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GENETIC POTENTIAL OF LOCAL HYBRIDS IN COMPARISON TO MULTINATIONAL HYBRIDS IN MAIZE (*ZEA MAYS* L.) FOR GROWTH AND YIELD CHARACTERISTICS

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ABSTRACT

Background Maize is one of the most important cereal crops. However, its average yield in Pakistan is very low than the top maize producing countries. Development of locally produced maize hybrids is therefore crucial for meeting the food security in the country.

Methodology The field experiment was conducted at Maize and Millets Research Institute (MMRI), Yusafwala Sahiwal, Pakistan during 2019 to compare the performance of local maize hybrids of this Institute with multinational hybrids of Monsanto, Pioneer and ICI. The experiment was laid out in Randomized Complete Block Design with three replications. Experimental material was consisted of seventeen maize hybrids (nine hybrids from MMRI while eight hybrids from different multinational companies). Analysis of variance (ANOVA), Tukey's HSD test of significance were performed. Regression analysis was done to assess the degree of association between different plant traits and grain yield.

Results The results suggested that local hybrid FH-922 out yielded (5202.4 kg ha^{-1}) all other hybrids due to its highest values for stand count, cob harvested and shelling percentage followed by Monsanto's DK-6789 (4991.4 kg ha^{-1}), DK-6714 (4923.3 kg ha^{-1}) and MMRI hybrid, FH-1012 (4835.4 kg ha^{-1}). Plant harvested, cob harvested, stand count and plant height found to have positive and significant relationship with grain yield as revealed in regression analysis. The lowest yield was observed in local hybrid, FH-949 (2724.3 kg ha^{-1}).

Conclusion The present investigation suggested that locally bred maize hybrid FH-922 could substitute the costly multinational maize seed, and use for improving maize yield in Pakistan.

INTRODUCTION

World population is increasing day-by-day at an exponential rate. It is projected to reach 8.5 billion in 2030 and 9.7 billion in 2050 (United Nation 2015). Currently, about 796 million people are malnourished. Providence of sufficient and continuous supply of quality food for such an immensely growing human population is one the most critical and challenging task for world's food scientists. To ensure their food security, crop production needs to be doubled to feed the world in upcoming era. Climate change has multiplied the problem of food security to an alarming situation by disturbing rainfall pattern and temperature (FAO 2015a). During 2003-13, crop sector faced a loss of US $13 billion due to flooding and storm damage as a result of climate change (FAO 2015b). So, to achieve sustainable agriculture production is a major challenge in ever changing climatic conditions.

Maize is the 3rd most important cereal crop in world after wheat and rice. It highly contributes towards global food security by giving highest grain yield potential under normal as well as drought and heat stress conditions of the several countries of Asia,

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Africa and Latin America, where millions of people directly depend upon maize for their livelihood. Among cereals crops, maize has enormous prospects to address problems related to food, feed, fodder and nutritional security (Ghani et al. 2020). Its grain is a good source of starch (72%), vitamin A & B (3-5%), oil (4-5%) and protein (8-12%) (Enyisi 2014). It is grown predominantly for poultry and livestock feed (65%) and for human nutrition requirement (35%) (Halidu et al. 2014). It is also used as raw material for the production of different industrial products including starch, cooking oil, paints, confectionery products, food sweeteners, adhesive, cosmetics and ethanol (Reddy and Jabeen 2016). Due to increasing demand of maize in these sectors, there is a need to increase per hectare yield of maize.

During 2019-20, maize was grown on an area of 1.413 million hectares and 7.236 million tons production was obtained with an average yield of 5121 kg ha^{-1} in Pakistan. It contributed 0.6% in GDP and 2.9% in value addition (GOP 2020). However, it has been observed that per hectare yield of maize in Pakistan (5.121 tons ha^{-1}) is very low as compare to other maize growing countries including Turkey (11.54 tons ha^{-1}), United State (10.51 tons ha^{-1}), Canada (9.24 tons ha^{-1}), Argentina (9.24 tons ha^{-1}), European Union (7.51 tons ha^{-1}) and China (6.32 tons ha^{-1}) (USDA 2021). The major reasons for low grain yield of maize in Pakistan are high temperature, diseases and insect-pest infestation, less availability of irrigation water, poor crop management and high input rates. Low quality and substandard seed with less adaptability and germination percentage is one of the main causes of lower per acre yield in Pakistan. Therefore, there is an utmost need to develop high yielding, climate resilient maize hybrids to fulfil the demands of different industries. So, the current study was planned to assess the performance of locally develop maize hybrids in comparison to multinational hybrids to provide highly yielding but low-cost cultivars to farming community of Pakistan.

MATERIALS AND METHODS

A field experiment was conducted at experimental area of Maize and Millets Research Institute, Yusafwala, Sahiwal to evaluate maize hybrids for their productivity and yield potential. The experimental material was consisted of seventeen maize hybrids of local and multinational origin. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications having net plot size 7 m × 4.5 m. Crop was sown on 12th of August 2019 with the help of dibbler to insure 20 cm plant-to-plant distance. Standard agronomic practices were performed for all genotypes. Data were collected for nine parameters viz., stand count (SC), days to 50% tasseling (DT), days to 50% silking (DS), plant height (PH), cob height (CH), plant harvested (P.Hr), cob harvested (C.Hr), shelling percentage (S%) and grain yield per hectare (GY). The crop was harvested on 23rd November 2019. Data was analyzed for analysis of variance (Kwon and Torrie 1964) by using statistical package Statistix 8.1, and statistical significance between genotypes was estimated using Tukey HSD (Tukey 1949). Regression analysis was also performed to compute relationship between grain yield and associated parameters (Steel et al. 1997). Name of maize hybrids used in the study and their origin are described in Table 1.

RESULTS AND DISCUSSION

Analysis of variance (ANOVA) was used to compute statistical differences between maize hybrids for yield and yield related traits. The results showed that statistically significant difference was present among hybrids under study (Table 2). The variations present among maize hybrids for grain yield and its associated traits depicted the differences present in their genetic background. Similar results were also reported by Ghani et al. (2020), Yousaf et al. (2018) and Saeed et al. (2020) who reported the presence of highly significant differences among indigenous and exotic maize hybrids for grain yield and its related parameters under both spring and kharif seasons.

Mean values and their statistical significance estimated for different plant parameters are given in Table 3. The results revealed that highly significant differences were present between maize hybrids for stand count ranging from 109 in FH-949 to 174 in FH-922 (Table 3). The variations between hybrids for stand count might be due to low germination of seeds or hard crust of soil which hindered the emergence of seedlings. The results displayed that highest stand count was observed in local maize hybrid FH-949 (174.7) followed by Monsanto's multinational hybrid DK-6789 (168.7) while lowest values were observed in two local hybrids YH-1898 (103.6) and FH-949 (109). The findings were in complete agreement with the results obtained by Ghani et al. (2017) who showed that grain yield had a direct positive association with stand count. Dyas to 50% tasseling and silking are one of the most important traits that determines the earliness and maturity of different hybrids. Results showed significant variations between maize hybrids for days to 50% tasseling and silking, displaying the fact that hybrids under study belonged to different groups of maturity (Table 3). Maize hybrids FH-949, FH-1012 and YH-1898 had highest mean values (55.7) while FH-1046 took 52.7 days to complete its 50% tasseling. Similarly, mean values for days to 50%

Table 1 Name of hybrids used in the study and their origin

Sr. No.	Hybrid	Origin	Sr. No.	Hybrid	Origin
1	FH-1137	MMRI, Yusafwala	10	20R52	Jullander Pvt Ltd.
2	FH-1036	MMRI, Yusafwala	11	AAS9633	Unknown
3	FH-1046	MMRI, Yusafwala	12	DK-6714	Monsanto Seeds
4	FH-1231	MMRI, Yusafwala	13	DK-6789	Monsanto Seeds
5	FH-949	MMRI, Yusafwala	14	Hycon 999	ICI, Pakistan
6	FH-922	MMRI, Yusafwala	15	Hycon 339	ICI, Pakistan
7	FH-1012	MMRI, Yusafwala	16	YH-1898 ©	MMRI, Yusafwala
8	NT-6654	Syngenta Seeds	17	Yusafwala Hybrid ©	MMRI, Yusafwala
9	30Y87	Pioneer			

Table 2 ANOVA for grain yield and related traits in different maize hybrids (* Significant at 5% probability, ** Highly significant at 1% probability)

SOV	df	SC	Tass.	Silk.	PH	CH	P.Hr	C.Hr	SH	GY
Replication	2	173.12	0.342	0.257	410*	2.02	175.82	176.37	0.058	74164
Genotypes	18	1097.5**	4.1**	3.8**	712**	341.8**	1082.5**	1091.2**	17.3**	1647520**
Error	36	129.95	0.257	0.362	190.1	14.10	124.78	127.34	0.621	67363
CV%		7.98	0.93	1.06	8.33	4.30	7.85	7.72	0.90	6.6

SC: Stand count, Tass: Days to 50% tasseling, Silk: Days to 50% silking, PH: Plant height, CH: Cob height, P.Hr: Plant harvested, C.Hr: Cob harvested, SH: Shelling percentage, GY: Grain yield per hectare

Table 3 Mean values of grain yield and associated traits and their statistical significance in seventeen maize hybrids

Genotypes	SC	Tass	Silk	PH	CH	P.Hr	C.Hr	SH	GY
FH-1137	138.0b-f	54.7abc	57.0a-d	166.0ab	83.0de	137.2b-e	141.0b-e	88.3abc	4105.6d-g
FH-1036	150.0a-d	55.3ab	57.7abc	167.0ab	97.3abc	149.1a-d	156.6a-d	89.7ab	4182.5c-f
FH-1046	137.7b-f	52.7de	55.0e	160.6ab	95.7abc	137.3b-e	140.3b-e	89.7ab	4132.1c-g
FH-1231	155.7a-d	53.3cde	55.7de	186.6a	102.0ab	154.1a-d	159.3a-d	87.0cd	4365.0b-e
FH-949	109.0ef	55.7a	57.7abc	143.1b	79.7ef	109.0ef	109.0e	87.1cd	2724.3i
FH-922	174.7a	52.0e	55.0e	181.7ab	104.3a	174.1a	173.7ab	90.3ab	5202.4a
FH-1012	155.0a-d	55.7a	58.0ab	166.0ab	89.0cde	154.7a-d	156.0a-d	82.7e	4835.4a-d
NT-6654	151.7a-d	54.0bcd	56.3b-e	168.1ab	78.0efg	150.7a-d	150.0a-d	86.3cd	4520.3a-e
30Y87	133.6c-f	55.4a	58.3a	159.6ab	83.3de	133.5c-f	138.0cde	84.5de	3531.3fgh
20R52	146.0a-d	54.0bcd	56.0cde	176.7ab	101.7ab	144.2a-d	149.3a-d	90.1ab	4041.1efg
AAS9633	143.3a-f	54.7abc	57.0a-d	157.7ab	67.7g	143.3a-d	150.0a-d	88.0bc	4617.3a-e
DK-6714	148.3a-e	55.3ab	57.3a-d	179.3ab	92.3bcd	148.0a-d	152.0a-d	85.3d	4923.3abc
DK-6789	168.7ab	53.3cde	55.7de	187.3ab	86.7cde	168.0ab	177.3a	86.0cd	4991.4ab
Hycon 999	160.7abc	55.3ab	58.3a	174.0ab	87.0cde	159.6abc	162.3abc	90.3ab	3344.3ghi
Hycon 339	130.0c-f	55.3ab	57.3a-d	149.3b	69.7fg	129.7c-f	134.3cde	84.6de	3458.9f-i
YH-1898	103.6f	55.7a	58.0ab	139.7b	82.3de	102.3f	110.1e	90.7a	2958.7hi
YWH	123.0def	53.7cd	56.0cde	142.0b	84.0de	123.0def	125.6de	86.3cd	3364.5ghi
Mean	**142.88**	**54.49**	**56.84**	**165.51**	**87.28**	**142.24**	**146.18**	**87.47**	**4076.4**
Tukey HSD 5%	**34.86**	**1.55**	**1.84**	**42.16**	**11.48**	**34.16**	**34.50**	**2.41**	**793.58**

SC: Stand count, Tass: Days to 50% tasseling, Silk: Days to 50% silking, PH: Plant height, CH: Cob height, P.Hr: Plant harvested, C.Hr: Cob harvested, SH: Shelling percentage, GY: Grain yield per hectare, YWH: Yusafwala Hybrid

silking were high in two multinational hybrids 30Y87 and Hicorn 999 while lowest mean values were reported in two local hybrids i.e. FH-1046 and FH-922. In kharif season, the hybrids taking less days to complete their 50% silking and tasseling got more days for their later reproductive stages before the onset of winter, which ultimately increased their grain yield. However, the scenario is totally opposite in case of spring sown maize crop where late maturing and late tolerant cultivars produced more yields as suggested by Yousaf et al. (2017) and Yousaf et al. (2020).

Plant height and cob height are two another important traits for maize hybrids producing higher yield. Tall hybrids have more efficient and powerful source system due to more plant biomass, which ultimately affect the grain yield through strong source-sink relationship. Significant variation were observed for plant height and cob height in maize hybrids, ranging from 139.7 cm to 186.6 cm for plant height and 67.7 cm to 102 cm for cob height (Table 3). Maize hybrids having more mean values for these traits (FH-922 and DK-6789) were also high yield, making a

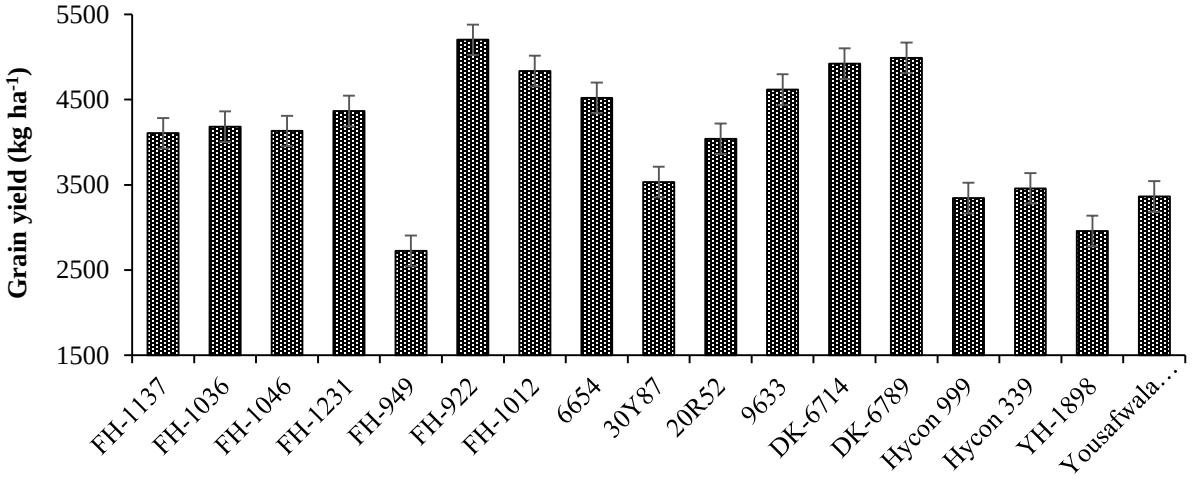

Figure 1 Comparison of grain yield per hectare of maize hybrids under study

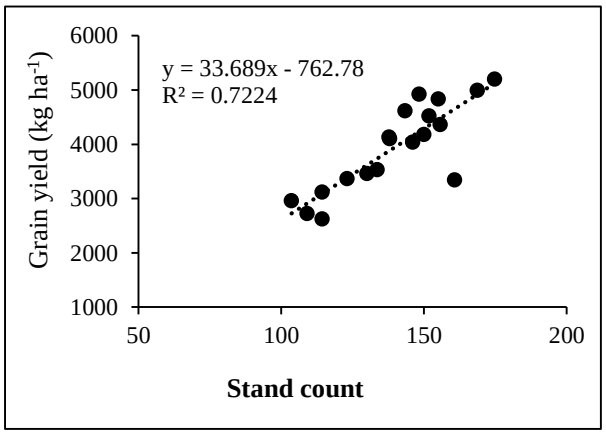

Figure 2 Regression analysis of grain yield as affected by stand count

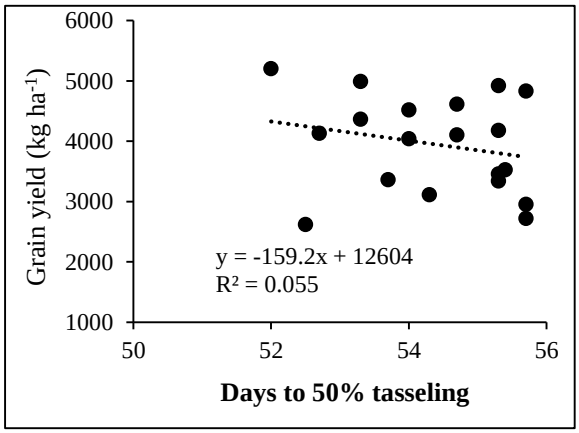

Figure 3 Regression analysis of grain yield as affected by days to 50% tasseling

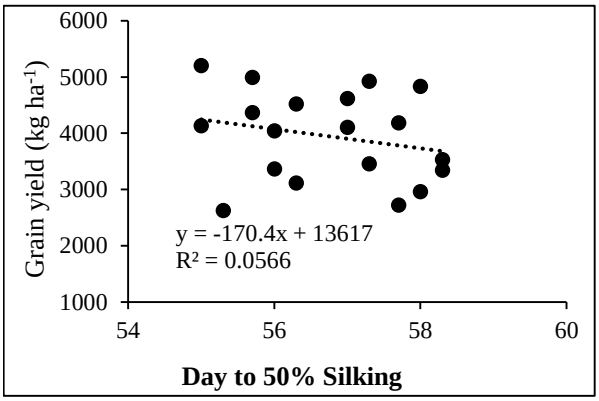

Figure 4 Regression analysis of grain yield as affected by days to 50% Silking

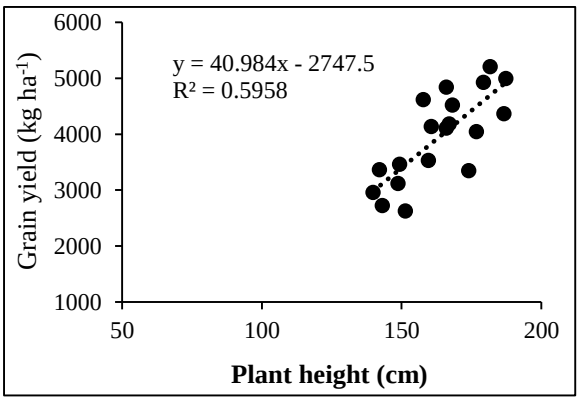

Figure 5 Regression analysis of grain yield as affected by plant height

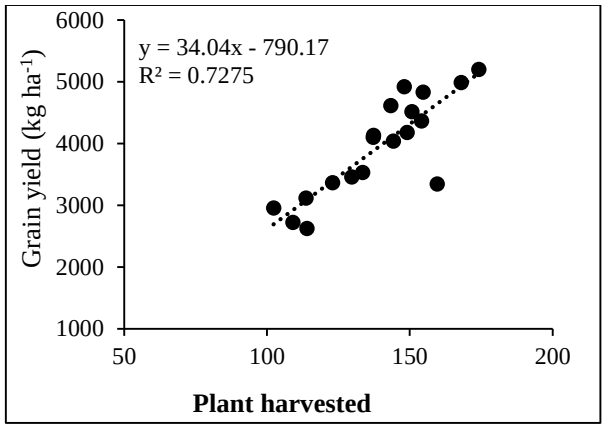

Figure 6 Regression analysis of grain yield as affected by plant harvested

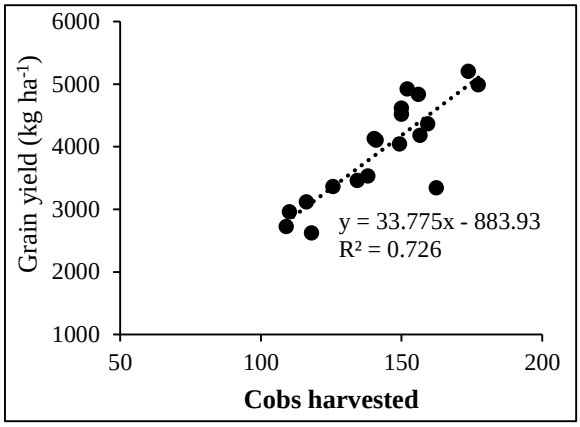

Figure 7 Regression analysis of grain yield as affected by cobs harvested

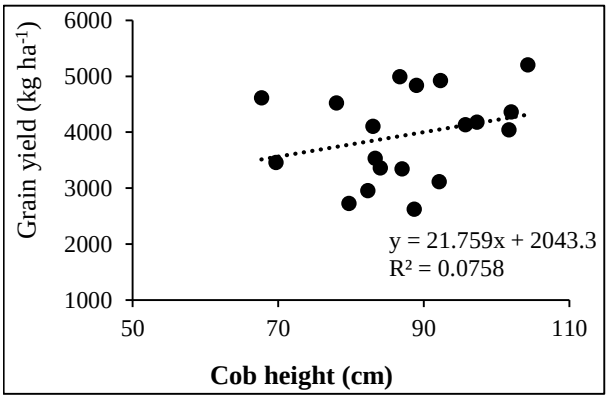

Figure 8 Regression analysis of grain yield as affected by cob height

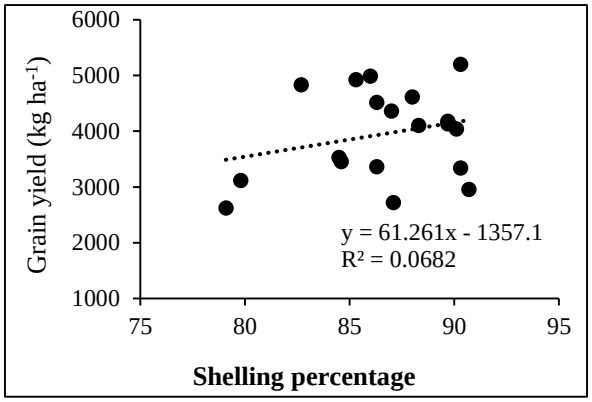

Figure 9 regression analysis of grain yield as affected by shelling percentage

direct positive association between grain yield and these traits. Similar results were also reported by Yousaf et al. (2018) who showed that grain yield had a direct positive correlation with plant height and cob height.

Grain yield has a direct positive association with plant population, which is actually number of plants per hectare. Results revealed the presence of significant variations among maize hybrids for plant harvested, ranging from 102.3 for YH-1898 to 174.1 for FH-922 (Table 3). Similarly, maximum mean value for cob harvested was 177 for DK-6789 followed by FH-922 (173.7). Shelling percentage is one of the most important traits that determines the actual yield of maize hybrids. Significant differences were observed among maize hybrids for shelling percentage, ranging from 82.7% in FH-1012 to 90.7% in YH-1898. The results were in complete accordance with the previously reported results of Shehzad et al. (2019) and Khalid et al. (2020).

Grain yield is a complex polygenic trait, affected severely by climate change. It is related to many plant parameters like plant height, number of cobs per plant, 1000-grain weight and harvest index (Akbar et al. 2008; Aminu and Izge 2012). So, any positive or negative change in above parameters may change the grain yield to more or less extent depending upon the association present between them. Results indicated that local hybrids differed significantly from multinational hybrids for yield and yield related parameters (Table 3 and Figure 1).

The results revealed that local maize hybrid FH-922 was the most productive and high yielding hybrids among the others by producing 5202.4 kg ha^{-1} followed by DK-6789 (4991.4 kg ha^{-1}) (Table 3 and Figure 1). It was also superior for cob height (104.3 cm) and number of plants harvested per plot (174.1). However, its performance was statistically at par with that of Monsanto's DK-6714 (4923.3 kg ha^{-1}) and a local hybrid FH-1012 (4835.4 kg ha^{-1}). The lowest grain yield per hectare was also exhibited by two local check hybrids FH-949 (2724.3 kg ha^{-1}) and YH-1898

(2958.7 kg ha^{-1}), respectively. The major reason behind the lowest yield of these hybrids was their lowest mean values for stand count, number of plants harvested and number of cobs harvested (Table 2). Similar findings were also obtained by Yousaf et al. (2021) who showed a direct relationship of grain yield with stand count, plants and cobs harvested, respectively.

Regression analysis is generally used to compute cause and effect relationship between different factors. The results indicated a significant relationship of stand counts, days to 50% tasseling, days to 50% silking, plant height, cob height, number of plants harvested, number of cobs harvested and shelling percentage with grain yield (Figures 2 to 9). Regression analysis revealed a strong positive relationship of grain yield with stand count (R^2=0.722; Figure 2). Regression analysis exposed that days to 50% tasseling (R^2=0.0550; Figure 3) and days to 50% silking (R^2=0.0566, Figure 4) had negative but non-significant relationship with grain yield. While, grain yield was also positively correlated with plant height (R^2=0.596; Figure 5), plant harvested (R^2=0.728; Figure 6), cob harvested (R^2=0.726; Figure 7), cob height (Figure 8) and shelling percentage (Figure 9).

The results from comparison between different hybrids showed that local hybrid FH-922 (5202 kg ha^{-1}) out yield all hybrids under study followed by DK-6789 (4991.4 kg ha^{-1}), DK-6714 (4923.3 kg ha^{-1}) and FH-1012 (4835.4 kg ha^{-1}). Main contributing parameters to grain yield were stand count, plant height, number of plants and cob harvested. Furthermore, local hybrids viz., FH-1012 and FH-1231 produced more yield than Pioneer's hybrids (30Y87) and (20R52), ICI's hybrids Hycon-999 and Hycon-339. The results were in line with Yousaf and Saleem (2001); Akbar et al. (2008); Rafiq et al. (2010); Aminu and Izge (2012) and Halidu et al. (2014), who found plant height and number of cobs per plant to be the most contributing traits in grain yield. However, Bahoush and Abbasdokhat (2008) suggested low and negative correlation of number of cobs per plot with grain yield. Regression analysis showed that selection based on plant height, number of cobs per plot along with high shelling percentage may be helpful in improving grain yield in maize. One local (FH-922) out-yielded all other hybrids and could be released for cultivation on large scale after multilocation trails.

CONCLUSION

Local hybrid, FH-922 out-yield (5202.4 kg ha^{-1}) all other hybrids while Monsanto's hybrids, DK-6789 (4991.4 kg ha^{-1}) and DK-6714 (4923.3 kg ha^{-1}) were statistically at par with FH-922. It was also revealed that plant harvested, cob harvested, stand count and plant height were highly correlated with grain yield. It was found that local hybrids could perform better than multinational hybrids due to their adaptability and compatibility with local environment.

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