YH-1898: A NEW HIGH YIELDING, HIGH TEMPERATURE TOLERANT LOCAL YELLOW MAIZE (*Zea mays* L) HYBRID

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ABSTRACT

YH-1898 is a full season high yielding and high temperature tolerant maize hybrid, developed at Maize & Millets Research Institute, Yusafwala, Sahiwal. This hybrid is tolerant to high temperature and stalk rot (*Fusarium moniliforme*). It gives good yield in both Spring and Kharif seasons. It was developed by crossing two local inbred lines, Y22 ♀ and Y27 ♂ in 2005. The hybrid was evaluated under different agro-climatic zones of Pakistan during 2008-2014 in different yield trials. In Spring 2013, YH-1898 stood first (out of 34 entries) while in Kharif 2013 it was at 2nd position (out of 44 entries) with an average yield of 10243 Kg/ha and 9030 Kg/ha, respectively in National Uniform Hybrid Maize Yield Trial. YH-1898 attained maximum grain yield of 12,300 Kg/ha at Jhang in Kharif 2009 and 12,003 Kg/ha in Spring 2014 at Gojra in farmer's field trails. In addition to being high temperature tolerant, it also stays green at maturity; hence its stalk can be used as fodder at harvesting. YH-1898 is the best hybrid recommended by the Punjab Seed Council during 2016 due to high grain yielding, high temperature tolerant, stay green at maturity and lodging resistance due to strong root anchoring. It has the potential to replace the Multinational hybrids presently under cultivation in Punjab.

Key words: *Zea mays* L., Heterosis, Yellow hybrid, YH-1898, Temperature Resilient, Maize.

INTRODUCTION

Maize is the third most important cereal crop in Pakistan after Wheat and Rice. It is used as food, feed and industrial crop around the world. It contributes towards food security in several developing countries of Asia and Africa. Among cereals, maize offeres immense opporutnities to address food, feed, fodder and nutritional security (Premlatha and Kalamani, 2010). Research achievements in the recent past and their faster adoption on large scale have stimulated higher growth rate in maize production than other major cereals. In near past, annual production growth rate in maize has been much higher in Asia over global average, reflecting tremendous potentional for innovations in maize to have greater impact on livelihood of small holding farmers in Asia. Maize grain has high nutritional value as it contains 9.87% (protein), 2.17-4.43 (fat), 2.10- 26.70% (fiber) and 44.60- 69.60% (carbohydrate), 11.6-20% moisture and 1.10-2.95% (ash) (Sule Enyisi, 2014).

Maize crop is called "the other gold" due to its diversified industrial consumption. As a very higher per acre yielding crop , it can provide subsistense to large number of persons. Food energy yielded by maize is estimated at about 6.9 million callories per hectare which is fairly high as compared to wheat (3.7 million) and rice (4.9 million) (Annonymus, 2010).

Exploitation of hybrid vigour in maize has gained much significance in view of tremendous increase in its yield. There is continuous need to evolve new hybrids having better yield and quality. Wynne *et al*. (1970) has reported significant increase in yield and yield contributing traits of F1 hybrids over parents. A varying degree of Heterosis was estimated for plant height, ear height, ear length, ear diameter, 1000- grain weight & grain yield over the parents (Muraya *et al.*, 2006). Heterosis was significant and positive for ear length, rows per ear, kernels per row and grain yield as observed by Muraya *et al*. (2006) and Singh *et al*. (2002). Tollenaar and Lee (2006) reported that in heterosis, the increase in kernel number is much greater relative to increase in dry matter accumulation during the grain filling period. High level of significance in variance of parents vs hybrids clearly indicate the existence of significant level of average heterosis in hybrid. Carena and Wicks (2006) detected an elite maize population hybrid that averaged 28.2 % high parent heterosis. Castellanos *et al*. (2009) reported the single crosses expressed a 37 % high parent heterosis on average. Premlatha and Kalamani (2010) studied that significant differences among parents and crosses revealed the choice of exploitation of heterosis for plant height, cob height and grain yield per plant.

Increase in per hectare yield of maize in Pakistan is mainly due to adoption of hybrid seed sold by Multinational Seed Companies. However, per acre yield of maize in Pakistan is far behind from major maize producing countries

like United State (10.73 metric tons/ha), Canada (9.36 metric tons/ha), Argentina (8.20 metric tons/ha), Turkey (8.73 metric tons/ha) and China (5.81 metric tons/ha) (USDA, 2016). So there is an immense need of improved cultivars that are not only higher in production but also possess tolerance to adverse climatic conditions. The new hybrid YH-1898 is a full season high yielding yellow maize hybrid equally good for Spring and Kharif season in Punjab. It is tolerant to high temperature and resistant to lodging. It was developed at Maize and Millets Research Institute, Yusafwala, Sahiwal by crossing of two well adapted locally developed inbred lines. This hybrid was evaluated in different yield trials at various locations in preliminary, advanced, multi-location National Uniform Maize Yield Trials and On-Farm large scale trials from 2008 to 2014. This hybrid has been approved for general cultivation in the 45th meeting of the Punjab Seed Council held at Lahore on 07-01-2016.

MATERIALS AND METHODS

Maize and Millets Research Institute Yusafwala Sahiwal has established its' own gene pool by deriving inbred lines from local and exotic material. The derivation of these lines was started in 1988. The new hybrid YH 1898 was developed at Maize and Millets Research Institute Yusafwala Sahiwal by crossing of two locally derived inbred lines Y22 ♀ and Y27♂ in Kharif, 2005. This hybrid was included in preliminary, micro and macro plot yield trials from 2008 to 2013, where it yielded higher against different Multinational checks. Due to its best performance, it was then evaluated in National Uniform Hybrid Maize Yield Trial conducted by National Agriculture Research Centre (NARC), Islamabad during 2013 where it was ranked first out of 34 entries. The experiments were laid out in RCBD with three replications on ten different locations in Punjab. Net plot of each entry in NUMYT trail was $5\times1.5m^2$. The new hybrid YH-1898 was further evaluated in station yield trials at farmer's fields and this hybrid performed very well at different locations in Punjab. Agronomic, Pathological and entomological studies were conducted during 2008-2014 and data were recorded to compare it with existing hybrids.

RESULTS

Yield Performance

YH-1898 has been tested in different agro climatic zones of Pakistan. The data of station and out station yield trials is given below:

(1) Station Yield Trials

The results (Table 1) showed that the new Hybrid YH-1898 performed better in all yield trials by giving 2.57 to 16.23 percent higher average grain yield than different multinational check hybrids. On an average new hybrid YH-1898 produced (9023 Kg/ha) grain yield which is 6.24 percent higher than check hybrid (8488 kg/ha).

(2) OUT STATION YIELD TRIALS

(a) ON FARM RESEARCH TRIALS

These On- Farm research trials were conducted at different locations in Punjab at different farmer's fields including new hybrid YH-1898 and different Multinational and Local Hybrids as Checks.

(i) On Farm Research Trial during Kharif, 2009

On- Farm research trial was conducted at seven different locations in Punjab at different farmer's fields during Kharif 2009.

The data showed that hybrid YH-1898 showed its worth and gave higher grain yield of (10213 kg/ha) than check hybrids on farmer fields during Kharif 2009. The new Hybrid YH-1898 gave 5.33% and 6.47% more grain yield over checks, Yusafwala Hybrid and 30Y87, respectively (Table 2).

(ii) On Farm Research Trial during Spring, 2014

On- Farm research trial was conducted at seven different locations in Punjab at different farmer's fields during spring 2014.

The new hybrid YH-1898 was on 2nd position and gave average grain yield of (10448 Kg/ha) after commercial hybrid NK-8711 (10681 Kg/ha) as shown in Table 3. The new hybrid gave 8.18% and 3.72%, more grain yield over check hybrids, Yusafwala Hybrid and FH-810, respectively but 2.23% less grain yield then commercial Hybrid NK-8711 and its yield remained at par with commercial hybrid, P1543.

(b) NATIONAL UNIFORM HYBRID MAIZE YIELD TRIALS

These trials were conducted consecutively for two seasons during Spring and Kharif 2013 by Coordinator Maize, Sorghum & Millets (MSM) and Coordinator National Agriculture Research Centre (NARC), Islamabad at different locations throughout Pakistan.

(i) Adaptability / National Uniform Maize Hybrids Yield Trial Spring 2013

Thirty-four entries of different maize hybrids were included from all over the Pakistan; it was conducted at nine different locations in Pakistan during spring 2013.

Table 1. Yield performance of YH-1898 in different Yield trials i.e. Preliminary, Micro- and Macro conducted during Spring / Kharif seasons (2008 to 2013) at MMRI Yusafwala Sahiwal.

Sr.#	Name of Trial	No. of Entries	Year	Promising Checks	Grain Yield(Kg/ha)		%increase over Check
					Checks	**YH-1898**	
1	Preliminary Yield Trial	16	Spring-2008	NK-8441	7927	8293	4.41
2	Preliminary Yield Trial	20	Kharif-2009	NK-6621	6707	8007	16.23
3	Micro plot Yield Trial	10	Kharif-2011	NK-6621	8510	8910	4.48
4	Macro plot Yield Trial	18	Spring-2013	NK-8711	10276	10650	3.51
5	Macro plot Yield Trial	12	Kharif-2013	30Y87	9017	9255	2.57
Average				8488	9023	6.24	

Table 2. Yield performance of YH-1898 in (Kg/ha) on-farm yield trial during Kharif-2009.

Sr. No.	Location	YH-1898	Yusafwala Hybrid	30Y87
1	Yusafwala	9684	8577	8015
2	Pakpattan	8669	8939	7956
3	Arifwala	8733	8626	8226
4	Abbaspur	9720	8785	9949
5	Sargodha	11027	10233	10517
6	Jhang.	12300	11360	11793
7	T.T. Singh	11360	11155	10408
Mean		10213	9668	9552
Increase over check		0	-5.33	-6.47

Table 3. Yield performance of YH-1898 in on-farm yield trial during Spring-2014.

Sr. No	Location	YH-1898	Yusafwala Hybrid	FH-810	NK-8711	P1543
1	362/JB,Korean	10,658	9,223	11,082	10,370	10,235
2	Chiniot	10,833	9,540	11,264	11,066	10,450
3	Khiddarwala	9,184	8,019	10,237	10,563	9,219
4	Gojra	12,003	11,123	11,685	10,800	10,459
5	49/GB Gojra	10,745	9,843	11,048	11,257	9,753
6	144/9-L Swl	10,645	10,791	8,533	10,685	10,846
7	136/9-L Swl	9,067	8,611	6,579	10,032	12,391
	Average Yield	10,448	9,593	10,059	10,681	10,440
	Increase over Check		-8.18	-3.72	+2.23	0.01

Table 4. Grain Yield performance of YH-1898 in NUMYT during spring 2013.

Grain Yield (kg/ha)							
Sr. No	Location	YH-1898	PX-12	FH-949	P1574	CV %	LSD at 5%
1	Manga Mandi	15336	13972	11618	14097	12.2	NS
2	Mardan	13666	14556	10850	11610	16.6	NS
4	Burewala	7923	8390	8383	8993	22.0	NS
5	Lahore	4620	5713	5223	7328	32.2	NS
6	AARI, Fsd.	5584	2661	2514	1406	13.2	187
7	NARC	9502	10133	7996	8864	16.1	NS
8	MMRI	15679	12691	16690	11685	15.1	961
9	CCRI Peersabak	12283	13749	11965	12316	18.5	NS
10	R-Y, Khan	7595	6715	7525	7886	21.9	NS
Average		10243	9842	9196	9354	22.6	NS
% increase / decrease			-3.91	-9.08	-8.68	-	-

The results (Table 4) showed that the new Hybrid HY-1898 produced 3.91 to 9.08 percent higher average grain yield (10243 Kg/ha) than check hybrids PX-12 (9842 Kg/ha), P1574 (9354 Kg/ha) and FH-949 (9196 Kg/ha). It also ranked 1st among 34 entries. However, the yield differences at most of the locations are statistically non-significant.

(ii) Adaptability / National Uniform Hybrid Maize Yield Trial Kharif 2013

Forty-four entries of different maize hybrids were included from all over the Pakistan; it was conducted at six different locations in Pakistan during Kharif 2013.

Table 5. Grain Yield performance of YH-1898 in NUMYT during Kharif 2013.

Grain Yield (kg/ha)							
Sr. No	Location	YH-1898	Y.Wala Hybrid	Dhoom-011	C-7085	CV %	LSD at 5%
1	Chiniot	9207	9172	10972	5521	4.7	948
2	Faisalabad	7787	9309	10915	4688	4.2	770
3	MMRI	11349	9073	10537	5786	5.1	876
4	NARC	10743	9535	11368	9337	4.8	899
5	Pakpattan	7823	7974	7943	6876	3.1	531
6	Arifwala	7270	6467	9150	5653	3.3	583
Average		9030	8588	10147	6310	4.9	771
% Increase / decrease		**0**	-6.9	+9.9	-31.6	-	-

The results (Table 5) revealed that YH-1898 was on 2nd position, exhibited grain yield (9030 kg / ha) which is 6.9 and 31.6 percent more than check hybrids, Yusafwala Hybrid (8588 kg/ha) & C-7085 (6310 Kg/ha) respectively, but 9.9% less than Dhoom-011 (10147 Kg/ha).

(c) HIGH TEMPERATURE STUDY:

The newly developed hybrid YH-1898 is tolerant against high temperature, even at more than 40 C it performed very good and ranked first in grain yield comparison with well-known commercial hybrid NK-8711. An experiment was conducted at research area of Maize & Millets Research Institute, Yusafwala Sahiwal during Spring 2016 and the trial of twenty-eight entries were sown late in mid-March for study the effect of high temperature, at the time of pollination of the crop the temperature ranges from 40 to 46 C as revealed in Table 6.

It is evident from the results presented in the (Table 6) that YH-1898 out yielded of all the hybrids including commercial Check i.e. NK-8711 by giving grain yield of 13877 kg/ha.

Table 6. Grain yield performance of YH-1898 comparison with commercial hybrid and other single cross hybrids at High Temperature.

Sr. No.	Hybrids	Grain Yield Kg/ha	Plants Harvested	Cobs Harvested	Days to 50 % tassel	Days to 50 % silk	Plant Ht. (cm)	Cob Ht. (cm)	Stand count
1	YH-1898	13877	20	21	64	67	205	113	14
2	YH-5415	12487	18	19	64	67	185	108	15
3	YH-5439	12405	19	20	62	65	210	118	17
4	YH-5421	12297	19	19	63	66	183	88	17
5	YH-5427	11567	16	17	65	68	180	83	17
6	YH-5434	11547	18	20	64	67	173	98	17
7	YH-5435	11283	16	18	64	67	190	98	18
8	YH-5417	11052	17	19	62	65	200	113	18
9	YH-5424	11018	18	19	63	66	180	98	19
10	NK-8711 (Check)	10588	17	18	63	66	180	95	20
11	YH-5416	10055	18	17	63	66	178	98	15
12	YH-5432	9900	12	14	64	67	190	98	14
13	YH-5426	9817	15	15	64	68	190	108	10
14	YH-5425	9692	15	15	64	67	198	113	13
15	YH-5418	9657	15	17	62	65	185	98	18
16	YH-5428	9637	15	15	64	67	175	98	14
17	YH-5431	9353	13	17	63	66	195	90	14
18	YH-5419	8905	15	16	61	64	205	108	17
19	YH-5423	8592	15	16	64	67	180	103	15
20	FH-949 (Check)	8587	16	15	64	67	195	105	18
21	YH-5429	8152	12	13	64	67	170	78	10
22	YH-5430	8137	12	14	64	67	208	110	15
23	YH-5438	8028	13	14	63	66	190	103	14
24	YH-5433	7978	12	13	63	66	200	103	12
25	YH-5422	5202	11	9	64	67	193	93	11
26	YH-5420	4905	16	15	61	64	175	103	13
27	YH-5437	3888	18	18	64	67	175	93	7
28	YH-5436	2863	17	17	63	67	193	100	6
CV %		7.05	9.9	7.05	1.04	1.07	3.36	5.27	16.48
LSD at 5 %		1074.3	5.97	2.21	1.44	12.9	10.8	12.9	4.83

(3) AGRONOMIC STUDIES:

(a) POPULATION TRIAL

The trial was conducted to evaluate different plant densities for obtaining maximum grain yield.

Table 7. Effect of Population Trial on Maize Yield Performance R x R = 75 cm.

Sr. No.	Plant Density/ ha	Pl. spacing	Grain Yield (kg/ha)				
			Spring 2014		Spring 2013		Kharif 2013
			YH-1898	FH-949	YH-1898	FH-949	YH-1898
1	133,333	10 cm	8332	9637	7766	10164	7554
2	**106,666**	12.5 cm	9284	12880	8465	10951	**8925**
3	88,888	15 cm	**11590**	13350	**8823**	10434	7883
4	76,190	17.5 cm	11020	13120	8558	9753	7387
5	66,666	20.0 cm	10390	11840	7876	9236	7015

The data (Table 7) showed that YH-1898 gave higher grain yield of 11,590 kg / ha & 8823 kg/ha with 88,888 plants / ha during spring 2014 and spring 2013 respectively, however, it gave higher yield of 8952 kg / ha during Kharif 2013 with plant density106, 666 plants/ha which conclude that plant spacing of 15cm is suitable.

(b) IRRIGATION TRIAL

Table 8. Showing Effect of number of Irrigations on Grain Yield of Maize.

Sr. No.	No. of Irrigation	Yield (Kg/ha)YH-1898	
		Kharif 2013	Spring 2014
1	8	7111	-
2	9	7923	7208
3	10	8115	8096
4	11	8379	8784
5	12	8715	9698
6	13	-	**10178**
7	14	-	9790

The results of (Table 8) showed that 13 irrigations in spring and 12 irrigations Kharif are required for obtaining maximum grain yield of YH-1898.

(c) FERTILIZER TRIALS

These trials were conducted to find out suitable level of NPK Fertilizer to obtain maximum grain yield of YH-1898.

Table 9. Showing Effect of Fertilizers Doses on Yield Performance in Maize.

Sr. #	Treatments			Grain Yield / ha (YH-1898)		
	Kg / ha			Spring 2010	Spring 2013	Kharif 2013
	N	P	K			
1	0	0	0	4043	5375	5811
2	200	100	100	10331	6513	7196
3	250	125	100	11184	7906	7858
4	300	150	100	**12485**	**8550**	**8423**
5	350	175	100	12350	8694	7617
6	400	200	100	11977	6490	7734

The results (Table 9) showed that maximum grain yield was obtained with fertilizer combination 300-150-100 NPK (kg/ha) as for as cost benefit ratio is concerned.

(4) AGRONOMIC REQUIREMENTS

The following agronomic requirements were recorded during agronomic studies for attaining maximum grain yield of the hybrid under consideration.

(5) PLANT PROTECTION

Maize Hybrids were evaluated to find out the resistance reaction against stalk rot disease through artificial inoculation.

Sowing time (optimum)	Spring = 15th January to 15th February Kharif = 15th July to 15th August
Planting geometry (optimum)	Planting method = Ridge sowing Row Spacing = 75 cm Plant Spacing = 15 cm
Seed rate (optimum)	25 Kg/ha
Plant population	88888 plants/ ha (Spring) 106,666 plants/ha (Kharif)
Fertilizer Requirement (optimum)	Spring = (N: P: K) = 300:150:100 Kharif = (N:P:K)= 250-125-100
Irrigation Requirement (optimum)	Spring= 13 Kharif= 12

Table 10. Screening of Maize Hybrids against Stalk Rot (*Fusarium moniliforme*) by Artificial Inoculation.

Sr. No.	**Name of Hybrids**	**Spring 2013**	**Kharif 2013**
1	YH-1898	R	MR
2	Yusafwala Hybrid	R	-
3	FH-949	R	MR
4	FH-985	MR	MR
5	FH-793	MR	MS
6	FH-811	MR	MR
7	NK8711	MS	-
8	31P41	MS	-
9	P1543	MS	-
10	6525	MS	-

The results (Table 10) showed that YH-1898 showed resistant to moderately resistant reaction against stalk rot.

ENTOMOLOGICAL MEASURES /ECONOMIC THRESHOLD LEVEL (ETL)

1) (ETL) Shot fly = < 10 % 2) (ETL) Maize Borer = < 10 %

The maize crop is totally susceptible to shoot fly, maize borer and aphid attack which may vary from season to season. The attack of insects can be managed by timely application of:

1. Seed treatment
2. Spray of proper insecticides
3. Granules
4. Biological Control (*Trichogramma* Cards)

(6) SALIENT CHARACTERISTICS

The following salient characteristics were recorded and estimated in comparison with the well-known commercial check hybrids 32 F10 and NK 8441.

Sr.#	Characters	YH-1898	32F10	NK-8441
1	Plant Height (cm)	215-225	180-185	210-220
2	Cob Height (cm)	90-97	74-80	110-115
3	Days to 50 % Tassel	82-85	76-78	83-85
4	Days to 50 % Silk	85-87	78-80	84-87
5	Leaf Color	Dark green	Green	Green
6	1000- grain weight g	350-400	275-290	300-325
7	Av. Grain Yield Kg/ha	10,300	8,870	10,100
8	Yield potential Kg/ha	12,700	12,000	12,500
9	Shelling % age	86	84	86

DISCUSSION

Development of superior crop cultivars is the ultimate goal of the plant breeders to obtain higher yield to replace the existing low yielding varieties/hybrids. New maize hybrid YH-1898 is a full season, high yielding, resistant to lodging and stalk rot. It gives better results in local agro-climatic conditions and has the ability to withstand even at high temperature. Suitable for both Spring & Kharif seasons. Its plant is mid cob bearing, medium statured with semi-erect leaves and spreading type medium tassel. Emergence of tassel (male part) takes 82 to 85 days and 62 to 64 days in Spring and Kharif, respectively, while emergence of silk (female part) takes 85 to 87 days and in 65-67 days in Spring and Kharif, respectively. Plant and cob height ranges from 215-225 cm and 95-97 cm respectively. Number of leaves per plant varies from 14 to 16 and it has additional stay green character at maturity so its stalk can also be used as fodder at harvesting. The 1000-grain weight is from 350 to 400 gm. Its average grain yield is 10,300 kg per hectare against its potential of 12,700 kg per hectare. The new hybrid YH-1898 being single cross hybrid has a potential for higher grain yields and tolerance against high temperature and diseases. This hybrid is quite comparable with commercial hybrids available in market. YH-1898 having brownish yellow grain color could fetch more prices in addition to ability of successfully grown in both autumn & spring seasons in Punjab.

Conclusion

Newly developed yellow hybrid YH-1898 is a full season, high yielding hybrid resistant to lodging and stalk rot. It gives better results in local agro-climatic conditions and has the ability to withstand even high temperature. It is suitable for cultivation in both Spring and Kharif seasons.

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