Geoforum 130 (2022) 96–104

Contents lists available at ScienceDirect

Geoforum

journal homepage: www.elsevier.com/locate/geoforum

Why Africa's New Green Revolution is failing – Maize as a commodity and anti-commodity in South Africa

Klara Fischer

Department of Urban and Rural Development, Swedish University of Agricultural Sciences, Box 7012, 750 07 Uppsala, Sweden

ARTICLE INFO

Keywords:
Political ecology
More than human
Green Revolution
Africa
Multispecies

ABSTRACT

The South African Government has for the past two decades spent significant resources on introducing smallholders to Genetically Modified (GM) maize with the aim to make agriculture a way out of poverty. However smallholder farming continues to decline and poverty is on the rise in the country. The present paper aims to explain this failure of the government to support its smallholders by describing the intra-actions between maize, politics and technological development in South African history. Importantly maize is understood here as an agent in that its materialities are not only being impacted by, but are also having impact on the outcome of farming practices and wider political economies. The paper describes how maize, as a result of intra-action between maize biology and choices made by farmers, politicians and breeders during the colonial era and apartheid, developed in parallel as a commodity serving the settler farmers, and an anti-commodity, or escape crop, providing subsistence to marginalised smallholders. While South Africa today is a democracy that spends significant resources on improving smallholder livelihoods, recent technological development and market concentration have increased rather than decreased the gap between commodity- and anti-commodity maize. As a result new GM and hybrid maize varieties introduced to smallholders today are badly equipped to facilitate a crop led New Green Revolution.

1. Introduction

The South African government is spending significant resources on smallholder agricultural development as the key route out of poverty (Fischer and Hajdu, 2015). Maize, simultaneously a major export crop, and a staple that offers subsistence to millions of smallholder farmers, lies at the heart of this effort (African Centre for Biodiversity, 2018; Fischer and Hajdu, 2015). The focus on agricultural development through maize in South Africa is part of a wider trend that in the past two decades has seen renewed attention being paid to crop technology and market integration as key components of agriculture led poverty reduction in Africa. Mention is often made of a 'New Green Revolution' for Africa (Patel, 2012; Schurman, 2018), with reference to how new higher-yielding varieties of wheat and rice led to widespread poverty reduction through agricultural development during Asia's Green Revolution in the 1960s (Hazell, 2009). It is argued that African smallholders are lagging behind because they have not adopted these modern, higher-yielding crop varieties (Dzanku et al., 2015).

Genetically modified (GM) crops, and recently hopes for crops gene-edited through technologies such as Crispr, occupy a central place in the discourse about this New Green Revolution (Cremer, 2017; Thompson, 2012; Eddens, 2019). However, South Africa remains the only African country to have introduced GM crops as a core part of its agricultural development. GM maize was first introduced in South Africa in 1998, soon after transition to democracy (Gouse et al., 2005). Most of the maize grown in the country is GM maize (ISAAA, 2018) cultivated on large commercial farms that produce 95 per cent of the country's maize (Greyling and Pardey, 2019). Simultaneously millions of South African smallholders who plant maize for subsistence, suffer from increasing rates of poverty and food insecurity (World Bank, 2018). In an effort to make agriculture a route out of poverty, GM maize has over the past two decades been promoted to South African smallholders through public–private partnerships aiming to commodify smallholder farming and reduce poverty through new crop technology and market integration. Nevertheless, there is little indication that this has led to a revival of smallholder agriculture (Fischer and Hajdu, 2015; Granlund, 2020). Instead, recent publications indicate that the rate of agricultural disengagement by the poorest has increased in recent years (de la Hey and Beinart, 2017; Shackleton et al., 2019). While the South African case is extreme in many aspects, as will be described in this paper, the failure of

E-mail address: Klara.fischer@slu.se.

https://doi.org/10.1016/j.geoforum.2021.08.001
Received 5 December 2020; Received in revised form 5 August 2021; Accepted 9 August 2021
Available online 19 August 2021

a New Green Revolution in South Africa also resembles what is happening elsewhere in Africa (Scoones and Thompson, 2011; Brooks, 2014; Cioffo et al., 2016; Ignatova, 2017; Schnurr, 2019).

This paper suggests that in order to understand the repeated failures of crop technology-led agricultural development in Africa, there needs to be a focus on two key factors. Firstly, and as already highlighted in a key critique of the New Green Revolution (e.g. Patel, 2012), contemporary agricultural development needs to be understood against the backdrop of history. In the case of South Africa, the black majority population's extreme dispossession of the means of production has had significant implications for contemporary agricultural development (Greyling and Pardey, 2019). This paper will show how large commercial farmers' accumulation by dispossession in South Africa has been facilitated by crop technology development and has filtered down to maize biology. Here, the analysis is facilitated by the concept of crops as commodities and anti-commodities (Hazareesingh and Maat, 2016a), by highlighting key differences in how maize developed in settler farming and on marginalised smallholder farms. The concept also facilitates comparison with other situations in which, starting with colonialism, peasant communities and their cropping systems have responded and persisted despite the imperatives of commercial cropping introduced by colonisers. The novelty of the anti-commodities approach is that it places crops at the heart of the analysis, conceptualising how the cultivation of particular crops becomes a form of resistance to, or distancing from commodified agriculture (Hazareesingh and Maat, 2016a).

Secondly, and this is the present paper's main contribution, greater attention needs to be paid to the agency of crops than has so far been the case. Much academic critique of the New Green Revolution emphasises its problematic focus on new crops as 'technological quick fixes' or 'silver bullets' (Brooks, 2013; Dowd-Uribe, 2017). This critique indirectly suggests that crop-led agricultural development does not work because crops do not have the inherent agency to create the change that those promoting them suggest. However, even at the dawn of agriculture, the material qualities of crops had implications for their political role in state-making and resistance (Scott, 2017). The aim of this paper is therefore to deepen the analysis of the role of crop agency in agricultural development.

I argue that the issue with the discourse on a New Green Revolution is not that it gives agency to crops, but that it isolates crop agency, while in fact crops are entangled in multispecies assemblages in which their agency is relational (cf. Rocheleau and Roth, 2007; Head and Gibson, 2012; Guthman, 2019). This means that whether and how smallholders benefit or lose out from new GM maize depends on factors that are inherent in the biology of maize (in line with the way in which Hazareesingh and Maat (2016 a, b) and Scott (2017) give agency to crops), but also on how these inherent properties intra-act (Barad, 2007) with local ecologies and farm practices as well as with markets and policies. The concept of intra-action here serves to draw attention to how interactions go deeper than mere exchange between fixed entities, highlighting how farming practices and wider politics affect and are affected by the inherent materialities of crops. With this in mind, this paper provides a historically situated critique of the idea of a maize-based New Green Revolution.

1.1. *Understanding South Africa's failed New Green Revolution through the lens of maize and deagrarianisation in Xopozo*

To give context to the broader historical analysis of the development of maize as a commodity and anti-commodity in South Africa, and to allow smallholders' voices to be heard, I draw on previously published and unpublished data from ethnographic fieldwork in three villages (265 households) in Xopozo tribal authority in the former Transkei homeland, today Eastern Cape province, in South Africa (see Jacobson, 2013 for a more detailed description). Fieldwork took place over five months in 2008, and shorter overnight stays of four to eight days in 2006, 2009, 2012 and 2019. The methods and material for the work carried out up to and including 2012 is described in detail in Jacobson (2013). Fieldwork in 2019 focused on understanding the changes in farming since 2012. It includes participant observation and interviews over five days. I interviewed 13 farmers who were still planting their fields and 14 who were not, and I returned to 11 households strategically selected to include families classed locally as ranging from very poor to rich whom I had followed to document changes in livelihoods and farming since 2008.

Xopozo is deeply rural and far away from the coast or any tourist attractions. In the past, families commonly had members migrating for work in the mines hundreds of kilometres away from home. Some still do, although, following a wider trend in South Africa's former homelands (Granlund and Hochfeld, 2019; Shackleton et al., 2019), unemployment has persisted at high levels since the country transitioned into democracy, and in recent years even increased (World Bank, 2018), while agricultural engagement has decreased in the same period. Noting the historical link between smallholder farming and mine work, those who are most successful in farming in Xopozo today almost invariably describe this as a result of being able to invest in farming thanks to previous employment or having family members employed in the mines.

Maize is central to the local culture, and farming implicitly means planting maize. Maize is the main ingredient in the majority of local dishes, although people are increasingly also eating (purchased) rice. Maize is planted for subsistence, as food for the household and feed for livestock. Farming in Xopozo is not undertaken with the purpose of maximising yields, but is adapted to local ecologies and availability of labour, and designed to spread risk. Maize is planted from October to January and harvested between May and July, with green, unripe, maize being harvested even earlier. Planting times depend on access to draught power, timing of (increasingly erratic) rains and the type of maize seed planted. Poorer households often have to plant later as they have to wait to borrow draught animals for ploughing from those who own livestock.

Many households in Xopozo, like in other smallholder communities in the Eastern Cape Province (Shackleton et al., 2019; Hajdu et al., 2020), have decided in recent years to give up cultivating the field altogether (while smaller home gardens continue to be cultivated). Apart from immediate labour constraints, which are the key reasons in the poorest households for abandoning field farming, other reasons include damaged fencing around the fields leading to a high risk of crop damage by cattle, lack of local seed, people having fewer cattle for ploughing and it being easier to buy food in the supermarket. These reasons are very similar to those given by smallholders in other parts of the province (de la Hey and Beinart, 2017; Shackleton and Hebinck, 2018; Shackleton et al., 2019; Hajdu et al., 2020). Previous research I have undertaken, however, shows that the poorest households never give up planting out of choice; for them farming is central to their food security (Fischer and Hajdu, 2015; Jacobson, 2013). In 2008, 54 per cent of all the fields in the three study villages were cultivated. This frequency of planting was reported by locals as representing a significant decline compared with in the past. Data from one of the villages indicate that in 2019 only 14 per cent (15/105) of the households cultivated their fields. That year was described by local farmers as typical of the limited engagement in farming in recent years.

The South African government has spent significant resources to reverse the trend of deagrarianisation in smallholder communities. Monsanto's demonstration trials in Xopozo in 2001 of GM Bt maize (Yieldgard), resistant to stem boring insects, and herbicide tolerant (Roundup Ready) maize (hereafter Bt maize and herbicide tolerant maize), initiated a row of agricultural development programmes funded by the government, all with significant private sector engagement, and all aiming to reengage smallholders in agriculture by introducing them to 'modern' GM maize varieties and stimulating them to become 'entrepreneurial' and 'business minded' (Jacobson, 2013). Xopozo has been targeted by at least three such development programmes in the past 20 years. Crop agency is here seen as central, and as separated from wider political and economic assemblages, as exemplified in the following statement in the South Africa Year Book issued by the government in reference to the introduction of GM maize to smallholders:

> *"Genetic modification (GM) provides a way to meet the growing demand for food without placing greater pressure on scarce resources"* (South Africa Year Book, 2018/2019: 17)

To understand the reasons behind the failure of the South African government to reengage smallholders in farming through the introduction of GM maize, this paper investigates the historical, political and technological developments that have intra-acted with and shaped maize biology and made it into a commodity and anti-commodity in South Africa, from the colonial era until today.

The next section (2) describes how maize might be understood as a commodity and anti-commodity in South Africa. There is then a section (3) that explores the role of maize biology more deeply, pointing out in particular how intra-actions between biology, technology and politics have shaped maize into a commodity and anti-commodity. Finally section 4 discusses what this means for the possibility of maize to be a driver of smallholder agriculture development in South Africa today.

2. South African maize as a commodity and anti-commodity

The concept of anti-commodity is only loosely defined in the literature as "*an enduring form of production and action in opposition to either actual commodities and their existing functions, or to wider social processes of commodification, rather than simply a momentary form of protest or reaction*" (Hazareesingh and Maat, 2016b: 6). This definition implies that a longitudinal perspective is needed in order to fully grasp how crops emerge as commodities and anti-commodities. Anti-commodity studies have demonstrated how local people have resisted full colonisation by sticking to indigenous crops or how they have nurtured anti-commodity versions of crops that the colonial system aimed to commodify, e.g. rice and tobacco (Gillbert, 2016; Hazareesingh, 2016; Maat, 2016; Richards, 2016; Sinha-Kerkhoff, 2016).

With reference to Scott's (1985) work on peasant resistance, Hazareesingh and Maat (2016a) emphasise that many of the forms of resistance described in anti-commodity studies, as with Scott's accounts of passive resistance, are not active rebellion, but rather examples of ways in which peasants have maintained their livelihoods and how particular crops and cropping practices have facilitated opportunities to defy full immersion in commercial agriculture introduced by the colonisers (see also Scott (2010)). Importantly, the emerging literature on anti-commodities does not suggest that communities on the fringes of the state or capitalism are escaping capitalism entirely (Grubacic and O'Hearn, 2016; Hazareesingh and Maat, 2016a; Scott, 2017). Rather, anti-commodities emerge "*as a result of increasing pressure from global commodity markets*" (Maat, 2016: 50) and need to be understood in relation to their commodity counterparts (Gillbert, 2016; Hyde, 2016).

This is how the development of maize as an anti-commodity in South Africa should be understood. Maize arrived in Africa in the 16th century, and in South Africa probably about a hundred years later. It was initially planted and consumed as a vegetable by both settler and African farmers, but with the discovery of diamonds it was turned simultaneously into a commodity crop and a staple and subsistence crop dominating South African agriculture (McCann, 2001). Initially both native and settler farmers reaped the benefits of a growing need to feed urban mineworkers (Bundy, 1988; McCann, 2001; Feinstein, 2005). However the settlers' desire to reduce competition from African farmers, and the emerging competition for labour between the mines and expanding, commercialising settler farms, were important drivers for increasingly dispossessing native Africans of the means of production. This culminated in the 1913 Natives' Land Act, which legislated restrictions on ownership and tenancy on land based on race, forcing the black majority population to live on 13 per cent of the land in what were known as 'homelands' (Bundy, 1988). This was a much more comprehensive dispossession than occurred in neighbouring countries. Hendricks (1990) describes how settlers in Zimbabwe took about 50 per cent of the land, in Namibia 43 per cent, in Malawi 5 per cent and in Zambia 3 per cent.

The anti-commodities literature is largely developed based on examples from contexts in which plantation agriculture for export was the colonisers' priority, such as West Africa and India (Hazareesingh and Maat, 2016a). In these contexts, escape crops or anti-commodities are described as those that facilitated an escape from plantation agriculture (Gillbert, 2016; Hazareesingh, 2016; Maat, 2016; Richards, 2016; Sinha-Kerkhoff, 2016). However, colonialism functioned by different logics across the African continent to suit the colonisers' needs. In many countries in southern and eastern Africa the colonisers needed cheap local labour to exploit the country's mineral wealth and/or an unusually large settler agriculture (Amin, 1972). In South Africa, it was both of these. The forced settlement of the black majority population in 'homelands' not only deliberately caused labour migration by preventing full subsistence on agriculture, but meant that wages could also be kept extremely low as labourers were expected to partly subsist on their family's farming in the reserves. A comprehensive system of laws and regulations ensured that African mine labour was prevented from permanently settling in urban areas and that agriculture at a 'sub-subsistence' level in the homeland continued to serve as a social security to migrant labourers. A system of 'one man one plot' also prevented wealthier black Africans to accumulate land, as this would have reduced the labour force as some farmers in the homelands would have been able to live off agriculture, while such accumulation at the same would have created a landless labour force which would need higher wages and social security to subsist (Wolpe, 1972). In sum, agriculture in the 'homelands' was kept un-commodified through external force rather than farmers' choices, and maize became the crop that simultaneously fed the migrant mine worker in town and ensured subsistence for his family on the margins of state enforcement (McCann, 2001). The malleability of maize enabled the parallel development into an anti-commodity in the homelands and a commodity in the large-scale commercial farming system in South Africa, as will be described in the next section.

3. The role of crop biology in turning maize into a commodity and anti-commodity

Crop materialities have an effect on whether and how particular crops turn into commodities or anti-commodities (Hazareesingh and Maat, 2016a). The term 'turn into' is important here, as it places an emphasis on the relationality and context dependency of what crops turn out to be. Particular materialities are repeatedly found in anti-commodity, and escape crops. Anti-commodity varieties of crops are frequently better adapted to local cultural preferences and microclimates, and have greater tolerance to adverse ecological and weather conditions, while they often yield lower than commodity crops (Grubacic and O'Hearn, 2016; Richards, 2016; Scott, 2017; Sinha-Kerkhoff, 2016; Teeken et al., 2012). However, it should not be taken as evident that lower yield is seen as a drawback. South African smallholders have repeatedly been found to emphasise e.g. tolerance to drought and suitability to home processing rather than yield levels when prioritizing maize varieties (Fischer and Hajdu, 2015; Marshak et al., 2021; McCann, 2005). In Xopozo, yield was not even mentioned by smallholders when listing and ranking important features in maize (Fischer and Hajdu, 2015).

Particular maize materialities can be identified as facilitating maize turning into an anti-commodity. Maize overtook the indigenous sorghum as the main food crop for South African smallholders in the first few decades of the twentieth century (Beinart, 1982), largely as a result of labour constraints and increased food insecurity resulting from the enforced migrant labour system (De Wet, 1990).

Sorghum has an open ear, which means that the grains are exposed. Sorghum therefore has to be guarded from birds when it is ripening. The grains of maize are covered by leaves and therefore it does not have to be guarded to the same extent, and can be left in the field to dry with much less damage from birds than sorghum. This reduced need for labour guarding the crop, and gave households more flexibility on when to harvest (McCann, 2001). Apart from the effects of labour migration, increasing school attendance by children (who used to guard the sorghum from birds) further reduced households' access to labour and had direct effects on the shift to maize (Beinart, 1982; own data).

Maize is also better suited to intercropping than sorghum since it is planted less densely, allowing for more intensive mixed cultivation. In Xopozo maize is planted in home gardens with a variety of other crops such as beans, pumpkins, potatoes and spinach, and in fields, located at some distance from the house, together with pumpkins and beans. It is likely that the practice of intercropping maize with pumpkins and beans was introduced already when maize came from the Americas. Beans put nitrogen into the soil, and the broad leaves of the pumpkins spread out and cover the ground, reducing competition from weeds. Today intercropping maize with pumpkin and beans is an unquestioned part of maize farming in Xopozo, to the extent that most smallholders who planted maize, pumpkin and beans, only mentioned that they planted maize. Another favourable aspect of maize for rural resource-limited households is that it can be consumed unripe (De Wet, 1990; McCann et al., 2006). This means that food-insecure households can harvest maize at a time of the year when grain stores are empty but next year's crop is not yet ripe.

As will be seen below, in comparison with many other staple crops, maize materialities are particularly malleable. This is not only an important feature in how it has developed so easily into an appreciated anti-commodity, but it has been equally important in turning maize into one of the world's major commodity crops.

3.1. Early development of maize as a commodity and its effects on anti-commodity maize

One important way in which maize's malleability makes it amenable to being both a commodity and anti-commodity is its varying starch composition. It is common to separate between two main types of food maize: dent and flint. The first maize to arrive in Southern Africa was deep red flint varieties with short time to maturity (McCann, 2005: 97). South African smallholder's local maize varieties derive from these flints. In Xopozo, local maize is referred to as 'Xhosa' maize, referring to the dominant ethnic group in the region and indicating a local sense of ownership. Traditional Xhosa maize is described as hard, red and shiny. Flints contain harder starches than dent varieties, making them better suited than 'dent' maize to home processing as the germ separates more easily from the bran when mortared (McCann, 2001). Due to their harder, protective outer layer, flints are also more tolerant of local storage conditions (Smale et al., 1991). However, it was with the commercial dent varieties that arrived later, such as Hickory King and Silver King (Saunders, 1930), that maize became more widely popular with commercial settler farmers (McCann, 2001). These dent varieties were also the early focus of commercial breeding in South Africa which, like breeding efforts in other African colonies, focused on varieties for the settler farmers. The softer dents are invariably preferred by the modern milling industry since they cause less damage to machinery (Smale and Jayne, 2003). The soft dent maize produced on settler farms became the staple for the mine workers. The mine workers also brought these new forms of maize to their rural homes as a result softer dent maize also made it into smallholders' fields and gardens. Indeed, smallholders in eastern and southern Africa have been found to have widely adopted and valued these open pollinated dent varieties, such as Hickory King and Silver King alongside their local flint varieties (Saunders, 1930; McCann, 2005).

Despite the intermingling of local flint varieties with commercial dents, smallholders in Xopozo have managed to preserve a significant degree of flintiness in their local Xhosa maize. This is indicated by the reactions of smallholders in Xopozo when they were introduced to Bt maize in 2001. Bt maize is a dent variety. Rather than acknowledging its resistance to local stem boring insects (the novelty of Bt maize), the common reflection about the new maize was how soft, fluffy and sweet it was (a typical dent-maize quality). Some liked the sweetness while others stated that the new maize was impossible to process as it "*just becomes powder*" and that, as described by a middle aged woman from a family considered as very poor "*Even if you toast it in the fire it shrinks and gets too small. That doesn't happen with the Xhosa maize. It always stays hard and good*". The harder grains of flint maize also makes it more tolerant to storage insects. It was frequently noticed that the new maize was very easily attacked by grain weevlis (Ingogwana) in storage as described, for example, by an elderly woman living alone with her grandchildren: "I*f you have harvested it [the Bt maize] and put it in storage, the Ingogwana easily attack it, although Xhosa maize is very strong.*"

While the early flint varieties of maize in South Africa were short maturing, breeding efforts serving settler farming in the late 19th century led to higher-yielding varieties, but with longer time to maturity. A longer time to maturity was not a limitation for settlers with abundant access to cheap (forced) labour and traction means. In contrast, smallholders now and in the past prefer short season maize varieties because they often plant maize late as they have to wait to borrow means of traction from each other or adapt planting time to the rains (Waddington et al., 1991; McCann, 2005). Smallholders also often deliberately plant some maize later to spread the risk of the crop being lost to drought or stem borer infestations (Byerlee and Eicher, 1997; Louette and Smale, 2000), problems that alternatively can be tackled by the manual removal of insects, applying pesticides and watering by farmers with abundant access to labour and inputs. Xhosa maize in Xopozo has, as a likely outcome of cross-pollination with early commercial varieties, over time increased its time to maturity. Today Xhosa maize, in contrast to short maturing modern hybrid and GM maize, has a comparatively long time to maturity. As a result, what smallholders repeatedly emphasised as positive about the new GM maize varieties that they were introduced to in recent years in Xopozo was that they, in local measures, matured quickly, which meant that they could be planted late and still be ready for harvest before the frost. This was particularly important for the poorest households who do not have access to their own cattle or money to pay for a tractor. A young mother living alone with three children, described how she would like to try the new maize from the project as "*I have noticed that the maize from the project gets ripe before the Xhosa maize*". Another woman, living alone with six children similarly described that "*I would like to try the one from the project because that one gets ready before the Xhosa maize*". Both these women were however excluded from the agricultural development projects that introduced Bt maize, because they did not plant their fields. Not planting your field was taken as an indicator by the government staff responsible for the agricultural development projects that you were not committed to farming, whereas in fact the reason that these two women, and many others in the poorest segment of the community, did not plant their fields were lack of both household labour and access to traction. It is noticeable that the poorest smallholders who would most directly improve their food security by having access to maize with a shorter time to maturity, were excluded from the programmes delivering Bt maize because they were not seen as sufficiently committed.

In contrast to the first, red maize varieties, the commercial dent varieties introduced in the late 19th century were white. A strife for homogeneity in breeding, and higher prices for dent maize on export markets, made colonial breeding efforts quickly turn their focus to this maize. Today white is indisputably the colour of Africa's staple crop (McCann, 2005). The desirability for white maize, and the simultaneous appreciation of 'red' Xhosa maize was repeatedly exemplified during my fieldwork in Xopozo. Red Xhosa maize was often described as more nutritious, especially for children and livestock, while white maize was generally desired for making 'pap' the South African maize porridge that is part of almost every meal in households in Xopozo.

While smallholders in Xopozo have managed to retain a degree of flintiness in their Xhosa maize, the effects of cross pollination on colour (like on time to maturity) was more obvious. What was still described as 'red' Xhosa maize, today was at the most dark yellow. It was noticed that this was an effect of cross-pollination. An elderly farmer, for example, told me that she planted the Xhosa maize Ngoyi, but it had changed. It used to be very red and shiny, she said, "*but now these days, maize changes a lot because many people plant other types of maize around. For instance, if you are planting white maize and red maize in the garden, they attract each other so you end up with the same type, both types of seeds combine in the maize.*"

3.2. Cross-pollination and the fluidity of maize varieties

Paying attention to crop materialities, it is important to note that a significant number of the core texts developing the concept of crops as commodities and anti-commodities focus on rice (Hazareesingh and Maat, 2016a; Maat, 2016; Richards, 2016; Glover and Stone, 2018). Rice is a self-pollinating crop, meaning that plants in a field do not exchange genes and thus remain largely genetically homogenous over generations when farmers save seed (Morris, 2002). Farmers can thus retain control over distinct local varieties. It also means that, while the Green Revolution's introduction of modern rice and wheat varieties affected Asian farmers' practices and social inequality (e.g. as described by Sinha 2021 in this issue), farmers did not become dependent on yearly seed purchases. Indeed, this has been highlighted as an important factor in the comparative success of the Asian Green Revolution in spreading new varieties to Asian smallholders. Rice and wheat farmers in Asia could benefit from newly developed and higher-yielding varieties by only adopting them once (Hazell, 2009).

As indicated in smallholders' experiences with maize above, the materiality of maize is different, leading to different human-crop assemblages than with rice. Maize is an open-pollinated species with its flower-pollinating ears on the same plant and on other plants. Thus if no measures are taken to control pollination, all the maize plants in a field, and even all the kernels on an ear, are potentially genetically different from one another, and from the parent plant (Duvick, 2001). Farmers taking their own seed can exert some selection pressure on the population level by selecting seed from plants and ears for features of choice, e.g. ear size, colour and texture. This is seen in e.g. how some degree of flintiness of Xhosa maize has been retained over the years in Xopozo. Through selection farmers can preserve some broad identity of a local variety, which will still essentially be genetically heterogeneous (Morris, 2002). The agency and unruliness of maize as an open pollinated plant is however clearly seen in research on traditional maize communities which shows that farmers perceive that they have limited possibilities to steer maize development in predictable ways (Bellon and Brush, 1994; Perales et al., 2003). This unruliness is also acknowledged by smallholders in Xopozo. There are a range of local Xhosa maize varieties such as Ngoyi, Inyezi, Gebehlungulu and Gasimxakaxa. However, these local varieties are by no means stable or homogenous either over time or between farmers. Gebehlungulu was described as navy or black, or navy and black with some mixed colours, Ibunga as red (although today it was yellow), and Inyezi as having white kernels on a red cob, being completely red or completely white, the common feature being its flintiness and shiny cob. One farmer who was very engaged and observant in his farming, regularly attempting small experiments, said, "*The Xhosa maize that I plant is Ingoyi, but it used to be Ibunga. Over the years as I have replanted and replanted, it has changed and now it has become Ingoyi. The difference between the two is that Ibunga is so watery inside and the cob is tall and umpha [the cob] is thin and Ibunga more easily gets Isihlava [a local name for a condition of the maize caused by stem borers, drought or nutritional deficiency]. Ingoyi doesn't easily get Isihlava and Ingoyi has not got the corns all the way up in the umpha so you see more of the umpha, whereas in Ibunga the corns go all the way up.*"

The malleability of maize and the constant interaction with the commodified maize system since the colonial era could also be seen in the blurred boundary between local Xhosa maize and maize purchased in town. Maize becomes Xhosa maize if people feel a sense of ownership over it and it is locally recycled for some time, although the cut-off point at which this happens is not fixed and varies between farmers. The white dent OPV Silver King, which is no longer produced, is described by many as a Xhosa maize, while others call it 'maize from the shop'. The man in the family with whom I lived is well known in the community for having good Xhosa seed. He has actively avoided being involved in recent development projects where GM maize varieties have been introduced as he is proud of his own Xhosa maize and likes to have control over his own seed supply. One day, several months into fieldwork, he told me that the Xhosa maize he has is in fact Sliver King and originates from seed that he was given by a white man in Gauteng when he was working in the mines in the 1970s. The mother of this man had earlier referred to the same set of seed as being the local Xhosa variety Inyezi (meaning shining). When I told her that her son had said that this seed was Silver King, she said that Inyezi and Silver King are the same and that they can have a red cob with white kernels or be completely white. The linguistic similarity between Inyezi (shining) and Silver King also indicates that there is a relation between the two. At the same time, original OPV Silver king is a dent variety (McCann, 2005), whereas the way it was frequently described as a local Xhosa maize indicates that it has features of flint maize – a likely result of cross-pollination and farmers' selection for flinty maize over generations. Another similar local 'hybrid' between Xhosa and purchased maize is Hekalking, which probably stems from, and is a local linguistic variety of, the previously grown OPV Hickory King (McCann, 2005).

3.3. Hybrid technology reinforces the gap between settler farmers and smallholders

While already early colonial breeding efforts aimed for homogeneity, the invention of hybrid technology reinforced this. In contrast to the creation of open-pollinated varieties (OPVs) like Silver King and Hickory King, bred for homogeneity at population level, when hybrid maize is created, pollination is controlled during several seasons to create pure inbred lines first. Subsequently two inbred lines are crossed to create 'hybrid vigour' – a plant that is more productive than its parents (Duvick, 2001). Hybrid development leads to more homogenous maize plants and reduces diversity in the maize population. This homogeneity was strived for in the industry as it smoothens the production process. However, it simultaneously reduces resilience to environmental dynamics and change. This is seen in repeated statements from Xopozo farmers about the Xhosa maize being more tolerant to wind, rain and strong sun than the maize from the project, as well as general statements about Xhosa maize being 'strong' and 'resistant'.

As the development of hybrid seed requires a controlled process and the investment of land, time and labour, the discovery of hybrid vigour quickly led to a corporatisation of maize seed development. Hybrids overall yield more than OPVs,[1] but in contrast to OPVs, yield levels drop significantly if hybrid seed is recycled. As farmers therefore need to obtain new hybrid seed every year to retain yields, hybridisation was the first breeding technology that enabled money to be made on seed (Kloppenburg, 2005). Hybrid technology in maize was also the first example of how a crop technology facilitated proprietary control. By controlling both inbred lines (the 'raw material' for hybrids) and hybrids, the private sector quickly took control of seed development. Hybrid development was a key factor in turning maize into a commodity

[1] It is disputed to what extent the high yields seen in hybrids are an outcome of the technology of hybridization or of the fact that vastly more resources have been spent on developing hybrids than developing OPV maize.

crop and at the same time, maize's biological disposition made it particularly easy to develop into hybrids. It is much more difficult to create hybrids from self-pollinators like wheat and rice.

The first hybrid maize varieties were distributed in South Africa in 1949, and by 1979, 98 per cent of all maize grown by settler farmers was hybrid maize (Greyling and Pardey, 2019). Hybrids together with synthetic fertilizer increased yields massively on settler farms. However the need for yearly seed purchases, the long time to maturity of early hybrids, their preference for being planted as a monocrop, and their responsiveness to labour-intensive management, irrigation and fertiliser, prevented smallholders from benefiting from these yield increases (McCann, 2005). The introduction of hybrid maize and synthetic fertiliser thus increased the already substantial gap between settler farms and subsistence farming of maize in the homelands.

After independence in many African countries in the 1960s public sector breeding shifted to become increasingly directed at serving smallholders (Friis-Hansen, 1995; Smale and Jayne, 2009). One example of this is the release of semi-flint hybrid maize in Malawi in the 1990s in an effort to make hybrids more appreciated by smallholders. South Africa remained under minority rule until 1994 and agricultural research and development continued for a much longer period to be almost exclusively directed at serving the large farmers (McCann, 2005).

3.4. Advancements in biotechnology and the reinforcement of maize as a commodity crop

Genetic engineering techniques were developed in the 1980s, with the first GM crops being marketed in the mid-1990s. With genetic engineering came the possibility of modifying plants' DNA more precisely by inserting specific gene sequences into plants, and it became possible to move genes between organisms that cannot sexually reproduce (Schnurr, 2019). While this technology was a milestone in the advancement of plant breeding, conventional plant breeding is still needed for breeding the variety that will hold the new GM trait. This means that GM technology does not replace earlier technologies of OPV and hybrids but is added to them. Thus the history of breeding maize for South Africa's settler farmers is not nullified with GM technology. In contrast GM traits on the market in South Africa are bred into a population of highly homogenous hybrids bred to suite commercial, high-input farming. Indeed, looking at the materialities of todays' GM maize through the lens of smallholder's needs and priorities, available Bt- and herbicide tolerant GM maize is signified by continuities from the past: giving high yields but being soft, sweet and 'impossible' to store, rather than by its often stated novelties of insect- and herbicide resistance.

With genetic modification, legislation has evolved to significantly increase opportunities for proprietary control over seed (Tansey, 2011). Conventionally bred crop varieties can be protected by plant variety protection, which is inscribed in the legislation in the majority of countries today, including South Africa, and gives recognition and financial returns to the plant breeder. Plant variety protection makes it illegal for farmers to use protected varieties to propagate their own seed for sale, or to share it with others, although farmers are allowed to replant protected seed on their farm (the farmers' privilege) (Collier and Moitui, 2009; Collier, 2012; Netnou-Nkoana et al., 2015). Data from one of the three villages in Xopozo in 2012 (Iversen et al., 2014) indicate that over 90 per cent of farmers (95 of 105 households) participated in activities of seed sharing. There were two dominant reasons for asking a neighbour for seed, failure to save own seed and wanting to try a new variety. Interviews and participant observation between 2008 and 2019 indicated that in particular the poorest and most vulnerable households often relied for their food security on receiving seed from neighbours and family. Small portions of seed, enough to plant a part of the garden, was commonly given for free (sharing seed as social obligation is widespread in smallholder communities; see e.g. similar descriptions of seed sharing from smallholder communities in Ethiopia and Malawi: McGuire, 2008; Bezner Kerr, 2013). Asking for seed with the reason of wanting to try a new variety was done across wealth groups. During the periods when different government programmes introduced Bt maize and herbicide tolerant GM maize in Xopozo, seed was frequently shared with households who did not classify to take part in the programme, and this sharing was also encouraged by the chief. It was widely unknown that this was illegal (Jacobson and Myhr, 2013).

In many countries around the world, including South Africa, GM seed is, in addition to being protected by plant breeders' rights, also protected by patents linked to specifically inserted DNA sequences, and through contract law where farmers have to sign technology licensing agreements with seed companies when purchasing their GM varieties. Together, these legislative measures make it illegal for farmers both to share seed and to save it for their own use (Collier and Moitui, 2009). The majority of smallholders in Xopozo save maize seed from the previous harvest. In 2008, 73 per cent (194 out of 265) of the smallholders in the three villages had not purchased any maize seed (own data). Data from 2012 on seed practices from one of the three villages indicate that 80 per cent (84 out of 105) of the smallholders recycle at least parts of their seed supply (Iversen et al., 2014). Of those that had purchased seed, the majority only purchased parts of their seed supply and combined this with own recycled seed. Also previously purchased seed was recycled.

When GM maize was introduced by extension officers and company representatives in Xopozo, it was emphasised that this seed should not or could not be recycled, using the isiXhosa term Udlambuqe, ('the maize you eat until it is finished') (Jacobson and Myhr, 2013). The term Udlambuqe was a widely used by smallholders in Xopozo for describing the maize varieties that they had been introduced to by development programmes in recent years. However, there has as of yet (2019) been no form of control or penalties for smallholders who have recycled or shared GM seed (this is noticeably different to the situation in Argentina, described by Racuhecker in this issue),[2] and there was no common understanding among smallholders about why the maize should not be recycled. Most smallholders had also tried to recycle both insect resistant Bt maize and herbicide tolerant maize with varying success. A few noticed a fall in yield (a result of the maize being hybrid) when recycled, but more commonly it was concluded that the reason that the seed was called Udlambuqe was that it simply could not be recycled as the seed was impossible to store, being so damaged by grain weevils in storage (a result of it being a soft dent variety).

3.5. GM technology undermines smallholders' access to seed

The increased proprietary control that is legally possible with GM seed as compared with conventional varieties has increasingly directed the private sector to focus on GM varieties. At the same time, almost all but the largest companies have been put out of business by the increasing costs of acquiring and using proprietary genetic material in breeding (Parfitt, 2013; Westengen and Winge, 2019). Today less than a handful of companies have control of the majority of all proprietary seed produced globally. The three largest players in order of size on the global seed market today are Bayer-Monsanto, ChemCina-Syngenta and Dow-Dupont (OECD, 2018). Based on available data, Westengen and Winge (2019) suggest that it is reasonable to draw the conclusion that the concentration of the seed industry mirrors a concentration of the genetic material (i.e. a reduction in genetic diversity). The global trend for the

[2] As of yet (2019), neither Monsanto nor other companies have chosen to enforce existing legislation in Xopozo. No smallholder in the studied villages has signed the technology licencing agreements that Monsanto enforces with large-scale farmers in South Africa, and there has so far been no follow-up from the companies or any government authority to verify whether smallholders are adhering to patent and biosafety legislation. This is described in more detail in Jacobson and Myhr, 2013.

privatisation of the seed industry, and the fact that GM crops allow for stronger proprietary protection and more benefits for the seed companies, can clearly be seen in the evolution of the South African maize seed market. All but one of the 27 maize breeders active in South Africa are in the private sector. Four companies – Monsanto SA (owned by Bayer), Pioneer Hi-Bred (owned by DowDupont), Pannar and Klein Karoo Seed – together own 68 per cent of all registered maize seed in the country (DAFF, 2018).

All seed for sale in South Africa should be registered with the registrar for plant improvement and listed in the South African variety list. The number of registered varieties on the list doubled between 2007 and 2018 (from 397 in 2007 to 794 in 2018, Table 1), indicating the formalisation and growth of the maize seed market. At the same time, the number of registered OPVs, the kind of seed that farmers can recycle, dropped from an already low number (from 38 to 31 registered varieties, reducing from 10 per cent to 4 per cent of the total number of registered varieties, Table 1). In 2018, GM maize varieties made up almost 50 per cent of all registered maize varieties (Table 1) and 80 per cent of all seed sales are of GM maize (DAFF, 2018).

Simultaneously with increasing formalisation of the seed market, seed prices have risen dramatically. While prices for OPV seed in the agricultural retailer stores in Flagstaff and Bizana, the urban centres closest to Xopozo, overall followed the consumer price index (South Africa Consumer Price Index) and doubled between 2008 and 2019 (from 103 to 200 Rand between 2008 and 2019 for a 10 kg bag), GM seed, which was five times dearer than a regular OPV in 2008, is now ten times more expensive (up from about 500–2000 Rand/10 kg).

Although the majority of smallholders in Xopozo save own seed, many smallholders also purchase seed occasionally, for example if they have failed to save sufficient amounts from the previous harvest. While still a minority practice, purchasing seed has become more frequent in recent years. Smallholders mentioned that an important reason for increased seed purchases is that it has become more difficult to get hold of local seed if you fail to save. Some connected this with the introduction of 'Udlambuqe' maize which is considered impossible to store (not for legal reasons, although it in fact is illegal, but because it does not tolerate local storage conditions). Another obvious reason for the lower availability of local seed is that field agriculture has declined so drastically, reducing the amount of locally available seed. The loss of local seed and the simultaneous steep rise in seed prices clearly creates risks for increased food insecurity, which has also been reported in recent years (Chakona and Shackleton, 2018; World Bank, 2018).

4. Discussion and conclusions

The aim of this paper was to deepen the analysis of the role of crop agency in agricultural development, with the idea that this would lead to a better understanding about why the maize lead New Green Revolution so far has not led to the envisioned poverty reduction through agriculture development in South Africa.

The paper develops the concept of crops as commodities and anti-commodities (Hazareesingh and Maat, 2016a) by bringing biology more firmly into the analysis of maize assemblages. In doing so, this paper shows how specific biological properties of maize made it particularly malleable to early efforts by the colonial regime in South Africa to exclude black Africans from commercial farming. Initial efforts to marginalize black smallholder farmers have subsequently, intentionally and unintentionally, been reinforced by political choices, market development and the advancement of plant breeding technology. The result is that available GM maize varieties in South Africa today are ill equipped to support smallholder farming. This is not to say that smallholders never want or can benefit from commodity maize. Indeed, as seen in this study maize was initially a profitable commodity crop for both black Africans and settlers. However, the way in which political choices and technological development over time have filtered down into maize biology has resulted in available commodity versions of maize today harboring properties that are significantly negative for smallholders, such as their soft dent-qualities making them 'impossible to store'.

It is not only the case that today's commodity maize is largely unsuited to smallholders however, but the paper also importantly shows how the development and expansion of commodity maize infringes on smallholders' ability to secure their food production and livelihoods by eroding 'escape' or 'anti-commodity' features of local maize varieties. Here is an important difference betwen maize, an open-pollinated crop, and rice which is self pollinating, and which has been the focus of a greater number of anti-commodity studies (Hazareesingh and Maat, 2016a). By thinking in terms of intra-action (Barad, 2007) and by bringing biology more firmly into anti-commodity studies, the paper here adds a dimension to that literature. In contrast to how (non hybrid) rice varieties stay largely distinct over time and between populations, the present paper shows how commodity maize varieties, most recently GM maize, over time have impacted the local maize gene pool, changing local varieties' morphology and therewith their anti-commodity use value. In the present case it is particularly clear how cross-pollination over time has increased local varieties' time to maturity. The case thus makes clear that the extent to whcih farmers can escape commodity agriculture through their crop choices is affected by crop biology.

Emphasising the importance of the historical dimension so central in anti-commodity studies (Hazareesingh and Maat, 2016a), this study also demonstrates that the particular properties attached to maize as a commodity or anti-commodity is an outcome of the historically contingent assemblages in which it is intra-acting. One example of this is how the time it takes for commodity maize to reach maturity has shifted in history. As described in this paper, the first maize in South Africa was early maturing (McCann, 2005). A great deal of research has confirmed how smallholders across contexts appreciate such early maturing maize because this gives room for flexibility in planting time, adapting to rains and availability of draught power (Fischer and Hajdu, 2015; McCann, 2005; Waddington et al., 1991). Subsequent breeding efforts by the colonial regime raised the yields of commodity maize to serve the growing urban maize market, but also increased time to maturity, which was not a limitation for settler farmers with abundant access to cheap labour. Contrary to early versions of anti-commodity maize in South Africa, anti-commodity 'Xhosa maize' today has a long time to maturity. It is likely that this is a result of its intermingling with early commercial varieties bred for the settlers. In contrast, today's commodity maize is short maturing. The reason is that, contrary to the cheap and abundant labour available to settler farmers in the past, commercial farmers in South Africa are today under similar pressure as other commercial large-scale farmers around the world to increase the yield-to-labour input ratio. Short-maturing varieties are therefore produced by the seed industry. Thus when the interests of commercial farmers and smallholders coincide, features of commodity maize might benefit smallholders. However, it must be noted in this context that in

Table 1
Registered varieties of OPV, hybrid and GM maize in 2007 and 2018 (based on South African variety list, as maintained by the registrar of plant improvement 2007 and 2018).

Year	Type of maize		
	2007	2018	Difference between 2007 and 2018 (count)
OPV maize (count/percentage of total)	38/ 10%	31/4%	−7
Hybrid maize (count/ percentage of total)	279/ 70%	375/ 47%	+96
GM maize (count/ percentage of total)	80/ 20%	388/ 49%	+308
Number of registered maize varieties (OPV + hybrid + GM)	397/ 100%	794/ 100%	397/+100%

contemporary commodity maize the property of early maturation is assembled with other properties such as the softness of being a dent variety, unsuited to local storage conditions, and with relations such as legal restrictions on sharing and recycling seed- thus overall not being of benefit to smallholders.

While some materialities of maize mainly are a result of historically contingent political and economic relations (like time to maturity), other properties are more durable, such as the fact that maize is an open-pollinated crop. An effect of the property of open-pollination is that maize is particularly easy to turn into hybrids. With the advent of hybrid technology control over the breeding process shifted from farmers to professional breeders. In other words hybrid technology "*uncouples seed as 'seed' from seed as 'grain' and thereby facilitates the transformation of seed from a use-value to an exchange-value*" (Kloppenburg, 2005: 93). Genetic modification further reinforces this commodification potential both biologically and legally. While it is theoretically possible to genetically modify OPV maize, which farmers could then recycle, the reality is that existing GM maize varieties on the South African market are all hybrids. A similar situation exists with the Monsanto-led introduction of genetically modified Bt cotton in India, where only hybrid varieties of cotton were genetically modified (Suresh et al., 2015), thus preventing the possibilities of farmers saving seed. There is an important difference between cotton and maize, however. Cotton is self-pollinating (like rice and wheat). With non-hybridised Bt cotton, farmers could therefore take their own seed with a high chance of the Bt trait remaining fairly stable over generations, similarly to how rice and wheat farmers could benefit from Green Revolution varieties without becoming trapped into yearly seed purchases. However, even if OPV maize were genetically modified, due to the high cross-pollination rates in maize, farmers taking their own seed from this maize could not be sure that the GM trait would remain in the next generation. In this regard, the particular materialities of maize facilitate a more extensive shifting of power over seed from the farmer into the hands of the few multinational seed giants.

The New Green Revolution initiatives in Africa today are driven by an idea about crops as autonomous agents driving agricultural development and market integration as an unquestioned good. Promotion of hybrid and GM maize varieties are coupled with ideas is that smallholders must abandon traditional practices and take charge of their own development into entrepreneurs (Fischer and Hajdu, 2015; Schnurr, 2019; Schurman, 2018; Vercillo et al., 2020). It is widely substantiated in the literature that the idea of smallholders' lack of entrepreneurship being a reason for their poverty is not only unfounded, but in fact drives development programs that undermine rather than support smallholders' livelihoods (Fischer and Hajdu, 2015; Jacobson, 2013; Schnurr, 2019; Schurman, 2018). It is equally well established that the narrow focus on yield levels and on hybrid and GM maize, widely promoted by governments, donors and industry to smallholders across Africa, ignores smallholder values of recycling and sharing seed, and as a result undermines food security (Lunduka et al., 2012; Bezner Kerr, 2013; Brooks, 2014, Marshak et al, 2021). The present paper acknowledges these facts but contributes a novel dimension to the analysis by showing how maize's biological properties and its political and technological entanglements cannot easily be separated: historical political choices, today's workings of the market, maize biology and technological development are all entangled and together reinforce commodification effects. This is why the South African variant of the New Green Revolution might be particularly ill-equipped to benefit smallholders. Today, South Africa is the most unequal country in the world, with smallholders in the former homelands being amongst the poorest in the country (World Bank, 2018), while the country simultaneously is the ninth largest maize exporter in the world and the only major maize exporter in Africa (Workman, 2019).

The choice by the South African government to introduce GM maize to smallholders today is a political one, not in the same way as early maize breeding was undertaken to fundamentally undermine smallholder farming in the past, but in the sense that in practice it has political effects. The fact that political choices favouring large farmers and the seed industry have filtered down into maize biology erodes the possibility of maize serving as an escape crop facilitating food security, it greatly increases the need for money in farming, and in particular undermines the possibility of farming serving the poorest.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

Thanks to two anonymous reviewers, and to Brian Kuns, Riccardo Bommarco, Jostein Jakobsen, Dominic Glover and Ola Westengen who have spent time reading drafts and given very useful and encouraging comments.

References

African Centre for Biodiversity, 2018. Input supply in South Africa's Smallholder Farmer Support Programmes: A Tale of Neo-Apartheid Plans, Dodgy Dealings and Corporate Capture. African Centre for Biodiversity, Johannesburg.
Amin, S., 1972. Underdevelopment and dependence in black Africa: historical origin. J. Peace Res. 9, 105–119.
Barad, K., 2007. Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning. Duke University Press.
Beinart, W., 1982. The Political Economy of Pondoland. Cambridge University Press Cambridge, pp. 1860–1930.
Bellon, M.R., Brush, S.B., 1994. Keepers of maize in Chiapas, Mexico. Econ Bot 48, 196–209.
Bezner Kerr, R., 2013. Seed struggles and food sovereignty in northern Malawi. J. Peasant Stud. 40, 867–897.
Brooks, S., 2013. Investing in food security? Philanthrocapitalism, biotechnology and development. SWPS 12–13.
Brooks, S., 2014. Enabling adaptation? Lessons from the new 'Green Revolution'in Malawi and Kenya. Clim. Change 122, 15–26.
Bundy, C., 1988. The Rise and Fall of the South African Peasantry. David Philip Publishers Cape Town.
Byerlee, D., Eicher, C.K. (Eds.), 1997. Africa's Emerging Maize Revolution. Lynne Rienner Publishers Boulder, London.
Chakona, G., Shackleton, C.M., 2018. Household food insecurity along an Agro-Ecological gradient influences children's nutritional status in South Africa. Front. Nutrit. 4, 72.
Cioffo, G.D., Ansoms, A., Murison, J., 2016. Modernising agriculture through a 'new' Green Revolution: the limits of the Crop Intensification Programme in Rwanda. Rev. African Polit. Econ. 43, 277–293.
Collier, D., 2012. Regulatory Frameworks Governing Seed Supply and Access: Implications for Traditional and Small-Scale Farmers in South Africa. University of Cape Town Cape Town.
Collier, D., Moitui, C., 2009. Africa's regulatory approach to biotechnology in agriculture: an opportunity to seize socio-economic concerns. African J. Int. Comparat. Law 17.
Cremer, J., 2017. CRISPR technology could bring the Green Revolution to Africa, Cornell Alliance for Science [on-line] https://allianceforscience.cornell.edu/blog/2017/10/crispr-technology-could-bring-the-green-revolution-to-africa/ (accessed 2020-10-23).
DAFF, 2018. South African grain seeds market analysis report 2018 Department of Agriculture Forestry and Fisheries, Pretoria.
de la Hey, M., Beinart, W., 2017. Why have South African smallholders largely abandoned arable production in fields? A case study. J. Southern African Stud. 43, 753–770.
De Wet, C., 1990. The socio-ecological impact of development schemes in the 'homelands' of South Africa. S. Afr. J. Sci. 86, 440–447.
Dowd-Uribe, B., 2017. GMOs and poverty: definitions, methods and the silver bullet paradox. Canadian Journal of Development Studies / Revue canadienne d'études du développement 38, 129–138.
Duvick, D.N., 2001. Biotechnology in the 1930s: the development of hybrid maize. Nat. Rev. Genet. 2, 69–74.
Dzanku, F.M., Jirström, M., Marstorp, H., 2015. Yield gap-based poverty gaps in rural sub-Saharan Africa. World Dev. 67, 336–362.
Eddens, A., 2019. White science and indigenous maize: the racial logics of the Green Revolution. J. Peasant Stud. 46, 653–673.
Feinstein, C.H., 2005. An Economic History of South Africa: Conquest, Discrimination, and Development. Cambridge University Press.

Fischer, K., Hajdu, F., 2015. Does raising maize yields lead to poverty reduction? A case study of the Massive Food Production Programme in South Africa. Land Use Policy 46 (0), 304–313. https://doi.org/10.1016/j.landusepol.2015.03.015.

Friis-Hansen, E., 1995. Seeds for African Peasants: Peasants' Needs and Agricultural Research, the Case of Zimbabwe. Nordic Africa Institute Uppsala.

Gillbert, E., 2016. Rice, civilisation and the Swahili towns: anti-commodity and anti-state? In: Hazareesingh, S., Maat, H. (Eds.), Local Subversions of Colonial Cultures: Commodities and Anti-Commodities in Global History. Palgrave Macmillan, Houndmills, Basingstoke, Hampshire.

Glover, D., Stone, G.D., 2018. Heirloom rice in Ifugao: an 'anti-commodity'in the process of commodification. J. Peasant Stud. 45, 776–804.

Gouse, M., Pray, C.E., Kirsten, J., Schimmelpfennig, D., 2005. A GM subsistence crop in Africa: the case of Bt white maize in South Africa. Int. J. Biotechnol. 7, 84–94.

Granlund, S., 2020. The promise of payday: exploring the role of state cash transfers in post-apartheid rural South Africa. Department of Urban and Rural Development. Swedish University of Agricultural Sciences, Uppsala.

Granlund, S., Hochfeld, T., 2019. 'That child support grant gives me powers' – exploring social and relational aspects of cash transfers in South Africa in times of livelihood change. J. Dev. Stud. 1–15.

Greyling, J.C., Pardey, P.G., 2019. Measuring maize in South Africa: the shifting structure of production during the Twentieth Century, 1904–2015. Agrekon 58, 21–41.

Grubacic, A., O'Hearn, D., 2016. Living at the Edges of Capitalism: Adventures in Exile and Mutual Aid. Univ of California Press.

Guthman, J., 2019. Wilted: Pathogens, Chemicals, and the Fragile Future of the Strawberry Industry. University of California Press.

Hajdu, F., Neves, D., Granlund, S., 2020. Changing Livelihoods in rural eastern cape, South Africa (2002–2016): diminishing employment and expanding social protection. J. Southern African Stud. 46, 743–772.

Hazareesingh, S., 2016. 'Your foreign plants are very delicate': peasant crop ecologies and the subversion of colonial cotton designs in Dharwar, Western India. In: Hazareesingh, S., Maat, H. (Eds.), Local Subversions of Colonial Cultures: Commodities and Anti-Commodities in Global History. Palgrave Macmillan, Houndmills, Basingstoke, Hampshire, pp. 1830–1880.

Hazareesingh, S., Maat, H., 2016a. Local Subversions of Colonial Cultures: Commodities and Anti-Commodities in Global History. Palgrave Macmillan, UK London.

Hazareesingh, S., Maat, H., 2016b. Introduction. In: Hazareesingh, S., Maat, H. (Eds.), Local Subversions of Colonial Cultures: Commodities and Anti-Commodities in Global History. Palgrave Macmillan, Houndmills, Basingstoke, Hampshire.

Hazell, P.B.R., 2009. Transforming Agriculture: the Green Revolution in Asia. In: Spielman, D.J., Pandya-Lorch, R. (Eds.), Millions Fed: Proven Successes in Agricultural Development. IFPRI, Washington, DC, pp. 25–32.

Head, L., Gibson, C., 2012. Becoming differently modern: geographic contributions to a generative climate politics. Prog. Hum. Geogr. 36, 699–714.

Hendricks, F.T., 1990. The Pillars of Apartheid: land tenure, Rural Planning and the Chieftancy. Department of Sociology. Uppsala University, Uppsala.

Hyde, D., 2016. East African railways and harbours, 1945–1960: from 'crisis of accumulation' to labour resistance. In: Hazareesingh, S., Maat, H. (Eds.), Local Subversions of Colonial Cultures: Commodities and Anti-Commodities in Global History. Palgrave Macmillan, Houndmills, Basingstoke, Hampshire.

Ignatova, J.A., 2017. The 'philanthropic' gene: biocapital and the new green revolution in Africa. Third World Quart. 38, 2258–2275.

ISAAA, 2018. Global Status of Commercialized Biotech/GM Crops: 2018. ISAAA, Manila.

Iversen, M., Grønsberg, I., van den Berg, J., Fischer, K., Aheto, D.W., Bøhn, T., 2014. Detection of transgenes in local maize varieties of small-scale farmers in Eastern Cape, South Africa. Plos One 9 (12). https://doi.org/10.1371/journal.pone.0116147.

Jacobson, K., 2013. From Betterment to Bt Maize: Agricultural Development and the Introduction of Genetically Modified Maize to South African Smallholders; PhD thesis. Department of Urban and Rural Development, Swedish University of Agricultural Sciences, Uppsala.

Jacobson, K., Myhr, A.I., 2013. GM crops and smallholders: biosafety and local practice. J. Environ. Develop. 22 (1) https://doi.org/10.1177/1070496512466856.

Kloppenburg, J.R., 2005. First the Seed: The Political Economy of Plant Biotechnology. Univ of Wisconsin Press Wisconsin.

Louette, D., Smale, M., 2000. Farmers' seed selection practices and traditional maize varieties in Cuzalapa, Mexico. Euphytica 113, 25–41.

Lunduka, R., Fisher, M., Snapp, S., 2012. Could farmer interest in a diversity of seed attributes explain adoption plateaus for modern maize varieties in Malawi? Food Policy 37, 504–510.

Maat, H., 2016. Upland and Lowland Rice in the Netherands Indies. Palgrave Macmillan Houndmills, Basingstoke, Hampshire.

Marshak, M., Wickson, F., Herrero, A., Wynberg, R., 2021. Losing practices, relationships and agency: ecological deskilling as a consequence of the uptake of modern seed varieties among South African Smallholders. Agroecol. Sustainable Food Syst. 1–24.

McCann, J., 2001. Maize and grace: history, corn, and Africa's new landscapes, 1500–1999. Comparat. Stud. Soc. Hist. 43, 246–272.

McCann, J., 2005. Maize and Grace: Africa's Encounter with a New World Crop. Harvard Univ Pr, pp. 1500–2000.

McCann, J.C., Dalton, T.J., Mekuria, M., 2006. Breeding for Africa's new smallholder maize paradigm. Int. J. Agric. Sustain. 4, 99–107.

McGuire, S.J., 2008. Securing access to seed: Social relations and sorghum seed exchange in eastern Ethiopia. Human Ecol. 36, 217–229.

Morris, M.L., 2002. Impacts of international maize breeding research in developing countries, 1966-98. Cimmyt.

Netnou-Nkoana, N.C., Jaftha, J.B., Dibiloane, M.A., J., E., 2015. Understanding of the farmers' privilege concept by smallholder farmers in South Africa. South African J. Sci. 111, 1–5.

OECD, 2018. Concentration in Seed Markets: Potential Effects and Policy Responses. OECD Publishing, Paris.

Parfitt, C., 2013. How are genetic enclosures shaping the future of the agrifood sector?.

Patel, R., 2012. The long green revolution. J. Peasant Stud. 1–63.

Perales, H., Brush, S., Qualset, C., 2003. Dynamic management of maize landraces in Central Mexico. Econ Bot 57, 21–34.

Richards, P., 2016. Rice as a commodity and anti-commodity. In: Hazareesingh, S., Maat, H. (Eds.), Local Subversions of Colonial Cultures: Commodities and Anti-Commodities in Global History. Palgrave Macmillan, Houndmills, Basingstoke, Hampshire.

Rocheleau, D., Roth, R., 2007. Rooted networks, relational webs and powers of connection: Rethinking human and political ecologies. Geoforum 38, 433–438.

Saunders, A., 1930. A new variety of maize. Farming South Africa 5, 257–259.

Schnurr, M.A., 2019. Africa's Gene Revolution: Genetically Modified Crops and the Future of African Agriculture. McGill-Queen's University Press Montreal, Kingston, London and Chicago.

Schurman, R., 2018. Micro (soft) managing a 'green revolution'for Africa: the new donor culture and international agricultural development. World Dev. 112, 180–192.

Scoones, I., Thompson, J., 2011. The politics of seed in Africa's green revolution: alternative narratives and competing pathways. IDS Bull. 42, 1–23.

Scott, J.C., 1985. Weapons of the Weak: Everyday Forms of Peasant Resistance. Yale University Press New Haven.

Scott, J.C., 2010. The Art of Not Being Governed: An Anarchist History of Upland Southeast Asia. Yale University Press, New Haven and London.

Scott, J.C., 2017. Against the Grain: A Deep History of the Earliest States. Yale University Press New Haven and London.

Shackleton, C., Mograbi, P., Drimie, S., Fay, D., Hebinck, P., Hoffman, M., Maciejewski, K., Twine, W., 2019. Deactivation of field cultivation in communal areas of South Africa: Patterns, drivers and socio-economic and ecological consequences. Land Use Policy 82, 686–699.

Shackleton, S.E., Hebinck, P., 2018. Through the 'Thick and Thin' of farming on the Wild Coast, South Africa. J. Rural Stud. 61, 277–289.

Sinha, S., 2021. From cotton to paddy: Political crops in the Indian Punjab. Geoforum. https://doi.org/10.1016/j.geoforum.2021.05.017.

Sinha-Kerkhoff, K., 2016. Yellow tobacco, black tobacco: indigenous (desi) tobacco as an anti-commodity. In: Hazareesingh, S., Maat, H. (Eds.), Local Subversions of Colonial Cultures: Commodities and Anti-Commodities in Global History. Palgrave Macmillan, Houndmills, Basingstoke, Hampshire.

Smale, M., Jayne, T., 2003. Maize in Eastern and Southern Africa:“ Seeds" of Success in Retrospect. EPTD Discussion papers. International Food Policy Research Institute, Washington DC.

Smale, M., Jayne, T., 2009. Breeding an “Amaizing” crop: improved Maize in Kenya, Malawi, Zambia and Zimbabwe. In: Spielman, D.J., Pandya-Lorch, R. (Eds.), Millions Fed: Proven Successes in Agricultural Development. IFPRI, Washington, DC, pp. 33–40.

Smale, M., Kaunda, Z., Makina, H., Mkandawire, M., Msowoya, M., Mwale, D., Heisey, P., 1991. Chimanga cha makolo, hybrids, and composites: An analysis of farmers' adoption of maize technology in Malawi, 1989-91. CIMMYT Economics Working Paper 91/04.

South Africa Year Book, 2018/2019. Agriculture Forestry and Fischeries. Government of South Africa.

South Africa Consumer Pice Index: Trading Economics, 2021. (Accessed 13 August 2021).

Suresh, A., Ramasundaram, P., Samuel, J., Wankhade, S., 2015. Cotton cultivation in India since the green revolution: technology, policy, and performance. Rev. Agrarian Stud. 4.

Tansey, G., 2011. Whose power to control? Some reflections on seed systems and food security in a changing world. IDS Bull. 42, 111–120.

Teeken, B., Nuijten, E., Temudo, M.P., Okry, F., Mokuwa, A., Struik, P.C., Richards, P., 2012. Maintaining or abandoning African rice: lessons for understanding processes of seed innovation. Human Ecol. 40, 879–892.

Thompson, C.B., 2012. Alliance for a Green Revolution in Africa (AGRA): advancing the theft of African genetic wealth. Rev. African Polit. Econ. 39, 345–350.

Vercillo, S., Weis, T., Luginaah, I., 2020. A bitter pill: smallholder responses to the new green revolution prescriptions in northern Ghana. Int. J. Sustain. Dev. World Ecol. 27 (6), 565–575. https://doi.org/10.1080/13504509.2020.1733702.

Waddington, S.R., Mudhara, M., Hlatshwayo, M., Kunjeku, P., 1991. Extent and causes of low yield in maize planted late by smallholder farmers in sub-humid areas of Zimbabwe. Farming Syst. Bull., Eastern and Southern Africa 9, 15–31.

Westengen, O.T., Winge, T., 2019. Farmers and Plant Breeding: Current Approaches and Perspectives. Routledge.

Wolpe, H., 1972. Capitalism and cheap labour-power in South Africa: from segregation to apartheid. Econ. Soc. 1, 425–456.

Workman, D., 2019. Corn Exports by Country World's Top Exports.

World Bank, 2018. Overcoming poverty and inequality in South Africa: An Assessment of Drivers, Constraints and Opportunities. The World Bank Washington.