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Correlation and Path Coefficient Analysis of Grain Yield and Yield attributed of elite line of Maize (*Zea mays* L.) Hybrids

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Increased production and productivity of maize will be attained by selection of best hybrids. However, selection on the basis of grain yield alone is usually not effective, because grain yield is a complex quantitative trait that depends on a number of factors. The objective of this study was to determine trait association and direct and indirect effects of yield related traits on grain yield of elite maize hybrids. A total of eleven pipeline maize hybrids and two standard checks (BH546 and BH547) were evaluated in a randomized complete block design with three replications during the 2015 main cropping season at Northwestern Ethiopia. Mean squares due to genotypes were highly significant for most grain yield and yield related traits indicating the existence of genetic variation among the evaluated genotypes. Grain yield showed positive and significant phenotypic and genotypic association with number of kernels per row. For other traits, the strongest positive phenotypic and genotypic association was observed between number of kernel rows per ear and ear diameter. Positive association between two desirable traits helps the plant breeder to easily improve both traits simultaneously. Ear diameter, number of kernels per row and ear length had positive phenotypic and genotypic direct effect on grain yield. This implied that ear diameter; ear length and number of kernels per row are important traits in determining yield performance. The information generated by this study could be useful for researchers who need to develop high yielding maize hybrids.

Key words: Correlation, Maize, hybrids, Path coefficient, trait association

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INTRODUCTION

Maize (*Zea mays* L.) is the third important cereal crop globally after wheat and rice [1]. Maize is the most important cereal food crop in Sub-Saharan Africa, particularly in Eastern and Southern Africa. In these regions, about 30-70% of total caloric consumption was that of maize [2]. Maize in Ethiopia ranks second after *Teff* in area coverage and first in total production. The results of the year 2013/14, Meher season post-harvest crop production survey indicated that the national average yield of maize is about 3.25 t/ha [2], this is by far below the world's average yield which is about 5.55 t/ha [4].

Grain yield is a complex quantitative trait that depends on plant genetics and its interaction with environmental conditions [5]. To determine such relationships, correlation analyses are used such that the values of two characters are analyzed on a paired basis, results of which may be either positive or negative [6]. The result of correlation is of great value in the evaluation of the most effective procedures for selection of superior genotypes. When there is positive association of major yield characters, component breeding would be very effective but when these characters are negatively associated, it would be difficult to exercise simultaneous selection for such characters in varietal development [7]. Phenotypic correlation indicates the extent of the observation having relation between two traits while genotypic correlation provides an estimate of inherent association between the genes controlling any two traits. For formulating selection indices for genetic improvement of yield, the cause and effect of the trait is very essential and can be done by path analysis [8].

Path analysis showed direct and indirect effects of cause variables on effect variables. In this method, the correlation coefficient between two traits is separated into the components which measure the direct and indirect effects. Generally, this method provides more information among variables than do correlation coefficients since this analysis provides the direct effects of specific yield components on yield, and indirect effects via other yield components [9].

In order to develop promising maize genotypes with higher yield potential, it is essential to know the correlation among different traits, especially with grain yield, which is the most important ultimate objective in any breeding program [10]. It is necessary to have a good knowledge of those characters that have significant correlation with yield because the characters can be used as indirect selection criteria to enhance the mean performance of varieties in a new plant population [11].

In order to obtain new inbred and hybrids that will outperform the existing hybrids with respect to a number of traits, the breeders had the option of selecting desirable genotypes in early generations or delaying intense selection until advanced generations [12]. In working towards this goal, particular attention is paid to grain yield as the most important agronomic characteristic but selection on the basis of grain yield character alone is usually not effective and efficient because grain yield is a complex quantitative trait that depends on a number of factors. For full understanding of the complex relationships between grain yield and other characters, the computation of direct and indirect effects of these traits on grain yield is essential. Therefore, before embarking on grain yield improvement it is necessary to understand the relationships existing between grain yield and other metric traits of the crop to improve the efficiency of breeding programs through the use of appropriate selection indices [13][14]. Therefore**,** the present study was conducted to determine trait association and direct and indirect effects of yield related traits on grain yield of elite maize hybrids.

MATERIALS AND METHODS

Description of Experimental Site

The experiment was conducted in 2015 at the Pawe Agricultural Research Center in North Western Ethiopia, Metekel Zone of BenshangulGumuz Regional State. Pawe Agricultural Center is located 575 kilometers away from Addis Ababa with latitude of 11^0 15′N and longitude of 36^o05'E at the elevation of 1050 meters above sea level. The mean annual rainfall is 1148.40mm, and the mean minimum and maximum temperatures of the area are 17.06 and 31.47 ^{0}C, respectively. The soil is nitosol with a pH ranging from 5.3-6.

Experimental Materials

Eleven pipeline maize hybrids with two checks, namely BH546 and BH547 were used for the study. The crosses were obtained from Bako, but some crosses originally introduced from CIMMYT breeding program. BH546 and BH-547 are medium maturing three way cross hybrids released recently by Bako National Maize Research Project for mid potential maize growing agro ecologies of Ethiopia. The description of the experimental pipeline hybrids are depicted in Table 1.

Design and Experimental Managements

The experiment was laid out in randomized complete block design (RCBD) with three replications. Each plot comprised of 2 rows of 5.1 m long with the spacing of 0.75 m between rows and 0.30 m between plants. Both rows were used to collect data on yield and other traits. Two seeds were planted per hill and later thinned out to one plant per hill after seedling establishment. Phosphate fertilizers in the form of diammonium phosphate (DAP) at the recommended rate of 100 kg/ha was applied equally to all plots at the time of planting. Nitrogen was applied in a form of urea (150 kg/ha). Half (75 kg/ha urea) was applied at planting and the remaining half was applied at knee height stage. Standard plant protection measures including weeding and other cultural practices were done as required.

Table 1: List of experimental materials used in the study

Entry	Stock ID	Pedigree
1	BK172-6	CML395/CML202//ILOO'E-1-9-1-1-1-1-1
2	BK172-3	CML395/CML202//CML312
3	BK172-17	CML395/CML32
4	BK123-97	Kuleni-320-2-3-1-1-1/DE-78-Z-126-3-2-2-1 1(g)//CML312
5	BK123-91	DE-78-Z-126-3-2-2-1-1(p)/Gibe-1-91-1-1-1//CML395
6	BK172-4	CML395/CML202//CML464
7	BK158-14	ILOO'E1-9-1-1-1-1/124 -b(109)
8	BK160-15	CML543/CML56
9	BK155-26	BK002/BK003
10	BK156- 18	BK002/CML312
11	BK159-17	ILOO'E1-9-1-1-1-1/CML312
12	Check 1	BH546
13	Check 2	BH547

DATA COLLECTION

Data on grain yield and other important agronomic traits were collected on plot and individual plant basis. For data individual plant basis, the average of five randomly sampled plants was used.

Data collected on plot basis

Days to anthesis (DA): The number of days from sowing up to the date when 50% of the plants started shedding pollen.

Days to silking (DS): The number of days from sowing to the date when 50% of the plants produced about 2-3cm long.

Anthesis-silking interval (ASI): Was recorded as the difference between days to 50% silk and anthesis.

Plant aspect (PA): Was recorded based on a scale of 1 to 5 where, 1 = best genotype (consider ear size, uniformity, disease infestation, husk cover) and 5 = poor genotype within each plot [15].

Days to physiological maturity (DM): It was recorded as the number of days after sowing to when 50% of the plants in the plot form black layer at the point of attachment of the kernel with the cob.

Stand count at harvest (SH): Was recorded as the total number of plants at harvest from each experimental unit.

Husk cover (HC): Was recorded as on a scale of 1 to 5; where 1 = tightly covered husk extending beyond the ear tip and 5 = ear tips exposed.

Number of ears harvested (NEH): This was recorded as the total number of ears harvested from each experimental unit. **Ear aspect (EA)**: Was recorded based on a scale of 1 to 5, where 1 = clean, uniform, large, and well filled ears and 5 = ears with undesirable features at time of harvesting from each plot.

Number of ears per plant (EPP): Was calculated as the total number of ears at harvest divided by total number of plants at harvest in that particular plot at harvest.

Thousand kernel weight (TKW): After shelling, random kernels from the bulk of shelled grain in each experimental unit was taken and thousand kernels were counted using a photoelectric seed counter and weighted in grams and then adjust to 12.5% grain moisture.

Above ground biomass yield (AGB): Plants from the experimental unit were harvested at physiological maturity and weighed in kg after sun drying and converted to hectare basis.

Harvest index (HI): The harvest index was calculated by dividing the economic (grain) yield (kg/ha) by above ground biomass (kg/ha) and expressed in percentage [16].

Grain yield (GY): After harvest, the total weight of ears per plot was recorded and then adjusted to 12.5% moisture and converted to hectare basis.

Data collected on plant basis

Ear height (EH): The height from the ground level to the upper most ear- bearing node of five randomly taken plants from each experimental unit was measured in centimeters. The measurement was made two weeks after pollen shedding had ceased.

Plant height (PH): The height from the soil surface to the first tassel branch of five randomly taken plants from each experimental unit was measured in centimeters. Like ear height, this was also measured two weeks after pollen shedding had ceased from the same plant that EH measured.

Ear length (EL): Length of ears from the base to tip was measured in centimeters. Data recorded represents the average length of five randomly taken ears from each experimental unit.

Ear diameter (ED): This was measured at the mid-section along the ear length, as the average diameter of five randomly taken ears from each experimental plot in centimeters using caliper.

Number of kernel rows per ear (NKRE): This was recorded as the average number of kernels row per ear from the five randomly taken ears for ear length and ear diameter measurements.

Number of kernels per row (NKR): Number of kernels per row was counted and average was recorded from five randomly taken ears.

STATISTICAL ANALYSIS

The data collected for all yield and yield-related traits were analyzed using PROC MIXED procedure in SAS computer software [17].Phenotypic and genotypic correlations were computed by using the formula described earlier [18].

$r_p = Covxy_p / (Varx_p \times Vary_p)^{1/2}$

Where, r_p= phenotypic correlation, $Covxy_p$ =phenotypic covariance between the traits x and y, $Varx_p$ and $Vary_p$ = phenotypic variance of the traits x and y respectively.

$r_g = Covxy_g / (Varx_g \times Vary_g)^{1/2}$

Where, r_g = genotypic correlation, $Covxy_g$ =genotypic covariance between the traits x and y, $Varx_g$ and $Vary_g$ = genotypic variance of the traits x and y respectively.

Path analysis is simple standardized partial regression coefficient, which splits the correlation coefficient into direct and indirect effects of the yield components on yield was estimated with the formula used earlier [19].

$$r_{ij} = p_{ij} + \sum r_{ik} p_{jk}$$

Where: r_{ij} is association between independent variables (i) and dependent variable j as measured by phenotypic and genotypic correlation coefficients, Pij is component of direct effect of independent variable (j) as measured by the phenotypic and genotypic path coefficients and $\sum r_{ik} p_{jk}$ is the summation of components of indirect effect of a given independent variable (i) on a given dependent variable (j) through all other independent variables.

RESULTS AND DISCUSSION

Analysis of Variance (ANOVA)

The analysis of variance revealed highly significant (*P* ≤ 0.01) genotypic variations for for grain yield, number of ears per plant, ear diameter, ear length, number of kernel rows per ear, number of kernels per row, thousand kernel weight and harvest index (Table 2).

The significant mean squares due to genotypes indicated the existence of variation among the hybrids, which could be exploited for the improvement of respective traits. The remaining traits such as days to anthesis, days to silking, anthesis-silking interval, days to physiological maturity, plant height, ear height, plant aspect, ear aspect and husk cover remained non-significantly different. Further genetic analysis and discussions were not done for the traits with non - significant genotypic variations. Significant genotypic differences for grain yield and yield related traits in maize in this study are similar to the findings of earlier studies [20, 21, 22, 23].

Correlation Analysis

Phenotypic and genotypic correlation analysis between grain yield and yield related traits are presented in Table 3. Grain yield showed significant and positive phenotypic association with number of kernels per row (r=0.48**) and 1000-kernel weight (r=0.33*). The strongest phenotypic association was observed between number of kernel rows per ear and ear diameter (r= 0.70**) followed by number of kernels per row and ear length (r= 0.57**). In line with the current study, positive and significant association of grain yield with number of kernels per row and thousand kernels weight were reported earlier [27]. In contrast to the findings of the current study, negative association between grain yield and number of kernels per row was found by earlier study [25]. Positive and significant associations of grain yield with thousand kernel weight and number of kernels per row is reported earlier [26]. Positive and significant associations of grain yield with thousand kernel weight and number of kernels per row is reported earlier [24]. Similarly, positive and highly significant phenotypic association between grain yield and number of kernels per row and thousand kernels weight were found [28].

At genotypic level grain yield showed positive and highly significant correlations with number of kernels per row (r=0.74**) (Table 3). The strongest genotypic association was observed between number of kernel rows per ear and ear diameter (r= 0.78**) followed by number of kernels per row and grain yield (r= 0.74**). Positive and significant association between number of kernels per row with grain yield was also reported earlier from studies on maize [29] [25]. Similarly, positive and highly significant genotypic correlations between grain yield and number of kernels per row were found [30].

Hence, the positive associations of the above mentioned traits with grain yield indicated that these traits are important that may be considered for indirect selection to improve grain yield, because grain yield can be simultaneously improved with a trait for which it showed strong relationship [13].

Table 2: Mean squares due to genotypes and errors for grain yield and yield related traits of maize pipeline hybrids evaluated at Pawe, 2015

Trait	Mean squares		
	Entry (df=12)	Replication (df=2)	Error (df=24)
Grain yield	9012605.00**	8380147.70	1373483.90
Days of anthesis	0.76ns	0.10	0.52
Days of silking	0.84ns	0.08	0.60
Anthesis-silking interval	0.13ns	0.03	0.16
Days of physiological maturity	3.03ns	0.41	2.08
Plant height	9.69ns	40.69	7.76
Ear height	248.76ns	232.79	134.31
Plant aspect	2.74ns	1.40	0.13
Ear aspect	0.09ns	0.08	0.05
Husk cover	0.04ns	0.20	0.03
Number of ears per plant	0.03**	0.00	0.01
Ear diameter	1.31**	0.45	0.03
Ear length	2.76**	0.21	0.84
Number of kernel rows per ear	2.93**	1.69	0.59
Number of kernels per row	18.81**	0.42	2.90
1000-kernels weight	1667.69**	155.43	397.32
Harvest index	61.56**	42.91	16.01

*and ** = Significance and highly significant, respectively, ns= non- significance

Table 3: Estimates of correlation coefficients at genotypic (above diagonal) and phenotypic (below diagonal) for yield and yield related traits of pipeline maize hybrids at Pawe, 2015

Traits	EPP	ED	EL	NKRE	NKR	TKW	HI	GY
EPP		-0.66*	-0.11	-0.70**	0.49	-0.20	0.16	0.22
ED	-0.34*		0.00	0.78**	-0.22	0.49	-0.23	0.26
EL	-0.13	0.14		0.01	0.51	0.17	0.52	0.41
NKRE	-0.48**	0.70***	0.16		-0.39	-0.02	0.05	-0.11
NKR	0.34*	-0.18	0.57**	-0.24		0.35	0.05	0.74**
TKW	-0.23	0.31	0.19	-0.02	0.27		-0.40	0.42
HI	0.13	-0.08	0.45	0.00	0.26	0.03		0.07
GY	0.25	0.30	0.31	0.00	0.48**	0.33*	0.03	

*and ** = Significance and highly significant, respectively, ED= ear diameter, EL= ear length, EPP= number of ears per plant, GY = grain yield, HI= harvest index, NKR= number of kernels per row, NKRE = number of kernels rows per ear, TKW = thousand kernel weight

Table 4: Phenotypic path analysis of the direct (bold) and indirect effects of yield related traits on grain yield of pipeline maize hybrids at Pawe, 2015

Traits	EPP	ED	EL	NKRE	NKR	TKW	HI	r_p
EPP	**0.29**	-0.17	-0.02	-0.14	0.13	-0.03	-0.02	0.25
ED	-0.10	**0.50**	0.02	0.20	-0.07	0.04	0.01	0.30
EL	-0.04	0.07	**0.12**	0.05	0.21	0.02	-0.05	0.31
NKRE	-0.14	0.35	0.02	**0.29**	-0.09	0.00	0.00	0.00
NKR	0.10	-0.09	0.07	-0.07	**0.37**	0.03	-0.03	0.48**
TKW	-0.07	0.16	0.02	-0.01	0.10	**0.12**	0.00	0.33*
HI	0.04	-0.04	0.05	0.00	0.10	0.00	**-0.12**	0.03

Where: ED= ear diameter, EL= ear length, EPP= number of ears per plant, GY = grain yield, HI= harvest index, NKR= number of kernels per row, NKRE = number of kernel rows per ear, TKW = thousand kernel weight.

The correlation among grain yield related traits were mixed, both in negative and positive direction. Number of kernels per row exhibited significant and positive phenotypic association with ear per plant, and highly significant positive association with ear length. Number of kernel rows per ear showed negative and highly significant phenotypic association with number of ears per plant and positive highly significance with ear diameter. The current finding is in line with the findings of [27] and [9]. Number of kernel rows per ear exhibited positive and significant genotypic association with ear diameter and significant negative association with number of ears per plant. Ear diameter showed negative significant genotypic association with number of ears per plant. Highly significant positive association among yield attributes indicates that, the increase in one trait will cause increase in the associated trait, which in turn will cause an increase in the yield.

Generally, the values of genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients for most of the traits. This suggests that the apparent associations might be largely due to genetic associations among the traits.

Phenotypic Path Coefficient Analysis

The phenotypic direct and indirect effects of yield-related traits on grain yield are presented in Table 4. Ear per plant, ear diameter, ear length, number of kernel rows per ear, number of kernels per row and thousand kernel weight exerted positive phenotypic direct effect on grain yield. Similarly, positive direct effects of ear diameter, ear length, number of kernels per row and thousand kernel weight on grain yield were reported earlier [24] [31]. Ear diameter, number of ears per plant, ear length and number of kernel rows per ear exerted positive direct effect on grain yield [23]. Harvest index exerted negative direct effects on grain yield but exhibited positive phenotypic correlation with grain yield due to their positive indirect effects through ear diameter.

The highest phenotypic direct effect on grain yield was exerted by ear diameter (0.50), followed by number of kernels per row (0.37). But, number of kernels per row exerted a maximum direct effect on grain yield [14].

The highest indirect effect belonged to ear diameter via number of kernel rows per ear. The test of significance cannot be applied to indirect effects, but they are considered significant if their value is higher than the value of direct effects. Although, direct effects of ear length on the yield was not statistically significant, the indirect effects of this trait via ear diameter, number of kernels row per ear, number of kernels per row and thousand kernels weight and harvest index on the yield are positive. Ear per plant had positive direct effect (0.29) on grain yield. However, it affects the yield negatively via ear diameter, ear length, number of kernels row per ear and thousand kernels weight. Although the number of kernels per row has statistically highly significant positive phenotypic direct effect on the yield, but it has negative indirect effect via ear diameter and number of kernel rows per ear. This means regarding number of kernels per

Table 5: Genotypic path analysis of the direct (bold) and indirect effects of yield related traits on grain yield of pipeline maize hybrids at Pawe, 2015

Traits	EPP	ED	EL	NKRE	NKR	TKW	HI	r_g
EPP	**-0.24**	-1.03	-0.01	0.85	0.49	0.16	-0.01	0.22
ED	0.16	**1.56**	0.00	-0.87	-0.22	-0.38	0.01	0.26
EL	0.03	0.00	**0.06**	-0.02	0.51	-0.13	-0.03	0.41
NKRE	0.18	1.21	0.00	**-1.12**	-0.39	0.02	0.00	-0.11
NKR	-0.12	-0.34	0.03	0.44	**1.00**	-0.28	0.00	0.74**
TKW	0.05	0.76	0.01	0.02	0.35	**-0.79**	0.02	0.42
HI	-0.04	-0.36	0.03	-0.05	0.05	0.31	**-0.05**	0.07

Where: ED= ear diameter, EL= ear length, EPP= number of ears per plant, GY = grain yield, HI= harvest index, NKR= number of kernels per row, NKRE = number of kernel rows per ear, TKW= thousand kernel weight

row, selection should be aimed to increase of this trait with the simultaneous increase of ear diameter and number of kernel rows per ear.

Genotypic Path Coefficient Analysis

The genotypic direct and indirect effects of yield-related traits on grain yield are presented in Table 5. Number of kernels per row exerted positive direct effect and exhibited positive significant genotypic correlation with grain yield. Ear diameter, ear length and number of kernels per row showed positive genotypic direct effect on yield and also had positive correlation with grain yield. These traits could be used as a reliable indicator in indirect selection for higher grain yield since their direct effect and association with grain yield were positive. Positive genotypic direct effect of number of kernels per row, ear length and ear diameter on grain yield [9]. Positive genotypic direct effect of ear diameter and ear length towards grain yield is reported earlier [23].

The highest genotypic direct effect on grain yield was exerted by ear diameter (1.56). Ear diameter and ear length had the highest direct effect on grain yield [24]. Similarly, ear diameter possessed high positive direct effect [32]. In contrast, thousand kernels weight exhibited the largest direct effect on grain yield [9]. The highest indirect effect belonged to ear diameter via number of kernels row per ear. Similar results were reported earlier [33].

Negative direct effects on grain yield were found for thousand kernel weight (-0.79), number of ears per plant (-0.24), number of kernels row per ear (-1.12) and harvest index (-0.05), but these traits exhibited positive correlation with grain yield except number of kernel rows per ear. The positive associations of these traits with grain yield were due to the positive indirect effects through other traits. Number of ears per plant had positive genotypic indirect effect on yield via ear diameter, ear length, thousand kernel weight and number of kernel rows per ear while thousand kernel weight had positive indirect effect via number of kernel rows per ear, number of ears per plant and harvest index but negative genotypic infect via ear diameter and number of kernels per row. Similar results were also reported by other authors for number of kernel rows per ear [34] [9] and for thousand kernels weight [32]. Thousand kernel weight exerted negative indirect effect on grain yield via number of kernels per row [35]. Harvest index exerted positive genotypic indirect effect via thousand kernel weight and ear diameter. The negative genotypic direct effect of number of kernel rows per ear and thousand kernel weight on grain yield is in agreement with earlier study [34]. Negative direct effect of number of kernel rows per ear on grain yield which is supported by the present study [32]. In contrast to the current study, number of kernel rows per ear exerted positive genotypic direct effect on grain yield [33]. Generally, some yield components such as ear diameter, ear length and number of kernels per row has big importance in determining yield.

CONCLUSIONS

According to the results, in order to bring an effective improvement of grain yield, more attention should be given for traits such as ear diameter, ear length and number of kernels per row which showed high positive phenotypic and genotypic correlation coefficients with a considerable direct and indirect effect on grain yield. This study showed the existence of positive and significant association of yield with number of kernels per row and thousand kernels weight, and identified the existence of positive direct effect of desirable yield related traits with grain yield. However, further evaluation of these and other hybrids at more locations and over years is advisable to confirm the promising results observed in present study. In general, it may be concluded that the information from this study could be valuable for researchers who intend to develop high yielding varieties of maize.

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REFERENCES

[1] FAO. (2014). World Agricultural Production http://faostat.fao.org/default.aspx. Accessed 14 April. 2013.

[2] Langyintou, A.S., Mwangi, W., Diallo, A.O., MacRobert, J., Dixon, J., Banziger, M. (2010) An analysis of the bottlenecks affecting the production and deployment of maize seed in eastern and southern Africa. Harare, Zimbabwe, CIMMYT.

[3] CSA, (2014). Agricultural sample survey. Report on farm management practices. Private peasant holdings, Meher season. Stat. Bull. Addis Ababa, Ethiopia. pp. 6-9.

[4] USDA, (2015). World Agricultural Production. Foreign Agricultural Service Circular Series/ USDA office of Global Analysis. WAP 4-15.

[5] Khatab, I.A., M.A. Farid and T. Kumamaru. (2016). Genetic diversity associated with heading date in some rice (Oryza sativa L.) genotypes using microsatellite markers. *Journal of Environmental & Agricultural Sciences*. 6: 58-63.

[6] Akhtar, L.H., R. Minhas, M.S. Bukhari and S.A.S. Shah. (2015). Genetic Analysis of Some Quantitative Traits in Cluster Bean (Cyamopsis tetragonoloba L.). *Journal of Environmental & Agricultural Sciences*. 4:48-51.

[7] Nemat,i., A., Sedghi, M., Sharifi, R.S and Seiedi, M.N. (2009) Investigation of correlation between traits and path analysis of corn (*Zea mays* L.) grain yield at the climate of Ardabil region (Northwest Iran). *Not. Bot. Hort. Agrobot. Cluj*, 37(1): 194-198.

[8] Nadagoud, K.V. (2008) Stability analysis of maize (*Zea mays* L.) inbred lines/ introduction for yield Parameters, published MSc thesis submitted to Dharward University of Agricultural sciences, Dharward, India: 1-85.

[9] Praveen, G. K., Y., Prashanth, V., Narsimha, R., Sudheer,S. K. and Venkateshwara, p. (2014). CHARACTER ASSOCIATION AND PATH COEFFICIENT ANALYSIS IN MAIZE (*Zea mays* L.) *International J. of Applied Biology and Pharmaceutical Technology, 5(1):257-260.*

[10] Malik, H. N., Malik,S.I.., Hussain, M., Chughtai, S.R. and H. I. Javed H.I. (2005). Genetic correlation among various quantitative characters in maize (Zea mays L.) hybrids. *Journal of agriculture and social sciences*, 262-265.

[11] Ojo, D.K., Omikunle, O.A., Oduwaye, O.A., Ajala, M.O. and Mao, S.A. (2006). Heritability, Character Correlation and Path Coefficient Analysis among Six Inbred-Lines of Maize (*Zea mays* L.). *World J. Agric. Sci.*, *2*: 352-358.

[12] Puri, Y.P., Qualset, C.O. and Williams, W.A. (1982). Evaluation of yield components as selection criteria in barley breeding. *Crop Sci*. 22: 927–931.

[13] Eleweanya, N.P., Uguru, M.I., Eneobong, E.E. and Okocha, P.I. (2005). Correlation and path coefficient analysis of grain yield related characters in maize (*zea mays* L.) under umudike conditions of South Eastern Nigeria. J Agric Food Environ Exten 4(1): 24-28.

[14] Mohammadi, S.A., Prasanna, B.M. and Singh, N.N. (2003). Sequential path model for determining interrelationships among grain yield and related characters in maize. *Crop Sci*. *43*: 1690-1697.

[15] Badu, A., Akinwale, B., Ajala R.O., Menkir, S.O., Fakorede, A., Oyekunle, M.A.B. (2011b). Relationships among traits of tropical early maize cultivars in contrasting environments. *Agronomic Journal* 103:717-729.

[16] Donald, C.M. (1962). In search of yield. *Journal of Australian Institute of Agricultural Sciences*, 28: 171-178.

[17] SAS, (2002). *Stastical Analysis of system software*, Version 9.0, SAS Institute, I.n.c., cary, NC, USA.

[18] Webber, C. R.and Moorthy, B. R. (1952). Heritable and non-heritable relationship and variability of oil content and agronomic traitistics in the F2 generation of soybean crosses. *J. Agron.,* 44: 202-209.

[19] Dewey, D.R and Lu, K.H. (1959). Correlation and path coefficients analysis of components of crested wheat grass seed production. *Agron . J.,* 51: 515-518.

[20] Dagne, W., Habtamu, Z., Labuschagne, M.T., Temam, H. and Singh, H. (2007). Heterosis and combining ability for grain yield and its components in selected maize inbred lines. *S. Afr. J. Plant Soil*, (3): 133-137.

[21] Akbar, M., Saleem M., Ashraf, M.Y., Husain, A., Azhar, F.M. and Ahmad, R. (2009). Combining ability studies for physiological and grain yield traits in maize at two temperature regimes. *Pakistan J. Bot*, 41(4): 1817-1829.

[22] Shushay, W. (2011). Line x tester analysis of maize *(zea mays* l*.)* inbred lines for grain yield and yield related traits in central rift valley of Ethiopia. M.Sc. Thesis. University of Haramaya, Haramaya.

[23] Hailegebrial, K., Getachew, A., Legesse, W. and Yemane, T. (2015). Correlation and Path Coefficient Analysis of Grain Yield and Yield Related Traits in Maize (*Zea mays* L.) Hybrids, at Bako, Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 5(15): 3195-3208.

[24] Hadji., T. (2004). Combining ability analysis for yield and yield related traits in quality protein maize inbred lines. MSc Thesis , Haramaya University, Haramaya, Ethiopia.

[25] Yousuf, M. and Saleem, M. 2001 Correlation analysis of S1 families of maize for grain yield and its components. *Int. J. Agric. Biol*. 4 (3):387- 388.

[26] Dagne, W. (2008). Genotypic variability and combining ability of quality protein maize inbred lines under stress and optimal conditions. PhD Thesis, University of the Free State, South Africa, p321.

[27] Sandeep,T. K. D., Mohan, R., Hariprasad,K.R. and Sudhakar, p. (2011). Targeting of traits through assessment of interrelationship and path analysis between yield and yield components for grain yield improvement in single cross hybrids of maize (*Zea mays* L.) *International J. of Applied Biology and Pharmaceutical Technology,* 2(3):123-129*.*

[28] Bullo, N. (2014). Correlation and path coefficients analysis studies among yield and yield related traits of quality protein maize (QPM) inbred lines. *International Journal of Plant Breeding and Crop Science,* 1(2): pp. 006-017.

[29] Mofidian, S.M.A., Choukan, Ghanadha, M.R. and Khodambashi, M. (2006). Inheritance of grain yield and its components in maize through generation mean analysis. *Iranian j Agric Sci*., 37-1 (2): 287-295.

[30] Jadhav, V.T., Shelke, D.K. and Suryawanshi, V.P. (2009). Correlation, regression and path coefficient analysis in maize hybrids. J Maharashtra Agric University, 34(2): 214-215

[31] Selvaraj, C.I and Nagarajan, P. (2011). Interrelationship and path coefficient studies for qualitative traits, grain yield, and other yield related attributed among maize (Zea mays L.). Int. J. Plant Breed. Genet. (In Press).

[32] Muneeb, M., Muhammad, S., Ghazanfar, H. and Muhammad, Y. (2013). Correlation and Path Analysis of Grain Yield Components in Exotic Maize (*Zea Mays* L.) Hybrids. *International Journal of Sciences: Basic and Applied Research,* 12(1): pp 22-27*.*

[33] Muhammad, R.C., Muhammad, R., Amer, H. and Muhammad, A. (2010). Studies on heritability,correlation and path analysis in maize (*Zea mays* L.). *Journal of Agricultural Research,* 48 (1): 35-38.

[34] Batool, Z., Danial, K., Alireza, P. and Farhad, S. (2012). Correlation and path coefficient analysis for determining interrelation ships among grain yield and related characters in corn hybrids (*Zea mays* L.). *IJACS*, 201(4): 1519-1522.

[35] Ali, N., Sedgh,i M., Seyed, R.S. and Seiedi, M.N. (2009). Investigation of Correlation between Traits and Path Analysis of Corn (*Zea mays* L.) Grain Yield at the Climate of Ardabil Region (Northwest Iran). *Notulae Botanicae Horti AgrobotaniciCluj-Napoca*, 37 (1): 194-198.

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