Novel approaches to promote and diffuse new potato varieties in Kenya

Landeo J. A., I. Barker and V Otazu

Juan A. Landeo, Leader of potato breeding program for resistance to late blight, the International Potato Center (CIP), SSA regional office PO BOX 25171, Nairobi 00603, Kenya; j.landeo@cgiar.org; Ian Barker, Head of Seed Systems, CIP SSA regional office PO BOX 25171, Nairobi 00603, Kenya ; i.barker@cgiar.org and Victor Otazu, Aeroponics seed specialist, CIP HQ, PO BOX 1558, Lima12, Peru; v.otazu@cgiar.org

Abstract

Current efforts for promotion and diffusion of new potato varieties in SSA countries focuses on a combined strategy to develop business-oriented sustainable seed systems including the private sector in producing clean seed stocks and the collaboration of public plant health regulatory institutions. A new private-public partnership model for the establishment of disease free seed production system is currently under development in Kenya with encouraging preliminary results. The model includes the Kenyan Plant Health Inspectorate Service (KEPHIS) to provide the protocols, procedures and health inspection services, private companies for production of large scale potato in-vitro plantlets and minitubers and CIP for strategic support and technical backstopping. Initially two private companies GTIL (Genetics Technologies International Ltd.) and Oserian Flowers specialized in tissue culture technologies on fruit trees, trees were involved in the production of potato in-vitro plants in large scale with high success. Later on, GTIL interested on minituber production, built it's first aeroponics unit together with a traditional system and is successfully producing minitubers. Two CIP derived varieties were used to test variety diffusion through adoption of aeroponics technology for minituber production. In 2009, Kisima farm and the national potato research station at Tigoni also joined GTIL in the production of minitubers via aeroponics technology. All three institutions and the four aeroponic units built are currently well established and under minituber production with a capacity of approximately 390,000 disease-free minitubers per year. This seed will provide clean stocks for the participants to start their seed production on a large scale in the country. The establishment of a sustainable private-based seed production system including pre-basic, basic and certified seed in a commercial scale will provide the tool needed for the more effective introduction and diffusion of new varieties in Kenya.

Keywords: Aeroponics, in-vitro plantlets, minitubers.

Introduction

Diffusion of new varieties requires the availability of clean seed stocks and an efficient sustainable seed system to bulk seed in a short time and make it available to farmers.

CIP's main activities on the diffusion of new varieties in SSA region are carried out together with the country's national potato programs and by using innovative approaches and technologies in line with client needs and local seed regulations. However, sustainable progress is difficult as most potato programs in SSA countries usually operate with insufficient funds and are frequently overburdened with many responsibilities such as production of pre-basic and basic seed and often certified seed; variety releases and diffusion; development of crop and disease management practices, development of post harvest technologies and other related technologies that make them unable to provide efficient services and outputs to meet farmers and consumers demands.

Well established private sector certified seed industries are non-existent in all SSA countries and the lack or insufficient amount of clean basic seed, usually produced by national potato programs and barely covering 1% of the total demand in most countries (Kinyae *et.al.*, 2005), is a major limitation. Most seed production and trade is informal and seed pathways are typically from farmer's saved seed, farmer to farmer and ware market to farmer (Kaguongo *et.al.*, 2007), consequently resulting in poor seed quality with the exception of very few specialized individual or group farmer organizations that manage to acquire limited amounts of basic seed from the national potato programs to propagate one or two additional field generations before is sold to ware

producers. In some countries, particularly in Kenya, some seed producers follow government regulated seed certification procedures, but due to the limited number of inspectors and not well-developed and efficient service systems, the majority prefer to produce uncertified seed, but assuring their own seed quality.

The lack of seed or insufficient amount of pre basic and basic seed is a major limitation in establishing a sustainable seed industry in most countries in SSA and because functioning seed systems are the principle vehicle for new variety uptake and diffusion, CIP initiated efforts in Kenya to develop a strategy that involves the private sector in the production of potato in-vitro plantlets and minitubers. The private sector provides additional sources of pre-basic and basic seed which are usually produced by government programs. Private labs with tissue culture facilities, dedicated to the flower industry, trees, fruit tress and industrial crops were targeted for these activities.

The strategy focuses on the following objectives: a) persuading selected private companies to respond to the unfulfilled demand of high quality potato seed in the country by entering the potato seed business, particularly in the production of large scale in-vitro plantlets and minituber production, to complement their own business industry, b) engaging government sponsored plant health inspectorate services (KEPHIS) in the inspection and detection of diseases and pests directly in materials grown in the private sector labs and screen houses and further supervision in later field generations and c) assisting selected private companies in the construction of quarantines screen houses for production of minitubers using both the traditional soil-based system and the new novel system that is nutrient solution-based called "aeroponics"; the latter increases the production of minitubers per plant five fold, replaces the need for substrate sterilization and reduces the final cost of tuber units significantly (Otazu *et.al.*, 2008; Struik and Wiersema, 2009).

Materials and methods

During the first phase, two interested private companies were selected and received technical backstopping for large scale production of in-vitro plantlets; the first, Genetics technologies International Limited (GTIL), a medium size company, located in Nairobi, and specialized in large scale in-vitro production of bananas, trees, fruit trees and herbal plants and the second, Oserian Flower Company, one of the largest companies located in Naivasha, and specialized entirely on export flowers for the European market. GTIL possesses 9 laminar flows, 6 growth chambers and over12 screen houses and Oserian has 30 laminar flows, 10 large growth chambers and numerous screen houses in addition to land. The plant quarantine station (PQS) of KEPHIS, was also included for minituber production of in-vitro plants produced by the two companies using traditional soil-substrate medium.

Advanced late blight resistant breeding materials included two varieties from Ethiopia CIP 384321.9 (Guasa) and CIP 384321.19 (Jalene) and five promising clones from population B3 Cycle 1 (B3C1), CIP 393280.82, CIP 391046.14, CIP 392657.8, CIP 393085.5 and CIP 393371.58; all derived from CIP's advanced late blight resistant breeding program and introduced as in-vitro plants from CIP HQ Lima, Peru.

The methodology in the first phase, involved the introduction of 50 in-vitro plants per clone from CIP Lima, received by PQS and delivered to both companies according to previous agreed protocol by KEPHIS. GTIL received three clones CIP 384321.9 (Guasa), CIP 384321.19 (Jalene) and CIP 393280.82 and Oserian four clones (CIP 391046.14, CIP 392657.8, CIP 393085.5 and CIP 393371.58). Both companies started multiplication of in-vitro plants in their own labs and tissue culture facilities to reach the requested target of 1,200 in-vitro plants per clone and delivered as rooted plantlets.

Sampling of in-vitro plants for virus detection was taken during in-vitro multiplication from both companies and also during the growing period at PQS quarantine screen houses. Water and soil samples were also taken from quarantine screen houses at PQS for bacterial wilt (BW) detection. All disease detection kits were obtained from CIP-Lima.

During the second phase, GTIL and a new interested private farm (Kisima farm) were involved in disease free minituber production while Oserian Flower Company remained on stand by but available for large scale production of in-vitro potato plants. Two commercial varieties derived from CIP, Tigoni and Asante, were used for the production of minitubers as pre-basic seed; and the new "aeroponic" technology (Kim *et.al.*, 1999; Farran and Mingo-Castel, 2006; Otazu *et.al.*, 2008) to produce minitubers was established in quarantines screen houses in both places plus an additional small soil-substrate based screen house at GTIL.

Results and discussion

Involving the private sector in the production of large scale in-vitro plantlets

Several visits to the private companies were carried out during mid 2007 to confirm their infrastructure, adequate tissue culture facilities, technical capacity and to motivate them to enter into the potato seed business sector by getting involved in large scale production of pre-basic seed (in-vitro plants and minitubers), traditionally produced by the research station KARI-Tigoni in limited amounts and unable to meet country's high quality seed demand. Similarly, visits were made to the Kenyan Plant Health Inspectorate Service (KEPHIS), seeking technical supervision and regulatory support to the private sector for their involvement in the potato seed industry including production of pre-basic, basic and certified seed. The KEPHIS approach resulted in an official agreement to support and collaborate with the private industry, the development of procedures and quarantine protocols for introduction of in-vitro plants originated from CIP-Lima and also from PQS, supervision of large scale disease free production of in-vitro plants and minitubers at the private tissue culture facilities and quarantine screen houses. Likewise, agreements with the two selected private companies for the production of large scale in-vitro rooted plantlets, as the first stage to demonstrate their capacity to manage and deliver disease free in-vitro plants from potato, were finalized . Approval for the involvement of private sector in the production of quarantine grown minitubers during a second phase was also reached as well as further field multiplication of basic and certified seed following a three generation seed production strategy ("3G") as a short-time frame work under establishment through a USAID funded CIP project (I. Barker and X. Kaiyun; pers. comm.).

Both private companies GTIL and Oserian delivered 1,200 well developed rooted plantlets per clone in an approximately 2-month period (Tables 1 and 2), although they could have produced larger amounts in the same period or shorter; demonstrating high capacity to produce successfully in-vitro plants from potato at large scale. There is no doubt that these companies after the first experience on producing potato in-vitro plants, could also produce minitubers if adequate quarantine infrastructure was made available; however, their decision to get involved in minituber production as a second stage would depend on the convincing evidence of high quality seed demand in the country, institutional support for building a private seed industry, and need for starter clean seed stocks (pre-basic and basic seed) in larger amounts. Only then, these private companies would show willingness to venture into the production of clean seed stocks and high quality seed, and invest on building the necessary infrastructure (quarantine screen houses). In this regard, CIP together with supporting funds from GTZ and USAID and other stakeholders is committed to provide technical backstopping to these companies, bring novel technologies for minituber production and build the necessary infrastructure on a partly subsidized basis.

Table 1. Production of in-vitro plants by Oserian Flowers and delivery of rooted plantlets

CIP clone Lumber	In Vitro plants from CIP	Plantlets used	Multiplied	Comments	Date	No. of days
393371.58	25 tubes/2 plts each	50	176	1st transfer	25/09/07	
		176	470	2nd transfer	24/10/07	
		470	1,200	3rd transfer	21/11/07	
			1,200	Delivery	10/12/07	75
391046.14	25 tubes/2 plts each	50	194	1st transfer	25/09/07	
		194	590	2nd transfer	24/10/07	
		590	1,200	3rd transfer	21/11/07	
			1,200	Delivery	10/12/07	75
392657.8	25 tubes/2 plts each	50	108	1st transfer	25/09/07	
		108	695	2nd transfer	24/10/07	
		695	1,200	3rd transfer	21/11/07	
			1,200	Delivery	10/12/07	75
393085.5	25 tubes/2 plts each	50	175	1st transfer	25/09/07	
		175	525	2nd transfer	24/10/07	
		525	1,200	3rd transfer	21/11/07	
			1,200	Delivery	10/12/07	75

Table 2. Production of in-vitro plants by GTIL and delivery of rooted plantlets

CIP clone number	In vitro plants from CIP	Plantlets used	Multiplied	Comments	Date	No. of days
384321.19	25 tubes/2 plts each	50	345	1st transfer	9/10/07	
		345	300	2nd transfer	5/11/07	
		300	1,200	3rd transfer	26/11/07	
			1,200	Delivery	10/12/07	61
384321.9	25 tubes/2 plts each	50	375	1st transfer	9/10/07	
		375	300	2nd transfer	5/11/07	
		300	1,200	3rd transfer	26/11/07	
			1,200	Delivery	10/12/07	61
393280.82	25 tubes/2 plts each	50	420	1st transfer	9/10/07	
		420	300	2nd transfer	5/11/07	
		300	1,200	3rd transfer	26/11/07	
			1,200	Delivery	10/12/07	65

Likewise, CIP has initiated studies to diagnose the current situation of the seed industry in the country, quantify the real seed demand and market and propose alternative scenarios for the development of potato seed industry in Kenya with high involvement of the private sector and other relevant stakeholders.

Involving the private sector in the production of in-vitro plantlets and minituber production through conventional soil-substrate based and nutrient-solution based methods

After the successful experience of both companies (GTIL and Oserian) in the production of in-vitro plants, and quarantine minituber production at PQS from in-vitro plants originated in these companies (Table 3), GTIL showed high interest on engaging in the production of minitubers (G1) and two additional field grown generations (G2 and G3) before is sold to seed suppliers and ware producers; whereas, Oserian more cautiously decided to wait for the seed demand study, although expressed immediate interest if market for the miniubers produced are ensured.

Table 3. Minitubers produced at PQS from in-vitro plants delivered by GTIL and Oserian

Clone number	Virus test	BW test	Total tuber weight kg.	Total no. of pots 2 plt/pot	Total no. of tubers (>5 gr)	Total no. of tubers clone	Total no. of tubers	Av. no. tubers/ pot
391046.14	-	-	35.0	497	3,500	1,500	5,000	10
393371.58	-	-	35.4	466	6,500	1,700	8,200	18
393280.82	-	-	18.4	400	2,000	1,350	3,350	8
384321.9	-	-	22.8	550	3,500	1,400	4,900	9
384231.19	-	-	75.2	552	4,120	1,450	5,570	10
Totals	**-**	**-**		**2465**	**19,620**	**7,400**	**27,020**	

* In-vitro clones from 2 clones (1,200 each) were delivered to KARI-Tigoni research station

During mid 2008, GTIL invested on remodeling two screen houses into quarantine environments out of which one is under traditional soil-based substrate and the second to host the nutrient-solution based unit "aeroponics" for disease free minituber production. All activities including remodeling of screen houses, construction of aeroponics units were done under full supervision and technical support from CIP. Two well known local varieties originated from CIP's germplasm, Tigoni and Asante, currently expanding in main potato

areas in the country, were recommended for production of clean seed stocks and further diffusion throughout the country. In late 2008, fifty disease free in-vitro plants per variety, obtained from PQS were delivered to GTIL as starting material for further multiplication. A total of 5,500 in-vitro plants for the two varieties were obtained for transplanting in both screen houses, out of which 3,500 were used in the soil-based substrate SH, hosting 1,620 pots at a rate of two plant per pot and 1,510 in the aeroponic units. Overall minituber production of approximately 90,000 minitubers were expected in early 2009 from both screen houses using conservative estimates of 8 tubers per pot in the traditional system and 50 tubers per plant in the aeroponic system (Otazu *et. al*., 2008; Struik and Wiersema, 1999). However, the overall minitubers production was significantly reduced to a total of 23,229 minitubers as plant growth and survival rate were severely affected by increasing temperatures during the summer season as well as tuberization response (Table 4). Despite the high temperature effects on plant growth and survival, the average rate of minituber production per pot (2 plants) in the traditional system was 14.6 minitubers /pot and 19.2 minitubers per plant in the aeroponics system.

Table 4. Minituber production of cvs. Asante and Tigoni at GTIL (Sept. – Dec. 2008)

Minituber production system	Total SH capacity plants/pots	No. of plants survived	Survival rate (%)	No. of minitubers produced	Ave. no. of tubers/pot/plant
Aeroponics	1,510	512	34	9,850	19.2
(plants)					
Traditional	1,610	916	57	13,379	14.6
(pots)					
TOTAL				**23,229**	

During early 2009, an additional interested private entrepreneur "Kisima farm" was also involved in the production of disease free minitubers via "aeroponics" as starter pre-basic seed (G-1) and intends further field production of basic and certified (G2 and G3). GTIL also constructed a second aeroponic unit with larger capacity (Figures.1 and 2) and CIP built another aeroponic unit at Kari-Tigoni in support to the potato research station. All units were built with technical backstopping from CIP and completed in late April 2009. Planting of in-vitro plants in all aeroponic units were done during the cool season (May – September 2009) and plant growth and development have been established successfully and expected to produce minitubers normally and at full capacity (Table 5). Minitubers produced by the private and public sector as pre-basic seed will be monitored by CIP who will also guide them into the production of additional two field multiplications as basic and certified seed (G2 and G3), before is sold to ware growers and seed suppliers. CIP is committed to provide technical backstopping and monitoring for the successful establishment of these seed systems, particularly in the private sector.

Table 5. Estimated number of minitubers on four aeroponic units and one traditional (May-September, 2009

Institution	SH type	No. Pots/plants	Mtbers/pot/plant	Total no. minitubers
GTIL	Traditional	1,620	8	12,960
	Aeroponics	1,570	50	78,000
	Aeroponics	2,100	50	105,000
Kisima	Aeroponics	1,950	50	97,500
Tigoni	Aeroponics	1,990	50	99,500
	TOTAL			**392,960**

Current CIP efforts to facilitate the establishment of private sector seed systems to improve seed quality and increased capacity to produce larger amounts of seed in Kenya, should result in a more sustainable seed

production system, but also contribute to satisfying the currently unmet demand for high quality seed in the country. It will also become a useful and efficient instrument for variety promotion and diffusion of already released varieties, with their associated pro-poor traits, and new ones being introduced through the breeding "pipeline" in the near future.

Figure1. Aeroponic unit at GTIL

Figure 2. Minituber production at GTIL

Involving the private sector seed systems in the promotion and diffusion of new varieties

CIP, with its partners, is facilitating the development of a well established large-scale private sector seed production system, including pre-basic, basic and certified seed and using more efficient and novel rapid multiplication technologies. This enhanced capacity for the production of quality seed will constitute the instrument needed to introduce new varieties and speed up their promotion and diffusion to farmers. By producing large amounts of pre basic, basic and certified seed in a short time framework and making them available to seed suppliers and ware producers, will make variety introduction and diffusion quick and efficient. On the contrary, the lack of seed systems or deficient schemes, as it is at present, makes variety introduction and diffusion lengthy and inefficient, consequently precluding farmers benefiting from additional agronomic and market qualities carried in these new varieties. Additionally, with efficient seed systems, variety replacement and diffusion can be done routinely as needed, responding to farmers and market needs and demands, and also to challenges from increasing environmental and disease constraints.

Complementary to CIP efforts to establish private sector seed systems and diffusion of varieties, CIP is also supporting KARI-Tigoni potato research station to officially release and register new varieties. In this regard a new set of late blight resistant clones with variety potential, high yielding capacity, broad adaptation and high quality for table and processing are currently evaluated in national performance trials (NPT) under KEPHIS supervision for formal variety releases and registration. Newly registered varieties will be the first to be introduced through the newly established seed system for promotion and diffusion, although, varieties Tigoni and Asante have been already used for both establishing the seed system and further diffusion to farmers.

Acknowledgements

The authors would like to acknowledge the financial support of the CIP core donors and in particular USAID and GTZ. The help of project partners including KARI-Tigoni, KEPHIS, GTIL, Kisima Farm and Oserian is alos gratefully acknowledged.

References

Crissman C. C., L. McArthur Crissman and C. Carli. 1993. Seed Potato Systems in Kenya: A Case Study. Lima, International Potato Center. 44 p.

Farran, I. and A.M. Mingo-Castel. 2006. Potato minituber production using aeroponics: Effects of Plant density and harvesting intervals. Amer J of Potato Res 83:47-53.

Kim H.S, E.M. Lee, M.A. Lee, I.S. Woo, C.S. Moon, Y.B. Lee and S.Y. Kim. 1999. Production of high quality potato plantlets by autotrophic culture for aeroponic systems. J Korean Soc Hort Sci 123:330-333.

Kaguongo, W.P., P. Gildemacher, P. Demo, W. Wagoire, P. Kinyae, J. Andrade, G. Forbes, G. Thiele and K. Guglie. 2007. Farmer practices and adoption of improved potato varieties in Kenya and Uganda. International Potato center (CIP), Lima, Peru. Social Science Working Paper 2008-5. 85p.

Kinyae P.M.; M. Nyongesa, P. Gildemacher, M. Wakahiu and A. Walingo. 2005. Promotion of research-farmer partnerships. Annual Report 2005, National Potato Research Center, KARI (Kenya Agricultural Research Institute) Tigoni. 39-42.

Rolot, J.L. and H. Seutin. 1999. Soilless production of Potato minitubers using hydroponic technique. Potato Res. 42:457-469.

Struik, P.C. and S.G. Wiersema. 1999. Seed Potato Technology. Wageningen Press. Wageningen, pp.175-216.

Otazu, V., I. Barker, E. Chujoy 2008. Innovation in seed potato production for developing countries using aeroponics. Conference Potato Science for the Poor. 25-28 March. Cusco-Peru.