

YS-18 A SINGLE STAND SORGHUM VARIETY WITH IMPROVED STALK AND YIELD POTENTIAL FOR AUTUMN SOWING

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Abstract The high pace of increasing population along with the diminishing effects of global warming are putting immense pressure on the agriculture system in terms of food security. Great concerns regarding yield enhancement have emerged for crops feeding livestock and the dairy industry. The development of high-yielding dual-purpose fodder varieties is a concurrent demand in breeding programs designed for grain and fodder yield improvement. Sorghum as being highly nutritious and low-input crop provides good prospects for breeding improvement. Because of this, this work was designed with the breeding strategy for sorghum grain and fodder yield improvement. Successive selection cycles with head-to-row, similar plant type, and bulking were adopted among the filial progeny of a cross between two lines ICS73 and ICSR8003. The uniform line YS-18 was then subjected to evaluation at the station and national yield trials. YS-18 secured 22% and 5% yield increase in station trials during 2018 and 2019 over the previously released check variety YS-16. In National uniform Yield Trials, the yield benefit of new candidate line YS-18 was 17% and 27% during 2020 and 2021. Variability studies indicate more grain (14%) and fodder (13%) yield potential than YS-16. This productivity enhancement with 6000 kg/hac grain yield potential and 40000 kg/hac fodder yield is a succession of targeted breeding strategy. Early maturing YS-18 bears sweet juicy stems with stay green broad leaves and long head size that have the potential to be utilized as green feed at cattle farms and the dairy industry. This work will provide a better understanding to a researcher for designing breeding programs for the development of high-yielding germplasm in crops.

Keywords: Sorghum variety; High yield; Fodder Potential; Vegetative Parts; Breeding; Selection

Introduction

Due to the rapid growth of the population, the demand for dairy products is steadily increasing (Rozhkova & Olentsova, 2020). The world's population is expected to exceed 9 billion by the middle of this century (Gu et al., 2021), while fodder requirements for livestock are approaching 630 million tonnes (Tubb & Seba, 2021). The demand for high-yielding crop varieties to feed humans and animals is a major concern for researchers today (Tian et al., 2021). This scenario becomes more complex as more supply is drawn from the same land

resources. The livestock industry is rapidly expanding in African and Asian countries, but there is a feed shortage in terms of both quality and quantity (Erdaw, 2023). Sorghum is ranked fifth among important crops (Ananda et al., 2020), with global production totaling 6.7 million tonnes from 45.3 million hectares. It is a nutritionally rich source for a proper animal diet, containing protein, fibre, minerals, and other dietary ingredients. It contains 7-8% protein, 2-3% fat, 1-2% minerals, and approximately 90% carbohydrates in its grain

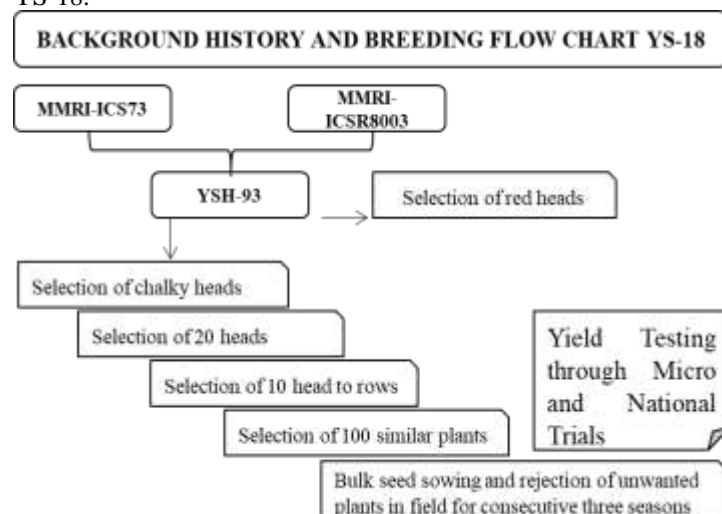
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(Ganapathy et al., 2015). It is well-adapted and grown in both irrigated and semi-arid areas with limited water resources and availability (Yahaya & Shimelis, 2022). Given the limitations imposed by global warming in each sector of agriculture, we must prioritize our breeding programs to meet industrial and farmer needs (Shahzad et al., 2021). In Pakistan, the cattle and livestock industry is very important and occupies a large portion of the GDP (Ilyas et al., 2022). It contributes 62% to agriculture and approximately 14% to the total GDP of the country, with a record growth rate of 3.26% in 2021-22. Given the rate of growth in this sector, there is an urgent need to develop new sorghum varieties to meet future demands (Akram et al., 2022; Asim et al., 2022). The development of sorghum varieties with high and sustainable production potential for both grain and fodder yield will benefit all farmers equally (Hossain et al., 2022; Zampaligré et al., 2022). This research paper will discuss the development and breeding methodology of YS-18, an early maturing, medium-heighted, high-yielding sorghum variety that was recently released for general cultivation in Punjab, Sindh, KPK, Balochistan, and GB. Variety has the advantage of not only higher yield but also uniformity in maturity and height, which is why it is preferred by the farmer community, as farmers are very concerned with crop yield. YS-16, released in 2016 for general cultivation, has good grain yield potential but is still unable to compete with exotic varieties due to limited commercialization. A single variety cannot compete against multinational corporations and exotic imported varieties. As a result, a new variety called YS-18 (YS-42) has been developed with high grain and fodder yields. It matures early, grows to medium height, has a high brix value, and is resistant to foliar diseases. Due to exceptional performance comparable to commercial checks in station and outstation trials, the case of this Open Pollinated Variety YS18 (YS-42) was presented to the 56th meeting of the Punjab Seed Council, and final approval was obtained for its general cultivation.

Material and Methods

This research is being carried out at the Maize and Millet Research Institute (MMRI) in Yusafwala, Sahiwal, Punjab, which has been providing a variety of development services for the maize, millet, and sorghum crops since 1958. YS-18 (YS-42) was developed by selecting red and chalky heads in the progeny of a cross between two numerous sorghum lines at MMRI (ICS73 line * ICSR8003). Further selection was made in chalky heads, and 20 disease-free uniform heads with good plant and yield characteristics were chosen for the next steps. Seed from these plants was sown in the following season using the head-to-row method, and the top ten

performing head-to-row selections were chosen to produce healthy and productive material. Only the most desirable plants were chosen from a lot of ten previously selected rows. The bulk methodology was then adopted, with strict rejection of unwanted plant type, head type, and other yield-contributing traits. This function was performed for three consecutive autumn seasons, and line uniformity was maintained throughout the entire procedure. The diagram depicts the background history and breeding flow chart for YS-18.



Following the selection of a consistent, early maturing, medium stature, high-yielding line, its productivity was assessed at farmer fields and across regions through national and station yield testing. During 2018 and 2019, the new variety's pure seed was utilized for station trials to assess its performance. Following the successful completion of the initial testing, Pakistan Agriculture Research Council (PARC) Islamabad's National Coordinator carried out a third-party evaluation for variety. In 2020 and 2021, the candidate line's adaptability was examined through National Uniform Yield Trials (NUYT). Following the completion of the compilation, the results of national trials at Yusafwala, Renala Khurd, Babawal-pur, and D.G. Khan were shared. At each crop stage, several morphological characteristics were measured, including plant height, 50% silking, plant leaf area, grain yield, and stalk yield. The gathered information was put through "analysis of variance" to determine whether candidate line YS-18 and check variety YS-16 had significantly different yield performance under various conditions, including reps, years, and varietal composition. R software and packages such as tidyverse, ggplot2, emmeans, and agri Tutorial were used for analysis and graphical presentation, with the statistical techniques listed in Table 1.

Results

Variation Studies

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Variation in plant and yield traits like plant height, 50% silking, Plant leaf area, grain yield, and stalk

yield under Reps, Years, and varietal effects was estimated assessed through ANOVA (Table 1).

Table 1. ANOVA on the effects of reps, Years and varieties for morphological and yield traits of YS-18 and check YS-16

	DF	Days to 50% silk	Flag Leaf Area (cm)	Grain Yield per hac	Plant Height (cm)	Stalk Weight per hac
Rep	2	0.89 ns	16.55 ns	660867.83 *	22.22 ns	23911715.05 ns
Years	2	13.39 ns	0.15 ns	223736.14 ns	184.72 ns	17238906.21 ns
Variety	1	2.72 ns	3060.75 **	694656.81 *	3755.56 **	102022444.79 *
Years:Variety	2	7.72 ns	17.02 ns	62641.8 ns	293.06 ns	1006159.22 ns
Residuals	10	3.62	61.13	118809.7	157.22	10307398.87

¹ * Significance at 5% probability, ** Significance at 1% probability, ns: non-Significant

The results showed that there was no silking time difference caused among varieties by any of the factors while plant height, flag leave area, grain, and stalk yield were varied due to varietal differences. This indicated the YS-18 and YS-16 differed in their potential for mentioned traits. Differences for while plan height and flag leave area were highly significant with only 1% pobability to vary while variations among grain and stalk yield were at significant levels.

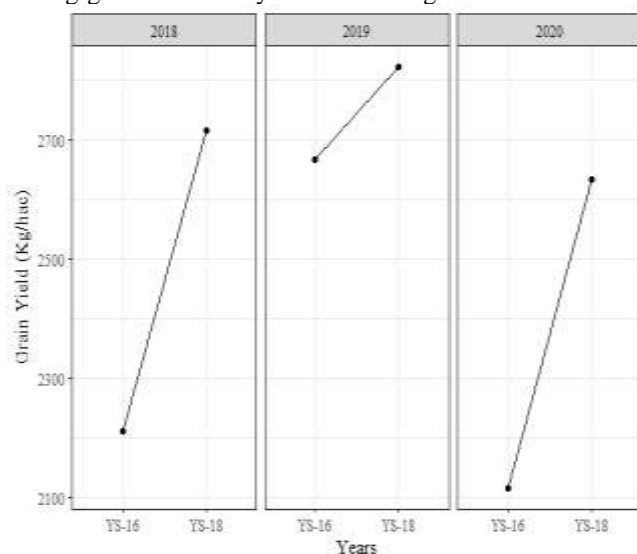


Figure 1: Grain Yield Response of tof YS-18 and check YS-16 during autumn 2018-20

he estimation of grain yield between two varieties was graphically illustrated in Figure 1. It was observed that higher grain yield was produced by YS-18 in three consecutive years 2018-20 as compared to YS-16. The average yield potential of YS-18 across the years was 2724 kg/ ha and YS-16 with 2331 kg/ ha, thus YS-18 secured 14% more yield benefit in these trials. YS-18 maintained a range between 2633-2823 kg/ hac and YS-16 stood between 2116-2666 kg/ hac.

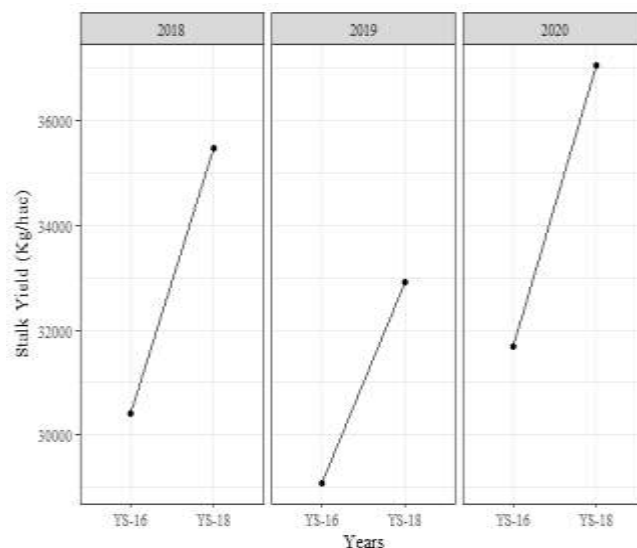


Figure 2: Stalk Yield Response of tof YS-18 and check YS-16 during autumn 2018-20

Similarly, stalk yield difference was estimated for two varieties and graphically illustrated in Figure 2. It was observed that a higher Stalk yield was produced by YS-18 in three consecutive years 2018-20 as compared to YS-16. The average yield potential of YS-18 across the years was 35154 kg/ ha and YS-16 with 30392 kg/ ha, thus YS-18 secured 13.5% more yield benefit in these trials. YS-18 maintained a range between 35479-37066 kg/ hac and YS-16 stood between 29084-30403 kg/ hac.

National Uniform Sorghum Yield Trial 2020

National Coordinator, Pakistan Agriculture Research Council (PARC) Islamabad convened this trial. National Uniform Sorghum Yield Trial 2020 was conducted at three locations in Punjab; Yousaf-wala, Bahawalpur, and D.G.Khan with 15 candidate varieties including YS-18(YS-42). The yield performance of these candidate lines is given in table 2. YS-18 maintained the 3rd position in this trail and surpassed the check variety by sustaining 17 % yield

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increase. On an average of three locations, YS-18 yielded 4041 kg / ha with securing a maximum yield 5649 kg / hac at the yusafwala site. This variety

outyielded 12 other candidate varieties by maintaining a yield benefit ranging from 2% to 217% on a cumulative average basis.

Table 2: Adaptability / National Uniform Sorghum Yield Trial Kharif 2020 (Grain Yield in Kg/ha)

Entries	Name	Yousaf wala	Bahawal pur	D.G Khan	Mean	% Increase
1	Nagina	6500	3778	3067	4448.33	-1.05
2	R-3636	3622	3267	1333	2740.67	60.61
3	W-3535	4088	3067	1200	2785.00	58.05
4	Q.S-499	986	2467	711	1388.00	217.12
5	16GS2670	2884	3956	1511	2783.67	58.12
6	YSH-134	3651	4022	4000	3891.00	13.12
7	YSS-10	5389	4822	--	5105.50	-13.79
8	Eagle	5039	4311	2400	3916.67	12.38
9	Sweet As	3590	2578	2000	2722.67	61.67
10	Omega-F1	6522	3733	2667	4307.33	2.19
11	Fakhr-e-Punjab (CHECK)	3842	2556	2178	2858.67	53.98
12	14SB7001	2281	2467	2667	2471.67	78.08
13	YS-16 (CHECK)	4039	4089	3156	3761.33	17.02
14	Sweet Betty	3495	2000	2800	2765.00	59.19
15	YSH-132	5250	4356	2667	4091.00	7.59
16	YSS-42	5649	3778	3778	4401.67	0.00
CV%		12.45	16.11	8.29		
LSD (0.05%)		867.33	927.35	333.97		

National Uniform Sorghum Yield Trial 2021

National Uniform Sorghum Yield Trial 2021 was conducted at four locations in Punjab; Yousaf-wala, Renal Khurd, Bahawalpur, and D.G.Khan with 14 candidate varieties including YS-18(YS-42). The yield performance of these candidate lines is given in Table 3. YS-18 maintained the 1st position in this

trial and surpassed the other candidate varieties including check variety (27 % yield increase). On an average of three locations, YS-18 yielded 3743 kg / ha with securing maximum yield 4878 kg / ha at the Bahawalpur site. This variety outyielded 13 other candidate varieties by maintaining a yield benefit ranging from 4.5% to 161% on a cumulative average basis.

Table 3: Adaptability /National Uniform Sorghum Yield Trial Kharif 2021 (Grain Yield in Kg/ha)

Entries	Hybrids/ Varieties	Yousaf-wala	Renala Khurd	Bahawal-pur	D.G. Khan	Mean	% Increase
1	Lasani	2640	3596	4167	3641	3511	6.63
2	W-3535	2764	2840	5000	3422	3506.5	6.77
3	16GS2670	2678	3111	4444	3378	3402.75	10.02
4	YS-16 (check)	1202	3929	2861	3711	2925.75	27.96
5	Victoria	1636	3863	3572	2589	2915	28.43
6	YSS-10	2411	2409	3000	3400	2805	33.47
7	PS-Shakri Sorghum	1438	3751	3722	3556	3116.75	20.12
8	Tower	3863	3582	3833	2400	3419.5	9.48
9	Omega F-1	2659	3622	4333	3711	3581.25	4.54
10	YSS-42	3522	3431	4778	3244	3743.75	0.00
11	Tarzen	2747	3767	4361	2622	3374.25	10.95
12	Sahara Queen	878	1600	1333	1911	1430.5	161.71
13	QS-499	2462	1849	2750	2178	2309.75	62.08
14	PS-Champion Sorghum	1247	3558	3917	2911	2908.25	28.73
CV%		43.34	43.03	5.92	6.07		

[Citation: Saeed, M., Javed, H.M., Shakir, M.S., Saddam, S., Shaikh, G.Y., Awais, M., Zahid, S., Rafiq, M., Asif, Z., Ahmad, H.M., Majeed, T., Akber A.R. (2024). YS-18 a single stand sorghum variety with improved stalk and yield potential for autumn sowing. *Biol. Clin. Sci. Res. J.*, 2024: 852. doi: <https://doi.org/10.54112/bcsrj.v2024i1.852>]

LSD (0.05%)	1670.20	1900.70	372.31	289.17		
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YS-18 was also tested in a total 9 trials from 2018 to 2021 against check YS-16. The candidate variety

secured an overall benefit of 18 % in all these trials and proved its supremacy over check variety. The summary of trials is given in Table 4.

Table 4. Overall Summary of Grain Yield Performance of YS-18 and YS-16 in all 9 Trials

Year	Name of trial	YS-18 (YS-42)	YS-16 Check	% increase over checks
Kharif 2018	Sorghum Station Yield Trial (MMRI)	2717.00	2212.00	+22.83
Kharif 2019	Sorghum Station Yield Trial (MMRI)	2823.69	2666.67	+05.89
Kharif 2020	National Uniform Yield Trial	4401.67	3761.33	+17.02
Kharif 2021	National Uniform Yield Trial	3743.75	2975.75	+27.96
Average		3421.52	2903.93	+18.42

Discussion

Sorghum is a beneficial food and feed in many aspects like its nutritional profile enriched with minerals, vitamins, fiber contents, and protein provides a good source of energy especially when used as cattle feed (Stefoska-Needham & Tapsell, 2020). Additionally, it can yield more with less input supply when compared to maize which is an exhaustive crop and thus provides an alternative opportunity for fodder production (Ndaru et al., 2020). New climate-smart and high-yielding varieties with enhanced capability of adaption is the need of the hour to meet the food and feed in the face of challenges to food security issues (Hasan et al., 2018). Breeding of plant vegetative attributes and yield components provides an esteemed opportunity for betterment in many crops including sorghum plants (Ross et al., 1983). Our newly bred variety YS-18 proved its adaptability to a diverse range of environments by maintaining a high grain yield and stalk yield benefits. Selection for medium plant height but with greater leaf area enabled this line to behave as dual purpose variety (Dong et al., 2013). This positive response is owing to the right selection and increasing frequency of desirable genes during each selection cycle (Anderson, 1971). Prominent improvement in grain and vegetative parts of YS-18 was observed during station as well as national yield testing. This productivity enhancement is owing to fixed genetic improvements that were made during its breeding and this also validates the efficiency and accuracy of our breeding methodology. This early maturing variety with dark green and broad leaves has a good potential to penetrate at farmer field. YS-18 has a sweet juicy stem with 13-14% brix value and can increase milk production when used for cattle feed. It showed high adaptability across the regions with mild to hot environments. The newly developed sorghum variety "YS-18" is medium-statured high grain and fodder yielding and heat resistant variety with medium maturity duration. Broad leaves along with stay green characters with palatable leaf structures furnish this variety with a

variety of characters. It bears a long head with nutritionally enriched chalky grains and dark green leaves set up grain and stalk yield potential up to 6000 kg/ha and 40000 kg/ha, respectively. It was approved for general cultivation in Pakistan in 2021 and widely cultivated across the Punjab province during the spring and autumn seasons.

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Declaration

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Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

The study was approved by authors.

Funding Statement

Not applicable

Conflict of Interest

There is no conflict of interest among the authors regarding this case study.

Authors Contribution

SAEED M and JAVED HM conducted this research work and all other authors assisted in writeup, data analysis, revision, editing and proof reading equally.



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