THE HISTORY OF WHEAT RESEARCH IN KENYA

By

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(The views expressed herein are those of the Author and do not necessarily reflect those of his employer or any other institution to which he is affiliated.)

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THE HISTORY OF WHEAT RESEARCH IN KENYA

1.0. THE INTRODUCTION OF WHEAT AND WHEAT RESEARCH IN KENYA

1.1. The wheat plant is not native to Kenya. It was introduced by missionaries into Kenya in the late nineteenth century and started with the growing of the crops in small missionary farms. Some years later early colonial settlers began to grow the crop using mainly Australian varieties. One of those early settlers, Lord Delamere, was the first to grow wheat extensively when in 1906, he planted some 1,200 acres of wheat. However, by 1908 stem rust had appeared in the country and the Australian varieties were susceptible to it. This led to the recruitment by Lord Delamere of a plant breeder from Britain to breed wheat varieties with resistance to rust and other suitable characteristics. The plant breeder was established at Njoro which was the first wheat growing area in Kenya situated in the Great Rift Valley, some nearly 200 kilometers (120 miles) west of Nairobi, the capital of Kenya. The breeding facility was run as a private station until 1927 when the government assumed responsibility for the station.

1.2. Parallel to lord Delamere's private efforts, government also initiated a wheat breeding program in Nairobi in 1911 in what was then known as the Scott Agricultural Laboratories (SAL) and later re-named the National Agricultural Laboratories (NAL) at independence and now a National Research Center of the more

recently formed parastatal, the Kenya Agricultural Research Institute (KARI). The government breeding work was transferred to Njoro in 1927 so that the work could be carried out at a more suitable site. It was then that Government assumed responsibility for the station previously established privately by Lord Delamere. From then on full responsibility for wheat research in Kenya passed into government hands.

2.0. THE WHEAT BREEDING PROGRAM

2.1. The record of wheat research in Kenya is a record of the fight against rust particularly stem rust. Thus Dixon notes that a review of and appreciation of the progress made in the breeding of wheats in Kenya must be set against the background of past achievements as well as set-backs against ever-changing rust races (Dixon, 1960).

2.2. Wheat in Kenya is afflicted by three types of rusts, that is, black stem rust (*Puccinia gramminis tritici*); brown leaf rust (*P. recondita*); and, yellow or stripe rust (*P. glumarum*). Stem rust occurs throughout the wheat growing altitudes in Kenya which ranges from 2,000 meters (6,000 ft) to 3,000 meters (9,000 ft) above sea level but it is more severe in the medium and lower altitude areas. Brown leaf rust occurs throughout the various altitudes but is seldom very serious. On the other hand, yellow

rust develops from about 2,300 meters (7,000 ft) upwards and can be more limiting than stem rust at the higher altitudes where it attacks as a rust of the ears. Among the above-mentioned three rusts, stem rust was of such importance that it was given absolute priority, especially in the early years of this Century, with work on yellow rust beginning only in the late 50's.

2.3. A number of authors have recorded the struggle against wheat rusts in Kenya (Dixon, 1960; Guthrie and Pinto, 1969; Hurd, Oggema and Evans, 1969; Lathbury, 1947; Pinto and Hurd, 1970; Thorpe and Dixon, 1958). The records show that although there has been ups and downs, the effort against the rusts has been, on the overall, one of the significant records of success in research in Kenya. One estimate has shown that returns to investments made over the years in wheat research have been high (33%) relative to returns from investments in conventional projects (Makau, 1984).

2.4. Since the days of Delamere, many plant breeders and other scientists have made important contributions to the wheat breeding program in kenya (Appendix I). Apart from tremendous improvements in wheat quality, their effort had resulted in the release of 143 wheat varieties by 1982 as exhibited in Appendix II.

2.5. The original crop of Australian varieties grew well and gave yields of up to 6 bags per acre until 1908 when stem rust

attacked all the varieties. However, an Italian variety Rieti showed some resistance and Lord Delamere, the pioneer wheat farmer, planted his 1200 acres with this variety - only to see the crop devastated by yellow ear rust. It was at this point that Lord Delemare decided to employ his own plant breeder, since importing seed from other countries did not succeed.

2.6. G.W. Evans, the plant breeder employed by Lord Delamere, began his work in 1910 by crossing Rieti with the Australian varieties and other Egyptian and Canadian varieties. Unfortunately, Evans died in 1914. One of the most notable varieties from Evan's work which survived for a long time is Equator.

2.7. Evan's work was continued on a part-time basis during World War I by the Government Mycologist W.J. Dowson but a full-time plant breeder, G.J.L. Burton was appointed in 1921 stationed at the then Scott Agricultural Laboratories. During the tenure of Burton a number of varieties such as Kenya Droop and Kenya Governor were developed. But it was also around this time (1926) that the problem of mutating or physiological races of stem rust arose in Kenya for whereas Kenya Governor was susceptible to the new rust race named K2, another variety B.286 remained resistant. Burton then tried many imported varieties but he found few that he could recommend for release.

2.8. The next important development was the visit to kenya by a well-known authority, Sir Rowland Biffen whose recommendations resulted in the formal establishment of the Government Plant Breeding Station at Njoro, effectively taking over the breeding responsibilities pioneered by Lord Delamere. At the same time another Plant Breeder, R.J. Lathbury, was appointed to lead in the work of the station. Lathbury has given a detailed description of his work (Lathbury, 1947). Most of this description is technical and need not concern us here. However, about 15 new varieties could be attributed to the tenure of Lathbury. Lathbury was joined by H.C. Thorpe in 1938 and was succeeded by the latter in 1947 when he retired. Outbreak of World War II caused considerable disruption in the work of the station but the country was fortunate during the war years as it had a run of good seasons with few changes in rust races. However, after the war Lathbury's and Thorpe's wheats were eclipsed by new rust races and the fight against the rusts had to be stepped up.

2.9. Research objectives continued to be centered around breeding for resistance against rust, other parameters largely unattended to. Wheat varieties continued to be bred which were resistant to rust but rather low in yield, quality and adaptability. As a result of this, large quantities of wheat had to be imported for blending purposes to meet the deficit. No work was done on agronomy.

2.10. Consequently, an entirely new and greatly expanded program was introduced in 1950, bringing in more imported lines to give a much broader and safer genetic basis for local varieties. These included varieties from Mexico where Dr. Borlaug and his colleagues in the Rockfeller funded program had concentrated on producing high-yielding varieties. Also Kenya for the first time look part in the International Spring Wheat Nursery - in 1953. A year later, it participated in the Near East Nurseries organized by the FAO. These developments ushered Kenya into a new era of wheat breeding with extensive international cooperation in the exchange of germplasm and testing work. Dixon reports that the International and FAO Nurseries yielded much new material for direct multiplication and for breeding purposes, both for stem rust and yellow rust resistance (Dixon, 1960). From 1954 onwards considerable investments in new laboratories, extra land and other facilities were made so that the new expanded research programs could be accommodated.

2.11. In 1967 the objectives of the wheat research program were expanded to include agronomy; de-regionalisation of wheat to areas where it could be grown by small scale farmers; and, the development of efficient plant and produce protection techniques against field and storage pests. In 1970 quality testing was expanded by setting up a new cereal chemistry laboratory.

2.12. Hurd and others have observed that the battle against rust is never won (Hurd, Oggema and Evans, 1969; Knott, 1967). Only continuous vigilance in a team approach between the pathologist and the plant breeder can keep ahead of the ever-changing rust organism. And so the battle continues up to today and into the foreseeable future. However, with new techniques in biotechnology, the future of wheat breeding might be even brighter.

3.0. RESEARCH EXPENDITURES

3.1. Between 1921 and 1982 wheat research expenditures have been supported by the Kenya Government, the Kenya Wheat Board (now part of the National Cereals and Produce Board) and various donor agencies. Such donor agencies include the UN Food and Agricultural Organization (FAO), the Danish Agency for International Development (DANIDA), the Canadian International Development Agency (CIDA), the International Development Research Center of Canada (IDRC), the Rockefeller Foundation and the Federal Republic of Germany.

3.2. It should be mentioned that although the major concern of the Plant Breeding Station at Njoro had always been wheat research, it has also been involved over the years in research in other commodities although on a lesser scale than wheat. Before

the Second World War, there were minor research programs in oats, maize, sunflower and pyrethrum. The maize research program was considerably expanded from 1935 and finances for maize and wheat research continued to be accounted for as one figure until 1963 when they were separated. By that time maize research had been moved to another research station. However, oats research continued at Njoro until 1973. New research programs were introduced on oil seed breeding (1967); barley breeding (1972); oil seed agronomy (1974); and, triticale research (1974). Therefore in order to obtain the true expenditures spent on wheat research, it is necessary to determine the component of the research expenditure at Njoro attributable to wheat research only.

3.3. Makau has undertaken a detailed determination of research expenditures for wheat research according to the various supporting sources enumerated in 3.1 above (Makau, 1984). He has further developed conversion factors for computing the research expenditures attributable to wheat out of the total budget for the whole station at Njoro. The conversion factors are based on a detailed study of accounting vouchers and files at Njoro on operational expenditures for the various commodities. The conversion factors estimated for computing the expenditures attributable to wheat research are:

Period	Conversion Factor
1921-47	0.75
1948-62	0.67
1963-73	0.75
1974-82	0.63

The resultant expenditures obtained for current research expenditures are given in column 6 of Table 1.

3.4. Makau went on to determine real research expenditures (1976) by using a Capital Formation Deflator (CFD). The deflator was calculated by first computing a Cost of Living Index (CLI) from 1921 to 1982 from data by Cowen (Cowen, 1978); the Kenya Statistical Abstracts (Republic of Kenya, various years); and, the East African Economic and Statistical Reviews (East African Community, various years). The CLI was then regressed on a CFD for 1952-79 obtained from unpublished papers by Ryan (Ryan, 1983). The regression equation was then used to estimate the CFD for the other years i.e 1921-51 and 1980-82, a full description of the determination of the CFD is given Appendix III. The CFD was chosen over other possible types of deflators because research expenditures were regarded as capital expenditures. The deflator and deflated expenditures are given in Table 1 columns 7 and 8 respectively.

TABLE 1: WHEAT PRODUCTION AND RESEARCH EXPENDITURE IN KENYA
1921 TO 1982

(1) Year	(2) Wheat Prod. (Tonnes)	(3) Yeild (Tonnes/H	(4) Area (Ha)	(5) Rainfall (mm/100)	(6) Current Research Exp. (K£)	(7) Deflator	(8) Deflated Research Exp. (K£)	(9) Wheat Prices (Shs/100Kg)
1921	3357.69	0.61	5547	0.6507	1675	0.4820	3475	
1922	3362.32	0.54	6249	0.7665	1538	0.4586	3354	
1923	5297.18	0.63	8468	1.1354	2545	0.4399	5785	
1924	5534.26	0.57	9718	0.8051	1597	0.4212	3792	
1925	7258.19	0.59	12404	1.0027	2218	0.4212	5266	
1926	10959.29	0.58	18873	1.1918	3129	0.4165	7513	
1927	15820.72	0.52	30416	0.7165	1999	0.3838	5208	
1928	20712.84	0.62	33595	0.7315	2511	0.3510	7154	
1929	26634.09	1.04	25603	0.6653	2472	0.3042	8126	
1930	17629.73	0.63	27885	1.2812	2699	0.2621	10298	
1931	7878.53	0.45	17483	0.8245	2500	0.2527	9893	
1932	5742.10	0.47	12196	1.0502	2435	0.2434	10004	
1933	13061.94	0.92	14175	0.7671	2320	0.2293	10118	
1934	16235.58	0.92	17619	0.5294	2354	0.1966	11974	
1935	13775.54	0.65	21115	0.8703	2290	0.1872	12233	
1936	14074.64	0.61	23251	1.0760	2347	0.1732	13551	16.70
1937	16664.43	0.72	23155	1.1286	1769	0.1778	9949	17.05
1938	17246.28	0.96	17922	0.8480	1831	0.1732	10572	19.05
1939	20360.00	0.90	22670	0.6241	2166	0.1919	11287	19.84
1940	20360.00	0.90	22670	0.9150	2048	0.1872	10940	22.59
1941	21604.04	0.52	41715	1.1701	1991	0.2012	9896	27.50
1942	37652.22	0.76	49540	1.0575	2192	0.2200	9964	27.50
1943	64725.96	1.14	56661	0.8819	2206	0.2246	9822	29.70
1944	53870.37	0.83	64869	0.8302	2540	0.2293	11077	30.25
1945	76366.07	1.06	72067	0.8859	3619	0.2340	15466	30.25
1946	74283.66	0.94	78949	0.8571	2680	0.2340	11453	30.64
1947	63289.51	0.81	78352	1.2902	2459	0.2434	10103	30.65
1948	94559.30	1.17	80625	0.8404	2196	0.2527	8690	36.02
1949	103569.02	1.15	90179	0.7599	3220	0.2668	12069	36.02
1950	130588.20	1.24	105734	0.7184	2981	0.2714	10984	43.78
1951	117355.55	0.96	121870	1.2780	4100	0.3136	13074	50.96
1952	111653.03	0.96	116484	0.6343	5449	0.2499	21805	57.27
1953	119511.60	1.02	117057	0.6071	5731	0.3583	15995	57.75
1954	138507.14	1.18	117543	1.0805	20715	0.2697	76808	57.70
1955	111987.64	0.80	140196	1.0318	15921	0.2864	55590	56.10
1956	114927.83	0.95	121611	1.1885	15043	0.2905	51783	57.93
1957	100797.44	0.99	101680	0.8076	31714	0.2999	105749	56.85
1958	96827.76	0.98	98959	1.3136	29652	0.2999	98873	57.56
1959	128204.88	1.22	105221	0.8839	50496	0.3020	167205	53.48
1960	109497.90	1.06	102853	0.8202	50765	0.3041	166948	51.28

TABLE 1 CONT.

(1) Year	(2) Wheat Prod. (Tonnes)	(3) Yeild (Tonnes/H	(4) Area (Ha)	(5) Rainfall (mm/100)	(6) Current Research Exp. (K£)	(7) Deflator	(8) Deflated Research Exp. (K£)	(9) Wheat Prices (Shs/100Kg)
1962	119788.90	1.15	104224	1.1059	28204	0.3280	85988	53.54
1963	130088.98	1.10	118126	1.0614	13185	0.3374	39078	53.54
1964	144257.50	1.19	121217	0.9613	13339	0.3374	39535	53.54
1965	133312.74	1.01	131396	0.5529	15910	0.3520	45199	53.54
1966	180652.50	1.31	137872	0.9503	46889	0.3675	127589	56.84
1967	240969.58	1.59	151771	0.6987	52562	0.4047	129879	56.78
1968	224528.61	1.34	167392	1.1624	51491	0.4105	125435	56.26
1969	217436.49	1.32	164609	0.8002	61001	0.4191	145552	54.51
1970	178443.61	1.39	128103	1.1445	72496	0.4439	163316	45.10
1971	170316.18	1.48	115188	0.9142	76082	0.4613	164930	50.61
1972	149585.76	1.43	104494	0.8382	82151	0.5050	162675	50.61
1973	137884.32	1.28	107427	0.7413	75423	0.5804	129950	56.72
1974	157832.73	1.50	105183	1.0764	72756	0.7276	99995	80.36
1975	175709.07	1.50	117333	1.1932	52338	0.8506	61531	104.71
1976	175930.38	1.47	119746	0.6986	55062	1.0000	55062	120.30
1977	170865.27	1.24	137871	1.1203	61303	1.0848	56511	133.33
1978	165271.59	1.39	119062	1.2730	141303	1.2084	116934	133.33
1979	114707.52	1.74	65862	0.9093	147139	1.3605	108151	143.64
1980	204498.09	2.05	99991	0.9093	163649	1.5959	102543	163.86
1981	234546.21	2.25	104401	0.9393	187371	1.9328	96943	166.67
1982	227628.45	2.02	112952	0.9566	231109	2.2183	104183	173.60
AV.	94683.15	1.05	78400	0.9316	32916		53920	
S.T.D	71925.89	0.40	47784	0.2059	49679		54979	

Sources: From Makau, 1984 as follows:

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3.5. The data for the expenditures shows that research expenditure rose slightly when the Government took over the research station at Njoro around 1927 - when the real (1976) research expenditures passed the K£ 10,000 mark. However, the expenditures continued to be more or less at the same level until after World War II. The rise of expenditures in the after-war years is mainly accounted for by the expansion of programs in the early 50's and the joining by Kenya in the international nursery and germplasm exchange programs. Expenditures continued to rise until there was a sharp decline in 1963-65. These were the years of independence (1963) when the colonial administration was pulling out of the country. Thereafter the current expenditures continued to rise steadily but in real times these expenditure began to go down from the mid-seventies due to inflationary pressure generated mainly by high oil prices arising from the 1972-74 dramatic oil price increases by OPEC.

4.0. PRODUCTION AND YIELDS

4.1. The area planted with wheat and the total production is presented in Table 1 Columns 4 nd 2 respectively. A column on rainfall as a critical factor in yield determination is also included (Column 5, Table 1). The yield in tonnes per hectare rose steadily from 0.61 in 1921 to 2.02 in 1982. This is a testimony of the contribution of improved technology on production which is a tribute to the tenacity and dedication of

the researchers over the years. In general it is apparent that despite the changing virulence of rust the researchers were always ahead in the battle as the figures show that there was no significant backward slip or lapse in yield over the years. On the contrary, the results show an ever increasing yield per hectare.

4.2. Those who are familiar with the critical place of breeding research in wheat against rust will no doubt know that the above increases in yield per hectare must be, to a large measure, attributed to the breeders. However, there are other factors which, though they may not have been as much responsible for yield increases, need to be mentioned here. Of special significance would be fertilizers, pesticides, extension and prices.

4.3. No data is available in Kenya, at least for the years 1921-82, on fertilizer consumption by individual crop. However investigations among the old wheat farmers show that use of fertilizers in wheat started around 1949 with the use of cotton seed ash. Shortly afterwards, the use of cotton seed ash was abandoned as it was found to introduce undesirable weeds into the wheat fields. It was replaced with the use of rock phosphate from Tororo in Uganda which was phased out quickly by the use of commercial fertilizer which began in the early 50's. Looking at the trend of data we don't see a spectacular rise in yields per

hectare at the time fertilizers started to be used. This raises the possibility that the quantity and quality of the fertilizer was such that its effect, compared with other factors would have been of far less importance than expected. It is also possible that in an econometric analysis, the effect of fertilizer can be embodied, at least in part, in the area coefficient.

4.4. In the case of pesticides, the major pesticides that would be used in Kenya would be fungicides. However, the aggressive breeding program has over the years made the use of fungicides completely unnecessary. In the estimation of the benefits of research, this would be counted as a benefit in the form of cost savings.

4.5. In assessing the impact of research, some studies also take into account expenditures in extension either as a separate item or consolidated with research expenditure. However, between most of the period 1921 and 1982 the wheat farmer was so knowledgeable about wheat growing that extension was virtually non-existent. The farmer was in direct contact with the research station to the extent that new varieties and techniques were adopted as soon as they came out. Annual field days used to be held but on the overall, research extension expenditures are not an important variable in the case of wheat production during those years. However, in more recent years, as wheat is taken up by less

experienced smaller-scale farmers in more arid areas, extension has taken on a greater significance.

4.6. The prices of wheat from 1936 to 1982 are given in table 1 Column 9. Wheat prices in Kenya have always been controlled. A more detailed analysis is required in order to determine their possible impact on productivity.

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APPENDIX 1

PERSONNEL AND NOTABLE EVENTS IN WHEAT RESEARCH IN KENYA 1906-1970

1906-08

1,200 acres of wheat grown in Njoro area by Lord Delamere were attacked by stem and stripe rust. He brought in G. W. Evans, the first plant breeder in Kenya.

1913

W. J. Dowson, Mycologist took responsibility from Evans during the First World War.

1921

G. J. L. Burton, Plant Breeder succeeded Dowson.

1927

The Plant Breeding Station at Njoro was established and wheat research was moved from the Scott Laboratories in Nairobi.

1927

R. J. Lathbury, Plant Breeder was appointed assistant to Burton and succeeded him as Director in 1936.

1938

H. C. Thorpe, Plant Breeder, joined the staff and replaced Lathbury as Director in 1946.

1952

G. E. Dixon, Plant Breeder, joined the staff and replaced Thorpe as Director in 1960.

1953

Old sources of rust resistance broke down and an important program was started.

1954-70

Several Plant Breeders contributed to the program including F. F. Pinto (1954-68), K. W. Lynch (1957-63), V. P. Patel (1960-), C. N. Kagira (1967-69), M. W. Oggema (1967-) and N.o. Kabonyo (1968-).

1956

E. J. Guthrie, Plant Pathologist was appointed and succeeded Dixon as Director in 1965.

1961

Introduction and testing of wheats from all parts of the world was started by means of a continuing grant from the Rockfeller Foundation. R. Little, Plant Breeder, took charge of this work in 1966.

1966

Canada supplied the following Plant Breeders: R. F. Peterson (1966-68), E. A. Hurd (1967-70), L. E. Evans (1968-69), K. W. Buchannon (1969-70), and R. De Pauw (1970-). Plant pathologists were W. F. Hanna (1966-68), G. J. Green (1968), J. W. Martens (1968-69), and D.E. Harder (1969-70). In 1970 M. W. Cormack, Plant Pathologist became the first Canadian Director.

1970

Quality testing was expanded by setting up a new cereals chemistry laboratory. J. B. Jabanputra was appointed Cereal Chemist. A. G. O. Whiteside, Cereal Chemist from Canada, assisted in equiping and organising this laboratory.

Source: Pinto, F. F. and E. A. Hurd, 1970. "Seventy Years with Wheat in Kenya" East African Agricultural and Forestry Journal. XXXVI, Special Issue.

APPENDIX II

WHEAT VARIETIES RELEASED IN KENYA 1920-1982

Registration No.	Name	Year
1	Equator	1920
2	Kenya Governor	1925
3	Kenya Droop	1929
4	Kenya Standard	1930
5	Kenya N. B. 230	1933
6	Kenya N. B. 256.G	1934
7	Sabanero	1934
8	Reward	?
9	Kenya 58.F	1937
10	Kenya 112.A	1936
11	Kenya 117.A	1939
12	Kenya 122	1939
13	Kenya 131	1939
14	DC X Ceres 721	1946
15	Kenya 291	1946
16	Regent	1946
17	Kenya 294.M	1947
18	Kenya 294.B	1948
19	M. K. 1066	?
20	Kenya 318.AJ	1949
21	Kenya 261.R	1949
22	Kenya 117A MK 11	1949
23	Rhodesian Sabanero	1949
24	Kenya Settler	1950
25	Kenya Ploughman	1950
26	Kenya 291, JMK 11	1950
27	Kenya 360.H	1951
28	Kenya 337	1951
29	Kenya Farmer	1951
30	Kenya 338 AA	1951
31	Kenya 184 P	1951
32	Kenya 350	1951
33	Kenya 341	1951
34	Kenya 321	1952
35	R. 64	1953
36	Carleton	1953
37	Kenya 351	1954
38	Kenya 354	1955
39	Kenya 356.A	1955
40	Kenya 261.A	1955
41	Kenya 356.B	1956
42	Kenya 358.AA	1956

43	Kenya 362.B.1.E.4	1956
44	Kenya 358.AC	1957
45	Kenya 358.P	1957
46	Kenya 358 R	1957
47	Kenya 363	1957
48	Kenya 362.B.1.A.1B	1957
49	Kenya 362.B.1.D.3.D	1957
50	1055/1	1957
51	1060/6	1957
52	Mida-cadet	1957
53	Capella	1957
54	Hopeful	1957
55	Impala	1957
56	Kenya 339	1958
57	Kenya B.1.A	1958
58	Kenya 367.AP	1958
59	Kenya 367 BR	1958
60	H. 462	1958
61	RL 2150/A	1958
62	Sabanero/1	1958
63	Kenya Curlew	1959
64	Kenya Eagle	1959
65	Kenya Kark	1959
66	Kanya Burzard	1959
67	Kenya Dove	1959
68	Kenya Plover	1959
69	Kenya Quail	1959
70	Africa-Mayo	1960
71	Kentana Yaqui	1960
72	Wisconsin-Supremo	1960
73	Mida-McMurachy-Exchanre	1960
74	S. Africa No. 43	1961
75	Yaktana 54	1961
76	Kenya 374	
77	A.K.M.S. X Yaqui 2	1961
78	Veranopolis	1961
79	Rushmore-Surpressa	1961
80	F.K.N 25	1961
81	Gala	1961
82	Kenya Jay	1961
83	Kenya Grange	1962
84	Yaqui 50	1962
85	Tama	1963
86	Menco	1963
87	Salmayo	1963

88	Lamana	1963
89	Catcher	1963
90	Yaqui 53	1963
91	Kenya Page	1963
92	Cabrino	1963
93	Fronthach	1963
94	Gem	1963
95	Pewter	1964
96	Fanfare	1964
97	Bailey	1964
98	Brewster	1964
99	Morris	1964
100	Fury	1964
101	Kenya Hunter	1964
102	Prime X 908 X Fn X CJ 54	1965
103	Kenya Blume	1965
104	Goblet	1965
105	Kenya Kudu	1966
106	Kenya Civet	1966
107	Kenya Leopard	1966
108	Romany	1966
109	Token	1967
110	Bonny	1967
111	Bounty	1967
112	Trophy	1968
113	Beacon	1968
114	Kenya Sungura	1969
115	Tai	1969
116	Kasuku	?
117	Twiga	1970
118	Kenya Kanga	1971
119	Kenya Bongo	1971
120	Kenya Swara	1972
121	Kenya Mamba	1972
122	Kenya Kiboko	1973
123	Kenya Nyati	1973
124	Kenya Kuro	1974
125	Kenya Mbweha	1974
126	Kenya Paka	1975
127	Kenya Tembo	1975
128	Kenya Nungu	1975
129	Kenya Nyoka	1975
130	Kenya Bata	1975
131	Kenya Fahari	1977
132	Kenya Kifaru	1977

133	Kenya Ngiri	1979
134	Kenya Nyangumi	1979
135	Kenya Zabadi	1979
136	Kenya Mwewe	1979
137	Kenya Njiwa	1979
138	Kenya Kengewa	1979
139	Paa	1981
140	Kenya Kongoni	1981
141	Kenya Kulungu	1982
142	Kenya Nyumbu	1982
143	Kenya Popo	1982

Source: National Plant Breeding Station, Njoro,1983.
Unpublished Data, Njoro,Nakuru.

APPENDIX III

DETERMINATION OF THE CAPITAL FORMATION DEFLATOR (CFD)

The figures available for a Capital Formation Deflator (CFD) were for the years 1952 to 1979 (Ryan, 1983). So the first task was to find any index stretching from 1921 to 1982. Then this index could be regressed on the 1952-79 CFD and the regression equation used to estimate the CFD values for 1921 to 1951 and 1980 to 1982. A Cost of Living Index (CLI) for 1921 to 1982 was constructed for this purpose. The following data was used to construct the CLI:

- A Consumer Price Index (CPI) constructed by Cowen (1978) for 1926 to 1936, Karatina Area, Nyeri.

- A Cost of Living Index (CLI) constructed by Cowen for 1934 to 1962, Karatina Area, Nyeri.

- A Retail Price Index (RPI) for the year 1958 to 1968 from the East African Economic & Statistical Reviews, Lower Income Group.

- A Consumer Price Index (CPI) for the years 1966 to 1975, from the Kenya Statistical Abstracts, Lower Income Group.

- A CPI for the years 1971 to 1982 from the Kenya Statistical Abstracts, Lower Income Group.

These indices were chosen for two reasons: First they had to be overlapping so that they could be converted into one another. Secondly, the indices had to be for the lower income groups. This is because the only index obtainable stretching into the early years was Cowen's and this was for a rural area, Karatina, Nyeri. The Lower Income Group Indices were chosen as they were assumed to be the ones likely to approximate more closely to rural consumers and cost of living indices such as Cowen's.

Referring to Table 2, column 2 contains Cowen's Consumer Price Index from 1926 to 1936. This index contains a gap after every even year and goes down only up to 1926. These gaps had to be filled and estimates for 1921 to 1925 worked out. For this purpose, a linear regression equation was computed using the data in column 2 and using a biannual periodicity. This regression equation was:

$$CPI = 142 - 13X, \quad 1930/32 = 0$$

$$r^2 = 0.868$$

where the value of X changes by a unit representing two years.

Table 2: CPI VALUES 1921 TO 1936 (1936=100)

Year (1)	Cowen's CPI Values (2)	Regression Estimates (3)	Odd Year Estimates (4)	The Complete Series (5)
1920		220		220
1921			214	214
1922		207		207
1923			200	200
1924		194		194
1925			193	193
1926	192			192
1927			180	180
1928	169			169
1929			154	154
1930	138			138
1931			136	136
1932	133			133
1933			128	128
1934	123			123
1935			112	112
1936	100			100

Source: Column 2: Cowen, M.P. 1978. Capital and Household Production: The case of Wattle in Kenya's Central Province, 1903-1964. Ph.D Thesis, University of Cambridge, Table 5.

Other Columns: Own Computation from column 2:
See notes on Appendix III

Using the above equation, the values for the years 1920, 1922 and 1924 were estimated and are shown in column 3. Then using both actual and estimated values from column 2 and 3 respectively, the values for the odd years were calculated by simply taking the average of the preceeding and the succeeding years. The values obtained for the odd years are shown in column 4. Column 5 simply consolidates all the values from columns 2, 3 and 4 into one column to show the complete CPI series.

The next step was to calculate conversion factors using the overlapping portions of the indices as shown in Table 3. Referring to this table, the brackets} or {indicate the areas of overlap for each pair of indices; the arrow indicates the direction of conversion; and the figure associated with the arrow is the conversion factor (C.F.) as computed from the overlapping area of the respective indices.

The final product of this conversion exercise is the CLI in column 3 stretching from 1921 to 1982. This CLI was then linearly regressed on the Capital Formation Deflator (CFD) available for 1952 to 1979. The regression equation obtained was:

CFD = -0.1404 + 0.00468 CLI, 1952-79 incl.

CFD = 1.0000 in 1976

CLI = 100 in 1962

R^2 = 0.990

The CFD values for 1921 to 1951 and 1980 to 1982 were then estimated using the above equation. The CFD values are given in column 7.

Table 3: Computation of Cost of Living Index (CLI), 1921 to 1982 and Capital Formation Deflator (CFD) 1921 to 1982

Year	CPI 1936=100	CLI 1962=100	RPI Oct. 1958=100	CPI Aug. 1971=100	CPI Jan/June 1975=100	CFD 1976=1.0000
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1921	214	133				.4820
1922	207	128				.4586
1923	200	124				.4399
1924	194	120				.4212
1925	193	120				.4212
1926	192	119				.4165
1927	180	112				.3838
1928	169	105				.3510
1929	154	95				.3042
1930	138	86				.2621
1931	136	84				.2527
1932	133	82				.2434
1933	128	79				.2293
1934	123	72				.1966
1935	112	70				.1872
1936	100	67				.1732
	C.F.=0.62					
1937		68				.1778
1938		67				.1732
1939		71				.1919
1940		70				.1872
1941		73				.2012
1942		77				.2200
1943		78				.2246
1944		79				.2293
1945		80				.2340
1946		80				.2340
1947		82				.2434
1948		84				.2527
1949		87				.2668
1950		88				.2714
1951		97				.3136
1952		94				.2499
1953		96				.3583
1954		97				.2697
1955		97				.2864
1956		98				.2905
1957		98				.2999
		C.F.=0.95				
1958		98	100			.2999
1959		98	101			.3020
1960		98	103			.3041
1961		99	105			.3114
1962		100	108			.3280
1963		100	108			.3374
1964		100	108			.3374
1965		109	115			.3520

		C.F.=1.31			
1966	112	118	90.1		.3675
1967	114	120	91.7		.4047
1968	115	121	92.4		.4105
1969	115	121	92.4		.4191
1970	117	123	93.9		.4439
			C.F.=1.49		
1971	125	132	100.9	68.5	.4613
1972	129	136	103.9	70.6	.5050
1973	148	156	119.5	82.2	.5804
1974	173	182	138.7	91.4	.7276
1975	208	219	166.9	108.2	.8506
1976	218	230	175.8	118.0	1.0000
1977	265	279	212.8	142.8	1.0848
1978	301	317	241.8	162.3	1.2084
1979	329	346	263.9	177.1	1.3605
1980	371	391	298.4	200.3	1.5959
1981	443	466	356.1	239.0	1.9328
1982	504	530	405.0	271.8	2.2813

Source: Column 2: Table 2
Column 3: Cowen, 1978. op. cit. Table A.6
Column 4: East African Economic and Statistical Reviews
Column 5: Kenya Statistical Abstracts
Column 6: Kenya Statistical Abstracts
Column 7: 1952 to 1979: Ryan, T.C.I 1983. Unpublished Data.
University of Nairobi.
Other years: Own computations: See notes on Appendix III