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RESEARCH ARTICLE

Studies on correlation and path co-efficient analysis of single cross hybrids in sweet corn

■ **M. Vani Praveena, S. C. Talekar and R. M. Kachapur**

SUMMARY

A total of 42 experimental hybrids generated by diallel mating design using 7 inbred lines of sweet corn were evaluated with parents and checks during *Kharif* 2019 at University of Agricultural Sciences, Dharwad. Green ear yield revealed a significant correlation in the positive direction with plant height, ear height, ear length, ear girth, number of kernel rows, and number of kernels per row at both genotypic and phenotypic levels, while a negative correlation was observed with days to 50% silking and Turcicum Leaf Blight. The highest value of correlation co-efficient for green ear yield was observed with green ear yield without husk, followed by the number of kernels per row and ear girth. However, there is no significant correlation between green ear yield and Total Soluble Solids. The genotypic correlation was found to be higher than the phenotypic correlation indicating high heritability of traits. Ear girth, ear height and the number of kernels per row displayed the highest positive direct effects on yield at the genotypic level and also manifested significantly positive indirect effects via plant height, ear height, green ear weight without husk, green fodder weight and the number of kernels per row. These three traits were likewise shown to have the most positive correlation with green ear yield. As a result, these attributes can be considered while selecting sweet corn genotypes for higher green ear yield.

Key Words : Correlation, Path co-efficient, Sweet corn

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MEMBERS OF THE RESEARCH FORUM

Author to be contacted :
M. Vani Praveena, Department of Genetics and Plant Breeding, Acharya N.G. Ranga University of Agriculture, **Bapatla (A.P.) India**
Email : vanipraveenamadhunapantula@gmail.com

Address of the Co-authors:
S. C. Talekar and R. M. Kachapur, All India Co-ordinated Maize Improvement Project, MARS, University of Agricultural Sciences, **Dharwad (Karnataka) India**

Maize is the third most important cereal crop produced globally after wheat and rice which serves 35% of human requirement and 65% of animal feed along with some industrial uses (Tippannavar *et al.,* 2019). Out of six variants of corn, sweet corn gained a huge market potential in both the national and global markets. It is also called sugar corn or pole corn which has sugar content higher than field corn. Recessive mutation at the sugary locus tends to accumulate 2-4 times more sugar (*i.e.* about 12 to 14%) in the endosperm which is highly water-soluble, making sweet corn different from normal corn (Vani Praveena *et al*., 2021). Sweet corn is classified into five groups based on the gene mutation in the endosperm. Allelic mutations at a sugary locus (*su*1) in normal sweet corn produced a high amount of sugar with a very high starch conversion rate after harvest if not provided with cold storage facility (Singh, 2014). High sugar accumulation with a low starch conversion rate was observed in super sweet corn cultivars with a mutation in the shrunken 2 (*sh*2) gene which made them suitable for long-distance transports and the development of extra sweet corn cultivars. Sweet corn cultivars with a mutation at *se* locus in *su*1 genetic background made sugary enhanced corns which are tender with extended shelf-life and high sugar levels than field corn. A combination of mutations *viz.,* *su*1, *sh*2 and *se* led to the development of synergistic corn with balanced sugars and tenderness (Szymanek *et al*., 2015). Augmented shrunken sweet corn is a new generation of shrunken sweet corn which is shrunken like super sweet corn and tender, juicy like sugar enhanced (*se*) types. Apart from tenderness and sweetness, sweet corn cultivation gained importance among Indian farmers for green fodder and green ear yield. However, only a few composites and hybrids were developed by the public and private sectors, respectively (Khanduri *et al*., 2011). This confined sweet corn cultivation to small areas in India by both farmers and private sectors to meet the rising market demand. This scenario necessitated the importance of developing sweet corn hybrids to meet the market demands with consumer preferences.

Yield is a complex trait that is influenced by several yield contributing quantitative traits. Plant disease and pest outbreaks are becoming increasingly common, lowering agricultural output and jeopardising global food security. Important diseases include sorghum downey mildew (Sharma *et al.*, 2010), chickpea dry root rot (Talekar *et al.*, 2017 and Talekar *et al.*, 2021), chickpea phyllody (Balol *et al.*, 2021), groundnut leaf spots (Kolekar *et al.*, 2016), pigeonpea wilt (Saxena *et al.*, 2012), sunflower necrosis (Sundaresha *et al.*, 2012) in determining grain yield variance among genotypes, genetic variability for disease resistance and yield components is crucial. Therefore, association studies among these characters are important to select elite genotypes in the breeding programme. Correlation describes the degree of relationship between two variables. The correlation co-efficient quantifies the degree of genic and non-genic relationship between two or more variables thus, facilitating indirect selection (Hallauer and Miranda Filho, 1988). Genotypic correlation doesn't include environmental effects and reveals a true association between yield-related traits. Whereas, the phenotypic correlation is affected by environmental effects and thereby given least importance than the genotypic correlation for indirect selection. The correlation co-efficient alone does not provide a clear picture of the interaction when more than two variables are involved since correlation is affected by a third variable (Bello *et al*., 2010). Path analysis is the most valuable statistical technique to establish the true relationship between variables in terms of cause and effect. Partitioning of correlation co-efficients into direct effect and series of indirect effects on dependent character is called path analysis which assesses the cause-effect relationship for an effective indirect selection. Thus, association studies help in establishing the degree and direction of a relationship between variables which is important for formulating breeding procedures. Also, the knowledge of the association between yield and its related traits improves the efficiency of indirect selection. Thus, present investigation was taken upto determine the relationship between yield and its related traits using correlation and path analysis.

MATERIAL AND METHODS

Location of the experiment:

The experiment was conducted at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *Kharif* 2019.

Experimental material:

Seven sweet corn inbred lines selected out of 37 lines obtained from Winter Nursery Centre, Hyderabad, ICAR-Indian Institute of Maize Research were used as parents. The crossing was effected in 7×7 diallel fashion during *Rabi* 2018 to develop 42 F_1 hybrids. The experimental evaluation of 42 F_1 hybrids along with 7 parents and 3 checks *viz*., Central Maize VL Sweet corn1, Madhuri and Misti was carried out during *Kharif* 2019 in Randomized Block Design with 3 replications.

Recording of observations:

Five competitive plants were tagged randomly for recording observations on days to 50% tasselling, days to 50% silking, plant height, ear height, ear length, ear girth, number of kernel rows per ear, number of kernels per row, ear weight without husk, green fodder weight, total soluble solids, resistance to turcicum leaf blight and green ear yield.

Statistical analysis:

To find the association between green ear yield and its component traits genotypic correlation co-efficients were calculated by applying the formula suggested by Johnson *et al.* (1955).

$$r = \frac{Cov.g.a.b}{\sqrt{(\sigma^2 g_a)\ x\ (\sigma^2 g_b)}}$$

where,

Cov.g.a.b = Genotypic covariance between traits a and b

s^2g_a, s^2g_b = Genotypic covariance for trait a and b

To know the direct and indirect effects of the yield components on yield, path co-efficient analysis was carried out using the simple correlation co-efficient as suggested by Wright (1921) and illustrated by Dewey and Lu (1959). Correlation co-efficients and path co-efficient were analysed using R software version 4.1.2.

RESULTS AND DISCUSSION

The correlation co-efficients and path co-efficients estimated between green ear yield and its component traits at genotypic and phenotypic levels are presented in Table 1 and 2, respectively. Genotypic and Phenotypic correlation co-efficients for 13 quantitative traits analyzed in sweet corn were presented in Table 1 and Fig. 1, respectively. Days to 50% tasselling manifested a significant correlation in a negative direction with ear height, ear length, number of kernel rows, number of kernels per row and green ear weight without husk at both genotypic and phenotypic levels, while the significant negative correlation with green ear yield is observed at phenotypic level alone. A significant and negative correlation was observed between days to 50% silking and other traits at both genotypic and phenotypic levels. A negative association of days to flowering and green ear yield indicates that the selection for an early flowering trait with less anthesis-silking interval among sweet corn cultivars will show a positive impact on increasing yield (Suhaisini *et al.*, 2016). Plant height manifested positive genotypic and phenotypic correlation with all the traits except for TSS and TLB. The highest correlation co-efficient values were observed between plant height and ear height (0.73), ear girth (0.82) and green fodder weight

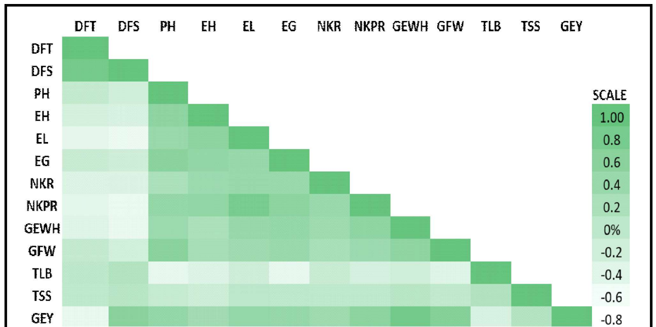

Fig 1: **Heat map of phenotypic correlation co-efficients for green ear yield and its attributing traits in sweet corn**

Table 1: Genotypic correlation co-efficients for green ear yield and its attributing traits in sweet corn

	DFT	DFS	PH	EH	EL	EG	NKR	NKPR	GEWH	GFW	TLB	TSS	GEY
DFT	1												
DFS	0.96**	1											
PH	0.05	-0.17**	1										
EH	-0.33*	-0.41**	0.73**	1									
EL	-0.73**	-0.78**	0.53**	0.67**	1								
EG	-0.16	-0.39**	0.82**	0.62**	0.56**	1							
NKR	-0.79**	-0.75**	0.46**	0.79**	0.86**	0.53**	1						
NKPR	-0.74**	-0.82**	0.61**	0.74**	0.94**	0.75**	0.76**	1					
GEWH	-0.59**	-0.70**	0.47**	0.59**	0.71**	0.82**	0.77**	0.87**	1				
GFW	-0.14	-0.34*	0.72**	0.65**	0.65**	0.76**	0.69**	0.69**	0.77**	1			
TLB	0.001	0.2275	-0.65**	-0.64**	-0.33*	-0.68**	-0.23	-0.42**	-0.41**	-0.53**	1		
TSS	-0.1	-0.015	-0.11	-0.17	0.13	0.11	-0.12	0.12	0.16	-0.1	0.18	1	
GEY	-0.61	-0.74**	0.53**	0.61**	0.8**	0.81**	0.76**	0.97**	1.02**	-0.75**	-0.53**	0.1	1

(0.72). Similar results of a positive association between plant height, ear height and green cob yield were reported by Sadaiah *et al*. (2013) and Gazal *et al*. (2018). Ear traits *viz*., ear height, ear length and ear girth manifested a significant positive correlation with all traits except with TLB and TSS.

The number of kernel rows and the number of kernels per row manifested a significant and positive correlation with green ear yield without husk, green fodder weight, green ear yield, plant height and other ear traits. Similar results of positive association among the traits of plant height, ear height, ear length, ear girth, and number of kernel rows per row were observed by Suhaisini *et al*. (2016), Niji *et al*. (2018) and Chinthiya *et al*. (2019). So, simultaneous selection for these positively correlated traits can be economical. Green ear yield without husk and green fodder weight exhibited a significant positive correlation with plant height, ear height, ear length, ear girth, number of kernel rows and number of kernels per row whereas, a negative significant correlation was observed with days to 50% silking and tasselling at both genotypic and phenotypic levels. No significant correlation in the positive direction was observed between TSS and ear yield, while significance in the negative direction was observed between TSS and ear height. This non-significant association between TSS and yield indicate the scope of developing hybrids with higher yields and sugar content (Khanduri *et al*., 2010 and Suhaisini *et al*., 2016). Green ear yield is positively correlated in a significant direction with plant height, ear height, ear length, ear girth, number of kernel rows and number of kernels per row while a negative correlation was observed with days to 50% silking and TLB. Significant positive correlations between cob yield, plant height and other ear traits were also reported by Olawamide and Fayeun (2020), Suhaisini *et al*. (2016), Aman *et al*. (2020) and Rajawade *et al*. (2018). For green ear yield highest value of correlation co-efficient was observed with green ear yield without husk (1.02), followed by the number of kernels per row

Table 2: Phenotypic (P) and genotypic (G) path co-efficients for green ear yield and its attributing traits in sweet corn

		DFT	DFS	PH	EH	EL	EG	NKR	NKPR	GEWH	GFW	TLB	TSS
DFT	P	-0.17	-0.09	-0.0014	-0.01	0.03	0.001	0.007	-0.02	-0.2	-0.02	0.0003	-0.003
	G	0.79	-1.12	-0.07	-0.29	-0.1	-0.28	0.35	-0.3	0.49	-0.08	0.0005	0.006
DFS	P	-0.14	-0.11	-0.005	-0.01	0.03	0.002	0.007	-0.02	-0.27	-0.06	-0.006	0.007
	G	0.76	-1.16	0.27	-0.36	-0.1	-0.65	0.34	-0.33	0.58	-0.2	0.12	0.0009
PH	P	0.01	0.02	0.02	0.02	-0.02	-0.006	-0.004	0.02	0.2	0.17	0.025	-0.009
	G	0.04	0.2	-1.53	0.65	0.07	1.37	-0.21	0.25	-0.39	0.42	-0.35	0.007
EH	P	0.04	0.03	0.012	0.05	-0.03	-0.005	-0.007	0.02	0.11	0.07	0.02	-0.02
	G	-0.26	0.48	-1.13	0.88	0.09	1.05	-0.35	0.3	-0.49	0.38	-0.34	0.01
EL	P	0.07	0.06	0.01	0.02	-0.06	-0.004	-0.009	0.03	0.23	0.101	0.01	0.003
	G	-0.58	0.91	-0.81	0.59	0.13	0.95	-0.38	0.38	-0.59	0.38	-0.18	-0.008
EG	P	0.02	0.02	0.01	0.02	-0.03	-0.01	-0.008	0.02	0.25	0.11	0.02	-0.001
	G	-0.13	0.45	-1.26	0.55	0.07	1.67	-0.24	0.3	-0.69	0.44	-0.37	-0.007
NKR	P	0.05	0.03	0.004	0.01	-0.02	-0.004	-0.02	0.02	0.19	0.07	0.007	-0.002
	G	-0.6	0.88	-0.72	0.7	0.11	0.9	-0.44	0.31	-0.64	0.4	-0.12	0.007
NKPR	P	0.07	0.05	0.01	0.02	-0.05	-0.006	-0.008	0.05	0.29	0.11	0.01	-0.003
	G	-0.5	0.96	-0.95	0.65	0.12	1.26	-0.34	0.41	-0.73	0.4	-0.23	-0.007
GEWH	P	0.06	0.05	0.008	0.01	-0.03	-0.005	-0.007	0.02	0.54	0.15	0.01	-0.008
	G	-0.4	0.82	-0.73	0.52	0.09	1.38	-0.34	0.36	-0.83	0.45	-0.22	-0.01
GFW	P	0.01	0.02	0.01	0.01	-0.02	-0.004	-0.005	0.019	0.29	0.29	0.02	-0.004
	G	-0.11	0.4	-1.11	0.58	0.09	1.28	-0.31	0.28	-0.65	0.58	-0.29	0.006
TLB	P	0.001	-0.01	-0.01	-0.01	0.01	0.005	0.002	-0.01	-0.11	-0.1	-0.05	0.016
	G	0.0008	-0.26	1	-0.57	-0.0046	-1.15	0.1	-0.17	0.34	-0.31	0.54	-0.012
TSS	P	0.005	-0.008	-0.001	-0.009	-0.0001	0.0001	0.0005	-0.001	0.03	-0.01	-0.007	0.11
	G	-0.08	0.01	0.17	-0.15	0.018	0.18	0.05	0.05	-0.14	-0.06	0.101	-0.06

(0.97) and ear girth (0.81). Thus, one can select the above three traits to realize high green ear yield (Ghosh *et al*., 2018).

In this study genotypic correlation was found to be higher than phenotypic correlation which indicates the characters under study have high heritability. Also, the difference between phenotypic and genotypic correlation was minute suggesting the environmental effect is less on correlation (Ambrish *et al*., 2020 and Suresh *et al*., 2021).

Path co-efficient analysis :

Correlation co-efficient values always don't reveal a true association between two variables since correlation values are also affected by the third factor. Therefore, cause and effect relationship should be worked out to reveal a true relation between dependent and independent variables (Chavan *et al*., 2020). Path analysis revealed the traits ear girth manifested the highest positive direct effect (1.67), followed by ear height (0.88), green fodder weight (0.58), TLB (0.54), number of kernels per row (0.41) and ear length (0.13) at genotypic level (Table 2). This indicates that these traits are directly associated with green ear yield. Similar results were reported by Chavan *et al*. (2020), Begum *et al*. (2016) for plant height and the number of kernels per row; Olawamide and Fayeun (2020) for days to 50% silking and tasselling; Yahaya *et al*. (2021) for plant height, cob length and cob girth; Reddy *et al*. (2021) for number of kernel rows, plant height and cob girth. The traits ear height, number of kernels per row and green fodder weight disclosed a positive direct effect on green ear yield at both genotypic and phenotypic levels indicating the least influence on the environment. Negative direct effects on yield were observed for the traits *viz*., days to 50% silking, plant height, number of kernel rows, green ear weight without husk and TSS at the genotypic level. The highest negative direct effect was observed for plant height (-1.53) which signifies that an increment in plant height will have a direct impact on green ear yield. These results were similar to earlier reports by Talekar *et al*., 2017, Hosamani *et al*., 2018 for days to silking, number of kernel rows per ear and Devasree *et al*., 2020.

Highest positive indirect effects were exhibited by traits *viz*., green ear weight without husk (1.38, 0.52, 0.36), plant height (1.37, 0.65, 0.25), green fodder weight (1.28, 0.58, 0.28), number of kernels per row (1.26, 0.65) and ear height (1.05, 0.88, 0.3) (Table 2). All of these traits contributed indirectly to green ear yield via ear girth, ear height and number of kernels per row, respectively. These results showed more emphasis should be given to an indirect selection of these traits to increase green ear yield. Similar results were reported by Soumya and Kamatar (2017), Jakhar *et al*. (2017) and Devasree *et al*. (2020). The data generated also highlighted residual effects at both genotypic and phenotypic levels with values of 0.07 and 0.15, respectively. This indicates that some traits which are due important in selection for green ear yield improvement need to be included in the study.

Conclusion:

In the present investigation although green ear yield without husk showed the highest positive correlation with green ear yield it displayed a negative direct effect at the genotypic level and a negative indirect effects on yield via other traits. Thus, selection for this trait may be misleading to achieve increased green ear yield. Ear girth, ear height and number of kernels per row displayed the highest positive direct effects on yield at the genotypic level and manifested a significantly positive indirect effect on green ear yield. These three traits also displayed a significantly high correlation with green ear yield in the positive direction. Therefore, these traits can be considered for the selection of sweet corn genotypes to realize increased green ear yield.

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