop Science*. 2014; 8(1):35-43.
- Mumtaz A, Sadaqat HA, Saeed M, Yousaf MI, Shehzad A, Ahmed HGMD, *et al.* Genetic Behavior of qualitative and seed yield related traits in *Brassica rapa*. *Zemdirbyste-Agriculture*. 2017; 104(2):147-156.
- Mumtaz A, Hussain D, Saeed M, Arshad M, Yousaf MI. Estimation of genetic diversity in sorghum genotypes of Pakistan. *Journal of National Science Foundation of Sri Lanka*. 2018; 46(3):271-280.
- Mumtaz A, Hussain D, Saeed M, Arshad M, Yousaf MI. Stability and Adaptability of Sorghum Hybrids Elucidated with Genotype–Environment Interaction Biplots. *Turkish Journal of Field Crops*. 2019 24(2):155-163.
- Nkongolo KK, Chinthu KKL, Malusi M, Vokhiwa Z. Participatory variety selection and characterization of Sorghum (*Sorghum bicolor* (L.) Moench) elite accessions from Malawian gene pool using farmer and breeder knowledge. *African Journal of Agricultural Research*. 2008; 3(4):273-283.
- Pakistan Bureau of Statistics. Ministry of Finance, Government of Pakistan, 2016.
- Pakistan Agriculture Research Council PARC. Maize, Sorghum and Millets. Pakistan Agriculture Research Council, Islamabad, Pakistan, 2019.
- Poehlman JM. *Breeding Field Crops*. 5<sup>th</sup> Edition, Wiley-Blackwell Publishing, USA, 2006.
- Rafique M, Saleem S, Altaf M, Mallhi AR. FH-1046: A spring season and heat resilient maize hybrid. *Journal of Agricultural Research*. 2018a; 56(1):07-12.
- Rafique M, Saleem S, Mallhi AR, Altaf M. FH-1046: A dual season heat resilient maize hybrid. *Journal of Agricultural Research*. 2018b; 56(2):81-85.
- Ritter KB, McIntyre CL, Godwin ID, Jordan DR, Chapman SC. An assessment of the genetic relationship between sweet and grain sorghums, within Sorghum

- bicolor ssp. *Bicolor* (L.) Moench, using AFLP markers. *Euphytica*. 2007; 157(1-2):161-176.
27. Selle PH, Liu SY, Cai J, Caldwell RA, Cowieson AJ. Graded inclusions of sodium metabisulphite in sorghum-based diets: I. Reduction of disulphide cross-linkages in vitro and enhancement of energy utilisation and feed conversion efficiency in broiler chickens. *Animal Feed Science Technology*, 2014; 190:59-67.
  28. Sramkova Z, Gregova E, Sturdik E. Chemical composition and nutritional quality of wheat grain. *ACTA Chimica Slovaca*. 2009; 2(1):115-138.
  29. Steel RGD, Torrie JWH, Dickey M. Principles and procedures of statistics. A biometrical approach. McGraw Hill Book Company, New York, 1997.
  30. Stevanovic M, Drinic SM, Dragicevic V, Camdzija Z, Filipovic M, Velickovic N, *et al.* An assessment of nutritional quality of hybrid maize grain based on chemical composition. *Genetika*. 2012; 44(3):571-582.
  31. Zia U, Mahmood T, Ali MR. Dairy Development in Pakistan. Food and Agriculture Organization of the United Nations, 2011.