Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com
J P P
Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(6): 527-531
Received: 30-08-2020
Accepted: 09-10-2020

Trait association and path coefficient analysis in maize (*Zea mays* L.) for grain yield and its attributes

Niranjan Kumar Chaurasia, RBP Nirala, Birender Singh and SS Mandal

Niranjan Kumar Chaurasia
Department of Plant Breeding and Genetics, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

RBP Nirala
Department of Plant Breeding and Genetics, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Birender Singh
Department of Plant Breeding and Genetics, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

SS Mandal
Department of Plant Breeding and Genetics, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Corresponding Author
RBP Nirala
Department of Plant Breeding and Genetics, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Abstract

The present investigation was carried out at the experimental area, Bihar Agricultural College, Sabour in *Kharif*-2019 with thirty one genotypes comprising seven inbred lines, their twenty one F_1's developed through diallel mating scheme and three hybrids as a check. Analysis of variance for design of experiment for fourteen quantitative characters revealed that mean squares due to genotypes were highly significant for all the characters studied. The results indicated that the genotypic correlation coefficient is greater than the corresponding phenotypic correlation coefficient for all the traits studied. Trait association at genotypic and phenotypic levels for grain yield and its attributes revealed that grain yield per plant had highly significant positive phenotypic association with plant height (0.789**), ear height (0.724**), ear length (0.875**), ear diameter (0.833**), kernel rows per ear (0.733**), kernels per row (0.884**), grains per plant (0.898**), 1000-kernels weight (0.324**) and shelling per cent (0.712**). The traits like, days to anthesis, days to silk, anthesis-silking interval and days to 50 per cent physiological maturity exhibited highly significant and negative association with grain yield per plant. Path coefficient analysis at phenotypic level revealed that the trait, days to 50 per cent silk (2.469) had the highest positive direct effect on grain yield per plant followed by grains per plant (1.019), 1000-kernel weight (0.383), ear height (0.086), ear length (0.085), kernel rows per ear (0.065), ear diameter (0.025) and days to 50 per cent physiological maturity (0.024). Hence, direct selection all for these traits will be effective.

Keywords: Genotypic correlation coefficient, phenotypic correlation coefficients and path coefficient analysis

Introduction

Maize is the third most important cereal crop after wheat and rice and is considered as one of the most versatile crop with greater adaptability under diverse agro-climatic environments. It is a multipurpose crop used as food, feed and industrial raw materials for diverse products that forced the breeder to boost the grain yield.

Grain yield is a complex trait influenced by several yield contributing traits and sole selection for grain yield is not much effective. Trait association and path coefficient analysis is widely used in plant breeding to determine the nature and magnitude of relationship between grain yield and its component traits and to classify certain components with profound impacts on grain yield as selection criteria for potential use.

A path coefficient is a standardized partial regression coefficient, which determines a predictor variable's direct influence on the response variable. This allows for the division of the coefficient of association into direct effect and indirect effects. Hence a sound knowledge of traits association and path coefficient is necessary for selection of traits for developing high grain yielding varieties

Materials and Methods

Thirty one genotypes consisting of seven inbred lines, their twenty one F_1's developed through diallel mating design and three hybrids as check. All these were evaluated for their agronomic performance during the Kharif, 2019 at experimental area, Bihar Agricultural College, Sabour. The experiment was carried out in randomized block design with three replications and 5m row length having row to row distance 60 cm and plant to plant distance 20cm.

The two seeds per hill were sown and after one week of germination thinning operation were performed to maintain single plant per hill. The recommended package of practices was followed for raising healthy crops.

The data were recorded on fourteen quantitative traits on ten competitive plants from each replication *viz*., days to anthesis, days to silk, anthesis silking interval, days to 50 per cent physiological maturity, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), kernel row per ear, kernels per row, grains per plant, 1000-kernel weight (g), shelling (%) and grain yield (g/p).

The mean values on different traits were analysed using online software "OPSTAT" developed by Chaudhary Charan Singh Agricultural University, Hissar. The correlation coefficients for different traits were calculated by the method suggested by Panse and Sukhatme (1967) [7]. The path coefficient analysis was performed as per the procedure suggested by Wright (1921) [15] and adopted by Dewey and Lu (1959) [4].

Results and Discussion

Analysis of variance for design of experiment for fourteen quantitative characters (Table 1) revealed that mean squares due to genotypes were highly significant for the characters *viz.*, days to 50 per cent anthesis, days to 50 per cent silk, anthesis-silking interval, days to 50 per cent physiological maturity, plant height, ear height, ear length, ear diameter, kernel rows per ear, kernels per row, grains per plant, 1000-kerenl weight, shelling per cent and grain yield per plant. These results indicated the existence of significant differences among the genotypes.

Table 1: Analysis of variance for design of experiment for fourteen quantitative characters in maize

Sources of variation	Mean squares							
	DF	DA	DS	ASI	DPM	PH	EH	EL
Replication	2	7.39	6.85	0.01	10.68	485.86	425.81	0.42
Treatment	30	42.19**	59.35**	4.23**	92.90**	1549.35**	622.30**	10.85**
Error	60	1.54	1.54	0.01	11.19	66.52	38.57	0.90

* & **: level of significance at 5 % and 1 %, respectively. DA: Days to 50 per cent anthesis, DS: days to 50 per cent silk, ASI: anthesis-silking interval, DPM: days to 50 per cent physiological maturity, PH: plant height, EH: ear height, EL: ear length.

Table 1: Contd…

Sources of variation	Mean squares							
	DF	ED	KRPE	KPR	GPP	1000-KW	SP	GYP
Replication	**2**	**0.01**	**0.08**	**0.00**	**1258.59**	**985.82**	**5.44**	**158.76**
Treatment	**30**	**0.71****	**23.14****	**123.57****	**31822.15****	**3824.33****	**299.08****	**2500.17****
Error	**60**	**0.01**	**0.33**	**5.18**	**924.96**	**446.10**	**2.97**	**97.28**

* & **: level of significance at 5 % and 1 %, respectively, ED: ear diameter, KRPE: kernel rows per ear, KPR: kernels per row, GPP: grains per plant, 1000-KW: 1000-kernel weight, SP: shelling per cent and GYP: grain yield per plant.

Trait association/correlation

The phenotypic and genotypic correlation coefficients of fourteen traits highlighted the presence of several statistically significant relationships and are presented in Table 2. The results indicated that the genotypic correlation coefficient is greater than the corresponding phenotypic correlation coefficient for all the traits studied indicating that the interrelationships were strongly inherent and low phenotypic expression was triggered by environmental factors. This result was in close conformity to Ram Reddy and Jabeen (2016) [13].

Trait association studied at phenotypic level indicated that grain yield per plant had highly significant and positive genotypic correlation with plant height (0.789**), ear height (0.724**), ear length (0.875**), ear diameter (0.833**), kernel rows per ear (0.733**), kernels per row (0.884**), grains per plant (0.898**), 1000-kernels weight (0.324**) and shelling per cent (0.712**), while, other traits showed highly significant and negative phenotypic correlation (Table 2). These results are in close conformity to the findings of Gosh *et al*, 2014 [1] for plant height, ear height and number of grains per cob; Dar *et al*, 2015 [18] for plant height, ear height, cob length, cob girth, number of kernel rows per ear, kernels per row and 100-grain weight; Huda *et al*, 2016 [5] for 1000-seed weight and number of grains per cob; Hiramani *et al*, 2018 for plant height, ear height, ear length and kernels per row; Prakash *et al*, 2019 [10] for 100-grain weight, shelling per cent, number of kernels per row, number of kernel rows per cob, plant height and ear height. The grain yield attributing traits showing positive and significant association with grain yield per plant indicated that grain yield per plant can be enhanced by selecting for these traits at the same time. Interrelationship among the other traits revealed the existence of highly significant and positive phenotypic correlation by shelling per cent with plant height (0.754**), ear height (0.721**), ear length (0.606**), ear diameter (0.846**), kernel rows per ear (0.863**), kernels per row (0.832**) and grains per plant (0.762**). These findings are in the close conformity with the finding of cob girth, kernels rows per ear and kernels per row (Prakash *et al*, 2019) [10] and plant height, cob length, shelling per cent, kernel rows per ear, kernels per row and 100-seed weight (Pandey *et al*, 2017) [16]. The trait 1000- kernel weight had significant to highly significant and positive phenotypic correlation with days to 50 per cent physiological maturity (0.372**), plant height (0.390**), Ear height (0.270**), ear length (0.278**) and ear diameter (0.237*). These results are in close conformity to plant height, Ear height, ear length and ear girth (Ram Reddy *et al*, 2013) [12] Grains per plant had highly significant positive phenotypic correlation with plant height (0.687**), ear height (0.660**), ear length (0.796**), ear diameter (0.805**), kernel rows per ear (0.792**) and kernels per row (0.956**). The character kernels per row exhibited highly significant positive phenotypic correlation with plant height (0.741**), ear height (0.756**), ear length (0.846**), ear diameter (0.830**) and kernel rows per ear (0.803**). These results are in close conformity to the finding of plant height, ear length, ear girth, kernel rows per ear (Arsode *et al*, 2018) [6], ear height (Prakash *et al*, 2019) [10], plant height, ear height, ear girth (Ramreddy and Jabeen, 2016) [13]. The trait, kernel rows per ear possessed highly significant and positive phenotypic correlation with plant height (0.743**), ear height (0.621**), ear length (0.652**) and ear diameter (0.917**) and are the similar results obtained by Ram Readdy *et al*, 2013 [12] and Sandeep *et al*, 2017 [11]. Highly significant and positive phenotypic association exhibited by the trait, ear diameter with plant height (0.800**), ear height (0.672**) and ear length (0.729**); ear length with plant height (0.734**) and ear height (0.691**); ear height with plant height (0.865**); days to 50 per cent physiological maturity with days to anthesis (0.697**), days to silk (0.695**) and anthesis-silking interval (0.388**); anthesis-silking interval with days to anthesis (0.465**) and days to silk (0.657**) and days to silk with days to anthesis (0.973**). The similar pattern of phenotypic association by ear girth with plant height, ear height and ear length (Sandeep *et al*, 2017) [11]; by ear length with plant height (Pavan *et al*, 2011) [9] and ear height (Prakash *et al*, 2019) [10]; by ear height with plant height (Gami *et al*, 2017) [8]; by days to maturity with days to 50 per cent tasseling, days to 50 per cent silking and ASI (Prakash *et al*, 2019) [10]; ASI with days to 50 per cent tasseling and days to 50 per cent silking (Ram Reddy *et al*, 2013) [12] and days to 50 per cent silking with days to 50 per cent pollen shedding (Gami *et al*, 2017) [8] were reported.

Table 2: Phenotypic and genotypic correlation coefficients for fourteen characters in maize

	Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		DA	DS	ASI	DPM	PH	EH	EL	ED	KRPE	KPR	GPP	1000-KW	Shelling %	GY(g/p)
1	DA		0.973** (0.972**)	0.465** (0.494**)	0.697** (0.867**)	-0.674** (-0.706**)	-0.581** (-0.588**)	-0.662** (-0.737**)	-0.651** (-0.675**)	-0.714** (-0.753**)	-0.755** (-0.797**)	-0.807** (-0.842**)	0.059NS (0.130NS)	-0.607** (-0.654**)	-0.734** (-0.762**)
2	DS			0.657** (0.684**)	0.695** (0.850**)	-0.696** (-0.728**)	-0.625** (-0.643**)	-0.657** (-0.727**)	-0.615** (-0.632**)	-0.685** (-0.713**)	-0.735** (-0.771**)	-0.769** (-0.795**)	0.000NS (0.047NS)	-0.600** (-0.636**)	-0.723** (-0.747**)
3	ASI				0.388** (0.453**)	-0.469** (-0.503**)	-0.501** (-0.553**)	-0.360** (-0.403**)	-0.232* (-0.245*)	-0.297** (-0.302**)	-0.352** (-0.378**)	-0.314** (-0.329**)	-0.190NS (-0.229*)	-0.317** (-0.325**)	-0.375** (-0.400**)
4	DPM					-0.282** (-0.356**)	-0.219* (-0.244*)	-0.323** (-0.349**)	-0.296** (-0.368**)	-0.429** (-0.522**)	-0.426** (-0.499**)	-0.485** (-0.571**)	0.372** (0.450**)	-0.295** (-0.356**)	-0.301** (-0.367**)
5	PH						0.865** (0.888**)	0.734** (0.787**)	0.800** (0.849**)	0.743** (0.804**)	0.741** (0.770**)	0.687** (0.711**)	0.390** (0.423**)	0.754** (0.809**)	0.789** (0.820**)
6	EH							0.691** (0.740**)	0.672** (0.714**)	0.621** (0.684**)	0.756** (0.786**)	0.660** (0.683**)	0.270** (0.320**)	0.721** (0.804**)	0.724** (0.762**)
7	EL								0.729** (0.793**)	0.652** (0.742**)	0.846** (0.861**)	0.796** (0.811**)	0.278** (0.330**)	0.606** (0.685**)	0.875** (0.924**)
8	ED									0.917** (0.946**)	0.830** (0.875**)	0.805** (0.832**)	0.237* (0.219*)	0.846** (0.878**)	0.833** (0.858**)
9	KRPE										0.803** (0.857**)	0.792** (0.826**)	0.022NS (0.025NS)	0.863** (0.883**)	0.733** (0.773**)
10	KPR											0.956** (0.963**)	0.010NS (-0.007NS)	0.832** (0.884**)	0.884** (0.904**)
11	GPP												-0.082NS (-0.106NS)	0.762** (0.797**)	0.898** (0.913**)
12	1000-KW													0.116NS (0.123NS)	0.324** (0.298**)
13	Shelling (%)														0.712** (0.754**)

Figures given in parentheses are genotypic effects
** & * :@1% & 5% level of significant, respectively.
DA: Days to anthesis, DS: Days to silk, ASI: Anthesis-silking interval, DPM: Days to 50 per cent physiological maturity, PH: Plant height, EH: Ear height, EL: Ear length, ED: Ear diameter, KRPE: Kernel rows per ear, KPR: Kernels per row, GPP: Grains per plant, 1000-KW: 1000-kernels weight, GY(g/p): Grain yield per plant

Path coefficient analysis

The coefficient of correlation which determines the association between any two characters does not necessarily be the assurance of a direct casual relationship since it does not indicate the contribution of variation in one trait in relation to observed variation in another. Correlation coefficients are useful in deciding the attributes of a complex trait such as grain yield but it doesn’t provide an accurate image of the relative worth of direct and indirect effects of each and every component traits on the grain yield. Analysis of the path coefficient showing the cause and effect of various yield attributes will provide a stronger index for selection instead of the coefficients for correlation. Therefore the studies on the path coefficient was conducted to know the direct and indirect effects of yield attributes on grain yield and are presented in Table 3. The path coefficient analysis at phenotypic level revealed that the trait, days to 50 per cent silk (2.469) had the highest positive direct effect on grain yield per plant followed by grains per plant (1.019), 1000-kernel weight (0.383), ear height (0.086), ear length (0.085), kernel rows per ear (0.065), eard diameter (0.025) and days to 50 per cent physiological maturity (0.024). These results are in close conformity with the findings of trait days to 50 per cent silking (Panday *et al*, 2017 and Ram Reddy *et al*, 2016) [16, 13]; days to physiological maturity and 100-seed weight (Panday *et al*, 2017) [16]; number of kernel rows per ear, ear length, ear height, ear girth, days to maturity and 100-seed weight (Ram Reddy *et al*, 2013) [12]; days to 50 per cent maturity and cob length (Verma *et al*, 2020) [14]. Hemavathy and Priyadharshini, (2019) [17] also reported that the trait, days to silking showed second highest positive phenotypic direct effects on grain yield. The high direct effects of these traits seemed to be the key explanation for their powerful association with grain yield per plant. Thus, direct selection will be effective for all these traits. Days to 50 per cent anthesis exhibited highest negative phenotypic direct effect on grain yield followed by anthesis-silking interval.

Table 3: Direct (diagonal) and Indirect (both side of diagonal) phenotypic and genotypic effects for fourteen characters in maize

Characters		1	2	3	4	5	6	7	8	9	10	11	12	13
		DA	**DS**	**ASI**	**DPM**	**PH**	**EH**	**EL**	**ED**	**KRPE**	**KPR**	**GPP**	**1000-KW**	**Shelling %**
1	DA	-2.101 (0.914)	2.402 (0.565)	-0.304 (0.042)	0.017 (-0.888)	0.041 (-0.159)	-0.050 (-0.053)	-0.057) (-0.291)	-0.016 (0.524)	-0.047 (-0.242)	0.115 (0.232)	-0.823 (-1.497)	0.023 (0.094)	0.080 (-0.007)
2	DS	-2.044 (0.888)	2.469 (0.581)	-0.429 (0.059)	0.017 (-0.870)	0.043 (-0.164)	-0.054 (-0.058)	-0.056 (-0.287)	-0.015 (0.490)	-0.045 (-0.229)	0.112 (0.224)	-0.784 (-1.413)	0.001 (0.034)	0.079 (-0.007)
3	ASI	-0.976 (0.451)	1.621 (0.398)	-0.654 (0.086)	0.009 (-0.464)	0.029 (-0.113)	-0.043 (-0.050)	-0.031 (-0.159)	-0.006 (0.190)	-0.020 (-0.097)	0.054 (0.110)	-0.320 (-0.584)	-0.073 (-0.166)	0.042 (-0.004)
4	DPM	-1.465 (0.792)	1.716 (0.494)	-0.254 (0.039)	0.024 (-1.024)	0.017 (-0.080)	-0.019 (-0.022)	-0.028 (-0.138)	-0.007 (0.285)	-0.028 (-0.168)	0.065 (0.145)	-0.494 (-1.015)	0.143 (0.325)	0.039 (-0.004)
5	PH	1.415 (-0.645)	-1.719 (-0.423)	0.307 (-0.043)	-0.007 (0.365)	-0.061 (0.225)	0.074 (0.080)	0.063 (0.310)	0.020 (-0.659)	0.049 (0.258)	-0.113 (-0.224)	0.700 (1.264)	0.149 (0.306)	-0.099 (0.009)
6	EH	1.22 (-0.538)	-1.544 (-0.374)	0.328 (-0.048)	-0.005 (0.250)	-0.053 (0.200)	0.086 (0.090)	0.059 (0.292)	0.017 (0.554)	0.041 (0.220)	-0.115 (-0.229)	0.673 (1.213)	0.104 (0.232)	-0.095 (0.009)
7	EL	1.389 (-0.673)	-1.622 (-0.422)	0.235 (-0.035)	-0.008 (0.358)	-0.045 (0.177)	0.059 (0.067)	0.085 (0.394)	0.018 (-0.615)	0.043 (0.238)	-0.129 (-0.251)	0.811 (1.442)	0.107 (0.239)	-0.079 (0.008)
8	ED	1.367 (-0.617)	-1.518 (-0.368)	0.151 (-0.021)	-0.007 (0.377)	-0.049 (0.191)	0.058 (0.064)	0.063 (0.313)	0.025 (-0.776)	0.060 (0.304)	-0.126 (-0.255)	0.820 (1.479)	0.090 (0.158)	-0.111 (0.010)
9	KRPE	1.498 (-0.688)	-1.691 (-0.415)	0.194 (-0.026)	-0.010 (0.535)	-0.046 (0.181)	0.053 (0.062)	0.056 (0.293)	0.023 (-0.734)	0.065 (0.321)	-0.122 (-0.250)	0.806 (1.468)	0.008 (0.018)	-0.113 (0.010)
10	KPR	1.586 (-0.729)	-1.814 (-0.448)	0.230 (-0.032)	-0.010 (0.511)	-0.045 (0.173)	0.065 (0.071)	0.072 (0.340)	0.020 (-0.679)	0.052 (0.275)	-0.152 (-0.291)	0.973 (1.711)	0.004 (-0.005)	-0.109 (0.010)
11	GPP	1.695 (-0.769)	-1.899 (-0.462)	0.205 (-0.028)	-0.011 (0.585)	-0.042 (0.160)	0.056 (0.062)	0.068 (0.320)	0.020 (-0.646)	0.052 (0.265)	-0.145 (-0.280)	1.019 (1.777)	-0.031 (-0.077)	-0.100 (0.009)
12	1000-KW	-0.123 (0.119)	0.001 (0.028)	0.124 (-0.020)	0.009 (-0.460)	-0.023 (0.095)	0.023 (0.029)	0.023 (0.130)	0.006 (-0.170)	0.001 (0.008)	-0.002 (0.002)	-0.083 (-0.188)	0.383 (0.723)	-0.015 (0.001)
13	SHELLING %	1.275 (-0.597)	-1.480 (-0.370)	0.207 (-0.028)	-0.007 (0.365)	-0.046 (0.182)	0.062 (0.073)	0.052 (0.270)	0.021 (-0.681)	0.056 (0.283)	-0.126 (-0.257)	0.776 (1.417)	0.044 (0.089)	-0.131 (0.011)

Figures given in parentheses are genotypic effects.

Residual effect: 0.045.

DA: Days to anthesis, DS: Days to silk, ASI: Anthesis-silking interval, DPM: Days to 50 per cent physiological maturity, PH: Plant height, EH: Ear height, EL: Ear length, ED: Ear diameter, KRPE: Kernel rows per ear, KPR: Kernels per row, GPP: Grains per plant, 1000-KW: 1000-kernels weight, GY(g/p): Grain yield per plant.

Conclusion

Present study highlighted that the traits like grains per plant, 1000-kernels weight, ear length, ear diameter, kernel rows per ear, kernels per row, plant height, ear height and shelling per cent seemed to be the prominent traits which can be used in selecting for high grain yield per plant because of their highly significant positive genotypic and phenotypic associations with grain yield per plant. Path coefficient analysis at phenotypic level revealed that the days to 50 per cent silk had the highest positive direct effect followed by grains per plant on grain yield per plant. Hence, direct selection for the genotypes with higher grain yield per plant, the weightage of all these traits would be given.

Acknowledgement

Authors thankful to Dean PGS, Bihar Agricultural University, Sabour, Bhagalpur for their financial support for accomplishing research works. Authors also thankful to publication committee to provide BAU communication number 897/201104 for the manuscript.

Conflict of Interest

Authors have not declared any conflict of interest.

References

1. Aditi Ghosh, Vaskar Subba, Anindita Roy, Amitava Ghosh, Sabyasachi Kundagrami. Genetic Variability and Character Association of Grain Yield Components in Some Inbred Lines of Maize (*Zea mays* L.), Journal of Agroecology and Natural Resource Management 2014;1(2):34-39.
2. Batool Zare, Danial Kahrizi, Alireza Pour Aboughadareh, Farhad Sadeghi. Correlation and path coefficient analysis for determining interrelationships among grain yield and related characters in corn hybrids (Zea mays L.), Intl J Agri Crop Sci 2012;4(20):1519-1522
3. Bello OB, Abdulmaliq SY, Afolabi MS, Ige SA. Correlation and path coefficient analysis of yield and agronomic characters among open pollinated maize varieties and their F1 hybrids in a diallel cross, African Journal of Biotechnology 2010;9(18):2633-2639.
4. Dewey OR, Lu KH. A correlation and path coefficient analysis of components of crested wheatgrass seed production, Agronomy Journal 1959;57:515-518.
5. MN Huda, MS Hossain, M Sonom. Genetic variability, character association and path analysis of yield and its component traits in maize (Zea mays L.) Bangladesh Journal of Plant Breeding and Genetics 2016;29(1):21-30.
6. Pandurang Arsode, K Murali Krishna, N Sunil, S Vani Sree. Correlation Studies for Grain Yield and Its Components in Hybrids of Quality Protein Maize (Zea mays L.), The J. Res. PJTSAU 2018;46(2-3):85-88.
7. Panse VG, Sukhatme PV. Statistical methods of agricultural research works.III Edition, ICAR, New Deihi 1985, 146.4.
8. RA Gami, JM Patatel, GK Chaudhary, SM Chaudhary. Study of Trait Alliance with Grain yield, Its Attributes of Different Land Races of Maize (Zea Mays L.), Current Agriculture Research Journal 2017;5(2):184-190.
9. R Pavan, HC Lohithaswa, MC Wali, Gangashetty Prakash, BG Shekara. Correlation and path coefficient analysis of grain yield and yield contributing traits in single cross hybrids of maize (Zea mays L.), Electronic Journal of Plant Breeding 2011;2(2):253-257.
10. R Prakash, R Ravikesavan, N Kumari Vinodhana, A Senthil. Genetic variability, character association and path analysis for yield and yield component traits in

maize (*Zea mays* L.) Electronic Journal of Plant Breeding 2019;10(2):518-524.

11. S Sandeep, M Bharathi, V Narsimha Reddy. Intercharacter Associations for Grain Yield and Its Attributes in Inbreds of Maize (Zea mays L.), Int. J. Pure App. Biosci 2017;5(4):1697-1701.
12. V Ram Reddy, Farzana Jabeen, MR Sudarshan, A Seshagiri Rao. Studies on genetic variability, heritability, correlation and path analysis in maize (zea mays l.) over locations, International Journal of Applied Biology and Pharmaceutical Technology 2013;4(1):195-199.
13. V. Ram Reddy, F Jabeen. Narrow sense heritability, correlation and path analysis in maize (Zea mays L.), SABRAO Journal of Breeding and Genetics 2016;48(2):120-126.
14. Vishal Verma, MS Yadav, Anil Kumar, GS Gathiye. Correlation and path analysis for seed yield and components traits in maize (Zea mays L.), Journal of Pharmacognosy and Phytochemistry 2020;9(1):2278-2280.
15. Wright S. Correlation and Causation. Journal of Agricultural Research 1921;20:557-585.
16. Yogesh Pandey, RP Vyas, Jaydev Kumar, Lokendra Singh, HC Singh, PC Yadav, *et al.* Heritability, Correlation and Path Coefficient Analysis for Determining Interrelationships among Grain Yield and Related Characters in Maize (Zea mays L.), International Journal of Pure and Applied Bioscience 2017;5(2):595-603.
17. Hemavathy AT, Priyadharshini C. Association Studies for Yield and Yield Components in Maize (*Zea mays* L.) Inbred Lines, International Journal of Currenet Microbiology and Applied Sciences 2019;8(7):494-500
18. Dar ZA, Lone AA, Alaie BA, Ali G, Gazal A, Gulzar S, *et al*. correlation studies in temperate maize (*Zea mays* l.) inbred lines, Plant Archives 2015;15(2):1191-1194.
19. Barman H, Barua NS, Barua PK, Kalita P, Sarmah D, Chaurasia NK *et al*. Correlation analysis in S1 lines of local maize (*Zea mays.* L) germplasms for grain yield and its attributes, Journal of Pharmacognosy and Phytochemistry, SP 2018, 2000-2002.