PN-ABB-404

ISNAR Reprint Series

No. 4

DEC 15 1988

Role of research in transforming traditional agriculture: an emerging perspective

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International Service for National Agricultural Research

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Of the thirteen centers in the CGIAR network, ISNAR is the only one which focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on organization, planning, manpower development, staff requirements, financial and infrastructure requirements, and related matters, thus complementing the activities of other assistance agencies. Additionally, ISNAR has an active training and communications program which cooperates with national agricultural research programs in developing countries.

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This paper was first published in 1988 in the Proceedings of the Seminar "Food and Nutritional Strategies: Concepts - Objectives - Application" (Brussels, 3-7 November 1986), R. Delleré & J.J. Symoens (Eds.), Technical Centre for Agricultural and Rural Co-operation & Royal Academy of Overseas Sciences (Brussels), pp. 335-355. It is reproduced in the ISNAR Reprint Series by kind permission of the Royal Academy.

Summary

The population pressures of the 1960s were basically responsible for major policy decisions to give a new direction to world agriculture, which had evolved for most of its 10,000 years around traditional practices. It was decided during this period to mobilize science and technology to transform this kind of agriculture into highly productive systems of farming. The concept of genotype-environment interactions was used to synthesize crop varieties which would take full advantage of improved levels of agronomic management. The newly discovered plant-type genes in wheat and rice have been extensively used in the process of genetic reconstruction of traditional cultivars of these crops which had been bred more for adaptation to stress environments than for high grain yields. Many developing countries took bold policy decisions to reorganize and strengthen their agricultural research services in pursuance of these objectives. The new agricultural technology developed in this way has already made a significant impact on food production in some of these countries, more particularly in Asia and Latin America.

The impact has been much less in Africa, where the national agricultural research systems are in an early stage of evolution following their colonial history. It has been argued that the problems of agricultural production in Sub-Saharan Africa are only quantitatively, not qualitatively, different from those of developing countries in other parts of the world. Africa also offers considerable potential for significant advances in agricultural production through the application of the new technology, and this must be the approach in the short term. In the long term, however, the problem of agricultural production in Africa will require a different kind of production technology for its relatively large areas of lands characterized by moisture and fertility stress. This new technology must be based on efficient techniques of soil and water management, with the agronomists playing a key role supported by soil scientists, water technologists, plant breeders and scientists form other disciplines. The multidisciplinary approach becomes particularly important in this context.

The paper concludes with a brief discussion of ISNAR's collaborative work during the past 6 years with a number of Sub-Saharan African countries to strengthen the organization and management of their agricultural research services.

Introduction

World agriculture, which has evolved mostly around traditional practices for most of its 10,000 years, encountered its first serious challenge in the early 1960s. In the traditional systems of farming, yields have been low, but in most years a balance could be maintained between production and food needs of human populations kept in check mostly by disease epidemics. There have been serious famines in some years arising mainly from failure of rains, but the perennial food shortages of the kind which began to emerge in the 1960s were a new phenomenon in the history of man's dependence on crop plants and domesticated animals for meeting his food needs. Two factors have been basically responsible for this new situation. First, and this is particularly important, the human populations started to multiply rapidly with the advent of life-saving drugs in the second half of this century. Most of the killer microbes could be kept in check if not eradicated. A good example of eradication is provided by the smallpox virus which, as claimed by the World Health Organization, has been completeley wiped out except for laboratory samples. Second, the increasing adoption of the plant-animal-human food chain - first in the developed countries and more recently in the developing countries - began to give rise to vastly increased demands for food and feed grains.

The Increasing Role of Science

Fortunately, this period of food shortages in the 1960s coincided with a time when a number of major scientific discoveries, made mostly in the earlier years of the century, were ready to be integrated with synergistic effects to give rise to a new kind of agricultural production technology - a technology characterized by high crop yields and new management practices. The new technology is based essentially on favourable genotype-environment interactions. The rediscovery of Mendel's work at the turn of the century made it possible for plant breeders to synthesize genotypes, combining genes from diverse sources for high crop yields and other desirable attributes such as disease resistance. Simultaneously, advances in the field of mineral nutrition of plants made especially at the Rothamsted experimental station in England, based on the pioneering work of the German chemist Liebig in the previous century, led to the development of chemical fertilizers to which the new genotypes would respond favourably. The stage was thus set for a major genetic reconstruction of crop plants to fit them in more productive and modern systems of farming.

Why Genetic Reconstruction?

Following their first domestication in the valleys of Tigris and Euphrates, crop plants in most parts of the world have been grown in stress environments - moisture stress, fertility stress and stress arising from competition with pests, pathogens and weeds. The selection pressures in these stress environments favour vegetative growth more than high grain yields. The plants must first survive in these competitive and difficult habitats before they can produce some seeds. They have been selected, therefore, more for dry matter production in their vegetative parts than in their reproductive parts.

The problem in the 1960s was how to recover more and more of this dry matter in the form of grains. The answer was provided by the discovery of plant-type genes (the *Norin 10* dwarfing genes in bread wheat and the *Dee-Geo-Woo Gen* dwarfing factors in rice). Using these genetic factors plant breeders like Vogel (1963), Borlaug (1968) and Beachell (1978) started to reconstruct two of the world's most important food plants - wheat and rice. Table 1 shows how the grain yield of wheat has increased in Great Britain, India and the United States with genetic improvement, especially in the more recent years, following the identification and use of plant-type genes. These genes have helped to reduce plant height, leading to greater resistance to lodging under conditions of high fertility and an increase in the proportion of grains relative to the straw (as measured in terms of harvest index). The varieties shown in Table 1 include those developed in the earlier years of the century and those evolved more recently following the process of genetic reconstruction using plant type genes.

Policy Decisions for Reorganization of Agricultural Research

It is in the context of these emerging new technologies and massive food deficits resulting from mounting population pressures that many developing countries have taken important policy decisions to reorganize and strengthen their agricultural research services. Looking back over the past 20 years, it seems remarkable how profound the changes have been in some of the developed countries. Fundamentally, the process of reorganization has helped to give these countries a new research infrastructure - more confident, more responsive and more committed to the needs of agricultural development in the country. The basic changes have been in respect of the institutional framework, linkages and organization within which agricultural experimental stations function in these countries. In developing countries, institutes of agricultural research have mostly formed an integral part of the department of agriculture, occupying the status of a subsidiary service. The administrative control and decision making in these services have rested with the civil service bureaucracy. The personnel and management policies have had little relation with the needs of a scientific organization, and linkages with the policy-making bodies concerned with agricultural development and with the field-based extension staff have been limited.

Nature of Reorganization. The reorganization of agricultural research in the last 20 years has changed all this with the transfer of research institutes and experimental stations from the direct administrative control of the departments of agriculture to the newly

Table 1

Old and New Varieties of Wheat, their Yield and Other Characteristics

Variety	Year of Release *	Economic Yield (t/ha)	Biological Yield (t/ha)	Harvest Index (%)	Height (cm)
Britain					
Little Joss	1908	5.22	14.50	36	142
Holdfast	1935	4.96	13.77	36	126
Capalle Desprez	1953	5.86	13.95	42	110
Maris Widgeon	1964	5.68	14.56	39	127
Maris Huntsmann	1972	6.54	14.21	46	106
Hobbit	1977	7.30	15.20	48	80
Mardler	1978	6.21	12.67	49	77
India					
Pb8A	1910	2.23	12.82	17	113
NP52	1920	3.12	13.74	23	115
NP165	1930	3.56	12.12	29	117
C591	1940	3.51	11.98	29	120
Hy65	1950	3.87	13.65	28	113
NP710	1960	3.20	12.12	26	108
Sonalika	1970	5.26	13.37	39	98
Arjun	1980	5.74	12.40	46	84
USA					
Honor	1920	2.95	–	–	116
Forward	1920	3.22	–	–	112
Valprize	1930	2.95	–	–	116
Yorkwin	1936	3.22	–	–	115
Nured	1938	3.09	–	–	114
Cornell 595	1942	3.49	–	–	112
Genesee	1950	3.56	–	–	111
Avon	1959	3.63	–	–	108
Yorkstar	1968	3.96	–	–	95
Arrow	1971	3.83	–	–	93
Ticonderoga	1973	4.37	–	–	85

* In the case of Indian varieties the decade of release has been indicated.

Adapted from Jain (1986).

created Agricultural Research Councils or National Research Institutes, which are managed mostly by the scientists themselves. Thus, in many of the Asian countries, the national agricultural research systems have been built in recent years around Councils which enjoy considerable autonomy in their operations and management of resources. In the Latin American countries, National Institutes have been set up which have taken over the functions which earlier rested with the Department of Agriculture. The basic concept in creating these new bodies for the management of agricultural research has been to combine commitment to development with a great deal of autonomy in the organization and management of research. The new Councils and the National Institutes, through their newly developed production technologies, must respond fully to the development needs of the government and the farmers, but at the same time they are not tied to the bureaucratic procedures of a government department, which could stifle the creative work of their scientists.

The reorganized research services have helped to bring about major changes in the management of scientific programs and resources, budgeting procedures and operations, personnel policies, linkages with extension and other development departments, linkage with policy makers and planners in the government, and coordination of research at the national and regional level. The head of the research service in most cases is a scientist with a better understanding of the research programs and the support they need in terms of trained manpower and other resources. In many cases, the head of the research service reports directly to the Minister of Agriculture or the Permanent Secretary, depending on the size of the country. In the larger Asian and Latin American countries, the concept has been that the head of the research service should have the necessary status to be able to communicate with the Minister of Agriculture so that the service is able to reach the policy-making level and influence it. On the other hand, the head of the research service must interpret the agricultural development goals of the government and translate them into research priorities, programs and projects consistent with those goals. Simultaneously, the research service should be able to provide an important input in the making of the development policy based on its understanding of the country's production potentials as determined by its agroecological, biological, edaphic and other resources.

Table 2

Investments in Agricultural Research in the Public Sector in Different Regions of the World

Region/sub-Region	Expenditure ($m of 1980)			Scientist Person-Years		
	1959	1968-1971	1980	1959	1968-1971	1986
W. Africa	44	92	206	412	952	2,466
E. Africa	13	49	75	221	684	1,632
S. Africa (excl. RSA)	2	6	17	146	191	299
W. Asia (excl. Israel)	13	52	95	287	1,223	1,699
S. Asia	32	73	191	1,433	2,569	5,691
S.E. Asia	9	37	103	441	1,692	4,102
E. Asia (excl. China, Japan)	6	24	50	637	1,120	1,591
China	54	502	644	1,250	12,250	17,272
N. Africa	21	50	62	590	1,122	2,340
Temp. S. America	31	57	80	364	1,022	1,527
Trop. S. America	35	129	269	570	2,698	4,840
Cent. America, Caribbean	14	30	113	491	1,160	2,167
N. Europe	95	230	410	1,818	4,409	8,027
E. Europe (excl. USSR)	196	436	553	5,701	16,009	20,220
Japan	135	498	684	7,200	12,600	15,671
N. America	669	1,221	1,336	6,690	8,575	10,305

Original source: Judd, Boyce & Evenson 1983; Adapted from Lipton (1985).

Increasing Investments in Research. The reorganization and strengthening of agricultural research in many developing countries has also seen a massive increase in investments. India, for example, with its 43 federal institutes and 26 state universities, has developed during the last 20 years one of the world's largest networks of experimental stations. The research system, employing nearly 20,000 scientists in the state and federal institutions, has set up a large number of coordinated research programs which bring together researchers from these institutions for work around major commodities and factors of production. Most other developing countries have also invested heavily in agricultural research during the last 20 years. This can be seen from Table 2, which gives estimates of investment of funds and scientific manpower in public-supported research in different parts of the world over a 21-year period from 1959 to 1980.

New Agro-Service Infrastructure. The strenghtening of agricultural research has been associated in many cases with the creation of a new infrastructure of agro-services, which are helping the farmers in the adoption of the new technology. Most developing countries do not have a well developed agri-business sector which could respond to the needs of the farmers. This gap is being filled in the short term through the creation of institutions, which would provide to the farmers a wide range of services, including the supply and distribution of various modern farm inputs, credit, marketing facilities, and above all, price support. In many cases, it was the demonstration on farmers' fields of the vastly increased production potential of the new technology which motivated the governments to take policy decisions for the creation of this new institutional framework. A good example is provided by India, which in the last 20 years has become the fourth largest consumer and producer of fertilizer nitrogen in the world. Also, India has made massive investments in the development of irrigation, with the result that it now has the second largest irrigation system in the world.

Impact of the New Technology

There are not many studies which bring out through a critical analysis the contributions which the new policies and investments in agricultural research have made in the form of increased production. However, the few studies of this kind which have been made clearly show that investments in agricultural research have been very rewarding. Perhaps the most comprehensive analysis of this kind has been made by Ruttan (1982) who studied agricultural research productivity in 23 developing countries. Ruttan observed an average annual rate of return of 55 per cent on investments. The studies covered research on food crops, livestock and commercial crops such as cotton and rubber. Few investments in scientific research give greater returns and it is clear that the process of strengthening of agricultural research services must continue for realizing the full production potential of agriculture in the developing countries. Some of the advances in agricultural production in recent years have been so spectacular that terms like

'green revolution' and 'quantum leap' in productivity have been used to describe these developments. Thus, Indonesia over a 15-year period more than doubled its rice production. Bangladesh, which at the time of its independence in the early 1970s experienced massive food deficits, is now close to self-sufficiency with record harvests of both wheat and rice in recent years.

Tables 3-7 and Figures 1 and 2 document some of the increases in agricultural production in a number of countries of Asia where the new agricultural technology has made significant impact. A recent report by FAO scientists shows that the growth rates of cereal production and yield have been higher in Asia and the Pacific region than in the rest of the world in recent years. The analysis presented by Tsutsui & Singh (1985) particularly refers to increased production of wheat and rice and coarse grains in these countries, as shown in Table 8. A large part of this increased production has been contributed by increased yields per unit of land (Table 9).

The Latin American countries have also recorded impressive gains in their agricultural production following the reorganization of their research services. This can be seen from Table 10, which shows the annual growth rates for production, area and yield for a large number of commodities. An exception to this general situation is provided by many countries of Sub-Saharan Africa, where with few exceptions production has tended to decline in recent years (Table 11).

Sub-Saharan Countries and Potential of Agricultural Research

The deteriorating food situation in many of the Sub-Saharan African countries has raised questions with regard to the role of agricultural research in that part of the developing world. In the wake of the 1984-1985 drought many reports were published, not all of which conveyed a balanced assessment of the situation. Thus, an impression seems to have been created in the minds of some people that Africa is all dry and its soils mostly unproductive so that research faces a more difficult challenge in that continent. While this may be true in the long term, there are gains to be made through research in Africa in the near future. The noted Kenyan entomologist Odhiambo (1984), for example, believes that the green revolution technology may not be very relevant to the small farmers' situation of the African countries. Odhiambo pleads for a new location-specific technology for resource-poor farmers who could harvest predictable yields from the same piece of land year after year. On the other hand, some scientists like Hugh Doggett (1984) who spent 26 years on agricultural research in East Africa, states that the answer to advancing agriculture in Africa lies in making it possible for the small farmer to produce more, and he will do so, if he finds it profitable to use modern farm inputs and new technology. According to him prices are a key issue: attractive, consistent farm-gate prices which would help bring about the increased production needed.

Table 3

Rice in Indonesia: Area, Production, Yield and per capita Availability

	Area harvested (ha)	Milled Rice Production (million t)	Yield (t/ha)	Per capita Availability (kg/pers./year)
1968	8.02	11.67	1.46	103.83
1969	8.01	12.25	1.53	106.61
1970	8.14	13.14	1.61	111.83
1971	8.33	13.72	1.65	114.24
1972	7.90	13.18	1.67	107.07
1973	8.40	14.61	1.74	115.86
1974	8.51	15.28	1.80	118.36
1975	8.50	15.19	1.79	114.99
1976	8.37	15.85	1.89	117.23
1977	8.36	15.88	1.90	114.82
1978	8.93	17.52	1.96	124.17
1979	8.80	17.90	2.03	124.39
1980	9.00	20.16	2.24	136.68
1981	9.38	22.29	2.38	147.71
1982	8.98	22.84	2.54	147.83
1983	8.94	23.46	2.62	148.39

Based on Affandi (1985).

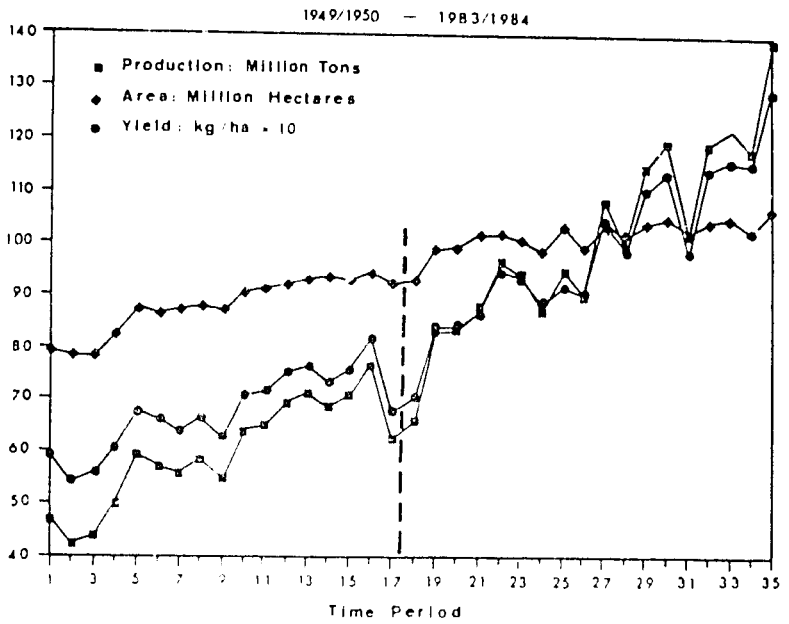

Fig. 1. - Production, area and yield of total cereals in India over the two time periods. The broken line separates the pre-high-yielding-varieties period of 18 years from the high yielding period of 17 years starting from 1967-1968.

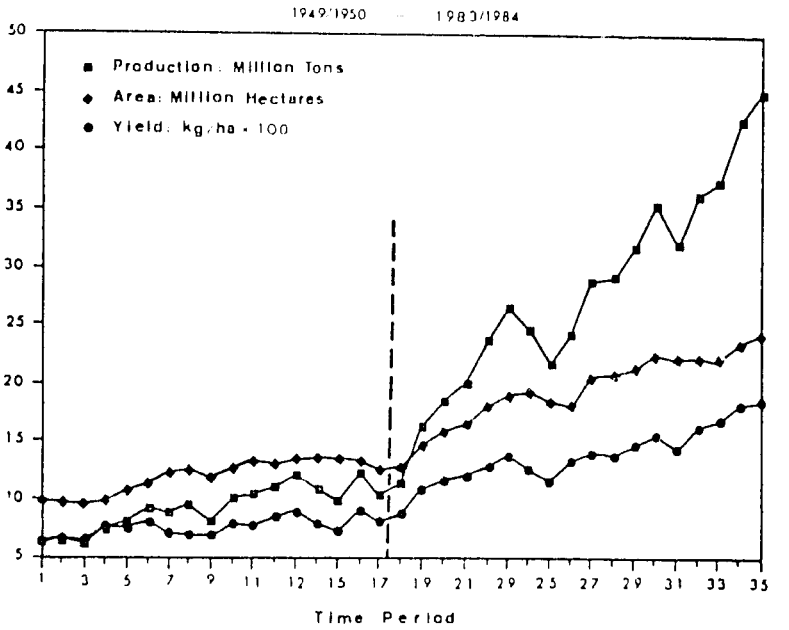

Fig. 2. - Production, area and yield of wheat in India over the pre- and post-high-yielding-varieties period.

Table 4

Rice in the Philippines: Area, Production and Yield per Hectare, Including the Proportion of High-Yielding Varieties

	1967-1968	1969-1970	1974-1975	1975-1976	1976-1977	1977-1978	1978-1979	1979-1980	1980-1981
				Thousand Hectares					
Area									
Total rice area harvested	3304	3113	3539	3579	3548	3509	2512	2709	2679
Proportion to HYV (%)	21.2	43.5	61.5	64.5	68.1	70.0	72.4	74.5	77.4
				Thousand Metric Tons					
Production									
Total rice production	4561	5233	5660	6160	6456	6895	7515	7836	7723
HYV	1212	2566	3989	4446	4956	5502	5882	6249	6742
Proportion of HYV (%)	26.6	49.0	70.5	72.2	76.8	79.8	78.3	79.7	87.3
				Kilograms per hectare					
Yield/Hectare									
All rice	1381	1681	1599	1514	1602	1729	2110	2155	2233
HYV	3275	3643	3652	3824	4055	4395	4640	4750	4970
Other varieties	2853	3413	3058	3322	3270	3165	3540	3600	3600
HYV toTV (%)	1.15	1.07	1.19	1.15	1.24	1.39	1.31	1.32	1,38

Source: Crop Statistics, Bureau of Agricultural Economics, Government of the Philippines.

Table 5

Increase in the Production (metric tons) of Some Major Crops in Malaysia from 1965 to 1983

	1965	1970	1975	1980	1983
Rubber	931,611	1,289,663	1,482,678	1,554,477	1,604,179
Oil Palm	152 818	430,784	1,296,416	2,617,079	3,065,918
Palm Kernel	34 544	91,000	252,000	247,500	403,700
Cocoa	n.a.	2,300	13,000	31,700	65,000
Rice	1,031,382	1,429,000	1,716,700	2,052,900	1,818,100
Tobacco	n.a.	8,199	21,128	24,914	24,144

Source: Hakim (1985).

Table 6

Increase in the Yield (metric tons) of Some of the Important Food Crops in South Korea (1962-1983)

	1962	1970	1975	1983
Rice	2.65	3.27	3.86	4.42
Barley	1.66	2.18	2.39	2.69
Soybean	0.54	0.79	1.13	1.24
Corn	0.68	1.45	1.72	3.66
Potato	1.69	2.26	2.56	3.10

Source: Kim (1985).

Table 7

Crop Production Planning and its Impact in Pakistan, over a Five-Year period (in million metric tons)

Crops	1977-1978	1981-1982	1982-1983	% Change Col. 4/Col. 2
1	2	3	4	5
Food Grains	12.86	16.32	17.47	(+) 36
Rice	2.95	3.43	3.45	(+) 17
Wheat	8.37	11.30	12.41	(+) 48
Maize	0.82	0.3	1.01	(+) 23
Others	0.72	0.66	0.60	(-) 7
Cash Crops	30.66	37.33	33.35	(+) 9
Oil Seeds	1.50	1.85	2.08	(+) 39
Pulses	0.81	0.49	0.69	(-) 15
Vegetables and Spices	1.21	2.72	2.98	(+) 35
Fruit	2.09	2.94	3.17	(+) 52

Based on Crop Statistics of Pakistan, 1985, Government of Pakistan, Islamabad.

Table 8

Growth Rates of Production, Yield and Area of Cereals and Some Important Foodgrains in the Asia-Pacific Region and the Rest of the World, 1974-1984

Geographic Entity	Average Annual Growth Rate			
	Cereal 1974-1984	Coarse Grain 1974-1984	Rice Paddy 1974-1984	Wheat 1974-1984
Production *				
Asia-Pacific Region (1)	3.8	2.9	3.2	6.7
Rest of World	1.7	1.4	1.8	2.2
World	2.5	1.7	3.1	3.4
Yield **				
Asia-Pacific Region	3.3	3.3	2.9	4.5
Rest of World	1.7	1.3	1.0	2.5
World	2.3	1.7	2.7	3.0
Area ***				
Asia-Pacific Region	0.5	- 0.3	0.3	2.1
Rest of World	0.0	0.1	0.8	- 0.3
World	0.2	0.0	0.3	0.4

* million tons
** kilograms per hectare
*** million hectares

(1) 27 countries including the 3 developed countries (Australia, Japan and New Zealand). These 3 countries collectively recorded a growth of 1.8% for cereal production compared to 3.8% for the region as a whole.

Table 9

Contributions of Yield and Area Increases to Cereal Production Growth in Asia-Pacific, 1963-1984

Period	Production	Yield		Cropped Area	
	Average Annual Growth Rate	Average Annual Rate of Increase	Percentage Contribution to Growth Rate of Cereal Production	Average Annual Rate of Increase	Percentage Contribution to Growth Rate of Cereal Production
1963-1973	2.8%	1.8%	64	1.0%	36
1974-1984	3.8%	3.3%	87	0.5%	13
1981-1984	6.5%	5.1%	81	1.2%	19

Table 10

Latin America: Annual Growth Rates of Production, Area and Average Yields of Important Crop Commodities (1969-1971 to 1978-1980)

Crop	Volume Produced	Harvested Area	Yield per Hectare
Cereals	2.4	0.7	1.6
Wheat	2.6	1.5	1.1
Rice	3.4	2.1	1.2
Maize	1.3	- 0.1	1.4
Soybean	5.5	2.6	2.8
Roots and Tubers	- 0.7	0.3	- 1.0
Potatoes	1.4	- 0.3	1.7
Cassava	- 1.1	0.7	- 1.8
Sugar Cane	3.5	2.3	1.1
Dry Legumes	0.7	1.1	- 0.5
Beans	0.5	1.3	- 0.7
Oil Seeds	14.2	11.1	2.8
Soybean	25.9	23.6	1.9
Vegetables	3.2	2.1	1.1
Fruits	3.5	0.3	3.2
Bananas	1.9	0.3	1.3
Citrus Fruits	7.5	–	–
Apples	7.1	–	–
Beverages and Tobacco	2.5	0.9	1.6
Cocoa	4.2	0.5	3.6
Coffee	1.9	0.8	1.0
Tobacco	4.1	2.3	1.7
Cotton	1.4	0.5	0.9
Vegetable Fibres	- 1.4	- 0.2	- 1.2
Other Crops	5.0	4.0	1.0
TOTAL CROPS	3.1	1.7	1.4

Source: Valdés & de R. Eugenia Muhnik (1985).

Table 11

Average Agricultural Sector Performance, Countries in Sub-Saharan Africa (1970-1981)

Country	Value of Agricultural Output : per capita Change 1970-1981 (%) (a)	Total Value of Agricultural Change 1970-1981 (%) (b)	Food Nutrients per-capita Change 1970-1981 (%) (c)	Total Food Nutrients Change 1970-1981 (%) (d)	Rank Order by Change in Food (%) (%) (e)	Per capita Dietary Energy + Nutritional Satisfaction (1978-1980) (f)	Value added per-capita in Agriculture in 1970 (1975 US $) (g)
(a) Countries with Rising Agricultural Productivity							
Ivory Coast	+ 16	+ 71	+ 13	+ 76	1	114	164
Rwanda	+ 7	+ 48	+ 5	+ 45	4	95	74
Benin	+ 7	+ 47	+ 8	+ 49	3	100	55
Zimbabwe	+ 6	+ 34	+ 11	+ 61	2	80	70
Burundi	+ 1	+ 26	0	+ 24	7	92	68
Cameroon	+ 1	+ 28	+ 2	+ 30	6	106	107
(b) Countries with Falling Agricultural Productivity							
Ethiopia	- 2	+ 7	- 16	+ 7	23	74	44
Burkina Faso	- 2	- 2	- 3	+ 27	8	85	40
Zambia	- 5	+ 16	- 4	+ 35	9	95	65
Kenya	6	+ 43	- 14	+ 31	20	89	62
Mali	- 7	+ 23	- 10	+ 20	13	85	48
Madagascar	- 7	+ 23	- 8	+ 22	11	107	101
Nigeria	- 9	+ 28	- 9	+ 29	12	99	160
Chad	- 9	+ 14	- 5	+ 18	10	76	67
Guinea	- 10	+ 18	- 10	+ 18	13	84	112
Sudan	- 12	+ 18	+ 4	+ 39	5	101	101
Togo	- 12	+ 19	- 11	+ 19	16	92	71
Tanzania	- 14	+ 20	- 11	+ 24	16	87	63
Zaire	- 14	+ 29	- 13	+ 17	19	96	18
Niger	- 14	+ 17	- 14	+ 18	20	92	109
Liberia	- 15	+ 24	- 12	+ 28	18	98	101
Ghana	- 15	0	- 28	0	27	88	264
Congo	- 16	+ 10	- 17	+ 9	24	99	77
Lesotho	- 16	+ 9	- 10	+ 16	13	107	32
Mauritania	- 22	+ 6	- 22	+ 6	25	89	93
Sierra Leone	- 23	+ 2	- 23	+ 3	26	92	71
Uganda	- 30	- 2	- 15	+ 18	22	80	195
Somalia	- 39	+ 7	- 39	+ 7	28	92	128

Source: Belshaw (1984), based on:
(a) FAO 1982, Production Year-Book 81; (b) *Ibid.*, 77; (c) *Ibid.*, 79; (d) *Ibid.*, 75; (e) Ranked according to change in food availability per-capita, 1970-1981; (f) FAO 1981, The State of Food and Agriculture, table 16; (g) FAO 1982, Production Year-Book, and World Bank 1983, World Development Report, Washington DC.

Assessment of Production Potential. A more balanced assessment of the production potential of Sub-Saharan Africa has been given by a group of FAO scientists (Kassam *et al.* 1984), on the basis of their project, which analysed the limits of food production as set out by soil and climatic conditions and by use and management of land. The FAO analysis leads to a number of important conclusions. The analysis shows a highly variable situation with 29.4 per cent of the African region showing dry desert conditions, and another 16 percent providing growing periods too short to be of much use. However, as much as 53.3 per cent of the land is climatically suitable for rainfed cereal production, with 19 per cent having shorter periods, 33.6 per cent having long periods and 0.7 per cent having year-round growing periods. At the country level, the analysis shows that those located mainly in the long-length period growing zones generally have the highest potential, while those in the drier areas have the least, and reflect the restrictive nature of the climate for rainfed production. Above all, the FAO analysis shows that improved technology of agricultural production has a key role in meeting the critical food needs of the African people and that the new agricultural technology is needed, both for rainfed agriculture as well as for production under more favourable conditions, which do occur in fairly large areas of land.

Strategy for Scientific Transformation of Agriculture in Africa

Many planners and policy makers, daunted by Africa's poorly understood agroecological situation, the predominance of traditional farming systems, the absence of highly evolved research and extension services and, in many cases, the absence of an integrated policy framework for agricultural development, have come to conclude that much of the increase in food production in the short and medium term must come from intermediate technologies and incremental yield increases. For many of them, the high-yield technology of the kind which has made so much impact in Asia and Latin America may not be relevant to African conditions. This would be a wrong approach to the food problems of Africa. As the FAO analysis clearly shows, lands with adequate growing periods and favourable conditions for crop growth can be found in most African countries. *We need to understand that the difference between Africa and Asia is a quantitative one and not a qualitative one.* It is not true that the African situation is basically different. The difference lies in the fact that there are more dry lands of limited productivity in Africa compared to the other continents.

Motivation for Change. Also, if a major program of modernization of agriculture is to be organized for Africa, it will be necessary to impress the policy makers and farmers about the potential of the new agricultural technology. This could not be done with a technology which promises only small and slow improvements. The motivation for investment in research will come more readily when the technology is seen to be vastly superior in its production potential. A technology of this kind could become a catalyst for major policy changes, leading to integrated programs of agricultural development, with research forming a key component of such programs. The foremost task, therefore, is to develop and extend in the more favourable areas the high-yield technology which exists in crops like wheat, rice, maize, sorghum and millet and which with major investments in adaptive research under local conditions could be transferred successfully to the African countries. The adaptive research will call for not only a massive program of testing and evaluation, but also for modifications based on breeding work under local conditions.

The Long-Term Approach. It is not widely recognized that the African countries in the last 20 years have made massive investments in agricultural research, as we saw in Table 2, and they do have scientific resources which could be utilized more effectively and more efficiently for short-term gains. None of this, however, would address the task of evolving a new kind of production technology for the stress environments. This must remain a most important goal of research, and in the long term, this new technology should help to provide a more complete answer to the problems of agricultural production in the African countries, and indeed, in many other parts of the developing world. While stressing the gains of the green revolution, we often fail to highlight the fact that even in South and South East Asia and in Latin America a very large part of the farming community located in unfavourable agro-ecological conditions has failed to gain from the new technology. In the long term, scientific leadership for this new kind of technology must be provided by the agronomists and soil scientists working in close collaboration with the breeders and the crop protection scientists. The emphasis in evolving this new technology will be on a multidisciplinary approach, with leadership resting mainly with the agronomists and soil scientists. The breeders, of course, will have an important role, but their task will be greatly facilitated by improved water and soil management practices.

If agricultural research has not made the same kind of impact on food production in the Sub-Saharan countries as it has done in many developing countries in other parts of the world, the answer must be seen not only in the more difficult agroecological situations, but also in the fact that many of these countries have yet to reorganize their research systems so as to give them the strenght to respond to the new challenge.

Consolidation of Resources. The African countries do recognize the role of research and, indeed, as Michael Lipton has pointed out, many of them have heavily invested in such research so that their expenditure in relative terms is greater than in South Asia, South East Asia and some of the other groups of developing countries. Lipton's answer to this apparent contradiction is that productivity of scientists in Sub-Saharan Africa appears to be lower than that of their counterparts in Asia and Latin America. This may be partly due to the fact that a large part of agricultural research in Africa may lack a sharp focus on development and the research services do not make effective use of their human and other resources

because of problems of management and organization. The emphsis will have to be on consolidation of scarce scientific resources to address priority problems of production rather than the creation of a large network of experimental stations following the classical model. Consolidation of the research station network, consolidation at the program level and greater focus on priorities are some of the key issues in research management in Sub-Saharan Africa. So also is the development of scientific manpower and development of linkages with the extension services and the farmers.

ISNAR's Collaboration with Sub-Saharan Africa

Some of these issues in research management have been addressed in recent years in a number of African countries in collaboration with the International Service for National Agricultural Research (ISNAR) and with organizations like the FAO. ISNAR, which was created by the Consultative Group for International Agricultural Research (CGIAR) in 1980 for the specific purpose of strengthening national agricultural research systems in the developing countries, has, as a matter of policy, placed greater emphasis on its collaborative work with the policy makers, planners and scientists in the African countries. ISNAR works in a variety of ways to strengthen the national research systems in Africa. In addition to their extensive collaboration in Kenya, ISNAR staff have worked in seven other African countries. The following brief account gives some idea of the nature of these collaborative activities.

In Cameroon, a report on the improvement of agricultural research management was presented to the Ministry of Higher Education and Scientific Research, which resulted in a request to organize a series of training and management seminars for their scientists and administrative staff. The first of these seminars was held at the Agricultural Research Centre of Nkolbisson with the participation of 37 staff members. ISNAR has now been requested by the Government of Cameroon to undertake a major review of this national research system. ISNAR participated in a joint mission with the World Bank and FAO Investment Centre in Rome to explore in the Ivory Coast how the present research efforts could be strenghtened and coordinated more effectively to achieve food self-sufficiency. This was a follow-up mission on the earlier work of ISNAR in cooperation with the Ivorian Ministry of Scientific Research. In Madagascar, where an ISNAR Mission worked in 1982, attention was focussed on the suggested reorganization and on research planning and programming. ISNAR made a major contribution in the preparation of a national research plan, and provided the services of a staff person for at least two years to work in agricultural research programming and evaluation, with funding from a World Bank loan, and to advise on agricultural research management. In Malawi, many of the recommendations made by ISNAR are being implemented and discussions have focussed on short-term training in specific areas of research management. In the coming months, ISNAR will be starting a major review of the national research systems of Ethiopia and Niger.

In Rwanda, ISNAR's review assisted in the development of a major World Bank/IDA-funded Agricultural Research Project. ISNAR staff took part in all project preparation discussion conducted by the Bank, and an ISNAR advisor is now in place there. In Somalia, ISNAR staff worked with scientists from four CG-Centres – IITA, CIMMYT, ILCA and ICRISAT – to define research programs in crops, livestock, and irrigation water management. In Sudan, following an indepth survey of training needs to improve the management of agricultural research, a joint ISNAR/ARC (Agricultural Research Cooperation of Sudan) workshop was held in Khartoum in 1985.

ISNAR assisted a Zaire task force consituted by the Executive Council of the country in designing the study methodology for an analysis of the country's agricultural research system. ISNAR continues to work with the four working groups set up for this purpose. In Zimbabwe, senior ISNAR staff participated in the annual review meeting of research and extension program in the Ministry of Agriculture. An additional involvement was the preparation of a medium-term training plan for the Department of Research and Specialist Services. Following these early contacts, ISNAR staff have worked with task forces of the Departement of Agricultural Research and Support Services in Zimbabwe in defining the mechanisms for priority setting, resource allocation and programming of research. An ISNAR team would soon carry out a review of the research system in Zimbabwe with a view to improving its institutional and management capacity.

Cooperative Acitivities. ISNAR's cooperative involvement with the African countries deepened in 1984 when it carried out a study of the integration of the activities of the IARC's in Southern Africa as part of the UNDP Study Project. The objective was to develop a plan for an integrated approach to the activities of the CG centres in the SADCC group of countries which include Angola, Botswana, Lesotho, Mozambique, Swaziland, Tanzania, Zambia and Zimbabwe - members of the Southern African Development Coordination Conference. Another example of this kind of cooperative involvement has been a program of management training organized for African agricultural research officials with the support of Cooperative Development for African Consortium (CDA). The program has included country-level studies in Zimbabwe, Sudan and Cameroon to identify training needs, development of training material for use in management and in seminars and support for such seminars at the regional and national levels. ISNAR organized these seminars in cooperation with a number of African institutions, including the Eastern and Southern African Management Institute (Tanzania), the Mananga Agricultural Management Institute (Swaziland), the Cameroonian Ministry of Higher Education and Scientific Research, the Rwandan Institute of Agricultural Sciences, and the Institut du Sahel in Mali. More than 150 agricultural research managers attended these seminars.

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