



FH-949: A SPRING SEASON AND HEAT RESISTANT MAIZE HYBRID

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ABSTRACT

FH-949, a spring season high yielding yellow maize hybrid resistant to heat and lodging, was developed at Maize Research Station, AARI, Faisalabad, Pakistan. It was constituted by crossing local inbred lines. This new hybrid was evaluated in preliminary, advanced, multi-location, national uniform and on-farm large scale yield trials at farmers' fields at various locations during 2007-2014 throughout Punjab and Pakistan. Maize hybrid FH-949 ranked first in national uniform yield trials during spring 2012-14. This hybrid also performed better on an average, in on-farm large scale yield trials at farmers' fields. Average grain yield of FH-949 was 11.9 mt h⁻¹. This hybrid also showed good tolerance against heat stress specifically in spring season. It has a great yield potential of 13.6 mt ha⁻¹ with 305-315 g 1000-grain weight and can replace all multi-locational hybrids presently under cultivation in Punjab. It was released for general cultivation during 2016.

KEYWORDS: *Zea mays*; maize; new hybrid; agronomic characters; temperature resistant; yield; Pakistan.

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INTRODUCTION

Maize (*Zea mays* L.) is a member of grass family Poaceae. It is a valuable grain crop which is cultivated throughout the world under varied agro-ecological conditions. It is often called as the "queen of cereals". Maize contributes a lot to the economic well-being of Pakistan due to its diversified industrial consumption (Alvi *et al.*, 2009). Being a very high per acre yielding crop, it can provide subsistence to a large number of persons. It contributes 2.1% to the value added in agriculture and 0.4% to country's GDP (Anon., 2016). Punjab stands first with respect to per hectare yield i.e. 5.975 t ha⁻¹ in 2016. In Punjab, spring crop shares 0.189 million hectares with a production of 1.434 million tons. Per hectare yield in spring crop is 7.6 tons as compared to kharif crop (5.1 t ha⁻¹) (Anon., 2016)). Nutritionally, maize contains 60 to 68% starch and 7 to 15% protein. The embryo which forms about 12% of the whole grain is the source of protein, fats and sugars (Hussan *et al.*, 2003). Yellow maize is the richest sources of vitamin-A. Maize has more riboflavin than wheat or rice and is rich in phosphorous and potash. Maize contains 1.2 to 5.7% edible oil (Afzal *et al.*, 2009; Ali *et al.*, 2008; Anon., 2016).

The yield increase in spring season crop is mainly due to 100% adoption of hybrid seeds but availability of heat tolerant maize hybrids for elevated temperature is scarce (Winterhalter *et al.*, 2010; Yang *et al.*, 2012). Globally, crop yield decreased by biotic or abiotic stresses. Drought, flooding, heat, wind and cold are the abiotic stresses (Witt *et al.*, 2012). Agriculture scientists

are facing the challenge of heat stress in the current situation. In view of increasing interest of growers in spring maize, several single cross hybrids were developed and evaluated at Maize Research Station, Ayub Agricultural Research Institute, Faisalabad. The present hybrid was developed for higher grain yield and heat tolerance especially in spring season. This hybrid showed high grain yield and heat tolerance in station and out-station yield trials (Messina *et al.*, 2011; Rafiq *et al.*, 2011; Rafique *et al.*, 2011). This locally developed hybrid is well adaptable to local agro-climatic conditions in spring season and its seed could be made available to the growers at a lower cost.

MATERIALS AND METHODS

FH-949 was developed during kharif-2006 by crossing two inbred lines F-271 (female) and F-165 (male) at Maize Research Station, AARI, Faisalabad, Pakistan. The inbred line F-271 was developed locally through inbreeding (S₀-S₆) during 2000-2006 and F-165 during 1997-2003 from source population available at the Station. After checking its general combining ability being male parent with local and exotic inbred lines, it was used in different combinations. This hybrid was included in preliminary yield trials in spring 2007 where it yielded 11.7 t ha⁻¹. Due to its yield performance and heat tolerance during spring season it was further tested in different station and out-station yield trials. For all the trials randomized complete block design was followed maintaining 20 cm plant to plant and 75 cm row to row distance.

Ten plants per plot were selected randomly from central two rows to record observations. Plant height was measured (at maturity) from base to top with the help of a measuring tape and then it was averaged. After physiological maturity, crop of whole plot was harvested, kept for some days in the field for sun-drying and threshed manually. Fresh seed yield was recorded separately for all plots at prevailing moisture level. Thereafter, these seed samples were sun-dried, again weighed and averaged to get accurate moisture level of about 8% to calculate final seed yield per unit area as given below:-

$$\text{Seed yield} = \text{Moisture factor} \times \text{fresh seed yield}$$

$$\text{Moisture factor} = \frac{\text{Dry weight of seed sample}}{\text{Fresh weight of seed sample}} \times 100$$

The data were analyzed by Fisher's analysis of variance technique whereas, least significant difference (LSD) test at 5 percent level of probability was used to compare the differences among treatment means (Steel et al., 1997).

RESULTS AND DISCUSSION

The hybrid was tested in Pakistan under different agro-climatic conditions during 2007-12. The data of station and out-station yield trials is given below:-

Station yield trials

Hybrid maize preliminary yield trial (Spring, 2007):

Single cross spring maize hybrid FH-949 was evaluated for first time in preliminary yield trial at Maize Research Station, AARI, Faisalabad during spring 2007. This trial comprised 12 entries including two commercial hybrids as checks. FH-949 ranked first with grain yield of 11730 kg ha⁻¹ while the checks NK-8441 and HIC-8464 yielded 10443 and 7750 kg ha⁻¹, respectively. FH-949 yielded 10.97 and 33.93% more grain yield than NK-8441 and HIC-8464, respectively (Table 1).

Hybrid maize preliminary yield trial (Spring, 2008):

Hybrid FH-949 was also evaluated in preliminary yield trial at Maize Research Station, AARI, Faisalabad during spring 2008. The trial comprised 12 entries

Table 1. Hybrid maize preliminary yield trial (Spring, 2007).

Hybrids	Grain yield (kg ha ⁻¹)	% increase/decrease
FH-949	11730	-
NK-8441 (C)	10443	-10.97
HIC-8464 (C)	7750	-33.93
CV%	5.83	
LSD (0.05)	935	

including two commercial hybrids as checks. FH-949 ranked at the top with grain yield of 10,476 kg ha⁻¹ (Table 2) while checks 32F10 and HIC-8288 yielded 7,938 and 4,823 kg ha⁻¹, respectively. FH-949 yielded 24.22 and 54.05% more grain yield than 32F10 and HIC-8288, respectively.

Table 2. Hybrid maize preliminary yield trial (Spring, 2008).

Hybrids	Grain yield (kg/ha ⁻¹)	% increase/decrease
FH-949	10476	-
32F10 (C)	7938	-24.22
HIC-8288 (C)	4823	-54.05
CV%	3.97	
LSD (0.05)	596	

Micro yield trials

Spring, 2009: A trial comprising nine entries including two multinational hybrids was conducted to evaluate maize hybrid FH-949 during spring 2009. The hybrid FH-949 gave 12.05 and 22.59% more yield as compared to commercial hybrids NK-8441 and 32F10, respectively (Table 3).

Table 3. Hybrid maize micro yield trial (Spring, 2009).

Hybrids	Grain yield (kg ha ⁻¹)	% increase/decrease
FH-949	11455	-
NK-8441 (C)	10074	-12.05
32F10(C)	8867	-22.59
CV%	5.36	
LSD (0.05)	940	

Spring, 2010: This trial consisting of nine entries including two multinational hybrids and one local check was conducted to evaluate maize hybrid FH-949 during spring 2010. Yield performance given in Table 4 showed that FH-949 gave 3.11, 26.36 and 35.0% more grain yield than local hybrid FH-810 and commercial hybrids 32F10 and 6525, respectively.

Table 4. Hybrid maize micro yield trial (Spring, 2010).

Hybrids	Grain yield (kg ha ⁻¹)	% increase/decrease
FH-949	8069	-
FH-810(C)	7818	-3.11
32F10 (C)	5942	-26.36
6525 (C)	5241	-35.0
CV%	7.50	
LSD (0.05)	966.1	

Macro yield trials

Spring, 2011 and 2012: Macro yield trial comprising nine entries including three checks (two commercial

and one local) was conducted in spring 2011 and 2012 to evaluate maize hybrid FH-949. Year-wise yield performance is shown in Table 5 and 6.

Table 5. Hybrid maize macro yield trial (Spring, 2011).

Hybrids	Grain yield (kg ha ⁻¹)	% increase/decrease
FH-949	10253	-
FH-810 (C)	8699	-15.15
NK-8441(C)	7503	-26.82
HIC-8288(C)	4699	-54.17
CV%	5.63	
LSD (0.05)	844	

During 2011, FH-949 gave 15.15, 26.82 and 54.17% more grain yield than local hybrids FH-810 and commercial checks NK-8441 and HIC-8288, respectively (Table 5). During 2012 also FH-949 gave 10.57, 13.73 and 34.36% more grain yield than local check FH-810 commercial hybrids 32B33 and HIC-

8288, respectively (Table 6).

Table 6. Hybrid maize macro yield trial (Spring, 2012).

Hybrids	Grain yield (kg ha ⁻¹)	% increase/decrease
FH-949	11213	-
FH-810 (C)	10027	-10.57
32B33 (C)	9673	-13.73
Hic-8288 (C)	7360	-34.36
CV%	7.14	
LSD (0.05)	1268	

National uniform hybrid maize yield trials (Spring, 2012 -14)

Spring, 2012: This trial was conducted by MSM Coordinator, NARC, Islamabad at different locations throughout Pakistan. The trial conducted in spring 2012 comprised 30 entries from different organizations. Grain yield data of nine locations are given in Table 7.

Table 7. Average grain yield (kg ha⁻¹) of maize hybrid adaptability trial (Spring, 2012).

Locations	P-1758	PL-71	HE-3415	FH-949	S-67208	C.V (%)	LSD (0.05)
Yousafwala	12258	13393	15610	13566	6303	17.76	NS
Monsanto Lahore	12378	13179	14205	9058	8750	9.42	548
Monsanto	12605	11635	14801	8805	8365	8.85	498
Pir-sabak	9045	10466	9103	9090	6163	28.67	NS
Arifwala	10232	12420	11590	9500	8954	23.7	NS
Depalpur	15183	5945	11861	10695	7638	26.86	NS
Mian-Channu	17520	15904	15957	13642	9334	10.46	789
Faisalabad	12343	11426	9749	13365	5933	23.5	NS
Kamokey	10897	11052	7489	10663	6697	19.87	825
Average	12496	11713	12263	10932	7571		
% increase/decrease	+12.51	+6.4	+10.85	-	-44.36		

The data showed that hybrid FH-949 gave average grain yield of 10,932 kg ha⁻¹, whereas, P-1758, HE-3415 and PL-71 produced respective grain yield of 12496, 12263 and 11713 kg ha⁻¹. However, yield differences were statistically non-significant at most of the locations.

Spring, 2013: This trial comprising 34 entries was conducted at nine locations. The results (Table 8) showed that hybrid FH-949 gave grain yield of 9,196

kg ha⁻¹, whereas, YH-1898, PX-12 and P1574 yielded 10243, 9842 and 9354 kg ha⁻¹, respectively.

Spring, 2014: The results of trial conducted during spring 2014 showed that FH-949 exhibited 35.32% more grain yield than Yousafwala hybrid (Table 9). However, it produced 3.26% less than KQS-HYM-1, which stood first in the trial as reported by Rafique *et al.* (2011).

Table 8. Average grain yield (kg ha⁻¹) for maize hybrid adaptability trial (Spring, 2013).

Location	YH-1898	PX-12	FH-949	P1574	CV %	LSD
Manga Mandi	15336	13972	11618	14097	12.2	NS
Mardan	13666	14556	10850	11610	16.6	NS
Burewala	7923	8390	8383	8993	22.0	NS
Lahore	4620	5713	5223	7328	32.2	NS
AARI, Fsd.	5584	2661	2514	1406	13.2	187
NARC	9502	10133	7996	8864	16.1	NS
MMRI	15679	12691	16690	11685	15.1	961
CCRI, Pir-Sabak	12283	13749	11965	12316	18.5	NS
R.Y. Khan	7595	6715	7525	7886	21.9	NS
Average	10243	9842	9196	9354	22.6	NS
% increase/decrease	+10.22	+6.56	-	+1.69		

Table 9. Mean grain yields (kg/ha) of maize hybrid adaptability trial (Spring, 2014).

Location	KQS-HYM-1	FH-949	Yusafwala Hybrid (C)	CV %	LSD (0.05)
Yusafwala	7680	7477	6915	14.3	445
Chichawatni	10705	8649	6029	15.8	549
Pioneer SWL.	13052	9039	6271	13.4	503
Faisalabad	10005	13471	9292	11.2	414
Mardan	10052	10453	7157	15.6	643
Islamabad	10815	10675	7608	16.1	683
Manga Mandi	10426	11280	10452	11.4	NS
Gujranwala	10140	9205	5250	10.8	350
Quetta	7804	7467	5844	17.4	NS
Average	10075	9746	7202	-	-
% increase/decrease	+3.26	-	-35.32	-	-

Yield performance of FH-949 at farmers, field

The results of this trial revealed that hybrid FH-949 gave 3.46% more grain yield than that of check hybrid FH-810 (Table 10).

On-farm maize yield trial (Spring, 2013)

The results (Table 11) revealed that hybrid FH-949 gave 10.43% higher yield than check Yusafwala hybrid

and 34.63 % higher than commercial check NK-8711 (Rafiq *et al.*, 2010).

Pathological studies

Fifty maize hybrids were tested for their resistant reaction against stalk rot by artificial inoculation (Spring 2013). Among these 14 hybrids showed resistant reaction against the disease including FH-949, YH-1898 and Yusafwala Hybrid as shown in Table 12.

Table 10. Performance of FH-949 at farm maize yield trial (kg ha⁻¹) during Spring, 2012.

Entry	Burnala, Faisalabad	Gojra Morh, Jhang	Khidarwala, Faisalabad	Gojra	Av. yield	% increase / decrease
FH-811	8937	10750	9550	9478	9678	+10.10
FH-793	8251	9970	8179	9185	8896	+2.20
FH-949	7873	10850	8030	8049	8700	-
FH-810 (C)	7263	9766	9170	7438	8409	-3.46

Table 11. Results of on- farm maize yield trial (Spring, 2013)

Entry	Jhang	Gojra	Chak 192 R.B, Faisalabad	Average yield (kg ha ⁻¹)	% increase/ decrease
FH-949	11420	11920	11044	11461	-
FH-793	11041	10973	10260	10758	-6.13
Y. Hybrid (C)	10775	9838	10522	10378	-10.43
NK-8711 (C)	-	-	8513	8513	-34.63

Table 12. Screening of maize hybrids against stalk rot (*Fusarium moniliforme*) by artificial inoculation (Spring, 2013).

Name of maize hybrids	Infestation of inoculated internode (%)	Scale	Reaction
-	1-25	1	Highly resistant
FH-810, FH-922, FH-949, FH-763, FH-974, FH-976, FH-988, FH-1012, FH-1034, FH-1046, FH-1114, YH-1898, YH-5079, Yusafwala Hybrid	26-50	2	Resistant
FH-793, FH-950, FH-985, FH-1020, FH-1025, FH-1033, FH-1036, FH-1096, FH-1112, FH-1116, FH-1120, FH-1123, FH-1124, FH-1125, FH-1127, FH-1136, FH-1137, FH-1138, FH-1139 FH-811, YH-5068, 8441, YH-5078, YH-5077, YH-5076, YH-5074, YH-5072, 6142.	51-75	3	Moderately Resistant
FH-1117, FH-1119, YH-5071, 8711, 6525, 32B33, 31P41, P-1543.	76-100	4	Moderately susceptible

Agronomic studies**Effect of plant density on grain yield of maize hybrid FH-949 (Spring, 2012)**

The data reveal that plant density of 88, 888 plants per hectare (15 cm plant spacing) gave significantly higher grain yield (12,417 kg ha⁻¹) (Table 13) and its components as reported by Betran *et al.*

(2003). Moreover plant density of maize plants per ha⁻¹ showed significantly higher yield for grain as reported by Edmeades *et al.* (2000) and Grassini *et al.* (2011). The new Hybrid FH-949 showed tolerance to temperature stress by better performance in good spring seasons. These results agree to those of Wannows *et al.* (2010) and Winterhalter *et al.* (2011).

Table 13. Effect of plant density on grain yield of maize hybrid FH-949 (Spring, 2012).

Plant densities	Plant spacing (cm)	Grain yield (kg ha ⁻¹)
133,333	10.0	10,184
106,666	12.5	11,648
88,888	15.0	12,417
76,190	17.5	9,425
CV%		7.33
LSD (0.05)		1,280.5

Recommended Production Technology

Standard recommendations regarding irrigation, fertilizer, seed rate and other agronomic practices for this hybrid are given in Table 14.

Spot Examination

Spot examination of FH-949 was carried out by the Members/Co-opted Members of Expert Sub-Committee. The Expert Sub-Committee recommended FH-949 for

approval vide No. PSC/HQ-COORD/43/14/70 dated 08-07-2014.

Table 14. Recommended production technology for maize hybrid FH-949.

Practices	Recommendation
Sowing time	15 Jan to 1 st week of March
Sowing method	Ridge sowing
Seed rate ha ⁻¹	25 kg
Row spacing	68 cm (2.25 ft)
Plant spacing	15 cm
Plant population ha ⁻¹	98765
Irrigation	12-14
Fertilizer (kg ha ⁻¹)	297-148-125 NPK

Quality Characteristics

Quality analysis of FH-949 hybrid in comparison with other hybrids was done in Cereal Technology Lab. Wheat Research Institute, AARI, Faisalabad. The results are given below:-

Table 15. Quality characteristics of FH-949

Name of hybrids/variety	Protein (%)	Moisture (%)	Starch (%)	Oil (%)
FH-949 (MRS Fsd.)	9.0	12.1	71.4	4.7
NT-6621 (Syngenta)	9.9	16.6	71.1	4.6
NK-8711 (Syngenta)	8.8	11.8	70.9	4.7
30Y87 (Pioneer)	10.2	16.6	70.9	4.5
P15M43 (Pioneer)	9.2	12.9	72.0	4.2
MALKA-2016 (MRS Fsd.)	9.8	16.0	70.9	4.8

Salient features of FH-949

Features	FH-949	FH-810	HIC-8288	32F10
Plant height (cm)	228-232	195-200	180-185	200-205
Cob height (cm)	100-107	105-110	74-80	95-101
Days to 50% tasseling	77-79	80-83	76-78	78-81
Days to 50% silking	79-82	82-85	78-80	80-83
Leaf colour	Dark green	Dark green	Green	Dark Green
1000 grain weight (g)	305-315	295-310	275-290	300-310
Av. grain yield (t/ha)	11.9	11.0	7.84	8.87
Yield potential (t/ha)	13.6	12.8	110	12.00
Shelling % age	86	84	85	86

Justification for Approval

The hybrid FH-949 was approved for general cultivation on the basis of following criteria:

- Medium maturing, heat tolerant hybrid suitable for spring season.
- High yielding dented grain having better shelling percentage (86%).
- Medium tassel promoting abundant pollen supply during hot spring season.
- Better root anchor leading to lodging resistance.
- Stays green at maturity.

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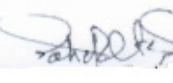
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CONTRIBUTION OF AUTHORS

S. No.	Name of author	Contribution	Signatures
1.	Muhammad Rafique	<ul style="list-style-type: none"> Development & maintenance of parent inbred lines hybrid FH-949. Evaluation of the hybrid at station, out station and national yield trials, data recording and data analysis of yield and related parameters. 	
2.	Saira Saleem	<ul style="list-style-type: none"> Searched the literature, research papers for citation and write up of the manuscript Reply of queries of referee. 	
3.	Muhammad Altaf	<ul style="list-style-type: none"> Data recording and data analysis of yield and related parameters. Recorded morphological and quantitative traits description of hybrid & parents for DUS studies. 	
4.	Ahsan Raza Mallhi	<ul style="list-style-type: none"> Reviewed the literature and assisted in writeup. 	