Assessment of National Plant Breeding and Biotechnology Capacity in Africa and Recommendations for Future Capacity Building

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The demands being placed on crop production are increasing, particularly in developing countries. In many instances, the rate of gain in crop yields has dropped while input costs (e.g., fertilizers) have undermined the potential benefits gained from introducing new varieties. This situation is particularly true in Africa. The challenge is to meet increased demands for food from a growing population by developing new varieties and improving agricultural production methods that are sustainable in the long term, with minimal negative consequences for the environment.

There is an opportunity to enhance agricultural production by applying the results of research to meet the demands for food security and environmental conservation. We believe that ensuring strong plant breeding programs in national agricultural research systems (NARS) will be essential in ensuring the sustainable use of plant genetic resources for the benefit of mankind.

Our first step was the assessment of the current state of 12 African plant breeding programs and trends in the allocation of resources within NARS. This has been the key to identifying gaps in order to develop strategies to strengthen sustainable use of Plant Genetic Resources for Food and Agriculture (PGRFA) in these programs.

The FAO of the United Nations, in collaboration with the Consultative Group on International Agricultural Research (CGIAR) centers and other stakeholders, is assessing plant breeding and related biotechnology country capacity, as set out in the Global Plan of Action (article 14) of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). As such, FAO is surveying country information and trends in resource allocation for plant breeding and biotechnology, with the aim of raising awareness and evaluating opportunities for investment. This is the first step towards designing national, regional and/or global strategies to strengthen the capacity of national plant breeding programs.

This report concentrates on 12 African countries. In this paper we 1) describe the survey mechanism used by FAO; 2) report on preliminary information gathered on 12 African countries; 3) summarize the recommendations made by an expert group which reviewed the preliminary information; 4) indicate the potential of the information available for planning breeding strategies; and 5) indicate how FAO views the road ahead.

THE SURVEY

In 2002, a draft questionnaire was designed to gather country information on resource allocation trends in plant breeding and biotechnology related activities. Later in the same year, a group of experts including representatives from CGIAR centers, the public and private sectors, and non-governmental organizations (NGOs), met at FAO, Rome, to discuss what information to obtain and what procedure to use. As a result, a questionnaire was developed. The first part of the survey focuses on organization type, the number of years in the business, and the number of full-time equivalent plant breeders and biotechnologists available on a 5-year basis for each 5-year period starting in 1985. The second part of the survey requests trend of plant breeding budgets again on a 5-year basis, the resource allocation per crop, and the resource allocation in germplasm improvement (prebreeding), line development, line evaluation, and in biotechnology. The survey also requests information on number of crosses, number of segregating populations, number of field trials and testing locations as well as the origin of the genetic resources used in the breeding programs. Finally, the survey concentrated on priority breeding environments, potential international support to strengthen national breeding programs, the number of varieties released, and the factors that are most likely to limit the success of plant breeding programs.

The work of gathering the information is assigned to a well-known and respected national plant scientist, preferably working in the area of plant breeding within each country. The survey is sent to all public and private plant breeding programs in the country. The scientist has the responsibility of not only gathering information but also preparing a technical report of the current national plant breeding status.

This paper provides information on 12 countries in eastern and southern Africa (Angola, Kenya, Malawi, Mozambique, Zambia, and Zimbabwe) and western Africa (Cameroon, Ghana, Mali, Niger, Nigeria, and Senegal) and preliminary assessments of needs and opportunities related to plant breeding to ultimately enhance agricultural productivity, food security, and poverty alleviation.

RESULTS OF THE AFRICAN SURVEY

Among the selected countries, Zimbabwe had the highest percentage increase in number of breeders and biotechnologists (205%), as it went from 20 in 1985 to 41 in 2001 (Table 1). This country was followed by Mozambique (from 10 to 28 breeders) and Senegal (from three to eight breeders). All other countries had increases smaller than 50%, except Angola and Malawi, where the number of breeders actually fell during that period. Even though percentage increases are useful indicators of trends, the numbers themselves are more informative in

Table 1. Number of plant breeders and biotechnologists in 1985 and 2001 in 12 African countries and their percentage change. In parentheses there are the numbers of biotechnologists in the respective countries in 2001.

Country	1985[z]	2001	Change (%)
Eastern and southern Africa			
Zimbabwe	20	41 (13)[y]	205
Mozambique	10	28 (1)	180
Kenya	39	52 (6)	33
Zambia	20	26 (0)	30
Angola	10	7 (2)	–30
Malawi	78	41 (0)	–47
Western Africa			
Senegal	3	8 (6)	167
Cameroon	27	38 (18)	41
Mali	30	40 (5)	33
Nigeria	42	55 (16)	31
Ghana	15	19 (17)	27
Niger	11	12 (0)	9

[z]No biotechnologists were present in 1985.
[y]Numbers outside parentheses are total numbers of breeders and numbers in parentheses are total numbers of bitoechnologists.

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that they reflect a country's capacity. For example, in 2001, the countries with the highest numbers of breeders were Nigeria with 55 and Kenya with 52 (Table 1).

The use of biotechnological tools did not appear to be an important component of the African countries' breeding strategies in 1985, as no biotechnologists were reported to be working in the selected countries. By 2001, however, the situation had changed dramatically. Among the 12 countries only three did not have any biotechnologists. In addition, countries including Cameroon, Ghana, Nigeria, and Zimbabwe had more than 10 (Table 2). Even though there are fewer reported biotechnologists working in the eastern and southern African countries than the ones in western Africa, we have evidence that the former region has more biotechnology research and related development currently underway. There are scientists working with tissue culture in the 12 African countries. This technique has been used in cassava, banana, pineapple, yams, sweet potato, and oil palm. Tools such as marker-assisted selection (MAS) and genetic engineering are limited to a few countries; only in Kenya, Nigeria, and Zimbabwe was there use of both technologies indicated. Cameroon, Ghana, and Niger indicated that MAS is being used on cassava and cowpea. Survey results from Nigeria imply that, at some level, genetic engineering is been applied in cassava, banana, and date palm (Table 2). In all cases, however, the impact of biotechnology tools has never been measured.

The educational level of African plant breeders has improved since 1985. Comparing the percentages of scientists with BS degrees across years, there was actually a decrease in almost all countries, except for Zambia, Malawi, Senegal, and Niger. The reason for this change is that scientists have pursued higher level degrees (Table 3). Overall, the number of breeders generally increased, except in Angola and Malawi. Only in Kenya, Senegal, Nigeria, and Ghana has the number of plant breeders with MS and PhD degrees increased dramatically, while in Angola and Mozambique there are more breeders with only BS degrees.

Only a limited number of crops are being widely bred across Africa (Table 4). Maize is the most common of these, followed by roots and tubers, and grain legumes. Other crops receiving country-wide attention include vegetables and fruits (Kenya, Malawi, Nigeria, and Senegal), sorghum and millet (Kenya, Mali, and Zambia), and fibers (Cameroon, Mali, and Zimbabwe).

Table 2. Biotechnology applications in use in 12 African countries in 2001. Data included information collected in the survey and FAO-BioDeC database (http://www.fao.org/biotech/inventory_admin/dep/default.asp). TC = tissue culture, MAS = marker-assisted selection, and GE = genetic engineering.

Country	TC	MAS	GE
Eastern and southern Africa			
Zimbabwe	Yes	Yes	Yes
Mozambique	Yes	No	No
Kenya	Yes	Yes	Yes
Zambia	Yes	No	No
Angola	Yes	No	No
Malawi	Yes	No	No
Western Africa			
Senegal	Yes	No	No
Cameroon	Yes	Yes	No
Mali	Yes	No	No
Nigeria	Yes	Yes	Yes
Ghana	Yes	Yes	No
Niger	Yes	Yes	No

Table 3. Educational level (%) of plant breeders in 1985 and 2001 in 12 African countries.

	Education level (%)					
	BSc		MSc		PhD	
Country	1985	2001	1985	2001	1985	2001
Eastern and southern Africa						
Zimbabwe	75	44	25	50	0	6
Mozambique	80	54	0	29	20	17
Kenya	50	13	40	48	10	38
Zambia	45	47	40	42	15	11
Angola	80	72	20	0	0	28
Malawi	26	29	45	4	29	27
Western Africa						
Senegal	0	25	100	25	0	50
Cameroon	37	34	37	32	26	24
Mali	47	31	33	42	20	27
Nigeria	55	7	38	38	7	55
Ghana	33	5	40	37	27	58
Niger	18	34	82	25	0	41

Table 4. Crops with the largest number of full-time equivalent breeders working in 12 African countries in 2001.

Country (no.)[z]	Maize	Roots and tubers	Grain legume	Other[y]
Eastern and southern Africa				
Zimbabwe (41)	14.4	0.0	0.0	26.6
Mozambique (28)	8.7	8.7	5.6	5.0
Kenya (52)	18.9	2.1	11.0	20.0
Zambia (26)	9.3	2.4	0.8	13.5
Angola (7)	2.5	1.4	1.4	1.7
Malawi (41)	8.2	5.7	2.1	25.0
Western Africa				
Senegal (8)	1.0	0.5	1.3	5.2
Cameroon (38)	4.4	6.2	0.3	25.1
Mali (40)	0.8	1.4	0.3	37.5
Nigeria (55)	12.0	5.0	1.2	36.8
Ghana (19)	1.7	4.8	1.8	10.7

[z]Numbers in parentheses represent full-time equivalent breeders.

[y]Vegetables and fruits: Kenya (3.5); Senegal (4.3), Malawi (6.5), and Nigeria (10.2). Sorghum and millet are important in Zambia (3.0), Kenya (5.0), and Mali (17.4). Fiber crops: Zimbabwe (4.0), Cameroon (5.0), and Mali (9.6).

RECOMMENDATIONS FOR FUTURE PLANT BREEDING CAPACITY BUILDING

The results of this survey were presented to a group of experts who attended a workshop organized by FAO in February 2005. The African report was presented as an example of the current state of breeding capacity in one region of the world, although the panel's brief was global. The aim was to bring together participants from many regions, representing a variety of backgrounds and possessing the necessary expertise to discuss the problem of the decline support in plant breeding and suggest how this might be solved. After three days of discussions, the group came up with the following recommendations for FAO, NARS, donors, CGIAR centers, and policymakers:

FAO

- Increase awareness among all stakeholders of the strategic importance of sustainable crop improvement through plant breeding.
- Encourage all stakeholders in plant breeding, in both developing and developed countries, to increase the awareness of its value and impact and apply appropriate biotechnology to development.
- Take note of the momentum that has been created through the Convention on Biological Diversity, the ITPGRFA and the Global Crop Diversity Trust, and establish, in a systematic manner, a platform for strategic thinking for future development of sustainable use of PGRFA, which would necessarily include plant breeding and the application of biotechnology.
- Consider establishing a fund to support sustainable plant breeding, including genetic enhancement, for crops that have not received the due attention of plant breed-