Research Policy 45 (2016) 1185–1194

Contents lists available at ScienceDirect

Research Policy

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

Why new crop technology is not scale-neutral—A critique of the expectations for a crop-based African Green Revolution

Klara Fischer

Department of Urban and Rural Development, Swedish University of Agricultural Sciences, P.O. Box 7012, SE-750 07 Uppsala, Sweden

ARTICLE INFO

Article history:
Received 7 January 2015
Received in revised form 24 February 2016
Accepted 11 March 2016

Keywords:
Scale-neutral
Crop
Smallholder
Green Revolution
Biotechnology
SST

ABSTRACT

Poverty reduction during the Asian Green Revolution has been attributed to the inherent scale neutrality of new crop varieties making them equally beneficial to small-scale and large-scale farmers. The term 'scale-neutral' is now reappearing in debates on agricultural development in Africa with claims that crop technology is inherently scale-neutral and that African smallholders will significantly benefit from new crop varieties not specifically developed for their contexts. Using a social shaping of technology (SST) perspective and the concept of biological embeddedness, this paper critically examines whether it is helpful to describe crop technology as scale neutral when drawing lessons from the Asian Green Revolution about how new crop technology can be of benefit to African smallholders. The paper describes how political commitment, rather than inherently scale-neutral crops, was central for the outcome of the Asian Green Revolution. It also highlights that while the effects of crop biology are often disregarded in adoption studies, biology significantly affected the ability of Green Revolution crop technology to benefit smallholders, and continues to do so today. Using maize and GM crops as examples, this paper suggests that GM crops in their current form have reinforced a technological trajectory established with hybrid technology and directed it away from smallholder practices and agroecologies. Consequently, describing crop technology as inherently scale-neutral is not helpful for understanding how crop technology works in Africa today and prevents important lessons being learned from the Asian Green Revolution.

1. Introduction

During the past decade, new crop technology[1] has been at the centre of debates on how to revitalise African smallholder agriculture. Parallels are frequently drawn with the so-called Green Revolution (GR) in Asia, where new varieties of wheat and rice (referred to interchangeably as high yielding varieties (HYV) or modern varieties (MV)[2]) introduced from the 1960s onwards proved to have significant poverty-reducing effects. These new crop varieties were described as scale-neutral, *i.e.* of equal benefit to large-scale and small-scale farmers (Feder and Umali, 1993; Feder, 1980). After two decades of inattention to agriculture in the global development community (Scoones and Thompson, 2011; McMichael, 2009), during which the term 'scale neutral' was seemingly dormant in the academic debate, the term is now reappearing in the debate on the potential of new crop varieties in general, and genetically modified (GM) crops[3] in particular, to benefit African

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

[1] The term 'new crop technology' is used in this paper to refer to crop technology that has not previously been adopted by that farmer. During the Asian GR this new crop technology consisted mainly of new varieties of rice and wheat developed in particular to give higher yields. Today in the debate on how African farmers might benefit from new crop technology, this new technology refers both to various new traits inserted in crops through genetic modification (see footnotes 2 and 3 for further clarification) and new conventionally bred (not genetically modified) crop varieties.

[2] For the sake of clarity and consistency, this paper only uses the terms HYV or MV when discussing how other authors have used these concepts. However, because crop species and modifications are seldom specified in the literature, in many places in the paper it is impossible to accurately state the crop and modification in question. In these cases, the paper employs the terms 'new crop varieties' or 'new crop technology' when talking generally about new crop varieties, or GR crop varieties/GR crop technology when referring to varieties released during the Asian GR.

[3] According to the European Union regulatory framework on GMOs (DIRECTIVE 2001/18/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC), a genetically modified organism (GMO) means "an organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination". The GM crops referred to in this paper are the genetically modified (GM) crops that dominate the market today (herbicide-tolerant and insect-resistant (Bt) crops). These are transgenic crops, meaning that sections of DNA from another organism have been inserted into the plant's DNA in order to produce new traits. There are also cisgenic GM crops, where DNA fragments or genes

http://dx.doi.org/10.1016/j.respol.2016.03.007
0048-7333/

smallholders.[4] It is being argued that as new crop technology is scale-neutral, it can be a key driver in the transformation of African smallholder agriculture (see e.g. Juma, 2013; Mosley, 2002; Wiggins et al., 2010; Qaim, 2009; Collier and Dercon, 2014). The fact that the Asian GR occurred under quite different circumstances seems not to temper these expectations. On the contrary, scale neutrality is frequently described as a function inherent in crops, seemingly unaffected by context. Collier and Dercon write in the present tense that "*most of these [HYV] are scale-neutral*" (2014, p.94). Qaim transfers the term to GM crops and state similarly that "*GM crops may also be well suited for small-scale farmers, because such seed technologies are scale neutral*" (2009, p.685). As exemplified in the abovementioned quotes, where crop species or genetic modification is not specified, it is also the rule rather than the exception for crop biology to be blackboxed in these discussions.

Crop technology has an important role to play in raising the productivity of agriculture in Africa today; however, for this to occur it must be appropriate for African farmers' practices and contexts (Scoones and Thompson, 2011). This requires a clear understanding of the function of any new crop technology *per se* and how the technology is co-shaped by its host crop, its end users and their contexts. This paper draws on literature, ideas and concepts from the field of social shaping of technology (SST) (Sørensen and Williams, 2002; Williams and Edge, 1996) and the concept of biological embeddedness (Russell, 2008) to critically explore the extent to which the term 'scale neutral' assists or hinders us in drawing lessons from the Asian GR when analysing the role of new crop technologies for African smallholders today.

Section 2 describes how SST in combination with the concept of biological embeddedness and farming systems research (FSR) is used here to analyse the social and biological influence at different scales on the interaction between new crop technology and smallholders. Section 3 draws on some of the influential literature on the Asian GR to describe how the concept 'scale neutral' was introduced to explain smallholder adoption of new crop technology during the Asian GR, while highlighting the acknowledged limitations of the term 'scale neutral' for describing what was going on. It goes on to point out factors shown to be important for the empirically observed scale neutrality. Section 4 discusses the re-appearance of the term 'scale neutral' in contemporary discussions on agricultural development in Africa and discusses the differences between the contemporary situation in Africa and the situation in Asia during the GR. It is highlighted how the increasingly privatised agricultural development regime, African land use characteristics and crop biology negatively affect the possibility for crop technology to work in a scale-neutral manner in Africa today. Section 5 focuses specifically on the framing of GM crops as scale-neutral in recent agricultural development debates. The talk of GM crops as scale neutral is placed in perspective by studying the empirical record on GM crops and smallholders today. This section shows how GM crops, rather than being scale neutral, can be usefully understood as a continuation and reinforcement of an established crop technological trajectory that started with hybrid technology. Conclusions are presented in Section 6.

2. Social shaping perspective to scale-neutral crop technology

In its broadest sense, the field of SST hosts research that in various ways demonstrates the social influence on technological change. It evolved from a critique of modernist perspectives on technology as artefacts with fixed functions, responding to objective problems in society (Sørensen and Williams, 2002). The literature describes three core features of SST, whereby it acknowledges the co-evolution of society and technology, the simultaneous negotiability (flexibility) and irreversibility of all technology, and the inherently political nature of technological development, since choosing one design and development trajectory over another has different implications for different social groups (cf. Williams and Edge, 1996; Sørensen and Williams, 2002).

It also adopts the term 'technological trajectory' (Dosi, 1982). Dosi (1982) concluded that technology outcomes are governed both by factors inherent to the technology and the external economic environment, and that technology not only consists of a set of physical devices (crops and their genetics in this case), but also of a set of disembodied (or discursive) factors such as the particular know-how, memories from past attempts, and ideas about future limitations and possibilities (Dosi, 1982, p.152). He developed the term 'technological trajectory', defined as "*the pattern of 'normal' problem solving activity (i.e. of* '*progress*'*)*" within a wider technological paradigm (Dosi 1982, p.152), where the technological paradigm governs how progress can be defined, and thereby limits the possible alternative solutions for defined problems.

Possibly as a result of its roots in sociological and historical research on technology, SST rarely includes biology[5] as an active part in shaping technology (see *e.g.* the complete lack of active nature in the anthology of SST research by Sørensen and Williams (2002)). However, the central role of biology in shaping living technologies, such as crop technology, is noted by Russell (2008), who draws on SST in analysing the biotechnology of GM cotton. Russell (2008) introduces the term 'biological embeddedness' to reflect the particular properties of technology that forms part of living biological entities. She describes biological embeddedness as "*both the literal embedding of a technology inside a living organism, and the metaphoric embedding of the technology in social, spatial and ecological settings by virtue of its biological nature*" (Russell, 2008, p.214).

Two particular dimensions of biological embeddedness described by Russell are drawn on here. First, the outcome of biologically embedded technology depends on the interactions between scientists' intentions, internal crop biology and the surrounding ecosystem. While Russell (2008) specifically talks about GM crops, this interaction between intentions, crop biology and ecology in shaping crop technological trajectories applies equally to any crop breeding activity (*e.g.* as outlined by Fitzgerald (1993) with regard to the development of hybrid maize). Second, as crop technology is generally able to reproduce itself, it is less dependent on the industrial production system[6] and therefore has greater

are moved between organisms from the same species, but these are not discussed here.

[4] After the academic references to scale neutral in the 1980s and 1990s (e.g. Feder, 1980; Feder and Umali 1993), the concept seems to have been fairly dormant until it reappeared in literature discussing crop technology in the 2000s (Mosley, 2002; Hazell et al., 2010; Wiggins et al., 2010; Collier and Dercon, 2014). With some time lag in relation to societal events, which is in the nature of academic work, this follows the general trend of the shifting centrality of agriculture in development policy over time. In sharp contrast to the attention given to crop technology during the Green Revolution in the 1960s and 1970s (and appearing in the academic literature up until the early 1990s), the role of agriculture in rural development was largely ignored throughout much of the 1980s and 1990s in the global development community (McMichael, 2009; Scoones and Thompson, 2011). This trend shifted at the start of the millennium (Andersson Djurfeldt, 2013), which can be seen in reports such as the publication *Agriculture at the Crossroads: International Assessment of Agricultural Knowledge* (Kiers et al., 2008) commissioned by the World Bank and the Food and Agriculture Organization (FAO), and the fact that the *World Development Report 2008: Agriculture for Development* (World Bank, 2007), was the first world development report in 25 years to be devote d to agriculture (McMichael, 2009).

[5] The term biology is used here to include all biological functions of the world from genetics to ecosystems.

[6] I here draw on Russell (2008, p. 215) to define industrial production system as the factory (or in the case of crops, e.g. the laboratory or research station) where a technology is developed.