Research Journal of

Botany

ISSN 1816-4919

Academic
Journals Inc.

www.academicjournals.com

Research Journal of Botany 1 (3): 139-143, 2006
ISSN 1816-4919

Soil Texture and the Phenotypic Expression of Maize (*Zea mays* L.)

[1]B.O. Akinyele and [2]A.B. Adigun
[1]Department of Crop, Soil and Pest Management,
Federal University of Technology, P.M.B. 704, Akure, Nigeria
[2]Cocoa Research Institute of Nigeria, Ibadan, Nigeria

Abstract: The effect of variation in soil texture on the phenotype of an early maturing downy mildew resistant (DMR-EST) yellow variety of maize (*Zea mays* L.) was investigated. The four soil types used were of different textural classes, namely clay loam, sandy loam, sandy clay and sandy-clay loam. Five plastic buckets of 5 L size were filled with each soil type, making a total of 20. The buckets were labelled appropriately and arranged in a Completely Randomized Design (CRD) in the screen house of the Cocoa Research Institute of Nigeria (CRIN), Ibadan, Nigeria. Three seeds of maize were sown in each bucket and later thinned to one plant two weeks after planting. Watering was done at an interval of three days. At the blooming stage, leaf length, leaf width, plant height and stem diameter were measured using a tape graduated in centimeters. After harvest, grain weight and grain weight per ear were determined using a weighing balance. Cob length was also measured using a tape graduated in centimeters and the number of grains per ear was counted. Data amassed were subjected to analysis of variance (ANOVA) and means separated using the Least Significant Difference (LSD). The only character that was stable across the soil types is the grain weight. All other characters varied from one soil type to the other.

Key words: Soil texture, variation, phenotype, maize

Introduction

Maize (*Zea mays* L.), referred to as corn by the Americans and Indians, literally means that which sustains life. It is a member of the grass family Poaceae (Purseglove, 1990). The cultivation of maize probably originated in Central America, especially in Mexico, from where it spread northwards to Canada and southwards to Argentina. The origin of maize has been a matter of controversy. According to Jennifer and Gregory (1997), the most common opinion is that the crop originated through domestication of the wild grass teosinte (*Zea mexicana*) which is native to Mexico, Guatemala and Honduras. Considerable cross-pollination between maize and teosinte has occurred during evolution. However, since the two species differ considerably in appearance, some researchers maintain that maize must have originated from a wild pod corn that is now extinct (Mangelsdorf, 1965). According to Purseglove (1990), maize is a highly variable, naturally cross-pollinated, markedly heterogeneous, complex species in which all forms hybridize freely. Though there is accumulation of considerable diversity in maize in Peru, there is no evidence to suggest that it originated there (Abu-Alrub *et al*., 2004). There is also no firm proof that maize was introduced into Peru from Mexico. However, Smith (1968) considered Peru to be a possible centre of origin because an archaeological maize material was found in the area. On the basis of evidence from modern races of maize, Grobman *et al*. (1961) are suggesting that the Andes may be a possible secondary centre of origin.

Corresponding Author: B.O. Akinyele, Department of Crop, Soil and Pest Management,
Federal University of Technology, P.M.B. 704, Akure, Nigeria

Today, wheat, rice and maize are the most important cereal crops in the world and are produced in greater quantities than any other crop. Though maize is third after wheat and rice in terms of the world total production, it has the highest average yield per hectare (FAO, 1991) and it is put to many domestic and industrial uses in different parts of the world. Obilana and Fajemisin (1977) reported that maize is one of the most important cereals widely grown for human consumption and for production of feeds for livestock. Industrially, maize grains are used to produce cooking oil, starch, syrup and dextrose plastics and there is a good proof that maize has more industrial uses than any other cereal. The consumption of maize in the various forms by man and his animals and its numerous industrial uses have aroused the interest of many researchers worldwide. Investigations carried out so far on maize have been focussed majorly on production of high yielding, pest and disease-resistant varieties. Odiyi (2005) undertook a study to improve on the level of resistance of maize plant to some borers. Ajala (1992) studied the inheritance of resistance in maize to spotted stem borer *Chilo partellus*. In his findings, Mihm (1995) opined that multiple insect and disease-resistant varieties are the key to success in maize pest management. The study of Mulamba and Mock (1978) was focussed on the improvement of yield potential of Eto Blanco maize. The efforts of the various researchers to produce high yielding, pest and disease-resistant varieties of maize are, no doubt, aimed at raising its production to the level that will satisfy the high demand for the crop.

In spite of the numerous research works on the synthesis of high yielding, pest and disease-resistant varieties, the yield of maize still remains low due to low soil fertility and poor soil fertility management. Researchers that have studied the performance of the maize plant in relation to the soil are only interested in what could be done to the soil to make it support and sustain maximum yield. They express their opinions on the Agronomist's point of view and are not interested in the effect of soil type on the phenotype of the plant. This study is undertaken, therefore, to investigate the effect of soil type on the phenotypic expression of maize with a view to revealing some probable heritable morphological characteristics of the plant.

Materials and Methods

The plant material used in this study is an early maturing downy mildew resistant (DMR-EST) yellow variety of maize collected from the seed bank of the Institute of Agricultural Research and Training (IAR and T), Ibadan, Nigeria. Soil types of different textural classes, collected from four different locations within the experimental plots of the Cocoa Research Institute of Nigeria (CRIN), Ibadan, Nigeria, were subjected to some routine laboratory analyses. Soil pH was measured in water (Soil: Water-ratio 1:1) and readings were taken using the pH meter. Available phosphorus was determined according to the Bray-1 method. Magnesium was determined using the method of extraction with ammonium acetate followed by atomic absorption spectrometry. Readings for the exchangeable bases were taken with the aid of Carning's 400-flame photometer while readings for the available phosphorus were taken using spectronic 20 m. Mechanical analysis was carried out using the method of Bouyoucos (1951). The four soil types analyzed are clay loam, sandy loam, sandy clay and sandy-clay loam, results of which are presented in Tables 1 and 2.

Table 1: Particle size analysis of the soil types

Soil type	% Sand (0.02-2 mm)	% Silt (0.002-0.02 mm)	% Clay (<0.002 mm)	Textural class
A	40	28	32	Clay loam
B	65	17	18	Sandy loam
C	49	15	36	Sandy clay
D	53	22	25	Sandy-clay loam

Table 2: Some chemical properties of the soil

Soil type	pH	Carbon (%)	Organic matter (%)	Nitrogen (%)	Phosphorus (mg kg^{-1})	Potassium (K^+) (C mol kg^{-1})	Calcium (Ca^{2+}) (C mol kg^{-1})	Magnesium (Mg^{2+}) (C mol kg^{-1})
A (Clay loam)	6.41	1.58	2.72	0.08	2.27	2.80	0.27	1.20
B (Sandy loam)	5.82	0.88	1.51	0.04	3.22	2.30	0.14	1.10
C (Sandy clay)	5.27	1.34	2.30	0.07	6.81	4.30	2.56	2.80
D (Sandy-clay loam)	6.23	2.10	3.61	0.11	6.47	2.70	2.38	1.70

Five plastic buckets of 5 L size were filled with each soil type, making a total of 20 buckets. The buckets were then labelled appropriately and arranged in a completely randomized design in the screen house of CRIN, Ibadan, where the experiment was carried out. Three seeds of maize were sown in each bucket and later thinned to one plant two weeks after planting. Adequate watering was done at an interval of three days. At the stage of blooming, leaf length, leaf width, plant height and stem diameter were measured using a tape graduated in centimeters. After harvest, grain weight and grain weight per ear were determined using a weighing balance. Cob length was also measured using a tape graduated in centimeters and the number of grains per ear was counted. Data amassed were subjected to Analysis of Variance (ANOVA) and means separated using the Least Significant Difference (LSD).

Results and Discussion

The soil plays a very important role in Agriculture. It is the natural medium for plant growth. It provides anchorage for plant roots and ensures a more or less continuous supply of water, mineral salts and other nutrients to the plant. The extent to which any of these functions is performed depends on the nature of the soil particles, which varies from one soil type to the other. For Agricultural operations, the moisture characteristics of the soil such as infiltration rate, permeability and water holding capacity are of primary importance. Also of importance are the plant nutrient supplies in the forms readily available to plants (Wynne and Marlowe, 1980). The available water determines the extent of mineralization of Nitrogen from soil organic matter and the amount of other nutrients in the soil for uptake by the maize plant. Under similar environmental conditions, according to Wiersum (1982), the availability of soil Nitrogen to plant usually increases as the texture becomes finer. Woodruff (1980) also observed that the supply of water to plants is usually greater in soil of moderately fine texture than in that of coarse texture in humid regions. It follows, therefore, that the success or failure of crop production is to a large extent dependent on the general make-up of the soil.

The environment of an organism is the sum total of the external conditions which affect the growth and development of that organism (Allard, 1960). In its broadest sense, Hudson (1960) sees the environment as including both the soil factors and the climatic factors. In wholly artificial environments, it is possible to bring all external factors under control. This implies that the effect of the variation of any one factor or any group of factors can be studied while the other ones are kept constant (Heywood, 1970). In this study, the maize plants were raised in the screen-house to provide common environmental factors except for the soil which varies mainly in the texture. The four different soil types used are clay loam, sandy loam, sandy clay and sandy-clay loam, all of which support maize growth as observed by Kochhar (1986) and Norman *et al*. (1965). To study the effect of environment, Wellensick (1960) opined that any effects of variation in the genetic constitution of the organism under investigation must first of all be excluded. This has been taken care of in this study by using pure lines of DMR-ESR maize variety.

Plant growth is a function of both the external factors (climate, soil, plants and animals) and the internal factor (genotype). According to Abercrombie *et al*. (1973), the phenotype of an organism is the sum of the characteristics manifested by the organism, as contrasted with its genotype. It is

Table 3: Measurements of maize characteristics

S/N	Soil type	Leaf length (cm)	Leaf width (cm)	Plant height (cm)	Stem diameter (cm)	Cob length (cm)	Grain weight (g)	Grain weight per ear (g)	No. of grains per ear
Means									
1.	A (Clay loam)	81.05	4.80	146.55	0.80	10.78	0.19	84.66	295.25
2.	B (Sandy loam)	74.20	4.08	116.38	0.68	8.60	0.17	59.86	231.25
3.	C (Sandy clay)	83.38	4.90	132.20	0.79	9.86	0.17	83.97	276.25
4.	D (Sandy-clay loam)	88.33	5.55	150.68	0.88	10.65	0.20	93.10	337.50
	LSD (0.05)	3.50	0.59	20.39	0.085	1.18	0.04	9.20	33.68
Mean difference									
	1 and 2	6.85	0.72	30.17	1.48	2.18	0.02*	24.80	64.00
	1 and 3	2.33*	1.10*	14.35*	0.01*	0.90*	0.02*	0.69*	19.00*
	1 and 4	7.28	0.75	4.13*	0.08	0.13*	0.01*	8.44*	42.25
	2 and 3	9.18	0.82	15.82*	0.11	1.28	0.00*	24.11	45.00
	2 and 4	14.13	1.47	34.30	0.20	2.05	0.03*	33.24	106.25
	3 and 4	4.95	0.65	18.48*	0.09	0.76*	0.03*	9.13*	61.25

* Mean difference not significant

important to realize that genes have the potentiality to produce a particular character but what is actually produced depends on the genic and the external environmental factors during plant development. During a growing season, the soil type, the climate, animals and other plant species, form a unique environment that interacts with the genotype resulting in an expression of a phenotype, including yield. Hence, the phenotype is a function of the genotype, the environment and the interaction between the genotype and the environment (Sevilla and Holle, 1995). The response of some phenotypic characters of maize to changes in the soil aspect of the environment was investigated in this study. Phenotypic characters investigated and from which data were collected are leaf length, leaf width, plant height, stem diameter, cob length, number of grains per ear, grain weight and grain weight per ear (Table 3).

Out of the eight characters studied, seven were affected by the soil type (Table 3). It is possible for plants to have the same genotype but different phenotypes owing to environmentally-produced variation (Abercrombie *et al*., 1973). This accounts for the significant differences observed in the leaf length, leaf width, plant height, stem diameter, number of grains per ear, grain weight per ear and cob length. Since these characters are imposed by habit conditions, the heritability of each of them is likely to be very low. The extent of variation in such characters depends on the phenotypic plasticity, which varies from one species to the other (Heywood, 1970). In this study, the only character that is stable across the soil types is the grain weight. In line with the finding of Sevilla and Holle (1995) that a morphological descriptor should have a constant phenotype in all environments, it is logical to suggest that grain weight is most likely to be one of the morphological descriptors of the maize variety used in this study. For taxonomic purpose, a character may be shown, by experience, to be 'good' or 'bad'. A good character is one that is not easily modified by environmental factors. Such characters are usually under the control of the genes. Hence, it is reasonable to infer that grain weight in this study is most likely to be under the control of the gene and therefore, its heritability is likely to be very high. From the argument that seven out of the eight characters investigated vary from one soil texture to the other, there is sufficient evidence to conclude that the phenotype of maize is, to a great extent, influenced by the texture of the soil.

References

Abercrombie, M., C.J. Hickman and M.L. Johnson, 1973. The Penguin Dictionary of Biology. 6th Edn., Penguin Books, New York, USA, pp: 320.

Abu-Alrub, I., J.L. Christianson, R. Ortiz, R. Sevilla and S. Madison, 2004. Assessing tassel, kernel and ear variation in Peruvian highland maize. Plant Genetic Resources Newsletter, FAO,-IPGRI Issue No. 137, pp: 34-41.

Ajala, S.O., 1992. Inheritance of resistance in maize to spotted stem borer *Chilo partellus* (Swin hoe). Maydica, 37: 363-369.

Allard, R.W., 1960. In: Principle of Plant Breeding. John Wiley and Sons Inc. New York Chichester, Brishane, Toronto, Singapore, pp: 467.

Bouyoucos, G.J., 1951. A recalibration of the hydrometer method of making mechanical analysis of soil. Agron. J., 43: 434-438.

Food and Agricultural Organization of the United Nations (FAO), 1991. Yearbook of Production. Vol. 45. FAO, Rome, Italy, pp: 265.

Grobman, A., W. Salhuana, R. Sevilla and Mangelsdoe, 1961. Race of Maize in Peru: Their Origin, Evolution and Classification. National Academy of Science. National Research Council Pub. 915, Washington DC.

Heywood, V.H., 1970. Plant Taxonomy, Edward Arnold (Publishers) Ltd.

Hudson, J.P., 1970. Control of the Plant Environment. Butterworts Scientific Publication, London.

Jennifer, G.K. and E. Gregory, 1997. Morphology and growth of maize. IITA/CIMMYT, Research Guide 9.

Kochhar, 1986. Tropical Crops: A Textbook of Economic Botany, London. Macmillan Publishers.

Mangelsdorf, P.C., 1965. The Evolution of Maize in Essays to Crop Plant Evolution. Ed. Sir Joseph Hutchinson. Cambridge Up.

Mihm, J.A., 1995. Maize Pest Management-Multiple Insect and Disease-Resistant Varieties are the Key to Success. In: Maize Research for Stress Environments. Jewell, D.C., S.R. Waddington, J.K. Ransom and K.V. Pixely (Eds.), Proceedings of the 4th Eastern and Southern Africa Regional Maize Conference Held at Harare, Zimbabwe. 28 March to 1 April 1994. Mexico D.F., pp: 170-181.

Mulamba, N.N. and J.J. Mock, 1978. Improvement of yield potential of Eto Blanco maize (*Zea mays* L.) population by breeding for plant traits. Egyptian J. Gene. Cytol., 7: 40-51.

Norman, M.J., A.T.C.E. Pearson and P.G.E. Searle, 1965. Tropical Food Crops in their Environment. Cambridge University Press.

Obilana, O.T. and J.M. Fajemisin, 1977. Methodology for improving maize (*Zea mays* L.) varieties in Nigeria. Paper presented at the 3rd National Seed Improvement Course, which took place at Moor Plantation, Ibadan, Nigeria. 15 August-16 September 1976.

Odiyi, A.C., 2005. Genetic variability in maize (*Zea mays* L.) for combined resistance to the pink stalk borer (*Sesamla calamistis* Hampson) and the African sugarcane borer (Eldana *sacchariha* Walker). Ph.D Thesis Federal University of Technology, Akure, Nigeria, pp: 104.

Purseglove, J.W., 1990. Tropical Crops. Monocotyledons, 1 Longman Crop Ltd. London, Reprinted.

Sevillar, R. and M. Holle, 1995. Plant Genetic Resources, UNALM, Lima, Peru.

Smith, C.E., 1968. The New World center of origin of cultivated plant and the archaeological evidence. Econ. Bot., 22: 253-566.

Wellesick, S.J., 1960. The Plant and its Environment. In: Control of the Plant Environment, Butterworts Scientific Publication, London.

Wiersum, L.K., 1982. Uptake of nitrogen and phosphorus in relation to soil structure and nutrient mobility. Plant and Soil, 16: 62-70.

Woodruff, C.M., 1980. Soil Moisture and Plant Growth (in relation to PF). Soil Sci. Soc. Am. Proc. S., pp: 36-41.

Wynne, D. Thorne and Marlowe D. Thornc, 1980. Soil, Water and Crop Production. The AVI Publishing Company, Inc. Westport Connecticut.