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EFFECTS OF AGRICULTURAL COMMERCIALIZATION ON FOOD CROP INPUT USE AND PRODUCTIVITY IN KENYA

by

Paul J. Strasberg, T. S. Jayne, Takashi Yamano, James Nyoro, Daniel Karanja, and John Strauss

MSU International Development Working Paper No. 71
1999

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January 1999

This paper is published by the Department of Agricultural Economics and the Department of Economics, Michigan State University (MSU). Funding for this research was provided by the Food Security II Cooperative Agreement (AEP-5459-A-00-2041-00) between Michigan State University and the United States Agency for International Development, through the Africa Bureau's Office of Sustainable Development, Africa Bureau, AID/Washington. Support was also provided under the Kenya Agricultural Monitoring and Policy Analysis Project (KAMPAP), supported by the United States Agency for International Development/Kenya. Supplementary support for this study is provided by the Office of Sustainable Development, Africa Bureau, AID/Washington.

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The authors would like to thank Gerald Nyambane and Margaret Beaver for research assistance.

ISSN 0731-3438

Published by the Department of Agricultural Economics and the Department of Economics, Michigan State University, East Lansing, Michigan 48824-1039, U.S.A.

CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

It is commonly argued that productivity growth in African agriculture will require a transformation out of the semisubsistence, low-input, low-productivity agriculture that characterizes most of rural Africa. Given population growth and the limits of area expansion as a means to increase crop production, productivity growth will increasingly entail the intensification and commercialization of smallholder agriculture, involving more intensive use of productivity enhancing inputs and more market oriented patterns of crop production.

The impacts of agricultural commercialization on smallholder welfare has been discussed for decades. Smallholder commercialization featuring high value nonfood crops has frequently been criticized in African contexts as having a negative effect on food production and food security. Without reliable and efficient food markets, commercialized cropping patterns may expose smallholder households to major risks of food insecurity. In contrast to this view, studies from a range of African countries demonstrate potential synergies between cash crop investment and food crop production. These studies found that the presence of commercially viable cash crops such as cotton and groundnuts had positive spillover benefits for smallholder food production in selected regions. These spillover benefits included increased adoption of fertilizer on food crops made possible by cash crop input delivery channels, and increased availability of farm credit through cash crop schemes with which to hire additional labor and finance investments in productive assets such as draft oxen and traction equipment. These studies raise the possibility that the promotion of cash crop production may, if suitably implemented, have important positive spillover effects on food crop intensification and productivity.

The objective of this report is to analyze the effects of smallholder commercialization on food crop input use and productivity in rural Kenya. The main research issues were:

1. To examine the determinants of smallholder fertilizer use on food crops, with a focus on the effects of household and regional agricultural commercialization;

2. To examine the determinants of food crop productivity, again with a focus on the effects of commercialization; and

3. To discuss the implications of the findings for policy and additional research necessary to improve the contribution of cash cropping to rural food productivity growth and food security.

For purposes of measuring the effects of crop commercialization, we defined the *household commercialization index* (HCI) as:

$$\text{HCI} = [\ \textit{gross value of all crop sales}_{\,hh\ I,\ year\ j} \,/\, \textit{gross value of all crop production}_{\,hh\ I,\ year\ j}\ ] * 100$$

This index measures the extent to which household crop production is oriented toward the market. A value of zero would signify a totally subsistence oriented household; the closer the index is to 100, the higher the degree of commercialization.

Analysis is based on a national rural household survey of 1,540 rural households implemented under the Kenya Agricultural Monitoring and Policy Analysis Project (KAMPAP), a joint collaboration between Tegemeo Institute/Egerton University, Michigan State University, and Kenya Agricultural Research Institute. Results are derived from two econometric models that determine the effects of commercialization at both the household and district levels on food crop fertilizer use and productivity.

A main premise of the paper is that the effects of commercialization are not uniform and cannot be generalized. The effects are hypothesized to differ both according to differences in the institutional/contractual arrangements between firms and smallholders, management decisions, and the level of credit and extension support provided to smallholders by the various private and parastatal firms involved in promoting smallholder cash crops.

The principle findings of the study are:

1. The degree of smallholder commercialization differs widely across zones in Kenya. Even within a particular zone, households differ significantly in the degree of commercialization;

2. Crop commercialization is not uniformly correlated with landholding or area cultivated among the households surveyed;

3. Household agricultural commercialization, *ceteris paribus*, generally has a significant and positive effect on food crop fertilizer use and productivity;

4. The effects of particular cash crops on these variables was found to differ markedly by region, independent of the household-level effects of agricultural commercialization;

5. As expected, smallholder adoption of hybrid maize seed, frequently in combination with fertilizer, was shown to have significant positive effects on productivity per unit of land; and

6. There is a meaningful payoff to formal education in terms of food crop productivity; fertilizer use was also found to positively associated with education.

In general, the results indicate that discussions of agricultural commercialization and its effects were positive in most cases. But this conclusion should not be overgeneralized. What matters is what kind of commercialization, how particular schemes are organized, and their effects on smallholder access to inputs, management advice, market outlets, price levels and price risks, etc.

The most important pathways by which crop commercialization may improve food crop productivity are hypothesized to be:

1. Crop commercialization provides a source of cash that allows the household to overcome credit-related constraints on the purchase of fertilizer and other cash inputs;

2. Participation in a cash crop (e.g., coffee) generally improves the household's access to inputs distributed through the cash crop marketing firm (e.g., coffee cooperatives), which may result in the household using some of that input on food crop production; and

3. Cash income from commercialized production patterns also facilitates the ability to purchase draft oxen and traction equipment that may promote food crop productivity.

The emerging picture indicates the benefits of attempting to address the risks and market failure aspects necessary to make increased agricultural commercialization viable rather than accept these risks and market failures as inherent, unalterable features of the African context that require a food first production orientation. Increased access to food depends on income growth, and for the majority of African smallholders dependent on agriculture, income growth is tied to productivity growth in agriculture, i.e., increasing the value of production generated from available household resources. A major task for future research is to understand better how successful commercialization arrangements linking smallholders and marketing/processing firms have been structured so that their successful ingredients can be replicated and incorporated more broadly into commercialization strategies in other regions. This is likely to yield high payoffs in terms of increasing agricultural productivity and food security.

1. INTRODUCTION

Increasing per capita food production and raising rural incomes are arguably the greatest challenges facing Kenya and Sub-Saharan Africa more generally. The history of economic development in other regions of the world indicates that agricultural productivity growth has been the major source of sustained improvements in rural welfare (Mellor 1990). Almost 80 percent of Kenya's population live in rural areas, depend on agriculture for their livelihood and most are classified as smallholders. It is commonly argued that productivity growth in smallholder agriculture will require a more commercialized orientation.[1] This implies that policy must be designed to encourage a transformation out of the semi-subsistence, low-input, low-productivity agriculture that characterizes much of rural Kenya.

The impact of cash cropping and commercialization on smallholder welfare has been discussed for decades. It has often been contended that the promotion of cash crops and commercialization of smallholder agriculture has contributed to poverty and food insecurity (Lappe 1977; von Braun and Kennedy 1986). According to this view, pervasive market failures pose undue risks for farmers to engage in significant cash cropping activities, especially if this makes households dependent on unreliable food markets to acquire food consumption requirements.[2] In fact, the Government of Kenya has been concerned about potential negative nutritional effects of cash-crop production since the 1970s when studies indicated that in some areas child nutritional status appeared to be negatively affected by cash crop production (Kenya 1981).

In contrast to assertions that cash cropping schemes' negatively affect food production in smallholder agriculture, studies from several African countries demonstrate potential synergies between cash-crop investment and food crop production. Studies in Mali (Dione 1989) and Senegal (Goetz 1990) found that the presence of commercially viable cash crops such as cotton and groundnuts had positive spillover benefits for smallholder food production in selected regions. These spillover benefits included increased adoption of fertilizer on food crops made possible by cash crop input delivery channels. Moreover, many participating smallholders were able to use cash crop revenue to overcome capital constraints to hire additional labor and finance investments in productive assets such as draft oxen and traction equipment. In these West African settings, growth in food crop production was fueled mainly by growth in farmers' income from cash crop production.

In the case of Kenya, a recent study of Siaya District (a cotton and maize zone) found that smallholders could increase expected farm profits by over one-third if they were to increase the proportion of cultivated area devoted to cotton each year. However, high transport costs and price uncertainty associated with acquiring cereals via relatively distant markets makes cotton

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[1] See, for example, the World Bank's *Agricultural Sector Memorandum: A Strategy for Agricultural Growth* (1997) and Timmer (1997) for generalized arguments.

[2] See von Braun and Kennedy (1986) and Fafchamps (1992) for a discussion.

specialization risky and unprofitable for households in remote locations (Omamo 1998). Alternatively, it is plausible that in some regions of Kenya, investments in rural infrastructure brought about by cash cropping may actually decrease food marketing costs and result in lower food acquisition prices for rural consumers. Recent findings from a cotton and maize zone in Mozambique suggest that some cotton development models which generate significant investments in transportation infrastructure by agribusiness firms are consistent with this view (Strasberg 1997).

The objective of this paper is to analyze the effects of smallholder commercialization on food crop input use and productivity in rural Kenya. A main premise of the paper is that the effects of commercialization are not uniform and cannot be generalized. The effects are hypothesized to differ both according to the type of crop featured in commercialization strategies and by region. Differences in the regional effects of a particular crop are hypothesized to be a function of differences in the institutional/contractual arrangements between firms and smallholders, management decisions, and the level of credit and extension support provided to smallholders by the various private and parastatal firms involved in promoting smallholder cash crops.

Analysis is based on a national rural household survey implemented under the Kenya Agricultural Monitoring and Policy Analysis Project (KAMPAP), a joint collaboration between Tegemeo Institute/Egerton University, Michigan State University, and Kenya Agricultural Research Institute. Results are derived from two econometric models that determine the effects of commercialization at both the household and district levels on food crop fertilizer use and productivity.

The report is organized as follows: Section 2 provides the conceptual framework motivating the analysis. Details about the household survey data and sample frame are described in Section 3. Section 4 presents descriptive information on crop specific commercialization and the extent of household commercialization in the various regions of Kenya. Sections 5 and 6 present information on food crop fertilizer use and productivity in the various regions of Kenya. Determinants of food crop fertilizer use and productivity are analyzed in Section 7. Lastly, Section 8 discusses conclusions, policy implications, and suggestions for future research.

2. CONCEPTUAL FRAMEWORK AND STUDY OBJECTIVES

Many smallholder cropping schemes in rural Kenya encourage production of cash crops such as coffee, tea, sugarcane, French beans, other vegetables, and wheat. Besides these primarily cash crops, many smallholders produce key food crops, such as maize, tubers, and cowpeas, with the intention of marketing a significant amount of their production.

The effects of smallholder commercialization on rural Kenyan food production and welfare were analyzed in a household level study by International Food Policy Research Institute (IFPRI) in a sugarcane scheme in South Nyanza District . The study found that farmers participating in the sugarcane scheme enjoyed significantly higher agricultural incomes than their neighbors who did not participate (Kennedy and Cogill 1987). Much of the difference in income was related to agricultural sales, with most, but not all of these sales being related to sugarcane. The authors also analyzed the effect of commercialization on calorie intake on a per adult-equivalent basis. Contrary to the concerns expressed by the 1981 Government of Kenya publication cited on page 1, the authors concluded that sugar income contributed, *ceteris paribus*, 360 calories per adult equivalent day to household energy intake.

A study of smallholder integration into cash cropping schemes in Mozambique confirms the positive effect that smallholder cash cropping schemes *can have* on smallholder welfare (Strasberg 1997). In the context of near complete input and credit market failure, the Mozambican Government invited multinational agroindustrial firms to form joint venture companies (JVCs) and rehabilitate cotton infrastructure with the hope that this would increase rural incomes by increasing smallholder cotton production. In return for monopsony cotton-buying rights in their areas of interest, these firms agreed to provide participating smallholders with reliable input supplies and extension services for cotton and food crops, and provide a guaranteed output market for smallholder cotton production. Econometric analysis showed that cotton producers in the zones of significant JVC investment had higher incomes and food production than their non-cotton growing neighbors. Despite the complete lack of availability of fertilizer and other modern inputs through spot markets, some households participating in a high-input cotton scheme used significant amounts of fertilizer on their maize plots. The case of Mozambique cotton indicates the potential synergies between cash and food crops in the context of outgrower schemes where input and credit markets otherwise fail.

Do these findings imply that cotton or any other cash crop should be promoted as a mechanism to increase smallholder food crop productivity? Not necessarily. Findings from Mozambique in a zone adjacent to the positive cash cropping regions provide an important contrast in this regard. In that region, also characterized by favorable agroecological conditions, agribusiness firms provided relatively little input supply and infrastructural support to the cotton subsector. With poor access to inputs for cotton or food crops, smallholder cotton yields were much lower than in the JVC-intensive zone (Strasberg 1997). Cotton production was shown to actually negatively affect household income, *ceteris paribus*. Also in contrast to the zones of higher JVC investment, the author found no statistically significant relationship between cotton and food production. On balance, these results imply that the **organizational details of smallholder cash cropping**

schemes make a difference as to the effects of commercialization on smallholder productivity and welfare. In other words, how input supply, production, output marketing and processing are organized are key determinants of the impact of cash cropping on participating smallholders and communities. With respect to Kenya, this implies that a particular cash crop (e.g., sugarcane) as promoted by a processing firm in one region may have different effects on food crop productivity than in a similar region where sugarcane is promoted by a different company. This paper seeks to identify those cases in Kenya where particular commodities and zones are found to have significant positive or negative effects on food crop fertilizer use and productivity.

Given the potential complementarities between cash crops and food crops, this paper seeks to achieve the following objectives:

1. To examine the determinants of smallholder fertilizer use on food crops, with a focus on the effects of household and regional agricultural commercialization;

2. To examine the determinants of food crop productivity, again with a focus on the effects of commercialization; and

3. To discuss the implications of the findings for policy and additional research necessary to improve the contribution of cash cropping to rural food productivity growth and food security.

3. THE DATA AND SAMPLE

The data used in this paper is based on a single-visit survey of 1,540 rural households in April 1997. This survey was designed and implemented under the KAMPAP, a collaboration between Egerton University/Tegemeo Institute, Michigan State University, and the Kenya Agricultural Research Institute, with financial support from the U.S. Agency for International Development Mission to Kenya.

Sampled households were randomly selected within rural areas of the six provinces where rain-fed agriculture is believed to comprise most of smallholder income. Twenty-two districts and 111 villages were selected within these six provinces designed to capture agroecological variation within each province. Turkana and Garissa Districts were excluded from this analysis due to their unique agricultural production characteristics (e.g., reliance on irrigated crop cultivation and dominance of pastoral economy). Also, households with land holdings in excess of 20 hectares (or 50.8 acres) were excluded to maintain the study's focus on the smallholder sector.[3] The resulting sample size in this analysis was 1,465 households. Smallholders were surveyed about their agricultural and non-agricultural income sources, practices, demographics and assets over the past two seasons.[4]

Table 1 presents sample characteristics, rainfall, and population density data for each sampled district. The 22 sampled districts are grouped into eight agro-regional zones; these zonal definitions are used in subsequent descriptive analysis.

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[3] Greer and Thorbecke (1986) define smallholder as a rural household that owns less than 20 hectares.

[4] For further information on questionnaire content, see Argwings-Kodhek (1998).

Table 1. Sample Characteristics, Rainfall and Population Density by Agro-Regional Zones

Agro-Regional Zone	Sampled Districts	Villages Sampled	Households Sampled	Mean Rainfall, Primary Harvest[1]	Population Density[2]
				mm-	inhabitants per square mile
Coastal Lowlands	Kilifi	4	53	783	46
	Kwale	3	20	783	46
	Taita Taveta	1	11	783	12
Eastern Lowlands	Kitui	2	21	266	22
	Mwingi	2	35	266	116
	Machakos	4	22	266	100
	Makueni	4	75	266	100
Western Lowlands	Kisumu	8	111	732	320
	Siaya	5	77	732	253
Central Lowlands	Narok	2	23	480	22
Western Transitional	Bungoma	6	87	1207	221
	Kakamega	10	148	1207	411
Western Highlands	Kisii	6	92	1122	517
	Vihiga	4	63	1207	411
Central Highlands	Muranga	6	71	611	340
	Nyeri	8	105	611	186
	Meru	6	83	658	116
	Laikipia	4	58	677	24
High-Potential	Trans-Nzoia	4	61	1176	160
	Uasin Gishu	6	96	969	25
	Bomet	4	42	1092	182
	Nakuru	8	111	772	118

[1] Mean annual rainfall recorded at nearest reporting station in Kenya Statistical Abstract (1997) during the months between planting and harvest of main harvest season (1985-94).
[2] Population densities derived from Kenya Statistical Abstract (1997).

4. CROP SPECIFIC AND HOUSEHOLD COMMERCIALIZATION INDICES

Most rural households in Kenya are commercialized to some degree. According to the 1997 KAMPAP survey, 78 and 80 percent of rural households sold some crops in the 1995/96 and 1996/97 cropping seasons, respectively.[5] Because of variation in rainfall, altitude, soil types and institutional factors across the 22 districts studied, there were wide differences in the degree of commercialization across districts. Table 2 demonstrates this variation by showing the average commercialization index for households in each district and the proportion of households in the 1996/97 season selling each of seven key crops: maize, wheat, coffee, tea, sugarcane, French beans, and other vegetables.

Maize is the most frequently produced and marketed crop among sampled households. While 32 percent of households sold maize, and more than 90 percent of households produced maize, we found a high degree of variation across sampled districts in terms of the proportion of households with maize sales. For example, in the high-potential areas of Narok, Nakuru, Uasin-Gishu and Trans-Nzoia, over one-half of surveyed households sold some maize. In many other areas commonly thought to be maize-deficit, maize sales were infrequent (e.g., Kilifi -- 2 percent, Vihiga -- 6 percent, and Kisumu -- 9 percent).

In contrast to maize, wheat production is geographically concentrated. Among surveyed districts, wheat is important in only three districts: Narok (where 68 percent of surveyed households sold wheat), Uasin-Gishu (52 percent) and Nakuru (35 percent). Almost no wheat is produced or sold in the remaining 19 districts.

Production and sales of Kenya's traditional smallholder export crops -- coffee, tea and sugarcane -- is also highly concentrated. For example, while only 19 percent of all households in the survey produce and sell coffee, more than half of the smallholders in three districts -- Muranga, Kisii and Nyeri -- have coffee trees.

In sum, Kenya's variation in agroclimatic conditions across its agricultural heartland gives rise to highly concentrated production of key cash crops in particular geographic areas. The analysis below is designed to examine the differences that the intensity of these cash crops may have on food crop fertilizer use and productivity, after controlling for other exogenous household and geographic characteristics.

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[5] The survey was conducted in April 1997. While this date follows the main harvest for the 1996/97 season for all crops in all regions, many smallholders had not completed marketing of commodities from this harvest by this date. As such, the survey instrument had two questions concerning sales from the 1996/97 agricultural season: quantity sold and quantity planned to be sold before the next harvest. Throughout this study, smallholder sales for 1996/97 were computed as the quantity already sold prior to the date of the interview plus that quantity planned to be sold.

Given that most households market some of their crop production, it is necessary to develop a useful proxy which captures the wide variation in terms of the intensity of commercialization across the sample. As such, we define the *household commercialization index* (HCI) as:

$$HCI = [\ \textit{gross value of all crop sales}_{\ hh\ I,\ year\ j} / \textit{gross value of all crop production}_{\ hh\ I,\ year\ j}\ ] * 100$$

This index measures the extent to which household crop production is oriented toward the market. A value of zero would signify a totally subsistence-oriented household; the closer the index is to 100, the higher the degree of commercialization.

The first two columns of data in Table 2 report the average household commercialization index variable for the two years in each district. The sampled households marketed 39 and 41 percent of all crop production, on average, in 1995/96 and 1996/97, respectively. Not surprisingly, we found wide variation across districts. For example, the relatively low-potential districts of Taita Taveta and Kitui have average household commercialization index values of only 7 percent. By contrast, in Bomet where 95 percent of households produce and sell tea, the mean household commercialization index reaches its highest level of 78 and 80 percent for the two years.

In the econometric analysis which follows we use the HCI for 1995/96 to represent a household's long-run level of agricultural commercialization. An important issue concerning the household commercialization index is the extent to which it provides consistent estimates of commercialization over time. We examine the consistency of this variable in two ways. First, as shown in Table 2, we found relatively little change in national or district mean values for this variable across the two years. Second, the correlation coefficient at the household level comparing $HCI_{95/96}$ and $HCI_{96/97}$ for the sample of 1,465 households is positive at 0.65 and statistically significant (p=0.01).

Another important concern about the suitability of the HCI for our analytical purpose is the degree to which household commercialization reflects farm size. One might hypothesize that the HCI would increase as a function of area cultivated. Recall, however, that we have confined our analysis to smallholders. Among our sample, we find the relationship between acres cultivated and $HCI_{95/96}$ statistically insignificant as measured by the correlation coefficient. In sum, based on these results, we believe that this index represents a useful indicator of the degree to which the household’s farm production decisions have a commercialized, market orientation.

Table 2. Household Commercialization of Key Cash and Food Crops by District

District	Household Commercialization Index 1995/96	Household Commercialization Index 1996/97	Commodity Sold, 1996/97: Maize	Wheat	Coffee	Tea	Sugar-cane	French Beans	Vege-table
	---- mean ----		--------------------- percent of households selling						------------------------
Kilifi	12	30	2	0	0	0	0	0	7
Kwale	22	36	16	0	0	0	0	0	16
Taita Taveta	9	7	18	0	0	0	0	0	27
Kitui	21	7	14	0	0	0	0	0	0
Machakos	15	13	18	0	0	0	0	0	14
Makueni	33	43	12	0	34	0	39	27	44
Meru	63	64	30	0	36	40	23	37	64
Mwingi	14	12	26	0	0	0	0	0	3
Kisii	47	41	42	0	78	38	2	0	34
Kisumu	20	30	9	0	1	0	31	0	3
Siaya	14	16	23	0	6	0	3	1	9
Bungoma	44	44	38	0	8	0	55	3	22
Kakamega	38	39	32	1	3	0	69	0	15
Vihiga	33	27	6	0	30	22	3	42	59
Muranga	36	43	12	0	82	14	4	4	12
Nyeri	66	63	32	0	56	56	4	0	13
Bomet	78	80	26	0	0	95	0	0	5
Nakuru	55	54	79	35	2	0	4	0	16
Narok	56	72	96	68	0	0	0	0	24
Trans-Nzoia	32	32	52	0	0	0	10	0	15
Uasin Gishu	49	53	63	52	0	0	0	0	9
Laikipia	17	24	5	2	0	0	2	5	20
Total	**39**	**41**	**32**	**7**	**19**	**13**	**18**	**6**	**20**

Source: KAMPAP Household Survey, 1996/97 season.

5. DESCRIPTIVE FINDINGS: FERTILIZER USE ON FOOD CROPS

According to a recent Tegemeo Institute study, smallholder fertilizer use in Kenya has been stagnant during the 1990s; in some areas there has been a dramatic decline (Argwings-Kodhek 1997). The study shows that, in nine districts across zones favorable for maize production, between 10 and 60 percent of smallholders surveyed reported using less fertilizer in 1997 than they did in 1991. This occurred despite the fact that in the intervening period, Kenya has completely liberalized fertilizer marketing. It had been anticipated that a liberalized system would be responsive to farmer needs and lead to increased fertilizer usage. The factors currently constraining fertilizer use by smallholders are discussed in Mose (1998).

This study shows that only 56 percent of households used fertilizer on food crops in the main harvest of the 1996/97 agricultural season. As Table 3 demonstrates, fertilizer usage is highly variable across and within the eight agro-regional zones. In some zones, such as Coastal Lowlands and Western Lowlands, there is almost no fertilizer use on food crops. A likely explanation of this phenomenon is farmer perception of the lack of financial profitability of fertilizer use given agroecological conditions and local input prices.[6] Elsewhere, throughout the higher potential zones, we find a significant proportion of farmers using no fertilizer on food crops. The determinants of this variation in fertilizer use is investigated in Model 1 below.

Table 3. Fertilizer Nutrient Use Per Acre on Food Crops by Agro-Regional Zone, 1996/97

	Fertilizer nutrient application per acre of food crops						
Agro-Regional Zone	**0 kgs**	**0 - 5 kgs**	**5-10 kgs**	**10-20 kgs**	**20-30 kgs**	**>30 kgs**	**Total[a]**
	---------------------------percent of households---------------------------						
Coastal Lowlands	96	2	0	1	0	0	100
Eastern Lowlands	71	22	2	5	0	0	100
Western Lowlands	96	2	0	2	1	0	100
Central Lowlands	83	4	9	4	0	0	100
Western Transitional	46	4	4	12	12	23	100
Western Highlands	25	13	16	22	14	10	100
Central Highlands	23	9	9	21	17	22	100
High-Potential	11	1	2	14	21	51	100
Total	**44**	**7**	**5**	**12**	**12**	**20**	**100**

Source: KAMPAP Household Survey, 1996/97 season.
[a] Row total may add up to more or less than 100 due to rounding.

[6] Retail fertilizer prices in Kenya were among the highest in the world, at $450-$500 for Diammonium Phosphare (DAP) in Western Kenya in 1997.

6. DESCRIPTIVE FINDINGS: SMALLHOLDER FOOD CROP PRODUCTIVITY

Logically we would expect that smallholder food crop productivity in a relatively high-potential zone would be significantly greater than in low potential areas. Results in Table 4 confirm that such low potential zones as Coastal Lowlands, Eastern Lowlands and Western Lowlands have significantly lower productivity per unit of land than the national average. In fact, the gross value of food production per acre in 1996/97 in zones such as Central Highlands, High Potential and Central Lowlands is significantly greater than the sample average. While agroecological differences may explain the inter-zone variation we observe, other factors are likely to be important as we seek to understand the significant variation in **intra-zone** productivity highlighted in Table 5.

Table 4. Gross Value of Food Production per Acre by Agro-Regional Zone, 1996/97

Agro-Regional Zone	Gross Value of Food Production
	Kenya Shillings / acre
Coastal Lowlands	4061
Eastern Lowlands	4280
Western Lowlands	5007
Central Lowlands	15032
Western Transitional	9952
Western Highlands	9548
Central Highlands	12340
High-Potential	12758
Total Sample	9535

Source: KAMPAP Household Survey, 1996/97 season.

Table 5 shows intra-zone quartile means of productivity in terms of Ksh/acre. Consider, for example, the case of Western Highlands, where the most productive quartile of households produced 19,216 Ksh of food crops per acre while the least productive quartile produced one-sixth that amount. And, given the relatively small areas planted (0.24 compared to 0.15 acres per capita for the two groups, respectively) and the importance of cropping agriculture in household income, these differences are likely to have meaningful impacts on household welfare. An examination of this table shows significant variation within each zone. In every zone, the value of food crops produced per acre for the highest quartile is over three times higher than that of the lowest quartile.

To what are these differences attributable? We consider the role of three factors -- fertilizer use, food area planted, and commercialization -- in a descriptive analysis before proceeding to an econometric model of productivity in the following section. Fertilizer use is likely to explain some of the productivity differences. For example, we find fertilizer application rates increasing with productivity per unit of land in four of the eight agro-regional zones (e.g., Western Transitional, Western Highlands, Central Highlands and High Potential). The positive relationship between fertilizer use and land productivity in these higher potential zones is to be expected. However, note that we found significant intra-zonal variation in fertilizer use and productivity in both the higher-potential as well as the less well endowed agro-regional zones.

Also note that land area planted to food crops on a per capita basis is negatively related to food crop productivity in four zones: Eastern Lowlands, Western Lowlands, Western Highlands and Central Highlands. A possible explanation is that the most land-constrained households tend to use more inputs per unit of land and obtain higher productivity per unit of land.

What does Table 5 tell us about the relationship between household-level commercialization and food crop productivity? In most zones (e.g., Coastal Lowlands, Eastern Lowlands, Western Transitional, Central Highlands, and High Potential), there is a positive relationship between the average household-level commercialization index $(HCI)_{96/97}$ and the productivity quartiles. No clear pattern emerges in the other three zones.

Table 5. Selected Farm Statistics by Zone and Quartile of Gross Value of Food Production Per Acre, 1996/97

Agro-Regional Zone	Gross Value of Food Production per Acre		Food Crop Area	Land Owned	Fertilizer Nutrients Applied to Food Crops	Household Commercialization Index
	Quartile	Ksh/acre	acres / person		kgs / acre	percent
Coastal Lowlands	1	1102	0.29	0.59	0.01	17
	2	2310	0.25	0.43	0.61	28
	3	3897	0.37	0.63	0	27
	4	8933	0.23	0.76	0.06	32
Eastern Lowlands	1	795	0.59	1.1	0.28	10
	2	2031	0.52	1	0.86	25
	3	3815	0.28	0.69	1.71	30
	4	10490	0.25	0.79	2.29	42
Western Lowlands	1	1309	0.4	0.76	0	27
	2	3074	0.47	0.97	0.01	22
	3	4806	0.33	0.73	0.06	22
	4	10839	0.28	0.62	1.35	27
Central Lowlands	1	8392	1.1	1.37	1.55	58
	2	12520	0.87	2.71	0	68
	3	16227	1.2	2.85	3.97	81
	4	21881	1.06	2.28	1.52	78
Western Transitional	1	3403	0.32	0.78	7.05	35
	2	6733	0.37	0.95	11.75	32
	3	10524	0.41	0.81	23.01	43
	4	19039	0.42	0.77	21.29	53
Western Highlands	1	2987	0.24	0.33	7.249	27
	2	5968	0.23	0.4	11.94	41
	3	9853	0.2	0.47	12.58	35
	4	19216	0.15	0.33	20.1	37
Central Highlands	1	2295	0.34	0.85	9.076	40
	2	7542	0.28	0.56	16.75	54
	3	12394	0.22	0.5	22.12	53
	4	27126	0.18	0.56	33.3	59
High Potential	1	5581	0.56	1.37	20.67	38
	2	10010	0.82	1.6	27.23	56
	3	13744	0.7	1.51	30.44	56
	4	21720	0.81	1.17	38.54	62

Source: KAMPAP Household Survey, 1996/97 season.

7. DETERMINANTS OF FOOD CROP FERTILIZER USE AND PRODUCTIVITY

In this section we develop and estimate econometric models of food crop fertilizer use and productivity. We hypothesized that a similar set of regressors should be included in each model; likewise, we hypothesized that variables that have a positive (negative) effect on fertilizer use will also have a positive (negative) effect on food crop productivity. Given this similarity, we present a conceptual discussion of both models below. The two equations below represent the theoretical framework of the determinants of fertilizer use on food crops and productivity.

1. fertilizer nutrient use per acre of food planted = *f* (agroecological factors, market infrastructure, socio-demographic characteristics, household assets, fertilizer price, household commercialization index, regional crop specific intensity indices)

2. gross value food output per acre of food crop = *g* (input use, agroecological factors, market infrastructure, socio-demographic characteristics, household assets, household commercialization index, regional crop specific intensity indices)

Definitions of each variable in these models and their expected signs are found in Table 6. Table 7 shows the mean and standard deviation of each variable incorporated in the model.

7.1. Testing for the Effects of Commercialization

As stated above, we seek to identify the effects of commercialization at both the household and crop specific levels. To analyze household-level effects, $HCI_{95/96}$ is included in both models. Note that the regressor used is the commercialization index from 1995/96 and is therefore exogenous to household productivity in the 1996/97 season.

Agroecological conditions (e.g., rainfall, soil type, altitude) vary considerably across Kenya, and influence heavily both fertilizer use and productivity. District-level dichotomous variables are included in both equations to control for these factors.

Notwithstanding the agroecological variation between districts, we hypothesized that the intensity of cash cropping activity and the institutional arrangements associated with how given crops are promoted within particular districts may also have significant effects on food crop fertilizer use and productivity. For example, two zones may exhibit similar potential for coffee production. It may be the case that in one of these zones the coffee processing company pays farmers in a timely way for their coffee output, alleviating a liquidity constraint for households wishing to purchase fertilizer for the following season while in the other zone

Table 6. Description of Variables Included in Econometric Models

Independent Variables		Anticipated Sign: Fertilizer Use	Anticipated Sign: Productivity
Household Commercialization Index			
HCI_{96}	Percent of gross value of household crop production marketed, 1995/96	+	+
Fertilizer Price and Distance			
fert_price	Price per kg of 50 kg sack of DAP (Ksh), 1996	-	instrument
fert_dist	Distance to nearest fertilizer seller (km)	-	instrument
Maize Hybrid Seed Use			
$hyseed\_acre_{97}$	Hybrid maize seed planting rate, 1996/97 main planting season (kg/acre)	excluded	+
$hyseed\_acre_{96}$	Hybrid maize seed planting rate, 1995/96 main planting season (kg/acre)	excluded	instrument
Infrastructure			
road_dist	Distance to nearest motorable road (km)	-	-
Household Assets			
acre_owned	Land owned (acres)	?	?
v_ag_equip	Value of agricultural equipment owned (Ksh)	+	+
v_livestock	Value of livestock owned (Ksh)	+	+
Household Demographics			
adults	Adults, older than 16 years old	+	+
mem_40	Percent of hh members over 40 years old	?	?
mem6_16	Percent of hh members between 6 to 16 years old	?	?
mem0_6	Percent of hh members under 6 years old	?	?
educ_mi	1 if at least one adult hh member completed primary school and educ_hi=0; 0 otherwise	+	+
educ_hi	1 if at least one adult hh member pursued post-secondary education; 0 otherwise	+	+
male_not_pres	1 if at least male adult member exists, but none of them residence more than 10 months of previous 12; 0 otherwise	-	-
no_adult_male	1 if no male adult member exists; 0 otherwise	-	-
Crop Specific Intensity Indices (CSII)			
pcta_coffee	Village percent of land planted to coffee, 95/96	?	?
pcta_tea	Village percent of land planted to tea, 95/96	?	?
pcta_sugar	Village percent of land planted to sugarcane, 95/96	?	?
pcta_fb	Village percent of land planted to French beans, 95/96	?	?
pcta_veg	Village percent of land planted to other vegetables, 95/96	?	?
District-level dichotomous variables = 1 for given district; 0 otherwise		?	?
Interaction terms District-level dichotomous variables - CSII		?	?

Table 7. Descriptive Statistics of Variables Used in Econometric Models

Variables	Model (1) Fertilizer	Model (2) Food Crop Productivity	Mean	Standard Deviation
gross value (Ksh/acre)		Dependent variable	9534	8341
fert_acre (kg nutrients/acre)	Dependent variable	Endogenous, instrumented	14.7	19.9
hyseed_acre (kg / acre)	x	Endogenous, instrumented	4.2	5.3
fert_price (Ksh / 50 kg sack)	x	Used as instrument	1346	88.9
fert_dist (km)	x	Used as instrument	8.23	11.2
HCI (percent)	x	x	39	32.6
road distance (km)	x	x	0.8	0.98
acre_owned (acre)	x	x	5.42	7.12
v_ag.equipment (Ksh)	x	x	$3.32*10^4$	$2.30 * 10^5$
v_livestock (Ksh)	x	x	$4.65*10^4$	$8.72 * 10^5$
adults	x	x	3.72	1.91
mem_40 (ratio)	x	x	0.22	0.2
mem6_16 (ratio)	x	x	0.33	0.21
mem0_6 (ratio)	x	x	0.12	0.15
educ_mi (0, 1)	x	x	0.41	0.5
educ_hi (0, 1)	x	x	0.42	0.49
male_not_pres (0, 1)	x	x	0.08	0.28
no_adult_male (0, 1)	x	x	0.07	0.25
pcta_coffee (percent)	x	x	2.77	5.1
pcta_tea (percent)	x	x	3.38	9.96
pcta_sugar (percent)	x	x	4.35	9.59
pcta_French beans (percent)	x	x	0.6	1.96
pcta_veg (percent)	x	x	2.64	3.83

Note: x indicates independent variables in the model.

such payments occur many months after harvest. Likewise, in two otherwise similar tea zones, tea companies may offer farmers differential output prices and infrastructural investment. Farm households in the zone where tea is relatively more profitable may more easily be able to access fertilizer and other inputs (e.g., hired labor and seed) than in the low tea price zone. Other pathways by which agribusiness firms operating in a particular area may interact with smallholders with respect to a particular crop are possible as well.

To test for the crop specific effects of the five leading cash crops -- coffee, tea, sugarcane, French beans and (other) vegetables -- we include commodity-specific indices measuring the proportion of cropped area to each at the village level. Further, to test for location-specific differences in the effect of each cash crop, we include district-crop interaction terms using a stepwise regression technique as follows:

a. We computed interaction terms between each district dichotomous variable and each of the five crop specific commercialization indices at the village level in those combinations where a particular commodity was defined as "intensely" produced within the given zone. The cutoff point in each case was where sales of the given crop was at least 1,000 Ksh per household; twenty-three district-crop combinations met this criterion.

b. We included each possible crop intensity/district interaction term in Model 1. Following standard stepwise regression procedures, the interaction terms with the lowest t-statistic were successively dropped until all remaining interaction terms were statistically significant. The stepwise procedure described above was carried out analogously with respect to Model 2.

In addition to the effects that commercialization is hypothesized to have on food crop fertilizer use and productivity, we also discuss other variables incorporated into these models.
First, following the standard specification for an input demand function, we include fertilizer price and the distance households must travel to obtain fertilizer in the fertilizer model; it is anticipated that each of these factors has a negative impact on fertilizer use.

Three sets of demographic variables are incorporated into each model. First, education is hypothesized to play a positive role in influencing both dependent variables. Education is proxied for by the creation of two dichotomous variables - *educ_hi* and *educ_mid*. These variables are computed with respect to the highest level of education achieved by any adult household member. If any adult household member has completed secondary (primary) school, *educ_hi (educ_mid)* is equal to one. If both conditions are met, only *educ_hi* is set equal to one. By separating these human capital-related variables in this manner we allow for the possibility of differences in the effects of different levels of educational achievement.

With respect to gender of the head of household, we define two types of female-headed households. *Male_not_pres* is a dichotomous variable equal to one where an adult male is part of the household roster but where he is absent from the household for more than ten months during the year. On the other hand, *no_adult_male* is equal to one in those instances where no adult male exists at all in a household. The omitted category is households with a male head present in the village year-round. We hypothesized that *male_not_pres* would have a positive effect on fertilizer access if the absent male earns income which capitalizes input purchases. On the contrary, we hypothesized that households with no adult male at all would have reduced access to fertilizer, reduced household labor and a lower level of productivity.

The final set of demographic variables concerns the age composition of household membership. *Mem_40, mem6_16* and *mem0_6* are three variables which control in each equation for the proportion of household members in each of four age groups; the omitted category is the age group 17-39.

Three variables are included in each model to control for household assets. Land holdings and the value of agricultural equipment and livestock owned by the household are hypothesized to have positive effects in both models.

7.2. Estimation Techniques

With respect to the fertilizer model, because 44 percent of sampled households applied no fertilizer to food crops, the distribution of this variable is censored and we therefore use a Tobit estimation technique. With respect to the productivity model, we find that both key purchased input variables -- fertilizer and hybrid maize seed -- are endogenous to the determination of productivity. As such, an instrumental variables approach is used for this model.[7]

7.3. Econometric Results

Table 8 highlights the significant and positive effect that agricultural commercialization has at both the household and crop specific levels in both models. First, at the household level, HCI is positive and significant in both models. The magnitude of HCI in the productivity model is 67, implying that a 10 percent increase in HCI from the mean level of 39 percent would, on average, results in a 670 Ksh/acre or 7 percent boost in food crop productivity, *ceteris paribus*. The strength of these findings is consistent with empirical findings from Mali, Senegal and Mozambique where robust complementary relationships were found between household-level cash cropping and food crop performance.

Of equal importance to our analysis are the effects of the five crop-intensity indices combined as evaluated in the relevant districts. In Table 9 we present the elasticities of the district-crop interaction terms where sales of the given crop exceeded 1,000 Ksh/household on average. This allows us to evaluate the marginal effect of the given district-crop combinations. For example, let us consider the Bungoma sugarcane effects in this table. Fertilizer shows a -0.2 value and is statistically significant at the p=0.01 level. This may be interpreted as follows: an increase in the proportion of cropped area to sugarcane by one percent in Bungoma would have the effect of decreasing the fertilizer nutrient rate on food crops by 0.2 percent. Similarly, a one percent increase in the proportion of cropped area to sugarcane in Bungoma would reduce food crop productivity per acre by 0.3 percent.

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[7] A joint test of endogeneity of fert_acre and hyseed_acre resulted in a Chi-squared value of 3.93, and failed to reject the hypothesis of endogeneity at the 0.10 probability level. Instruments used to model *fert_acre* in Model 2 include *fert_price* and *fert_dist*. *Hyseed_acre 96* is used to instrument *hyseed_acre97*.

Based on Table 9, several of the cash crops clearly have opposite effects on food crop fertilizer use and productivity. For example, the elasticities of coffee on fertilizer and productivity are positive and significant in Muranga and Nyeri. Meanwhile, the effect of coffee on both variables in Meru is negative. Similar conflicting results exist for sugarcane and French beans. The most important insight from this table for our analysis of the effects of cash cropping on Kenyan food crop fertilizer use and productivity is that the effects vary significantly by zone. Given that these differences occur above and beyond the effects of individual districts -- which are controlled for using the district-level dichotomous variables -- this would suggest that the effects of any particular cash crop cannot be generalized.

Whereas Table 9 presented the *marginal* effects of small changes in the level of cash cropping intensity across the relevant crop and district combinations, Table 10 displays a simulation of the *average* effects of the same combinations. This exercise is important, given that promotion of particular crops through outgrower marketing/processing arrangements really represents a non-marginal change in agriculture where it occurs. Interpretation of the results is straightforward; for example, let us consider the case of Muranga and coffee. The fertilizer effect is positive 14 and statistically significant at the p=0.01 level. This suggests that were coffee not present in Muranga, the level of fertilizer use on food crops would be 14 kgs per acre lower, holding constant all other factors. Similarly, coffee's presence has increased food crop productivity by 4,000 Ksh per acre in this district, *ceteris paribus*. These simulation results highlight two major points: (1) that long-term production and marketing investments in input-intensive crops have had important spillover effects on the productivity of other crops grown in the region; and (2) the effects of cash cropping on food crop productivity cannot be overgeneralized, owing to unique region-specific conditions including possible institutional differences in the design and organization of the cash crop schemes.

Beyond these effects of commercialization, Table 8 shows four other econometric results that merit discussion. First, and as expected, fertilizer price and the distance to a paved road (an indication of travel costs) both have significant negative effects on fertilizer use, *ceteris paribus.*

Second, human capital as proxied for by the two education dichotomous variables, both have significant and positive effects on fertilizer use. *Educ_mid* and *educ_hi* are both positive and significant in both models. Their coefficients suggest that a household with at least one member having completed primary school enjoys a nearly 10 percent jump in food crop productivity

Table 8. Results of Econometric Models of Food Crop Fertilizer Use and Productivity [a]

Variables	(1) Fertilizer Nutrient Application per Food Crop Acre		(2) Gross Food Crop Productivity per Food Crop Acre	
	Coefficient	t-stat	Coefficient	t-stat
HCI	0.14**	5.77	66.8**	3.94
fert_acre [b]	—	—	-203	1.42
fert_price	-0.12**	4.27	—	—
fert_dist	-0.15	0.83	—	—
hyseed_acre [b]	—	—	485**	2.9
road_dist	-2.46*	1.85	-261	0.81
acre_owned	0.03	0.31	-44.8	1.1
v_ag.equipment	$1.5*10^{-6}$	0.62	0.002	1.56
v_livestock	$1.9*10^{-5}$*	1.99	0.003	0.8
adults	-0.49	1.04	-6.37	0.04
mem_40	-1.54	0.35	257	0.15
mem6_16	-4.42	1.02	1221	0.77
mem 0_6	-4.72	0.76	2662	1.21
educ_hi	7.01**	3.25	1399*	1.71
educ_mid	4.52*	2.16	1228*	1.71
male _not_pres	2.54	1.02	-850	1
no_adult_male	2.87	0.98	-1193	1.21
pcta_coffee	2.51**	4.15	309*	2.31
pcta_tea	0.17	0.82	-39.5**	0.52
pcta_sugar	-0.97**	5.17	-223**	2.73
pcta_vegetables	-0.39	0.95	51.8	0.58
pcta_French_beans	-7.11**	3.09	-2716**	2.8
pcta_coffee* Meru	-3.81**	5.1	-1247**	3.21
pcta_coffee* Kisii	-3.39**	4.37	—	—
pcta_coffee*Muranga	-2.34**	2.94	—	—
pcta_tea*Meru	—	—	-428*	2.01
pcta_tea* Vihiga	4.65**	2.01	—	—
pcta_tea*Muranga	—	—	-933**	2.94
pcta_sugarcane*Kisumu/Siaya	0.88*	1.72	246*	2.29
pcta_sugarcane*Bungoma	0.76**	3.14	—	—
pcta_vegetables*Kilifi/Kwale /Taita Taveta	1.96*	2.06	—	—
pcta_vegetables*Trans Nzoia	-6.92*	1.95	-3070*	1.89
pcta_French_beans*Meru	6.97**	2.97	2440*	2.52
pcta_French_beans*Vihiga	17.0**	4.81	4329**	3.06
Kilifi / Kwale / Taita Taveta	-82.8**	8.31	-9572**	3.13
Kitui / Mwingi Machakos	-48.5**	8.42	-10356**	3.32

Variables	(1) Fertilizer Nutrient Application per Food Crop Acre		(2) Gross Food Crop Productivity per Food Crop Acre	
	Coefficient	t-stat	Coefficient	t-stat
Makueni	-39.0**	6.28	-7266**	2.5
Meru	20.1**	2.25	12983**	3.15
Kisii	6.31	0.71	-7758**	2.76
Kisumu / Siaya	-36.6**	4.07	-8185**	2.7
Bungoma	-5.05	0.84	343	0.3
Kakamega		OMITTED		
Vihiga	-106**	6.01	-16521*	2.46
Muranga	6.87	0.75	1841	0.8
Nyeri	-35.6**	3.97	-4694*	1.89
Bomet	-3.57	0.31	-3683	0.97
Nakuru	6.27	0.97	-1216	0.77
Narok	-38.4**	3.97	-3256	0.66
Trans-Nzoia	18.8**	2.97	5128*	2.11
Uasin Gishu	13.6*	2.12	1180	0.8
Laikipia	-58.8**	7.08	-13087**	3.43
constant	172**	33.9	10842**	3.32
se	20.2			
Number of observations	1465		1465	
			Wu-Hausman statistics = 3.93	
			Adjusted R-square = 0.06	

Note: **a** * indicates 10 percent significant level. ** indicates 1 percent significant level. Numbers in parentheses are absolute t values. **b** Instrumental variables are the price of DAP, the distance to the nearest fertilizer seller, and maize hybrid seed use from the previous year.

compared to households without any member having achieved this level of schooling. This may be due to better management skills of more educated members as well as a greater propensity to seek out information on input use, appropriate dose rates, and so on.

Third, and as expected, the level of hybrid maize seed use per acre (as instrumented) was found to have a significant and positive effect on food crop productivity, *ceteris paribus*. The magnitude of the coefficient, 485, indicates that an additional kg of hybrid seed applied on a food crop field -- from current mean levels -- increases the gross value of production per acre by approximately 5 percent.

Fourth, land holdings per capita were found to have a **negative** but not statistically significant effect on productivity. This would suggest that farm size has no clear effect (within the smallholder sector) on food crop productivity.

Table 9. Elasticities of Crop Specific Commercialization Indices on Fertilizer Use and Productivity

Agro-Regional Zone	District	Coffee		Tea		Sugarcane		Vegetable		French Bean	
		Fert	Prod	Fert	Prod	Fert	Prod	Fert	Prod	Fert	Prod
Coastal Lowlands	Kilifi / Kwale / Taita Taveta							0.8	0.1		
Eastern Lowlands	Kitui / Mwingi / Machakos										
	Makueni							-0.3	0.1	-0.9**	-0.4**
Central Lowlands	Narok										
Western Transitional	Bungoma					-0.2**	-0.3**				
	Kakamega					-0.9**	-0.6**				
Western Highlands	Kisii	-0.5**	0.4*	0.03	0.02			-0.1	0.02		
	Vihiga			0.8	-0.01					3.1**	1.0**
Central Highlands	Muranga	0.1**	0.3*	0.01	-0.1**						
	Nyeri	0.8**	0.2*	0.1	-0.1						
	Meru	-0.2**	-0.3**	0.04	-0.2*			-0.1	0.03	-0.02**	-0.1*
	Laikipia							-0.3	0.1		
High Potential	Trans-Nzoia							-0.2*	-0.2		
	Uasin Gishu										
	Bomet			0.3	-0.2						
	Nakuru							-0.04	0.01		

Notes: * indicates 10 percent significance level; ** indicates 1 percent significance level.

Table 10. Simulation of the Average Effects of Commodity Specific Commercialization on Food Crop Fertilizer Use and Productivity by District[1]

Agro-Regional Zone	District	District Dichotomous Variable Coefficients		Coffee		Tea		Sugarcane		Vegetable		French Bean	
		Fert [a]	Prod	Fert	Prod	Fert	Prod	Fert	Prod	Fert	Prod	Fert	Prod
Coastal Lowlands	Kilifi / Kwale / Taita Taveta	-2**	-10**							0	0		
Eastern Lowlands	Kitui / Mwingi / Machakos	-4**	-11**										
	Makueni	-12**	-7*							-1	0	-2**	-2**
Western Lowlands	Kisumu / Siaya	-1**	-8**					-0.01**	0.1*				
Central Lowlands	Narok	-6**	-3										
Western Transitional	Bungoma	-4	0					-3**	-4**				
	Kakamega	omitted						-12**	-5**				
Western Highlands	Kisii	5	-8**	-8**	4*	1	0			-1	0		
	Vihiga	-49**	-17*			6	0					23**	8**
Central Highlands	Muranga	6	2	14**	4*	0	-2**						
	Nyeri	-29	-5*	-16**	2*	2	0						
	Meru	19*	13**	-6**	-4**	1	-3**			-4	1	-1**	-1**
	Laikipia	-4**	-14**							0	0		
High Potential	Trans-Nzoia	18**	5*							-7*	-3		
	Uasin Gishu	13*	1										
	Bomet	-3	-4			8	-2						
	Nakuru	6	-1							-1	0		

Notes: [1] Fertilizer effects are in kg nutrient per acre; Productivity effects are in 1000s of Ksh per acre.

* indicates 10 percent significance level;. ** indicates 1 percent significance level. [a] District-level effects are evaluated relative to Kakamega District, which was found to represent the median district ranked by food crop productivity and fertilizer use per hectare.

8. CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

Most of the productive agricultural regions in Kenya, and in Africa more generally, are already under cultivation. Area expansion is not a viable long-term option for agricultural growth in Africa. Developing strategies to increase the value of agricultural production per unit of land is a top priority. At the same time, as landholdings become smaller with increased population density in many areas, household food security will increasingly depend on maximizing productivity and incomes from limited land in order to purchase food to meet consumption requirements on a year-round basis.

Smallholder commercialization, particularly into higher-value export crops, has frequently been criticized in African contexts as having a negative effect on food production and food security. Without reliable and efficient food markets, commercialized cropping patterns may expose smallholder households to major risks of food insecurity. However, recent studies of commercialization from Mali, Senegal and Mozambique have found significant complementarities between cash cropping and smallholder food security. The emerging picture indicates the benefits of attempting to address the risks and market failure aspects necessary to make increased agricultural commercialization viable rather than accept these risks and market failures as inherent, unalterable features of the African context that require a food-first production orientation. Increased access to food depends on income growth, and for the majority of African smallholders dependent on agriculture, income growth is tied to productivity growth in agriculture, i.e., increasing the value of production generated from available household resources. Increased commercialization and integration of rural credit, input, labor, and food markets are likely to be an unavoidable feature of highly productive agricultural systems (Mellor 1990; Timmer 1997).

This study examined the effects of agricultural commercialization on food crop fertilizer use and productivity. We investigated these relationships through both descriptive and multi-variate analyses. The principle findings of this study include:

1. The degree of smallholder commercialization differs widely across zones in Kenya. Even within a particular zone, households differ significantly in the degree of commercialization;

2. Crop commercialization is not uniformly correlated with landholding or area cultivated among the households surveyed;

3. Household agricultural commercialization, *ceteris paribus*, generally has a significant and positive effect on food crop fertilizer use and productivity;

4. The effects of particular cash crops on these variables was found to differ markedly by region, independent of the household-level effects of agricultural commercialization;

5. As expected, smallholder adoption of hybrid maize seed, frequently in combination with fertilizer, was shown to have significant positive effects on productivity per unit of land; and

6. There is a meaningful payoff to formal education in terms of food crop productivity; fertilizer use was also found to be positively associated with education.

In general, the results indicate that discussions of agricultural commercialization and its effects should not be overgeneralized. What matters is what kind of commercialization, how particular schemes are organized, and their effects on smallholder access to inputs, management advice, market outlets, price levels and price risks, and so on.

The most important pathways by which crop commercialization may improve food crop productivity are hypothesized to be:

1. Crop commercialization provides a source of cash that allows the household to overcome credit-related constraints on the purchase of fertilizer and other cash inputs;

2. Participation in a cash crop (e.g., coffee) generally improves the household's access to inputs distributed through the cash crop marketing firm (e.g., coffee cooperatives), which may result in the household using some of that input on food crop production; and

3. Cash income from commercialized production patterns also facilitates the ability to purchase draft oxen and traction equipment that may promote food crop productivity.

Those in the policy community concerned about promoting rural income growth should be aware of an additional potential benefit of successful cash-crop promotion in SSA settings. That is, cash cropping schemes may, if appropriately structured, bring about social benefits for the communities involved. Consider the cases of Mali and Senegal cash cropping schemes highlighted above where both authors found broader benefits:

> "...there are also complementarities between food crops and cash crops...The (cotton parastatal in Senegal), for example, organizes farmers into producer associations, provides literacy programs in rural areas, erects storage facilities for coarse grains, and constructs roads providing access to rural areas. In some instances, it would have even been impossible to access the surveyed villages throughout the year without those roads...the evidence for such complementarities in Senegal generally corroborates similar findings from Mali (Dione 1989)."

We hope these findings are incorporated into the way policy makers, researchers and private sector investors conceptualize the potential role of commercialization schemes in the development strategy for smallholder agriculture. The Government of Kenya is seeking policies designed to increase rural incomes through productivity-enhancing technology packages. Cash crop promoters such as sugarcane mill owners or coffee processors can be important investors and partners in this process, but their performance is critical to determining whether the welfare outcomes for smallholders are positive or negative. A major task for future research is to understand better how successful commercialization arrangements linking smallholders and marketing/processing firms have been structured so that their successful ingredients can be replicated and incorporated more broadly into commercialization strategies in other regions. This is likely to yield high payoffs in terms of increasing agricultural productivity and food security.

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