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Plant breeding and food security: Targeting the needs of resource-poor farmers in plant breeding programs for marginal areas

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Introduction

The current understanding of food and nutrition security is the result of a longer term process (CFS, 2012). Since the world food summit in 1996, the following definition of food security has been used widely:

"Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." (FAO, 2002)

Accordingly, aid organizations use a framework for food security assessments, which strongly relates to this definition. It rests on the three pillars of food security[1]: Availability, access and utilization. Availability of food mainly refers to quantitative aspects, such as sufficient agricultural production, based on the resources available and the environment. Access to food entails economic and social means which allow people to buy or barter for adequate food. It is a question of individual people's means or "entitlements" to get food, but besides this, also requires appropriate functioning of agricultural and food markets. Quality aspects, such as preparing meals with adequate nutritional value or proper storage and preparation of food, including basic knowledge on nutritional requirements (i.e. for children) and food hygiene, are summarized under "utilization".

In recent years, awareness has been growing that food alone is not sufficient to secure a satisfactory nutritional and health status. The term food security should thus be used with a clear understanding of what it means, its limitations, and how it interacts with behavior and non-food factors (Gross et al., 2000; Pinstrup-Andersen, 2009). These discussions led to a further expansion of the aforementioned food security definition to a concept called food and nutrition security (CFS, 2012). It builds a bridge to the non-food aspects of nutrition and health, such as drinking water, sanitation, health services and care.

Resource-poor farmers and poor people living in marginal areas are among the most vulnerable groups affected by food insecurity. In the past, most conventional plant breeding programs were based on the assumption that varieties that are successful under favorable conditions would also bring advantages to farmers in the less favorable areas. However, it is now increasingly recognized that agricultural research needs to be more specifically targeted, and that poor farmers working under marginal conditions do not "automatically" profit from breeding work done under

[1] http://www.fantaproject.org/focus/foodsecurity.shtml, accessed October 19, 2012

more favorable conditions. Rather, plant breeding for marginal environments requires that the specific set of conditions which is typical for such environments will be addressed (Bellon, 2006).

The aim of our study was to assess the potential of decentralized, participatory plant breeding approaches (PPB) to respond to this challenge and to document evidence how PPB projects contribute to various aspects of food security, giving special consideration to rural people in marginal areas. These findings should then result in initial conclusions with regard to the future orientation of plant breeding programs that target the needs of resource-poor farmers.

Material and Methods

The food security framework resting on the three conditions of availability, access and utilization formed the basis for our assessment. We searched for evidence how each of these three aspects had been addressed by PPB programs. For this purpose, written documents such as published literature as well as project reports were evaluated for proven or potential contributions of PPB programs to food security. We present examples for such contributions in this paper.

Results and Discussion

PPB and availability of food

Higher yields and improved yield stability form an important part of PPB strategies for marginal areas. In one of the first PPB projects to be published in a scientific journal, Sperling et al. (1993) showed that female farmers in Rwanda were able to realize an average yield increase of 38% by selecting for breeding lines of beans in their own fields. They were not even selecting directly for yield but for other characteristics associated with adaptation to their cultivation system and environment. Christinck et al. (2000) established that farmers in Rajasthan, India, associate specific morphological traits in pearl millet with drought tolerance. Through consistent observation of these traits in the breeders' own selections, populations emerged within a few years combining the good yield potential of the modern varieties in "good years" with yield stability under drought conditions (vom Brocke et al., 2003). In Uganda, three varieties of sweet potatoes came out within a few years of PPB work that delivered, at various sites in Uganda and in Tanzania, as high or higher yields than the existing varieties. These PPB varieties were also tested for other characteristics such as resistance against disease and harmful insects. In some cases, yields were double that of the existing local varieties, with one PPB variety 26% above the trial average (Mwanga et al., 2009).

Aside from higher yields, the length of the hungry season can be substantially shortened. A study from Honduras by Classen et al. (2008) claims that a considerable shortening of the hungry season could be attained, from an average of just under six weeks down to an average of less than two weeks. The longest hungry period among the program participants was eight weeks, compared to twenty weeks reported by non-participants.

PPB and access to food

Poor farmers usually have direct access to food grown on their own farm. However, they may also need to purchase food, depending on the season and the amount of food harvested from their land. PPB programs can help to increase poor farmers' access to food by developing varieties that allow farmers to generate a higher income i.e. by improving marketing possibilities. In Latin America, the work of the CIAL[2] committees has led to the release of multiple varieties of beans and other species which command better prices at the market owing to their special coloring[3]. Yet an interesting concept that has not been fully exploited is the development of improved varieties

[2] Comité de Investigación Agricola Local (CIAL); a network of local initiatives for participatory development and assessment of technologies, such as varieties.

[3] http://programafpma.com, accessed October 19, 2012

for industrial processing that would open up new sources of income for the farmers as well as other population groups. Examples can be found in the work of LI-Bird in Nepal, where a sector for non-traditional products such as biscuits and pasta has emerged from local and PPB varieties[4]. There are also instances of processing criteria being included in PPB projects to produce chips or baby food from potatoes or sweet potatoes (Grüneberg et al. 2009). Such approaches could be very interesting for farmers in marginal regions, although actual studies on the income effect of such projects are still to be published.

Another issue that affects the income of poor farmers and thus their ability to purchase additional foodstuffs is cost-cutting for agricultural inputs, such as pesticides, fertilizer and seed. An example of this is provided by a study from the Philippines. MASIPAG is a network made up of farmers, scientists and NGOs that has improved the living conditions of the rural population through the spread of organic farming practices and a wide range of PPB training activities. An impact study examining the rice yields from organic-run farms, farms converting to organic practices, and conventional farms, found no significant differences in yield. This means that the organically run farms can attain the same yields without the usual inputs, which is attributable to PPB varieties, among other factors (Bachmann et al., 2009). Net income per hectare was for the organically operated farms one and half times higher than for the conventionally run farms.

Seed occupies a unique position among agricultural inputs, for it being the foundation of all food production. Informal and local seed systems are vitally important to access seed, particularly for poor farmers. Studies from Mozambique and Mali show that the majority of all seed transactions there take the form of gifts. When seed is paid for, the price is generally in the range of normal grain prices or below (Rohrbach & Kiala, 2007, Siart 2008), a practice that can be found in many other regions as well. Hence, the potentials of PPB for improving access to food are not restricted to improving individual traits, but also by securing access to seed for vulnerable groups.

PPB and food utilization

Grüneberg et al. (2009) describe decentralized PPB approaches for diverse tropical tubers, including cassava, potatoes, sweet potatoes, yam, and taro. These plants show considerable genetic variability, particularly in their levels of iron, vitamin A, zinc and carotene. A deficiency in any of these substances is associated with malnutrition or hidden hunger. Regional preferences for such tubers differ widely and are based on appearance (color), as well as cooking and processing qualities for the various regional dishes. The involvement of farmers and consumers in the early stages of the breeding program when variability of the material is still high is described as a way of avoiding false selection decisions that can result in a variety being rejected in spite of having nutritional advantages.

Independent of the development of new varieties, PPB has a role to play in the conservation and transmission of local knowledge relating to nutrition. Detailed descriptions of existing or known varieties with special purposes, including dietary and medicinal characteristics and suitability for particular food preparations, are often compiled during PPB programs. PPB activities thus tend toward increasing appreciation of food diversity, particularly when projects are effectively linked to agrobiodiversity conservation and management issues.

Conclusions and Outlook

The particular strength of PPB approaches is the impact they can make in those very situations where rural people are afflicted by food insecurity. They tend to start with efforts geared towards meeting and understanding farmers' and/or users' needs. PPB programs with a focus on food and nutrition security thus have the opportunity to focus directly on women's needs, or even more

[4] See, for example, http://www.farmersrights.org/bestpractices/success_benefit-sharing_5.html (accessed October 19, 2012)

specifically those of mothers of young children. While working on varieties, seeds and other aspects of crop production, methods for food processing, and knowledge about child nutrition can be addressed simultaneously, with good chances for immediate outcomes (Lugutuah et al., 2012).

Progress can be achieved for specific production conditions and user groups, not only through breeding in its narrowest sense, but by bringing the context, the objectives and the direction of the breeding program more sharply into focus. In order to effectively target the needs of resource-poor farmers, plant breeding programs should aim at integrating plant breeding and agrobiodiversity management by adopting decentralized forms of organization. Food quality aspects need to be specifically addressed alongside productivity goals and access to seed be secured by developing further the institutionalization of stakeholder participation in plant breeding and seed programs. In fact, the whole impact chain "from field to plate" has to be considered; a well-developed link to research into economic, nutritional and health effects for vulnerable groups would complement any research in this field.

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