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ECONOMIC ANALYSIS OF YIELD LOSSES DUE TO DISEASES - A CASE STUDY OF EARLY LEAF SPOT OF GROUNDNUT IN MALAWI[1]

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ABSTRACT

This paper attempts to quantify the economic losses due to early leaf spot in Malawi. Based on yield loss estimates, the mean annual production loss in groundnut in on-station and on-farm situations is estimated at 34.3% and 18.9%, respectively. Early leaf spot of groundnut alone causes a mean annual loss of US $ 4.79 million to the national income. Groundnut being a major export earner, eliminating yield losses due to early leaf spot would contribute up to 46% of the trade balance. The impact of early leaf spot management on household food security and on farm income is also analyzed. The results show that depending on the area allocated to groundnut cultivation, an additional 1.75 to 14.0 persons per family could be made food-secure by controlling early leaf spot. Implications for research policies on disease management are derived from the results of the analyses. It is stressed that unless economically viable technological alternatives are developed for reducing yield losses, the potential benefits of crop production cannot be fully realized.

Key Words: **Groundnut, peanut, early leaf spot, yield losses, economic analysis, food security**

RÉSUMÉ

Cette étude essaye de quantifier les pertes économiques dues à la maladie des feuilles d'arachides tachées précocement au Malawi. La perte moyenne annuelle de production d'arachide dans les centres de recherches où dans les fermes, basée sur les estimations des pertes en rendement est évaluée à 34,3% et 18,9% respectivement. La maladie des feuilles d'arachide tachées précocement cause à elle seule une perte moyenne de 4.79 millions de $ US dollars au revenu national. Les arachides étant un important générateur de revenus à l'exportation, l'élimination des pertes de rendements dues à la maladie des feuilles tachées précocement contribuerait à près de 46% de la balance de payement. L'impact de la gestion de la maladie des feuilles tachées précocement sur la sécurité alimentaire et sur le revenu des fermes a aussi été analysé. Les résultats ont montrés que selon les régions affectées à la culture de l'arachide, entre 1.75 et 14 personnes supplémentaires peuvent acquérir la sécurité alimentaire grâce au contrôle de la maladie de feuilles tachées précocement. Les implications pour les programmes de recherches sur la gestion de maladies sont issues des résultats des analyses. Il est important de noter que si l'on ne développe pas des technologies alternatives économiquement viables pour la reduction des pertes de rendement, les bénéfices potentiels de la production de cette culture ne pourront pas être réalisés entièrement.

Mots Clés: **Arachide, cacahouète, maladies des feuilles tachées précocement, pertes en rendement, analyse économique, sécurité alimentaire être réalisés**

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INTRODUCTION

Crop losses due to diseases have a direct impact on the welfare of farm households as well as on the national economy. The impact of these losses is felt more severely when the commodities are traded in the world market and the country earns foreign exchange from crop exports. In their attempts to help farmers reduce crop losses, government agencies are faced with the problem of resource allocation in two areas - (i) to allocate investment in research leading to technology development in managing the diseases, and (ii) to analyze the extent to which market infrastructure needs to be improved in order to make disease control inputs such as fungicides more accessible to farmers. The latter also includes designing policies relating to input subsidies so that the benefits from such technology are fully realized. To address such policy questions, adequate information on the extent of crop losses and their impact on farm households and on the overall economy is essential. Unfortunately, studies that quantify such impacts of crop diseases are rather scanty in developing countries.

In this paper, we use a case study of groundnut (*Arachis hypogaea L.*) in Malawi. Yield losses due to early leaf spot (*Cercospora arachidicola* Hori.) were analyzed in terms of their economic impact on farm households and on the national economy. The specific objectives of this paper are: to estimate the impact of losses in groundnut yields due to early leaf spot on the gross domestic product (GDP), export volume, value of exports, and the trade balance; to study the effects of yield losses on farm income and household food security; and to derive policy implications for investment in research on the management of early leaf spot.

GROUNDNUT PRODUCTION AND MARKETING IN MALAWI

Groundnut is Malawi's fourth most important export crop after tobacco, sugar, and tea and the most important leguminous crop. In the smallholder sector, groundnut is the second most important crop after maize, and provides a supplementary source of cash income. The majority of the crop (over 63%) is produced in the Central region covered by the Lilongwe and Kasungu Agricultural Development Divisions (ADDs). Pod yields are low, averaging 700 kg ha^{-1}. Until recently, the Agricultural Development and Marketing Corporation (ADMARC), a parastatal of the Government of Malawi was the sole purchaser of groundnut from the farmers. Some groundnut is traded locally, and some is consumed domestically as food. Groundnut purchased by ADMARC is graded and sold in the export market. A portion of the produce is also crushed for oil.

EARLY LEAF SPOT OF GROUNDNUT

Diseases are considered to be a major constraint to groundnut production in Malawi (Mercer, 1977; Subrahmanyam, 1983, 1991; Ngwira, 1985; Bock, 1987; Kisyombe, 1987a). A large number of fungal, viral, and nematode diseases have been reported to occur in the country. Most of the diseases are widespread in the country, but only a few are economically important on a national basis. Early leaf spot is the most destructive disease of groundnut in Malawi, and is especially serious in the Central region.

ECONOMIC ANALYSIS OF EARLY LEAF SPOT: A CASE STUDY

In analyzing the impact of early leaf spot on the household and national economy, Malawi presents a typical case for several reasons: i) field trials have been conducted at the Chitedze Agricultural Research Station near Lilongwe for the past 20 years, and the magnitude of responses to fungicidal control of early leaf spot are available for all these years; ii) the groundnut cultivar Chalimbana was used in these studies in most years; iii) the cultivar Chalimbana covers a major portion of the total area under groundnut cultivation in Malawi, and iv) the field trials were carried out in the Central region, the main groundnut production area.

DATA SOURCES

The data on area, production, and yield of groundnut for the past 11 years were taken from the Guide to Agricultural Production in Malawi,

published by the Ministry of Agriculture, Malawi. The data on groundnut prices, ADMARC purchases, and the volume and value of exports were taken from various Economic Reports published by the Office of the President and Cabinet. The data on trade balance and the groundnut contribution to the trade balance were taken from various issues of Economic and Financial Review of the Reserve Bank of Malawi. Yield losses from early leaf spot on which the impact analysis is conducted were computed using the data from fungicidal trials conducted from 1970/71 to 1990/91 at the Chitedze Agricultural Research Station.

TRENDS IN GROUNDNUT AREA AND PRODUCTION IN MALAWI

In analyzing the yield losses due to diseases and their impact on the general economy of the country, it is important to recognize the changes in trends of area under the crop, production, and yield. Such an analysis by itself could provide an explanation for the changes in these variables due to the diseases. Table 1 presents the data on area, production, average yield, and value of groundnut in Malawi for 11 years (1980/81 to 1990/91).

The area under groundnut is highly responsive to its relative price with maize, the major staple food crop of Malawi. The total area under groundnut was stable in the first half of the 1980s, and started declining after 1988/89 with an average decline of about 5.2% per year.

The total production increased during the mid-1980s, and has showed a decline since 1987/88 coincident with the decrease in area. The average decline in production for the period from 1981/82 to 1990/91 is 4.7% per annum. Differences in growth rates between area and production could be attributed to variations in yield (which is largely dependent on rainfall) and severity of early leaf spot, and the combination of these two factors.

Yields ranged from 249 kg ha^{-1} in 1988/89 (a drought year) to 501 kg ha^{-1} in 1985/86, which had the highest rainfall during that decade. Since groundnut production technology remained the same over the period under study, the variation in yield levels could be largely attributed to the rainfall situation and to the severity of early leaf spot.

The total value of groundnut production showed a slight increase despite the declining trends in area and production. They were compensated by increasing groundnut prices.

GROUNDNUT PROCUREMENT, PRICES, AND EXPORTS

Groundnut is an important source of foreign exchange in Malawi. To understand the impact on the export market of production losses due to early leaf spot, it is important to investigate the

TABLE 1. Area, production (metric tons, MT), average seed yield, and value of groundnut in Malawi, 1981/82 to 1990/91[1]

Crop season	Area (000 ha)	Production (000 t)	Average seed yield (kg ha^{-1})	Value (m MK)[2]
1980/81	143	50.1	350	16.52
1981/82	145	52.3	369	17.80
1982/83	146	53.9	369	28.01
1983/84	145	54.8	378	32.34
1984/85	136	62.3	458	42.98
1985/86	176	88.2	501	65.25
1986/87	210	88.2	420	65.27
1987/88	176	76.9	437	55.38
1988/89	140	34.9	249	28.59
1989/90	48	18.5	385	16.45
1990/91	70	0.9	441	30.87

[1] Guide to Agricultural Production, Ministry of Agriculture, Malawi
[2] Value in millions of Malawi Kwacha (US $ 1 = MK 3.22)

marketing channels of groundnut from the producer to the export market.

The extent to which the impact of early leaf spot will be felt on export earnings depends on the quantity of groundnut purchased by ADMARC, and on the quantity exported. Table 2 shows the price of groundnut paid to farmers, the quantities and values of purchases, and the ADMARC purchases as a percentage of total production. The price of groundnut ranged from Malawi Kwacha (MK) 0.33 kg^{-1} in 1980/81 to MK 1.00 kg^{-1} in 1990/91. Despite the increase in price, the production showed a decreasing trend. This is partly due to increase in the price of maize which competes with groundnut for land area in Malawi.

About 62% of the groundnut produced in Malawi in 1980/81 was purchased by ADMARC. The quantity purchased by ADMARC declined until 1984/85, after which it increased to 60% in 1986/87. The quantity purchased has again declined in recent years. Data on the export price of groundnut, value of groundnut exported, and exports as a percent of total exports are presented in Table 2. The value of groundnut exports has declined during the 11 year period indicating a relationship between exports and ADMARC purchases. Groundnut exports have declined steadily over the 11 year period in absolute terms and as a percentage of total exports, the latter from 7.4% in 1980/81 to 0.1% in 1989/90 and 1990/91. This is partly due to the pricing policy of the government which promotes maize over other crops.

ESTIMATION OF YIELD LOSSES FROM ON-STATION AND ON-FARM TRIALS

Data on the estimates of yield losses due to early leaf spot for the years 1970/71 to 1990/91 are given in Table 3. Data from the on-farm trials are also available for some years (Mwenda and Cusack, 1989). The yield of groundnut sprayed with chlorothalonil is given along with yield of unsprayed groundnut. Based on these values the avoidable yield loss is calculated using the formula:

Avoidable yield loss (%) = [(Yield of fungicide sprayed - Yield of unsprayed) / Yield of fungicide sprayed] x 100.

There is a considerable yield variation in both fungicide-sprayed and unsprayed fields, and hence in the yield loss over the years. This is possibly due to the variation in rainfall, since the variety of groundnut (Chalimbana) and the fungicide (chlorothalonil) applications have remained largely unchanged over the years. This indicates that estimating the impact of diseases based on only a few seasons of trials may not provide a true picture, at least under rainfed, low-input production systems in developing countries.

Based on the five trials conducted on farmers' fields in Lilongwe ADD, Mwenda and Cusack

TABLE 2. Purchases and exports of groundnut by the Agricultural Development and Marketing Corporation (ADMARC) in Malawi

Crop season	Groundnut price (MK kg^{-1} seed)	Purchase by ADMARC (000 MT)	Value (m MK)	% of total production purchased by ADMARC	Export price (MK kg^{-1})	Value of groundnut exported (m MK)	Export of groundnut as a % of total value of national export
1980/81	0.33	31.4	10.4	62.7	0.31	15.9	7.4
1981/82	0.34	19.5	6.6	37.3	0.72	10.6	4.6
1982/83	0.52	10.6	5.5	19.7	1.09	4.6	1.8
1983/84	0.59	10.2	6.0	18.6	1.27	2.9	1.1
1984/85	0.69	9.9	6.8	15.9	1.49	1.1	0.3
1985/86	0.74	18.1	13.4	20.5	1.56	5.2	1.3
1986/87	0.74	53.2	39.4	60.3	1.61	15.5	3.5
1987/88	0.72	44.8	32.3	58.2	1.54	13.1	2.2
1988/89	0.82	15.6	12.8	44.8	1.56	23.9	3.2
1989/90	0.89	0.6	0.5	3.2	1.96	1.0	0.1
1990/91	1.00	4.5	4.5	14.4	1.96	0.7	0.1

MT = metric tons; MK = Malawi Kwacha

TABLE 3. Estimated losses in seed yield of groundnut due to early leaf spot at Chitedze Agricultural Research Station, Malawi

Crop season	Seed yield (kg ha^{-1})[1]		Avoidable yield loss (%)
	Fungicide sprayed	No fungicide (control)	
1970/71	3159	1773	43.9
1971/72	2860	1703	40.5
1972/73	3628	2344	35.4
1973/74	2133	1364	36.1
1974/75	2207	1589	28.0
1975/76	2797	1200	57.1
1976/77	2964	2118	28.5
1977/78	3670	1707	53.5
1978/79	3609	2510	30.5
1979/80	2507	1613	35.7
1980/81	1859	1085	41.8
1981/82	2011	1472	26.8
1982/83	3101	1774	42.8
1983/84	2167	1796	17.1
1984/85	3326	1882	43.4
1985/86	2299	1681	26.9
1986/87	3171	2023	36.2
1987/88	3400	1894	44.3
1988/89	1413	594	58.0
1989/90	3045	2596	14.8
1990/91	1810	1350	25.4

1. Source of data: Kisyombe, 1980 (1970/71 to 1979/80), Ngwira, 1984 (1983/84), Kisyombe, 1987b (1984/85 to 1985/86); Ngwira, 1985 (1980/81 to 1982/83), Kisyombe, 1987c (1986/87); Anon., 1988 (1987/88); Gondwe, 1989 (1988/89); Bock and Hildebrand, unpublished (1989/90); and Subrahmanyam, unpublished (1990/91).

(1989) estimated that the average response to disease control on farmers' field was about 55% of the on-station response. Using this relationship between on-station and on-farm responses, the yield losses due to early leaf spot were calculated (Fig. 1).

POTENTIAL YIELD AND PRODUCTION LOSSES DUE TO EARLY LEAF SPOT

Given the estimates of yield losses due to early leaf spot in on-station and on-farm situations, groundnut production losses for Malawi as a whole could be calculated. However, this required translation of yield losses in terms of the potential yield of groundnut if early leaf spot was effectively controlled. The potential yield in this study was

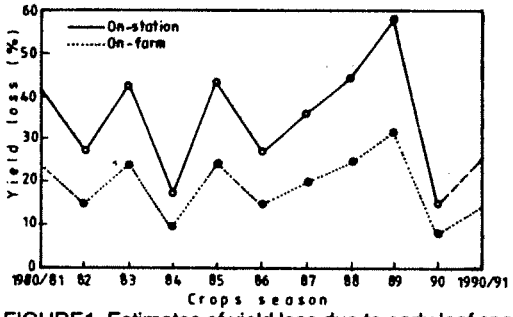

FIGURE1. Estimates of yield loss due to early leaf spot of groundnut at Chitedze Agricultural Research Station (on-station) and on farmers' fields (on-farm) in Malawi. Yield losses in farmers' field is derived from yield losses at the Chitedze Agricultural Research Station using a discount factor of 55 % based on farmers' yield trials (Mwenda and Cusack, 1989).

computed as the actual yield under disease pressure plus the yield loss due to disease. The average potential yields based on estimated yield losses are given in Table 4. Potential yield based on yield losses in on-station trials ranged from 451 kg ha^{-1} in 1989/90 to 809 kg ha^{-1} in 1984/85. At the on-farm level, the potential yield ranged from 417 kg ha^{-1} in 1983/84 to 602 kg ha^{-1} in 1984/85. Yield losses calculated from the potential yield and actual yield presented in Table 1 are also given in Table 4. Yield losses ranged from 67 kg ha^{-1} in 1989/90 to 351 kg ha^{-1} in 1984/85 in on-station trials. Yield losses in farmers' field trials ranged from 34 kg ha^{-1} in 1989/90 to 144 kg ha^{-1} in 1984/85.

Groundnut production and value losses due to early leaf spot are presented in Table 5. These values are based on yield loss percentages in both on-station and on-farm situations.

Production losses were estimated as yield loss under on-station and on-farm conditions by multiplying with area under groundnut production (Table 1). The total production during the 11 years ranged from 18.5 thousand tones in 1989/90 to 88.2 thousand tones in 1985/86 (Table 1). Production losses, however, ranged from 3,196 metric tons (MT) in 1989/90 to 61,156 MT in 1987/88 in the case of on-station conditions. Under on-farm conditions, the production losses ranged from 1,631 MT in 1987/88 to 24,772 MT in 1988/89 (Table 5).

The value losses associated with these production losses were calculated using the price of groundnut prevailing in each of the years under

TABLE 4. Potential seed yield and yield losses of groundnut in Malawi due to early leaf spot based on yield loss estimates for on-station and on-farm situations

Crop season	Potential average yield (kg ha^{-1})[1]		Losses in average yield (kg ha^{-1}) due to early leaf spot	
	On-station	On-farm	On-station	On-farm
1980/81	601	455	251	104
1981/82	504	433	135	64
1982/83	645	483	276	114
1983/84	456	417	78	39
1984/85	809	602	351	144
1985/86	685	588	184	87
1986/87	658	524	238	104
1987/88	785	578	348	141
1988/89	592	366	343	117
1989/90	451	419	67	34
1990/91	591	513	150	72

[1]Yields under present conditions of no disease control, adjusted for yield losses as estimated for on-station and on-farm conditions.

TABLE 5. Estimated effect of early leaf spot on national groundnut production and value losses based on yield losses at on-station and on-farm situations

Crop season	Production loss (000 MT)		Value loss (million MK)	
	On-station	On-farm	On-station	On-farm
1980/81	35.94	14.94	11.9	4.9
1981/82	19.59	9.25	6.7	3.1
1982/83	40.30	16.58	21.0	8.6
1983/84	11.32	5.70	6.9	3.4
1984/85	47.79	19.54	33.0	13.5
1985/86	32.43	15.30	24.0	11.3
1986/87	50.05	21.93	37.0	16.2
1987/88	61.16	24.77	44.0	17.8
1988/89	48.07	16.31	39.4	13.4
1989/90	3.20	1.63	2.8	1.5
1990/91	10.52	5.02	10.5	5.0

MT = metric tons; MK = Malawi Kwacha

study. Under on-station conditions, these value losses ranged from MK 2.8 million in 1989/90 to MK 44.0 million in 1987/88. Value losses ranged from MK 1.5 million in 1989/90 to MK 17.8 million in 1987/88 under on-farm conditions.

IMPACT OF LOSSES DUE TO EARLY LEAF SPOT ON GDP, EXPORTS, AND TRADE BALANCE

The value of losses due to early leaf spot as a percentage of the GDP is given in Table 6. The national GDP ranged from MK 1163 million in 1980/81 to MK 5950 million in 1990/91. The losses of groundnut due to early leaf spot as a percent of GDP based on yield losses at on-station ranged from 0.06% in 1989/90 to 1.67% in 1984/85. Under on-farm conditions, the losses ranged from 0.03% in 1989/90 to 0.69% in 1984/85. The averages for the 11 years are 0.90% (on-station) and 0.38% (on-farm).

The losses in US dollars, based on the prevailing exchange rates during the 11 year period, are given in Table 6. The loss in groundnut

production due to early leaf spot ranged from US $ 1.0 - 19.4 million (mean US $ 11.35 million) under on-station conditions and US $ 0.5 - 7.9 million (mean US $ 4.79 million) under on-farm conditions.

The impact of early leaf spot on groundnut exports and on the trade balance of Malawi is presented in Table 7. The quantity of groundnut exported as a percentage of total groundnut produced shows a similar trend. While almost 70% of groundnut produced was exported during the early part of the decade, exports declined to 0.4% in 1990/91. The decline in export could also be attributed to several factors such as quantity produced, volume of groundnut purchased by ADMARC, world market prices, storage losses, and quality control (e.g., aflatoxin contamination) regulations of the importing countries. However,

TABLE 6. Loss in national income due to early leaf spot of groundnut in Malawi

Crop season	Gross domestic product (m MK)	Loss (%) in GDP due to early leaf spot based on yield loss measured at:		Exchange rate (MK/US $)	Value loss in US $ (m)	
		On-station	On-farm	On-	On-station	farm
1980/81	1163	1.01	0.42	1.12	10.6	4.4
1981/82	1245	0.53	0.25	1.05	6.3	3.0
1982/83	1437	1.44	0.60	1.17	17.9	7.4
1983/84	1707	0.39	0.20	1.47	4.6	2.3
1984/85	1945	1.67	0.69	1.70	19.4	7.9
1985/86	2198	1.08	0.51	1.87	12.9	6.1
1986/87	2614	1.39	0.62	2.20	16.8	7.4
1987/88	3413	1.27	0.52	2.56	17.2	7.0
1988/89	4388	0.89	0.30	2.74	14.4	4.9
1989/90	5076	0.06	0.03	2.80	1.0	0.5
1990/91	5950	0.18	0.08	2.85	3.7	1.8

mMK = Million Malawi Kwacha

TABLE 7. Losses in exports and trade balance due to early leaf spot of groundnut in Malawi

Crop Season	Groundnut exported (000 MT)	Quantity of groundnut exported as % of production	Value of export loss due to early leaf spot (m MK)		Trade balance (m MK)	Export loss as % of trade balance	
			On-station	On-farm		On-station	On-farm
1980/81	34.66	69.3	8.21	3.41	129.3	5.95	2.47
1981/82	6.39	12.2	0.81	0.38	-69.5	-2.18	-1.16
1982/83	2.66	4.9	1.03	0.43	-69.9	-3.09	-1.27
1983/84	0.85	1.6	0.10	0.05	-93.1	-0.19	-0.12
1984/85	3.98	6.4	2.11	0.86	64.7	7.07	2.87
1985/86	9.96	11.3	2.71	1.28	-72.9	-6.73	-3.67
1986/87	8.21	9.3	3.45	1.51	-79.7	-8.80	-4.10
1987/88	14.32	18.6	8.19	3.32	-38.6	-45.99	-18.32
1988/89	6.47	18.6	7.32	2.48	-328.5	-4.99	-1.44
1989/90	0.34	1.8	0.05	0.03	-657.1	-0.01	-0.01
1990/91	0.14	0.4	0.04	0.02	-434.4	-0.02	-0.01

MT = metric tons
mMK = Million Malawi Kwacha

to quantify the value of losses in export of groundnut due to early leaf spot, it is necessary to relate the actual export to potential export when early leaf spot is effectively controlled while keeping other factors constant. The value of losses in exports due to early leaf spot ranged from MK 0.04 million in 1990/91 to MK 8.21 million in 1980/81 based on the on-station estimates. Similar values based on on-farm yield losses show that the losses in groundnut export ranged from MK 0.02 to 3.41 million during the same period. The extent of these losses as a percent of trade balance provides a better indication of the impact of such losses. This is because the gains from disease control could have reduced the trade balance to the same extent. The export losses in groundnut as a percentage of the trade balance ranged from 0.01% in 1989/90 to 45.9% in 1987/88 under on-station conditions. It ranged from 0.01% in 1989/90 and 1990/91 to 18.3% in 1987/88 under on-farm conditions, assuming that all increased groundnut production was exported. These values show the significance of yield loss reduction on improving the trade balance.

THE IMPACT OF EARLY LEAF SPOT ON HOUSEHOLD FOOD SECURITY AND FARM INCOME

The analysis of the impact of early leaf spot on national income, exports, and trade balance has concentrated on the macro variables that affect the national economic environment. However, the impact of yield losses is more pronounced at the household level. The impact of early leaf spot on household food security and on farm income was analyzed using a spreadsheet simulation approach (Table 8). In this analysis, farm households are assumed to grow maize, the predominant food crop, and groundnut, a major cash crop in the Central region of Malawi, by allocating the available land between these two crops. In Malawi, the majority of farmers cultivate areas ranging from less than 0.5 ha to about 2.0 ha. For example, in Lilongwe ADD, about 12% of households cultivate less than 0.5 ha, 25% cultivate 0.5-1.0 ha, 42% cultivate 1.0-2.0 ha and about 21% cultivate more than 2.0 ha (Babu, 1991).

In general, households cultivating more than 2.0 ha are not affected by food insecurity irrespective of the crops grown (Ministry of Agriculture, 1991). Thus for the simulation analysis, five different categories of farm households were considered based on the total area cultivated of 0.25, 0.5, 1.0, 1.5, and 2.0 ha. For each category of land area cultivated, various combinations of maize:groundnut area allocation were considered. Yield loss (Yldlos) due to early leaf spot based on on-farm trials in Malawi (525 kg ha^{-1}) (Mwenda and Cusack, 1989) applied to all sizes of farms. The production (Prodlos) losses due to early leaf spot therefore varied according to the area allocated to groundnut, ranging, for example, from 131.3 kg (0.25 ha under groundnut) to 1050 kg (2.0 ha under groundnut). This is the additional quantity of groundnut that the farm household could have produced if the disease was effectively controlled.

The value of production loss represents the potential income gain if the disease was to be controlled. In assessing the value of this income gain to household food security, it is convenient to convert this income gain into maize equivalent, since maize is the main staple food for 95% of rural households in Malawi. Depending on the area allocated to groundnut, this income gain could buy 477 - 3780 kg of maize. In Malawi, the per adult equivalent requirement of maize, to ensure household food security, is 270 kg per year. The number of units of households made food secure due to disease control (Gnpcfs) thus ranges from 1.8 to 14.0, depending upon the area of groundnut cultivated. However, this gain is in addition to the groundnut and maize produced from the area allocated to each crop. The yield of maize would vary depending upon the variety grown (local, composite, or hybrid) and the use of inputs such as chemical fertilizers. For the present analysis, the farmers are assumed to cultivate only local maize without fertilizers. In Malawi, less than 10% of the maize area is sown to hybrids and less than 20% of farmers use fertilizers (World Bank, 1989). An average yield of 800 kg ha^{-1} of local maize is used for the present analysis. Depending on the area under maize, the number of units which attain food security from maize production (mzpcfs) ranged from 0.74 (with 0.25 ha under maize) to 5.18 (with 1.75 ha under maize). The total food security (Totfsec) from the production of maize, most of which is consumed

by households, and the income gain from early leaf spot control are given in Table 8. Note that the income generated by the groundnut produced without the control of early leaf spot is not included in this calculation, because it is assumed that the income will be spent on non-food commodities. Depending on the crop allocation patterns, 1.75 to 14 persons could be made food-secure.

IMPLICATIONS FOR RESEARCH POLICY ON DISEASE CONTROL

One of the major constraints to increase agricultural productivity through research is the limitation of resources available for investments in research. With limited resources and a variety of research activities, it is important to allocate funds carefully on priority basis so that the benefits from the research investments are maximized. While several approaches are available for priority setting in agricultural research, lack of adequate information on the potential benefits and associated cost of research makes it difficult for research managers to use these methods (Barker, 1988). Even those who use these methods to allocate resources may do it incorrectly if the information on the economics of research from one or more commodities relating to different research areas in not available. The present paper aims at providing such information for research on benefits of control of early leaf spot of groundnut.

TABLE 8. Farm level impact of groundnut yield losses due to early leaf spot, and implications on farm income and food security

Totarea[1]	Mzarea[2]	Gnarea[3]	Yldlos[4]	Prodlos[5]	Mz/Gnut[6]	Gnpcfs[7]	Mzprod[8]	Mzpcfs[9]	Totfsec[10]
2.00	1.00	1.00	525	525.0	21.0	7.0	800	2.96	9.96
	1.50	0.50	525	262.5	10.5	3.5	1200	4.44	7.94
	1.75	0.25	525	131.3	5.3	1.8	1400	5.18	6.93
	0.75	.25	525	656.3	26.3	8.8	600	2.22	10.97
	0.50	1.50	525	787.5	31.5	10.5	400	1.48	11.98
	0.25	1.75	525	918.8	36.8	12.3	200	0.74	12.99
	0	2.00	525	1050.0	42.0	14.0	0	0	14.00
1.50	0.75	0.75	525	393.8	15.8	5.3	600	2.22	7.47
	1.25	0.25	525	131.3	5.3	1.8	1000	3.70	5.45
	1.00	0.50	525	262.5	10.5	3.5	800	2.96	6.46
	0.50	1.00	525	525.0	21.0	7.0	400	1.48	8.48
	0.25	1.25	525	656.3	26.3	8.8	200	0.74	9.49
	0	1.50	525	787.5	31.5	10.5	0	0	10.50
1.00	0.50	0.50	525	262.5	10.5	3.5	400	1.48	4.98
	0.75	0.25	525	131.3	5.3	1.8	600	2.22	3.97
	0.25	0.75	525	393.8	15.8	5.3	200	0.74	5.99
	0	1.00	525	525.0	21.0	7.0	0	0	7.00
0.50	0.25	0.25	525	131.3	5.3	1.8	200	0.74	2.49
	0	0.50	525	262.5	10.5	3.5	0	0	3.50
0.25	0	0.25	525	131.3	5.3	1.8	0	0	1.75

[1] Total area (ha.) under cultivation
2 Area (ha.) under maize cultivation
[3] Area (ha.) under groundnut cultivation
[4] Loss in groundnut yield (kg ha^{-1}) due to early leaf spot based on on-farm trials
[5] Loss in groundnut production (kg ha^{-1}) due to early leaf spot
[6] Bags of maize that can be purchased by the produce loss due to early leaf spot
[7] Number of food security units due to the control of early leaf spot
[8] Production from the maize
[9] Percapita food security from maize
[10] Maize food security + groundnut food security

Several policy implications could be derived for allocating resources towards developing an economically viable disease control strategy for early leaf spot based on the analysis presented earlier. The results of this paper clearly indicate the extent of losses in national income due to early leaf spot. Given that groundnut is an important export crop, and that yield depends critically on the control of early leaf spot, it is clear that there could be huge gains (higher exports and smaller trade deficit) by developing an optimal disease management technology. Similar gains from other research areas in groundnut and from research in other commodities should be quantified and compared as a basis for any method of priority setting in agricultural research. However, adequate extension is needed for successful adoption of technology. In recent years, control of early leaf spot using over six sprays of chlorothalonil has proved to be economically non-viable at the smallholder level under rainfed agricultural systems (Mwenda and Cusack, 1989). Unless attention is paid to these aspects, the potential benefits of early leaf spot control may not be fully realized.

CONCLUSIONS

In this paper, an economic analysis of the losses in groundnut yields due to early leaf spot was attempted to provide information on the extent of losses to national income, exports, and trade balance. Also, the impact of early leaf spot on the food security and income of farm households was examined. This paper is a first step in understanding the gains from research which could be used as a basis for setting priorities in allocating research resources, along with similar information on other competing commodities. The benefits of disease management technology could vary depending on the nature of supply shift, change in the demand for the commodity, and in the price of commodity in the world market, if it is traded externally. Using the present information, future research should include calculation of rate of return of investment on disease management research in groundnut. Similar analyses should be conducted in other groundnut-growing countries. This would enhance the understanding of the impact of crop improvement research on groundnut.

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