International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: SJIF: 5.995
Available Online at www.journalijcar.org
Volume 6; Issue 10; October 2017; Page No. 6548-6552
DOI: http://dx.doi.org/10.24327/ijcar.2017.6552.0964

Research Article

CORRELATION AND PATH ANALYSIS OF YIELD AND YIELD-CONTRIBUTING TRAITS OF MAIZE LANDRACES

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A R T I C L E I N F O

Article History:

Received 15th July, 2017
Received in revised form 19th August, 2017 Accepted 25th September, 2017
Published online 28th October, 2017

Key words:

Correlations, Path coefficient, maize landraces, Grain yield.

A B S T R A C T

Grain yield is an expression of the potential of a genotype to be cultivated at a particular location; however understanding how yield components contribute to harvested yield is essential to the success of breeding programs. In this study, yield components of fifteen maize landraces were investigated in a randomized complete block design with three replications. Broad sense heritability was 67.10% and 98.98% for number of primary branches and days to 50% silking respectively. Genotypic coefficient of variation (GCV) ranged from 5.10% for leaf width and was highest, 45.8% for number of secondary branches. The highest phenotypic coefficient value recorded was 15.27% for number of tertiary braches. One-hundred seed weight (r^2 = 0.87) and number of kernels per row (r^2 = 0.80) were positively correlated with grain yield traits. Path coefficient analysis showed that grain yield was significantly and positively correlated with plant height (0.87), hundred seed weight (0.87), and number of kernels per row(0.80). Suggesting selection for high yield in maize landraces can be done considering these traits.

INTRODUCTION

Grain yield is the principal determinant of the economic value of cultivated cereal crops and depends on a number of contributing traits (Saidaiah *et al.*, 2008). In Africa, maize landraces are commonly used and low grain yield is one of the challenges that farmers face because of their poor productivity (Devi *et al.,* 2013). To address this challenge, this study examines relationships amongst a wide range of traits associated with grain yield using fifteen landrace maize varieties.

High yield in cereal varieties can be associated with both vegetative and reproductive characteristics. For example Saidaiah *et al* (2008) showed that the grain yield of 41 F1 genotypes of maize was positively correlated with plant height, ear height, number of ear leaves and hundred seed weight. In a second study, ear weight, hundred seed weight, plant height and number of leaves per plant had shown positive significant correlation with grain yield on maize.

Making an improvement in grain yield you need to study and understand the relationship between grain yield and other contributing traits (Eleweanya *et al.*, 2015) which assist in selection. This information provided with researchers in varieties (Khodadad *et al.*, 2013). Thus the objective of the study was to bring out the yield components important in grain yield and its relationship in breeding programme.

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MATERIALS AND METHODS

Study area

The study was conducted during the 2014/2015 cropping season at the Selian Agricultural Research Institute which is located in the Arusha region of Tanzania at 10° 22'S and 40° 10'E and is at 1378 m above sea level. Mean annual temperature and rainfall are 19.2°C and 1103 mm respectively. The soils are silty loams and volcanic in origin.

Experimental design

Fifteen maize landraces collected from areas within the Arusha, Kilimanjaro and Manyara regions were used. The study materials were laid out in a Randomized Complete Block Design (RCBD) with three replicates. Plot size was 3 × 3 m. Each plot had 4 rows with 10 plants per row; thus row spacing was 0.75 m between and 0.3 m within rows and there were 40 plants in each plot. Two seeds were sown in a hill and later thinned to one plant per hill. The recommended level of phosphorus, 30 kg P/ha was applied at sowing as 65.2 kg/ha of diammonium phosphate which also supplied 11.7 kg N/ha at this stage. To meet the recommended level of application of nitrogen, 60 kg N/ha, 48.3 kg/ha of urea was applied 56 days after seedling emergence.

Measurements

The following measurements were made following the protocol developed by IBGRI (1991). Mean values were calculated for those based on a selected number plants per plot. Height, length and diameter were measured to the nearest centimeter. Unless otherwise stated, measurements were done on ten plants selected randomly in each plot except for hundred seed weight, leaf orientation, kernel type, colour and row arrangement, husk cover, stay green, ear damage and tassel arrangement which used five randomly selected plants:

- Days to 50% tasseling and 50% silking: the number of days between sowing and when half of the plants in each plot had tasseled and silked, respectively.
- Plant height (cm): the vertical distance between the point where the tassel of the plant started emerging and ground level.
- Ear height (cm): the vertical distance between uppermost bearing ear and ground level.
- Leaf length (cm): the distance between the ligule and apex of the leaf which subtends the uppermost ear.
- Leaf length above the upper ear (cm)**:** Using a modified metric ruler, the length between the ligule and apex of the leaf which subtends the uppermost ear.
- Leaf width above upper ear (cm): Using a modified metric ruler, the width mid-way along the length of the leaf subtending the uppermost ear.
- Tassel length (cm): The distance between the base and tip of the tassel.
- Tassel branching space (cm): The distance between the point where the tassel branching starts to the point where branching ends.
- Tassel peduncle length (cm): The distance between the leaf sheath and tassel branch.
- The numbers of primary, secondary and tertiary branches on a tassel.
- Number of kernel rows: number of rows in the central part of the uppermost ear.
- Cob diameter (cm): the diameter of the uppermost ear cob.
- Number of kernels per row: the number per row on 10 ears.
- Hundred seed weight (g)**:** The weight of 100 seeds in each plot.
- Grain yield (t/ha)**:** The yield from the two harvested middle rows in a plot after grain weight and moisture content recorded with moisture meter using the formula in equation**.**

$$\text{Grain Yield}\left(\frac{t}{ha}\right) = \frac{10}{Pa}\ Pw\frac{(Sw - Cw)}{Sw}\frac{(100 - Sm)}{86}$$

where: Pa = plot area (m^2), Pw = plot grain yield (kg), Sw = sample weight (kg), Cw = cob weight of ear samples (kg) and Sm=grain sample moisture content at harvest (%).

- Leaf orientation: The most frequent leaf orientation where 1 is erect, and 2 is pendant.
- Kernel type was rated as 1: floury; 2: semi-floury; 3: dent; 4 semi-dent; 5: semi-flint; 6: flint; 7: pop; 8: sweet; 9: opaque; 10: tunicate; or 11: waxy.
- Kernel colour was rated as 1: white; 2: yellow; 3: purple; 4: variegated; 5: brown; 6: orange; 7: mottled; 8: white cap; or 9: red.
- Kernel row arrangement was rated as 1: regular; 2: irregular; 3: straight; or 4: spiral.
- Husk cover as the effectiveness of the ear leaves covering of the uppermost ear rated as the most frequent of either 3: poor; 5: intermediate; or 7: good.
- Stay green as the greenishness at maturity rated as the most frequent of either 3: low; 5: medium; or 7: high.
- Ear damage as damage associated with ear rot and insects damage rated as the most frequent of either 0: none; 3: little; or 7.
- Tassel arrangement at the milk stage rated as the most frequent of either 1: primary; 2: primary-secondary; or 3: primary-secondary-tertiary.

Statistical analysis

Plot means for all variables were subjected to analysis of variance using GenStat Discovery 15th edition. Means for each landrace were separated was using the Turkey test at the 5% level of significance. Genotypic (GCV) and phenotypic (PCV) coefficients of variation were estimated (Burton and De Vane, 1953), broad-sense heritability (H_2b) calculated (Hanson *et al*., (956), and correlation coefficients and path coefficient analysis done (Dewey and Lu, 1989).

Results

Broad-sense heritability

Broad-sense heritability, h^2_b ranged between 67.1% and 98.9% (Table 1). Days to tasseling and silking had the highest heritability (> 98%); number of primary branches had the lowest (67.1%). Seven of the 19 traits, grain yield, tassel branching space, numbers of primary, secondary and tertiary branches, number of kernals per row and leaf width, had h^2_b < 80% (Table 1)

Genotypic and phenotypic coefficients of variation

Phenotypic coefficients of variation (PCV) ranged from 0.4% to 15.2%; all values were ≤ 6.2% except for number of tertiary (15.2%) and secondary (13.5%) branches (Table 1). Genotypic coefficients of variation (GCV) ranged between 5.1% (leaf width) and 45.8% (number of secondary branches). Seven traits, number of kernel rows and kernals per row, leaf width, ear length and diameter, and days to tasseling and silking had GCV ≤9.8% (Table 1).

Table 1 Esimates of broad-sense heritability (h^2_b), and genotypic (GCV) and phenotypic (PCV) coefficients of variation of 15 maize landraces for the studied variables

Traits	GCV%	PCV%	h^2_b (%)
Leaf length	6.47	1.90	86.25
100seedweight	8.23	2.80	80.91
Grain yield	16.78	3.50	75.45
Tassel peduncle length	15.08	3.10	83.94
Tassel length	13.98	2.30	82.74
Tassel branching space	12.57	4.50	79.82
Plant height	11.21	6.20	93.84
Number of tertiary branches	37.16	15.20	68.45
Number of secondary branches	45.77	13.50	77.92
Number of primary branches	14.91	2.80	67.09
Number of kernel row	9.10	1.20	85.29
Number of kernel per row	9.76	2.60	68.45
Leaf width	5.07	1.50	76.32
Ear length	8.49	1.90	80.60

Ear height	19.99	6.00	97.16
Ear diameter	6.02	0.40	85.43
Days to tassel	7.06	0.60	98.84
Days to silking	6.60	0.70	98.85
Cob diameter	10.42	2.60	86.88

Estimates of genotypic correlation coefficients among yield and yield components

The direction and magnitude of association between yield and yield components differed (Table 2). Genotypically plant height showed a significantly positive correlation with ear height (r = 0.99) but a significantly negative correlation with grain yield (r = -0.91), number of kernels per row (r = -0.89), and hundred seed weight (r = -0.95). Ear height similarly showed significant negative correlation with these traits. One-hundred seed weight and number of kernels per row were significantly and positively correlated with grain yield (Table 2).

Table 2 Genotypic correlation coefficient among yield and yield components

	P H	EH	100SWT	NKPR	GY
Plant height	1.00				
Ear height	0.99*	1.00			
One hundred seed weight	-0.95*	-0.95*	1.00		
No. kernals per row	-0.89*	-0.89*	0.82*	1.00	
Grain yield	-0.91*	-0.91*	0.87*	0.80*	1.00

*****Significant at 5% level
Key: PH = plant height, EH = ear height, 100SWT = hundred seed weight, NKPR = number of kernels per row, GY = grain yield

Path coefficient analysis

There was significant variability in causal relationships among components that can influence grain yield. The correlation between plant height and grain yield was strongly significant and negative (-0.91). Indirect effects had low non-significant correlations; similarly, ear height also had a significantly negative correlation with yield (-0.91), mainly due to highly negative indirect effect via plant height (-0.91). One hundred seed weight correlated was significantly and positively with grain yield (0.87); again this was mainly due to the indirect effect of plant height (0.87).Similarly, number of kernels per row were also significantly and positively correlated with grain yield (0.80) that was mainly due to the indirect effects via plant height (0.82) (Table 3).

Table 3 Direct and indirect effects of yield and yield components

	Source of variation	Effects
1	(PH) vs. grain yield (r_{15})	-0.91*
	Direct effect (P_{15})	-0.91
	Indirect effect via (EH) ($r_{12}P_{25}$)	0.05
	Indirect effect via (100SWT) ($r_{13}P_{35}$)	-0.01
	Indirect effect via (NKPR) ($r_{14}P_{45}$)	0.06
	Total	-0.91*
2	(EH) vs. grain yield (r_{25})	-0.91*
	Direct effect(P_{25})	-0.05
	Indirect effect via (PH) ($r_{12}P_{15}$)	-0.91
	Indirect effect via (100SWT) ($r_{23}P_{35}$)	-0.01
	Indirect effect via (NKPR) ($r_{24}P_{45}$)	0.06
	Total	-0.91*
3	(100SWT) vs. grain yield (r_{35})	0.87*
	Direct effect (P_{35})	0.01
	Indirect effect via (PH) ($r_{13}P_{15}$)	0.87
	Indirect effect via (EH) ($r_{23}P_{25}$)	0.05
	Indirect effect via (NKPR) ($r_{34}P_{45}$)	-0.06
	Total	0.87*
4	(NKPR) vs. grain yield (r_{45})	0.80*
	Direct effect (P_{45})	-0.07
	Indirect effect via (PH) ($r_{14}P_{15}$)	0.82
	Indirect effect via (EH) ($r_{24}P_{25}$)	0.05
	Indirect effect via (100SWT) ($r_{34}P_{35}$)	0.01
	Total	0.80*

Residual effect (R_{X5}) = 0.60
Key: PH = plant height (EH) = ear height, 100SWT = hundred seed weight (NKPR) = number of kernel per row.

DISCUSSION

The results of heritability analysis showed that most of the variables studied displayed high values of broad sense heritability. These results are in line with those reported by Munawar *et al.* (2013), and Kumar *et al*. (2014) on maize. Plant height with broad sense heritability of 98.37% was also reported by Khalil *et al.* (2011) and Kapoor and Chinka (2015) on wheat and maize. High heritability 0.87 for grain yield had been reported by Shahrokhi *et al*. (2013) on maize. However Yagdi and Sozen (2009) reported low heritability for plant height in their study on wheat. Likewise, Miti *et al*. (2010) reported low heritability 0.32 on grain yield for maize grown under low nitrogen conditions. Such a contrasting findings could be attributed to differences in populations as well as environmental conditions. Majumder *et al*. (2008) and Devi *et al*. (2013) reported high heritability for plant height, grain yield and hundred seed weight on wheat and maize respectively.

The present investigation revealed high heritability estimates for grain yield per plant, plant height, ear height, hundred grain weight, days to 50 per cent silking which is similar to the results obtained by Vashistha *et al*. (2013) on maize. Tengan *et al*. (2013) reported high broad sense heritability estimates for plant height (95%), ear height (81%) on maize. High estimates of broad sense heritability values is an indication of less environmental effects on phenotypic variation observed in this study and therefore selection based on those characters can be effective in improving maize breeding programme.

The magnitude of genotypic coefficient of variation values for all traits were higher than the corresponding phenotypic coefficients of variation values. This indicates that these characters are influenced more by genetic effects. Similar results were reported by Munawar *et al*. (2013) in maize. However kadri *et al*. (2010) observed that phenotypic coefficient of variation was higher than genotypic coefficient of variation in *Eruca* spp. High genotypic coefficient of variation on plant height, ear height, number of kernels per row and hundred seed weight obtained in this study are similar to the findings done by Kumar *et al*.(2014) on maize. High genotypic coefficient of variation has also been reported by Vashistha *et al*. (2013) on anthesis silking interval, grain yield, ear height, harvesting interval, number of grains per cob, number of grains per row, and hundred seed weight thus offers scope for genetic improvement through selection. The higher values of genotypic variance and genotypic coefficient of variance obtained in this study indicated that these traits can be used for selecting maize landraces for traits of interest.

Genotypic correlations coefficient of yield and yield components

Genotypically grain yield correlated significantly and positively with number of kernels per row (0.80) which agrees with findings of Wannows *et al*. (2010) who found positive significant genetic correlation of grain yield with number of kernels per row in maize.

Number of kernels per row showed significant positive correlation with hundred seed weight genotypicaly. Similar results were obtained by Yousuf and Saleem (2001) on maize. The trend of relationship of hundred grain weight with grain yield was positive and significant at genotypic level.

Therefore selection based on these traits would be effective for increasing grain yield. Similar results were obtained by Dilruba *et al*. (2014) and Reddy *et al*. (2013) on maize and rice. Grain yield was significantly negatively correlated with ear height (-0.91) at genotypic which is similar with results obtained by Olakojo and Olaoyeet (2011) in maize. Implying that as you select plants with low ear height you reduce grain yield at the same time for the genotypes under study. Plant height displayed significant and positive correlation with ear height at genotypic levels. Similar results were observed by Rafiq *et al*.(2010) on maize.

From this study the correlation coefficients of the pairs of characters revealed the presence of significant and positive correlation of grain yield with number of kernels per row and hundred seed weight. This indicated that increasing these attributes, could increase grain yield. Moreover, number of kernels per row, hundred seed weight and grain yield were associated positively among themselves significantly, suggesting that selection for yield improvement can be done by selecting for number of kernels per row and hundred seed weight without much compromization. However if traits have high positive correlations among themselves but no direct effects on grain yield would expect to be of no usefulness in selection programme for high grain yield genotypes.

Path coefficient analysis

Results on path coefficient analysis revealed that hundred seed weight correlated significantly and positively with grain yield and had indirect effects via plant height thus hundred seed weight interacts well with plant height in determining yield. Aslam *et al*. (1992) reported similar results on soybean. However the direct effect of hundred seed weight on grain yield was positive, but very low which do not qualify to be considered on yield increase.

Genotypic correlations between number of kernels per row and grain yield was significant positive due to indirect effect of number of kernels per row via plant height. Therefore selection for more number of kernels per row automatically will increase grain yield. Similar results reported by Ahmad and Saleem, (2003) on maize. This study suggests that selection for tall plants with high number of kernels per row and with heavier hundred seed weight will increase grain yield.

Acknowledgement

Sustainable Intensification of Maize-Legume for Eastern and Southern Africa (SIMLESA) for financial support for this study. Selian Agricultural Research Institute (SARI) scientists and technicians for technical support and provision of the land to conduct this study.

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How to cite this article:

Nestory S *et al* (2017) 'Correlation And Path Analysis Of Yield And Yield-Contributing Traits Of Maize Landraces', *International Journal of Current Advanced Research*, 06(10), pp. 6548-6552.
DOI: http://dx.doi.org/10.24327/ijcar.2017.6552.0964

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