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Estimation of Genetic Improvement of Maize in Ghana under Three Levels of Nitrogen Fertilizer Application

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ABSTRACT

Recent release and promotion of hybrid maize production in Ghana necessitated a study to estimate the genetic improvement of maize (*Zea mays* L.) in Ghana under three levels of nitrogen fertilizer application. The experiment was conducted in 2002 major and minor seasons at Fumesua and Kwadaso representing four planting environments. Three local accessions, seven improved open pollinated varieties and two quality protein maize hybrids released from 1972 to 1997 were evaluated in a two factor, randomized complete block design in a split-plot, with four replications in each environment. Nitrogen levels (0, 45, 90 kg N ha^{-1}) were randomized in the main plots and the 12 varieties were randomized in the sub-plots. Analyses of variance showed highly significant (P<0.01) Genotype x nitrogen interactions for grain yield, shelling percentage and blight disease but significant (P<0.05) for cob diameter and rotten ears. Significant (P<0.01) linear regression analysis indicated that yield gains attributed to genetic improvement were 12.5, 35.1 and 33.1 kg/ha/yr at 0, 45 and 90 kg N ha^{-1} respectively implying an annual contribution to farm income of US$2.4M, US$4M and US$4.4M respectively. The study showed that progress has been made in genetic improvement of maize in Ghana since the mid-1950s.

Key words: *Genetic Improvement, Quality Protein, Zea Mays*

1. INTRODUCTION

Maize (*Zea mays* L.) was first introduced into Ghana by the Portuguese in the early 16th century (Dickson, 1971). However, maize history in Ghana started in the 1930's. Between 1939 and 1942 T. L. Williams released C50 and introduced a yellow variety called Tsolo from South Africa. J. McEwen between 1954-1961 released Nyankariwana Nos.1 and 2, both yellow varieties. W.K. Agble also released Ghana synthetic as (GS1, GS2 and GS3) between 1956 and 1960 and in 1961, E.V. Doku developed Mexican 17 while M.K Akposoe released Composite 4, Composite 2, Composite W, La Posta CRI and Golden Crystal between 1968 and 1972. Breeders at CRI in Ghana have released several improved maize varieties since the early 1970's. (Agble, 1960; 1974; 1981; Twumasi-Afriyie, 1992; 1997; Tripp and Marfo, 1997). Average maize yields in farmers fields thus increased from 1.0 to 1.6 ton/ha between 1991 and 1998 (PPMED, 1991; 1998). This increase could be attributed to adoption of improved maize varieties and production technologies by growers in the country (Morris *et al.*, 1999). Genetic improvement studies are thus show the importance of plant breeding to the public and identify traits or target environments that may require increased efforts by breeders. Again, results from such studies could reveal progress made in genetic improvement in released varieties since the inception of a particular breeding programme (Cox *et al.*, 1988). Linear regression is usually applied to yield versus year of release, the slope giving the annual rate of progress as kilograms per hectare per year or percentage per annum (Evans and Fischer, 1999). Failure to detect long term linear progress for yield in crop plants may be due to non random sampling of the cultivar population, dilution of a few improved cultivars with unimproved cultivars, or lack of true genetic progress (Casler *et al.*, 2000).

Progress in yield is often slow in those crops where the main emphasis has to be on quality (Douches *et al.*, 1996). Evidence for contribution of breeding to increases in maize yield has been reported in several studies (Russell, 1974, 1984, 1985a, 1986; Duvick, 1977, 1984; Crosbie, 1982; Tapper, 1983; Castleberry *et al.*, 1984; Meghji *et al.*, 1984). Genetic gains of between 33 and 92 kg/ha/year were obtained using the hybrids and when OPVs were used it ranged from 56-89%. In the USA for example, the genetic contribution to increased maize yields ranged from 58 to 90% (Russell, 1984; Duvick, 1984; Carlone and Russell, 1987). Castleberry *et al.*, 1984 reported a 51 and 87 kg/ha/yr genetic improvement in maize at low and high fertility conditions respectively. In Ontario, Tollenaar (1989) reported 1.7%/yr genetic improvement in maize. In France, Derieux *et al.*, 1987 reported 93% per year gain in genetic improvement of maize. Kuhn and Givers (1980) also reported 41.2% yield gain in maize attributed to genetic improvement. Duncan *et al.*, 1978, Whynne and Gregory, 1981 and Mozingo *et al.*, 1987 reported peanut improvement of 3 to 100%. Specht *et al.*, 1999 reported 22.6 to 31.4 kg/ha/yr yield improvement in Soybean; Woodfield and Caradus (1994) indicated 0.14% improvements in white clover. Cox *et al.*, (1988) reported a 16.2 kg/ha/yr with 0.6 and 0.4% per year yield gain in wheat. However, there was complete absence of genetic progress at Hutchison in 1987 due to defoliation by tan spot and suggested that this trait has not undergone improvement over the years. Ortiz-Monasterio *et al.*, (1997) on the other hand, reported 1.1, 1.0, 1.2 and 1.9% per year on a relative basis and 32,43,59,89 kg/ha/yr on absolute basis when provided with 0, 75, 150 and 300 kg N ha^{-1} ; In Ghana, Sallah *et al.*

(1998) estimated yield gains per year of 32, 45 and 56 kg ha^{-1} equivalent to 1.3, 1.4 and 1.7%/yr at 0, 80 and 160 kgNha^{-1} respectively. Improved varieties are normally responsive to chemical fertilizers (Castleberry *et al*., 1984). The recent release and promotion of hybrid maize production in Ghana therefore, necessitated the current genetic improvement studies under 3 levels of nitrogen application.

2. MATERIALS AND METHODS

The 12 genotypes used with their characteristics are presented in Table 1 below.

Table 1. Variety, origin, characteristics, year released and purpose for release of 12 maize varieties studied.

Variety	Varietal type	Parental type	Grain type	Year released	Reasons for Release
LA92/015B	OPVN †	Local accession	Flint segregating	1955¶	Low yield potential, Segregating white, yellow and purple; Flint.
LA92/014B	OPVN	Local accession	Flint segregating	1955	Low yield potential, Segregating white, yellow and purple; Flint
Ohawu local	OPVN	Land accession	Flint segregating	1955	Low yield potential, Segregating white, yellow and purple; Flint
Intermediate maturity 105-110days					
Aburotia	OPVN	Cimmyt Tuxpeno PB 16	White, Dent	1984	Yield, earliness and short plant height
Golden crystal	OPVN	Local selection	Yellow, Flint/Dent	1972	Yield and yellow colour
Abeleehi	OPVN	Cimmyt Ikene 8149SR BC2 &BC5	White, Dent	1990	Yield and maize streak virus resistance
Mamaba	3WHQPM‡	(Ent.6x Ent 70) xEnt.5	White, Flint	1997	Yield and hybrid QPM
Dadaba	3WHQPM	(Ent.24xEnt27)x P28	White, Flint/Dent	1997	Yield and hybrid QPM
Obatanpa	OPVQPM§	GH8363SR C1	White, Flint/Dent	1992	Yield, OPVQPM and Maize streak virus resistance
Late maturity 110-120 days					
Composite 4	OPVN	Parental lines of Central and South American Origin	White, Dent	1972	High yield and tolerance to lodging
Dobidi	OPVN	Cimmyt Pop. 43 (La Posta)	White, Dent	1984	Yield, improved husk cover and resistance to lodging
Okomasa	OPVN	Cimmyt Pop.43SR (La Posta)	White, Dent	1988	Yield, tolerance to lodging and Maize streak virus

†Open Pollinated Variety (Normal maize); ‡Three Way Hybrid (Quality Protein Maize);
§Open Pollinated Variety (Quality Protein Maize);
¶Assumed to reflect the year active breeding was initiated in Ghana

The study was conducted during the 2002 major and minor seasons at Fumesua and Kwadaso in the forest zone which lie on latitude 6^0 43’ N and longitude 1^0 36’ W. The soils at both sites are classified as Ferric Acrisol but Fumesua belong to the Asuansi series while that at Kwadaso is of the Kumasi series (FAO/ UNESCO, 1964). Soil samples were taken for analysis during planting at depths of 0-15 cm and 15-30 cm (Table 2).

Table 2. Soil chemical analysis of the study areas for 2002 major (A) and minor (B) seasons

	Fumesua 2002A		Kwadaso 2002A		Fumesua 2002B		Kwadaso 2002B	
	……… Soil depth cm……………….				……..…………Soil depth cm………………			
Determination	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
P^H (1:2.5)	6.8	5.4	7.5	6.9	7.6	8.1	7.6	7.1
OC (%)	0.89	0.29	1.04	0.29	1.13	0.7	0.92	0.44
OM (%)	1.53	0.50	1.79	0.5	1.95	1.21	1.59	0.78
TN (%)	0.13	0.06	0.16	0.06	0.14	0.07	0.11	0.06
C/N ratio	7.0	4.8	6.9	4.9	7.98	10.0	8.83	8.53
P (mg/kg)	25.8	24.0	10.4	2.6	160.8	131.6	106.9	46.4
K (Cmol/kg)	0.67	0.16	0.87	0.35	0.23	0.21	0.25	0.14
Na (Cmol/kg)	0.32	0.25	0.22	0.13	0.17	0.17	0.18	0.17
Ca (Cmol/kg)	6.6	2.1	7.4	3.3	4.4	3.1	3.4	2.7
Mg (Cmol/kg)	1.1	0.8	0.8	0.6	0.7	0.4	0.8	0.3

OC= Organic carbon; OM= Organic matter; TN= Total nitrogen

The experimental fields were planted to maize in previous seasons in all environments. The experimental design was a two factor randomized complete block design in split plot arrangement with four replications in each environment. The nitrogen levels and varieties were randomized in the main plots and sub- plots respectively. Fields were slashed and harrowed. Each variety was planted in two row plot, 5 m long with spacing of 75 cm between rows and 22.5 cm within rows. Three seeds were planted per hill and later thinned to one plant per hill. All the genotypes received a basal application of phosphorus (P) as triple super phosphate at 60 kg P_20_5 ha^{-1} and potassium (K) as potassium chloride (KCl) at 30 kg K_20 ha^{-1}. Nitrogen was applied as sulphate of ammonia at 0, 45, and 90 kg N ha^{-1}. Data were recorded from the two-row plot of each variety for field weight, grain moisture (%) at harvest, number of rotten ears at harvest, maize blight disease, shelled grain weight and shelling percentage (shelling %=grain weight /field weight x 100), cob diameter (measured with the calipers mid way). Grain yield was expressed in kg/ha at 15 % moisture using the formula: Grain yield = (Grain weight (kg)/harvested area x (10,000m^2 /ha) x (100- % grain moisture)/85. The data were analysed for each environment and combined over environments according to Gomez and Gomez (1984) using the MSTATC soft ware. Linear regression equation represented by Y = a + bx where Y = yield or other agronomic traits, a = intercept, b = slope of the line or amount of change in Y for each unit change in x where x = years (Sallah *et al*., 1998; Mozingo *et al*., 1987).

3. RESULTS AND DISCUSSIONS

The combined analyses of variance across the four environments with their means for these traits are presented in Tables 3-6. The G x N interactions were highly significant ($P<0.01$) for grain yield, shelling percentage and blight disease and significant ($P<0.05$) for cob diameter and rotten ears. This indicated that the genotypes reacted differently to the different nitrogen levels used in the study and as such it should be possible to select specific varieties for specific N levels. The G x N interactions in grain yield obtained confirmed that by Sallah *et al*., 1998.

Table 3. Mean grain yields (kg/ha) and shelling percentage of 12 maize genotypes evaluated under 3 levels of nitrogen in 4 environments of year 2002

Source of Variation	DF	Grain Yield (kg/ha)	Shelling (%)	Cob diameter (cm)	Blight (score)	Rotten (no.)
Environment(E)	3	140326326**	15567**	3.16**	237**	9.8**
Reps./E	12	1949389*	132NS	0.12**	1.36**	2.9**
Nitrogen (N)	2	112194879**	190NS	1.28**	0.03NS	0.7NS
N X E	6	1435793NS	155NS	0.05NS	1.11*	1.1NS
Error (a)	24	731888	64	0.03	0.33	0.8
Genotypes (G)	11	14017920**	344**	0.71**	1.40**	1.1**
G X E	33	648902**	46**	0.04*	0.54**	0.5NS
G X N	22	2118614**	51**	0.03*	0.44**	0.7*
G X E X N	66	257926 NS	33NS	0.02NS	0.19NS	0.4NS
Error (b)	396	290721	26	0.03	0.20	0.4
CV %		14.4	6.8	6.7	15.6	57.4
Grand mean		3756	74.9	2.4	2.9	1.1

**Significant at $P<0.01$ respectively; †For comparison of genotype means; ‡For comparison of N treatment means; §For comparison of genotypes within N level

Table 4. Mean squares of combined analysis for grain yield, shelling%, cob diameter, blight and rotten ears in 12 maize genotypes studied under 3- levels of nitrogen fertilizer application in four environments in year 2002

	.........Grain Yield kg/ha…………				………..Shelling %....................			
Variety	0N	45N	90N	Mean	0N	45N	90N	Mean
Ohawu local	2473	2900	3445	2939	81.1	79.7	77.5	79.4
AA92/014[B]	2881	3596	4220	3566	78.6	78.8	76.9	78.1
AA92/015[B]	2588	3229	3901	3239	78.4	78.8	75.7	78.0
Goldencrystal	2815	3731	4544	3697	77.8	72.2	72.7	74.2
Composite 4	2877	3283	3683	3281	76.9	73.8	72.2	74.3
Aburotia	2930	3951	3954	3612	77.6	74.7	75.4	75.9
Dobidi	3051	3842	4478	3790	73.9	73.7	72.3	73.3
Okomasa	3011	3675	4552	3746	72.5	69.2	69.0	70.2
Abeleehi	3001	3690	4279	3657	74.2	75.5	71.7	73.8
Obatanpa	3399	4145	4841	4128	72.8	70.7	71.6	71.7
Mamaba	2898	5405	5533	4612	72.5	75.2	73.7	73.8
Dadaba	3307	5170	5951	4809	72.7	79.0	77.2	76.3
Mean	2936	3885	4448	3756	75.8	75.1	73.8	74.9
LSD (0.05)†				375**				3.5**
LSD (0.05)‡				216**				2.0**
LSD (0.05)§				172**				0.12**
CV%				14.4				6.8

*, ** Significant at P<0.05 and P<0.01 respectively.

Table 5. Mean cob diameter (cm) and rotten ears (no.) of 12 maize genotypes evaluated under 3 levels of nitrogen in 4 environments of year 2002

	……Cob diameter (cm)..……				…………Rotten ears (No.)……..…			
Genotypes	0N	45N	90N	Mean	0N	45N	90N	Mean
Ohawu local	2.1	2.1	2.3	2.2	3.2	3.2	3.6	3.3
AA92/014[B]	2.3	2.4	2.4	2.4	2.8	2.9	2.6	2.8
AA92/015[B]	2.1	2.2	2.2	2.2	3.0	2.8	2.9	2.9
Goldencrystal	2.2	2.3	2.5	2.3	2.7	3.0	3.2	3.0
Composite 4	2.5	2.5	2.6	2.5	2.9	2.9	2.9	2.9
Aburotia	2.4	2.4	2.5	2.4	2.9	2.8	2.7	2.8
Dobidi	2.3	2.3	2.3	2.3	3.1	2.7	2.8	2.9
Okomasa	2.4	2.5	2.5	2.5	2.9	3.0	2.8	2.9
Abeleehi	2.2	2.3	2.5	2.3	2.8	2.6	2.5	2.6
Obatanpa	2.5	2.5	2.7	2.6	2.9	2.8	2.8	2.8
Mamaba	2.3	2.4	2.5	2.4	2.8	2.8	2.7	2.8
Dadaba	2.2	2.3	2.4	2.3	2.6	2.9	3.0	2.8
Mean	2.3	2.4	2.5	2.4	2.9	2.9	2.9	2.9
LSD (0.05)†				0.1**				0.3**
LSD (0.05)‡				0.1*				0.2**
LSD (0.05)§				0.04**				NS
CV%				6.7				15.6

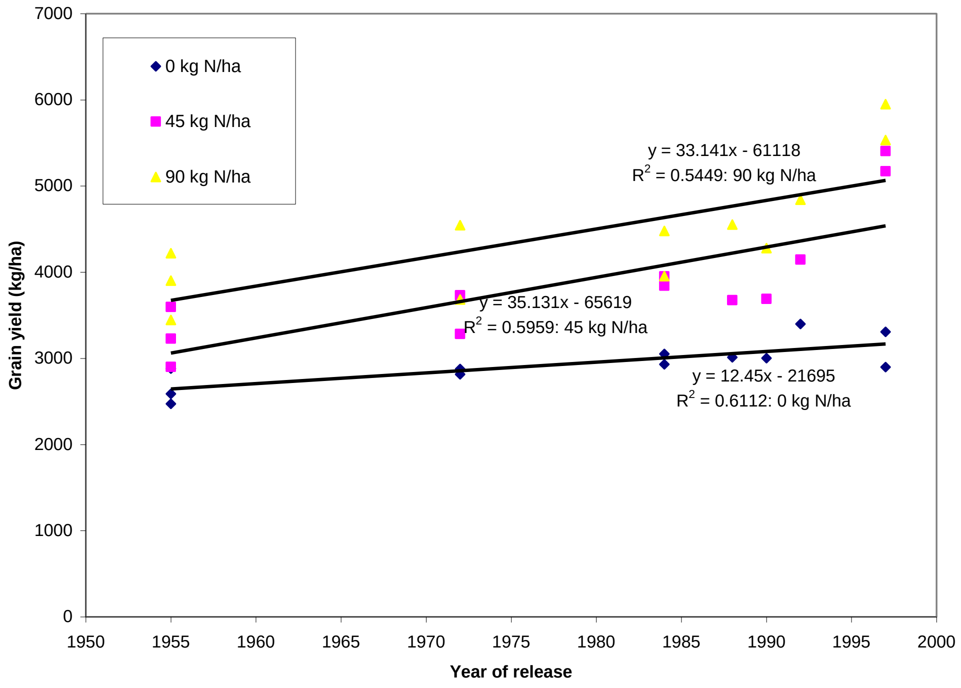
*, ** Significant at P<0.05 and P<0.01 respectively; NS=Non significant †For comparison of genotype means; ‡For comparison of N treatment means; §For comparison of genotypes within N level

Table 6. Mean blight (score) of 12 maize genotypes evaluated under 3 levels of nitrogen in 4 environments of year 2002

	Blight (score)#			
Genotypes	0N	45N	90N	Mean
Ohawu local	3.2	3.2	3.6	3.3
AA92/014[B]	2.8	2.9	2.6	2.8
AA92/015[B]	3.0	2.8	2.9	2.9
Goldencrystal	2.7	3.0	3.2	3.0
Composite 4	2.9	2.9	2.9	2.9
Aburotia	2.9	2.8	2.7	2.8
Dobidi	3.1	2.7	2.8	2.9
Okomasa	2.9	3.0	2.8	2.9
Abeleehi	2.8	2.6	2.5	2.6
Obatanpa	2.9	2.8	2.8	2.8
Mamaba	2.8	2.8	2.7	2.8
Dadaba	2.6	2.9	3.0	2.8
Mean	2.9	2.9	2.9	2.9
LSD (0.05)†				0.3**
LSD (0.05)‡				0.2**
LSD (0.05)§				NS
CV%				15.6

**SignificantatP<0.01respectively; NS=Nonsignificant; †For comparison of genotype means; ‡For comparisonof Ntreatmentmeans; §For comparison of genotypes within N level; # 1-5=free, 5=very heavy infection

Linear regression analysis showed yield gain (b-value) attributed to genetic improvement was 12.5 kg/ha/year at zero fertilizer N, 35.1 kg/ha/yr at 45 kg N ha^{-1} and 33.1 kg/ha/yr at 90 kg N ha^{-1} and the R^2 values associated with the linear regressions were 0.61, 0.60 and 0.54 at 0, 45 and 90 kg N/ha, respectively (Fig.1).



Regression analysis for mean grain yield versus year of release of12 maize varieties evaluated at three N levels in four environments in 2002

Linear regression analysis for grain yield and four agronomic traits as well as the yield gain per year expressed as a proportion of the yield of the local variety (Ohawu local) at each level of fertilizer N are presented in Table 7. The yield gain per year was 0.5% at zero N, 1.2% at 45 kg N ha^{-1} and 1.0% at 90 kg N ha^{-1}. Genetic gain in this study for grain yield were low compared to the 70 kg/ha/yr obtained in the U.S Corn Belt and 69 kg/ha/yr obtained in north America (Russell, 1974; Crosbie, 1982; Castleberry *et al*., 1984; Duvick, 1977; Russell, 1984; Carlone and Russell, 1987; Tollenaar, 1989) and 32,43,59,89 kg/ha/yr on absolute basis when provided with 0,75,150 and 300 kg N ha^{-1} reported by Ortiz-Monasterio *et al*., (1997). The gain in yield obtained in this experiment was about half of that obtained by Sallah *et al*. (1998) when they compared entirely open pollinated varieties but at higher N levels than what was used in this experiment. The difference in yield gain between this study and previous ones may be attributed to differences in the genotypes and the environments used (Sallah *et al*., 1998). Notwithstanding the low values obtained, significant yield gains observed at all levels of N fertilizer confirmed the previous work by Sallah *et al*., 1998 that progress had been made since the maize breeding programme was initiated nearly six decades ago.

Linear regression analysis for shelling percentage, cob diameter and blight are presented in Table 7. Linear regression analysis for shelling percentage, showed negative linear estimates with gains -0.2%/year at zero fertilizer N and -0.1%/yr at both 45 and 90 kg N ha^{-1}, but the gains were only significant (P<0.01) at zero N. This implied earlier varieties had higher shelling percentage than more recent varieties at zero N. Breeding was therefore, ineffective in improving the shelling percentage in the maize varieties when nitrogen fertilizer was applied. Linear regression analysis showed improvement in cob diameter attributed to genetic improvement as 0.004cm/year or 0.2% per year for all three N levels (0, 45 and 90 kg N ha^{-1}). The gains however, were not significant. The results again indicated that breeding was ineffective in improving the cob diameter of the maize varieties, probably because breeders did not directly select for this trait but selected mainly for higher yields, better quality and tolerance/resistance to pests and diseases, and not directly for shelling percentage and cob diameter (Cox *et al*., 1988). It may therefore be appropriate for maize breeders to select directly for these traits. Linear regression analysis for blight showed negative estimates as 0.004/yr., 0.005/yr. and 0.008/yr. at zero fertilizer N, 45 and 90 kg N ha^{-1} respectively. However, these linear estimates were not significant. Blight reduction of -0.1 to -0.2% per year did not yield any significant gain because incidence of blight disease was not severe during the study period. Similarly, Cox *et al*., 1988 observed no significant genetic progress in tan spot at Hutchison due to defoliation.

Linear regression analysis for rotten ears (Table 7) indicated gain due to genetic improvement as 0.01 ears/yr, 0.01ears/yr and -0.001ears/yr. at 0, 45, and 90 kg N ha^{-1} respectively. The gain was not significant at 90 kg N ha^{-1}. Ear rot reduction of 0.9 to1.1% per year due to genetic improvement indicated that breeding was effective in improving maize resistance/tolerance to the rot disease. This improvement was achieved, because breeders intentionally, selected for ear rot resistance.

Table 7. Absolute and relative genetic gains in grain yield and four agronomic traits of 12 genotypes evaluated under three levels of nitrogen in four environments in 2002.

	Grain Yield		Shelling %		Cob diameter		Rotten ears (no.)		Blight (score)	
Nitrogen Level	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative
Kg/ha	kg/ha/yr	%/yr	% /yr	%/yr	cm/yr	%/yr	No./yr	%/yr	Score/yr	%/yr
0	12.5**	0.5**	-0.2**	-0.2**	0.004 NS	0.2 NS	0.01*	1.1*	-0.004 NS	-0.1 NS
45	35.1**	1.2**	-0.1 NS	-0.1 NS	0.004 NS	0.2 NS	0.01**	0.9**	-0.005 NS	-0.2 NS
90	33.1**	1.0**	-0.1 NS	-0.1 NS	0.004 NS	0.2 NS	-.001NS	-0.1 NS	-0.008 NS	-0.2 NS

*, ** Slope (b-value) significantly different from zero at P<0.05 and P<0.01 respectively; NS= Not significantly different at P=0.05

Maize prices between 1955 and 1997 are presented in Table 8. Maize prices per 100kg ranged from ₵5 to ₵64,326 respectively for this period.

Table 8. Maize prices between 1955 and 1997

Year	1955	1972	1984	1988	1990	1992	1997
Maize price (₵) per 100 kg	5	17	2,338	6,859	8,633	10,048	64,326

Source: SRID, 2001

Table 9 shows the contribution of genetic gains to farm income. Genetic gain in grain yield of 12.5kg/ha/yr. at 0 kg N ha^{-1} amounted to approximately ₵21 billion (US$2.4M) annual contribution to farm income. At 45 kg N ha^{-1}, genetic gain in grain yield of 35 kg/ha/yr. amounted to a yearly increase in value of ₵48,371 per ha and this gave rise to approximately ₵34 billion (US$4M) annual contribution to farm income. At 90 kg N ha^{-1}, genetic gain in grain yield of 33 kg/ha/yr. amounted to a yearly increase in value of ₵52,907 per ha and this gave rise to approximately ₵37 billion (US$4.4M) annual contribution to farm income. These increases were more than doubled what was obtained in peanut by Mozingo *et al*., 1987.

Table 9. Contribution of genetic gain to farm income

		0N		45N		90N	
Genotypes	Year released	Yield (kg/ha)	Value (₵/ha)	Yield (kg/ha)	Value (₵/ha)	Yield (kg/ha)	Value (₵/ha)
Ohawu local	1955	2473	124	2900	145	3445	172
AA92/014^B	1955	2881	144	3596	180	4220	211
AA92/015^B	1955	2588	129	3229	161	3901	195
Goldencrystal	1972	2815	479	3731	634	4544	772
Composite 4	1972	2877	489	3283	558	3683	626
Aburotia	1984	2930	113,039	3951	152,430	3954	152,545
Dobidi	1984	3051	117,708	3842	148,224	4478	172,761
Okomasa	1988	3011	206,524	3675	252,068	4552	312,222
Abeleehi	1990	3001	259,076	3690	318,558	4279	369,406
Obatanpa	1992	3399	341,532	4145	416,490	4841	486,424
Mamaba	1997	2898	1,864,167	5405	3,476,820	5533	3,559,158
Dadaba	1997	3307	2,127,261	5170	3,325,654	5951	3,828,040
b-value		12.5kg/ha/yr	₵29,425/ha/yr	35kg/ha/yr	₵48,371/ha/yr	33kg/ha/yr	₵52,907/ha/yr
Annual contribution to farm income= (Maize area x b-value in ₵)			₵20,597,500,000 Equiv to US$2.4M		₵33,859,700,000 Equiv to US$4M		₵37,034,900,000 Equiv to US$4.4M

Maize area =700,000 h

4. CONCLUSIONS

The results of this study indicated that, progress has been made in genetic improvement of maize in Ghana since breeding programmes actively began in the mid-1950s. Significant improvement in yield potential and ear rot disease of maize under low to medium levels of soil fertility were observed. Breeding also contributed significantly to increased farm income.

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