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Magnitude of Variation for Fodder Related Traits in Two Maize Populations

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Abstract: This study was conducted during the years 2002-2003 at the Research Farm of NWFP Agricultural University, Peshawar (Pakistan) to compare selected maize populations for fodder parameters. Two maize populations, one developed through recurrent selection (DRS) and the other through mass selection (DMS), each comprising of 125 S_1 families were tested in modified Randomized Complete Block Design (RCBD) with two replications. Six fodder related traits viz., plant height, internode length, stem girth, flag leaf area, dry matter content and fresh fodder yield were determined. Mean squares from the analysis of variance among S_1 families for both maize populations indicated highly significant ($p \leq 0.01$) differences for all the parameters. Data ranged from 58.7-201.9 and 60.8-184.1 cm for plant height, 6.6-16.3 to 13.0-18.5 cm for internode length, 0.7-2.0 to 0.7-1.6 cm for stem girth, 9.7-177.2 to 9.0-120.0 for flag leaf area, 124.0-680.0 to 182.0-652.0 g kg^{-1} for dry matter content and 600.0-6720.0 to 360.0-5040.0 kg ha^{-1} for fresh fodder yield in DRS and DMS population, respectively. The mean values were 124.5 and 134.5 cm for plant height, 11.9 and 12.6 cm for internode length, 1.0 and 1.1 cm for stem girth, 52.1 and 43.8 cm^2 for flag leaf area, 354.2 and 392.8 g kg^{-1} for dry matter content and 2167.9 and 2166.2 kg ha^{-1} for fresh fodder yield in DRS and DMS population, respectively. Coefficient of variation was comparatively smaller (less than 10%) for plant height, internode length and stem girth in the DRS population and plant height, internode length, stem girth and dry matter content in the DMS population. The wider range among S_1 families of both populations depicts the existence of sufficient variation for these traits which can, therefore be exploited in maize breeding programs aimed at improving fodder characteristics.

Key words: Maize, *Zea mays* L., mean, range, coefficient of variation

INTRODUCTION

Maize (*Zea mays* L.) ranks first in both production (720 million metric tons) and productivity (4906 kg ha^{-1}) in the world among cereal crops (FAO, 2004). It is an important Kharif fodder crop in the North West Frontier Province (NWFP) with a wide range of maturity. It is adaptable to widely varying climatic and soil conditions and is extensively grown in temperate, subtropical and tropical regions of the world. The range of cultivation for maize crop stretches from 50° N to 40° S latitude and altitude from sea level to 3,300 m. It is relatively short duration and fast growing crop and can be grown twice a year.

Being a short duration cereal crop, it has attained top priority in the areas of higher mountains especially the northern parts of Pakistan and the State of Azad Jammu and Kashmir, where chilling conditions and snowfall limits the growing period of other cereals (Saeed and Saleem, 2000). With the possibility of raising two crops in a year from the same field, it is potentially capable of producing large quantity of food grains and fodder unit $area^{-1}$.

Maize provides the cheapest and most valuable fodder for animals, especially milch cattle. Maize green fodder contains 1.56% protein, 0.30% fats and 5.20% fiber (Nazir *et al*., 2003). Being highly productive and bearing abundant leaf growth, the farmers grow it for green fodder. When used as grain crop, the stalk and leaves of maize are kept as stover, although significant variation exists for nutritional quality traits of the Stover and whole plant forage in maize (Wolf *et al*., 1993). Differences in the rate of dry matter accumulation in different parts of the plant are related to changes in morphological structure.

The production of maize fodder crop ha^{-1} is low in Pakistan as compared to many other countries of the world. This is because very little attention has been paid in the past to the improvement of maize as fodder crop. In spite of its significant importance as a fodder crop in the country, a limited number of maize varieties have been

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developed and grown purely for fodder purposes. In order to provide an adequate and regular supply of nutritious fodder to meet the requirements of milk, meat, butter and other products for human consumption, efforts are needed to develop maize varieties suitable for fodder purposes. It is dire need to develop maize varieties, which are capable of rapid growth and accumulate heavy foliage in short period of time.

Before embarking on a successful breeding program in any crop species, some basic information about the magnitude and pattern of variation is a prerequisite which are always helpful for the breeders to select a suitable procedure to get the desired objectives. Variation in quantitative as well as qualitative traits could be studied through appropriate statistical approach such as the mean value of population and the spread of values on either side of the mean which is called the variances calculated as the squared deviation from mean. Inheritance of quantitative characters can not be studied through classical techniques of genetic analysis applied so successfully to the study of qualitative characters. Therefore, inheritance of quantitative characters is studied through Biometry (Singh, 2001).

The measurement and evaluation of variability is extremely important in agricultural and biological sciences. It is essential in order to draw a meaningful conclusion from a given set of observations. There are two major measures used, measure of central tendency and measure of dispersion (Chishti *et al.*, 2002). The commonly used measure of central tendency is mean, median and mode. Mean is generally used to study phenotypic values of species characteristics. The variability of the phenotypic observation also called as spread, dispersion or scatter of the phenotype reflects the diversity of a specific parameter. The mean does not tell us about the spread of the values, therefore common measures of dispersion such as range, mean deviation, variance and standard deviations are used. Range is the simplest measure of dispersion and it is used to study the variability in the agronomic traits in different crop species. It is the difference between the largest and smallest value of data (Khan *et al.*, 1994). Coefficient of variation is also an important measure of variability, commonly represented by CV. Coefficient of variation is the percent ratio of the standard deviation of a sample to its mean (Singh, 2001).

Keeping in view the importance of maize as a fodder crop, the present study was conducted to compare two maize populations developed through recurrent selection and mass selection for different fodder characteristics.

MATERIALS AND METHODS

Two maize populations viz. DRS; developed through recurrent selection wherein three cycles of selection were completed while DMS; developed by successive use of mass selection for three years from the same broad base population, were compared for various fodder related yield characteristics. The study was carried out at the Research farm of NWFP Agricultural University, Peshawar (Pakistan).

One hundred and twenty five S_1 families from each population were evaluated during the Kharif crop season of 2002 and 2003. Families from each population were assigned to five blocks, each containing 25 S_1 families in a modified randomized complete block design (replicates in block design) with two replications. Each family was planted in single row plots of 2.5 m length with row to row and plant to plant distances of 0.30 and 0.12 m, respectively. Normal cultural practices were applied to the crop throughout the experimental period. Data were recorded on important fodder parameters at the time of initiation of tasseling. The parameters included plant height, internode length, stem girth, flag leaf area and dry matter content, all measured on 10 randomly selected plants plot^{-1}, while fresh fodder yield was measured on whole plot basis. Plant height was measured as the distance from the ground to the base of the tassel of main axis. Internode length was measured 30 cm above soil surface. Stem girth was measured using vernier caliper. Flag leaf area was measured by calculating the entire length of the flag leaf and width at the maximum width point and was adjusted by a factor according to Montgomery (1962). For dry matter content a sample of 1,000 g of green fodder from each treatment was taken and sun dried for approximately 15 days to ensure constant moisture content and then re-weighed using electronic balance. Fresh fodder yield was measured by weighing the fresh green plants on plot basis and then converted to hectare^{-1} yield.

The data collected were analyzed using analysis of variance procedure according to Steel and Torrie (1980) for various plant parameters in each maize population to observe differences among S_1 families.

RESULTS AND DISCUSSION

Mean squares from the analysis of variance indicated highly significant ($p \leq 0.01$) differences among the S_1 families of both maize populations for all the fodder characters during both crop seasons of 2002 and 2003 except in the DMS population for internode length which was significant at $p \leq 0.05$ probability level (Table 1). However, pooled analysis showed highly significant differences ($p \leq 0.01$) for all traits in both the populations (Table 2). Present results are in conformity to the earlier findings of Ihsan *et al.* (2005) who reported significant variation for plant height, ear length and 100 kernel weight among maize hybrids. Similarly, Sener *et al.* (2004) recorded significant differences among maize hybrids

Table 1: Mean squares for various fodder traits of S_1 families of two maize populations (DRS and DMS) during 2002 and 2003

Source	df	Plant height	Internode length	Stem girth	Flag leaf area	Dry mater content	Fres fodder yield
DRS 2002							
Blocks	4	2936.74**	15.79**	1.08**	1999.61**	12864.71**	2129817.6**
Reps/block	5	1103.30**	14.73**	0.22**	513.04^{ns}	4963.24**	687801.6**
Families/block	120	468.26**	4.12**	0.02**	832.04**	2560.63**	777806.4**
Error	120	55.91	0.58	0.01	311.26	337.01	177681.6
DMS 2002							
Blocks	4	1007.75**	2.53^{ns}	0.18^{ns}	131.25^{ns}	3217.30**	933321.6**
Reps/block	5	63.59^{ns}	1.18^{ns}	0.15**	15.93^{ns}	1511.10**	532339.2*
Families/block	120	745.96**	4.37**	0.042**	412.31**	3139.50**	1180684.8**
Error	120	49.70	1.13	0.01	127.51	373.90	173779.2
DRS 2003							
Blocks	4	1500.07**	4.25**	0.08**	382.98^{ns}	2294.43**	534297.6^{ns}
Reps/block	5	200.46^{ns}	1.96^{ns}	0.09**	680.21^{ns}	1486.89*	808934.4**
Families/block	120	576.92**	2.97**	0.03**	918.17**	1417.06**	2318438.4**
Error	120	182.94	0.99	0.01	371.15	554.47	235334.4
DMS 2003							
Blocks	4	394.09 **	14.23**	0.02^{ns}	264.25^{ns}	3555.45**	207464.18^{ns}
Reps/block	5	170.58**	11.34**	0.08**	865.76**	368.68^{ns}	515947.71**
Families/block	120	485.91**	2.67*	0.03 **	455.67**	834.72**	1350154.11**
Error	120	43.30	1.79	0.01	182.94	219.78	149131.70

ns = Non significant, * = Significant at p = 0.05 probability level, ** = Significant at p = 0.01 probability level

Table 2: Pooled mean squares for various fodder traits of S_1 families of DRS and DMS populations averaged over two years (2002-2003)

Source	df	Plant height	Internode length	Stem girth	Flag leaf area	Dry matter content	Fresh fodder yield
DRS							
Years	1	185700.75**	2.06^{ns}	0.08**	18790.17**	37134.96**	39762000**
Blocks	4	633.30**	4.47**	0.63**	1203.88**	11645.85**	696355**
Rep (Block)	5	746.70**	4.08**	0.23**	1056.79**	3331.91**	1145692**
Family (Block)	120	764.30**	4.31**	0.03**	860.43**	2255.72**	2333896**
Years* family (Block)	124	394.52**	3.19**	0.04**	899.11**	1779.75**	801232**
Error	245	128.36	1.03	0.02	337.03	500.28	209457
DMS							
Years	1	31637.67**	102.33**	0.03^{ns}	5142.04**	22044.80**	19468^{ns}
Blocks	4	614.53**	4.07*	0.01^{ns}	88.93^{ns}	3744.96**	335692^{ns}
Rep (Block)	5	201.28**	6.51**	0.21**	513.43**	1347.73**	220262^{ns}
Family (Block)	120	835.71**	3.86**	0.05**	499.57**	2454.36**	1670988**
Years* family (Block)	124	410.40**	3.49**	0.02**	366.42**	1568.46**	828365**
Error	245	46.20	1.55	0.01	159.57	301.62	167599**

ns = Non-significant, ** = Significant at 0.01 probability level

for plant height and stem diameter. Nazir *et al.* (2003) reported that maize varieties differed significantly for days to 50% silking, plant height and grain yield. Similarly, Alias *et al.* (2003) reported significant differences for plant height, leaf area plant^{-1}, number of kernels cob^{-1}, stover yield ha^{-1} and harvest index. Asghar and Mehdi (1999), Ayub *et al.* (1998) and Fountain and Hallauer (1996) also found significant differences among S_1 progenies in maize populations for most of the fodder traits in their relevant studies.

Range, mean and coefficient of variation: The ranges, means and coefficient of variation for fodder traits viz. plant height, internode length, stem girth, flag leaf area, dry matter content and fresh fodder yield are given in Table 3 and 4.

Ranges: During 2002, data ranged from 58.7 to 149.5, 7.2 to 16.4, 0.7 to 2.0 cm, 9.7 to 177.2 cm^2, 124.0 to 612.0 g kg^{-1} and 600.00 to 3960.00 kg ha^{-1} for plant height, internode length, stem girth, flag leaf area, dry matter content and fresh fodder yield in DRS population, respectively. Similarly, values for DMS population ranged from 60.8 to 172.2 cm, 7.7 to 18.5 cm, 0.7 to 1.6 cm, 9.0 to 95.3 cm^2, 182.0 to 732.0 g kg^{-1} and 480.0 to 4920.0 kg ha^{-1} for plant height, internode length and stem girth, flag leaf area, dry matter content and fresh fodder yield, respectively (Table 3). During crop season 2003, plant height, internode length and stem girth, flag leaf area, dry matter content and fresh fodder yield for DRS population ranged from 66.9 to 201.9 cm, 6.6 to 15.9 cm and 0.7 to 1.5 cm, 18.8 to 154.4 cm^2, 156.0 to 340.0 g kg^{-1} and 600.0 to 6720.0 kg ha^{-1} respectively. In DMS population ranges were 89.0 to 184.8 cm, 13.0 to 16.0 cm and 0.82 to 1.5 cm, 13.7 to 120.0 cm^2, 284.0 to 578.0 g and 360.0 to 5040.0 kg ha^{-1} for plant height, internode length and stem girth, flag leaf area, dry matter content and fresh fodder yield, respectively (Table 3). Pooled analyses showed that in DRS population for plant height, internode length, stem girth, flag leaf area, dry matter content and fresh fodder yield data ranged from 58.7 to 201.9 cm, 6.6 to 16.3 cm, 0.7 to 2.0 cm, 9.7 to 177.2 cm^2, 124 to 680 g kg^{-1} and 600 to 6720 kg ha^{-1}, respectively. In DMS population values ranged from 60.8 to 184.1 cm, 13 to 18.5 cm, 0.7 to 1.6 cm, 9.0 to

Table 3: Range, mean and coefficient of variation for fodder traits of two maize populations (DRS and DMS) during 2002 and 2003

	DRS			DMS		
Parameter	Range	Mean	CV (%)	Range	Mean	CV (%)
Year 2002						
Plant height (cm)	58.7-149.5	105.3	7.1	60.8-172.2	126.6	5.6
Internode length (cm)	7.2-16.4	11.9	6.4	7.7-18.5	13.1	8.1
Stem girth (cm)	0.7-2.0	1.1	10.2	0.7-1.6	1.1	8.1
Flag leaf area (cm^2)	9.7-177.2	46.0	38.4	9.0-95.3	40.7	27.8
Dry matter content ($g\ kg^{-1}$)	124.0-612.0	337.0	10.9	182.0-732.0	406.1	9.5
Fresh fodder yield ($kg\ ha^{-1}$)	600.0-3960.0	1885.9	22.4	480.0-4920.0	2172.5	19.2
Year 2003						
Plant height (cm)	66.9-201.9	143.9	9.4	89.0-184.1	142.5	4.6
Internode length (cm)	6.6-15.9	12.0	8.3	13.0-16.0	12.2	10.9
Stem girth (cm)	0.7-1.5	1.1	6.7	0.8-1.5	1.2	6.9
Flag leaf area (cm^2)	18.8-154.4	58.3	33.1	13.7-120.0	47.1	28.5
Dry matter content ($g\ kg^{-1}$)	312.0-680.0	371.5	12.7	284.0-578.0	379.6	15.8
Fresh fodder yield ($kg\ ha^{-1}$)	600.0-6720.0	2449.9	19.8	360.0-5040.0	2160.0	17.9

Table 4: Pooled range, mean and coefficient of variation for fodder traits of two maize populations (DRS and DMS) averaged over two years

	DRS			DMS		
Parameter	Range	Mean	CV (%)	Range	Mean	CV (%)
Plant height (cm)	58.7-201.9	124.5	9.09	60.8-184.1	134.5	5.0
Internode length (cm)	6.6-16.3	11.9	8.50	13.0-18.5	12.6	9.8
Stem girth (cm)	0.7-2.0	1.1	9.33	0.7-1.6	1.1	7.7
Flag leaf area (cm^2)	9.7-177.2	52.1	35.22	9.0-120.0	43.8	28.8
Dry matter content ($g\ kg^{-1}$)	124.0-680.0	354.2	12.63	182.0-652.0	392.8	8.8
Fresh fodder yield ($kg\ ha^{-1}$)	600.0-6720.0	2167.9	21.11	360.0-5040.0	2166.2	18.8

120.0 cm^2, 182 to 652 g kg^{-1} and 360 to 5040 kg ha^{-1} for plant height, internode length, stem girth, flag leaf area, dry matter content and fresh fodder yield, respectively (Table 4).

The ranges for most of the traits in both populations indicated larger values. Wider range among S_1 families of these populations indicates the presence of sufficient genetic variation for these traits. Large continuous distribution indicated primarily quantitative inheritance wherein both additive and non additive genetic effects for traits are considered to be of importance. Large ranges observed in the two populations showed that the additively controlled characters were considerably influenced by the environment. The variation among S_1 families for these traits could be promising for the improvement of these populations in the desired direction. Similarly higher mean and range values were also obtained by Asghar and Khan (2005) in S_1 families of maize population.

Means: Mean values during 2002 in DRS population for plant height, internode length, stem girth, flag leaf area, dry matter content and fresh fodder yield were 105.3, 11.9 and 1.1 cm, 45.9 cm^2, 337.0 g kg^{-1} and 1885.9 kg ha^{-1} respectively. The means in DMS population were 126.6 cm, 13.1 cm, 1.1 cm, 40.7 cm^2, 406.1 g kg^{-1} and 2172.5 kg ha^{-1} for plant height, internode length, stem girth, flag leaf area, dry matter content and fresh fodder yield, respectively (Table 3). During 2003, the mean of plant height, internode length, stem girth flag leaf area, dry matter content and fodder yield for DRS population was 143.9 cm, 12.0 cm, 1.1 cm, 58.3 cm^2, 371.5 g kg^{-1} and 2449.9 kg ha^{-1}, respectively. Similarly mean values for the DMS population were 142.5 cm, 12.2 cm, 1.2 cm, 47.1 cm^2, 379.6 g kg^{-1} and 2160.0 kg ha^{-1}, respectively during the crop season 2003. Means across the two years for plant height, internode length, stem flag leaf area, dry matter content and fresh fodder yield in DRS population were 124.5 cm, 11.9 cm and 1.0 cm, 52.1 cm^2, 354.2 g kg^{-1} and 2167.9 kg ha^{-1} respectively, while in DMS population were 134.5 cm, 12.6 cm, 1.1 cm, 43.8 cm^2, 392.8 g kg^{-1} and 2166.2 kg ha^{-1} for plant height, internode length, stem girth, flag leaf area, dry matter content and fresh fodder yield, respectively (Table 4).

Our study indicated that the mean values for DMS population were comparatively greater than DRS population for majority of the traits during the two years (2002-2003). In DMS population, comparatively higher mean were recorded for characteristics such as plant height, stem girth, internode length, dry matter content and fresh fodder yield than DRS population, while DRS population showed comparatively higher values for flag leaf area during crop season 2002. The DMS population revealed high mean values for majority of the traits as compared to DRS population during the crop season 2003 which confirms the effectiveness of mass selection for maize population improvement. Pooled analysis over two years showed that mean values were higher in DRS for flag leaf area and fresh fodder yield, whereas DMS population surpassed in plant height, stem girth and internode length. Higher mean values were recorded for majority of the traits by Asghar and Khan (2005) while comparing two maize populations for seedling parameters. Our results are also in agreement with the findings of Mehdi and Ahsan (1999, 2000). Variability in genetic potential among varieties is major component of variable yield.

Coefficient of variation: During the present study coefficient of variation was less than 10% (Table 3) for plant height and internode length (DRS population) and plant height, internode length, stem girth and dry matter content (DMS population) in 2002. In 2003, less than 10% CV was recorded for plant height, internode length and stem girth (DRS population) and plant height and stem girth (DMS population). Table 4 showed that pooled CV across the two years was less than 10% for plant height, internode length and stem girth in DRS population and plant height, internode length, stem girth and dry matter content in DMS population. By comparing the two populations, it is revealed that DRS population showed comparatively greater CVs for plant height, stem girth, flag leaf area, dry matter content fresh fodder yield in 2002 and for plant height, flag leaf area, fresh fodder yield, in 2003. DMS population surpassed DRS population for internode length in 2002 and internode length, stem girth, dry matter content in 2003. However, by comparing the two populations across the two years, DRS population had higher CVs for plant height, stem girth, flag leaf area, dry matter and fresh fodder yields while DMS showed higher values for internode length.

In present study for majority of the traits CV was lower. Our results are in agreement to the Mehdi *et al.* (2001) also found lower CV for various characteristics in maize. However, Mehdi and Ahsan (1999) reported variable (both lower and higher) values of CV for different maize traits.

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