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Combing Ability of Yield and quality Contributing Attributes in Fodder Maize (*Zea maize* L.)

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ABSTRACT: India is land of agriculture from ancient times. Currently India is largest cattle holders in the world, but in output lack behind European countries. According to IGFRI vision 2050, India faces fodder scarcity of 35% in green fodder, 10.95% in dry fodder and 44% in concentrate which results in reduction of livestock output (meat milk and other bi products). Maize have excellent capacity to adopt environments, high nutritional value and higher growth rate can make it game changer. Current experiment conducted in the SKUAST-K, ten fodder maize lines were crossed in a half diallel fashion during. In the *Kharif* season 2020 at CSKHPKV Hill Agriculture Research Centre Bajaura and the forty-five crosses were produced. The crosses were evaluated at three locations of Jammu and Kashmir during *Kharif* 2021. Observations were recorded on 1. Fodder Yield traits – Plant Height, Green fodder yield. 2. Fodder Quality traits- Crude Protein content %, Acid dietary fibres%, Neutral detergent fibres %. In results found. KDFM 179 and KDFM 180 revealed the highest GCA while KDFM 177 and KDFM 184 revealed Lowest GCA. Cross combination *viz.*, KDFM 176 × KDFM 178, and KDFM 183 × KDFM 187 reveled Heighest SCA for yield triats. While parent KDFM 181 (GCA) and cross combination- KDFM 181 × KDFM 183 (SCA) performed best in both yield and quality traits.

Keywords: Fodder maize, combing ability, gca, sca.

INTRODUCTION

The plant *Zea mays* L., commonly known as maize, is a prominent member of the *Maydeae* tribe within the *Poaceae* family, which is known as the grass family. The term "*Zea*" originated from an ancient Greek term referring to a cultivated grass used for food, which was first domesticated over 9,000 years ago in the southern regions of Mexico. The origin of the word 'maize' can be traced back to the Taino language of the Caribbean islands, specifically the word '*mahiz*', which later evolved into '*maiz*' in Spanish (Erenstein *et al.*, 2022).

Various scientific hypotheses have been put forth to elucidate the origins of maize. Four hypotheses were examined, including the tripartite hypothesis, the catastrophic sexual transmutation theory, the *Tripsacum – Zea diploperennis* hypothesis, and the teosinte hypothesis. Among these, the teosinte hypothesis received significant attention and was widely discussed by scientists (Doebley, 2004).

The somatic chromosome number of maize is 2n = 20, with a genome size of 2.3 gigabases and over 32,000 genes. Maize exhibits remarkable adaptability across various environments, enabling its cultivation on a global scale (Dawe, 2022).

Fodder crisis in India. Fodder can be divided into three parts – Dry, Green, and concentrated. In India, fodder always becomes a serious issue. Several government reports claim that India under an alarming situation- In the 34th Parliamentary Standing Committee Report indicated IGFRI, Jhansi reported that by 2025 shortage of 117 MT of Dry Fodder, about 23%, 400 MT of Green fodder, about 40%, concentrates of 40 MT about 38% (Singh *et al.*, 2022).

Maize as fodder crop. Maize holds a prominent position as a "noble" fodder crop owing to its manifold advantages and significant contributions to livestock nutrition. In this review paper, we will explore the various reasons why maize (*Zea mays*) is widely recognized as a noble fodder. Maize, a versatile and widely cultivated crop, has gained significant attention in the field of animal husbandry due to its exceptional nutritional value and numerous benefits as a feed source. This paper aims to provide an overview of the key factors that contribute to maize's esteemed status as a superior fodder option. First and foremost, maize possesses a remarkable nutrient profile that makes it highly desirable as a feed for livestock. It is rich in carbohydrates, proteins (Hoque *et al.,* 2022).

MATERIAL AND METHODS

Ten lines fodder lines selected from the Dryland agriculture research station, Rangreth (J&K). 10 fodder lines collected from the Dryland Agriculture Research Station, Rangreth, Srinagar, are given below - KDFM 176 (IC- 335185 (11)), KDFM 177 (IC- 335188 (48)), KDFM 178 (IC- 338984 (4)), KDFM 179 (IC- 334969 (24)), KDFM 180 (IC- 334966 (21)), KDFM 181 (IC-335194 (13)), KDFM 182 (IC- 334973 (38)), KDFM 183 (IC- 334965 (20)), KDFM 184 (IC- 334974 (39)), KDFM 187 (IC- 335184 (10)). These lines crossed in the CSKHPKV Hill Agriculture Research Centre Bajaura (H.P.) during the Kharif season 2020 in Half-diallel fashion. Forty-five crosses obtained and further evaluated during the Kharif season 2021 over three locations in Jammu and Kashmir *viz.,* 1. Regional Research Station and Faculty of Agriculture, Wadura, SKUAST-Kashmir, 2. Dryland Agriculture Research Station, Rangreth, Srinagar, 3. Mountain Crop Research Center, Larnu.

Crop shown during the Kharif season 2021 with all necessary agronomic practices row length – 2m, with spacing – 20x60cm, SFM1 utilized as check verity. The observations were taken based on 1. Fodder Yield traits – Plant Height, Green fodder yield 2. Fodder Quality traits- Crude Protein content, Acid dietary fibres, Neutral Dietary fibres.

RESULTS AND DISCUSSION

A. General combing ability

The general combing ability is demonstrated in Table 1. The results of the study revealed that KDFM 178, KDFM 179, KDFM 180, KDFM 181, KDFM 182, and KDFM 187 exhibited significant and desirable positive general combining ability (GCA) for Plant Height. Among these, KDFM 181 demonstrated the highest GCA effect with a value of 6.481**. In their findings, Chikuta *et al.* (2017); Eldie (2021) observed a significant general combining ability (GCA) for plant height. This suggests that the genetic factors influencing plant height play a substantial role in determining the observed variations. The results from these studies contribute to our understanding of the genetic control of plant height and provide valuable insights for plant breeding and improvement programs. Further research is justified to explore the specific genes and mechanisms underlying this observed GCA effect on plant height. Parents KDFM 178, KDFM 179, KDFM 180, KDFM 181, KDFM 182, KDFM 187 produced significant and desirable positive GCA for green fodder yield. KDFM 181 produced maximum GCA effect that is 24.802**. Eldie *et al.* (2021) found significant GCA in Green fodder yield per ha.

The parental lines, KDFM 179, KDFM 180 and KDFM 181, exhibited noteworthy and favorable general combining ability (GCA) in relation to the percentage of crude protein content. The highest GCA effect observed in this study was produced by KDFM 181, with a value of 0.139**. This indicates a significant impact of KDFM 181 on the trait under investigation.

The parental lines KDFM 182, KDFM 183, and KDFM 184 exhibited noteworthy and desirable negative general combining ability (GCA) effects for the percentage of acid dietary fibres. The results of the study indicate that KDFM 182 had the highest GCA effect, with a value of -0.681**. This suggests that KDFM 182 had a significant impact on the trait being measured.

The parental lines KDFM 176, KDFM 177, KDFM 180, KDFM 182, and KDFM 183 exhibited significant and desirable negative general combining ability (GCA) effects for the percentage of neutral detergent fibre (%NDF). The results of the experiment showed that KDFM 182 had the highest GCA value, which was -0.598**. This indicates that KDFM 182 had a significant impact on the overall performance of the experiment.

The studies conducted by Rathod *et al.* (2021); Suneetha *et al.,* (2000); Indubhai *et al.* (2015) yielded noteworthy results regarding the genetic combining ability (GCA) for various quality traits, such as crude proteins, acid dietary fibre, and neutral detergent fibre. These findings demonstrated a significant positive impact on the desired traits.

B. Specific combining ability

Table 2 presents the estimated specific combining ability (SCA) effects of forty-five F1 hybrids for various traits, based on pooled data from multiple environments. The results of our study indicate that none of the cross combinations showed significant and desirable specific combining ability (SCA) effects for all the traits analyzed. The results of our study revealed that there were indeed several cross combinations that exhibited notable and meaningful Specific Combining Ability (SCA) effects.

The study involved a total of forty-five cross combinations, out of which sixteen combinations were found to have desirable and significant specific combining ability (SCA) for plant height. These combinations included KDFM 176 × KDFM 177, KDFM 176 × KDFM 178, KDFM 176 × KDFM 183, KDFM 176 × KDFM 187, KDFM 177 × KDFM 184, KDFM 178 × KDFM 179, KDFM 178 × KDFM 182, KDFM 178 × KDFM 183, KDFM 179 × KDFM 183, KDFM 180 × KDFM 187, KDFM 181 × KDFM 182, KDFM 181 × KDFM 183, KDFM 181 × KDFM 184, KDFM 181 × KDFM 187, KDFM 182 × KDFM 183 and KDFM 183 × KDFM 187. These combinations exhibited positive effects on plant height, indicating their potential for further breeding programs or selection for desired plant height traits. The cross combinations KDFM 176 × KDFM 183 (12.404**) and KDFM 180 × KDFM 187 (13.900**) were found to be the best in terms of producing height SCA for Plant Height.

The study examined a total of forty-five cross combinations, out of which twenty-one combinations, such as KDFM 176 × KDFM 177, KDFM 176 × KDFM 178, KDFM 176 × KDFM 184, KDFM 177 × KDFM 180, and others, demonstrated desirable and significant specific combining ability (SCA) effects for green fodder yield. These results indicate a positive impact on the overall yield of green fodder. The cross combinations KDFM 176 × KDFM 177 (67.974 **) and KDFM 181 × KDFM 183 (59.901 **) showed the highest specific combining ability (sca) effects for this trait. These cross combinations were identified as the best for achieving desirable outcomes in this trait.

The result of combining twenty crosses with forty is a total of sixty crosses. This combination could potentially yield a diverse range of outcomes and variations. Further analysis and discussion would be needed to explore the specific characteristics and traits that may arise from The cross combinations KDFM 176 × KDFM 177, KDFM 176 × KDFM 182, KDFM 176 × KDFM 183, KDFM 176 × KDFM 187, KDFM 177 × KDFM 179, KDFM 178 × KDFM 180, KDFM 178 × KDFM 182, KDFM 178 × KDFM 183, KDFM 178 × KDFM 187, KDFM 179 × KDFM 180, KDFM 179 × KDFM 182, KDFM 179 × KDFM 183, KDFM 180 × KDFM 182, KDFM 180 × KDFM 183, KDFM 180 × KDFM 184, KDFM 180 × KDFM 187, KDFM 181 × KDFM 182, KDFM 181 × KDFM 183, KDFM 181 × KDFM 184, and KDFM 183 × KDFM 187 exhibited desirable and significant specific combining ability (SCA) effects. The cross combinations KDFM 181 × KDFM 182 (0.386 **) and KDFM 181 × KDFM 183 (0.366 **) showed the highest specific combining ability (sca) effects, indicating that they are the best cross combinations for improving crude protein content.

In this study, a total of forty-five cross combinations were evaluated, and fourteen of these combinations showed desirable and significant specific combining ability (SCA) effects for acid dietary fibre percentage. The cross combinations that exhibited these effects were KDFM 176 × KDFM 178, KDFM 176 × KDFM 181, KDFM 176 × KDFM 183, KDFM 176 × KDFM 184, KDFM 177 × KDFM 182, KDFM 178 × KDFM 181, KDFM 178 × KDFM 187, KDFM 179 × KDFM 180, KDFM 179 × KDFM 181, KDFM 180 × KDFM 184, KDFM 182 × KDFM 183, KDFM 182 × KDFM 184, KDFM 182 × KDFM 187, and KDFM 184 X×KDFM 187. These results indicate that these specific cross combinations have a significant impact on the acid dietary fibre percentage. The cross combinations KDFM 182 × KDFM 183 (-3.260 **) and KDFM 182 X KDFM 187 (-1.583 **) exhibited the highest specific combining ability (sca) effects, indicating that they are the most favourable cross combinations for this particular trait.

Eleven cross combinations out of forty-five Cross combination KDFM 176 × KDFM 181, KDFM 176 × KDFM 184, KDFM 177 × KDFM 178, KDFM 177 × KDFM 183, KDFM 178 × KDFM 187, KDFM 179 × KDFM 180, KDFM 179 × KDFM 181, KDFM 180 × KDFM 184, KDFM 182 × KDFM 183, KDFM 182 × KDFM 184, KDFM 182 × KDFM 187 showed desirable (Negative) and significant SCA effects for neutral dietary fibre %. Cross combinations viz. KDFM 177 × KDFM 178 (4.361 **), KDFM 179 × KDFM 181 (-6.609 **) produced highest sca for this trait, revealed as best cross combinations for this trait.

The results of the study show that the plant height and green fodder yield per hectare were evaluated using the SCA method. In line with the findings of Sheunda *et al.* (2019), the study conducted by Prakash *et al*. (2010) also yielded noteworthy and positive results.

The studies conducted by Rathod *et al.* (2021); Suneetha *et al.* (2000); Indubhai *et al.*, (2015) yielded noteworthy and statistically significant findings regarding the traits of crude proteins, acid dietary fibre, and neutral detergent fibre.

Table 1: Pooled GCA effect for Yield and fodder quality trait in maize.

Parents	Plant Height	Green fodder yield per ha.	Crude protein %	Acid dietary fibre %	Neutral detergent fibre %
KDFM 176	-3.343**	-2.996**	-0.013	0.500**	-0.039
KDFM 177	-0.177	-12.235**	-0.018	0.181**	-0.091
KDFM 178	1.712**	15.027**	-0.006	0.174**	0.170
KDFM 179	1.064**	14.932**	0.068**	0.138**	-0.191
KDFM 180	1.296**	13.445**	0.107**	0.174**	-0.402*
KDFM 181	6.481**	24.802**	0.139**	0.381**	0.316
KDFM 182	-5.408**	-14.206**	-0.186**	-0.681**	-0.598**
KDFM 183	-4.516**	-25.859**	-0.121**	-0.637**	-0.371*
KDFM 184	0.018	-15.194**	0.032*	-0.320**	0.893**
KDFM 187	2.874**	2.283*	-0.003	0.152**	0.313
SE± (g)	**0.024**	**0.135**	**0.036**	**0.161**	**0.161**
SE± (g_i-g_j)	**0.036**	**0.202**	**0.053**	**0.240**	**0.240**

Table 2: Pooled SCA effects of yield and quality attributes in fodder maize.

Sr. No.	CROSS	PH	GFY/ha.	CP	ADF	NDF
1.	KDFM 176 × KDFM 177	6.812 **	67.974 **	0.105 *	1.730 **	2.535 **
2.	KDFM 176 × KDFM 178	2.923 **	53.494 **	-0.574 **	-1.248 **	-0.793
3.	KDFM 176 × KDFM 179	-4.095 **	-8.114 *	0.03	-0.104	-1.043
4.	KDFM 176 × KDFM 180	-1.660	-38.456 **	-0.009	-0.041	0.001
5.	KDFM 176 × KDFM 181	-8.179**	-36.891**	-0.475 **	-1.074 **	-2.061**
6.	KDFM 176 × KDFM 182	-5.512 **	-71.047**	0.261 **	-0.152	-0.936
7.	KDFM 176 × KDFM 183	12.404 **	-33.573**	0.274 **	-0.985 *	-0.229
8.	KDFM 176 × KDFM 184	-2.271 *	20.189 **	-0.268 **	-0.329 **	-2.594 **
9.	KDFM 176 × KDFM 187	6.650**	-46.538 **	0.279 **	-0.064	-0.158
10.	KDFM 177 × KDFM 178	-7.355 **	-7.532 *	-0.014	1.322 **	-4.361 ***
11.	KDFM 177 × KDFM 179	-4.151 **	-23.877 **	0.156 **	-0.019	0.054
12.	KDFM 177 × KDFM 180	-1.160	11.635 **	-0.027	0.067	0.651
13.	KDFM 177 × KDFM 181	-13.123 **	-76.824 **	-0.081	-0.189	0.46
14.	KDFM 177 × KDFM 182	-0.345	9.961**	-0.323 **	-0.567 **	1.435**
15.	KDFM 177 × KDFM 183	-2.570 **	23.605 **	-0.310 **	0.111	-1.298 *
16.	KDFM 177 × KDFM 184	4.784 **	-37.560 **	0.348 **	1.627 **	0.592
17.	KDFM 177 × KDFM 187	-0.183	49.794 **	0.039	0.066	1.284 *
18.	KDFM 178 × KDFM 179	4.516 **	17.081 **	-0.667 **	0.143	2.960 **
19.	KDFM 178 × KDFM 180	-2.605 **	-18.561 **	0.094 *	0.952 **	0.07
20.	KDFM 178 × KDFM 181	-15.234 **	-60.021 **	0.029	-1.071 **	-0.814
21.	KDFM 178 × KDFM 182	3.210 **	20.640 **	0.320 **	0.451 **	2.499 **
22.	KDFM 178 × KDFM 183	7.874 **	18.660 **	0.244**	1.441 **	2.923 **
23.	KDFM 178 × KDFM 184	-1.216	-8.681 *	0.003	0.623 **	1.009
24.	KDFM 178 × KDFM 187	1.706	-15.591 **	0.260 **	-0.449 **	-1.845 **
25.	KDFM 179 × KDFM 180	-1.956 *	-7.448 *	0.143 **	-1.545 **	-1.778 **
26.	KDFM 179 × KDFM 181	-7.030 **	-10.623 **	-0.090 *	-1.534 **	-6.609 **
27.	KDFM 179 × KDFM 182	1.303	26.234 **	0.280 **	0.743 **	0.616
28..	KDFM 179 × KDFM 183	8.967**	30.581 **	0.137 **	1.466 **	2.790 **
29.	KDFM 179 × KDFM 184	1.766	11.439 **	-0.082	2.004 **	2.248 **
30.	KDFM 179 × KDFM 187	0.132	21.228 **	-0.047	0.576 *	2.039 **
31.	KDFM 180 × KDFM 181	-3.738 **	-14.484 **	-0.173 **	0.763 **	0.824
32.	KDFM 180 × KDFM 182	-0.3738**	0.009	0.319 **	1.018 **	0.471
33.	KDFM 180 × KDFM 183	-0.265	3.999	0.320 ***	0.341**	0.867
34.	KDFM 180 × KDFM 184	-1.91	19.846 **	0.090 *	-0.276*	-1.108 *
35.	KDFM 180 × KDFM 187	13.900 **	33.149 **	0.169 **	0.262 *	0.472
36.	KDFM 181 × KDFM 182	10.442 **	50.293 **	0.386 **	1.185 **	1.631 **
37.	KDFM 181 × KDFM 183	9.661 **	59.901 **	0.366 **	1.118 **	2.227 **
38.	KDFM 181 × KDFM 184	12.238**	58.257 **	0.113 *	1.315 **	2.229 **
39.	KDFM 181 × KDFM 187	2.604 **	35.640 **	0.004	0.873 **	2.276 **
40.	KDFM 182 × KDFM 183	2.995 **	-52.382 **	-0.709 **	-3.260 **	-2.145 **
41.	KDFM 182 × KDFM 184	-2.095 *	-18.518 **	-0.240 **	-1.179 **	-3.295 **
42.	KDFM 182 × KDFM 187	-11.618 **	-53.647 **	-0.205 **	-1.583 **	-2.499 **
43.	KDFM 183 × KDFM 184	-3.098 **	-16.843 **	0.084	0.290 *	-0.783
44.	KDFM 183 × KDFM 187	3.301* *	15.615 **	0.119 **	0.627 **	0.73
45.	KDFM 184 × KDFM 187	-6.489 ***	-11.292 **	-0.378 **	0.645 **	0.51
	S.E ±(S_{ij})	**0.887**	**0.049**	**0.108**	**0.486**	**0.22**
	S.E ±(S_{ij}- S_{ik})	**1.454**	**0.671**	**0.178**	**0.798**	**0.284**

CONCLUSIONS

The performance of KDFM 181 in the GCA analysis for yield traits demonstrated its superior performance as the most effective general combiner for yield traits. The cross combination of KDFM 181 and KDFM 183 has demonstrated superior performance in terms of yield attributes.

FUTURE SCOPE

The potential of maize to alleviate India's fodder scarcity problem is substantial. The research society's lack of emphasis on forage maize research appears to be a deficiency. Lack of well-defined and standardized criteria for determining DUS (Distinctness, Uniformity, and Stability) in this context is one of the most significant challenges in the field of fodder trait evaluation. This lack of specificity is a significant barrier to precisely assessing and characterizing forage characteristics. In India, relatively few commercial forage maize varieties are produced. African tall, J1006, and Shalimar forage maize 1 are examples of noteworthy varieties. However, compared to other commodities, the variety of commercial varieties remains relatively limited.

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