Research Article

Comparative performance of various maize (*Zea mays* L.) cultivars for yield and related attributes under semi-arid environment

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ABSTRACT

Maize (*Zea mays* L.) crop is used both for food and feed purpose. However, its yield level is much lower than the potential due to plant density, inadequate fertilizer use, inadequate water supply, weed infestation, insect pest attack and the selection of unsuitable cultivars under a given set of environments. Suitable hybrid improves the growth yield and quality of maize. Keeping this in view, the present study was therefore, designed to compare the production potential of different available maize cultivars (V_1= Rafhan-2396, V_2=Rafhan-2331, V_3=Rafhan-2395, V_4=Rafhan-2301, V_5=Rafhan-2315, V_6= Rafhan-2303, V_7=Rafhan-3333, V_8=FH-1898, V_9=FH-1046, V_{10}=FH-985, V_{11}=DK-91) and to select a suitable one for maximum yield potential under the Agro-climatic conditions of Sargodha. The experiment was laid out in RCBD having three replications. Data regarding plant population at harvest, days to tasseling, days to silking, plant height at maturity (cm), number of cobs per plant, number of grains per cob, number of grain rows per cob, grain weight per cob (g), cob length (cm), 1000-grain weight (g), grain yield (kg ha^{-1}), biological yield (kg ha^{-1}), harvest index (%) and grain to pith ratio was taken with standard procedure. Results of the experiment indicated that maximum plant population at harvest (200.67), number of cobs per plant (1.30), cob length (20.57 cm), number of rows per cob (20), number of grains per cob (611.67), 1000-grain weight (263.87 g), grain weight per cob (163.23 g), grain yield (6920 kg ha^{-1}), biological yield (19687 kg ha^{-1}), harvest index (36.72%), grain pith ratio (5.17) were obtained from DK-919. In view of the above results, it can be concluded that maize hybrid DK-919 has better potential for grain yield as compared to other hybrids.

Key Words: *Maize; Hybrid; Sargodha; Growth; Yield*

INTRODUCTION

In all over the world Maize (*Zea mays* L.) crop is used both for food and feed purpose [1-3]. Soil nutrient status is important for maintaining high quality and sustainable crop production [4]. The unique energy capturing capability and efficient use of CO2 as C4 plant have made it capable of producing maximum grain yield per unit area as compared to all other cereal crops [5]. In Pakistan maize is ranked 3rd in term of area and production [6]. The problem is that quality seed of improved maize genotypes; especially hybrid maize is not available. Currently only 28-30 percent of maize area is under hybrids cultivation.

Average grain yield of maize varieties in Pakistan is low on account of suboptimal plant density, inadequate inputs availability, biotic and abiotic stresses and the selection of unsuitable cultivars under a given set of environments [7]. At present yield level is much lower than the potential of our existing varieties due to plant density, inadequate fertilizer use, inadequate water supply, weed infestation, insect pest attack and the selection of unsuitable cultivars under a given set of environments [8]. Maize varieties produce significantly different yields at different locations [9]. It is necessary to evaluate maize varieties in various agro-ecological zones for their adaptation and yield potential [10].

Yield is the primary objective in selection of maize hybrids. Hybrids generally have higher yield potential than open pollinated varieties. Hybrid maize has long ears, more grain rows per ear and greater grain yield than the open pollinated cultivars [11]. In Pakistan, maize is the staple food for a large population especially in hilly areas. This crop is capable of producing the largest quantity of grains per unit area [12]. The conventional varieties are losing their potential gradually. The crop yield in Pakistan has declined during the last decade despite the accessibility to a wide range of inputs. The cause of yield decline is the sowing of low yielding composite varieties [8]. Keeping this in view, the present study was therefore, designed to compare the production potential of different available maize hybrids and to select a suitable one for maximum yield potential under the Agro-climatic conditions of Sargodha.

MATERIALS AND METHODS

Experimental site, design and treatments

A field experiment was conducted to investigate the comparative yield performance of different maize hybrids at the Research Area of College of Agriculture, Sargodha, Pakistan. The experiment was laid out in RCBD having three replications. The soil of experimental site was analyzed before sowing the crop. The soil of experimental soil was sandy loam having pH (7.21), organic matter (0.98%), Total N (0.061%), available P (7.43 mg kg^{1}) and available K (165.33 mg kg^{-1}). The experiment was comprised with 11 numbers of different maize cultivars. V_1=Rafhan-2396, V_2=Rafhan-2331, V_3=Rafhan-2395, V_4=Rafhan-2301, V_5=Rafhan-2315, V_6=Rafhan-2303, V_7=Rafhan-3333, V_8=FH-1898, V_9=FH-1046, V_{10}=FH-985, V_{11}=DK-91.

Crop husbandry

Seedbed was prepared by pulverizing the soil with cultivator followed by planking. Maize hybrids were sown with the help of dibbler using seed rate 25 kg ha^{-1} with plant to plant distance of 20 cm and row to row distance 75 cm. The NPK fertilizer was applied @ 300, 150, 125 kg ha^{-1}, respectively with the source of Urea, DAP and Potassium Sulphate. Entire dose of the phosphorus and potassium and 1/3rd nitrogen was applied at the time of sowing. Remaining nitrogen was applied in three splits. 50 kg ha^{-1} of urea was applied when the plant height was at 46 cm height and another 50 kg ha^{-1} of urea was applied at 91 cm plant height and then 100 kg ha^{-1} of urea was applied before the flowering stage. The plant population was maintained in all treatments by gap filling and thinning after germination. All other agronomic operations were kept uniform for all treatments.

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Observations

Data regarding plant population at harvest, days to tasseling, days to silking, plant height at maturity (cm), number of cobs per plant, number of grains per cob, number of grain rows per cob, grain weight per cob (g), cob length (cm), 1000-grain weight (g), grain yield (kg ha^{-1}), biological yield (kg ha^{-1}), harvest index (%) and grain to pith ratio was taken with standard procedure.

Procedure for recording the data

Data on different stages of crop were obtained by the following procedures. For recoding plant at harvest, the number of plants in each plot were counted and then converted into number of plants per hectare. For recoding days to tasseling, ten plants were randomly selected and counted the days needed to complete tasseling. To record the days to silking, ten plants were randomly selected and counted the days needed to complete silking. To measure the plant height at maturity (cm), ten plants of maize were randomly selected from each plot at the time of final harvest and their heights were measured from soil surface to the top with the help of measuring tape and then average was calculated. Number of cobs per plant was counted from ten plants selected at random from each plot and then averaged. Grain number per cob was counted from ten randomly selected cobs from each plot and then averaged. To record the number of grain rows per cob, ten cobs were taken as a sample and number of rows was calculated and then averaged. To record the grain weight per cob (g), grains of ten randomly selected cobs from each plot were taken separately and weighed on an electric balance. Their average weight was calculated to get the grain weight per cob. To measure the cob length (cm), ten cobs were taken randomly from each plot and length in cm of each cob was measured and averaged. To record the 1000-grain weight (g), three samples of 1000-grains were taken randomly from bulk of plot yield after shelling the cobs and then weighed on an electric balance and then average 1000-grain weight was recorded. To record the grain yield (kg ha^{-1}), all the cobs from each plot were separated and cobs were allowed to sun dried for a week and the shelled with a mechanical sheller and weighed to have grain yield per plot and then grain yield was converted into kg per hectare. To record the biological yield, the crop was left in the field and was allowed to dry for a week, and then whole the plants (stalk+cobs) of each plot were weighed. Harvest index indicates the ratio of grain yield to biological yield. It was calculated by the following formula.

$$\text{Harvest Index \%} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

. Economic yield=Grain yield; Biological yield=Total biomass of the crop

Grain pith ratio was calculated by using the formula

$$\text{GPR} = \frac{\text{Grain yield}}{\text{Pith yield}}$$

Statistical analysis

Analysis of variance was carried-out with Fisher's analysis of variance procedure and treatments' means were compared by using the least significant difference test (LSD) at 0.05 probability [13].

RESULTS AND DISCUSSION

Plant population at harvest (ha^{-1})

Plant population is an important yield determining parameter. Recommended plant population maintenance plays a vital role to obtain higher yield in maize. Data about plant population at harvest is presented in Table 1. Data indicated that different hybrids did not affect the plant population significantly. The plant population ranged between 65410 to 65598 plants ha-1. Maximum plants were observed in the plot where Rafhan-2303 was sown and lowest were observed in Rafhan-2331. These results did not differ with those reported by Kazyutin et al. [14] who also recorded uniform plant population among various maize hybrids.

TABLE 1

Comparative growth performance of different maize (*Zea mays* L.) cultivars under local conditions of Sargodha.

Treatments	Plant population at harvest ha^{-1}	Plant height (cm)	Days to Tasseling	Days to Silking	Number of cobs $plant^{-1}$
V_1=Rafhan-2396	65534	178.67^{bcd}	53.02^{ab}	56.33^{ab}	0.93
V_2=Rafhan-2331	65410	177.71^{bcd}	53.32^{ab}	56.33^{ab}	1.10
V_3=Rafhan-2395	65502	165.67^{d}	52.63^{ab}	55.67^{ab}	1.10
V_4=Rafhan- 2301	65423	171.00^{bcd}	52.06^{abc}	55.00^{abc}	0.96
V_5=Rafhan-2315	65535	167.00^{bd}	52.05^{abc}	55.00^{abc}	0.96
V_6=Rafhan-2303	65598	179.00^{bcd}	54.03^{a}	57.00^{a}	1.06
V_7=Rafhan-3333	65479	166.01^{d}	53.07^{ab}	56.67^{ab}	0.93
V_8=FH-1898	65454	171.67^{cd}	48.37^{abcd}	51.33^{abcd}	1.10
V_9=FH-1046	65441	193.10^{ab}	48.14^{bcd}	51.0^{bcd}	1.07
V_{10}=FH-985	65501	187.67^{abc}	46.23^{cd}	49.33^{cd}	1.17
V_{11}=DK-919	65508	200.70^{a}	45.76^{d}	48.66^{d}	1.34
LSD	NS	17.776	5.713	5.760	0.219

Means sharing similar letter(s) do not differ significantly at p=0.05

Plant height (cm)

Plant height is a genetically as well as environmentally controlled factor. Data regarding plant height is given in Table 1, which indicated that maize hybrids differs significantly for plant height. Maximum plant height (200.67 cm) was recorded in hybrid DK-919 which was at par with FH-1046 (193.00 cm) and FH-985 (187.67 cm) and the lowest plant height (165.67 cm) was observed in Rafhan-2395 which was statistically at par with Rafhan-2315 (167.00 cm) and Rafhan-3333 (166.00 cm). This was due to the fact that plant height is a genetically controlled factor so the height of different varieties does not remain equal. These results are in accordance with the results of [15] who also reported difference of plant height in various hybrids. Our results are opposite to the results of Hussain et al. [16] who reported that maize hybrids did not differ from each other in plant height.

Days to tasseling

Data regarding the effect of different hybrids on the number of days taken to tasseling are given in Table 1. It is clear from the table that all maize hybrids differed significantly for number of days taken to tasseling. Hybrid DK-919 performed best and took fewer days (45.66 days) for tasseling which was statistically similar with FH-1898 (48.33 days), FH-1046 (48 days) and FH-985 (46.33 days). The longer number of days for tasseling was recorded in Rafhan-2303 (54 days). These results are in agreement with Anjum et al. [6] who also reported variation in days to tasseling among different hybrids.

Days to silking

Data regarding the effect of different hybrids on the number of days taken to silking are given in Table 1. It is obvious from the table that all maize hybrids differed significantly for number of days taken to silking. Hybrid DK-919 performed best and took fewer days (48.66 days) for silking which was statistically similar with FH-1898 (51.33 days), FH-1046 (51 days) and FH-985 (49.33 days). The longer number of days for silking was recorded in Rafhan-2303 (57 days). These results are in agreement with Anjum et al. [6] who also reported variability in days to silking among maize hybrids. This variability might be attributed to genetic or environmental factor.

Number of cobs per plant

Data regarding number of cobs per plant are given in Table 1. Data revealed that the number of cobs per plant was not significantly influenced by hybrids. Maximum number of cobs per plant (1.30) was recorded in hybrid DK-919 and minimum number of cobs per plant (0.93) was found in Rafhan-3333. These results are validated by the conclusion drawn by Khan, [17] who demonstrated that number of cobs per plant was non-significant among various hybrids.

Cob length (cm)

Data representing cob length are presented in Table 2. Data indicated that all the hybrids differs significantly in the case of cob length. Maximum cob length (20.57 cm) was found in hybrid DK-919 which is statistically at par with FH-985 (19.54 cm) and lowest cob length (17.06 cm) was recorded in case of Rafhan-2301. These results were in agreement with Gul et al. [8] who reported significantly different cob length in various maize hybrids.

TABLE 2

Comparative yield performance of different maize (*Zea mays* L.) cultivars under local conditions of Sargodha

Treatments	Cob length (cm)	Grain Rows per Cob	Harvest Index (%)	Grain Pith Ratio
V_1 =Rafhan-2396	17.150^{c}	15.33^{de}	34.37	3.49^{e}
V_2 =Rafhan-2331	17.987^{bc}	16.00^{de}	34.40	3.50^{e}
V_3 =Rafhan-2395	18.323^{bc}	16.01^{de}	36.72	3.68^{de}
V_4 =Rafhan- 2301	17.067^{c}	15.00^{e}	35.30	3.47^{e}
V_5 =Rafhan-2315	18.260^{bc}	15.33^{de}	35.24	3.57^{e}
V_6 =Rafhan-2303	18.330^{bc}	16.00^{de}	35.36	3.62^{de}
V_7 =Rafhan-3333	18.070^{bc}	16.33^{cde}	36.36	3.80^{de}
V_8 =FH-1898	18.240^{bc}	17.00^{cd}	32.51	4.17^{cd}
V_9 =FH-1046	18.460^{bc}	18.00^{bc}	34.84	4.55^{bc}
V_{10} =FH-985	19.540^{ab}	19.00a^{b}	34.99	4.79^{ab}
V_{11} =DK-919	20.570^{a}	20.66^{a}	35.16	5.17^{a}
LSD	1.756	1.803	NS	0.569

Means sharing similar letter(s) do not differ significantly at p=0.05

Number of grain rows per cob

Grain yield is directly related to number of grains per cob. The more number of grains per cob results in more grain yield. Data representing number of grains per cob are presented in Figure 1. A perusal of the data indicated significant effect of all the hybrids on number of grains per cob. Higher number of grains per cob (611.67) was found in hybrid DK-919 which was statistically at par with FH-985 (597.33) and FH-1046 (58133). Lesser number of grains per cob (550.67) was found in Rafhan-2396 which was statistically at par with FH-1046 (581.33), FH-1898 (576.33), Rafhan-2331 (565.33), Rafhan-2303 (565.33), Rafhan-3333 (564), Rafhan-2315 (560.67), Rafhan-2301 (560) and Rafhan-2395 (555.67). These results are also in agreement with Shariot-Ullah et al. [18,19] who noted significant difference in number of grains per cob among maize hybrids.

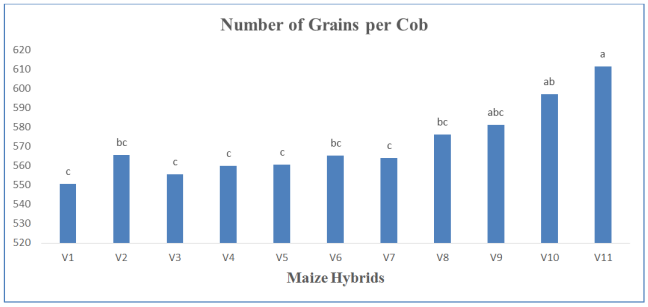

Figure 1) *Effect of different maize hybrids on number of grains per cob. V_1=Rafhan-2396, V_2=Rafhan-2331, V_3=Rafhan-2395, V_4=Rafhan-301, V_5=Rafhan-2315, V_6=Rafhan-2303, V_7=Rafhan-3333, V_8=FH-1898, V_9=FH-1046, V_{10}=FH-985, V_{11}=DK-919*

1000-Grain weight (g)

More the 1000-grain weight of a crop, more the grain yield will be and vice versa. Data representing 1000-grain weight are given in Figure 2. Data in table indicated highly significant results. There was a prominent effect of different hybrids on 1000-grain weight. Heavier 1000-grain weight (263.87 g) was recorded in DK-919 which was statistically at par with FH-985 (259.23 g). Lighter 1000-grain weight (227.03 g) was found in Rafhan-2331 which was statistically at par with FH-1898 (243.37 g) Rafhan-2303 (230.93 g), Rafhan-3333 (238.87 g), Rafhan-2315 (234.03 g), Rafhan-2301 (235.23 g), Rafhan-2396 (236.33 g) and Rafhan-2395 (236.67 g). This was due to the fact that 1000-grain weight is a genetically controlled factor so 1000-grain weight of different hybrids was different. As for the effect of environmental factors on 1000-grain weight is concerned it could not be neglected but the selection of suitable hybrid can manage the influence of environment. The same results were also reported by Tahir et al. [7] who noticed a substantial impact of maize hybrids on the 1000 grain weight.

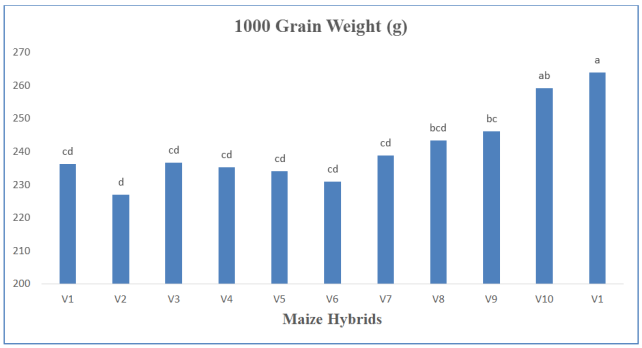

Figure 2) *Effect of different maize hybrids on 1000 grain weight (g) of maize. V_1=Rafhan-2396, V_2=Rafhan-2331, V_3=Rafhan-2395, V_4=Rafhan-2301, V_5=Rafhan-2315, V_6=Rafhan-2303, V7=Rafhan-3333, V_8=FH-1898, V_9=FH-1046, V_{10}=FH-985, V_{11}=DK-919.*

Grain weight per cob (g)

Data regarding grain weight per cob are presented in Figure 3. A significant difference in weight per cob is evident from the table. Maximum grain weight per cob (163.23 g) recorded in DK-919 which was statistically at par with FH-1046 (155.60 g), FH-985 (154.03 g) and FH-1898 (150.47 g). Minimum grain weight per cob (133.97 g) was recorded in Raftran-3333 (133.97 g) which was statistically at par with Rafhan-2395 (136.27 g) and Rafhan-2331 (136.23 g). The maximum grain weight per cob in DK-919 might be due to more number of grains per cob. The same results were also reported by Jing et al. [20] who noted the differences in grain weight per cob among maize hybrids.

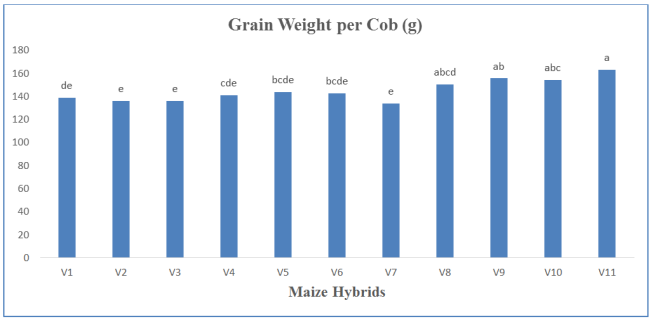

Figure 3) *Effect of different maize hybrids on grain weight per cob (g) of maize. V_1=Rafhan-2396, V_2=Rafhan-2331, V_3=Rafhan-2395, V_4=Rafhan-2301, V_5=Rafhan-2315, V_6=Rafhan-2303, V_7=Rafhan-3333, V_8=FH-1898, V_9=FH-1046, V_{10}=FH-985, V_{11}=DK-919.*

Grain yield (kg ha^{-1})

Grain yield of a crop is the ultimate objective of all the research of grain crops. Data regarding grain yield are presented in Figure 4. Data in the table indicated that maize hybrid varied significantly for grain yield. Significantly the highest grain yield (6920 kg ha^{-1}) was obtained from hybrid DK-919 and it was statistically similar with FH-985 and FH-1046 which produced grain yield of (6633.3 kg ha^{-1}) and (6518.3 kg ha^{-1}) respectively. The significantly lowest grain yield (5870 kg ha^{-1}) was obtained from Rafhan-2301 which was statistically at par with Rafhan-2395 (6315.7 kg ha^{-1}), Rafhan-2315 (6111.3 kg ha^{-1}), Rafhan-3333 (6064.0 kg ha^{-1}), Rafhan-2303 (6049.0 kg ha^{-1}), Rafhan-2396 (6008.7 kg ha^{-1}), FH-1898 (5959.0 kg ha^{-1}) and Rafhan-2331 (5903.0 kg ha^{-1}). More grain yield in DK-919 was due to more number of cob

per plant, number of row per cob, number of grains per cob, grain weight per cob and 1000-grain weight in this hybrid. These results are in agreement with Gul et al. [8] those of reported that potential yield of a hybrid is greater than the synthetic variety.

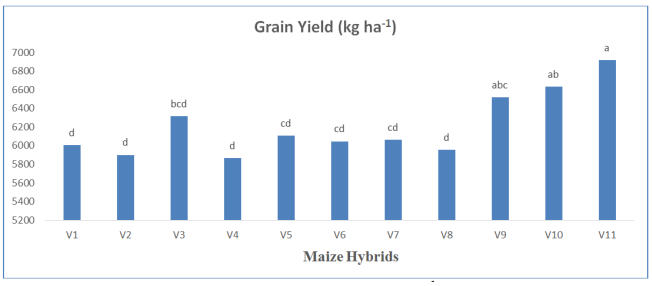

Figure 4) *Effect of different maize hybrids on grain yield (kg ha-1) of maize. V1=Rafhan-2396, V2=Rafhan-2331, V3=Rafhan-2395, V4=Rafhan-2301, V5=Rafhan-2315, V6=Rafhan-2303, V7=Rafhan-3333, V8=FH-1898, V9=FH-1046, V10=FH-985, V11=DK-919.*

Biological yield (kg ha^{-1})

Data regarding biological yield are presented in Figure 5. Data in the table indicated highly significant differences among maize hybrids for biological yield. High amount of biological yield (19687 kg ha^{-1}) was obtained from hybrid DK-919 and it was statistically similar with FH-985 and FH-1046 which produced grain yield of (18957 kg ha^{-1}) and (18736 kg ha^{-1}) respectively. The minimum amount of biological yield (16652 kg ha^{-1}) was found in Rafhan-2301. The maximum biological yield in hybrid DK-919 can be attributed to the maximum plant-height, grain and stover yield in this hybrid. These results are supported by the findings of Hussain et al. [16] who observed significant difference for biological yield among various hybrids.

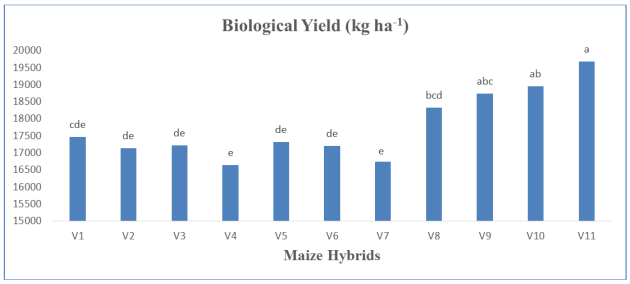

Figure 5) *Effect of different maize hybrids on biological yield (kg ha-1) of maize. V1=Rafhan-2396, V2=Rafhan-2331, V3=Rafhan-2395, V4=Rafhan-2301, V5=Rafhan-2315, V6=Rafhan-2303, V7=Rafhan-3333, V8=FH-1898, V9=FH-1046, V10=FH-985, V11=DK-919.*

Harvest index (%)

Harvest index is the ratio of economic yield to biological yield. It is a vital parameter indicating the photosynthetic efficiency of a crop for transformation of assimilates into the economic yield. Data regarding harvest index are presented in Table 2. Data in the table indicated that different hybrids responded non-significantly for harvest index. The higher harvest index (36.72%) was exhibited by Rafhan-2395 as against minimum (32.51%) in FH-1898 but these are not varying up to the level of significance. The harvest index remained invariable. These results are in agreement with those of Akram et al. [21] who reported that harvest index was non-significant among maize hybrid.

Grain pith ratio

Data representing grain pith ratio are given in Table 2. Data in table indicated highly significant results. There was a prominent effect of all the hybrids on grain pith ratio. Higher grain pith ratio (5.17) was obtained from DK-919 which was statistically similar with FH-985 (4.79). The lowest grain pith ratio (3.47) was found in Rafhan-2301. This was due to the fact that grain pith ratio is a genetically controlled factor so it is different in different hybrids. These results are in line with the results of Hamann [22] who observed different maize grain pith ratio in maize hybrids.

CONCLUSION

TIn view of the above results, it can be concluded that maize hybrid DK-919 has better potential for grain yield as compared to other hybrids. It was statistically similar with FH-1046 and FH-985. So hybrid DK-919, FH-1046 and FH-985 are best suited maize hybrids in the agro-climatic conditions of Sargodha.

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