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The adoption of intensive monocrop horticulture in southern Cameroon

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Abstract

Results from a 1997 survey of 208 households in the humid forest zone of southern Cameroon indicate that African policy makers seeking to intensify agricultural production should focus attention on the horticultural sub-sector. The survey, which gathered information on horticultural production practices, found that the average expenditure on agro-chemical inputs by horticultural producers using monocrop production systems was 190 US$/ha, which greatly exceeds the FAO reported national average expenditure of 6.50 US$/ha. A logit model of monocrop adoption indicated that the size of land holding per household had a negative effect on adoption, congruent with population-driven technical change and that increases in unit transportation costs significantly decreased the probability of adoption. These findings suggest that policy makers should target horticultural intensification in areas of higher population density and promote investment in rural roads. The age of the household head had a significant negative and elastic effect on adoption, which in combination with an increase in the cohort of younger farmers in the rural population induced by macro-economic events contributed to the spread of intensified horticulture. In the study area, roughly two-thirds of rural households also produce cocoa and the quantity of cocoa produced was positively associated with adoption of intensive horticultural systems suggesting that export crop promotion indirectly facilitated diversification of agriculture. Women's participation in intensive monocrop production was limited and efforts to promote their greater involvement are recommended.

JEL classification: D21; O33; Q12

Keywords: Logit; Monocrop; Agricultural intensification; Cash crop synergy

1. Introduction

Rural poverty remains a pressing problem in Africa (IFAD, 2001). To meet rapidly growing food demand and raise rural income, it is widely believed that African farmers must intensify their crop production systems by increasing the amount of inputs used per unit area of agricultural land. The use of inorganic and organic fertiliser, improved seed, irrigation and pesticides by farmers in sub-Saharan Africa is among the lowest in the developing world. In Cameroon the mean expenditure per ha of fertilisers and pesticides in 2000 is estimated by FAO at 6.50 US$/ha with the bulk of these expenditures

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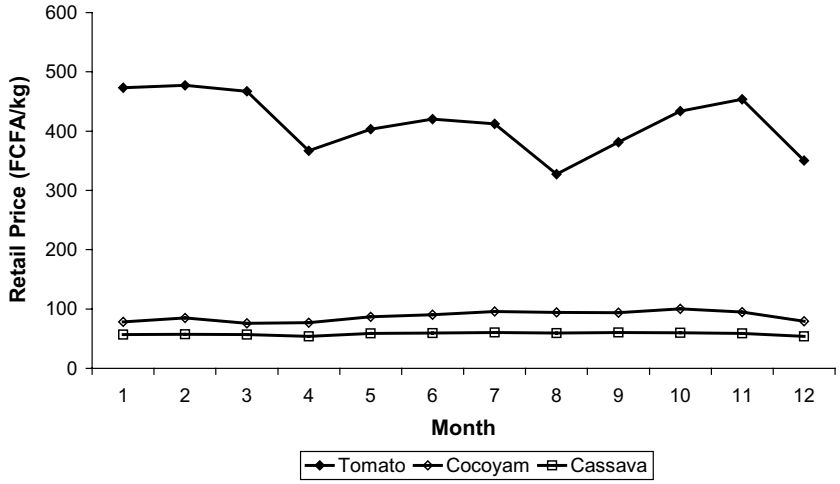

Fig. 1. Average nominal monthly retail prices of tomato, cocoyam and cassava in Yaounde, December 1993 to July 2001. *Source*: Gockowski and Ndoumbe, monthly prices provided by the Direction de Statistiques et Comptabilité Nationale, Ministery of Planning and Territorial Administration.

incurred in the export crop sector (coffee, cocoa and oil palm).

Low levels of agricultural intensification have been linked to the non-suitability of agricultural lands, inappropriate agricultural policies, nonexistent agro-chemical production capacity, poor infrastructure, weak research and extension institutions, and the low prices of staple commodities (Reardon et al., 1997; Zeller et al., 1999). Underdeveloped rural credit markets also limit agricultural intensification and productivity growth that depends on the increased use of purchased inputs (von Braun et al., 1993; Poulton et al., 1998). Intensification is also commodity-specific with horticultural crops often among the most intensively produced. The higher value of horticultural crops relative to staple foods is a key factor. A comparison of mean monthly tomato and staple food prices in the Yaounde market in recent years illustrates the 'high value' nature of horticultural crops common to many African food markets (Fig. 1).

To facilitate agricultural intensification in Africa, better understanding is needed of those examples where the process has already taken hold. Contributing towards that end, this paper examines the adoption of intensified monocrop systems of horticultural production among smallholders in southern Cameroon. A logit regression of the adoption determinants is developed and the elasticities of adoption for certain policy variables estimated.

2. Area description, survey methodology and adoption model

The study area in southern Cameroon was selected based on anecdotal observation of the growing importance of intensified horticultural production in this region (Fig. 2). Rural densities lie between 36 and 70 persons per km^2 although denser pockets in excess of 150 persons are not uncommon (RGPH, 1993; Santoir, 1995). Population pressures are generally higher than in most other areas of central Africa, yet lower than in much of humid west Africa. The climax vegetation is semi-deciduous moist tropical forest. Mean annual rainfall ranges from 1350 to 1700 mm distributed in a bimodal pattern which permits two rain-fed cropping seasons: the first, from March to June and the second, from August to November. 25% of rural households also crop during the dry season from December to February in inland valley bottoms using hand irrigation or water from hydro-morphic soils (IITA unpublished data).

Up until the spread of monocrop systems of horticultural production beginning in the 1970s, the three cropping systems which predominated in the farming

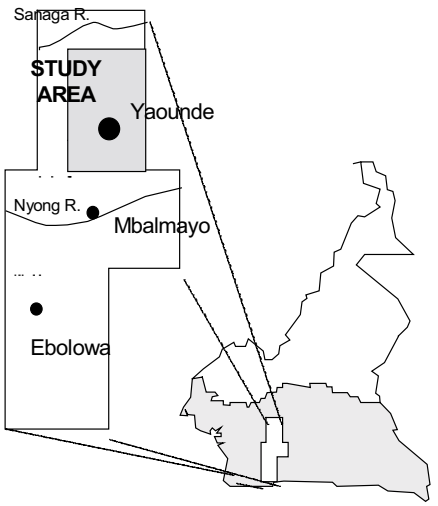

Fig. 2. Location of study area relative to forest margins ecoregional benchmark of southern Cameroon. *Sources*: Gockowski and Ndoumbe.

systems of the study area were the melon seed field, the mixed food crop field and the cocoa agroforest. The first two are annual crop systems that are rotated with a fallow period in order to restore soil fertility. As rural populations have grown, fallow periods have declined and differences in land holdings have become more accentuated. For households with limited land holdings, the melon seed field, which requires long fallow periods of 10–15 years, has dropped out of the farming system. The mixed food crop system is managed by women and has remained an integral part of the farming system since pre-colonial times (Guyer, 1984). This cropping system provides the bulk of household food supply as well as marketed surpluses of food crops. Most households cultivated the field twice in the first and second rainy season on different sites. With rare exception agro-chemicals are not applied. Cultivation of cocoa in small agroforests is an important revenue source for approximately two-thirds of households in the area and accounts for approximately one-third of total revenues in these households (IITA unpublished household data).

Horticultural crops are marketed from surpluses emanating from the mixed crop field and from specialised monocrop systems of horticultural production cultivated by men. The latter system is a relatively recent incorporation, first described in the mid-1970s (Guyer, 1984). Discussions with village elders confirm this as the period in which commercial horticultural production began to develop. An important characteristic of the monocrop system is a high level of agro-chemical use.

A randomised two-stage cluster sample of rural households was conducted in July of 1997 to investigate the importance of horticultural cash crops in rural livelihoods. The study area was divided into eight squares of 18 km × 18 km and clusters (villages) nearest the geographic centre of each square selected from two strata: (i) those villages lying on all-weather roads and (ii) those on seasonal roads as indicated on 1:200,000 topographic maps. Within villages, the survey team selected households randomly by choosing every nth household. The sampling interval n was equal to $N/13$, where N was the counted total number of households in the village and 13 the desired sample size for each village. A local guide assisted in the enumeration of households. In all, 16 villages were sampled and a total of 208 households interviewed using a structured questionnaire administered in the local Beti dialect. The questionnaire gathered detailed production information on the two most important commercial crops produced by the household. The survey data were used to characterise practices in horticulture production, and to model the adoption of intensive monocrop systems.

The adoption of intensive monocrop production systems was modelled using the logit discrete binary regression model (Maddala, 1983; Amemiya, 1985). The model assumes an underlying latent adoption variable y_i^* defined by the relationship:

$$y_i^* = \beta' x_{ik} + u_i$$

where we assume that u_i are IN(0, σ^2).

However, in practice we observe y defined by

$$y_i = 1, \quad \text{if } y_i^* > 0, \ y = 0 \text{ otherwise}$$

The likelihood function of the logit model is

$$\text{Prob}[Y_i = 1] = \frac{\exp[x_i'\beta]}{\{1 + \exp[x_i'\beta]\}}$$

If we let x_{ik} equal the kth element of the vector of explanatory variables x_i and β_k the kth element of β, then the expression for the derivatives of the

probabilities given by the logit model is

$$\frac{\partial}{\partial x_{ik}} L(x_i'\beta) = \frac{\exp(x_i'\beta)}{[1+\exp(x_i'\beta)]^2}\beta_k \quad (1)$$

And the elasticities of the probability of belonging to the group of adopters is given by

$$\varepsilon(x_{ik}) = \frac{(\partial L/\partial x_{ik})x_{ik}}{\exp(x_i'\beta)/[1+\exp(x_i'\beta)]} \quad (2)$$

The model focus is on the determinants of the adoption of intensive monocrop production systems. The reduced form of the model is

$$\begin{aligned}\text{ADOPT} = {} & \alpha_0 + \beta_1\text{MEN} + \beta_2\text{WOMEN} + \beta_3\text{CHILD} \\ & + \beta_4\text{AGE} + \beta_5\text{EDUC} + \beta_6\text{MELON} \\ & + \beta_7\text{MFOOD} + \beta_8\text{COCOA} + \beta_9\text{WPROD} \\ & + \beta_{10}\text{COSTKM},\end{aligned}$$

where the dependent variable (ADOPT) equals one, if the production system used by the household to produce its most commercially important horticultural crop was a monocrop, and otherwise equals zero.

The household endowment of family labour is expected to positively affect the probability of adoption, given the labour-intensive nature of commercial horticulture production and relatively undeveloped local labour markets. Labour variables in the model include the number of adult males (MEN), adult females (WOMEN), and children under 16 years of age (CHILD). The age of household heads (AGE) and their educational attainment (EDUC) capture differences in the quality of management.

Land endowments play an important role in the intensification process (Boserup, 1965; Binswanger and McIntire, 1987). In southern Cameroon, the institution of patrilineal inheritance with an equal division of land holdings along with very limited land sales and rapid population growth has led to a decline in the average land holding per farm household. Congruent with Boserup's population-driven view of technical change, this should increase the probability of intensified horticultural production. Accurate measures of farm size were difficult to obtain through farmer interview, as land had not been surveyed and local area measures do not exist. To address this measurement issue, the number of melon seed fields cropped in the last 12 months (MELON), was used as an instrumental variable. The 10–15 year fallow requirement for this field implies that only households with large landholdings can still maintain this system. To test whether intensive horticulture is replacing cultivation of the traditional mixed crop field, a count of the number of these fields cropped in the last 12 months (MFOOD) was included in the model.

Research elsewhere (Govereh and Jayne, 1999; Strasberg et al., 1999) has documented synergy between cash crop and food crop intensification due in part to the alleviation of liquidity constraints when credit markets are missing. To test the hypothesis that cocoa revenues provide liquidity that increases the probability of intensified moncrop horticultural production, the level of cocoa production (COCOA) in the 12 months prior to the interview was included.

Women's participation in the process of technical change is often constrained by information gaps and impaired access to productive resources (Bzugu and Kwaghe, 1997; Orr, 2000). A dummy variable (WPROD), indicating cases where the principal decision-maker was a women, tests for gender differences in the participation in intensive monocrop production.

The condition of rural roads and the amount of vehicular traffic affect market access and search and information costs, which have been shown to influence intensification processes (Odhiambo, 1998; Zang and Fan, 2001). Although the 16 villages in the sample are within 100 km of Yaounde, local differences in road quality and the amount of vehicular traffic can be significant. The per kilometre cost of personal bush taxi transport to Yaounde (COSTKM) provides an instrumental measure of these differences and is expected to have a negative impact on the probability of adoption.

3. Results

All of the 208 households had marketed at least one horticultural crop in the 12 months prior to the interview. A remarkable diversity of crops was marketed with the mean household selling nearly 18 different crops. Overall, households identified 34 different crops as among their principal (first and second rank in importance) sources of horticultural revenues. Tomato, dessert bananas and green maize were cited most frequently (Table 1).

Table 1
Frequency of production as 'most important' or 'second most important' commercial horticultural crop among southern Cameroon households ($n = 208$)

Crop species	Frequency (percent of households)
Tomato	35.6
Bananas	29.3
Green maize	23.6
Okra	17.8
Leafy green (Solanum scabrum)	12.0
Hot peppers	11.1
Citrus	7.7
Cassava leaf	6.7
African plum (Dacryodes edulis)	5.8
Avocado	4.8

Fifty-seven percent of the households produced their most important market crop using an intensive horticultural monocrop system, while 43% used the traditional mixed food crop field to produce market surpluses. Producers using monocrop systems reported expenditures on fertilisers and pesticides of 190 US$/ha (versus 6.50 US$/ha for all agricultural lands in Cameroon) establishing the monocrop horticultural system as among the most input-intensive crop systems in Cameroon. Monocrop producers were more likely to use fertilisers, pesticides, modified soil tillage and improved seeds to produce horticultural crops than were producers using the traditional mixed food crop field (Table 2). They were also on average ten years younger, better educated, and produced more cocoa than producers using traditional mixed crop technology (Table 3).

For the adoption model, 170 producer records were used to analyse the predicted model effects; 38 of the households visited were unable to supply complete data for all eleven variables in the model and had to be dropped from the logit analysis. All the variables except WOMEN had the qualitative effects predicted, 5 of the 10 independent variables affected the probability of adoption at statistically significant levels ($P <$

Table 2
Frequency of management practices among monocrop versus mixed food crop systems

Management practice	Horticultural cropping system	
	Monocrop (percent of households indicating)	Mixed food (percent of households indicating)
Application of inorganic fertilisers**	62	6
Application of organic fertilisers**	19	4
Application of pesticides**	80	11
Planting of improved seed**	68	15
Soil mounding at weeding**	66	31
Raised bed/ridge tillage**	52	19

** $P < 0.05$ (test of independence: $\chi^2(1) = 3.841$).

Table 3
Descriptive statistics of logit model variables by adopter ($n = 97$) vs. non-adopter ($n = 73$) groups

Variable description	Mean averages			Standard deviation
	Adopter	Non-adopter	Overall	
AGE of household head (years)	42.2	52.5	46.5	13.7
EDUC educational attainments of household head (1–9)	4.10	3.42	3.81	1.72
MEN adult men living in household (no.)	2.04	1.99	2.02	1.84
WOMEN adult women living in household (no.)	1.75	1.93	1.83	1.27
CHILD children (<15 years) in household (no.)	1.64	1.23	1.46	1.90
COCOA 75 kg bags of cocoa produced (no.)	7.27	3.25	5.55	8.18
WPROD proportion of women decision makers	0.02	0.26	0.12	0.33
MELON melonseed fields (no.)	0.18	0.64	0.38	0.85
MFOOD mixed crop fields (no.)	2.37	2.31	2.35	1.64
COSTKM transport cost to Yaounde (FCFA/km)	13.2	14.8	13.9	2.79

Table 4
Logit adoption model results

Variable	Coefficient	Standard error	Asymptotic *t*-ratios
Constant	5.070		
AGE***	−0.052	0.017	−2.979
EDUC	0.055	0.127	0.435
MEN*	0.242	0.137	1.770
WOMEN	−0.284	0.215	−1.318
CHILD**	0.264	0.119	2.220
COCOA*	0.065	0.034	1.907
WPROD***	−3.015	0.882	−3.420
MELON***	−0.852	0.281	−3.029
MFOOD	−0.049	0.145	−0.339
COSTKM**	−0.184	0.083	−2.213
McFadden R^2	0.319		

Actual	Predicted		Total
	0	1	
Frequencies of actual and predicted outcomes			
0	51	22	73
1	12	85	97
Total	63	107	170

Two-tail tests.
* $P < 0.10$.
** $P < 0.05$.
*** $P < 0.01$.

Table 5
Elasticity of the probability of adoption of intensive monocrop with respect to three policy-related variables (estimated at the means)

Variable	Elasticity of probability $\varepsilon(x_{ik})$
AGE	−1.055
COCOA	0.160
COSTKM	−1.123

0.05), and the model correctly classified 80% of the households (Table 4).

Using Eqs. (1) and (2), the calculated elasticities of adoption were elastic for AGE and COSTKM and inelastic for COCOA, the only policy variables whose marginal effects were significantly different from zero (Table 5).

4. Discussion of results

The positive effects of the number of men (MEN) and the number of children (CHILD) suggests that family labour is mobilised among adopters, although the issue is not entirely clear for child labour. If the decision-maker views children's education as an investment good, an increase in the number of children would increase the decision maker's demand for his/her children's education which could provide an alternative to the labour demand hypothesis for the positive coefficient on CHILD. Further investigation of intra-household revenue distribution, labour allocation, and household expenditure is required to resolve this issue. The number of women in the household (WOMEN) and the educational attainment of the household head (EDUC) did not influence the probability of adoption, although there was a significantly greater educational attainment (Student's $t = 2.59$, $P = 0.01$) among adopters (Table 3).

When women were the principal agent in management decisions (WPROD), there was a lower probability of adoption. Women's wide range of responsibilities in village society limits their capacity for adopting labour-intensive technology systems. In the few cases where women were utilising monocrop systems they were mainly producing traditional African leafy vegetables in the dry season when other labour demands are reduced.

The negative effect of MELON, a proxy measure of land availability, indicates that increasing land constraints positively influence the adoption of commercial horticultural production systems. This suggests that, ceteris paribus, efforts to promote intensification of horticulture production should target areas of relatively high population pressure.

The number of subsistence-oriented mixed food crop fields, MFOOD, did not influence the adoption of monocrop horticulture. Production from this field system remains an important household objective for both adopters and non-adopters alike. Many adopting households have included the monocrop field on the front end of the mixed food crop/fallow rotation thereby economising on labour for fallow clearing while maintaining the subsistence contribution of the mixed food crop field. The important cultural role attached to the cultivation of the mixed food crop field by the women of southern Cameroon (Guyer, 1984) and the limited access of most households to rural food markets also contribute to its persistence among adopting households.

The cash requirements for intensive horticulture production combined with the failure of formal rural credit institutions present a constraint to adoption especially for resource-poor households. Financial demands of intensive production likely underlie the positive effect of cocoa revenues (COCOA) on adoption. Mean cocoa sales among adopters during the survey were more than double those of non-adopters; the injection of cocoa revenues estimated at more than 500 US$ into the household economy facilitated diversification into other enterprises. Similar effects between coffee and intensive horticulture have also been noted in the western region of Cameroon (Temple and Fadani, 1997). This suggests that past policies in Cameroon supporting small holder tree crop production had a positive impact on the adoption of intensified commercial horticulture production, although the effect is relatively inelastic (Table 5).

The age of the household head was negatively associated with the probability of adoption. Younger farmers were more likely to adopt and the effect of age on the probability of adoption was elastic (Table 5) suggesting that policies, which impact demographics and migration patterns would also affect the probability of adoption. Macroeconomic events beginning in the late 1980s may have slowed rural–urban migration and increased the cohort of young farmers in the rural population (Gockowski and Ndoumbé, 1999).

The instrumental variable for rural road infrastructure and communications, COSTKM, also had significant and elastic effect on the probability of intensive horticulture production. Elasticity at the sample mean (maximum) is −1.12 (−2.59), which underscores the importance of public investments in rural transportation infrastructure in the process of agricultural intensification.

5. Conclusions

Horticulture is providing a pathway for intensification among smallholders in southern Cameroon driven by growth in urban market demand and high relative prices. Its integration in the traditional farming system enables the economical use of soil amendments that provide a means for addressing the pressing issue of soil nutrient depletion.

Demographic changes have played a major role in the intensification of horticultural production. Rapid rates of urbanisation, which in Cameroon averaged over 7% in the 1970s and 1980s, have resulted in substantial demand growth in the urban markets of West and central Africa. A slowing of rural-to-urban migration in the 1990s associated with macroeconomic structural adjustments including the 1994 currency devaluation appears to have increased the cohort of younger farmers in the study area. Younger farmers were significantly more likely to adopt intensive monocrop systems. This is an example of the important second-order effects of structural adjustments that often escape the notice of policy makers.

Marketing costs have a significant and elastic effect on the adoption of intensive horticulture systems. Greater public investment in rural roads and a downward adjustment of tariffs currently exceeding 100% on new transport vehicles would help lower marketing costs. The diffusion of information on input and crop prices, and quality differentials for these relatively volatile markets is another public intervention which would lower market search costs and enhance market efficiency. Local language radio broadcasts are among the most cost-effective methods of information provision (Robbins, 2000).

The combined influence of transport cost and increasing land scarcity on the adoption of intensified production systems suggests targeting development efforts in areas of higher population densities with better road infrastructure. For central Africa, rural areas in the periphery of urban centres are the most likely domains for horticultural intensification, rather than the hinterlands characterised by poorly developed transport infrastructure and sparse populations. Appropriate domains in west Africa are likely to be larger than in central Africa due to higher overall population densities and better rural infrastructure.

The synergy between cocoa production and horticulture intensification suggests that promotion of traditional export crops has contributed to the diversification of agricultural systems in the study area. Whether similar processes of diversification and intensification have occurred among the cocoa and coffee producers of Cote d'Ivoire, Nigeria and Ghana warrants further study.

Women producers were not participating in intensive monocrop production. Efforts to address this

situation should consider the promotion of dry season production of African traditional leafy vegetables, when women's labour demands are lower, and when the price of these commodities rises two- to three-fold.

The importance of intensive horticultural production will continue to grow, especially if rapid urbanisation continues. As the conditions contributing to intensification in southern Cameroon may not be the same in other parts of West and central Africa, further investigations of these processes across the region are needed.

Acknowledgements

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