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Farmers' Perspectives on Biotechnology Innovation on a New Cassava Variety in Tamil Nadu

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Abstract

Cassava (*Manihot esculenta* Crantz) is a highly productive tuber crop growing on marginal land, providing rural communities in India with nutritious food, as well as income generated by huge industrial demand for sago and starch. In Tamil Nadu (TN) alone it supports over 10,000 smallholder farmers. To sustain the livelihoods of this community of smallholder farmers, the Indo-Swiss Collaboration in Biotechnology (ISCB) works towards cassava virus (i.e. Cassava Mosaic Disease) resistant varieties. Socio-economic partners collaborate with biotechnologists to support ISCB Cassava project's objectives of improving food security and rural development, by supporting development of biotechnological products according to end users' perspective (i.e. smallholder farmers and other value chain players). Using a combination of qualitative participatory research methods, this study addresses the needs and constraints of the farmers and other players, related to the cassava planting material system in the cassava industrial production area of Dharmapuri, Namakkal and Salem districts of Tamil Nadu. By understanding farmers' and other players' needs, will make the innovation more likely to be adopted. Moreover, the research aims at creating a network of public and private partners to rely on for the dissemination of innovations. In an area where cassava is largely produced for starch and sago, farmers seem mainly concerned about varieties with high yield and high starch content, shape and colour. In order to assure farmers acceptance of a new variety to be introduced, the yield and starch content should be as high as, or greater than the varieties currently in use. Though cassava planting material is available and affordable, when a new variety is released, the current planting material distribution strategy seems to be inadequate for market penetration. Socio-economists and biotechnologists agree on the fact that market-oriented distribution strategy needs to be further analysed and built, by including other players from the private and public sector.

Key words: Cassava, planting material, innovation adoption, famers' needs, variety selection

Introduction

Small and marginal farmers in South India are challenged with unpredictable rains and droughts, soil nutrient reduction, food and nutrition security issues as well as unstable market access (IFAD, 2011). Agricultural innovation can provide a more resilient, diverse, efficient and economically sustainable production in order to face these challenges (The World Bank, 2012). Operating since 1974, the Indo-Swiss Collaboration in Biotechnology (ISCB) is a long-standing bilateral research and development program jointly funded and directed by the Department of Biotechnology (DBT), the Ministry of Science and Technology, the Government of India and the Swiss Agency for Development and Cooperation (SDC). With the aim of contributing to food security in India through biotechnological innovations to support a sustainable and climate-resilient agriculture system for smallholder farmers, ISCB has been supporting collaborative research of Indian and Swiss biotechnologists. During the first phases, the programme focused on curriculum development, capacity building and infrastructure improvement of Indian Universities. During the 90s, the competition with imported biotechnology products was increased in India by the market liberalization, which brought technology transfer and links with the private sector at the centre of ISCB's focus (Jenny 1999). In addition, the growing concern about food security, poverty reduction and sustainable use of natural resources globally (Douthwaite et al., 2002) pushed ISCB to move towards a more holistic approach including socio-economists in the research process following a participatory circular value chain approach by establishing multi-stakeholder platforms, where farmers' needs are at the centre of the "participatory circular value chain" (Figure 1). Representatives from the private sector, non-governmental organisations (NGOs), government entities and farmers become key stakeholders in project planning and implementation in order to develop products with high potential of adoption by the target groups (EPFL, 2016).

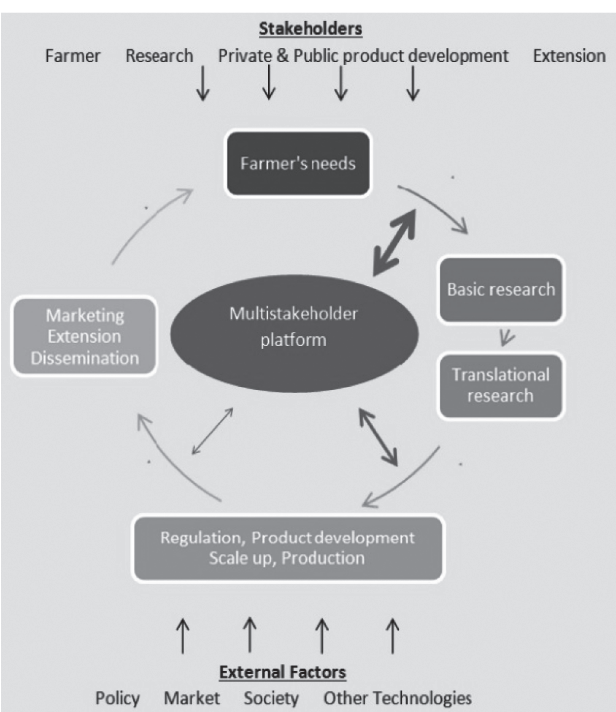

Fig.1. ISCB Participatory Circular Value Chain Concept (Source: EPFL, 2016)

In the framework of the current phase of ISCB, the Indo-Swiss Cassava Network Project has the goal of developing new and improved cassava varieties to strengthen virus resistance and contribute to increase cassava production. Tuber diseases can in fact cause losses up to 100%. The project is conducted in partnership by the Indian and Swiss research centres in biotechnology. Indian and Swiss Socio-economic partners collaborate with the biotechnologists towards the ex-ante assessment of biotechnological products' acceptance and processes addressing smallholder farmers' constraints, needs and perspectives, and at the same time creating a network of public and private partners to rely on for the dissemination and adoption of the innovations once they will be put in place.

Developing a cassava variety with improved resistance to biological constraints is thought to be an innovation that when successfully developed and adopted, has the potential to contribute to increased food and nutrition security, income generation, and livelihood improvement in Southern India. The Socio-economic investigation focuses on different following aspects relevant to technology transfer, product development, public acceptance and adoption by the end users. These topics include the issue of the acceptance of cassava varieties resistant to CMD and whitefly – genetically modified or not – but different from the ones currently used, by farmers and industries.

Cassava is generally produced by smallholder farmers as a subsistence crop around the world. Productivity is important for industrial uses of cassava such as starch production, but stability of production is important for regions where cassava is the main subsistence crop (Ceballos et al., 2004). For industrial uses, the roots need to have high dry matter content whereas for consumption the cooking quality or starch characteristics are more important than yield for instance (Ceballos et al., 2004). Large scale plantings are developing increasingly in response to the large demand for cassava. However, it varies very much from country to country. Setimela (2004), Ceballos et al. (2004) and Cock (1985) pointed out that the propagation of cassava at the global level is mostly based on the traditional method of stem cutting. Farmers in Africa and Latin America usually get their planting material from rural markets, neighbours and from their own cassava fields (Kenneth, 2012; Nweke, 2009). There is no commercial viable seed propagation system or industry for cassava production (Lebot, 2009; Hillocks et al., 2002). The propagation rate is low (10 to 15 times) (Rajendran et al., 2005). Propagation via true seed takes place under natural conditions and is used in breeding programs, but it takes long to establish and usually plants are smaller and weaker than the plants originating from stem cuttings. However, the main advantage of a seed system would be a lower disease transmission (Hillocks et al., 2002; Ceballos et al., 2004). Cassava is considered to lack full attention from the research and not to be a priority for the private or public sector (Lebot, 2009; Hillocks et al., 2002; Fermont et al., 2008; Bellotti et al., 1999; Legg et al., 2014). Thus, very few improved cultivars or stem cuttings free of pests are accessible (Bellotti et al., 1999). Moreover, the diffusion and adoption of new varieties is slow due to different elements namely, the low multiplication rate (1:10), the geographical dispersion of farmers, weak extension systems and low availability of planting material, financial costs for diffusion of planting material and expensive inputs needed for some varieties (Kenneth, 2012; Lebot, 2009; Plucknett et al., 2010). In Latin America, Hillocks et al. (2002) also put forward that cultivars relying on expensive inputs are not well adapted for cassava growers. The most efficient way of improving cassava production seems to be the identification of superior local germplasm which are then recommended to local growers and slowly transferred to regions around (Hillocks et al., 2002). Participatory research however can be successful since it enables to identify farmers' needs and to further conduct trials on the farmers own land. In some cases, communities adopt a production system after visiting a neighbouring community implied in research projects (Bellotti et al., 1999). For example, in the Democratic Republic of Congo, an emergency response program was established in 2001 to fight the outbreak of the CMD. The first part of the program focused on distributing clean planting material of existing cassava varieties and develop further varieties resistance to CMD but also accepted by consumers. Stems were distributed to villages which already had access to rural extension services and farmers 'associations as well as community-based organisations (CBOs) were already established. Within villages, planting material was disseminated from farmer to farmer. Some planting materials were then further transferred to different neighbouring villages where nurseries were established and planting material was once more propagated. Within three years, the target villages and neighbouring communities had access to quality planting stems (Rusike et al., 2014). According to Taylor et al. (2004), traditional breeding will continue to be problematic and is unlikely to provide a solution which suits the different needs of smallholder farmers as well as commercial production. Integrating needs of local cassava stakeholders in the biotechnology research priorities is an important way to face the problem of contaminated planting material (Aerni, 2006). Yet, many challenges remain in the distribution of clean planting material, for instance, the centralized production of clean material, the challenges in distributing them to marginal areas and the financial costs it implies (Aerni, 2006). Furthermore, most of the times, farmers are not involved in the choice of varieties and techniques and this will have an impact on adoption. According to Kenneth (2012) to improve adoption and diffusion of varieties, it is necessary to integrate the needs of local cassava stakeholders in the biotechnology research priorities. Once new varieties are adapted to local needs, farmers can be trained to undertake the rapid multiplication of cassava stems, in order to diffuse the new variety faster. Yet, if local needs are not considered, farmers will continue giving preference to cassava landraces. For instance, in Ghana cassava varieties from the International Institute of Tropical Agriculture (IITA), having high storage root yield and resistance to pests and disease such as the CMD were released, yet cassava landraces remain predominant in Ghana (Manu-Aduening et al., 2006). In fact, participatory plant breeding (PPB) mostly focused on crops propagated by seed, whereas cassava as mentioned is vegetative propagated and farmers generally do not use their seedlings and prefer using the vegetative propagation from known cultivars.

Materials and Methods

The study focuses on the major industrial cassava production area in Tamil Nadu, namely the districts of Dharmapuri, Namakkal, and Salem and used a combination of qualitative participatory research methods, such as six key informant interviews (with academics from Swiss and Indian institutes), 25 in-depth interviews with different involved players (farmers, starch and sago factories, research institutes, extension workers

(KVKs) and seed company) and two focus group discussions with farmers and extension workers. This study addresses in a participatory manner the needs and constraints of the farmers and other players, related to the cassava planting material system in the cassava industrial production area in relation to an imminent introduction of a new variety (genetic modified or not) resistant to CMD.

Results and Discussion

In Tamil Nadu, cassava is an important crop both as a source of carbohydrates in the food system- mainly in the Southern districts- but mainly as a raw material for the industrial system in the larger cassava industrial production area in the Northern districts of Dharmapuri, Namakkal, Salem and Erode. Most of the cassava is transformed into starch whether used for the food industry or the non-food industry and only a very small quantity is used to produce cassava chips (from raw cassava) or is consumed directly (cooked or boiled roots) by the farmers.

Cassava is very suitable to the local conditions of the studied area, both environmental/agronomic ones (soil composition, unpredictable rains) and socio-economic conditions (low input required, long duration of the crop, low labour requirements compared to other crops). The cassava is produced both in hilly areas as well in the plain. In hill areas the production is merely rain-fed. In the plain areas, cassava fields are both irrigated (70% of the area, through 70% conventional and 30% drip irrigation) and rain-fed (30% of the area). Difference occur in the yield, with 7-10 ton/ha in the plain area and 3-5 ton/ha in the hilly areas.

Farmers started producing cassava a few generations ago in India (about a century ago). The cultivation spread in Kerala State as food crop, while in Tamil Nadu it slowly became an industrial crop (Premkumar et al., 2000) for the production of starch and sago in Namakkal and Salem districts. The cultivation is mainly for the market, but farmers also consume a small share of their cassava production everyday as chips or boiled tubers, and for the workers' meals.

Inversely to the situation in Africa where cassava is usually grown together with maize, sorghum and pigeon pea (Hillocks et al., 2002), in the industrial production area of Tamil Nadu, intercropping practices on cassava field is rare. According to FAO (2013), extensive experiment in Thailand demonstrated that rotating cassava with groundnuts, followed by pigeon pea in the same year, contribute to cassava yield, while yields under continuous cassava mono-cropping tends to decrease. A few progressive farmers in the studied area in Tamil Nadu are aware of it, but they continue to grow cassava under continuous mono-cropping practice as most of the farmers in the region.

The cassava planting material system in the study area can be defined as an informal planting material system, as a formal system and a market for cassava planting material is very limited. The main players involved in the cassava planting material system are depicted in Figure 2.

The most common way to source cassava planting material in Tamil Nadu is to re-use the cassava stems from their own fields. In fact, cassava is a crop that has been planted in the region for over four generations. Thus, every year, farmers gather some cassava stems which they store for the next planting season. From time to time, farmers exchange planting material, to try new variety and/or to regenerate their own material. This happens only if there is trust among the neighboring farmers, and if costs are not too high to reach the other farmer's field.

Fig.2. Cassava planting material system's actors in the industrial area of Tamil Nadu

As in most of parts of the world (Setimela, 2004, Ceballos et al., 2004 and Cock, 1985), also in the industrial production area of Tamil Nadu, the propagation of cassava is mainly based on the traditional method of stem cutting (more than 90% of the farmers), with major constraints such as low multiplication rate, the difficulty of storing planting material (bulky material and easily perishable), transmission of CMD and other diseases. The constraint of bulkiness of planting material could potentially be overcome by providing mini-setts, using smaller stem cuttings or only nodes, but seedlings must first be raised in a nursery (these conditions exists only in drip irrigation systems whereas it is minimum in ridges and furrow and rain fed plains) and transplanted to fields afterwards. The multiplication through mini-sett technique is currently adopted by research centres in field experimental plots in selected areas of Tamil Nadu on virus free planting materials of Sree Prakash, Sree Rekha, Sree Jaya, Sree Vijaya, Sree Visakham, Vellayani Hraswa, H-226, H-165, H-97 and M-4 varieties obtained from ICAR-CTCRI-Regional Centre, Bhubaneswar (ICAR-CTCRI, 2015). There is a need to investigate on the outcome of these field trial experiments and on the way to extend the outreach of this practice.

Half of the cassava planting material yearly produced by Central Tuber Crops Research Institute (CTCRI) is distributed to Tamil Nadu through the Tamil Nadu Agricultural University (TNAU) –Tapioca and Castor Research Centre (TCRS) Yethapur and KVK (Figure 3). The rest goes to the cassava industry. The TCRS conducs Front Line Demonstrations (FLD) and Multi Location Trials (MLT). It distributes some of the planting material directly to the selected

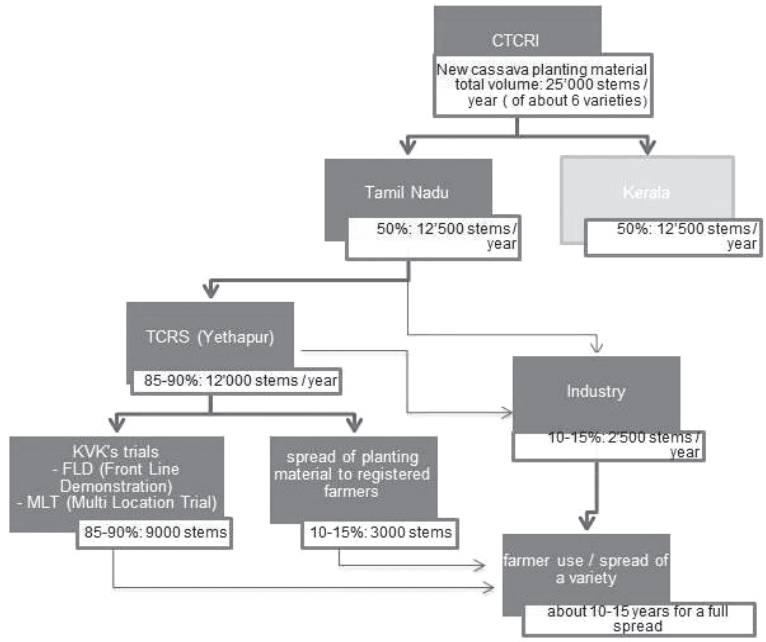

Fig.3. Distribution of cassava planting materials from ICAR- CTCRI in the industrial production area of Tamil Nadu

progressive farmers. During the harvesting time, they will discuss with KVK about the variety development, yield, starch content and resistance to pest and diseases. Farmer sell 300 stems to 5-6 other farmers on a cost basis (3Rs/stem). Farmers have the options to either purchase the stems at the KVK or from other farmers. The farmers who reach first the new planting material are commonly progressive farmers, participating in trials in their fields. Once reached farmers' fields, the new variety is spread among farmers in the area. Not only the KVK, but also the industrial sector is a pathway for variety distribution to farmers. On average, it takes about 10-15 years for the full spread of a variety. ICAR-CTCRI's capacity of multiplying cassava planting material on station is 25'000 stems per year (about 12'500 stem cuttings correspond to a total cultivation surface of 1 ha at planting density of 5000-6000 stems/acre).

So far, only one private seed R&D company developed a new variety of cassava in Tamil Nadu (Rasi 20 in 2012), as a gesture of support towards the local farmers, who were interested in planting high yielding varieties. Besides, direct distribution to a few farmers, in 2014 an association of sago and starch factories bought the planting material (1st generation stems) and distributed it to some (progressive) farmers belonging to the association at Rs 15 per stem. Planting material is also provided by starch and sago industries. According to some farmers, sometimes new planting material is introduced by industry level actors without following the due process, to better address farmer/industry needs (for example the case of the Thai white and black variety). It was also reported that it can be imported by farm employees coming from other regions/ countries. Industries are linked to farmers' groups, with whom they disseminate new planting material. However, only a few farmers belong to these farmers' groups because of the distance.

Though, according to farmers, planting material is available and affordable, they claim the lack of availability of new varieties, as the current planting material distribution strategy seems not to be adequate for market penetration. When a new variety is released, a market-oriented distribution strategy needs to be further analyzed and built in a concerted way by including all the involved players, namely the research institutes and universities, KVK, starch and sago factories, farmers (both progressive and non-progressive). Table 1 summaries the constraints and opportunities of the current distribution of planting material.

The most common varieties preferred by industry and farmers are Mulluvadi and Kunguma Rose, which confirms the data from previous research (Srinivas and Anatharaman, 2006). Additional varieties found in prominent quantities in the sago and starch factories and on farmers' fields are H226 (for its ease of pealing), Black Thai, White Thai (characterized by high starch content), Burma, H165. The preferred traits for farmers and industry are shown in Table 2. Currently, it is difficult for the farmers to find a variety with high yield, starch content, whiteness and at the same time less susceptible to CMD. However, so far there is no definitive scientific data on the impact of CMD on yield reduction in cassava.

There is currently no cassava variety used by the farmers which is resistant to CMD in the industrial production area of Tamil Nadu. However, CMD is not recognised by the farmers as a main problem, as farmers claim little or no yield loss due to CMD. It was reported that with 100% CMD affected fields, cassava yields up to 50t/ac if handled by appropriate nutrient management which has been explored. Though CMD resistance is not a marketing asset to farmers, according to farmers and other stakeholders, farmers would be ready to adopt the introduced CMD resistant variety if it also meets the other criteria. CMD resistant varieties are now in pipeline of the biotechnology partners of the Cassava Network project. Based on these preferences, farmers seem to accept new varieties easily.

Among other constraints like uncertain rainfall, inadequate water for irrigation, the major problems reported by the interviewed stakeholders are the low starch content - since the price offered by the factories is based on starch content points – the shortage of farm employees, and the price regulation. Though there are strong price fluctuation, interviewed stakeholders reported that farmers continue to grow cassava for its comparative advantage of adaptability to the local conditions and the low inputs required, making this crop profitable also when the price reaches low.

Regarding the biotechnology intervention on improved cassava varieties, the views and perceptions of different stakeholders towards genetic modified (GM) variety vary from one player group to another and also depends on the end use of the product, whether it is for human consumption or for industrial use. Farmers seem to be rather in favour of GM if it will increase the yield and the starch content, even though some may be doubtful to apply GM material on their fields for the fear of a negative impact on the environment and their fields. Nevertheless, most farmers are not aware of the GM technology in general. In the case of human consumption,

Table 1. Constraints and opportunities of the current distribution strategy

Constraints	Opportunities
Low availability of new introduced variety	Decentralizing planting material production
No reach of all famers (non-progressive with low contacts with progressive ones and KVK)	Decentralising the material distribution strategy including other key players: progressive farmers/farmers' organisations
Farmers' low interest in purchasing planting material	Using mini-sets to speed up the spread
Bulkiness of planting material	Incentives to seed farmers in Tamil Nadu
CMD persistence in planting material	Raising awareness about the advantages of the new planting material: farmers would be willing to pay
Lack of farmers' awareness about CMD	Improving services provided by KVKs on information and dissemination of new varieties
Lack of incentive for seed company	
Risk about introducing material from other countries through industries/workers (viruses)	

Table 2. Farmers' and industry's preferred traits in used cassava varieties (according to the interviews)

Preferred traits	Level of preference by farmers	Level of preference by industry
• High starch	High	High
• High yield	High	High
• Drought tolerance	High	Medium
• Short duration	Medium	Medium
• Pest and diseases resistance/tolerance	Medium	Medium
• Tuber form: easy to harvest	Medium	Low
• Whiteness	Medium	High
• Genetic modified variety	Medium	Medium
• Low input	Low	Low
• Low fibre	Low	Medium
• Easy pealing	Low	Medium
• Mealiness	Low	Low

GM cassava is not seen positively by traders, producers' associations, extension workers as they reckon that consumers will have a lower acceptance. In the case of industrial use, there are divergent opinions about the introduction of GM cassava. On one hand, most of the stakeholders think that higher productivity or better quality of the material will be the positive factors to look at. On the other hand, players like researchers, associations of producers and extension workers think that the current pressure from NGOs in India would pose a great problem to the use of GM cassava having an impact on consumers. The wrong connotation of GM among farmers and consumers will have to be tackled, also in the case of a governmental clearance.

Conclusion

As stated by Amankwah et al. 2015, innovation can stem from multiple sources taking into account the end users', needs and interest, i.e. those of farmers and their indigenous knowledge. Though time and resources investments and logistical challenges can discourage a high degree of participation (Amankwah et al., 2015), considering farmers' and other players' needs will make the introduction of the new variety more likely to be adopted. Moreover, putting in place an efficient planting material distribution strategy involving all the stakeholders will provide an effective and rapid dispersal of the new varieties benefitting all the farmers.

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