



Major In Vitro Techniques for Potato Virus Elimination and Post Eradication Detection Methods. A Review

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Abstract

Potato is an economically important agro-industrial crop that is conventionally propagated, however; its potential transmission of viruses through seed tubers from generation to generation is a major limitation of potato yield production. In order to produce potato virus-free and sufficient amount of potato seed tubers, several approaches of in vitro methods for virus elimination have been developed. Meristem culture has been used alone or combined with techniques such as thermotherapy, electrotherapy, cryotherapy and chemotherapy as the best alternative method for treating potato infected by viruses. Recent literature has shown that to eliminate potato virus significantly depends upon the potato cultivar, antiviral agents, type of virus, the duration of heat treatment. Appropriate duration for efficiency elimination is still under investigation. Viral elimination rate can be detected through serological methods such as enzyme-linked immunosorbent assay (ELISA) and molecular biology technique such as real time reverse transcriptase polymerase chain reaction (real time RT-PCR) that are used for pre and post elimination virus detection to evaluate the efficiency and the accuracy of virus elimination method. The purpose of this review is to highlight virus elimination methods in potato and recommending the most effective tool for virus detection in order to ensure the production of potato plantlet free of viruses.

Resumen

La papa es un cultivo de importancia económica agro-industrial que se propaga de manera convencional, no obstante, la potencial transmisión de virus a través del tubérculo-semilla de generación en generación es una limitación mayor en la producción del rendimiento. Con el fin de producir papa libre de virus y suficiente cantidad de tubérculo-semilla de papa, se han desarrollado varias estrategias de métodos in vitro para la eliminación de los virus. El cultivo de meristemas se ha usado solo o combinado con técnicas tales como termoterapia, electroterapia, crioterapia y quimioterapia, como el mejor método alternativo para tratar papa infectada por virus. La literatura reciente ha demostrado que para eliminar virus significativamente se depende de la variedad de papa, agentes antivirales, tipo de virus, la duración del tratamiento térmico. Aun esta bajo investigación la duración apropiada para la eliminación eficiente. El nivel de la eliminación del virus puede detectarse por métodos serológicos, tales como el inmunoensayo con enzimas conjugadas (ELISA) y técnica de biología molecular, como la reverso-transcripción de reacción en cadena de la polimerasa en tiempo real (RT-PCR) que se usan para la detección del virus pre y post eliminación para evaluar la eficiencia y la precisión del método de eliminación del virus. El propósito de esta revisión es resaltar los métodos de eliminación de virus en papa y en la recomendación de la herramienta más efectiva para la detección de virus para asegurar la producción de plántulas de papa libres de virus.

Keywords Potato seed tubers · Virus elimination methods · Meristem culture · Chemotherapy · Thermotherapy · Electrotherapy · Cryotherapy

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Introduction

Potato (*Solanum tuberosum* L.) plays an important role for sustainable world food security and it is among the four largest crop produced annually at high proportion of the global total area and yield after rice, wheat and

maize (Wang et al. 2011). International center for potato (CIP) and its partners have shown potato as playing a dual role in food security, firstly as cash crop at the market and as food grown for consumption with great nutritive value (Devaux et al. 2014). As demographic growth continues to increase and causes not only steady hunger rates in developing countries, but also uncertainties in crop production yield. It has been highly recommended by FAO (2009), and was found to be one of the primary food sources for andean people (Lutaladio and Castaldi 2009). After being introduced into China as the first potato producing country and among the world biggest population countries through Silk Road, it has made a great contribution in food security of Chinese people (Zhang et al. 2017).

Vegetative propagation using potato tuber seeds are the main used method by farmers (Otroshy 2006). Among the main majors issue associated with vegetative clonal multiplication of potato-seed, susceptibility to viral, bacterial and fungal diseases are accounted (Loebenstein 2001). According to Bamberg et al. (2016), world potato-producing regions are fast infected by viruses and the use of infected plant seed tubers has been reported to be the main avenue of disease spread within pandemic regions (Legg and Thresh 2003). However, farmers are unable to detect visually viral diseases symptoms, due to their variability and poor expression on leaves.

Previous research has reported that about 40 species of viruses are infectious to potato worldwide (Valkonen 2007). The yield reduction due to viral diseases may go up to 75%, and only infection caused by potato virus X (PVX) alone can reduce the yield up to 15–30%; and a high proportion of tuber yield reduction has been reported to be caused by potato leaf roll virus (PLRV) and some strains of potato virus Y (PVY) (Mellor 1987). According to Loebenstein (2001), at least 37 viruses occur worldwide in potato, these are PLRV, potato aucuba mosaic virus (PAMV), potato mop-top virus (PMTV), potato virus A (PV A), potato virus M (PVM), potato virus S (PVS), PVX and PVY to cite a few. And others are found in limited geographical areas of the world; these include arracacha virus B (AVB), beet curly top virus (BCTV), eggplant mottled dwarf virus (EMDV), potato black rings pot virus (PBRV), potato virus U (PVU), potato T virus (PVT) and tobacco streak viruses (TSV).

Among virus species mentioned above, PLRV, PVA, PVM, PVS, PVX, and PVY have been reported to significantly affect cultivated potato and reduce potato crop production in general (Wang et al. 2011). Further results showed PVY to be the most prevalent potato virus worldwide due to some genetic modification that occurred in this viral species (Davie et al. 2017). Example is given to potato tuber necrotic ringspot

disease PTNRD which is a most prevalent disease induced by PVY, probably caused by emerging of the biological and genetic diversity of PVY leading to increased viral incidence in seed production (Karasev et al. 2013). Very recently, molecular characterization of potato spindle tuber viroid (PSTVd) isolates from potato has been done to reveal the viroid variants (Qiu et al. 2016). Epidemiologically, the main viruses that are causing mosaics in potato plants are PVY, PVA, and PVM and sometimes by PVX, and these diseases can be caused by one of the viruses or by coinfection of both of them (Kostiw 2011). PVS is prevalent over the world but it is less important given that it only causes little reduction in yield production (Loebenstein 2001).

Effort has been and are still being made to eradicate virus propagation for establishing a national standard and producing certified seed potatoes from in vitro virus-free stock plantlets to certified seed tubers (Grade II) that are delivered to potato growers for commercial production (Danci et al. 2012). The aim of this review is to provide a comprehensive and systematic overview of previous studies related to the developed in vitro methods and modified complex methods for potato virus elimination and post-eradication detection methods.

Major Potato Virus Elimination Methods

Potato is the first major food crop where in vitro techniques have been applied for virus-free plantlets production (Khurana 2004). Apart from the application of genetic engineering techniques for the development of potato virus resistance (Orbegozo et al. 2016), in vitro methods are the most practically used methods to preserve potato genotype as potato cultivars are highly heterozygous clones and are maintained vegetatively (Bamberg et al. 2016). Therefore, to control potato viruses, virus-free seed tubers is an effective and practical means which is used (Faccioli and Colombarini 1996). Several methods have been used to eliminate plants viruses and it has been the same for virus infected potato. Cryotherapy, electrotherapy, meristem culture, thermotherapy, and chemotherapy are the main methods used in many countries (Table 1). Previous literatures have shown thermotherapy and/or chemotherapy to be the most important and reliable methods for obtaining virus-free plants from clonally propagative infected potato (Bamberg et al. 2016), and meristem culture to be the routine method for producing virus-free potato plants (Danci et al. 2012). Cryotherapy was found to be more rapid, efficient and simple method for producing potato virus-free plants than meristem culture (Wang et al. 2006, 2008). All above mentioned methods are discussed in this review.