Correlation between Agronomic and Chemical Characteristics of Maize (*Zea Mays* L.) Genotypes after Two Years of Mass Selection

Chukwu, S.C.[1], L. G. Ekwu[2], G.C. Onyishi[3], E.O. Okporie[4], I.U. Obi[5]

[1, 2, 4]Department of Crop Production and Landscape Management, Ebonyi State University, Abakaliki

[3]Department of Crop Science and Technology, Federal University of Technology, Owerri

[5]Department of Crop Science, University of Nigeria, Nsukka

Abstract: ***This particular study was carried out to determine the degree of relationship existing between agronomic and chemical characteristics of the 71 maize genotypes in order to provide information that would guide the choice of parents for developing synthetics or hybrids with high agronomic and nutritional values. Correlation analysis was used to monitor the relationships that existed between different agronomic and chemical traits of the genotypes and correlation co-efficient (r) was determined using SPSS 2007 version.Results obtained in both two planting seasons of 2013 and 2014 showed that plant height had positive correlation with yield components such as number of tassels/plant, number of ears, number of rows/cob and number of seeds/row, cob length and circumference.However, there was no significant correlation between agronomic and chemical characteristics measured, especially the yield components, except number of seeds per row and oil which correlated positively. Also, significant and negative correlation was observed between amylose and amylopectin. The negative but non-significant correlation between protein and lysine implies that more and effective selection pressure on the genotypes could cause them to be uncorrelated. Since no significant relationship existed between chemical characteristics and most agronomic traits, it indicated that good chemical quality such as high protein as well as high oil maize can be bred and selected without necessarily affecting the agronomic traits such as plant and ear heights.***

Keywords: Correlation, Genotype, Agronomic Character, Chemical Character, Selection

1. Introduction

Maize (*Zea mays* L.) has been described as a golden crop because every part of the crop is useful to man and his animals [1]. It is a major cereal crop for human nutrition, worldwide. Maize has a very wide and various utilizations and because of that, the main goal of all maize breeding programmes is to obtain new varieties (composites, synthetics, inbred lines, hybrids, etc) that will outperform the existing varieties with respect to yield and/or other traits. In working towards this goal, particular attention is paid to grain yield as the most important agronomic trait. Besides, attention should be paid to the quality of kernel itself, i.e., chemical composition, quantity and quality, mainly if we take into consideration one of the most important maize uses in developing countries as human consumption [2].

Maize grains, nutritionally, is known to be predominantly carbohydrate but has small proportions of protein, oil, amylose, amylopectin and other minerals [3, 1, 4]. The nutritional well-being and health of all people are vital prerequisites for the development of societies. Significant advances have been made in genetic enhancement of crop plants for nutritional value. However, malnutrition still remains a widespread problem, and is particularly severe in developing countries with low per capita income. Globally, nearly 200 million children below five years are undernourished for protein, leading to a number of health problems, including stunted growth, weakened resistance to infection and impaired intellectual development.

The total protein content of maize grain is highly elastic. Typical maize lines consist of 8-12% protein, but selection has resulted in a high protein line with over 32% protein and a low protein line with 4% protein [5]. Even though high protein is possible in maize, selection for yield has increased starch and decreased total protein [6]. While total protein content in maize varies, in monogastric diets, maize is nutritionally limited by deficiencies in lysine and tryptophan[7].High oil maize hybrids have a different chemical structure and higher agronomic value than standard maize hybrid. High oil maize is used in pharmaceutical industry to get quality maize oil and it is attractive in curing coronary heart diseases of man [8]. Previous studies of maize conventional hybrids have generally indicated that genetic factors have a greater influence on oil content than environmental factors. Oil content is an important trait of maize grains to be considered when the crop is used as animal feed since oil has more calorific value than starch [9].

Medici *et al.* [10] observed a positive correlation between lysine and oil contents in the hybrids, in the lines and even in the control cultivars. Cervants*et al.* [11] found that a high (r = 0.97) and significant (P = < 0.01) correlation coefficient between the real protein (some of the contents of all amino acids) and the crude protein content in the cereals.Sreckov*et al.* [12] studied the correlation between grain yield and oil content in two testcross populations of maize. They found, in both studied populations, that grain yield showed low correlation with kernel oil content. The relationship was negative (r = -0.110) with the first population (NSU1 x B73), while in the second population (NSU1 x 568/II NS) grain yield was positively associated with kernel oil content. Normal starch consists of two types of polysaccharide: amylose and amylopectin. Among a variety of starch cultivars, maize starch has been of particular scientific interest since this kind of starch with different amylose and amylopectin ratios can be directly provided by the nature/agriculture [13].

Mittelmann*et al.* [14] evaluated the grain yield and grain oil content of 10 maize genotypes and their hybrids in a field experiment. The means of the populations varied from 4.22 to 4.94% for oil yield in a dry matter basis, and this variation was independent of the variation for grain yield. Therefore.theobjective of this particular study was to determine the degree of relationship existing between agronomic and chemical characteristics of the maize genotypes in order to provide information that would guide the choice of parents for developing synthetics or hybrids with high agronomic and nutritional values.

2. Materials and Methods

2.1 Location

This research was carried out at the teaching and research farm of the department of Crop Production and Landscape Management, Ebonyi State University, Abakaliki, Nigeria. The study region falls within the tropical rain forest zone of south-eastern Nigeria and it's located between latitude $06^0 4^I$N and longitude 08^0 65^IE at the elevation of 71.44mm above sea level. It has a bimodal rainfall pattern and its rainfall per annum ranges between 1700-2000mm which is between April to July and August to November for early and late season plantings, respectively. The relative humidity at dry season ranges between 60-80% [15] and the soil belongs to the order ultisols.

2.2 Genotypes

Seventy one genotypes sourced from different parts of Nigeria were evaluated in a randomized complete block design (RCBD) with three replications. The experimental plot for the first year planting season of 2013 measured 55.5m x 17m with row length of 5.25m in each block, comprising twenty hills per row. All the 71 genotypes were planted out in the field in anear to row progenies fashion on a well pulverized flat plot on Saturday, 18^{th} May, 2013. The initial seed rate was two seeds per hill but later thinned down to one plant per hill. The planting spacing was 25cm x 75cm within and between rows, respectively at one seed per hill, giving a theoretical plant population of 53,333 per hectare. Sowing was done on flat drills after ploughing and harrowing using a tractor as applicable under conventional tillage system.

The tassel-bag-shoot-bag method of hand pollination as described by Obi [8] was used to self individual maize plants. Phenotypically desired plants were self-pollinated and each self-pollinated plants was covered with the tassel bag to avoid any form of pollen contamination. A similar procedure was followed to obtain selfs in the three blocks.Agronomic characteristics measured and recorded include plant and ear heights, days to 50% tasselling and silking, number of tassels and ears per plant, number of rows/cob, cob length and circumference, 100-seed weight and kernel density at 15.5% moisture content.The crude protein of the maize samples was determined by the micro Kjedahl method as described by Pearson [16].Lysine contents in the samples were determined using the modified Obi [17]method.Amylose content in the maize samples was determined by the method described by AOAC [18].Proximate system for food analysis that employs the continuous solvent extraction using soxhlet's extractor as described by AOAC [18] was used in determining the percentage oil content of the maize samples.

All the progeny seeds (selfs) of the 71 genotypes were planted out again in isolation in the second year planting season of 2014 in order to allow each genotype to random mate, so as to enhance exchange of genetic materials and increase genetic variability. The genotypes were evaluated for agronomic traits and desired agronomic attributes were measured both in the field and off the farm and harvesting of the open pollinated ears were done at the 135 DAP using black layer formation and browning of the husk as signs of maturity[19, 8].

2.3 Data Analysis

Correlation analysis [20]was used to monitor the relationships that existed between different agronomic and chemical traits of the genotypes. Correlation co-efficient was determined using SPSS, 2007. Correlation co-efficient (r) is given by the equation:

$$r = \frac{\sum xy}{\sqrt{\sum x^2 . \sum y^2}} = \frac{Cov\,(XY)}{\sqrt{\sum x^2 . \sum y^2}} \quad (1)$$

$$\text{Where:} \sum xy = \sum X_i Y_i - \frac{\sum X_i . \sum Y_i}{n}; \quad \sum x^2 = \sum X^2_i - \frac{\sum (X_i)^2}{n}; \quad \sum y^2 = \sum Y^2_i - \frac{\sum (Y_i)^2}{n}$$

3. Results

Result obtained on the correlation analysis between agronomic and chemical characteristics of the 71 genotypes is as presented in Table1. Plant height correlated positively and significantly with ear height (r = .941**), days to 50% tasselling and silking (r = .720** and .746**), number of tassels (r = .672**), number of ears (r = .254**), cob length (r = .716**), cob circumference (r = .395**), number of rows/cob (r = .424**), number of seeds/row (r = .608**). Number of tassels also had positive and significant correlation with cob length (r = .414**), number of seeds/row (r = .352**) but negatively correlated with 100-seed weight (r = -.272*). Cob length also correlated positively and significantly with cob circumference (r = .242*), number of seeds/row (r = .708**). Cob circumference had positive and significant correlation with number of rows/cob (r = .478**) while number of rows/cob correlated positively and significantly with number of seeds/row (r = .307**). Result also showed that number of seeds/row had positive and significant correlation with oil (r = .320**). Negative and significant correlation was observed between amylose and amylopectin (r = -1.000**).

The result obtained on correlation analysis of the 71 genotypes after the second year evaluation is as presented in Table 2. Plant height correlated positively and significantly with ear height (r = .829**), days to 50% tasselling and silking (r = .376** and .357**) and number of tassels (r = .481**). Cob length had positive and significant correlation with cob circumference (r = .351**) and number of seeds/row (r = .425**). Cob circumference correlated positively and significantly with number of rows/cob (r = .512**) while number of rows/cob correlated positively and significantly with number of seeds/row (r = .399**). The correlation analysis also indicates that 100-seed weight had positive and significant correlation with kernel density (r = .745**).

Table 1: Correlation co-efficients of the agronomic and chemical traits in 2013 cropping season

	Plant ht.	Ear ht.	50% tas-selling	50% silking	Tassel No./ plant	Ear No./ Plant	Cob length	Cob circf.	Row No./ cob	Seed No. /row	100 seed wt.	Kernel dens.	Protein	Lysine	Oil	Amy-lose	Amy-lopec
Plant ht.	I																
Ear ht.	.941**	I															
50% tassel.	.720**	.730**	I														
50% silk.	.746**	.734**	.904**	I													
Tassel no.	.672**	.671**	.667**	.690**	I												
Ear no.	.254*	.219	.195	.238*	.053	I											
Cob length	.716**	.664**	.544**	.523**	.414**	.229	I										
Cob circf.	.395**	.296*	.208	.335**	.184	.147	.242*	I									
Row no.	.424**	.405**	.375**	.359**	.220	.012	.223	.478**	I								
Seed no.	.608**	.579**	.432**	.432**	.352**	.203	.708**	.094	.307**	I							
100seed wt	-.106	-.103	-.174	-.164	-.272*	.122	.050	-.048	-.049	-.013	I						
Kernel den	-.076	-.131	-.112	-.093	-.144	-.001	-.125	.009	-.153	-.092	.089	I					
Protein	-.127	-.125	-.204	-.162	-.156	.031	-.159	-.175	-.015	-.130	.184	-.008	I				
Lysine	.006	-.035	.024	.034	.049	.031	-.066	.167	-.138	-.100	-.034	.141	-.529**	I			
Oil	.147	.167	.157	.085	.046	.126	.170	-.088	.166	.320**	.003	-.239*	-174	.012	I		
Amylose	-.286*	-.302*	-.097	-.143	-.145	-.118	-.056	-.187	-.101	-.144	.129	.083	.067	-.014	.170	I	
Amylopec.	.286	.303*	.097	.143	.145	.118	.055	.187	.100	.144	-.129	-.082	-.066	.016	-.169	-1.000	I

*Correlation is significant at 5% level of probability (P = 0.05)
**Correlation is significant at 1% level of probability (P = 0.01)

Table 2: Correlation co-efficients of agronomic traits for the 71 genotypes evaluated in 2014 cropping season

	Plant ht.	Ear ht.	50% tassel-ing	50% silking	Tassel No./ Plant	Cob length	Cob circf.	Row No./ Cob	Seed No. /row	100 seed wt.	Kernel dens.
Plant ht.	I										
Ear ht.	.829**	I									
50% tassel.	.376**	.303**	I								
50% silk.	.357**	.344**	.842**	I							
Tassel no.	.481**	.569**	.342**	.387**	I						
Cob length	.032	.061	.234**	.298*	.003	I					
Cob circf.	-.085	.014	-.138	-.024	-.095	.351**	I				
Row no.	.015	.030	-.132	-.074	-.006	.095	.512**	I			
Seed no.	-.054	-.001	-.065	.015	-.049	.425**	.538	.399**	I		
100seed wt	.206	.127	.103	.147	.098	-.001	-.165	-.067	.037	I	
Kernel den	.202	.143	.083	.082	.050	-.153	-.292	.042	-.047	.745**	I

*Correlation is significant at 5% level of probability (P = 0.05)
**Correlation is significant at 1% level of probability (P = 0.01)

4. Discussion

Correlation analyses of agronomic and chemical characteristics after 2013 planting season revealed significant and positive correlations in most agronomic traits. In both two planting seasons, plant height had positive correlation with yield attributes such as number of tassels/plant, number of ears, number of rows/cob and number of seeds/row, cob length and circumference. The result which we found on this research is in agreement with Alviet *al*. [21], Akbar *et al*. [22] and Bocanskiet *al*. [23] who found positive correlations between grain yield and morphological traits of plants. In contrast, Sreckovet *al*. [12] reported negative values of coefficient of correlations between grain yield and plant height.

However, there was no significant correlation between agronomic and chemical characteristics measured, especially the yield components, except number of seeds per row and oil which correlated positively. Obi and Onyishi[24] found that selection of increased chemical constituents in maize such as protein, oil, amylose and amylopectin does not affect the agronomic traits such as plant height, ear height, 100-seed weight, kernel density and days to 50% silking of the crop. Rainji*et al*. [25] and Muhammad *et al*. [26] found oil content to be significantly and positively correlated with agronomic trait such as plant and ear heights. However, Okporie and Oselebe[27] found that oil content and kernel weight were uncorrelated in random-mated population selected for oil content.

Positive association found between number of seed/row and kernel oil from this study is in agreement with Salem *et al*. [28] and Sreckov*et al*. [12] who reported similar results.Oil content was in positive correlations with cob length and 100-kernel weight, in both planting seasons and with plant height and kernel row number and ear height. Our results are similar to the findings of Sreckov*et al*. [29] who studied genetic potential of these two populations after 16 cycles of phenotypic recurrent selection. At 568/II testcrosses they found low positive relation between kernel oil content and ear length and kernel row number. They also found positive correlation between oil content and plant height and 100–kernel weight. Also, contrary to our results they established positive correlations between kernel oil content and ear height.

Also, significant and negative correlation was observed between amylose and amylopectin. Increase in the amylopectin content must have affected the amylose content. Obi and Okporie[30] reported that while the percentage of amylose increased, the percentage of amylopectin decreased and vice versa. The change they observed was followed by changes in the amount of oil and protein produced. There was a corresponding decrease in endosperm weight and increase in pericarp and germ weight resulting in concurrent increase in oil and protein. The negative but non-significant correlation between protein and lysine implies that more and effective selection pressure could cause them to be uncorrelated.

Since no significant relationship existed between chemical characteristics and most agronomic traits, it indicated that good chemical quality such as high protein as well as high oil maize can be bred and selected without necessarily affecting the agronomic traits such as plant and ear heights. This result is contrary to the work by Obi and Okporie[30] and Obi and Onyishi[31] who found oil content to be significantly and positively correlated with plant and ear heights. This departure may be due to sample size and/or source populations. The results also showed that source varieties affected the correlations and made generalization of some of the results difficult. Apparently, increase in the chemical constituents (protein, lysine, oil, amylose and amylopectin) under selection appeared not to have adversely affected the agronomic traits measured.

5. Conclusion

Since no significant relationship existed between chemical characteristics and most agronomic traits, it indicated that good chemical quality such as high protein as well as high oil maize can be bred and selected without necessarily affecting the agronomic traits such as plant and ear heights.

References

[1] I.U. Obi. What Have I Done as an Agricultural Scientist? Achievements, Problems and Solution Proposals. An Inaugural Lecture of the University of Nigeria, Nsukka. Printed by UNN Press Ltd,2006.

[2] C.C. Laurie, S.D. Chasalow, J.R. Ledeaux, R.M.C. Carrolla, D. Bush, B. Hange, C. Lai, D. Clark, T.R. Rocheford and J.W. Dudley. The genetic architecture of response to long-term artificial selection for oil concentration in the maize kernel. *Genetics*, 168: 2141-2155, 2004.

[3] E.O. Okporie and I.U. Obi. Estimation of genetic gains in protein and oil of eight populations of maize (*Zea mays* L.) after three cycles of reciprocal recurrent selection. *J. Sci. Agric., Food Tech. Environ*., 2: 40-45, 2002.

[4] A.K.K. Achakzai. Effect of water stress on cations accumulation by maize seedlings (*Zea mays* L.). *J. Chem. Soc. Pak.*, 30(2): 271-275, 2008.

[5] C. Lucas. Regulation of floury2-mRFP expression in response to long term selection for grain protein concentration in maize: University of Illinois at Urbana-Champaign: 1-77 p, 2010.

[6] M. Scott, J. Edwards, C. Bell and J. Schussler. Grain composition and amino acid content in maize cultivars representing 80 years of commercial maize varieties. *Maydica*: 417-423, 2006.

[7] A. Darrigues, C. Buffard, K.R. Lamkey and M.P. Scott. Variability and genetic effects for tryptophan and methionine in commercial maize germplasm. *Maydica* 50: 147 – 156, 2005.

[8] I.U. Obi.*Maize, Its Agronomy, Diseases, Pest and Food Values.* Optimal Computer Solutions Ltd. Enugu, Publishers. 76 Agbani Road Enugu, Nigeria, XXVIII +, pp: 206, 1991.

[9] M.H. Abou-Deif, B.B. Mekki, E.A.H. Mostafa, R.M. Esmailand S.A.M. Khattab. The Genetic Relationship Between Proteins, Oil and Grain Yield in Some Maize Hybrids. *World Journal of Agricultural Sciences* 8 (1): 43-50.2012.

[10] L.O. Medici, S.A. Gaziola, V.A. Varisi, J.A.C. Paula, R.R. Ferreira and R.A. Azevedo. Diallelic analysis for lysine and oil contents in maize grains. *Scientia Agricola*, 66: 204-209, 2009.

[11] M. Cervantes, F. Copado, S. Espinoza, M. Cervantes and N. Torrentera. Prediction of the amino acid content in wheat based on the crude protein value. Proceedings, Western Section, American Society of Animal Sci., pp: 54, 2003.

[12] Z. Sreckov, A. Nastastic, J. Bocanski, I. Djalovic, M. Vukosavljevand B. Jockovic. Correlation and path analysis of grain yield and morphological traits in test-cross populations of maize. *Pak. J. Bot.*, 43: 1729-1731, 2011.

[13] P. Liu, F. Xie, M. Li, X. Liu, L. Yu, P. J. Halley and L. Chen. *Carbohydrate Polymers*, 85, 180–187, 2011.

[14] A. Mittelmann, J.B. Miranda Filho, G.J.M. Lima, C. Hara-Klein, R.M. Silva and R.T. Tanaka. Diallel analysis of oil content in maize. RevistaBrasileira de Agrociencia, 12: 139-143, 2006.
[15] FDALR. Reconnaissance Soil Survey of Anambra State, Nigeria. Soils Report FDALR, 1985.
[16] D. Pearson. The Chemical Analysis of Foods. 7th Edn. Churchill Livingstone Pub. Co. London and New York, pp: 575, 1976.
[17] I.U. Obi. Application of 2,4,6, - Trinitrobenzene – 1 – Sulphuric Acid (TNBS) Method for the determination of available lysine of maize seed. *Agric.Biol. Chem.* 46 (1): 15-20, 1982.
[18] AOAC. 1995. Association of Official Analytical Chemists: Official Methods of Analysis. 16th Ed. Washington D.C. USA.
[19] R. Baker. Black –layer development. *World farming* 15: 14 –19, 1973.
[20] I.U. Obi. Introduction to Regression, Correlation and Covariance Analysis (with worked examples). Printed and bound in Nigeria by Optimal International Ltd., 113 Agbani Rd. Enugu. 2nd Ed. Pp. 105, 2011.
[21] M.B. Alvi, M. Rafique, M.S. Tariq, A. Hussain, T. Mahmood and M. Sarwar. Character association and path coefficients analysis of grain yield and yield components maize (*Zea mays* L.). *Pak. J. Biol. Sci.*, 6(2): 136-138, 2003.
[22] M. Akbar, M.S, Shakoor, A. Husein and M. Sarwar. Evolution of maize 3–way crosses through genetic variability, broad sense heritability, characters association and path analysis. *J. Agric.Res.*, 46(1): 39-45, 2008.
[23] J. Bocanski, Z. Sreckov and A. Nastasic. Genetic and phenotypic relationship between grain yield and components of grain yield of maize (*Zea mays* L.). *Genetika*, 41(2): 145-154, 2009.
[24] I. U. Obiand G.C. Onyishi. Development of synthetics of high protein, oil, amylose, amylopectin and low oil maize (*Zea mays* L.) from two cycles of reciprocal recurrent selection. Ph.D thesis submitted to the department of Crop Science, UNN. Unpublished, 1992.
[25] R. Rajni, K.R. Sarkar and D. Singh. Correlations and regressions among oil content, grain. Yield and yield components in maize. *Ind. J. Agric. Sci.*, 53: 285-288, 1983.
[26] S. Muhammad, A. Muhammad, A. Muhammad and M. Atif. Comparative evaluation and correlation estimates for grain yield and quality attributes in maize. *Pak. J. Bot.*, 40(6): 2361-2367, 2008.
[27] H. O. Oselebeand E. O. Okporie. Correlation of protein and oil contents with five agronomic characters of maize (*Zea mays* L.) after three cycles of reciprocal recurrent selection. *World J. Agric. Sci.*, 3(5): 639-641, 2007.
[28] M. Sallem, M. Ahsan, M. Aslam and A. Majeed. Comparative evaluation and correlation estimates fog grain yield and quality attributes in maize. *Pak. J. Bot.*, 40(6): 2361-2367, 2008.
[29] Z. Sreckov, J. Bocanski and M. Ivanovic. Genetic and phenotypic correlations between oil content and morphological traits in high oil maize population NSU1. *Genetika*, 39(2): 103-112, 2007.
[30] E. O. Okporie and I. U. Obi. Development of acid tolerant, high yielding and high nutritional maize variety after two years of mass selection. *Sci. of Agric food tech and Envir.* Vol.4 pp 23 – 30, 2004.
[31] I. U. Obi and G.C. Onyishi. Development of high protein population of maize (*Zea mays* L.) from two cycles of reciprocal recurrent selection. *Samaru J. Agric. Res.*, 11: 63 – 68, 1994.