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A RELATIONSHIP IN PLANT DISEASE CONTROL METHODS  
BETWEEN THE UNITED STATES OF AMERICA AND KENYA  
ON SELECTED MAJOR FIELD CROPS

A Thesis

by

RICHARD KIPRONO MIBEY

Submitted to the Graduate College of  
Appalachian State University  
Partial fulfillment of the requirement for the degree of  
MASTER OF SCIENCE

May 1978

Major Subject: Biology

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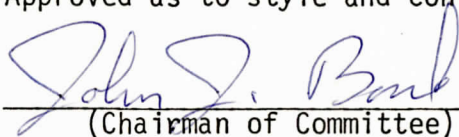
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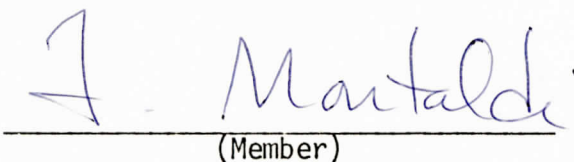
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ABSTRACT

A RELATIONSHIP IN PLANT DISEASE CONTROL METHODS  
BETWEEN THE UNITED STATES OF AMERICA AND KENYA  
ON SELECTED MAJOR FIELD CROPS

(May 1978)

Richard K. Mibey, B.A., Warren Wilson College  
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Directed by: Dr. John Bond

Both Kenya and the United States experience many of the same crop problems. Though both countries differ a great deal in economy and development, several disease control procedures can be shared. The use of resistant varieties, crop rotation, chemical seed treatment and cultural practices are useful practices in both countries.

Though chemical treatment of crops is not in extensive use on most of the Kenyan crops as in the United States, this practice is certain to be used in the future due to industrial growth and economic development. Though technical knowledge and good farming management is certain to be employed in the near future, Kenya would still need to limit the extent of chemical application for the safety of the environment. Unlike the United States, the majority of the people in Kenya have no access to running water and therefore use either springs, well or river water for domestic purposes. It is imperative that this natural resource be kept free of chemical contamination. One way to do this is to avoid chemical application of field and farm crops.

## ACKNOWLEDGEMENTS

Special thanks go to Dr. John Bond, who helped organize and direct this research, Dr. Sandra J. Glover, who financed the trip around the United States where the author investigated the crops described in this study, and to Dr. Francis Montaldi for his advice and encouragement to carry out this study. I would also like to thank Dr. I. W. Carpenter, Jr. for his help in identifying the crops while on the trip. Much thanks also go to Mr. Gene Brewer of the United States Department of Agriculture in Boone, North Carolina for his help in contacting various agricultural research stations in the United States.

I appreciate the fine work of the typist, Mary L. Crowder.

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## INTRODUCTION

Having been raised up in an area where the people rely very heavily on subsistence farming, the desire to help my people improve crop production has led me to undertake this research study.

There are many factors that hinder successful crop yield year after year, but the major problems are drought, disease, and technical knowledge. "Agricultural development is difficult in Kenya for it requires the transformation of people from subsistence agriculture into scientifically oriented agriculture." (15)

In the field of plant pathology, it is reported that coffee berry disease is the most important plant disease in Kenya. "In 1967 an estimated 30% of the crop was lost from this disease and a total loss of the crop occurred on many farms." (11) The availability of information on disease control measures on United States crops and the opportunity to travel and observe the crops around the United States aroused my interest in investigating United States methods of disease control and their applicability to Kenyan crops.

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The citations of this thesis follows the style of the Journal of Bacteriology.

## HISTORICAL REVIEW

Wheat (Triticum)

This study will consider selected major diseases of wheat. These diseases are common to both the United States of America and Kenya.

Bunt, covered smut or stinking smut is caused by Tilletia foetida (Wallr.) Liro occurs in cool soil temperatures following planting. Infection takes place in seedlings prior to emergence as bunt spores on the seedcoat infect young seedlings. The fungus grows with the plant to maturity and replaces normal kernels with smut spores. These may break during harvest to reinfect the soil. Characteristics of bunt smut are: bluish-green heads that are more open than heads not affected, a mass of black powdery spores in place of grain, intact glumes, and a fishy odor (14).

Loose smut, caused by the fungus Ustilago tritici (Pers.) Rostr., occurs when humidity is high during bloom. Loose smut infects wheat flowers and grows into the embryo of the seed which, the next year, produces smutted heads. The noticeable characteristic of the disease is the black smut spores covering the head parts (14).

Seed rots and seedling blights are caused by several seed and soil fungi which attack germinating seeds and seedlings, especially if seed is of poor quality and germination conditions are not ideal. The noticeable characteristics of these diseases are a poor stand of uneven weak plants and poor root systems (14).

Wheat streak mosaic is caused by a virus vectored by the wheat curl mite Aceria turipae. Characteristic symptoms of this disease include:

yellowing, stunted growth, mottled and prostrate tillers. This disease caused severe damage to the wheat crop in Kansas in 1949 and 1959 (8).

Soil-borne mosaic is caused by a virus vectored by the fungus Polymyxa graminis. This disease was first noticed in Kansas along the Missouri River and southeastern Kansas in 1952. Diseased plants appear yellow, stunted, and have a reduced vigor. The disease favors low and wet areas. The pathogen can survive in a dry barren soil for over ten years thus making crop rotation ineffective (9).

Leaf rust is caused by the fungus Puccinia recondita (Eriks.) Carleton which prefers mild winters, humid environments with constant dew, and slow drying conditions during the months of April and May. The disease is common in the eastern part of Kansas. The distinctive features are: small, circular, red pustules on leafy portions of the plant, shriveled grain, and early dying of leaves (14).

Stem rust is caused by the fungus Puccinia graminis Pers., and it occurs in warm, moist weather with frequent dews and slow drying during April and May. The distinctive features are: oblong, dark red pustules on leaves, stem, and head, and shriveled grain. Telial stage develops at maturity (14).

Take-All is caused by Ophiobolus graminis Sacc., and is favored by continuous wheat cultivation and fertilizer imbalance. The distinctive features are: short plants, light colored patches on leaves, rotted roots, dead wheat with shriveled grain, and plants with shiny black lower stem portions (14).

Cephalosporium stripe is caused by the fungus Cephalosporium gramineum and is favored by continuous wheat cultivation, early planted



wheat, and slightly acidic soils. The major symptoms are: narrow yellow stripes across the entire leaf length, stunted growth, and lodging (14).

### Tobacco (Nicotiana)

Tobacco, the major crop of the southeastern United States, faces many disease problems. The following tobacco diseases affect the burley tobacco crop in North Carolina and surrounding states.

Black shank is caused by the fungus Phytophthora parasitica var. nicotianiana (Breda de Haan) Tucker. The disease spreads quickly under wet conditions, killing many plants. The fungus is able to survive in the soil for several years without host plants being present. At first the symptoms of the disease resemble drowning, later symptoms manifested are wilting, yellowing, and root rot. Other symptoms include discing of pith and blackening of the lower stalks. Wet weather accelerates the spread of Black shank because the zoospores produced are carried with rain water to other plants in the field (1).

Fusarium wilt is caused by the fungus Fusarium oxysporum Schlecht. The disease is found in sandy river and creek bottom soils, and is less common in rich upland soils. Fusarium wilt, or "yellows," is distinguished by yellowing and the gradual death of leaves on one side of the plant. The bud tends to bend toward the yellow leaves in small plants. Leaves on one side of the large plant may turn yellow from the ground up and finally wilt and die. When split, the inside of the stalk with yellow leaves reveals a ring of discolored tissue. The discoloration can be traced down the stalk into one of the roots. There are many strains of this pathogen. One strain is able to infect not only tobacco

but also attack watermelons, tomatoes, potatoes, sweet potatoes, cotton, or other crops with a history of Fusarium wilt. Tobacco grown in fields in which these other crops have been grown may become infected (1).

Tobacco mosaic is caused by tobacco mosaic virus (TMV). Symptoms of this disease include mottling of leaves and dwarfing of plants. The virus is spread mechanically by laborers in the field and machinery (1).

### Maize (Zea)

Maize, a major crop of the Midwest, with Iowa the leading corn producer in the nation, is subject to several diseases. No attempt has been made to include all corn diseases, only those that occur on a regular basis in the Midwest have been considered.

Seedling blight is caused by various fungi: Diplodia zeae (Schw.) Lev., Gibberella zeae (Schw.) and Pythium spp. Characteristics of the disease include death of the embryo before germination, and small lesions on roots and lower portions of the shoot. Often the first interval above the seed is rotted and, as a result, the food and water supply from the seed to the shoot is blocked.

Seedling blight is caused by several fungi in the genus Pythium. Maize grain are more susceptible to infection under cool wet conditions and when the grain has been damaged in harvest. Also, old grain is more susceptible than freshly harvested grain (10).

Stalk rot is caused by the fungi usually of the following species: Diplodia zeae (Schw.) Lev., Gibberella zeae (Schw.), and Fusarium moniliforme Sheldon. Distinguishing features include dark brown lesions that may appear close to the nodes shortly after pollination. Also,

rotted stalks have a pink tint inside and intact vascular bundles. Other symptoms include early death of leaves and finally killing of plants (10).

Crazy top is caused by the fungus Sclerospora graminicola (Sacc.) Shroet. Symptoms of the disease include: tassel proliferation, excessive ear shoots, numerous internodes above the ear, stunting, narrow leaves, excessive tillering and total suppression of tassel and ear formation. This fungus overwinters as oospores within infected tissue or in the soil. The oospores germinate and swimming zoospores are produced during floods. The zoospores penetrate the shoot of the young maize plant. The fungus also attacks wild grasses, sorghum, and small grains (10).

Corn smut is caused by Ustilago maydis (D.C.) Cda. The main symptom is gall formation on ears, leaves, silks, tassels, and stems. The most susceptible tissue is embryonic tissue and shoot tissue. The galls become filled with teliospores. These spores overwinter, germinate in the spring, and produce basidiospores. The basidiospores initiate infection (10).

Southern corn leaf blight is caused by Helminthosporium maydis Nisik & Miyake. The disease symptoms include tan elliptical lesions on leaves (6 to 12 mm wide and .6 to 1.5 mm long) with a reddish-brown border often surrounded by a yellowish area. Heavily infected leaves may be killed. The fungus overwinters as mycelium in corn residue. Spores produced by this mycelium next spring initiate infection of the following year's corn crop (10).

Northern corn leaf blight is caused by Helminthosporium turcicum Pass. Symptoms of the disease include long elliptical lesions

(25 to 150 mm long) that are gray-green to tan in color. The fungus does not grow through to the kernels although the husks may be infected. The fungus overwinters in infected crop residue as spores and mycelium. Spores are wind blown to hosts and lesions appear about two weeks after infection (10).

Common corn rust is caused by the fungus Puccinia Sorghi Schw. Symptoms are long, oval, brown-orange pustules scattered on both the upper and lower leaf surfaces. Pustules or uredia develop on any part of the corn plant above ground. These contain orange urediospores which are able to infect corn. Later in the season, uredia are replaced with telia which contain teliospores. These spores overwinter germinate and produce basidiospores which infect Oxalis spp. Eventually aeciospores are produced on Oxalis spp. which infect corn. Disease development is favored by humid cool weather. Under some conditions the fungus is able to overwinter as urediospores (10).

Maize dwarf mosaic virus incites the disease maize dwarf mosaic. Symptoms include: shortened internodes, yellow and green striped leaves, and mottled older leaves. The virus is vectored by several species of aphids (10).

Fusarium kernel rot is caused by the fungus Fusarium moniliforme Sheldon. A major symptom is pinkish grain caps. The grain later becomes shriveled and rots (10).

### Peanuts (Arachis)

Peanuts, a major crop of the southeastern United States, are grown extensively in the Carolinas and Georgia. Along with drought, the crop

genera and species: Helminthosporium oryzae B. de Haan, Pythium spp., Rhizoctonia solani Kuehn., Fusarium spp., and Sclerotium rolfsii Sacc. Symptoms of the disease include: dwarfing and yellowing of seedlings, spotty stands, and decayed seeds (5).

Blast, also known as rotten neck, is caused by the fungus Piricularia oryzae Gav. Symptoms of the disease include spots or lesions on leaves, nodes, and panicles. The fungus can also infect the junction of the sheath and the leaf blade. The disease is most prevalent during wet warm weather and plants planted late are most susceptible (5).

Sclerotium oryzae Catt. causes stem rot of rice. The disease symptoms include: spotty stands, watersoaked areas on sheaths, and black spots on sheaths and lodging. A sign of the fungus is the presence of black sclerotia in the base of the stem (5).

Brown leaf spot is caused by the fungus Helminthosporium oryzae B. de Haan. The disease causes extensive damage in Texas. Symptoms of this disease are dark brown to gray spots on coleoptiles, leaf sheaths, panicle branches, leaves and glumes, also grain may be chalky or lightweight (5).

Kernel smut is caused by Neovossia horrida (Tak.) Padwick & Khans. Both yield and quality of the grain is affected by this disease. The endosperm is replaced by smut spores but the embryo remains alive and is able to germinate. During moist conditions, infected grain swell and break open revealing the spores. Late planted rice is most susceptible as are plants grown under conditions of fertility imbalance (5).

Brown-bordered leaf and sheath spot is a soil-borne disease and

is caused by the fungus Rhizoctonia oryzae (Ryker & Gooch). The sclerotia formed by the fungus is able to overwinter in the soil or rice straw. Symptoms include: sheaths with large irregular spots with reddish-brown borders, dead leaves, and lodging. The disease is most prevalent under warm moist conditions. Plants given excess nitrogen are more susceptible than plants receiving less nitrogen. The pathogen is also able to infect grasses other than rice (5).

#### Potatoes (Solanum)

Like many of the crops already mentioned, potato diseases are initiated by different organisms: bacteria, fungi, and viruses. Only the main diseases are mentioned here.

Early blight is caused by the fungus Alternaria solani Ell. & G. Martin. Characteristic symptoms include small, angular, brown spots forming circular rings on the basal leaves. Heavily infected leaves may be killed (5).

Late blight is caused by the fungus Phytophthora infestans (Mont.) d By. Disease symptoms include watersoaked leaves and stems. Under moist conditions, hyphae can be seen on the adaxial surface of infected leaves. Infected tubers develop a firm rot in the field and a soft rot in storage (5).

Potato scab is caused by the actinomycete Streptomyces scabies (Thaxt.) Waks. & Henrici. Infected tubers have irregular, round, and often rough cork spots. Though injury does not penetrate deeply into the tubes, scabby potatoes are not appealing. The disease prefers alkaline to acidic soils (5).

### Sugarcane (Saccharum)

This crop encounters many disease problems, but only the major diseases have been accounted for in this study.

Sugarcane mosaic is caused by a mosaic virus. The virus is vectored by several species of aphids. Symptoms include mottled leaves, yellowish and dwarfed plants. No external symptoms are visible. The virus may be transmitted mechanically. The chief distinguishing feature of the disease is the pink to orange coloration inside the lower part of the plant nodes (5).

Red rot is caused by the fungus Colletotrichum falcatum Went. All portions of the sugarcane plant are subject to attack but the seed pieces are most severely infected. Characteristic symptoms are: weak plants, poor seed piece development, and redding of inner stalks. Also, red to gray lesions may form on the leaves. The seed may rot (5).

Pineapple disease is caused by the fungus Ceratostomella paradoxa Dade. The disease causes greatest damage to the seed piece. Characteristic symptoms are: red to black stalk core, a faint pineapple-like odor, and severely infected seed pieces may completely rot (5).

### Cotton (Gossypium)

The following cotton diseases are common in the United States of America and Kenya. The methods of disease control reported on this crop are practiced in the United States.

Bacterial blight, angular leaf spot, vein blight, black arm, and boll rot are caused by the bacterium Xanthomonas malvacearum (E.F. Sm.) Dons. Roots are the only portions of the cotton plant not affected by

the disease. Some symptoms are: angular spots on leaves, watersoaked areas on veins, and bolls which later turn black (5).

Verticillium wilt, caused by the fungus Verticillium albo-atrum Reinke & Berth., is a soil-borne disease. The symptoms of this disease are: stunted seedlings, yellowing of older plants, and wilting. Internal portions of infected stems are discolored (5).



## MATERIALS AND METHODS

This research study was written as a result of a field trip undertaken by the biology department of Appalachian State University around the United States, parts of Mexico and Canada. The trip was taken from June 20, 1977 to August 5, 1977. The journey started in Boone, North Carolina and proceeded through all the southeastern states including Florida. From Florida, the group went to Texas, with a short trip into Mexico.

The group reached California early in July and traveled to British Columbia, Canada, through Oregon and Washington. After going through all the northwestern and midwestern states, the group returned to Boone early in August 1977.

The author observed crops and diseased plants grown in each state. All crops were recorded according to their state; however, only crops of major importance in both the United States of America and Kenya were considered for this study.

The author investigated control methods used in Kenya and the United States on eight major crops: wheat, tobacco, maize, groundnuts (peanuts), rice, potatoes, sugarcane, and cotton. Some suggestions are given that would serve both the United States and Kenya in controlling the diseases of these crops.

The data used in this research study were obtained by writing letters to various experimental stations throughout the United States. A short trip was made to Kenya, but no information on disease control could be secured.

The contributions of this trip to this study are great.

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Wheat	Seed rot and seedling blight is caused by the fungi: <u>Helminthosporium</u> spp., <u>Fusarium</u> spp., <u>Sclerotium rolfsii</u> .	<ol style="list-style-type: none"> <li>1. Seed treatment with fungicides.</li> <li>2. Planting seeds no deeper than necessary.</li> <li>3. Crop rotation (5).</li> </ol>	Crop rotation with small grains and non-cereal crops such as soybeans. Also, proper planting of seeds.
Wheat	Wheat Streat Mosaic is caused by a virus carried by the wheat curl mite <u>Aceria tulipae</u> (8).	<ol style="list-style-type: none"> <li>1. Destruction of volunteer wheat two weeks prior to planting.</li> <li>2. Late planting (after Hessian fly free date).</li> <li>3. Resistant varieties: Eagle, Triumph 64, Trison, Gage, Scout, Danne, and Sage (8).</li> </ol>	Destruction of volunteer wheat before planting a new crop. Also, the use of available resistant varieties like Eagle and Triumph.
Wheat	Soil-borne Mosaic is vectored by the fungus <u>Polymyxa graminis</u> .	<ol style="list-style-type: none"> <li>1. Late planting to avoid cool and wet weather.</li> <li>2. The use of resistant varieties, Shawnee, Pronto, Santanta, Chanute, Homestead, Gage, Centurk, and Buckskin (8).</li> </ol>	Strongly recommend the use of resistant varieties like Shawnee and Pronto.

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Wheat	Leaf rust is caused by the fungus <u>Puccinia recondita</u> .	Resistant varieties such as Cloud, Sage, and Parker (5).	The use of resistant varieties such as Cloud, Sage, and Parker.
Wheat	Stem rust is caused by the fungus <u>Puccinia graminis</u> .	Resistant varieties such as Homestead (5).	The use of resistant varieties such as Homestead.
Wheat	Take-all disease is caused by the fungus <u>Ophiobolus graminis</u> .	<ol style="list-style-type: none"> <li>1. Crop rotation using oats and non-cereal crops for about three years.</li> <li>2. Proper fertilization (5).</li> </ol>	Strongly recommend rotation out of wheat for a period of two to three years with other cereals, except barley and rye.
Wheat	Cephalosporium Stripe is caused by the fungus <u>Cephalosporium gramineum</u> .	<ol style="list-style-type: none"> <li>1. A crop rotation using non-cereal crops for a period of one to two years.</li> <li>2. Burning stubble.</li> <li>3. Plowing early after harvest to allow stubble to decay (5).</li> </ol>	Rotation with non-cereal crops for one to two years. Also, plowing early after harvest to allow enough time for stubble to decay.

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Wheat	Bunt, also called covered smut or stinking smut, is caused by the fungus <u>Tilletia foetida</u> .	<ol style="list-style-type: none"> <li>1. Seed treatment with the fungicide Ortho weed seed Protectant (captan 20%, HCB 20%).</li> <li>2. The resistant varieties: Trison, Satanta, Chanute, and Bison (5).</li> </ol>	The use of the resistant varieties like Trison and Satanta.
Wheat	Loose smut is caused by the fungus <u>Ustilago tritici</u> .	<ol style="list-style-type: none"> <li>1. Seed treatment using Carboxin (Vitavax 200).</li> <li>2. Hot water seed treatment.</li> <li>3. The use of resistant varieties Triumph 64, Scout, and Eagle (5).</li> </ol>	Hot water seed treatment and the use of resistant varieties like Triumph 64, Scout, and Eagle.
Tobacco	Black shank is caused by the fungus <u>Phytophthora parasitica</u> var. <u>nicotianae</u> .	Resistant varieties such as Virginia 509, Burley 37, Burley 49, and Burley 64 (12). Planting grass sod in infested field to allow the fungal spores enough time to disappear (1).	A crop rotation with cereals be employed to allow time for the fungal population to diminish.

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Tobacco	Fusarium wilt is caused by the fungus <u>Fusarium oxysporum</u> .	Resistant varieties: Kentucky 12, Kentucky 14, MS Kentucky 14 x 18, and MS Kentucky 21 x Kentucky 12 (12).	Crop rotation with oats or other related cereals (4).
Tobacco	Mosaic is caused by the tobacco mosaic virus.	Resistant varieties: Burley 49, Kentucky 12, Kentucky 14, Kentucky 10, Burley 64, and Burley 21 (12).	Sanitation, since the disease is spread by contact. The growers clean their equipment when moving from infested areas to healthy plots (1).
Maize	Seedling blight is caused by several fungi: <u>Diplodia zeae</u> and <u>Gibberella zeae</u> are both soil-borne. <u>Pythium</u> spp. is seed-borne (10).	Seed treatment with the fungicide captan (50% wp)	The disease is controlled by seed treatment with fungicides in dusted forms when packing.
Maize	Stalk rot is caused by the fungi <u>Pythium</u> spp., <u>Macrophomina phaseoli</u> , <u>Diplodia macrospora</u> , <u>Helminthosporium maydis</u> , and others.	<ol style="list-style-type: none"> <li>1. Planting clean seed (5).</li> <li>2. Rotation with small grains, soybeans, or forages (6).</li> <li>3. Proper soil fertilization balancing N and K (5).</li> </ol>	Would encourage the use of healthy seeds, crop rotation with small grains, legumes, or forages.

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Maize	Crazy top is caused by the fungus <u>Sclerophthora macrospora</u> .	Proper soil drainage.	Is not of economic importance on the Kenyan crop but would recommend adequate soil drainage if the disease becomes devastating.
Maize	Corn smut caused by the fungus <u>Ustilago maydis</u> .	<ol style="list-style-type: none"> <li>1. Hybrids showing a high incidence of smut should not be planted.</li> <li>2. Balance of nitrogen. Disease incidence is increased in fields high in nitrogen (10).</li> <li>3. Mechanical injury during cultivation should be avoided.</li> <li>4. Destruction of galls on infected plants (5).</li> </ol>	<p>That hybrids showing a high incidence of smut be avoided and that the farmer remove and burn galls from infected plants in home gardens before they rupture.</p> <p>The author has recommended the above methods because they would not be costly to the farmer and are easy to perform, yet effective.</p>

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Maize	Southern corn leaf blight is caused by the fungus <u>Helminthosporium maydis</u> .	<ol style="list-style-type: none"> <li>1. Using double cross hybrids: Ind. 851, Ind. 874, Ind. 828, Ind. 872, Ind. 814, Ind. 837 (3).</li> <li>2. Plowing under infected crop refuse.</li> <li>3. Maintaining a low plant population.</li> <li>4. Fungicide application on the leaves (10).</li> </ol>	Cultural practices such as plowing under infected crop refuse, a low plant population, and possibly the use of double cross hybrids like Ind. 851, Ind. 874, Ind. 828, Ind. 872, Ind. 814, Ind. 837 (4).
Maize	Northern corn leaf blight is caused by the fungus <u>Helminthosporium taricum</u> .	<ol style="list-style-type: none"> <li>1. It is recommended that fungicides be applied starting when lesions are first found (5).</li> <li>2. Plant double cross hybrids: Ind. 851, Ind. 874, Ind. 828, Ind. 872, Ind. 814, Ind. 837 (4).</li> </ol>	<ol style="list-style-type: none"> <li>1. Crop rotation with small grains, soybeans, or forages.</li> <li>2. The use of double cross hybrids such as Ind. 851, Ind. 874, Ind. 828, Ind. 872, Ind. 814, Ind. 837 (4).</li> </ol>
Maize	Corn rust is caused by the fungus <u>Puccinia sorghi</u> .	<ol style="list-style-type: none"> <li>1. Using resistant varieties.</li> <li>2. Application of fungicides in early stages of the disease.</li> </ol>	The use of resistant varieties favorable to Kenyan climate. Seed treatment and crop rotation have no effect on the disease (4).

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Maize	Fusarium kernel rot is caused by the fungus <u>Fusarium moniliforme</u> .	Proper drying of grain to 13% or less moisture content (10).	It would be best to harvest the corn soon after they are fully ripened since the disease is associated with wet conditions.
Peanuts	Sclerotinia blight is caused by the fungus <u>Sclerotinia minor</u> .	<ol style="list-style-type: none"> <li>1. Leafspot schedule using: Benlate + Manzate + oil or Benlate + Dithane M-45 + oil.</li> <li>2. Burning hay on fields where severe damage occurred.</li> <li>3. The resistant variety Florigiant (13).</li> </ol>	<ol style="list-style-type: none"> <li>1. The use of resistant varieties, possibly Florigiant.</li> <li>2. Hay be burned in infested fields.</li> </ol>
Peanuts	Southern stem rot is caused by the fungus <u>Sclerotium rolfsii</u> .	<ol style="list-style-type: none"> <li>1. Plowing deeply in order to bury old crop residues.</li> <li>2. Crop rotation with cotton, corn, grain sorghum, and small grain.</li> <li>3. The resistant variety NC-2.</li> <li>4. Soil Fungicide PCNB.</li> <li>5. Vitavax 10G applied at the rate of 10 to 12 lbs. formulation per acre.</li> </ol>	<ol style="list-style-type: none"> <li>1. Deep plowing to bury old crop residues.</li> <li>2. Crop rotation with cotton, corn, grain sorghum, and small grain is possible since all these crops are grown in Kenya also.</li> </ol>



CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Peanuts	Cylindrocladium black rot of peanuts is caused by the fungus <u>Cylindrocladium crotalarie</u> .	<ol style="list-style-type: none"> <li>1. All diseased plants are disced under prior to digging and combining operations.</li> <li>2. All diseased plants are removed and either burned or buried.</li> <li>3. Equipment is washed to remove microsclerotia.</li> <li>4. Crop rotation using corn for a period of three to five years (13).</li> </ol>	<ol style="list-style-type: none"> <li>1. Diseased plants be disced under before digging.</li> <li>2. It is possible for the diseased plants to be removed for burning or burying.</li> <li>3. A crop rotation with corn and small grain for three to five years is possible since corn is also raised in Kenya.</li> </ol>
Peanuts	Pod rot is caused by two fungi: <u>Pythium myriotylum</u> and <u>Rhizoctonia solani</u> .	<ol style="list-style-type: none"> <li>1. Podox L in combination with Temik and Furadan.</li> <li>2. PCNB or PCNB + Mocap (13).</li> </ol>	<ol style="list-style-type: none"> <li>1. A crop rotation with unrelated crops.</li> <li>2. Since the fungus is capable of colonizing most crop residues, it is best that they be burned before the next crop is planted (5).</li> </ol>

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Rice	Seedling blight and seed decay is caused by several fungi: <u>Helminthosporium oryzae</u> , <u>Pythium</u> spp., <u>Rhizoctonia solani</u> , <u>Fusarium</u> spp., and <u>Sclerotium rolfsii</u> .	<ol style="list-style-type: none"> <li>1. Seed treatment using captan orthocide, terrazole + PCNB and Terra-coat L-205.</li> <li>2. Maintaining a low flood.</li> <li>3. Shallow seeding of rice (5).</li> </ol>	<ol style="list-style-type: none"> <li>1. Shallow seeding of rice and a low flood.</li> <li>2. Seed treatment using available chemicals.</li> </ol>
Rice	Blast is caused by the fungus <u>Piricularia oryzae</u> .	<ol style="list-style-type: none"> <li>1. Planting early and a reduction in nitrogen application help reduce the severity of the disease.</li> <li>2. Adequate flooding (5).</li> </ol>	Soil tests for nitrogen balance and a proper flood management program. Soil tests can be done at the National Agricultural Laboratories in Nairobi.
Rice	Stem rot is caused by the fungus <u>Sclerotium oryzae</u> .	<ol style="list-style-type: none"> <li>1. Rotation with non-cereal crops.</li> <li>2. Proper water management and a reduction in nitrogen applications (5).</li> </ol>	A crop rotation program using cotton and other unrelated crops.
Rice	Brown leaf spot is caused by the fungus <u>Helminthosporium oryzae</u> .	<ol style="list-style-type: none"> <li>1. Balanced soil fertilization.</li> <li>2. Crop rotation.</li> <li>3. Adequate soil drainage (5).</li> </ol>	<ol style="list-style-type: none"> <li>1. Balanced soil fertilization.</li> <li>2. Crop rotation.</li> <li>3. Water management and proper soil preparation.</li> </ol>

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Rice	Kernel smut is caused by the fungus <u>Neovossia horrida</u> .	<ol style="list-style-type: none"> <li>1. Resistant varieties.</li> <li>2. Low nitrogen in the soil.</li> </ol>	<ol style="list-style-type: none"> <li>1. The use of resistant varieties where applicable.</li> <li>2. A reduction rate of nitrogen fertilizer.</li> </ol>
Rice	Brown-bordered leaf and sheath spot is caused by the fungus <u>Rhizoctonia oryzae</u> .	<ol style="list-style-type: none"> <li>1. The use of resistant varieties.</li> <li>2. Reduced seeding rates and nitrogen applications.</li> <li>3. A control of grass and weeds (5).</li> </ol>	<ol style="list-style-type: none"> <li>1. The use of resistant varieties.</li> <li>2. A reduction in the seeding rates and nitrogen application.</li> <li>3. Control of grass and weeds.</li> </ol>
Potato (Irish)	Early blight is caused by the fungus <u>Alternaria solani</u> .	Control is accomplished by using the following fungicide applications: Zinc-ion maneb (80% wp) Diathane M-45 Manzate 200 (5).	The use of chemicals to reduce disease incidence on potatoes had been employed in Kenya in the early 1950's by the English settlers (2). The use of fungicides, Zinc-ion Maneb (80% wp), Diathane M-45, and Manzate 250 for use in combating the disease on the Kenyan crop.

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Potato (Irish)	Scab is caused by the Actinomycete <u>Streptomyces scabies</u> .	<ol style="list-style-type: none"> <li>1. Avoid planting in alkaline soils.</li> <li>2. Proper irrigation programs during early stages of growth.</li> <li>3. A four to six year rotation with legumes.</li> <li>4. Severely infested fields must be avoided (5).</li> </ol>	<ol style="list-style-type: none"> <li>1. Alkaline-producing soil amendments such as manure, ashes, lime, nitrate or soda, or calcium cyanamide should be avoided.</li> <li>2. Crop rotation of four to six years with legumes preceding potatoes should be employed,</li> <li>3. Severely infested fields must be avoided.</li> </ol>
Sugarcane	Mosaic virus vectored by several species of aphids.	<ol style="list-style-type: none"> <li>1. Resistant varieties and using disease-free seed.</li> <li>2. Fields are rouged to eliminate diseased cane at the seedbed stage (5).</li> <li>3. By the destruction of grasses and weeds that harbor the aphids (12).</li> </ol>	<ol style="list-style-type: none"> <li>1. The use of available resistant varieties and a mosaic-free seed.</li> <li>2. That fields be rouged several times at the seedbed stage to eliminate mosaic infected plants.</li> <li>3. Destruction of grasses and weeds that harbor the aphids would be possible here.</li> </ol>

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Sugarcane	Ratoon stunting is caused by a virus.	<ol style="list-style-type: none"> <li>1. Hot water treatment of seed at 50°C for three hours or hot air 54°C for eight hours.</li> <li>2. Sterilization of all cutting implements (5).</li> </ol>	<ol style="list-style-type: none"> <li>1. That cane seed be treated in hot water 50°C for three hours.</li> <li>2. Since the disease is spread by cutter planters, harvesters, knives, and stubble shovers, these instruments should be sterilized.</li> </ol>
Sugarcane	Red rot is caused by the fungus <u>Colletotrichum falcatum</u> .	<ol style="list-style-type: none"> <li>1. Resistant varieties.</li> <li>2. Early planting and good seed preparation (5).</li> </ol>	The use of the available resistant varieties and a good seedbed preparation.
Sugarcane	Pineapple disease is caused by the fungus <u>Ceratostomella paradoxa</u> .	<ol style="list-style-type: none"> <li>1. Fungicide treatment of seed pieces prior to planting (8).</li> <li>2. The use of good quality plants for quick germination.</li> <li>3. Avoid planting under cold and wet conditions (5).</li> </ol>	The farmer should avoid planting under cold and wet conditions.

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Cotton	Bacterial blight (Angular leaf spot or Blackarm) is caused by <u>Xanthomonas malvacearum</u> .	<ol style="list-style-type: none"> <li>1. Seed treatment using Busan (30% + 60% E.C.) at the rate of 2.3 oz/100 lbs. Captan (50% wp) <ul style="list-style-type: none"> <li>- Captan</li> <li>- Orthocide at the rate or .75 to 4 oz/100 lbs. slurry</li> <li>1.13 to 2.7 oz/100 lbs. dry</li> </ul> </li> <li>2. Eliminating crop residues after harvest (5).</li> <li>3. Crop rotation using cereal crops (5).</li> </ol>	<ol style="list-style-type: none"> <li>1. Destruction of crop residues by plowing under after harvest and crop rotation to reduce a source of inoculum since it wouldn't be as costly.</li> <li>2. Seed treatment using Busan (30% + 60% E.C.) at the rate of 2.3 oz/100 lbs. Captan (50% wp). <ul style="list-style-type: none"> <li>- Captan</li> <li>- Orthocide at the rate of .75 to 4 oz/100 lbs slurry</li> <li>1.13 to 2.7 oz/100 lbs. dry.</li> </ul> </li> </ol>

CROP	DISEASE/PATHOGEN	CONTROL METHODS IN THE UNITED STATES OF AMERICA	RECOMMENDED CONTROL METHODS FOR KENYA
Cotton	Verticillium wilt is caused by the fungus <u>Verticillium albo-atrum</u> .	<ol style="list-style-type: none"> <li>1. Using resistant varieties such as Acala 70, Paymaster 909, Acala 3080.</li> <li>2. Proper application of fertilizers, shallow cultivation and a rotation with unrelated crops help reduce the severity of the disease (5).</li> </ol>	<ol style="list-style-type: none"> <li>1. The use of the resistant varieties Acala 70, Paymaster 909, and Acala 3080 since these varieties are grown in Texas, a state that has a climate similar to that of Kenya.</li> <li>2. A balanced fertility program may not work because it could be an expensive project to perform. But controlled irrigation, crop rotation, and shallow cultivation to avoid root pruning would be practical.</li> </ol>

## DISCUSSION AND CONCLUSION

According to the information given in the table, the author has recommended most of the United States methods for combating diseases in Kenya. This is a result of the diseases being common to both countries though their climatic conditions differ considerably. Not all methods practiced on the United States crops would benefit Kenyan crops. The author strongly recommends the use of resistant varieties because the use of chemicals in developing countries is not only costly but also detrimental to the health of the inhabitants as chemicals could be washed down into main streams and lakes. Most of the water used for domestic purposes is secured locally by the residents from untreated sources such as the rivers, streams, ponds, and lakes that may have collected run-off water.

There are several methods of controlling plant diseases, but only four major ones have been considered here: the use of resistant varieties, crop rotation, chemical treatment, and cultural practices. The author has strongly recommended the use of resistant varieties because it would be appropriate for those who may not have the technical knowledge for chemical applications and soil treatments. Chemical use not only requires special knowledge but may also be expensive. The use of less resistant or more susceptible varieties should not be ignored because many of the less resistant varieties have a good yield potential. The wheat variety, Sage, is susceptible to bunt and soil-borne mosaic virus diseases, yet is one of the highest yielding varieties and has a good relative quality. Another wheat variety, Parker, is susceptible to soil-borne mosaic virus, wheat streak mosaic, and stem rust,



but has both a good yield potential and relatively high quality. Until varieties that are not only resistant to diseases but also have a good yield potential and superior quality are developed, it will be necessary to consider chemical treatment, crop rotation, and other cultural practices.

Another method of disease control considered to be important on the Kenyan crop is crop rotation. In this method most plants and non-hosts are rotated in a way that reduces the population of the pathogen on a site. The object of crop rotation as a disease control measure is to reduce the incidence of a certain pathogen in the soil by growing crops resistant to or immune from its attack. As shown on page 20 of the table, the control of southern stem rot of peanuts has been achieved by a rotation with cotton, corn, grain sorghum, and small grain. Since cotton, corn (maize) and grain sorghum does well in Kenya, this method would be effective. The scab disease of potatoes (Irish) as shown on page 24 of the table is controlled by a four to six year rotation with legumes preceding potatoes in the United States and since both crops are grown in Kenya, the method would be applicable.

Crop rotation is effective but is limited in its application to certain crops like sugarcane. A few crops like this can do well in an area that is favorable for its growth and development, but it would be rare to find a crop that is of the same economic importance and can do well in the same plot. Also, crop rotation may not be of much effect against soil-inhabiting organisms that are capable of surviving in the soil for several years even in the absence of a host (7). These and other factors would lead us into employing other methods of disease

control.

Chemical treatment is a method that is widely used in the United States to eradicate pathogens in most crops. Of the eight crops listed on the table, there is no disease that escaped chemical treatment. This procedure involves spraying, dusting, and seed treatment and is designed to put a toxic barrier between the host plant and the inoculum or eradicate established pathogens during the growing season. As shown on page 26 of the table, I have recommended chemical seed treatment on bacterial blight of cotton for the Kenyan crop because the job can be done during packaging and the farmer is prevented from mishandling the chemicals. Chemical treatments have not been encouraged for fear that they may later be proven hazardous to the environment.

Cultural practices may be employed to avoid disease. Examples are: choice of location, time of planting, seedbed preparation, plant spacing, and plowing. These procedures have been chosen because they are easy to perform and can be very effective. In the case of bacterial blight of cotton as shown on page 26 of the table, the disease incidence is reduced by plowing under plant refuse after harvest. Another cotton disease, Verticillium wilt as shown on page 27 of the table, is controlled in the United States by shallow cultivation to avoid root pruning. These procedures have been recommended for use on the Kenyan crop because they would not be a difficult task to undertake. As shown on page 18 of the table, there are some diseases, such as crazy top of corn, that have no other method of control except cultural. This particular disease is reduced by adequate soil drainage or the avoidance of planting in low, wet areas. This procedure is employed in the United States and it would

be applicable to the Kenyan crop. Another disease controlled by cultural procedures is the southern stem rot of peanuts. Control in North Carolina is brought about by deep plowing to bury old crop residues infected with pathogens. This method has also been recommended for use on the Kenyan crop because tractor machinery is now extensively used and deep plowing can be accomplished.

Hot water treatment has been recommended to treat cane used for seed to combat Ratoon stunting of sugarcane disease. The cane used for seed is treated with hot water at 50°C for two to three hours to destroy the virus. This method has been recommended because it is the best procedure presently employed in the United States and it can be easily applied in Kenya.

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The typist for this thesis was Mary L. Crowder.

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