

# Chapter 1. Introduction

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## Abstract

Potato is an important crop for food security. However, it is very vulnerable to diseases and pests and these are partly seed-borne and therefore transmitted from one generation to the next. Breeding is cumbersome while multiplication is slow. These issues can be solved by a new technology: hybrid breeding based on true potato seed. This book gives an overview of relevant developments in creating new opportunities making use of this technology. This introductory chapter describes the aims of the book, provides a main agenda for debate on this new technology and outlines the structure of the book and briefly indicates the contents of its chapters.

**Keywords:** hybrid breeding, true potato seed, *Solanum tuberosum*, agro-industrial context, international development context

## 1.1 Preamble

Potato (mainly *Solanum tuberosum* L.) is arguably the world's third food crop for human consumption and grown all over the world. Accordingly, there is an important role for the potato in achieving global food security today and in the future. However, as a vegetatively propagated tuber crop the potato is highly vulnerable to diseases and pests, and its bulky and water-rich produce is difficult to transport and store. On a global level, propagation, storage and distribution of high-quality seed tubers is one of the main constraints that limit production (Tadesse *et al.*, 2020; Schulte-Geldermann *et al.*, 2022). In developing countries, the yield per hectare is often low, mainly due to the use of poor starting material and sub-optimal cultivation methods (Gildemacher *et al.*, 2009; Thomas-Sharma *et al.*, 2016). With the abundant use of chemical crop protection products, potato cultivation also has a high environmental impact. Therefore, there is a pressing need for potato varieties that can be grown in more sustainable ways, with higher yields in different climate zones and under diverse agro-ecological conditions (Edelenbosch and Munnichs, 2020).

Compared with other major crops, breeding of the common tetraploid potato is a cumbersome and time-consuming process and genetic improvement has been slow. This is partly caused by the large number of traits for which breeders need to select (especially for potatoes that are grown as table potatoes or for the food processing industry), but partly also due to the tetrasomic inheritance. In the last decade there has been a concerted effort to develop a novel approach in potato breeding

which makes available potato starting material for cultivation in the form of diploid hybrid true potato seed (Lindhout *et al.*, 2011; Jansky *et al.*, 2016; Lindhout *et al.*, 2018). This seed is devoid of (almost all) contaminating pathogens and pests and can be rapidly propagated, and easily transported and stored. The diploid hybrid potato also promises to significantly accelerate the process of breeding compared to conventional practices today (Lindhout *et al.*, 2018; Su *et al.*, 2020). As a result, this new hybrid potato may provide a highly promising response to the global challenges of food security, sustainability and climate change.

## 1.2 Aims of the book and main agenda for debate

The promises of hybrid potato breeding, the topic of this book, strongly resonate with a more general debate in the literature about the role of plant breeding in responding to the United Nations Sustainable Development Goals (SDGs) (Zimmer and De Haan, 2019). Especially relevant in this context is SDG 2, with the achievement of global food security, improved nutrition and promotion of sustainable agriculture as its major aims. How could hybrid potato breeding contribute to these goals? In order to better understand the potential of this innovation, this book focuses on the societal goals and system conditions that may guide and shape the future of hybrid potato. In considering this future, two issues can be identified as the main topics for debate:

- Hybrid breeding will be an important driver for rapid variety development, creating new added value, both commercially and from a societal point of view. This raises questions about the needs to which this variety development should respond. How to connect commercial interests and values with innovation that contributes to the common good, responding to food security, sustainability and climate change as major societal challenges expressed in the global sustainable development goals?
- Hybrid varieties will become available as true potato seeds that can be propagated, stored and transported as a commercial (or public) source of clean and high-quality planting material, but with less growth vigour than the commonly used seed tubers. This creates new opportunities and challenges for the organisation of potato value chains, with cultivation systems that may vary from direct sowing by farmers, to using plantlets or (mini)tubers produced in special nurseries. What would be the implications of these various system choices for different stakeholders in the potato sector?

To discuss these issues, this book brings together the visions, knowledge and experiences from a wide community of scholars and professionals, representing the worlds of breeding, business, international development, policy making and a variety of disciplines ranging from the natural to the social sciences. Most contributions to this book stem from an international online conference about the future of hybrid potato, organised with support of the Netherlands Food Partnership, that took place on November 30<sup>th</sup>, 2020, with more than 150 participants worldwide (Stemerding *et al.*, 2020).

## 1.3 Two system contexts

In this book, the hybrid potato is discussed as a system innovation which may affect almost every step in the potato value chain. Accordingly, hybrid potato breeding and hybrid true potato seed

are viewed together as a potentially disruptive and game changing technology, involving all players in the sector. For a further understanding of the impact of this innovation, the hybrid potato is considered in two different global system contexts, including on the one hand the agro-industrial context of Western Europe, and on the other hand the international development context of Africa.

A well-developed agro-industrial system, like the potato sector in Western Europe, may lend itself in many ways to the introduction of a hybrid potato, although it may also have to undergo significant system transformations to enable a successful introduction of hybrid varieties and seed. In developing countries, on the other hand, and in Africa in particular, we find a mostly informal potato sector dominated by smallholder farmers. In this international development context, a hybrid potato offers new opportunities, but the conditions for potato cultivation with commercially sourced hybrid seed are much more challenging. By considering the future of hybrid potato in both system contexts, the agenda for debate is elaborated in this book in more concrete, context-specific ways.

## 1.4 Structure of the book and chapter contents

The chapters in this book cover three related thematic subjects. In the second and third chapter the hybrid potato breeding system is introduced and different scenarios are discussed as possible futures for this system, including the implications of these futures for food security, sustainability, and public policy making. The next two chapters focus on the prospects and impacts of hybrid potato innovation for the Dutch potato sector as a vibrant centre in the international potato world, and discuss ensuing policy challenges in the field of international seed regulation. These two chapters specifically relate to the agro-industrial system context in which hybrid breeding must gain a foothold as a potentially disruptive innovation. In the next five chapters the focus of the book shifts to the international development system context. These chapters include discussions of the potential impact of hybrid potato in Sub-Saharan Africa, the role and responsibilities of corporations in this context, and the different ways in which public-private partnerships may help to harness hybrid potato breeding for smallholder farmers. On the basis of these contributions, the final chapter of this book addresses the major findings, in particular regarding the complex nature of hybrid potato innovation, the goals of hybrid variety development, and the organisation and inclusiveness of hybrid potato seed and production chains.

In Chapter 2, the approach and potential of hybrid potato breeding is discussed in comparison with traditional potato breeding (Lindhout and Struik). By generating and selecting inbred homozygous diploid parent lines, a hybrid diploid potato breeding programme can be established which enables faster and more predictable breeding than traditional tetraploid breeding. The multiplication of uniform hybrid seeds can be done under strict phytosanitary conditions and is much more efficient than the multiplication of seed tubers. Thus, hybrid breeding and hybrid true potato seeds have great potential to contribute to global food and nutrient security. However, the introduction of hybrid breeding is also challenging as it involves a potentially disruptive system innovation, changing many steps in the seed and potato production chain.

Chapter 3 focuses on the wider system conditions that may shape the future of hybrid potato (Edelenbosch and Stermerding). It describes how this future has been explored in an interactive process with a variety of stakeholders from the potato sector and beyond. The aim of this process was to foster responsible innovation by seeking ways in which innovation in potato breeding can respond to major societal challenges. With the input of the participants, scenarios were developed showing how the future of hybrid potato may take different directions in a complex interplay of technological and societal developments, with different implications for food security and sustainability on a global level. The participants discussed both the plausibility and desirability of these different scenarios and the major lessons that could be drawn from this scenario exercise.

In Chapter 4, the position of the Netherlands as the largest exporter of seed potato tubers worldwide is put in historical perspective (Louwaars). The chapter explains how the geographical location of the Netherlands in combination with political, institutional and technological developments have resulted in the unique position of the country in the area of seed potato tubers. These developments include public support for potato breeding science, collaboration between farmer-breeders, companies and the government, an early operating system for the protection of plant breeders' rights, and seed quality controls and phytosanitary services as important policy issues of concern. The chapter also discusses the implications of new technological developments like hybrid breeding for the leading position of the Netherlands.

Chapter 5 addresses the global regulatory frameworks that have been established in the agro-industrial context for registration, protection and commercialisation of potato as a crop that is commercialised via seed tubers (Meijerink). The chapter discusses in a systematic mode to what extent existing frameworks apply to new hybrid varieties and true seed, and to what extent these frameworks need to be adjusted or even newly created. In considering these issues the chapter also refers to established requirements and rules for hybrid vegetable crops belonging to the same nightshade family as potato. Although current systems for these hybrid vegetables could be used as examples to legislate hybrid true potato seeds, the routes to do so may not be easy.

Chapter 6 discusses the potential significance of the hybrid potato for potato cultivation in Sub-Saharan African (Gildemacher and Ter Steeg). In this international development context, access to high-quality seed potato tubers remains a most important barrier for intensification of smallholder potato production. On the basis of a seed potato and value chain analysis, the chapter explores how hybrid breeding and seed could improve the availability and use of high-quality planting material and break the deadlock of stagnating productivity levels. Internationally and commercially produced hybrid potato seed can be made available to smallholder farmers through a decentralised system of local multiplication, producing plantlets or tubers as high quality and clean planting material. Another major opportunity of hybrid breeding is variety development tailored to the needs of African smallholder farmers.

Chapter 7 also focuses on the opportunities offered by hybrid true potato seed to foster the development of the different potato sectors in East Africa (Den Braber, De Vries, Kacheyo, Struik and Descheemaeker). For a better understanding of the merits of hybrid potato seed in an international development context, this chapter takes the earlier experiences with True Potato Seed

(TPS) as a starting point, showing that TPS-based potato production systems are feasible in a wide variety of agroecological and socioeconomic circumstances. However, a crucial requirement for an effective and inclusive introduction of the novel hybrid true potato seed, is the mutual alignment between the technological characteristics of this innovation and the diverse needs, preferences and realities of African potato farmers. Therefore, the chapter emphasises the involvement of farmers and other stakeholders as a precondition for responsible innovation in potato breeding.

Chapter 8 highlights recent experiences of Dutch vegetable seed companies with the introduction and marketing of improved hybrid varieties in an international development context, focusing on tomato in Tanzania and shallot in Indonesia (Ter Steeg and Gildemacher). By considering the – seed, farm and market – system transformations that were required for a successful introduction of hybrid varieties in these cases, the authors draw lessons for hybrid potato seed innovation. The success of the introduction of hybrid potato will depend on the entire systemic context, and the magnitude of the systemic changes required for the introduction of hybrid seed and varieties is an important indicator of the chance of success. The promises of hybrid potato may fuel the necessary change of the seed, farm and market system, but the challenge is to find a balance between disruption and integration.

Chapter 9 focuses on Dutch potato breeding companies who are world leaders in the export of certified seed potato tubers and are also in the position to play a pivotal role in hybrid breeding (Swart and Van de Poel). The chapter explores how these companies perceive their responsibility with regard to food security and sustainability as Sustainable Development Goals (SDGs). It shows that firms indeed keep these goals in focus from a Corporate Social Responsibility (CSR) point of view. However, whereas firms connect breeding as their private core business with CSR and SDGs in a quite straightforward way, the chapter emphasises that food security and sustainability are complex societal challenges, whereby hybrid breeding needs to be considered as a common good, and CSR requires a collective effort, with cooperation between firms, public institutions, civil society and farmers' organisations.

Chapter 10 again addresses the issue of cooperation, arguing that neither the private nor the public sector can fully harness the potential of hybrid diploid breeding alone (Beumer and Almekinders). The central question of this chapter is how public-private collaborations can best be organised to enable access for smallholder farmers to the benefits of hybrid potato breeding. It explores – from a commons perspective – four models for institutionalising public-private partnerships and assesses the potential of each model for overcoming the challenges of access for smallholder farmers. A better understanding of the strengths and weaknesses of these different models might serve as a starting point for the public and private sectors to come together and discuss how they can combine their forces for the benefit of smallholder farmers around the world.

Chapter 11 summarises the major findings from the different chapters for both the agro-industrial and international development context, focusing on hybrid variety and seed value chain development as the major topics for debate (Stemerding, Struik, Lindhout and Gildemacher). In the agro-industrial context, hybrid potato may transform as well as strengthen established business models and also creates a need for adjustment of global regulatory frameworks. In

the international development context, the introduction of hybrid potato will require either transformation of existing seed, farm and market systems, or integration in these systems. Public-private collaboration will be needed to facilitate the development and dissemination of varieties that are suited to the specific conditions and needs of smallholder farmers, also responding to the challenges of poverty, food security and climate change.

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