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The impact of agricultural research in Africa: aggregate and case study evidence

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Abstract

This paper presents case-study results and aggregate data to evaluate the impact of research in African agriculture. Of 32 case studies, all but eight report annual returns over 20% and many are far higher, with most gains arising in the late 1980s and 1990s. Spurred by policy reforms and changing incentives, these innovations have led to sustained growth in aggregate cereal crop yields since 1985. Africa's belated 'green revolution' is based on new varieties (often with early maturation for drought escape), complemented by new management techniques (typically labor-intensive efforts to conserve soil moisture and build soil fertility). © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

Total investment in African agricultural research increased during the 1960s and 1970s, but has stagnated or declined since then (Pardey et al., 1997). Low levels of support may be due to the failure of research to generate visible gains. This paper shows that past benefits of research in Africa were obscured by other factors, and that recent changes have made the gains from research much clearer.

Using aggregate data, we show that the continent's decline in per-capita production occurred between 1973 and 1985, a period of exceptionally rapid population growth, frequent civil unrest, and heavy taxation of agriculture, all of which severely reduced productivity. Without research, performance during this period might have been even worse than it was.

Using case studies, we show that by the late 1980s, numerous techniques produced by research were being adopted, and are now producing high levels of social gain. These include new varieties, whose principal feature is often early maturity for drought escape, as well as new management techniques aimed at moisture retention and soil fertility. This type of technical change is very different from that which produced the green revolution in Asia and Latin America, where greater moisture availability made short stature and fertilizer responsiveness the keys to higher yield.

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2. Aggregate evidence on agricultural performance

Although the data are limited, Africa-wide conditions can perhaps best be described using FAO index numbers for production, exports and imports, as shown in Fig. 1. After a period of relatively good performance in the 1960s, the FAO index of total agricultural production per capita fell consistently from 1971 to 1984, for a cumulative decline of 22% (from about 115 to 90). In the same period, the volume of agricultural exports fell even more sharply, for a cumulative decline of over 40% (from about 120 to near 70). And the volume of agricultural imports rose also, more than tripling over the period (from around 40 to 130).

The onset of the decline in the 1972–1973 and the beginning of recovery in 1985 can perhaps be linked to climate change, particularly in the Sahel region where rainfall was below long-term averages during this entire period. But Africa as a whole appears to have had normal weather (Nicholson et al., 1988; Le Houérou et al., 1993), so sustained agricultural weakness during the long 1971–1984 period, and subsequent recovery must have been due to causes other than climate.

Some clues as to the causes of agricultural stagnation are provided by focusing on cereal grains. In Fig. 2, we show average cereal grain yields for all Sub-Saharan Africa, West Africa, and the Sahel from 1960 to 1995, calculated from USDA data. The continent, region and subregion show somewhat different year-to-year variation, but a strikingly similar 20-yr period of yield stagnation from 1964 until their lowest point in 1984. Most remarkably, after 1984, there is a sustained improvement in yields through 1995 in all three areas.

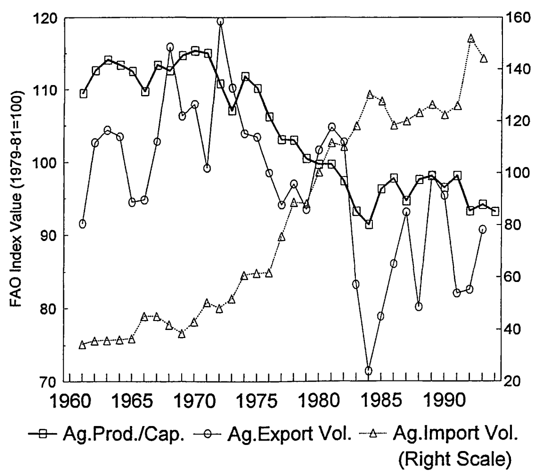

Fig. 1. African agricultural production, export and import volumes, 1961–1994.

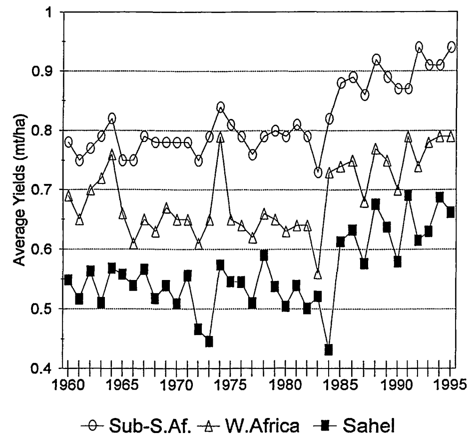

Fig. 2. Average cereal yields in Africa, 1960–1995.

Total production, shown in index-number terms on Fig. 3, is a result of both yields and area. Again, USDA data show a break after 1984, which is most dramatic for the Sahel. All three areas had significant increases in total cereal grain production from 1960 to 1984, but growth accelerated sharply in the following decade particularly in the Sahel.

Figs. 2 and 3 are aggregate averages, around which there is enormous variability at the level of individual crops and countries. Measurement error certainly

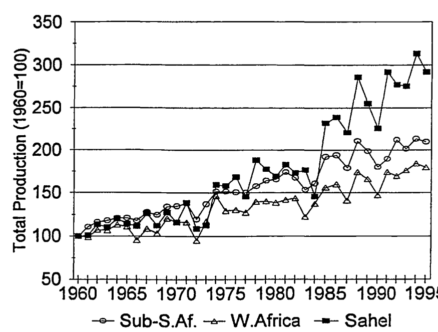

Fig. 3. Index of total cereal production, 1960–1995.

plays a role, although sustained trends such as those shown here are unlikely to be due to chance alone. And it is important to note that aggregate growth could occur even if yields for all crops and countries are constant, if production were to shift towards higher-yield crops and countries.

Several possible explanations could account for Africa's apparent success in raising aggregate yields over the past decade. Access to markets and improved incentives after policy reforms is clearly important, as is higher rainfall in some regions, reduced population growth, and relative political stability. But Africa's success in increasing average cereal yields also points to an untold story of successful technology development and transfer, as farmers adopt increasingly productive seed varieties and production techniques.

Some of the intensification observed after 1984 involves pre-existing techniques that were used more intensively after policy reform changed farmers' incentives. But the mid-1980s also saw the widespread release of new grain varieties and cultivation techniques developed by African researchers and their overseas partners. It was only in the 1970s that many research programs began to focus on food crops or on smallholders in marginal areas, and agricultural research programs often take 10 or more years to bear fruit. The exact duration of research and extension effort varies widely by program, but across Africa and in the Sahel, the fruits of the first post-Independence research programs began to reach farmers only in the mid-1980s.

3. Case studies of agricultural research impacts

To assess the contribution of research to Africa's agricultural recovery and economic growth, it is helpful to proceed on a case-study basis, with impact assessments of individual research programs. Since 1993, the authors have provided training and technical assistance to colleagues in numerous national agricultural research services, and collaborated directly on a number of studies across the continent.

In this paper, to present as large a sample of case studies as possible, we provide rate-of-return estimates from other comparable studies alongside our own research. This compilation updates previous surveys of research impacts in Africa (Oehmke and Crawford, 1996), permitting comparison with results for the world as a whole (Echeverria, 1990; Evenson et al., 1979).

Estimates from 11 analyses done prior to 1993 are summarized in Table 1, while Table 2 summarizes the results of 21 case studies completed since then. Most of these 32 studies were never published, as they were written for and circulated among an audience of specialists in a particular country. Perhaps the most striking result of this compilation is that, of the 32 studies we found, only 8 report rates of return below 20%—and the costs of these relative failures would be more than offset by the numerous cases of very high returns.

The research programs addressed in these studies may not be a random sample of research activity, but

Table 1
Rate-of-return studies for African agricultural research prior to 1993

Author(s) and year	Country	Commodity	Time period	Rate of return (%)
Abidogun (1982)	Nigeria	Cocoa	–	42
Makau (1984)	Kenya	Wheat	1924–74	33
Evenson (1987)	Africa	Maize and staple crops	1962–80	30–40
Karanja (1990)	Kenya	Maize	1955–88	40–60
Mazzucato (1992)	Kenya	Maize	1955–88	58–60
Mazzucato and Ly (1992)	Niger	Cowpea, millet and sorghum	1975–91	<0
Schwartz et al. (1993)	Senegal	Cowpea	1981–86	31–92
Sterns and Bernsten (1994)	Cameroon	Cowpea	1979–92	3
Howard et al. (1993)	Zambia	Maize	1979–91	21
Laker-Ojok (1992)	Uganda	Sunflower, cowpea and soybean	1986–91	<0
Boughton and de Frahan (1992)	Mali	Maize	1969–91	135
Ewell (1992)	East Africa	Potato	1978–91	91

Source: Reproduced from Oehmke and Crawford (1996), p. 5; plus Ewell (1992).

Table 2
Rate of return results from impact studies since 1993

Crop	Country	Period	Technology	I.R.R. (%)	Source
Maize	Burkina Faso	1982–93	New cultivars	78	1
	Ghana	1968–91	New cultivars+inorganic fertilizer	74	2
	Malawi	1957–92	New cultivars	4–7	3
	Zimbabwe	1930–40	New cultivars	43.5	4
Cotton	Senegal	1985–93	New cultivars+inorganic fertilizer	34 to 37	5
Rice	Senegal	1995–04	New cultivars+inorganic fertilizer	66 to 83	6
	Sierra Leone	1976–10	New cultivars (for mangroves)	18 to 21	7
	Sierra Leone	1979–93	New cultivars (for inland valleys)	34	8
	Guinea Bissau	1980–94	New cultivars (for mangroves)	26	9
Sorghum	Mali	1970–99	New cultivars (various)	50	10
	Sudan	1979–92	Hybrid (HD-1)+inorg. fert.+irrig.	53 to 97	11
	Sub-Sah. Af.	1985–09	New cultivars (striga resistant)	56	12
	Cameroon	1980–92	New cultivar (S-35)	2	2
	Zimbabwe	1980–99	New cultivar (SV-2)	22	13
Millet	Mali	1970–99	New cultivars (various)	66	10
	Namibia	1988–99	New cultivar (Okashana 1)	11	13
Wheat	Kenya	1921–90	All wheat research	0–12*	14
	Kenya	1921–90	All wheat research	14–30*	15
NRM	Burkina Faso	1990–04	Zai manure pits	53	16
	Burkina Faso	1988–94	Stone dikes	7	17
All agric.	South Africa	1990–04	All research activities	44*	18
	South Africa	1947–92	All research activities	58*	19

Asterisks (*) indicate econometric estimates. All others are economic-surplus measures.
Sources: 1. Ouedraogo et al., 1995; 2. Sanders, 1994; 3. Smale and Heisey, 1994; 4. Kupfuma, 1994; 5. Seck et al., 1994; 6. Fisher et al., 1995; 7. Tre, 1995; 8. Edwin and Masters, 1997; 9. Seidi, 1996; 10. Yapi et al., 1996; 11. Ahmed et al., 1994; 12. Aghib, 1996; 13. Anandajayasekeram et al., 1995; 14. Makanda and Oehmke, 1996; 15. Akgungor et al., 1996; 16. Ouedraogo and Bertelsen, 1997, 17. Ouedraogo and Illy, 1996; 18. Khatri et al., 1995; 19. Arnade et al., 1996.

they cover programs facing heavy criticism, as well as those seen as successful, and include a broad cross-section of the major types of research programs. Our compilation confirms that returns to research in Africa are similar those found elsewhere, showing high payoffs for a wide range of programs. The contribution of research to agricultural performance and economic growth is not obvious, since it occurs gradually, and is spread widely across the population, but the net benefits are significantly larger than the funding provided.

A striking result from our compilation is that the research failures are often—but not always—in the most difficult agroecological regions. Several competing hypotheses could explain this result. The first and perhaps dominant view is that payoffs tend to be lower in lower-potential areas because the environment's low reserves of soil and water limit any possible production increases. A second and more nuanced view would be that those productivity-enhancing innovations, which are discovered in these regions, are limited in their applicability, due to the diversity of micro-environments found in low-rainfall areas. A third explanation would involve the political-economy problems of these areas, where weak governments are often unable to provide key public goods. But all of these hypotheses are contradicted by the sustained yield increases observed for the Sahel in Figs. 2 and 3 above, which shows that sustained productivity growth is possible even in that very harsh environment.

Perhaps the most compelling general explanation for some programs' failure is simply that local institutions had not (yet) found the right mix of activities to produce cost-effective technologies in those locations. For example, on Table 1, the very low rate of return to research in Niger found by Mazzucato and Ly (1992) can be associated with that country's very weak seed-multiplication system, which effectively prevented the widespread dissemination of new varieties. On

Table 2, the relatively low gains from a project to promote stone dikes in Burkina Faso documented by Ouedraogo and Illy (1996) can be associated with that project's provision of credit to farmers for the purchase of rock phosphate to accompany the stone dikes, which accounted for a significant portion of the project's costs, but may have contributed little to its benefits. In these and other cases, detailed impact assessments provide key lessons for the design of future projects, but provide no evidence that research itself is unproductive. Indeed, despite the late start and occasional failures of Africa's foodcrop research programs, case studies provide ample evidence that high-impact innovations are now emerging in all of Africa's agroclimatic zones.

4. Conclusion: aggregate and case-study results in comparative perspective

The aggregate and case-study evidence presented here helps explain why productivity growth in Africa has occurred later and less dramatically than the 'green revolution' in Asia and Latin America. Africa's agricultural intensification in the late 1980s and 1990s shares some features of the earlier changes in Asian and Latin American agriculture, notably the increased use of labor and purchased inputs to sustain higher yields per hectare. But there are also major differences, and Africa's productivity growth is clearly less visible in farmers' fields or off-farm markets. In particular, much productivity growth in the green revolution areas of Asia and Latin America was driven by the adoption of short-stature fertilizer-responsive crop varieties, in the context of relative moisture abundance—and led to sharp rises in marketed surplus of food grains (Falcon, 1970). In contrast, much of Africa's productivity growth has occurred through early-maturing varieties aimed stabilizing yields in short rainy seasons—and has occurred in food-deficit environments, where marketed surplus consists of livestock, oilseeds, cotton and other products (Sanders et al., 1995). This contrast suggests that Africa's productivity growth was delayed in part simply because the relevant research occurred relatively late, and has been hidden from view simply because the relevant benefits are not easily observed. Nonetheless, the work reported here demonstrates convincingly that African research, like similar efforts elsewhere, does yield great economic gains in terms of the level and stability of farmers' income, and in terms of national economic growth.

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