Original Research Article

Association analysisover seasons among morphological,physiological and yield components with kernel yield in maize (*Zea mays* L.)

ABSTRACT

Grain yield in maize is a complex character controlled by many factors. The knowledge of the degree of relationship between yield and yield component characters will aid the breeders to launch successful crop improvement programmes. The present investigation comprising Forty five single cross hybrids made from 10 inbred lines of maize through diallel mating design were evaluated for three seasons *viz*.,*rabi*, *summer* and kharif from 2016-17 to 2017-18.Kernel yield had consistent significant and positive associations with SPAD meter readings, specific leaf area, cob length, cob girth,number of kernel rows cob^{-1},number of kernels row^{-1},100 kernel weight and harvest index in *rabi*, *summer* and *kharif* seasons. Similar trend of positive and significant association of kernel yield with all the above characters was recorded at genotype level. Days to 50% tasseling, days to 50% silking, days to maturity and specific leaf weight showed consistent negative and significant correlations with kernel yield both at phenotypic genotypic level.The associations of anthesis-silking interval with kernel yield were consistently negative and non-significant in all the three seasons at phenotypic level. Plant height showed either negative and significant or negative but non-significant association with kernel yield across seasons. The characters *viz*., SPAD meter readings, specific leaf area, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels row^{-1}, 100 kernel weight and harvest index might be given due importance, while formulating selection indices as these characters had showed consistent positive and significant associations with kernel yield. Therefore present research work carried out will be helpful in a reliable selection of parental lines as well as for the development of high yielding verities for further breeding programs.

Key Words: Maize, Association Analysis, Kernel Yield, Yield Components

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop after wheat and rice and is consideredone of the most versatile crops with greater adaptability in various agro-ecological regions. It is a multipurpose crop used as food, feed, and industrial raw materials for diverse products. The principal goal of maize breeding programs is to develop new hybrids/ varieties that outperform existing hybrids/ varieties with respect to many characters.The kernel yield is a complex character influenced by several yield-contributingcharacters and environment. Hence, selection for kernel yield alone may not be much effective(Talebi *et al*., 2007). Knowledge of interrelationships between kernel yield and its contributing components significantly improves the efficiency of breeding programs through the use of appropriate selection indices (Pavlov *etal.*,2015 and Dan Singh *et al*.,2017).Correlation measures the degree of association: genetic or non-genetic between two or more characters and is measured by a correlation coefficient (Gomez and Gomez, 1984). Phenotypic correlation involves both genetic and environmental effects, whereas genotypic correlation is the association of breeding values of the two characters (Falconer, 1981; Muhammad and Muhammad, 2001; and Menkir, 2008).Both measure the extent to which degree the same genes or closely linked genes cause co-variation in two different characters (Hallauer and Miranda, 1988). The present study was conducted to determine the extent and nature of themorphophysiological and yield components relationship with kernel yieldin maize through asimple coefficient correlation analysis.

MATERIAL AND METHODS

Forty five single cross hybrids developed from 10 inbred lines of maize through diallel mating design (Method II and Model II) were evaluated for their performance over three seasons*viz*.,*rabi*, *summer*and *kharif*from 2016-17 to 2017-18 at Agricultural Research Station, Perumallapalli, A.P. The experiment was laid out in a randomized block design with three replications with five meters row length with 75 × 20 cm in *kharif*and 60× 20 cm in both *rabi* and *summer*between rows and between plant to plant spacing was adopted respectively. The two seeds per hill were dibbled and one week after germination thinning operation was carried out to maintain single plant per hill. All the recommended package of practices was followed in raising a healthy crop. Data were recorded for 15 morpho-physiological and yield contributing characters on five randomly selected plants in each replication.The mean values for different characters were analysed using online software “OPSTAT” developed by Chaudhary Charan Singh Agricultural University, Hissar. Correlation coefficients for different characters were estimated by the method suggested by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Phenotypic and genotypic correlation coefficients worked out for all the 15 characters over three seasons *i.erabi*, *summer* and *kharif* are presented in Table 1. Genotype correlations were in general greater in magnitude than the phenotypic correlations indicating the lesser influence of environments on the expression of the characters.

Kernel yield had consistent significant and positive associations with SPADmeter reading (0.39**, 0.50** and 0.26**), specific leaf area (0.44**, 0.27** and 0.22**), cob length (0.53**, 0.49** and 0.45**), cob girth (0.62**, 0.59** and 0.52**), number of kernel rows cob^{-1} (0.59**, 0.69** and 0.56**), number of kernels row^{-1} (0.58**, 0.57** and 0.57**), 100 kernel weight (0.65**, 0.57** and 0.52**) and harvest index (0.26**, 0.29** and 0.32**) in *rabi*, *summer* and *kharif* seasons, respectively at phenotypic level. Similar trend of positive and significant association of kernel yield with all the above characters was recorded at genotype level.The significant and positive associations of SPAD meter readings (Ghirmireand Timsina 2015), cob length (Rafique *et al*. 2004; Rigon and Rigon, 2014;Ghirmire and Timsina 2015; Vijay Kumar *et al*, 2015 and Hailegebrial and Yemane, 2015), cob girth (Ghirmire and and Timsina, 2015; Vijay Kumar *et al*, 2015 andHailegebrial and Yemane, 2015), number of kernel rows cob^{-1} (VijayKumar*et al*, 2015), number of kernels row^{-1} (Ghimire and Timsina, 2015; Vijay Kumar *et al*, 2015 and Jemal *et al*, 2020), 100 kernel weight (Ghirmoreand Timsina, 2015; Vijay Kumar *et al*, 2015; Jemal *et al*, 2020andWoldu Mogesse, 2021) were reported by several research workers in maize.

Days to 50% tasseling (-0.45**, -0.27** and -0.48**), days to 50% silking (-0.40**, -0.26** and -0.47**), days to maturity (-0.48**, -0.36** and -0.31**) and specific leaf weight (-0.42**, -0.30** and -

0.29**) showed consistent negative and significant correlations with kernel yield at phenotypic level. Ghimire and Timsina (2015) reported that more number of days to 50% tasseling and days to 50% silking will result in more vegetative growth and less time for reproductive growth and leads to less yield. Negative associations of days to tasseling, days to silking with days to maturity with kernel yield as recorded in the present study are desirable in maize breeding aimed at the development of high yielding hybrids/varieties with earliness.These results are in agreement with the findings of Ghimire and Timsina (2015);VijayKumar*et al.* (2015) and Woldu Mogesse(2021) in maize.

The associations of anthesis-silking interval with kernel yield were consistently negativebut non-significant (-0.03, -0.10 and -0.09) and significantly negative at genotypic level with kernel yield in all the three seasons. Plant height showed either negative and significant or negative but non-significant (-0.03, -0.24** and -0.32**) association with kernel yield across seasons. Contrary to the present study results, Ghilmire and Timsina (2015), Hailegebrial and Yemane (2015) and Jemal *etal*. (2020) reported positive and significant associations of plant height with kernel yield in maize. This may be due to variation in the study environment, experimental material and number of genotypes handled in the study.

Associations among the characters revealed that days to 50% tasseling had significant positive correlations with days to 50% silking, days to maturity, specific leaf weight and negative significant association with SPAD meter reading, specific leaf area, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels row^{-1}, 100 kernel weight, harvest index at both phenotypic and genotypic level. Days to 50% silking showed positive and significant associations with anthesis-silking interval. Days to maturity showed negative and significant associations with SPAD meter readings, specific leaf area, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels row^{-1}, 100 kernel weight and harvest index.

Association of days to maturity withSPAD meter readings, specific leaf area, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels row^{-1}, 100 kernel weight and harvest index were consistently significant and negative, while these same characters had positive and significant association with specific leaf weight in all the three seasons.Anthesis-silking interval showed inconsistent negative or positive associations with plant height, SPAD meter readings, specific leaf area, specific leaf weight, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels row^{-1}, 100 kernel weight and harvest index except with days to maturity.

In the present study plant height had consistent significant and negative associations withSPAD meter readings, specific leaf area and positive and significant associations with specific leaf weight.Contrary to these findingsWoldu Mogesse(2021)observed significant and positive correlations of plant height with ear height, days to maturity, ear length, ear diameter, number of kernels row^{-1} and number of kernel row cob^{-1} at phenotypic and genotypic level.This could be due to variation in the experimental material, sample size and environment.

SPAD meter readings, specific leaf area, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels row^{-1}, 100 kernel weight and harvest index showed consistent significant and positive associations among characters at phenotypic and genotypic level across three seasons. However, specific leaf weight had consistently showed significant and negative associations over three seasons both at phenotype and genotype level with SCMR, specific leaf area, specific leaf weight, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels row^{-1}, 100 kernel weight and harvest index.

CONCLUSIONS

From the present investigation it is evident that SPAD meter readings, specific leaf area, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels row^{-1}, 100 kernel weight and harvest index had consistent positive and significant associations with kernel yield. Hence, simultaneous selection of these characters might be given due importance, while formulating selection indices or making selections for high yielding hybrids.

REFERENCES

Dan Singh Jakhar, Rajesh Singh and Amit Kumar. 2017. Studies on path coefficient analysis in Maize (*Zea mays* L.) for grain yield and its attributes. *Int.J.Curr.Microbiol.App.Sci*. 6(4): 2851-2856.

Falconer, J.S. 1981. Introduced to Quantative Genetics 2nd edition. Longman, New York USA.

Ghimire, B and Timsina, D. 2015. Analysis of yield and yield attributing traits of maize genotypes in Chitwan, Nepal. *World Journal of Agricultural Research*. 3(5): 153-162.

Gomez, K.A and Gomez, A.A. 1984. *Statistical Procedure for Agricultural Research.* International Rice Research Institute, Manila, Philippines. pp:305.

Hailegebrial, K and Yemane, T. 2015. Studies of heritability, genetic parameters, correlation and path coefficient in elite Maize (*Zea mays* L.) hybrids. *Academic Research Journal of Agricultural Science and Research*. 3(10): 396-303.

Hallauer, A.R and Miranda, F.J.B. 1988*. Quantitative Genetics in Maize Breeding*. 2nd edition. Iowa State University Press, Iowa, Ames. USA.

Jemal Aman, Kassahun Bantte, SentayehuAlamerew and Desta Berhe Sbhatu. 2021. Correlation and path coefficient analysis of yield and yieldcomponents of quality protein Maize (*Zea mays* L.) hybrids at Jimma, Western Ethiopia. *International Journal of Agronomy*. Volume 2020, Article ID 9651537, 7 pages https://doi.org/10.1155/2020/9651537.

Menkir, A. 2008. Genetic variation for grain mineral content in tropical-adapted maize inbred lines. *Food Chemistry, Science World Journal*. 110(1): 454-464.

Muhammad, Y and Muhammad, S. 2001. Correlation analysis of S1 families of maize for grain yield and its components. *International Journal of Agriculture and* Biology. 387-388.

Panse, V.G and Sukhatme. 1967. *Statistical methods for Agricultural workers*. Published by ICAR, New Delhi.

Pavlov, J., Delic, N., Markovic, K., Crevar, M., Camdzija and Stevanovic, M. 2015. Path analysis for morphological traits in maize (*Zea mays* L.). *Genetika*, 47(1): 295-301.

Rafique, M., Hussain, A., Mahaood T., Alivi, A.W and Alvi, M.B. 2004. Heritability and interrelationships among grain yield and yield components in Maize (*Zea mays* L.). *International Journal of Agriculture and Biology*. 6(6): 1113-1134.

Rigon, J.P.G and Rigon, C.A.G. 2014. Quantitative descriptors and their direct and indirect effects on corn yield. *Bioscience Journal Uberland*. 30(2): 356-362.

Talebi, R., Fayaz, F and Jeloder, N.A.B. 2007. Correlation and path coefficient analysis of yield and yield components of Chickpea (*Cicer arietinum* L.) under dry condition in the west of Iran. *Asian Journal of Plant Science*. 6: 1151-1154.

Vijay Kumar, S. K. Singh, P. K. Bhati, Amita Sharma, S. K. Sharma, Vinay Mahajan. 2015. Correlation, path and genetic diversity analysis in Maize (*Zea mays* L.). *Environment & Ecology*. 33(2A): 971-975.

Woldu Mogesse. 2021. Correlation and path coefficient analysis for grain yield and yield related trait of Maize (*Zea mays* L.) inbreed lines. *Int.J.Curr.Res.Aca.Rev*. 9(2): 138-150.

Table 1. Estimates of phenotypic and genotypic correlation coefficients among morpho-physiological and yield components and with kernel yield in maize over seasons

Character(s)	Season(s)	DT	DS	ASI	DM	PH	SPAD	SLA	SLW	CL	CG	NKRC	NKPR	KW	HI	KY
DT	*Rabi*	**1.00**	0.86**	0.10	0.46**	0.03	-0.24*	-0.23**	0.20*	-0.30**	-0.49**	-0.36**	-0.32**	-0.34**	-0.24**	-0.45**
	Summer	**1.00**	0.96**	0.33**	0.40**	0.11	-0.40**	-0.32**	0.32**	-0.26**	-0.32**	-0.24**	-0.28**	-0.24**	-0.30**	-0.27**
	Kharif	**1.00**	0.93**	0.09	0.46**	0.35**	-0.34**	-0.34**	0.34**	-0.37**	-0.46**	-0.37**	-0.52**	-0.42**	-0.40**	-0.48**
DS	*Rabi*	0.94**	**1.00**	0.56**	0.50**	-0.02	-0.19*	-0.16	0.11	-0.30**	-0.39**	-0.26**	-0.25**	-0.30**	-0.22*	-0.40**
	Summer	1.00**	**1.00**	0.59**	0.39**	0.13	-0.38**	-0.33**	0.33**	-0.27**	-0.32**	-0.26**	-0.30**	-0.25**	-0.29**	-0.26**
	Kharif	1.00**	**1.00**	0.45**	0.46**	0.38**	-0.34**	-0.38**	0.37**	-0.39**	-0.46**	-0.42**	-0.54**	-0.45**	-0.38**	-0.47**
ASI	*Rabi*	0.28**	0.61**	**1.00**	0.24**	-0.09	0.03	0.09	-0.13	-0.06	0.02	0.06	0.05	-0.01	0.02	-0.03
	Summer	0.92**	0.94**	**1.00**	0.14	0.13	-0.14	-0.19*	0.18*	-0.15	-0.16	-0.17*	-0.19*	-0.16	-0.11	-0.10
	Kharif	1.62**	1.54**	**1.00**	0.19*	0.16	-0.11	-0.19*	0.17*	-0.15	-0.15	-0.23**	-0.20*	-0.20*	-0.08	-0.09
DM	*Rabi*	0.61**	0.65**	0.36**	**1.00**	-0.11	-0.23**	-0.27**	0.23**	-0.35**	-0.44**	-0.41**	-0.42**	-0.38**	-0.31**	-0.48**
	Summer	0.52**	0.53**	0.60**	**1.00**	0.19*	-0.47**	-0.26**	0.28**	-0.40**	-0.42**	-0.40**	-0.53**	-0.39**	-0.34**	-0.36**
	Kharif	0.56**	0.59**	1.54**	**1.00**	0.27**	-0.23**	-0.31**	0.26**	-0.37**	-0.47**	-0.41**	-0.33**	-0.25**	-0.23**	-0.31**
PH	*Rabi*	0.01	-0.04	-0.12	-0.15	**1.00**	0.16	-0.16	0.16	-0.02	-0.01	0.16	-0.07	-0.01	0.05	-0.03
	Summer	0.14	0.16	0.35**	0.26**	**1.00**	-0.26**	-0.30**	0.32**	-0.19*	-0.15	-0.16	-0.35**	-0.21*	-0.10	-0.24**
	Kharif	0.49**	0.52**	1.42**	0.38**	**1.00**	-0.16	-0.29**	0.24**	-0.23**	-0.22*	-0.36**	-0.36**	-0.32**	-0.24**	-0.32**
SPAD	*Rabi*	-0.30**	-0.23**	0.06	-0.27**	0.19*	**1.00**	0.31**	-0.23**	0.50**	0.48**	0.51**	0.36**	0.49**	0.37**	0.39**
	Summer	-0.50**	-0.51**	-0.60**	-0.66**	-0.36**	**1.00**	0.44**	-0.45**	0.47**	0.60**	0.54**	0.65**	0.49**	0.32**	0.50**
	Kharif	-0.58**	-0.65**	-2.21**	-0.58**	-0.31**	**1.00**	0.36**	-0.32**	0.41**	0.39**	0.34**	0.44**	0.34**	0.26**	0.26**
SLA	*Rabi*	-0.38**	-0.24**	0.21*	-0.58**	-0.43**	0.69**	**1.00**	-0.90**	0.48**	0.44**	0.43**	0.39**	0.53**	0.29**	0.44**
	Summer	-0.55**	-0.56**	-0.60**	-0.54**	-0.59**	0.77**	**1.00**	-0.98**	0.35**	0.30**	0.24**	0.50**	0.22*	0.24**	0.27**
	Kharif	-0.66**	-0.62**	-0.10	-0.62**	-0.67**	0.95**	**1.00**	-0.91**	0.25**	0.35**	0.34**	0.26**	0.23**	0.30**	0.22**
SLW	*Rabi*	0.33**	0.17*	-0.26**	0.54**	0.38**	-0.56**	-0.97**	**1.00**	-0.43**	-0.36**	-0.40**	-0.34**	-0.50**	-0.27**	-0.42**
	Summer	0.53**	0.54**	0.59**	0.54**	0.61**	-0.76**	-1.00**	**1.00**	-0.36**	-0.31**	-0.25**	-0.52**	-0.23**	-0.24**	-0.30**
	Kharif	0.65**	0.61**	0.13	0.57**	0.59**	-0.94**	-0.83**	**1.00**	-0.25**	-0.37**	-0.35**	-0.25**	-0.24**	-0.23**	-0.29**
CL	*Rabi*	-0.44**	-0.34**	0.07	-0.47**	-0.07	0.79**	0.86**	-0.80**	**1.00**	0.64**	0.60**	0.50**	0.62**	0.46**	0.53**
	Summer	-0.55**	-0.55**	-0.53**	-0.76**	-0.32**	0.91**	0.73**	-0.74**	**1.00**	0.50**	0.37**	0.41**	0.43**	0.28*	0.49**
	Kharif	-0.55**	-0.60**	-1.85**	-0.52**	-0.41**	0.91**	0.62**	-0.71**	**1.00**	0.63**	0.53**	0.42**	0.49**	0.29**	0.45**
CG	*Rabi*	-0.68**	-0.51**	0.09	-0.54**	-0.03	0.65**	0.92**	-0.88**	0.96**	**1.00**	0.67**	0.53**	0.66**	0.32**	0.62**
	Summer	-0.40**	-0.39**	-0.29**	-0.52**	-0.22**	0.77**	0.50**	-0.50**	0.86**	**1.00**	0.58**	0.59**	0.60**	0.33**	0.59**
	Kharif	-0.62**	-0.62**	-1.01**	-0.59**	-0.33**	0.77**	0.69**	-0.74**	0.89**	**1.00**	0.62**	0.49**	0.56**	0.37**	0.52**
NKRC	*Rabi*	-0.53**	-0.41**	0.07	-0.62**	0.15	0.76**	0.90**	-0.87**	0.98**	1.00**	**1.00**	0.52**	0.69**	0.40**	0.59**
	Summer	-0.33**	-0.35**	-0.44**	-0.69**	-0.28**	0.79**	0.57**	-0.57**	1.01**	0.85**	**1.00**	0.56**	0.67**	0.29**	0.69**
	Kharif	-	-0.68**	-1.04**	-0.68**	-0.50**	0.94**	0.79**	-0.85**	1.03**	0.95**	**1.00**	0.53**	0.45**	0.19*	0.56**

		0.68**														
NKPR	*Rabi*	-0.62**	-0.52**	0.03	-0.62**	-0.07	0.60**	1.01**	-0.91**	0.99**	0.87**	0.92**	**1.00**	0.56**	0.30**	0.58**
	Summer	-0.39**	-0.42**	-0.55**	-0.72**	-0.53**	0.92**	0.84**	-0.84**	0.98**	0.80**	0.93**	**1.00**	0.57**	0.36**	0.57**
	Kharif	-0.75**	-0.76**	-1.29**	-0.59**	-0.51**	0.85**	0.64**	-0.67**	0.80**	0.76**	0.92**	**1.00**	0.47**	0.34**	0.57**
KW	*Rabi*	-0.47**	-0.41**	-0.05	-0.52**	-0.01	0.66**	0.91**	-0.93**	0.91**	0.83**	0.93**	0.89**	**1.00**	0.37**	0.65**
	Summer	-0.25**	-0.28**	-0.41**	-0.53**	-0.34**	0.64**	0.45**	-0.46**	0.81**	0.81**	1.05**	0.91**	**1.00**	0.26**	0.57**
	Kharif	-0.56**	-0.63**	-2.38**	-0.32**	-0.41**	0.56**	0.45**	-0.46**	0.73**	0.73**	0.72**	0.70**	**1.00**	0.46**	0.52**
HI	*Rabi*	-0.31**	-0.27**	0.03	-0.47**	0.15	0.51**	0.67**	-0.56**	0.65**	0.46**	0.71**	0.57**	0.55**	**1.00**	0.26**
	Summer	-0.49**	-0.52**	-0.66**	-0.47**	-0.25**	0.50**	0.46**	-0.44**	0.67**	0.55**	0.63**	0.55**	0.61**	**1.00**	0.29**
	Kharif	-0.53**	-0.56**	-1.39**	-0.30**	-0.43**	0.69**	0.77**	-0.61**	0.49**	0.54**	0.45**	0.63**	0.58**	**1.00**	0.32**
KY	*Rabi*	-0.56**	-0.50**	-0.07	-0.66**	0.01	0.47**	0.84**	-0.81**	0.78**	0.84**	0.83**	1.00**	0.81**	0.41**	**1.00**
	Summer	-0.34**	-0.34**	-0.26**	-0.59**	-0.25**	0.76**	0.68**	-0.70**	0.93**	0.79**	0.87**	0.87**	0.86**	0.55**	**1.00**
	Kharif	-0.64**	-0.71**	-2.31**	-0.44**	-0.49**	0.48**	0.54**	-0.67**	0.80**	0.69**	0.83**	0.87**	0.70**	0.39**	**1.00**

*Significant at 5% level of significance; **Significant at 1% level of significance; Values upper diagonal indicates phenotypic correlations; Values lower diagonal indicates genotypic correlations

DT=Days to tasseling; DS=Days to silking; ASI=Anthesis-silking interval; DM=Days to maturity; PH=Plant height; SPAD=SPAD meter readings; SLA=Specific leaf area; SLW=Specific leaf weight; CL=Cob length; CG=Cob girth; NKRC=Number of kernel rows cob^{-1}; NKPR=Number of kernels row^{-1}; KW=100 kernel weight; HI=Harvest index; KY=Kernel yield plant^{-1}