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Research Article

Genetic variability and correlation studies of yield and phytic acid in F_2 populations of maize (*Zea mays* L.)

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Abstract
A genetic study in the F_2 populations of three crosses *viz,* UMI1200 x UMI1099, UMI1201 x UMI1099 and UMI1210 x UMI1099 was carried out in Kharif 2017. The genetic parameters studied include genotypic and phenotypic coefficient of variances, heritability, genetic advance as percent of mean and correlation coefficient. Performance of the individual genotypes of all the three F_2 populations for 17 traits including seed yield and phytic acid revealed the presence of significant difference among genotypes, indicating the presence of genetic variability. Marginal difference between genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) indicated that variability was due to genetic factors for most of the traits studied. Traits that exhibited high heritability along with high genetic advance as percentage of mean (GAM) which can be used for selection were identified. Association studies depicted that plant height, cob placement height, cob length, cob breadth, number of rows per cob, number of kernels per row, cob weight, hundred kernel weight and shelling percentage exhibited positive correlation with yield. Correlation between yield and phytic acid content was found to be non-significant in the current study which revealed that selection can be progressed in both directions independently and its possible to obtain inbreds with low phytic acid content and high yield in the later generations through effective breeding and selection strategies.

Key words
Maize, Variability, Association, Phytic acid, Yield

Introduction

Maize *(Zea mays L.)* is a cereal grain said to be first domesticated by indigenous people of South Mexico about 10,000 years ago. It is known as “Queen of Cereals” and is a diploid (2n=2x=20) annual grass belonging to Poaceae family. Maize is one of the most valuable cultivated crop because of its high productivity and multiple uses. Maize has ample amount of both macro and micro nutrients. Macro nutrients include carbohydrates (70%), proteins (10%), oil (4%), fat (5-7%) and micronutrients include minerals, tocopherols, carotenoids, anthocyanins, phenolic compounds and phytic acid.

Among the maize nutrients the ‘double-edged sword’ is phytic acid. Phosphorous in plant seeds is mostly stored in the form of phytic acid. Phytic acid (*myo*-inositol-1, 2, 3, 4, 5, 6-hexa*kis* phosphate or Ins P_6) typically represents approximately 75% to 80% of maize (*Zea mays*) seed total phosphorous content. It is deposited as mixed phytin salts of mineral cations such as K, Mg, Fe and Zn. Ins P_6 is a strong chelator of mineral cations like iron, zinc, manganese and to a lesser extend calcium forming mixed salts (Hallberg *et al.*, 1989). Phytates also reduce the digestibility of starch, protein, fats and slow down their absorption. Removal of phytic acid increases bioavailability of many cations and thus the nutritional value of the meal. Genetic and molecular studies in phytic acid content in maize kernels has contributed to use of this trait as a modifiable source and incorporate it into high yielding lines to develop high yielding low phytic acid cultivars by backcross breeding methods. As an effort in this direction of developing best inbreds with high yield and low phytic acid content, the present study is an attempt to study the segregating F_2 population of three previously identified *lpa* x high yield crosses to obtain information on genetic parameters and association between yield, phytic acid and their components that could be useful in formulating efficient breeding programmes.

Material and Methods

Three F_2 populations of three low phytate crosses *viz;* UMI1200 x UMI1099, UMI1201 x UMI1099 and UMI1210 x UMI1099 were evaluated during *Kharif* 2017 in the experimental fields of Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore using standard agronomic practices. All segregants were individually tagged and biometrical observations *viz.*, Days to Tasseling, Days to Silking, Anthesis Silking Interval, Plant

Height (cm), Cob placement height (cm), Tassel Length (cm), Number of Tassel Branches, Cob Length (cm), Cob Breadth (cm), Number of Rows per Cob, Number of Kernels per Row, Cob Weight (g), Hundred Kernel Weight (g), Shelling Percentage (%) and Single Plant Yield (g) were recorded for each plant individually. Two biochemical traits *viz.*, Phytic Acid (mg/g), Inorganic Phosphorous (mg/g) were measured using dried seed samples. The individual data obtained were recorded and used for statistical analysis.

Biometrical observations were taken up both during vegetative and reproductive stage at field and cob traits were recorded after harvesting following the methods used by Najar *et al.*, 2018; Yadav, 2005; Yadav and Singh, 2010. The seeds after harvest were dried and subjected to biochemical analysis following modified methods by Davies and Reid, 1979.

Phenotypic and genotypic variance were calculated from the data according to Goulden (1939) and Empig (1970). PCV and GCV were calculated by formulae suggested by Burton (1925). Heritability and genetic advance as percentage of mean were estimated using formulae given by Hanson *et al.*, (1956);). Association analysis between yield, phytic acid and component traits were worked out according to Johnson *et al.*, 1955.

Results and Discussion

There was significant difference between the genotypes for all the traits under study. Estimates of phenotypic and genotypic variances (PV and GV), phenotypic and genotypic coefficients of variability (PCV and GCV), heritability and genetic advance as percent of mean for different characters were calculated and given in Table1.

Cob weight recorded highest PV (833.60) and GV (833.23) while inorganic phosphorous content recorded the lowest (0.14, 0.12). The phenotypic and genotypic coefficient of variations were high for plant height (164.83,152.05), cob placement height (225.45,184.02), tassel length (81.53,80.27), number of tassel branches (49.18,40.76), cob length (40,38.94), cob breadth (29.20,28.40), number of rows per cob (30.30,23.25), number of kernels per row (222.03,219.10), cob weight (574.46,574.20), hundred kernel weight (210.07,181.27), shelling percentage (58.96,57.27), phytic acid (60.82,60.34) and single plant yield (625.53,622.70). Similar works done before reported that marginal difference between GCV and PCV revealed that variability was due to genetic factors whereas environmental effects were predominant in traits like days to tasseling and silking. Therefore selection based on genetically controlled, less influenced by environment characters is effective.

Heritability gives the contribution of genetic causes to the phenotypic variance and predicts the extent to which it is transmitted to further generations. High heritability does not always indicate a high genetic gain, heritability is recommended to be considered in association with genetic advance to identify the selection criteria.

Heritability and GAM studies on quantitative and biochemical traits in the F_2 population of all three crosses indicated that high heritability was reported by all the traits except Anthesis Silking Interval. The genetic advance represents the genetic gain under selection pressure. High GAM was shown by 12 traits *viz.*, cob placement height (23.02), tassel length (30.96), number of tassel branches (37.24), cob length (33.86), cob breadth (30.36), number of rows per cob (24.62), number of kernels per row (62.94), cob weight (40.97), hundred kernel weight (43.09), phytic acid (45.85), inorganic phosphorous (119.66) and single plant yield (47.25). Utilizing traits with high heritability and high genetic advance as percent of mean can lead to effective selection. The results obtained were in accordance to similar works reported by Najeeb *et al.*, 2009 and Bello *et al.*, 2010. Hence, the selection of genotypes based on above traits will transmit their genetic potential to the next generation efficiently.

Correlation studies provide the extent and direction of relationship between yield and its attributes which helps in formulating best selection indices for the breeding programmes. In the present study, phenotypic correlation coefficient among pairs of characters has been calculated to identify the component traits closely related to yield and phytic acid content and given in Table 2.

The single plant yield showed significant and positive correlation with plant height (0.76), cob placement height (0.136), cob length (0.381), cob breadth (0.330), number of rows per cob (0.363), number of kernels per row (0.546), cob weight (0.969), hundred kernel weight (0.446) and shelling percentage (0.427). Therefore increase in any of the characters results in increase of single plant yield.

Phytic acid is the main storage form of phosphorus in plants. It reduces the bioavailability of phosphorous for absorption by monogastric animals such as poultry. Phytic acid had no significant correlation with yield. It was in agreement with result that *lpa* mutations had little or no effect on yield and can be used to breed crops with substantially enhanced nutritional quality (Raboy *et al.,* 2015). It had a significant negative correlation with hundred kernel weight (-0.142). Negative correlation between hundred kernel weight and phytic acid (PA) indicated that, simultaneous improvement in different directions is possible for these traits which was also reported by Dhole and Reddy (2015). Breeding programmes have to be formulated to break the undesirable linkage between seed weight and phytic acid to end up with high yield and low phytic acid in grains. Phytic acid content reported a significant and negative correlation with inorganic phosphorous content (-0.924). Similar studies done showed that this negative relation was the reason why total phosphorus content remained same but as the phytic acid content decreased, the available phosphorous get increased. (Raboy, 1990; Vitali *et al.*, 2008)

Shelling percentage showed a positive correlation with number of kernels per row (0.222), cob weight (0.206) and hundred kernel weight (0.171). Hundred kernel weight had positive and significant correlation with number of kernels per row (0.111) and cob weight (0.445) which was supported by research findings of Khayatnezhad *et al.* (2010). It also showed significant negative correlation with number of rows per cob (-0.204) which was similar to the result obtained by Sesay *et al. (*2017). Cob weight had positive significant correlation with plant height (0.760), cob length (0.386), cob breadth (0.299), number of rows per cob (0.344) and number of kernels per row (0.532). This results were in accordance with Malik *et al.* (2005); Nataraj *et al.* (2014). Number of kernels per row was positively correlated with plant height (0.152), cob length (0.630), cob breadth (0.274) and number of rows per cob (0.112). Similar trend was seen in works of Munawar *et al.* (2013); Rafiq *et al.* (2010). Number of rows per cob had significant positive correlation with cob breadth similar to studies by Mohammadi *et al.* (2003). It also had negative correlation with days to silking (-0.147) and days to tasseling (-0.135) which was similarly reported by Sesay *et al.* (2017). Cob breadth had significant positive correlation with cob placement height and cob length (Raghu *et al.*, 2011; Saidaiah *et al.*, 2008). Cob length was positively correlated with plant height and cob placement height. This was supported by works of Chakraborti *et al.*, (2009). Cob placement height was positively correlated to plant height (0.610) which was similar to reports by Nzuve *et al.* (2014); Salami *et al.* (2007); Tengan *et al.* (2012). Plant height was negatively correlated with days to silking (-0.075) and days to tasseling (-0.093). Days to silking and days to tasseling were positively correlated (0.956). These were supported by Kashiani and Saleh, (2010); Pavan *et al.* (2011). Thus high yield can be achieved by using characters that have positive correlation with single plant yield as selection indices.

Lpa maize has a lot of scope for future research. The data obtained in this study can be utilized as a tool to produce high heterotic impact groups. Heterotic groups that have significant divergence can be used to develop elite inbreds and use them to produce hybrids with high heterotic potential for required characters. Negative linkage between high yield and high phytate content can be broken to develop best inbreds with high yield and low phytic acid content and thus reduce the phytic acid induced nutritional and environmental problems. This research will also lead to develop lpa inbreds which in turn will help in development of lpa hybrids. Thus the reduction of cost of feed in poultry sector may be achieved and bioavailability of the feed may be increased.

References

Burton, G. (1925). Quantitative inheritance in pearl millet (*P. typhoides* L.). *Agronomy J, 50*, 503.

Chakraborti, M., Hossain, F., Kumar, R., Gupta, H., and Prasanna, B. (2009). Genetic evaluation of grain yield and kernel micronutrient traits in maize. *Pusa AgriScience Vol.* ***32***, 11-16.

Davies, N. T., and Reid, H. (1979). An evaluation of the phytate, zinc, copper, iron and manganese contents of, and zn availability from, soya-based textured-vegetable-protein meat-substitutes or meat-extenders. *Br J Nutr,* ***41***(3), 579-589.

Dhole, V. J., and Reddy, K. S. (2015). Genetic variation for phytic acid content in mungbean (Vigna radiata L. Wilczek). *The Crop Journal,* **3(**2), 157-162.

Empig, L., Lantican, R., and Escuro, P. (1970). Heritability Estimates of Quantitative Characters in Mung Bean (Phaseolus aureus Roxb.) *Crop science*, **10** (3), 240-241.

Goulden, C. H. (1939). *Methods of statistical analysis*. 25-26.

Hallberg, L., Brune, M., and Rossander, L. (1989). Iron absorption in man: ascorbic acid and dose-dependent inhibition by phytate. *The American journal of clinical nutrition*, **49**(1), 140-144.

Hanson, C., Robinson, H., and Comstock, R. (1956). Biometrical Studies of Yield in Segregating Populations of Korean Lespedeza *Agronomy journal,* **48** (6), 268-272.

Johnson, H. W., Robinson, H., and Comstock, R. (1955). Estimates of Genetic and Environmental Variability in Soybeans. *Agronomy Journal,* **47** (7), 314-318.

Kashiani, P., and Saleh, G. (2010). Estimation of genetic correlations on sweet corn inbred lines using SAS mixed model. *Am J Agric Biol Sci, 5***(**3), 309-314.

Khayatnezhad, M., Gholamin, R., Jamaati-E-Somarin, S., and Zabihi-E-Mahmoodabad, R. (2010). Correlation coefficient analysis between grain yield and its components in corn (Zea mays L.) hybrids. *American-Eurasian J. of Agriculture and Environmental Science,* **9** (1), 105-108.

Malik, H., Malik, S. I., Hussain, M., Chughtai, S. R., and Javed, H. I. (2005). Genetic correlation among various quantitative characters in maize (Zea mays L.) hybrids. *Journal of Agriculture and Social Sciences, 3***,** 262-265.

Mohammadi, S., Prasanna, B., and Singh, N. (2003). Sequential path model for determining interrelationships among grain yield and related characters in maize. *Crop Science,* **43(**5), 1690-1697.

Munawar, M., Shahbaz, M., Hammad, G., andYasir, M. (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), 22-27.

Najar, Z. A., Sheikh, F. A., Najeeb, S., Shikari, A. B., Ahangar, M. A., Sheikh, G. A., and Wani, S. H. (2018). Genotypic and morphological diversity analysis in high altitude maize (*Zea mays* L.) inbreds under Himalayan temperate ecologies. *Maydica,* **63** (1), 7.

Najeeb, S., Rather, A., Parray, G., Sheikh, F., and Razvi, S. (2009). Studies on genetic variability, genotypic correlation and path coefficient analysis in maize under the high altitude temperate conditions of Kashmir. *Maize Genetics Cooperation Newsletter* (83).

Nataraj, V., Shahi, J., and Agarwal, V. (2014). Correlation and path analysis in certain inbred genotypes of maize (Zea mays L.) at Varanasi. *International Journal of Innovative Research and Development,* **3**(1).

Nzuve, F., Githiri, S., Mukunya, D., and Gethi, J. (2014). Genetic variability and correlation studies of grain yield and related agronomic traits in maize. *Journal of Agricultural Science,* **6** (9), 166.

Pavan, R., Lohithaswa, H., Wali, M., Prakash, G., and Shekara, B. (2011). Research Note 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,* **2** (2), 253-257.

Raboy, V. (1990). The biochemistry and genetics of phytic acid synthesis. *Inositol metabolism in plants,* 52-73.

Raboy, V., Peterson, K., Jackson, C., Marshall, J. M., Hu, G., Saneoka, H., and Bregitzer, P. (2015). A Substantial Fraction of Barley (Hordeum vulgare L.) Low Phytic Acid Mutations Have Little or No Effect on Yield across Diverse Production Environments. *Plants (Basel),* **4** **(**2), 225-239. doi: 10.3390/plants4020225

Rafiq, C. M., Rafique, M., Hussain, A., and Altaf, M. (2010). Studies on heritability, correlation and path analysis in maize (*Zea mays* L.). *J. Agric. Res,* **48**(1), 35-38.

Raghu, B., Suresh, J., Kumar, S. S., and Saidaiah, P. (2011). Character association and path analysis in maize (*Zea mays* L.). *Madras Agricultural Journal,* **98**(1-3), 7-9.

Saidaiah, P., Satyanarayana, E., and Kumar, S. S. (2008). Association and path coefficient analysis in maize (*Zea mays* L.). *Agricultural Science Digest,* **28**(2), 79-83.

Salami, A., Adegoke, S., and Adegbite, O. (2007). Genetic variability among maize cultivars grown in Ekiti-State, Nigeria. *Middle-East J. Sci. Res, 2***(**1), 09-13.

Sesay, S., Ojo, D. K., Ariyo, O. J., Meseka, S., Fayeun, L. S., Omikunle, A. O., and Oyetunde, A. O. (2017). Correlation and path coefficient analysis of top-cross and three-way cross hybrid maize populations.*African Journal of Agricultural Research,***12***(10),* 780-789

Sharma, R., Maloo, S., and Joshi, A. (2014). Research Note Genetic variability analysis in diverse maize genotypes (*Zea mays* L.). *Electronic Journal of Plant Breeding, 5***(**3), 545-551.

Sujiprihati, S., Saleh, G. B., and Ali, E. S. (2003). Heritability, performance and correlation studies on single cross hybrids of tropical maize. *Asian J. Plant Sci,* **2**(1), 51-57.

Tengan, K., Obeng-Antwi, K., and Akromah, R. (2012). Genetic variances, heritability, and correlation studies on selected phenotypic traits in a backcross breeding program involving normal and opaque-2 maize. *Agriculture and Biology Journal of North America,* **3**(7), 287-291.

Vitali, D., Vedrina Dragojevic, I., and Sebecic, B. (2008). Bioaccessibility of Ca, Mg, Mn and Cu from whole grain tea-biscuits: Impact of proteins, phytic acid and polyphenols. *Food Chem*, **110**(1), 62-68. doi: 10.1016/j.foodchem.2008.01.056

Yadav, V. K. (2005). *Distinctness, Uniformity And Stability (Dus) Testing Of Maize (Zea Mays L.) In-Bred Lines By Using Morphological And Molecular Markers.* Govind Ballabh Pant University of Agriculture and Technology; Pantnagar.

Yadav, V. K., and Singh, I. S. (2010). Comparative evaluation of maize inbred lines (Zea mays L.) according to DUS testing using morphological, physiological and molecular markers. *Agricultural Sciences*, **1**(03), 131.

Table 1. Estimates of variability parameters for different traits in maize F_2 genotypes

Characters	Mean	PV	GV	PCV	GCV	h^2	GA	GAM
Days to Tasseling	52.11	4.51	3.06	8.65	5.86	67.82	2.97	5.69
Days to Silking	54.95	4.27	3.29	7.77	5.99	77.05	3.28	5.97
Anthesis Silking Interval	2.84	0.21	0.18	18.01	2.89	16.07	0.24	8.33
Plant Height	192.03	316.53	291.97	164.83	152.05	92.24	33.81	17.61
Cob Placement Height	120.26	271.13	221.30	225.45	184.02	81.62	27.69	23.02
Tassel Length	34.99	28.52	28.08	81.53	80.27	98.45	10.83	30.96
Number of Tassel Branches	10.33	5.08	4.21	49.18	40.76	82.88	3.85	37.24
Cob Length	14.03	5.61	5.46	40.00	38.94	97.34	4.75	33.86
Cob Breadth	12.72	3.71	3.61	29.20	28.40	97.24	3.86	30.36
Number of Rows Per Cob	12.49	3.78	2.90	30.30	23.25	76.74	3.07	24.62
Number of Kernels Per Row	23.16	51.42	50.74	222.03	219.10	98.68	14.58	62.94
Cob Weight	145.2	833.60	833.23	574.46	574.20	99.96	59.45	40.97
100 Kernel Weight	35.75	75.10	64.81	210.07	181.27	86.29	15.41	43.09
Shelling Percentage	80.98	47.75	46.38	58.96	57.27	97.13	13.83	17.07
Phytic Acid	12.09	7.35	7.29	60.82	60.34	99.21	5.54	45.85
Inorganic Phosphorous	0.34	0.14	0.12	11.76	11.68	99.34	0.41	119.66
Single Plant Yield	117.84	737.16	733.82	625.53	622.70	99.55	55.68	47.25

PCV- Phenotypic Coefficient of Variation; GCV- Genotypic Coefficient of Variation ; h^2 – Heritability; GA-Genetic Advance; GAM-Genetic Advance as percentage of Mean

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Table 2. Correlation coefficients between yield, phytic acid and its component traits in F_2 maize progenies

N=696	DT	DS	ASI	PH	CH	TL	NTB	CL	CB	NRPC	NKPR	CW	100KW	SP	PA	IP	SPY
DT	1	.956**	-0.038	-.075*	-0.04	0.06	-0.036	0.039	-0.003	-0.147*	0.008	0.023	0.023	0.067	-0.021	0.014	0.041
DS		1	.257**	-.093*	-0.033	0.053	-0.039	0.016	-0.008	-0.135*	-0.009	0.029	0.028	0.07	-0.037	0.027	0.047
ASI			1	-0.068	0.015	-0.019	-0.018	-.076*	-0.015	0.036	-0.053	0.026	0.022	0.027	-0.057	0.045	0.029
PH				1	.610**	0.001	-0.025	.245**	0.104	.081*	.152**	.076*	-0.034	0.04	0.093	-0.079	.076*
CH					1	-0.032	-0.062	.135**	.152**	.152**	.094*	.134**	0.027	0.059	0.014	-0.026	.136**
TL						1	.160**	0.028	0.038	0.016	0.018	-0.043	-0.029	-0.053	0.01	0.008	-0.056
NTB							1	-0.002	0.064	-0.018	0.036	0.008	-0.02	-0.087	-0.029	0.035	-0.018
CL								1	.199**	.083*	.630**	.386**	-0.04	0.117	-0.01	0.008	.381**
CB									1	.742**	.274**	.299**	-0.159	0.217	0.004	-0.012	.330**
NRPC										1	.112**	.344**	-.204**	0.19	0.025	-0.026	.363**
NKPR											1	.532**	.111**	.222**	-0.138	0.099	.546**
CW												1	.445**	.206**	-0.152	0.116	.969**
100KW													1	.171**	-.142**	0.137	.446**
SP														1	-0.078	0.006	.427**
PA															1	-.924**	-0.159
IP																1	0.106
SPY																	1

DT- Days to Tasseling; **DS**- Days to Silking; **ASI**-Anthesis Silking Interval; **PH**-Plant Height(cm); **CH**-Cob placement height(cm); **TL**-Tassel Length(cm); **NTB**-Number of Tassel Branches; **CL**-Cob Length(cm); **CB**-Cob Breadth(cm); **NRPC**-Number of Rows per Cob; **NKPR**-Number of Kernels per Row; **CW**-Cob Weight(g); **100KW**-Hundred Kernel Weight(g); **SP**-Shelling Percentage(%); **PA**-Phytic Acid(mg/g); **IP**- Inorganic Phosphorous(mg/g);**SPY**-Single Plant Yield(g)

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).