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# Tools and approaches for vegetable cultivar and technology transfer in West Africa: A case study of new hot pepper variety dissemination in Mali

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Agricultural research and extension in sub-Saharan Africa has focused mainly on basic staples and traditional commodity exports. Despite the nutritional, medicinal and economic importance of vegetables, the subsector is largely neglected by extension services in favor of staple crops. Since 1992, AVRDC– The World Vegetable Center has been engaged in demand-driven vegetable extension through direct training of farmers and dissemination of production manuals. In Mali, the center has successfully introduced three new high yielding, early maturing, and locally adapted hot pepper varieties of *Capsicum annuum* through distribution of extension materials, multidisciplinary and participatory approaches, and teamwork. The promotion strategy was based on field visits, farmer participatory variety selection, on-farm discussion sessions with producers, sensory quality testing and organization of demand creation fairs to enhance technology delivery. The combined efforts successfully raised awareness about hot pepper among smallholder farmers in four villages, who are requesting additional seeds for planting. Prior to the intervention, *C. annuum* hot peppers were not well-known in the area compared with *Capsicum frutescens* and *Capsicum chinense*. High quality seeds must be available for farmers if the new hot peppers are to achieve their full potential for higher incomes and nutrition security. Lessons learned include the need to disseminate more extension materials and facilitate extensive interactions and partnerships with stakeholders to achieve greater impact.

**Key words:** Agricultural knowledge and information systems, hot pepper, home gardens, innovation systems, nutrition security, rural household livelihoods, technology adoption.

## INTRODUCTION

Worldwide, diseases related to imbalanced diets, cause 2.7 million deaths annually and are among the top mortality risk factors (Ezzati et al., 2002). Enhanced consumption of vegetables and a greater diversity of available foods can help address the double burden of

micronutrient deficiency and chronic diseases. This is of particular relevance in sub-Saharan Africa, where only slight progress has been made in reducing child malnutrition over the past decade. Nevertheless, agricultural research and extension sub-Saharan Africa was focused mainly on staple crops, particularly, cereals, while relatively little attention was given to vegetables despite their nutritional, medicinal, and economic importance (Keatinge, 2011). Historically, this observation is partly attributed to the emphasis on the use of cereal

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crops to ward off the scourge of hunger in many parts of the world after World War II. The global food supply began to increase in the 1960s due to the development of more productive varieties of wheat and rice by Dr. Norman Borlaug and others (Murgai, 2001; Briggs 2009). Achievements occurred primarily in specific regions of Asia and Latin America. Similar success did not occur in many parts of sub-Saharan Africa, where the world's poorest and fastest-growing populations live, mostly due to inadequate infrastructure and insufficient understanding of the local nature of agricultural development. It must be emphasized, that people's attitudes toward consumption are driven first by their food choices and second by affordable access to yield-boosting technologies, including improved crop varieties. An abundance of staples will amount only to a "Grain Revolution" if the vegetables required to balance the diet are not equally abundant. As staples are traditionally consumed with vegetables in the region, a "Revolution of Greens" is necessary as well (Tenkouano, 2011).

Despite the relatively small growing area devoted to vegetables in West Africa, vegetable cultivation has significant potential to increase income and improve nutrition throughout the region. Addressing malnutrition requires the provision and consumption of food that contains essential micronutrients for a balanced diet. Increased fruit and vegetable consumption has been widely promoted because of the health benefits of many non-nutrient phytochemicals associated with health maintenance and prevention of chronic diseases (Steinmetz and Potter, 1996). The lack of locally adapted, improved varieties has been one of the major constraints to enhance productivity and bring about year-round production that could ensure increased availability and consumption of vegetables. While breeding technologies and related sciences are available to develop improved nutrient-rich and health-promoting vegetable varieties that can be consumed alongside major staples for a balanced diet, the crucial role of participatory agricultural extension tools and approaches to promote innovation and technology dissemination must not be overlooked.

In West Africa, hot pepper is used as a condiment to add color, flavor, taste, pungency, and nutrients (vitamins A and C, iron, potassium, and dietary fibers) to soups, stews, sauces that compliment the basic foods made out of cereals, tubers and /or roots. It can be consumed fresh, processed into canned sauces, dried whole/broken fruits or powder for local and export markets. In the local markets, fresh hot peppers are sold per single fruit, per set of few fruits, per basket full, or per kilogram. Although, *Capsicum annuum* hot peppers are agronomically the easiest to grow, harvest, process, and sell, they are almost unknown to local consumers and markets in Mali where *Capsicum chinense* and *Capsicum frutescens* more popular. A joint project initiative by AVRDC – The World Vegetable Center and AfricaRice showed that in countries such as Benin, some varieties of *C. annuum*

hot peppers are the most preferred by women traders because they can fill their baskets more quickly (AfricaRice, 2006), implying that they can make more money with only few hot pepper fruits. This paper highlights AVRDC's participatory research and extension approaches to promote vegetable production and consumption to alleviate micronutrient malnutrition and increase farm income in West Africa. It focuses on a case study of integrated innovative approaches used to promote three new varieties of hot pepper among rural households and consumers in Mali.

### **Overview of AVRDC's vegetable extension service and delivery in West Africa**

AVRDC – The World Vegetable Center is the world's leading international non-profit research and development institute committed to alleviating poverty and malnutrition in developing countries through increased production and consumption of nutritious and health-promoting vegetables. Since 1992, AVRDC's Regional Center for Africa, with offices located in Tanzania, Mali, Cameroon, and Madagascar, has been instrumental in breeding improved varieties of globally important and indigenous vegetables for uptake and commercialization by private seed companies. AVRDC's 20 years of experience in Africa has led to the development, release, and in some cases, commercialization of about 60 improved vegetable varieties. These improved, high yielding varieties have good disease resistance, drought and heat tolerance, and long shelf life, among many other traits.

### **Vegetable breeding and capacity building in seed production and delivery**

AVRDC employs a participatory approach to variety selection. On-station and on-farm variety evaluation and organoleptic testing with various groups (farmers, students, national agricultural research and extension systems (NARES), non-governmental organizations [NGOs], seed companies and other partners) is conducted from project inception to completion. Seeds of advanced lines are distributed to partners for on-station, multilocation, and on-farm trials. Occasionally, logistical support is provided to seed company partners to conduct multilocation trials following field guidelines provided by AVRDC while adhering to the procedures of variety release and registration in specific countries. Following official variety release, seed companies may freely commercialize the variety, subject to meeting the prevailing official seed certification standards. The seed companies report back from time to time to an accredited agency (or to AVRDC under certain conditions) for high quality foundation seed. By doing this, the Center can

ensure its vegetable breeding activities meet market/consumer demand and that the gap between variety release and adoption is bridged. In Niger for example, the Center executed a joint vegetable breeding project with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) from 2007 to 2011. The major focus was to purify and promote heat tolerant varieties of several globally important (e.g., tomatoes) and indigenous vegetable crops (e.g., African eggplant) through development of the vegetable seed sector in West Africa. In 2009, the project trained 67 small-scale seed producers, trainers and farmers from Niger, Mali, Burkina Faso, Togo, Benin, and Senegal in vegetable seed production and processing. Under the West African Seed Alliance (WASA) and AVRDC's Vegetable Breeding and Seed Systems for Poverty Reduction in Africa project, 30 vegetable growers from Mali, Burkina Faso and Niger received the training in 2010. In addition, 15 training courses (on-station and on-farm) on various aspects of vegetable production, such as growing vegetables during the rainy season, were conducted in Niger. Many trainees were able to grow rainy season vegetables for the first time on small plots alongside their millet fields, which increased their household income and nutritional status.

### **Vegetable production: Manuals, training of trainers and farmer training**

The Center has developed production manuals and leaflets that outline cultural practices for globally important and indigenous vegetables. The manuals and leaflets describe varieties suitable for specific agro-ecological zones, sowing times, nursery preparation techniques, seedling transplanting, crop management, harvesting, and post-harvest management. Based on earlier field experience with home garden models, a healthy diet gardening kit containing seed of 18 nutritious vegetable crops was developed at the Regional Center for Africa in Arusha, Tanzania. Approximately, 170 to 250 kg of vegetables were produced in a 6 m x 6 m plot year-round by following the kit's planting plans with 18 crop combinations (Chadha and Oluoch, 2007). For example, the Bandiagara region in northern Mali is well-known for shallot production. Following a participatory needs assessment in six selected communities, farmers requested AVRDC's assistance to diversify their vegetable production. Seven demonstration plots with new cultivars of seven AVRDC mandate vegetables (African eggplant, okra, tomato, roselle, hot pepper, amaranth, and onion) were established in the communities. A combined team of AVRDC, NARES, and NGO field staff monitored the progress of the new AVRDC vegetable varieties in the demonstration plots and compared them to the non-improved landraces grown in farmer's fields. Representatives of 39 farm households assessed the advantages and disadvantages of these new varieties

through their own learning experiences and observation.

### **Public-private sector partnerships link farmers to markets**

To address the socio-economic challenges along the vegetable value chain, AVRDC actively supported the public and private sector by providing improved inbred lines that accelerate cultivar development, sharing the Center's disease screening protocols, and conducting training in genetic improvement and seed production. To increase the share of high quality seeds, location-specific alliances need to be formed with companies capable of fulfilling the necessary breeding, selection, varietal registration, and marketing activities. Through the innovation platform, a forum initiated by the Center's Vegetable Breeding and Seed Systems for Poverty Reduction in Africa project — AVRDC has been instrumental in establishing collaborative networks of public-private sector stakeholders in vegetable research and development to learn from each other's experience in sub-Saharan Africa. In Mali, the platform includes among others, private seed company partners; NARES such as the Institute of Rural Economy (IER) and the National Committee for Agricultural Research and Department of Plant Protection of the Agricultural Ministry; NGOs such as Citizens Network for Foreign Affairs (CNFA); and community-based farmer groups. These partnerships have afforded AVRDC with a good understanding of the use and management of intellectual property rights and how to protect these rights to ensure that the Center's target clients are able to access the technologies they need. During 2009 - 2011, for example, more than 500 kg of foundation seeds of five varieties (tomato 'ICRI-Xina,' lettuce 'Maya,' okra 'Konni,' hot pepper 'Saffi,' melon 'Ein-Dor') were produced and provided to West African Seed Alliance for further multiplication and promotion among farmers, who also received training in seed production. In Niger, a follow-up survey of farmers trained in seed production was conducted with the assistance of the farmer's cooperative. Survey results indicated that in 2010, about 150 women belonging to three associations under the cooperative initiated seed production of 'Konni' in four villages in the Tillaberry region of Niger. Ainoma, a local seed company known for producing only staple seeds, for the first time produced and marketed 150 kg seed of 'Konni' and 'ICRI-Xina.'

### **Demand creation activities**

In addition to capacity building through farmer field schools, field days and seed fairs were organized to demonstrate the potential of the new varieties and their economic benefits to greater numbers of farmers. Awareness is enhanced through technology displays

during national agricultural shows. As part of the Center's strategy to disseminate quality seed and promote vegetable consumption in Mali, farmers received small quantities of seed during various demand creation activities, including household surveys, focus group discussions, national agricultural shows, seed fairs, and events such as Mali's *International Day of Nutrition*. The Center's socioeconomists and community development specialist follow-up on seed distribution through questionnaires and phone surveys to track farmers' progress with the improved seed, and to provide feedback to breeders to ensure that future downstream research and breeding efforts are tailored to the needs of producers and consumers. Information is collected on crop type, variety name, method of sowing, germination, crop area, performance of the variety, quantity of production, and whether the produce was sold at the market or consumed at home.

### Nutritious recipes

Other complementary dissemination efforts include recipes displayed at public and social gatherings and distributed through radio, newspapers, brochures, and even in songs. Consumption levels of some nutrient-rich vegetables are still rather low, partly due to bitterness. Through modification for enhanced palatability, traditional recipes for crops such as amaranth, spider plant, African nightshade, Ethiopian mustard, and African eggplant have generated resurgence in the popularity of indigenous vegetables. Using the concept of biofortification, AVRDC has developed high beta-carotene tomato, which is being promoted in Mali and other countries in sub-Saharan Africa. Consuming just one of these orange-colored tomatoes can provide a person's entire daily vitamin A requirement (Keatinge and Easdown, 2009).

The Center improved the nutritional value of indigenous vegetables by modifying traditional recipes. These recipes are suited to local food tastes and habits, and have been published in leaflets and distributed to farmers directly or through partners. Farm families are encouraged to consume some of the vegetables they grow for market. A combination of promotional strategies has been used to encourage the production and consumption of vegetables among vegetable producers, consumers in rural and urban areas, and small processing enterprises. "Women's Secret," a major promotional campaign to enhance vegetable consumption in Mali, encourages women to add vegetables to their recipes, try preparation methods that are less time-consuming, and use dried vegetable powders for flavoring instead of artificial stock cubes.

Taking advantage of the African value system, in which people may be willing to spend more money during social gatherings and ceremonies, or might want to receive social recognition for serving loved ones with perceived "high value" food, the tasty, healthy recipes are

promoted for use during weddings, baptisms and religious festivities.

## MATERIALS AND METHODS

### Variety and agronomic trials

AVRDC's long-term breeding program to improve *C. annuum* (both hot and sweet pepper) introduced several genotypes for testing in West Africa with the objective of providing better options for smallholders. A number of varieties were used to promote *C. annuum* hot pepper in Mali. However, particular emphasis was given to three AVRDC-bred varieties AVPP9905, AVPP0002, and AVPP0105 because of their wide adaptation, heat tolerance, earliness (<145 to 150 days from sowing to maturity), high yield, and virus resistance. These three lines were selected at AVRDC headquarters in Taiwan as PP9955-15, PP0007-2244, and PP0107-7058, respectively. At AVRDC in Taiwan, efforts were made to document resistance to *Chilli veinal mottle virus* (ChiVMV) in PP0107-7058, resistance to *Cucumber mosaic virus* (CMV) in PP0107-7058 and PP0007-2244, and resistance to *Potato Virus Y* (PVY) in all the three varieties evaluated. Although, some work on Pepper veinal mottle virus (PVMV) was conducted at AVRDC, it predated the development and release of these lines, so potential resistance should be further confirmed. The three varieties were later introduced and evaluated in multiple locations in Benin, Burkina Faso, Chad, The Gambia, Niger, Togo, and Mali. AVPP9905 was evaluated in the seven countries from 2005 to 2010, while AVPP0002 and AVPP0105 were evaluated in Mali and The Gambia from 2008 - 2010.

### Variety and technology dissemination

On-farm action research and promotional activities were conducted between 2008 and 2010 at six different locations (Figure 1) including ICRISAT's Samanko Station, located 25 km Southwest of Bamako, Djelibougou in Bamako District, Koni village in the Rural Commune of N'gouraba, Kirina village in the Rural Commune of Mande, Sebenikoro village about 15 km from Kati City, and Bandiagara in the Mopti Region. These locations are situated in the major vegetable production zones of Mali (Kati, Bamako, and Bandiagara) where farmers have access to local markets and urban markets in Bamako, Kati, and Mopti. Vegetables are produced during both dry and rainy seasons with opportunities for processing through sun-drying and/or pounding. All locations have access to extension services such as the National Directorate of Agriculture and the Office de la Haute Vallée du Niger (OHVN). Participants who attended the research and development activities conducted at Samanko Station came from different vegetable growing areas such as Bamako, Kati, Sikasso, and Segou, while farmers from the other five communities were local residents, providing an opportunity to disseminate information through farmer-to-farmer knowledge diffusion.

A combination of extension strategies, materials, tools and techniques were used to promote the new hot pepper varieties in Mali. To create awareness about *C. annuum* in general and the three varieties in particular, a series of promotional and dissemination activities were conducted, including; i) demonstration plots and field visits on-station and on-farm, ii) participatory variety selection, iii) discussions with the target beneficiary farmers prior to and/or after field visits, iv) sensory quality testing, v) cooking demonstrations, and vi) displays of fresh and processed fruit and distribution of fact sheets and/or seeds at nutrition and seed fairs and other events. Depending on what was most appropriate, these activities were conducted in one or more of the six locations

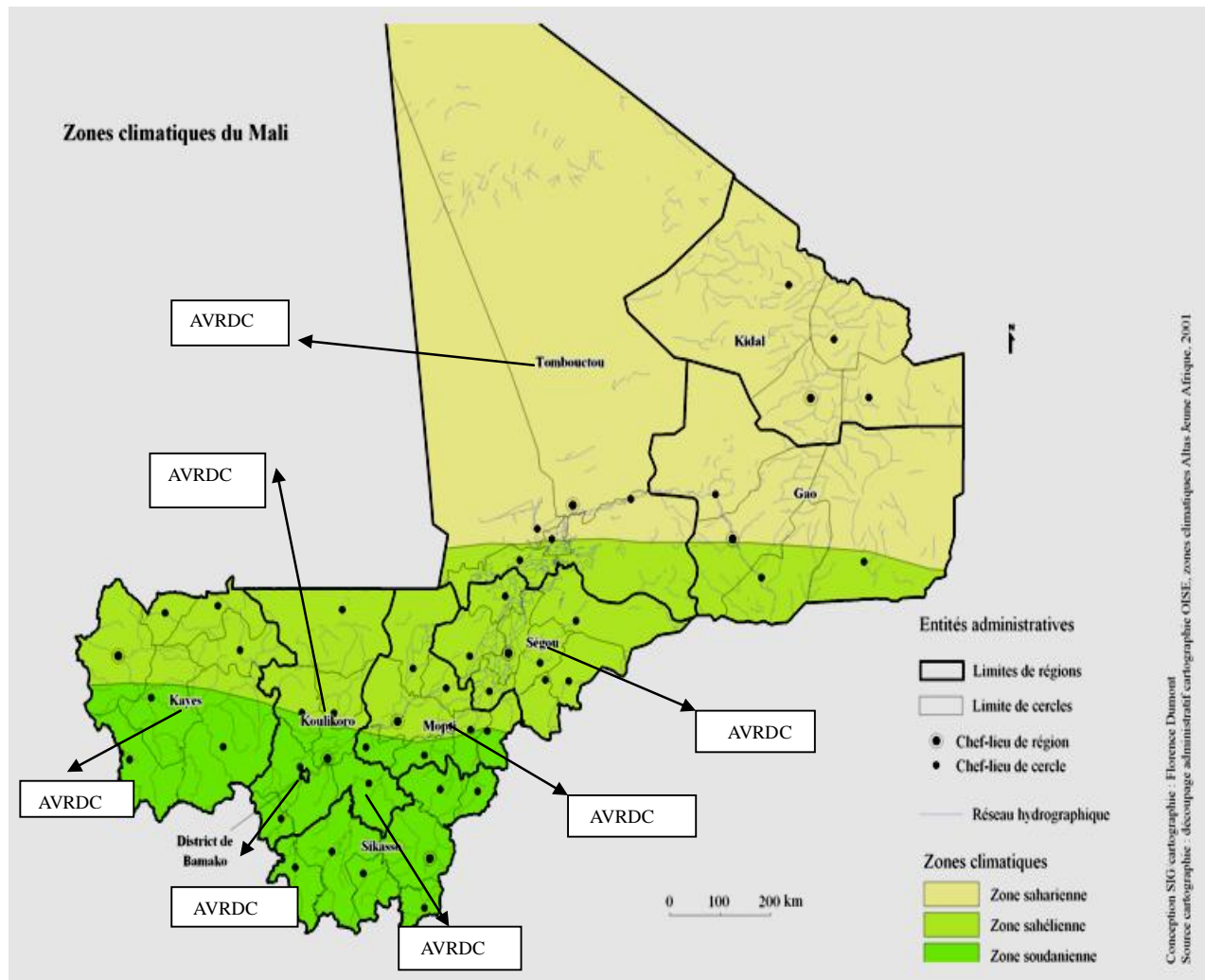


Figure 1. Map of Mali showing study action sites.

described above. The target audience included rural youth, adult producers, men and women producers, traders and/or consumers, seed producers, and seed dealers. AVRDC staff, NARES extension agents, and representatives of ICRISAT and West Africa Seed Alliance conducted the activities. Demonstration plots were implemented by AVRDC in collaboration with local NARES representatives whenever possible. Plot monitoring was conducted by participating farmers under supervision of the NARES representative and/or AVRDC. During the crop production cycle, one day was selected at the fruit-bearing stage at each location for a field visit, participatory variety selection, sensory quality testing, or cooking demonstration.

Extension materials used were mostly designed to be self-explanatory. For example, fact sheets showed two colour pictures of each variety (one for a standing plant with fruits and another picture of harvested fruits). They also described the nature and geographic origin of the varieties, their horticultural and agronomic features, fruit and seed characters, as well as, organoleptic characters such as pungency. Demonstration plots and field visits provided opportunities for farmers to see the *C. annuum* pepper varieties in a form of actual standing plants with fruits, know the varieties, their fruitfulness, and yield potential. Cooking demonstrations, nutrition stands, organoleptic tests, the recipes, and processed product

samples provided more information to the target audience about the uses of *C. annuum* pepper. The extension materials were used to create awareness of *C. annuum* pepper among farmers, traders, and consumers, and how the vegetable can be utilized and demonstrate, what benefit it can return in terms of yield, income, labor saving (ease of harvest), and nutrition. Discussions during meetings helped farmers realize that *C. pepper*, especially, varieties such as Nisonidia, Bafarima and Nafama can be easily used as a strategic crop to provide substantial income, and hence, sustainably reduce poverty in West Africa.

## RESULTS AND DISCUSSION

### Agronomic trials and variety evaluation

Results from the agronomic trials of the hot pepper varieties in the seven countries suggested marketable yield range of 2.42 to 21 t/ha and average yield of 11.77 t/ha for AVPP9905. During the same period, a total of 39 varieties were evaluated in the sub-region. The average

hot pepper yield across all the 39 entries was 7.97 t/ha. Compared with this average yield, the performance of AVPP9905 was 47.68% higher. In Mali, the expected hot pepper yield was 7.54 t/ha for the 2010 rainy season (DNA, 2009), very similar to the mean yield of 7.97 t/ha across 39 varieties evaluated in seven countries from 2005-2010. Compared with this expected yield, AVPP9905 pepper suggests a yield increase of more than 50% in Mali. The Food and Agriculture Organization's (FAO) 2009 estimates suggest green hot pepper yield of 2.14 t/ha for Benin, 3.5 t/ha for Burkina Faso, 3.58 t/ha for Ghana, 5.67 t/ha for Mali, 6 t/ha for Cote d'Ivoire, 7.8 t/ha for Nigeria, and 9.2 t/ha for Niger (FAOSTAT, 2011). These corresponded to a mean yield of 5.42 t/ha for West Africa, hence, suggesting a yield increase of more than 100% in this sub-region by AVPP9905. Average yields of AVPP0105 and AVPP0002 in Mali were 10.56 and 9.40 t/ha, respectively. Compared with the average yields of green hot peppers from the FAO data (5.42 t/ha), these two varieties suggested more than 90 and 70% yield increases respectively, for Mali. In addition, they offer opportunities for increased income with 150 to 200 fruits/plant for AVPP0105 and 200 to 250 fruits/plant for AVPP0002. AVPP0105, AVPP9905 and AVPP0002 normally have low, medium and high pungency, respectively. They also have elongated fruits, which are relatively small for AVPP0002 (2.66 g/fruit), medium for AVPP0105 (4.43 g/fruit), and large for AVPP9905 (15.46 g/fruit). The latter has firm fruits that are pale yellow at immature stage and orange-red at mature stage. Together, the three varieties offer great diversity in fruit size and pungency. Such diversity is desirable because it creates opportunities to meet the taste and preference needs of a range of consumers and end-users. In March 2011, the three hot peppers were released under the local names of Nisondia (AVPP9905), Bafarima (AVPP0002), and Nafama (AVPP0105) by the national release agency of Mali (LABOSEM) and registered in volume III of the Official Seed Catalogue of Mali.

### Variety and technology dissemination

Success of the hot pepper promotion was measured by observing the behavior of various stakeholders (farmers, consumers, and the private sector) after the intervention. It is worth recalling that *C. annuum* hot peppers were almost unknown to the local population, who often referred to it as "Chinese pepper." After the intervention, fruit of the three varieties was seen in markets of Kanadjiguila (Rural Commune of Mande), Yirimadio, Taliko, and Bugudani (Kati Circle), and in the local market of Lafiabougou (Bamako District). Investigations using a formal questionnaire and qualitative data analysis undertaken by the AVRDC pepper breeder in November, 2010 showed that these hot peppers were introduced by day laborers from Samanko Station and other local

people from the Samanko neighborhood to whom the peppers harvested from the demonstration plots were either given away or sold at cheap prices to offset the cost of resources invested in the distribution process. Investigations revealed that in the local markets mentioned above, the elongated fruits of the three new hot peppers varieties were attractive to people because of their size, shape, and bright color and that they sold at 10 to 25 F CFA/single fruit for the bigger fruits. Smaller fruits were sold at 25 F CFA/set. After the intervention, farmers seem to have understood the usefulness of these *C. annuum* pepper as a strategic solution to easily increase their income. Many requested seed from field personnel to plant large areas, especially, at Kirina, Koni, Kati, and Bandiagara. At the same time, it was encouraging to see that stakeholders in the seed sector have also requested seed samples of these varieties. While seed requests from the private sector have been met, those from interested farmers need attention from the private sector, NGOs, and other development organizations.

### CONCLUSION AND RECOMMENDATION

The results of this case study have shown that a combination of integrated community-based innovative tools and approaches can successfully raise awareness of improved vegetable cultivar and technology transfer among smallholders. Farmers are requesting seed of the three new pepper varieties for planting. This is encouraging because prior to the intervention, it was difficult to envision that farmers and consumers in Mali would show interest in *C. annuum* hot pepper compared with *C. frutescens* and *C. chinense*. This intervention has shown that it is possible to create excitement and interest in new varieties through targeted promotion and participation. Sometimes, people are reluctant to use a technology because they are not aware of it, do not know how to use it, or have concerns about the ability of the technology to improve their livelihoods. The results of the study underscore the importance of strengthening research-extension-farmer linkages at the community level. The close collaboration and thoughtful exchange of information and opinion between partners, stakeholders and beneficiaries made this intervention a success.

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