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Farmer seed networks make a limited contribution to agriculture? Four common misconceptions

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ABSTRACT

The importance of seed provisioning in food security and nutrition, agricultural development and rural livelihoods, and agrobiodiversity and germplasm conservation is well accepted by policy makers, practitioners and researchers. The role of farmer seed networks is less well understood and yet is central to debates on current issues ranging from seed sovereignty and rights for farmers to GMOs and the conservation of crop germplasm. In this paper we identify four common misconceptions regarding the nature and importance of farmer seed networks today. (1) Farmer seed networks are inefficient for seed dissemination. (2) Farmer seed networks are closed, conservative systems. (3) Farmer seed networks provide ready, egalitarian access to seed. (4) Farmer seed networks are destined to weaken and disappear. We challenge these misconceptions by drawing upon recent research findings and the authors' collective field experience in studying farmer seed systems in Africa, Europe, Latin America and Oceania. Priorities for future research are suggested that would advance our understanding of seed networks and better inform agricultural and food policy.

Introduction

Around the world, researchers, policy makers, and foundations are working hard to improve seed provisioning to farmers in developing countries in order to increase agricultural productivity, nutrition and rural well-being. Between 2007 and 2012, for example, fifty percent of the World Bank's 191 projects promoting

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sustainable agriculture, totaling $513m, had a seed system component (Rajalahti, 2013, cited in McGuire and Sperling, submitted for publication). The Alliance for a Green Revolution in Africa (AGRA) has placed particular emphasis on strengthening the seed sector and promoting the commercialization, distribution and adoption of improved crop varieties (AGRA, 2013). Many development donors have projects, some spanning more than a decade, aimed at improving farmer access to adapted and certified seed, as well as supporting the informal seed sector (FANRPAN, 2010; Gill et al., 2013). In addition, a diverse array of donors and NGOs invest considerable effort in supporting community-based initiatives that assist farmers in farmer seed enterprises, seed production and seed sharing (e.g., Kugbei et al., 2000; Gyawali, 2010; Tin et al., 2011; Lacoste et al., 2012).

Seed systems also lie at the nexus of important on-going debates on themes ranging from seed sovereignty and the implications of intellectual property rights to GMOs and conservation of agrobiodiversity and plant germplasm. These debates bring researchers, policy makers, farmers, activists and politicians together across divides in ideology and praxis over seed legislation, regulation and commercialization (Kloppenburg, 2010; Aistara, 2012; Da Via, 2012; Bezner Kerr, 2013; Demeulenaere, 2014). Informing these debates and seed policy interventions is a community of researchers who seek to understand better how seeds circulate through societies and communities, in diverse contexts (e.g., Coomes, 2010; Calvet-Mir et al., 2012; Thomas et al., 2012; Pautasso et al., 2013; Reyes-García et al., 2013; Coulibaly et al., 2014; Labeyrie et al., 2014). The problem of understanding seed circulation is a complex one because farmer seed systems are embedded in social relations and institutions that constitute the social, economic and political fabric of rural life; no single discipline can provide the conceptual and analytic tools needed for a compellingly holistic account. Research to date has made significant advances, demonstrating the need for much closer attention to farmer seed systems in the development of national seed policy and for closer integration between 'formal' (commercial or state-led) and 'informal' (farmer) seed sectors (Almekinders and Louwaars, 2002; Louwaars et al., 2013; Pautasso et al., 2013; Coulibaly et al., 2014; Deu et al., 2014).

This paper is the product of a series of interdisciplinary workshops conducted biannually over three years that examined the nature, role and significance of farmer seed networks in Africa, Europe, Latin America and Oceania. The workshops brought together the NetSeed network, a French initiative funded by CESAB-FRB (*Centre de Synthèse et d'Analyse sur la Biodiversité-Fondation pour la Recherche sur la Biodiversité*), to share datasets and field experience of researchers working on farmer seed provisioning in different societies, cultures and economies (Pautasso et al., 2013). Participants contributed considerable depth of field-based understanding of farmer seed networks to workshop discussions from a diversity of disciplinary perspectives, including ecology, plant genetics, anthropology, ethnobotany, sociology, political science, geography and development studies. Workshop discussions entailed an iterative consensus-building process that resulted in a general conclusion among participating researchers that important misunderstandings persist in the research and policy communities about farmer seed networks that merit broader discussion.

In this paper we highlight four common misconceptions about farmer seed networks that limit the appreciation of their importance in the international food and agricultural policy community. By 'common misconception' we mean an oversimplification, overgeneralization or misunderstanding that is embraced by important actors in debates, discourses or interventions aimed at promoting seed system development. Clearly such misconceptions are not necessarily universally held, but we provide evidence for each that such views are embraced by at least some influential commentators and organizations working to further the development of seed systems, farmers' rights, or seed sovereignty. We challenge these views by drawing on recently published research findings as well as our collective field experience in studying farmer seed networks in diverse settings and populations. Although recognizing that seed access is relevant to broader concerns related to, for example, agrobiodiversity, rural livelihoods and agrarian futures, we focus our attention specifically on the nature, dynamics and contributions of farmer seed networks to agriculture. Our aim is to advance understanding of the importance of farmer seed networks in ways that better inform research and policy in agricultural development, food policy and agrobiodiversity/germplasm conservation.

Defining farmer seed networks

What do we mean by 'farmer seed networks'? Farmer seed networks transfer seed (and other generative material such as cuttings, pseudostems or tubers) from domesticated or undomesticated plants via farmer-to-farmer gifting, swapping, bartering, or purchase, and also via trading or sale which occurs outside of the commercial seed sector and formal regulation. The planting material flowing through such networks may come from a range of sources, including farmers' own fields and gardens and those of other farmers, local or district markets, NGOs and foundations, National Agricultural Research Systems (NARSs) and International Agricultural Research Centers (IARCs), and agro-dealers and other commercial seed suppliers. Much literature refers to such networks as belonging to 'informal seed systems' through which landraces and local seed varieties flow – in contrast, and often in opposition, to 'formal seed systems' which convey improved, certified seed to farmers (e.g., Biemond et al., 2013a). While recognizing that categories of 'informal/formal' are a useful short-hand in discussions about seed systems, we avoid their use in this paper for three reasons: (1) this dichotomous depiction reinforces certain misconceptions; (2) much permeability exists between 'formal' and 'informal' systems; and (3) 'informal' can convey, misleadingly, a sense of absence of or diminished role of social rules and norms that govern circulation. As such, farmer seed networks can take a variety of forms and configurations, and we consider them broadly to be social networks that emerge with the formation of ties by seed transfer events.

The four misconceptions identified through our consensus-building process and challenged in this paper are:

1. Farmer seed networks are inefficient for seed dissemination;
2. Farmer seed networks are closed, conservative systems;
3. Farmer seed networks provide ready, egalitarian access to seed; and,
4. Farmer seed networks are destined to weaken and disappear.

For each, we outline the proposition made and explicate the supporting reasoning and argument, pointing to specific examples that suggest that the view holds currency and sway among influential organizations, observers, scientists or advocates. We then present counter-case arguments, illustrated by recent published findings and our field experience, which challenge the proposition, such that it may be viewed as a misconception. As discussions in our workshops revealed, opinions on these propositions can vary widely even among a group that is unified by a common interest in farmer seed networks; our hope is that the reader will consider our casting as fair and judge the arguments taken together *in toto* that farmer seed networks do indeed make an important, understudied and underappreciated contribution to agriculture. We conclude with a discussion of priorities for future research on farmer seed networks and their policy implications.

I: 'Farmer networks are inefficient for seed dissemination'

Misconception: Farmer seed transfers contribute limited volume and dubious quality of seed for agricultural production, and thus are inefficient drivers of agricultural development.

This misconception underpins many current agricultural development policies and initiatives aimed at promoting large-scale seed production and marketing by states, multilateral agencies, foundations, or private enterprises. These efforts seek "to make quality seed available to small-scale farmers. Since the benefits of modern plant breeding can reach farmers only through an efficient seed system, there is an urgent need to develop the private seed sector" (World Bank, 2006: 25). Proponents of this view relegate farmer-to-farmer exchanges or trade of planting material within local market places to the status of 'informal networks', and consider they contribute an unreliable and limited supply of uncertified seed, often of dubious quality, for agricultural production, resulting in "slow adoption of improved varieties, low yields and heightened susceptibility to crop diseases" (ICARDA, 2014; see also AGRA, 2013). In many countries, farmer-to-farmer transfers of seed have been actively discouraged by state agricultural policy that promotes commercial seed provision and modernization of agriculture (Aistara, 2011; Thomas et al., 2011). Indeed, farmer seed networks are often seen as a transitional stage on an 'evolutionary' path to formal commercial systems delivering improved varieties, persisting only due to limitations in farmers' education, purchasing power, or access to better outlets (Maredia and Howard, 1998: 2; AGRA, 2013: 54). In this view, prescriptions for improving yields and reducing poverty lie in provision of improved seeds through the formal seed system (Awotide et al., 2012; Martens et al., 2012).

Challenging the misconception

A growing literature challenges this view in three ways. First, formal or commercial seed provision plays a limited role in developing countries, supplying a very small proportion of what farmers sow, often measured well below 10% (Badstue et al., 2007; Dyer et al., 2011; Jarvis et al., 2011; Okry et al., 2011; Samberg et al., 2013; Sperling and McGuire, 2013). Even for staple crops receiving the bulk of policy and fiscal support (e.g., maize), formal seed systems often supply less than 20% (Louwaars et al., 2013, for sub-Saharan Africa). No firm figures as yet exist of the amount of crop seed and other planting material moving through farmer seed networks, but global estimates of 80–90% (e.g., Sperling and McGuire, 2010a), which include seed self-provisioning, seem reasonable. While some observers might respond that this merely indicates the weakness of more 'evolved' (i.e., commercial) supply channels (AGRA, 2013), we contend that the considerable contribution of farmer seed networks in seed delivery indicates they currently serve farmers' needs rather well, and can be favorable in terms of choice, accessibility, cost, and non-economic utility (e.g., social values).

Second, farmer seed networks are important for building viable and diverse crop populations, and for the spatial as well as social distribution of genetic, morphological and varietal diversity, for staple and for minor crops. Studies have confirmed that farmer seed circulation is important in shaping gene flow among crop varieties. Farmer networks are particularly important for the transmission of non-core crops and other plant species which are often ignored by formal supply; Ellen and Platten (2011), for example, highlight how seed transfers in English garden allotments build agrobiodiversity beyond what is available from commercial suppliers. This diversity is also the basis for future crop improvement (Louafi et al., 2013). A wide body of literature is now available on how these networks have shaped the amount and distribution of diversity in many crops, including maize (Bellon et al., 2011; Dyer and López-Feldman, 2013; Hellin et al., 2014; Orozco–Ramírez et al., 2014), sorghum (Deu et al., 1994, 2014; Barnaud et al., 2008), barley (Abay et al., 2011; Bajracharya et al., 2012; Jensen et al., 2013), millet (vom Brocke et al., 2003; Allinne et al., 2008), wheat (Bishaw et al., 2010; Thomas et al., 2012; Chentoufi et al., 2014), quinoa (Fuentes et al., 2012), cassava (Dyer et al., 2011; Kawa et al., 2013; Fu et al., 2014), and others (Jarvis et al., 2007).

Third, farmer seed networks can provide quality planting materials that are acceptable to farmers (Sperling and McGuire, 2010b). Claims that formal channels are the sole guarantors of 'quality seed' conflate two aspects of quality best kept distinct: genetic quality (attributes such as yield potential or seed color) and seed quality *per se* (seed health, germination ability, freedom from contaminants). These claims are also normative, as seed quality in farmer seed networks is rarely studied (Almekinders and Louwaars, 1999). For genetic quality we note that farmer networks commonly supply material which farmers appreciate, including varieties with traits not produced by formal breeding (such as tolerance of characteristic local stresses, or particular organoleptic qualities; Ceccarelli, 1994; Bellon et al., 2011) or crops neglected by formal research. There is evidence that farmer networks can maintain morphological and yield characteristics of elite improved varieties over multiple seasons (e.g., Deu et al., 2014). For seed quality *per se*, recent work challenges the notion that farmer networks only keep subgrade seed in circulation, finding few significant differences in quality between seed from farmer or formal sources (Bishaw et al., 2012, 2013; Gibson, 2013), and no evidence to support the claim that seed recycling negatively affects quality (Biemond et al., 2013b). Practices and institutions – e.g., around seed selection and storage, or social certification in neighborhoods and markets (Thiele, 1999; Sperling and McGuire, 2010a) – exist to maintain quality in farmer seed networks, not least to avoid exclusion of the supplier from these networks. Farmer seed networks are simply conveyors of seed, and should not be conflated with the practices and institutions that shape seed quality. This does not negate the fact that there is much scope for improving quality in farmer networks, but seed quality can also be poor under formal regulation, due to inappropriate standards or weak enforcement (Tripp and Louwaars, 1997).

II: 'Seed networks are closed, conservative systems'

Misconception: Farmer seed networks are considered to be of limited value to agricultural development because they are closed systems that circulate seed of local varieties through exchanges among farmers over small geographical areas where infrastructure and markets are poorly developed.

Farmer seed networks are considered to be integral to the 'informal' seed system that enables farmer access to seed – joining farms and enabling seed flow – but are distinct and apart from the formal sector which conveys new varieties and fresh, certified seed from plant breeders to farmers. Farmer seed networks are denoted as being geographically and socially marginal, and insular. In contrast, national breeding and seed supply systems in the formal sector are promoted as the best means to increase the adoption of modern varieties and to raise productivity (for a current example, see AGRA, 2014). On strengthening seed systems for food security, ICARDA (2014) writes, "80–90% of food grains in many developing countries still depend on informal seed systems that consist of recycling older varieties saved during harvest and uncoordinated exchanges of seed among farmers."

Challenging the misconception

Far from being closed systems, farmer seed networks convey new domesticates, varieties and planting material from the wild as well as modern varieties from the formal sector into agricultural production. The movement of wild materials from forests and grasslands into cultivated ecosystems has been an important source of new domesticates and novel diversity in both the New and Old World (Jarvis and Hodgkin, 1999; Dansi et al., 2010). New varieties created by on-farm management and adapted to local environmental and market conditions are disseminated through farmer seed networks, increasing crop diversity and enhancing incomes (Bellon and Risopoulos, 2001; Zannou et al., 2004). Networks extend the reach of markets and commercial seed supply, bringing seed to farmers where markets are thin or inaccessible to some. Frequent transfers of small quantities of planting material can effectively disseminate new varieties (David and Sperling, 1999; Aw-Hassan et al., 2008; Bishaw et al., 2010; Garine et al., 2014). Increasingly, international and national agricultural agencies are recognizing the efficiency of informal farmer seed networks and turning to them to disseminate improved varieties where linkages between the formal sector and farmers remain weak (Kabore et al., 2010). Farmer networks also provide the pathways for diffusion of creolized varieties (hybrids of local and improved varieties), further broadening the spectrum of useful diversity available to farmers as improved varieties, particularly of open-pollinated crops, 'go wild' (Aistara, 2011; van Heerwaarden et al., 2012; Deu et al., 2014; Westengen et al., 2014b). Dyer et al. (2011: 1) note, "[c]assava populations are surprisingly open and dynamic: farmers exchange germplasm across localities, particularly improved varieties, and distribute it among neighbors at extremely high rates vis-à-vis maize." Seed transfer is typically accompanied by the transmission of information about crop varieties, their agronomic requirements, yields, consumption qualities, and vulnerabilities to pests and disease. Indeed, farmer seed networks are an important channel for the conveyance of agricultural novelty, innovation and diversity across farmer populations, regions and ecosystems, and often are capable of doing so more efficiently than other systems in much of the developing world.

In addition to being open systems, farmer seed networks often extend well beyond local communities and environments (Zimmerer, 2010), and are dynamic in their formation and operation. Farmer networks can exhibit small-world properties (i.e., local networks with some long-distance links), as seed transfers sometimes stretch several hundred kilometers, cross national boundaries, and span distinct agroecosystems – between forests and savannas, across elevation gradients in mountains, and between floodplains and uplands (Zimmerer, 1996; Caillon, 2005; Emperaire et al., 2008; Coomes, 2010; Bellon et al., 2011). Such transfers typically entail small quantities but they are vital for building crop and varietal diversity and for renewing planting stock, and are important for gene flow, diffusing genetic material (including transgenes) (Smale et al., 2008; Jensen et al., 2013). Van Heerwaarden et al. (2012) write, "[e]ven though farmers predominantly rely on local seed sources, infrequent long-distance flow causes transgenes to spread much further than would be expected in the absence of seed flow." Field research has enabled the visualization and analysis of farmer seed networks and the identification of farmers who hold a nodal position as individuals who are particularly important in the custody and dissemination of planting material (Salick et al., 1997; Subedi et al., 2003). As yet, however, researchers have been limited by available analytical techniques and field protocols from being able to portray the dynamic and contingent nature that field reports suggest may characterize seed transfer events (Poudel et al., 2008; Abay et al., 2011; Kawa et al., 2013). Farmer seed networks and specific nodal farmers thus may be more ephemeral than implied by recent cross-sectional studies using social network analyses (Poudel et al., 2015). This dynamism also presents challenges for understanding plant trade systems (Pautasso and Jeger, 2014).

The open and dynamic nature of farmer seed networks enables them to be responsive to changes in contextual conditions and resilient to environmental and price shocks. Seeds are effectively stored in farmer networks – something quite distinct from physical storage in granaries or community seed banks – and these networks offer an important alternative to providing seed in times of shortage. Some farmers give seeds or exchange seeds with others to ensure particular varieties will persist beyond their farms and local environments and remain available to them at a later date if needed, for example for taro in Vanuatu (Caillon, 2005). Farmer networks – which include local markets – help ensure access to varieties at risk; more broadly, they enable and incentivize on-farm conservation of crop and varietal diversity by linking farmers together and providing channels for mutual assistance, i.e., a seed safety net (Sperling and McGuire, 2010a). The act of exchanging seed gives rise to a social obligation that ensures that seed be available upon need. Storage on-farm, by merchants, or at community level enables the generation of seed that may be remitted to donor farmers, and in this way, seed networks serve the function of providing seed access in the face of climatic shocks, pest and disease outbreaks, etc. While aspects of such 'in-network storage' may break down under extreme conditions (e.g., social ties weakened after war; Sperling, 1997), for most farmers in the developing world, farmer seed networks are vital in ensuring long-term access to diverse crop planting material.

III: 'Farmer networks ensure ready, egalitarian access to seed'

Misconception: In informal seed systems, seeds and germplasm move fluidly among farmers, with few barriers to exchange and at minimal cost.

Advocates of seed sovereignty, farmers' rights and informal seed systems may presume that seeds and germplasm move fluidly among farmers and at minimal cost. Seed movement among farmers is enabled by a variety of features central to the ethos of peasant life: social and cultural norms of mutual assistance; reciprocity and solidarity in agrarian societies; a proclivity for gifting and exchange 'in-kind' over monetized exchange; a reticence to embrace formal property rights over local resources, including planting material; and, resistance to the commodification of seed. Accordingly, in the absence of markets, farmers' social networks transfer seeds 'for free', and farmers do (and should, by their rights) have ready, unfettered and undifferentiated access to planting material (Brush, 1992; Calle, 1996; Correa, 2000; Rudebjer et al., 2011; Meienberg and Lebrecht, 2014). The presumed 'informality' of rural social relations that guide seed circulation is understood as placing few impediments in the way of seed transfers. Initiatives by NGOs and aid agencies aimed at promoting farmer seed networks through, for example, collective banks, seed fairs, and seed swapping, often rely upon the assumption of low barriers to seed sharing and an idealization of the terms of seed exchange (Pratten, 1997; Practical Action, 2011; Lacoste et al., 2012; Navdanya, 2012).

Challenging the misconception

A growing body of empirical research on farmer seed networks indicates, however, that the notion of 'frictionless' circulation of planting material through rural social networks and seed systems – providing farmers with ready and equitable access to seed – is problematic.

In agrarian societies, desirable seeds are considered to be a scarce resource, one that is allocated by institutions – whether markets or other social institutions – which govern seed movement via specific social and cultural norms. These institutions have the effect of discriminating among farmers such that some have better access to seed than others. Seed access is conditioned not only by the biological properties and ecology of plants that influence seed production and viability (and thus availability), but also by cultural practices (e.g., how crops are cultivated, seeds stored and managed, etc.) as well as by institutions and social relations that impede or enable seed flow and thus determine the social scarcity of seed (David and Sperling, 1999; Dennis et al., 2007; McGuire, 2008; Jarvis et al., 2011). Such social relations and institutions may center on domains unrelated to seed transfer or even to agriculture – such as marriage, kinship, or labor sharing – but they can have an important influence on seed circulation. A major thrust of research today lies in identifying and describing how such institutions condition farmers' access to seed. Among the Fang people of Gabon, for example, the movement of seeds in metapopulations across kingroups is shaped by marriage prohibitions (Delêtre et al., 2011). Kawa et al. (2013) in Amazonia found that rural social networks can constrain varietal distribution and contribute to low crop diversity in agricultural communities. Communities with weak social networks have been shown to be more vulnerable to adverse conditions because of constrained access to locally adapted seed, compared to those with strong social networks (Poudel et al., 2005). Similarly, social exclusion in seed circulation can occur among individuals, such as widows, orphans or tenant farmers (Bezner Kerr, 2013, Table 3). The circulation of seeds can also be limited by ethnolinguistic boundaries, as in the case of maize in Chiapas (Brush and Perales, 2007) and of sorghum in Kenya (Labeyrie et al., 2014) or in Africa more widely (Westengen et al., 2014a). Cases of local institutions explicitly supporting free access to seed in traditional societies are in fact relatively rare (see Garine et al., 2014).

In addition to the rural institutions and social relations that mediate the flow of crop planting material, farmers themselves are selective about with whom they share seed and germplasm. Seeds are much more than an input to agricultural production for farmers – they are a source of wealth, pride, and identity. For instance, among certain indigenous groups in Amazonia varietal diversity of manioc is seen as a reflection of farmer expertise (Emperaire and Peroni, 2007; Heckler and Zent, 2008) and even as being central to the notion of womanhood (Heckler, 2004), so access to varietal diversity through intergenerational transmission (mother–daughter) is particularly important (Chernela, 1986). Boster (1985, 1986) observes that seed transfers create social bonds among the Aguaruna that reinforce the relationship between the bride and her in-laws, strengthening social cohesion and building cultural consensus. When farmers in Vanuatu discover a new variety of taro when opening a garden in an old fallow, they seek to disseminate the propagules among as many other farmers as possible, to perpetuate the finder's name through time (Caillon and Degeorges, 2007). In contrast, farmers in many regions may also strive to protect their special varieties, through exclusion in 'secret gardens', deception and reluctance to offer planting material to others despite norms of mutual assistance and sharing (Cleveland and Murray, 1997; Coomes and Ban, 2004; Demeulenaere and Bonneuil, 2011).

Seed exchanges are transacted bearing in mind the potential social costs and benefits of sharing material and information, as well as the trustworthiness of the parties involved. When farmers lack confidence in seed produced by neighbors, they seek out seed in local markets (Sperling and McGuire, 2010a) which they may in turn circulate onwards, farmer-to-farmer; where markets provide poor quality seed, farmers may prefer sourcing from reputable neighbors (Badstue et al., 2007; Bicksler et al., 2012). As such, trust plays an important role in terms of the selection of seed source, whether by gift or sale, but also in determining with whom a farmer exchanges seed. In addition to trust, recent studies have sought to identify household and farmer characteristics that influence seed sharing.

Seed transfers have been shown to be affected by farmer age, gender and wealth status (Howard, 2003; Rana et al., 2007; Barnaud et al., 2008; Delêtre et al., 2011) and often entail debt or specific social obligations. Indeed in some cases, farmers prefer to purchase seed rather than having to borrow them (Smale et al., 2008). Samberg et al. (2013) found that one-third of farmers in southern Ethiopia would, in principle, ask neighbors for seed, but only 11% actually did so; they did not want to shamefully 'beg'. In the extreme, the fear of curse dissuades farmers from seeking seed from others (Sumberg and Okali, 1997; Labeyrie, 2013). Heritage and cultural identity values can be enhanced when seeds are acquired from a relative or community elder (Meinzen-Dick and Eyzaguirre, 2009). Alvarez et al. (2005: 541) observe both obligation and debt in seed provision among farmers, "an older farmer will never ask a younger one for seeds; in the field, older people must help younger ones, not the opposite... Older Duupa are reluctant to be indebted in any way to younger individuals."

Like agrobiodiversity, seed sharing is often associated with wealth, and gifting is sometimes used to enhance the donor's prestige (McGuire, 2008). Farmers with leadership positions and greater ethnobotanical knowledge (but not necessarily higher cultivar diversity) are found to be more likely to give out seeds than others (Kiptot et al., 2006; Kawa et al., 2013). Farmer mobility and migration, which are often linked to wealth, also are related to seed sharing as more opportunities arise to both accumulate and disseminate new varieties (Eloy and Emperaire, 2011). Farmers are also known to shape their social networks to secure specific crop varieties – for instance, in Vanuatu there were no direct and public exchanges of varieties following a seed fair; however, farmers did notice who was cultivating what, and over several years purposefully built their networks to access a particular variety they desired (Caillon, 2005). The lability and malleability of rural social networks provide farmers with opportunities to acquire seeds and thus influence seed circulation and distribution among farmers, with the result that some farmers benefit from better access to planting material than others. In short, farmer seed networks do not necessarily ensure equitable access to seed among farmers or communities.

IV: 'Farmer seed networks are destined to weaken and disappear'

Misconception: Crop and seed commercialization and related regulation will extinguish farmer seed networks, replacing them with commercial (formal) seed provision systems.

According to this view, the expansion of markets for agricultural products and key inputs, including seeds, is transforming relations – by design or by effect – in ways that threaten the continuance of farmer seed networks. Seed commoditization, often an explicit objective of agricultural modernization policy (Pray and Umali-Deininger, 1998), is linked to commerce-oriented seed legislation and regulation that restrict which actors and germplasm can be involved in seed transfers (Kloppenburg, 1989). In post-war France, for example, the state suppressed the circulation of seed from traditional varieties of wheat and other crops to promote improved, commercial varieties (Bonneuil and Thomas, 2010). Today, seed quality standards such as certification, catalogs of varieties allowable for trade, and the promotion of intellectual property rights over germplasm, are all intended to direct seed flow toward market channels, not only in Europe and North

America but also increasingly in developing countries (Santilli, 2011; Aistara, 2012; de Jonge, 2014). Such regulation, accompanied by the promotion of commercial seed outlets such as agro-input shops by development donors (Toenniessen et al., 2008), is seen to restrict greatly the scope for farmer seed network actors and exchanges (Zerbe, 2001; Odame and Muange, 2011; Bezner Kerr, 2013). At the same time, interest among farmers themselves may be waning, as more diversified and monetized livelihoods change farmers' weighing of the benefits and transaction costs of seeking out sources and seed from commercial outlets versus farmer seed networks (Zimmerer, 2003; Bellon, 2004; Fuentes et al., 2012; Samberg et al., 2013). According to this view, these combined forces inexorably lead to the withering away of farmer seed networks. While some farmer-to-farmer exchanges may persist, restrictions to farmers' autonomy by an ascendant commercial system, coupled with weakening of the social institutions that underpin seed exchanges, would increasingly render these transactions marginal in seed systems. Interestingly, groups holding opposing views of the desirability of agricultural commercialization and their impacts often espouse a common view: that farmer seed networks today are imperiled (e.g., Lipper et al., 2005; African Centre for Biosafety, 2012; Navdanya, 2012; de Jonge, 2014).

Challenging the misconception

While the perception of threat to farmer seed transfers and to farmers' choices is understandable, and often well founded, farmer seed networks are likely to persist over the long run in the face of commercialization, legislation and regulation. Indeed, impacts on farmer-to-farmer seed transfer should not be conflated with the broader and often troubling effects of commercialization on smallholders' livelihoods (Amanor, 2012; de Jonge, 2014) and agrobiodiversity (Zimmerer, 2010; Gilbert, 2013; Dyer et al., 2014). The nature and structure of farmer seed networks co-evolve reflexively with their commercial and regulatory context, reflecting farmers' changing needs, interests and strategies for engagement with market-oriented agricultural development, food policies and seed legislation. There are at least four factors that support the persistence of farmer seed networks, despite commercial and regulatory pressures.

First, seeds move through farmer seed networks regardless of their provenance and mode of acquisition. Ample evidence indicates, across many countries, that farmers routinely exchange cash or services to access seed from local markets, shops, or each other, often as their primary source of seed (Dennis et al., 2007; McGuire and Sperling, 2013; Samberg et al., 2013). Seeds originating from commercial seed systems may be sold through farmer seed networks alongside local or creolized varieties (van Heerwaarden et al., 2009; CRS et al., 2013). Whereas farmer networks may be more monetized than in the past (Sperling, 1997; McGuire, 2008; Samberg et al., 2013), network exchanges and relationships persist, and many aspects of complementarity exist between these networks and commercial seed provisioning (van Heerwaarden et al., 2009; Zimmerer, 2013). This hybridity is increasingly recognized by development actors, and particular linkages are promoted in order to disseminate useful varieties (Louwaars and de Boef, 2012; Deu et al., 2014), build local enterprises (Almekinders, 2011; Li et al., 2014) and conserve agrobiodiversity (Almekinders et al., 2000). Commercial relationships are not anathema to farmer seed networks.

Second, farmer seed networks channel non-commercialized seed for many crops and serve a range of purposes that go unmet by commercial seed provision. Farmer networks may be the sole seed source, particularly for crops overlooked by research (e.g., local vegetables) or commercial seed supply (e.g., vegetatively-propagated, grain legumes – due to profitability challenges (Cromwell, 1996). For crops that are commercially available, farmer seed networks may still be preferred for utilitarian reasons such as variety choice, taste, balance of price with risk, and ease of access (e.g., Bellon, 1996; Louwaars and de Boef, 2012; Dyer and López-Feldman, 2013). Moreover, seed exchanges are important to farmers for reasons other than seed access, such as maintaining and forging social ties or building social capital and prestige (Badstue et al., 2006; Labeyrie et al., 2014; Orozco–Ramírez et al., 2014). Seed sharing relationships are found even within commercialized seed systems (Isakson, 2009; Ellen and Platten, 2011; Graddy-Lovelace, 2014), reflecting the importance and attraction of seed networks to farmers.

Third, restrictive regulations on seed transfers that accompany commercialization are often difficult to implement and enforce among farmers who have good reasons to continue to exchange seeds. Transaction costs for regulating small and localized farmer seed transfers are high, making enforcement often impractical and uneconomical. Indeed, seed of varieties that underpinned the Green Revolution as well as those of genetically modified crops grown in India, China and Argentina have spread widely through farmer-to-farmer exchanges (Kesan and Gallo, 2005; Herring, 2007; Ho et al., 2009; Ramaswami et al., 2012), highlighting enforcement challenges, even for seed with high commercial interest. Also, innovative alternative forms of regulation are emerging that aim to help entrepreneurs in farmer seed networks thrive within commercial regulation, e.g., through recognizing new categories of vendors, quality standards (FAO, 2006; López-Noriega, 2012), and ownership or provenance designation (e.g., Salazar et al., 2007). While recognizing that strict regulation and enforcement have acted to restrict farmer seed networks in specific instances, we note that the cost of enforcement and the creative actions of farmers generally act in practice to counter restrictions to seed movement.

Finally, and relatedly, farmers increasingly are able to mobilize collectively and push back against commercialization and restrictive regulation. In Europe and North America, farmers have acted to strengthen existing farmer networks and/or develop new ones, with aims to preserve varietal diversity and farmer control over seed transfer for commercial as well as non-commercial crops (Steinberg, 2001; Campbell, 2012; Thomas et al., 2012; Phillips, 2013). Responses include political mobilization that directly contests restrictive commercialization and articulates alternative agrarian futures (Aistara, 2012; Navdanya, 2012; Demeulenaere, 2014; GRAIN, 2015), sometimes leading to policy innovations, e.g., around seed legislation or plant variety protection (Aistara, 2014; de Jonge, 2014; Kloppenburg, 2014; Winge, 2014). As such, farmer seed networks are emerging as a site of popular resistance where particular versions of globalization are contested. In supporting farmer-to-farmer seed transfers, many contest, for example, the emphasis on policies promoting international trade and productivity increases over other important considerations such as the viability of small farms, local farmer agency, or sustainability (Kloppenburg, 2010; Da Via, 2012; Bezner Kerr, 2013). This illustrates another way in which such networks are taking on an importance beyond simply the conveyance of seeds and germplasm. While farmers may have more practical interests, such as preserving access to diversity and sovereignty over seed, many see the symbolic importance of farmer seed networks in agrarian struggles.

Concern over threats to farmer seed networks spring from worry over the loss of traditional varieties, local knowledge, gift transactions (Bocci, 2009; Bezner Kerr, 2014) and their independence and ways of agrarian life – all of which are serious concerns, worthy of attention and discussion, but are distinct from the relationships of exchange that underpin and beget farmer seed networks. Farmer seed networks are not in robust health

everywhere, but agricultural modernization has differentiated impacts on farming, farmers are far from passive in the face of change, and many aspects of farmer seed networks are resilient and co-optively adaptive to new market and regulatory environments, persisting (or reemerging) in a range of hybrid forms and settings.

Discussion and conclusions

In this paper we examined four current views regarding farmer seed networks and criticized them as misconceptions that influence both the understanding and appreciation of the importance of seed networks in agriculture. Our critiques are based on recently published research and the experience of the authors in studying and working with farmers on their seed systems. Certain elements of the critique of each view are well known to those who work on seed systems; others are perhaps not, or less so. More importantly, our purpose in making this critique was to marshal a compelling argument supported by recent empirical evidence that addresses the rhetorical question that guides this paper – how important are farmer seed networks? – and to advance this understanding for those on all sides of policy, research and advocacy discussions on 'formal', 'informal' and 'integrated' seed systems.

Farmer seed networks make a vital contribution to agriculture because they are an effective means of moving seed not only farmer-to-farmer, but also from nature, local markets, national seed agencies, research stations, agro-dealers, and agribusiness to farmers throughout the countryside. Seed networks are about the conveyance of planting material and should not be conflated with seed quality or with particular sources. They are open systems that draw material from the wild and from improved varieties, redirecting geneflow and enabling farmers to reshape – by cultivation and further seed transfer – crop populations and the biogeography of genetic, morphological and varietal diversity (Alvarez et al., 2005; Thomas et al., 2012). Such material can move quickly and over long distances from farmer to farmer as shown by historic (e.g., Perrier et al., 2011; Fuentes et al., 2012; Roullier et al., 2013) and recent introductions (Dyer et al., 2011); large quantities of high-quality seed are not required to move in order for new planting material to have transformative effects on agrobiodiversity or farmers' lives.

Although such networks are open systems, this does not mean that seeds are free or that seed flow goes unimpeded among communities, farmers, families, ethnic groups or polities. Seeds bear social costs and meanings. Transfers among farmers follow and reinforce social relations around identity, status and wealth and access to planting material is more typically unequal than egalitarian, even in the absence of market-mediated seed relations. In-network storage of seed is an important safety net for farmers in the face of crop seed loss and calamity, and an important complement to physical storage in granaries or community seed banks. Recognizing the efficiencies of farmer-to-farmer seed circulation, NARSs, IARCs and foundations are increasingly working to use farmer seed networks to disseminate improved varieties and certified seeds (Gyawali, 2010; Gibson, 2013; Joshi et al., 2014). In most developing regions, where formal seed systems have limited reach, a paucity of linkages to outlets and considerable inefficiencies in seed delivery – due to poor infrastructure, thin markets and pervasive poverty – farmer seed networks overcome high transaction and transport costs. For this reason much of the developing world's seed moves through these networks. And such farmer seed networks are likely to persist even as more commercial seed sectors and seed markets develop – one has only to look at how European farmers demand access and control over their seed to see that the formal sector will not push out farmer-to-farmer seed transfers (Bocci and Chable, 2009; Da Via, 2012).

To go beyond the misconceptions challenged in this paper, we close by arguing for more in-depth study of farmer-to-farmer seed circulation and farmer seed networks. Research to date has been largely exploratory in nature, based on a growing number of punctual case studies, and few systematic and comparable data are as yet available (Dyer and López-Feldman, 2013). More research is needed to better understand the structure, diversity and functional properties of seed networks. Comparative research which spans geographical scales, ecologies, cultures and economies is particularly promising but would require common data collection protocols and a clearer (and shared) conceptual framework for understanding factors that condition seed transfer as a dynamic, contingent and embedded social process. In particular, distinguishing between studies of seed transfer events (with a specific time and 'orientation', i.e. direction of flow specified) and those of social networks of suppliers/recipients (not necessarily oriented or fixed in time) would sharpen analysis and add clarity to discussions. A growing suite of analytic techniques is becoming available from ecology, economics and social network analysis (Snijders et al., 2006; Borgatti et al., 2009; Jackson, 2011; Doreian and Conti, 2012; Fletcher et al., 2013; Miranda et al., 2013) that will enable researchers to advance beyond a descriptive mapping of network structures (visualization) to examine factors affecting network functioning. This will be especially important for developing an understanding of how these networks evolve and respond to change, or relate to key emergent properties such as diversity or resilience. Both the openness and dynamism of seed networks will continue to pose especially thorny methodological and analytical challenges to researchers who inevitably must sample farmers and seed circulation events selectively. Meeting these challenges would represent significant breakthroughs.

On-going debates over broad issues such as the benefits of regulatory harmonization, the rights of farmers or the future of food policy and agriculture are rife with speculation and rhetoric which cloud understanding of how farmer seed networks articulate in the broader policy context, i.e., beyond seed provisioning. Interdisciplinary collaborations that bring ethnobotanists, plant scientists and other agricultural specialists together with social scientists and jurists are potentially fruitful in this endeavor (Pautasso et al., 2013). An improved understanding of the seed network-rural policy nexus would expand the analysis of a policy or intervention beyond single and intended impacts, to consider indirect or unexpected effects on farmer seed networks. This can also give rise to new and more nuanced narratives, informing policy initiatives that more effectively leverage the advantages of farmer-based seed transfer (e.g., for diffusion of improved varieties) and strengthen seed systems to the benefit of farmers, for instance, by promoting diverse provisioning channels and new partnerships that improve farmers' access and choice, supporting local systems for managing quality (FAO, 2006), or recognizing local identities and ownership (Graddy, 2013). Finally, the diverse ways in which farmer seed networks engage entrepreneurially with markets merits much closer study, from local seed value chains (Sperling and McGuire, 2010a) to creolized 'stealth seeds' (Herring, 2007) and counterfeit seeds (sold with deliberately false claims for variety identity or seed quality; Sseguya et al., 2012). Such research promises to provide the foundations for advancing the common goals of promoting sound food and agricultural policies, conserving plant germplasm and agrobiodiversity for future generations, and enhancing the well-being of farmers around the world.

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