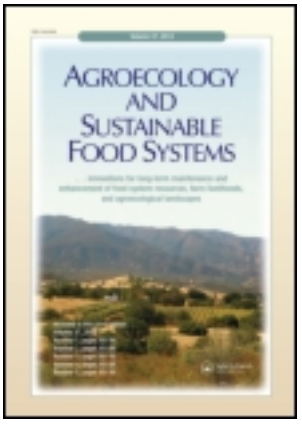

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Smallholder Perspectives on Soil Fertility Management and Markets in the African Green Revolution

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The African Green Revolution (AGR) describes a drive by governments and international philanthropic and research organizations to raise agricultural production through Integrated Soil Fertility Management (ISFM) and improved access to input and output markets. This article draws on data from three studies that took place in Northern Ghana as the AGR unfolded between 2008 and 2012, focusing specifically on soil fertility management (SFM) and access to credit markets. It finds that the AGR idea does incorporate some elements farmers find useful, indeed, that they are implementing autonomously, such as use of organic soil amendments. However, the underpinning emphasis on commercialization does not allow room for them to practice site-specific SFM and subsistence mechanisms that they have developed as responses to risk. Some aspects of the AGR are themselves disadvantageous, for example repayment of credit at harvest time, the emphasis on inorganic fertilizer and land titling schemes. Despite advocating farmer choice, the current hegemonic implementation of the AGR makes it unlikely to support farmers' sustainable agroecological practice.

KEYWORDS African Green Revolution, ISFM, markets, Northern Ghana

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INTRODUCTION

The 21st century has seen a concerted effort by African Governments, international philanthropic and research organizations and private enterprises to bring smallholders into modernized, commercialized agriculture. This African Green Revolution (AGR) focuses on raising production through integrated soil fertility management (ISFM) as well as providing better access to markets upon which to sell such produce (Toenniessen et al. 2008; Sanginga and Woomer 2009; Vanlauwe, Bationo, et al. 2010). The approach is, however, contested, by commentators focused on the ecological and political implications (Altieri 2009; Odame and Muange 2011; Koopman 2012). The start of the current phase of the endeavor could reasonably be seen as the 2006 Abuja fertilizer summit, where African Union member countries pledged to increase fertilizer application rates from an average of 8 kg/ha to 50 kg/ha by 2015 (African Union 2006). The Alliance for a Green Revolution for Africa (AGRA) was founded at this event, marking a new injection of energy into the campaign, and enough evidence has accumulated since to facilitate analysis of the movement. Accordingly, this article draws on data from five years of research in Northern Ghana on soil fertility management (SFM) and maize commercialization. It starts by describing the AGR and the divided opinions on it. Data from three interlinked projects are presented. The implications of each are noted, and the discussion contextualizes the results relating to SFM and markets with reflections on land ownership and economic differentiation. This leads to the conclusion that although the AGR endorses some valuable mechanisms and practices that farmers are already using, such as organic SFM, its overall commercial orientation prevents it from fully meeting all farmers' needs. It also contains elements that have the potential to further disadvantage farmers who prefer not to adopt its hegemonic ideology.

THE AFRICAN GREEN REVOLUTION

The AGR builds on the technologist model of the 1960's Asian Green Revolution (GR). Its main thrust is that institutional and financial reforms are just as important as technological fixes, and that if this is recognized, many of the less advantageous effects that resulted from the 20th-century GR, such as land consolidation, proletarianization, and environmental degradation, can be avoided (Bumb 2009; Sanginga and Woomer 2009; Vanlauwe 2009). Through engaging in agroecosystems that integrate market innovations as well as modern agronomic techniques, farmers are envisaged as taking a market route to food security (Orr et al. 2001; Bationo 2004).

One of the central pillars of the AGR, institutional reform, encourages public private partnerships (PPPs). AGRA itself is an example of this, as an alliance between governments, international agricultural research

institutions, private philanthropy and commercial interests. The market innovation element of the AGR includes novel credit mechanisms. Such methods act to drive the uptake of costly technologies such as fertilizer. The activities of two more PPPS illustrate how this works in the study context.

First, the Ghanaian Millennium Development Authority (MiDA) is one of the compacts funded by the USA's Millennium Challenge Corporation. MiDA provides fertilizer loans to smallholders with its Commercial Development of Farmer-Based Organizations project (International Fertilizer Development Center 2011). Through the Bank of Ghana, loans are made available to nongovernmental private finance initiatives, who then disburse them to organizations of 50 farmers. Second, the Ghana Grains Partnership involves the government of Ghana, international fertilizer producers and retailers Yara and Wienco, major Ghanaian and African banks, a broker, Prorustica, and the smallholder association Masara N'Arziki in the study site. The banks provide fertilizer credit to farmers through the cooperative (Guyver and MacCarthy 2011). In both MiDA and Masara N'Arziki schemes, farmers may repay credit at harvest time in maize or cash. By participating in these schemes, the Ghanaian government implements its commercial agriculture project, emphasizing the establishment of value chains and PPPS (Ministry of Food & Agriculture 2011). Governments, private companies, and smallholders thereby collude in the push toward a commercialized agroecosystem.

The promises of the AGR sound attractive. There is little question that most smallholders would appreciate higher yields and more profits. This article tackles the more important issue of what less beneficial elements the AGR may entail, and whether farmers need to risk getting involved in them to enjoy the benefits it offers.

COMMENTARY ON THE AGR

Debate over the AGR centers around land ownership and seed, issues that are inextricably linked to this article's central concerns of ISFM and marketization. Farmers use these resources to implement longstanding practices developed in response to their social as well as natural surroundings. This section, therefore, sets the discussion over the AGR in its socioeconomic and environmental context.

Land ownership is particularly contentious. In Northern Ghana, the dominant land tenure system reflects a pattern common across the continent. Chiefs have customary ownership of most land outside urban areas and allocate portions of this to individual families. Every generation, that land is subdivided among the sons of a patriarchal household head, and the resultant scarcity and continual cropping has been blamed for soil fertility decline. Farmers who operate under such customary systems do not hold legal title to the land they cultivate. Recognizing this, MiDAs land tenure

facilitation project energetically supports the Ghanaian government's efforts at individual land titling that have been ongoing since the 1986 Land Title Registration Law. The argument underlying this effort is that land can act as loan collateral, and the capitalization this engenders facilitates more efficient production and, therefore, less risky market access (Deininger 1999). The evidence, however, does not always bear this out (Pinckney and Kimuyu 1994). Another dimension is added to the debate when the potential for "distress sales" of land is considered, resulting, in some cases, in land dispossession (Peters 2009; Jones-Casey and Knox 2011; Patel 2012). In the context of 21st-century land grabs by international companies, issues of land ownership have become even more important (High Level Panel of Experts on Food Security and Nutrition 2011; Obeng-Odoom 2013). In terms of the relationship between tenure and agricultural management, the dominant, but disputed, rhetoric is that farmers with legal titles are more likely to invest in their land, for example with organic ISFM or tree planting (Robertson and Pinstrup-Andersen 2010). The counter argument is that secure usufruct rights can be a sufficient incentive (Pretty et al. 2002; Food and Agriculture Organization of the United Nations 2001; Wiggins et al. 2011). When farmers are sure of secure continued access to land, for example, under the customary arrangements or family ownership systems they have traditionally engaged in, they may be equally willing to improve it as when they own formal titles.

Despite the importance of land, the less tangible input of labor has traditionally been conceived of as the limiting factor in West African agriculture (Swindell 1985). In the past, it derived largely from the family or from reciprocal group labor, sources that are difficult to cost. This is changing, however, as land shortage emerges and a labor market becomes more established. Farmers consider the relative availability of land and labor as they decide which of a range of land management techniques to implement, and the balance may make the difference between cultivating and fallowing a particular field. Some evidence for this can be seen in the way farmers fertilize their compound farms in West Africa: Preferential application of organic fertilizer to these easily accessible and relatively secure sites has been recorded throughout the 20th-century (Fortes et al. 1947; Prothero 1957; Harris and Yusuf 2001; Karbo and Agyare 2002).

A further consideration that influences farmers' practice is the availability of material inputs such as seed and agrochemicals. As farming systems become more commercialized these expensive inputs are becoming essential (de Ridder et al. 2004). One that has attracted particular attention in the debate over the AGR is seed.

The use of improved, hybrid seed, like land, is controversial. Despite giving better yield than landraces, its poor reproductive capacity and necessary annual purchase raise question about sovereignty and ownership: As farmers commercialize, they come to rely more on such external inputs over

which they have less control (Amanor 2010; Thompson 2012). The suitability of exotic seed for maintaining ecosystem diversity is also questioned (Altieri 2009).

ISFM necessarily involves such external inputs, advocating the use of improved varieties alongside synthetic and natural soil fertility amendments. It has been defined as

> a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs, and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at maximizing agronomic use efficiency of the applied nutrients. (Vanlauwe, Chianu, et al. 2010, 4)

Soil amendments such as inorganic and organic fertilizer are just part of a range of management techniques that include crop rotation, intercropping, mulching, and coppicing, and ISFM does emphasize the importance of using a variety of such methods. This stance arises in recognition of the complex decisions farmers make as they implement land management practices. They consider the availability and nature of physical and human resources as well as the demands of their preferred cropping pattern, and, therefore, use multiple SFM practices not only to maximize the benefits to the soil but also the effectiveness of the available production factors. Nevertheless, as the quotation above implies, within the AGR the emphasis is on amendments and inputs, and the issue of whether organics or inorganics should be prioritized has attracted much debate (e.g., Bationo et al. 2012). The thrust of the ISFM paradigm is that organic treatments are valuable primarily as a means toward increasing the agronomic efficiency of the "entry point," inorganic fertilizer (Vanlauwe, Bationo, et al. 2010).

In terms of agronomy, yield differences between organic and inorganic treatments are context specific and often negligible (Adediran et al. 2005; Jiang et al. 2006; Rasool et al. 2008; Ayuke et al. 2011; Pinitpaitoon et al. 2011), contributing toward the consensus that combined application of the two is optimum. The potentially directly deleterious ecological effects of inorganic fertilizer use, such as eutrophication and acidification, are less applicable in Northern Ghana considering the low rates applied to the sandy savanna soils. More relevant are the indirect effects of low soil organic matter reincorporation, resulting in lower soil water and nutrient retention. In the moisture and nutrient limited savanna these are primary considerations, and this environmental frame shapes farmers' agricultural practice. Indigenous technologies such as *zai* and *wafipa* compost pits have developed in response in East and West Africa respectively (Malley et al. 2001; Reij and Waters-Bayer 2001; Uphoff 2002).

More contentious is comparison of the relative costs of organics and inorganics and the resultant debate on subsidy. Poor production and distribution mechanisms and international trade tariffs mean fertilizers are at

least four times as expensive in Africa as Europe (Druilhe and Barreiro-Hurle 2012), obstructing implementation of the Abuja declaration. Kofi Annan, as AGRA chairman, contextualizes this issue, noting that European and American farmers are heavily subsidized, in contrast to the conventional position on African policy (Wiggins and Leturque 2010; Annan 2012). Despite the yield increases that subsidies can engender (Denning et al. 2009), pro-free-market commentators opine that they should only be used to pave the way for market provision of unsubsidized fertilizer (Morris et al. 2007; Minot and Benson 2009). "Smart" subsidies like Malawi's voucher scheme, derided and lauded in equal measure, are the compromise solution (Dorward and Chirwa 2011). The emphasis on free-market fertilizer purchase is one facet of the AGRs valorization of a market-led ideology.

Marketization and profit generation are the core aims of the AGR. Some authors of an agroecological persuasion agree that local market access is an integral element of a functioning agroecosystem (Pretty 1995). Food sovereignty advocates are less convinced (Holt-Giménez and Altieri 2012). Market entry does increase exposure to risk. The issue is often getting enough goods to the market to make profit and getting them there on time, both of which involve financial outlay up front (Hazell and Poulton 2007; Oduro and Osei-Akoto 2007). Access to credit and infrastructural provision are, therefore, important in facilitating meaningful market engagement (Moseley et al. 2010). Another route to market involves assistance from an associate, such as an outgrower organization, that can bear some of the risk and facilitate links to inputs (Coulter et al. 1999; Robertson and Pinstrup-Andersen 2010). The question then becomes how much risk the respective partners absorb: the power relations between such organizations and the farmers they enroll are questioned by authors such as Porter and Phillips-Howard (1997). Diversification and subsistence continue to play risk reduction roles in such situations (Bryceson 1999).

The particular problematic of the AGR is thus nested in a matrix of environmental, social and economic concerns. Reflecting the complexity of the issues involved, there is some thoughtful commentary on the AGR that recognizes its potential advantages as well as its capacity to disempower farmers (Odame and Muange 2011; Sumberg et al. 2012). The challenge is to understand which elements of the AGR agenda may be beneficial and how they could be implemented so as to minimize disadvantageous effects. Simultaneously, some aspects may need to be treated with caution or rejected. In the complex and heterogeneous African agricultural environment, different combinations of solutions bear relevance between contexts, so the techniques of the AGR should form part of the "basket of options" (Ngwenya 2009) that livelihoods authors describe (Sanginga et al. 2009; Rakodi 2002). It is important to ascertain whether any element of the AGR in fact prevents farmers retaining the situation-appropriate strategies they have themselves developed over time to avoid risk.

The rest of this article tracks the progress of the AGR over five years in Dagbon, in the Guinea savanna of Northern Ghana. Here, about 25 miles from the regional capital of Tamale, farmers crop maize for subsistence and sale as part of a mixed farm-household system that incorporates grains, legumes, livestock, tubers, livestock, and, increasingly, vegetables. The savanna soils are fairly low in organic matter and nutrients (Kowal and Kassam 1978), and input and output market access has hitherto been quite limited (Bumb et al. 2011; Druilhe and Barreiro-Hurle 2012). Three linked studies are considered. Performed around the time AGR policies began filtering down to farmers, the first presents and explains farmers' opinions on the role of infrastructural provision for compost transportation. The second examines the relative advantages of organic and inorganic fertilizers and the third, five years on, reflects upon the effect of fertilizer credit provision. The data indicate that although the AGR advocates choice, this rhetoric is not always borne out in practice. The approach, when implemented as a package, is not, therefore, able to facilitate the livelihood choices that would benefit all farmers.

2008–2009: THE IMPORTANCE OF TRANSPORT INFRASTRUCTURE

The first in this set of investigations explored the factors that prevented Northern Ghanaian farmers from composting (see Bellwood-Howard 2013). In 2008, visits to communities in the Guinea Savanna revealed that, despite describing compost as more sustainable and advantageous, many semi-subsistence maize farmers were not using it extensively in their farms. To investigate what was constraining its use, a quantitative cross-sectional survey consulted 386 such farmers across three villages. The farmers were pursuing the rained subsistence maize farming typical of the area, with groundnuts as additional cash crops. Many also kept cattle, small ruminants, and poultry. Sampling was purposive and stratified. In two villages, Zaazi, in Savelugu-Nanton district, and Ypilgu, in Tolon-Kumbungu district of Ghana's Northern Region, the male household head and, if available, one of his wives were interviewed using a structured questionnaire. These were complemented by interviews with one junior man and woman from every household (there were no female headed households, and one household comprised only bachelors). In the third village, Yong, in Savelugu-Nanton district, composting was less common, so one male and one female respondent were interviewed from every household. The sample size thus exceeded 10% of the combined population of all three communities. When a target respondent was unavailable, for example due to migration, an alternative individual of similar status was sought from within the same household. The main question was "What do you find the most difficult aspect of composting?" Respondents were able to choose from 17 categories that

had been derived from content analysis of 30 in-depth qualitative semi-structured interviews with residents of the same villages. They identified the factors they considered the most, the second most and the third most constraining. Demographic data was also collected for each of the respondents. The descriptive statistics presented here were produced using SPSS (Ver. 16). As in all the three studies, the ethnographic methods of participant observation and informal conversation were indispensable. As no compost was being made in the 2008–2009 dry season when this survey took place, such participant observation happened in the course of daily household life.

The intention had been to weight the responses to the main question according to their ranking as first, second, or third worst. However, Figure 1 shows that farmers were overwhelmingly of the opinion that poor transportation facilities were the primary barrier to composting. Even when weighting was applied, this result held, so the raw data for the "worst" barrier are presented.

This result was interpreted as indicating a lack of financial capital: when asked to suggest solutions to this problem, 47.1% of the whole sample suggested replacing the small, cheap bicycles and headpans they had hitherto been using with larger, more expensive vehicles (*benzirra*), like hand-pulled trucks, wheelbarrows, or donkey carts.

In 2012, return visits to these communities in farming season showed that in Ypilgu, farmers had begun to implement such a solution. Individuals

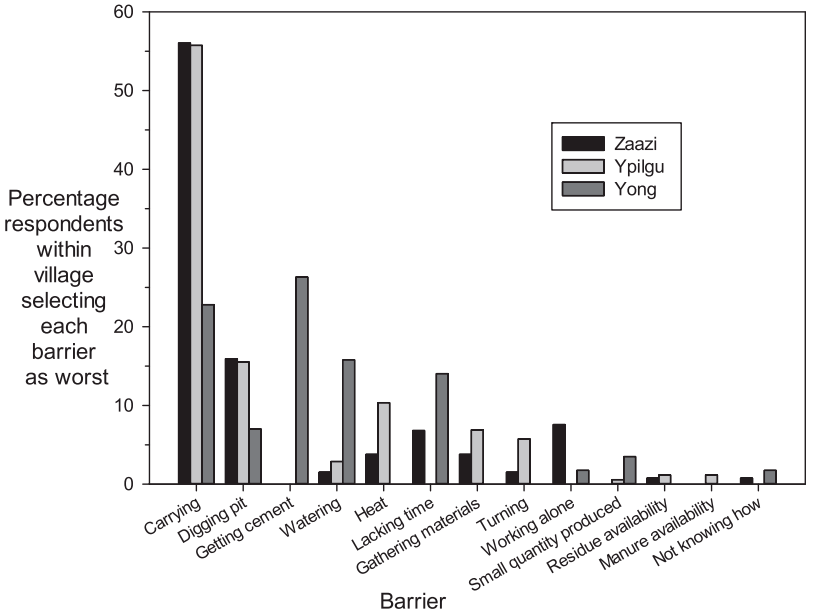

FIGURE 1 Proportion of respondents in Zaazi, Ypilgu, and Yong villages selecting each barrier to composting as worst.

had begun to purchase bullock carts, to the extent that five farmers owned them by 2013 and a market for their hire had emerged. Individuals' personal financial capital accumulation facilitates ownership or rental of such *benzirra*, so this qualitative data seems to indicate that local market engagement could conceivably go some way toward solving this transport problem and promoting more sustainable fertilization practice based on organics. The actions of the farmers who participated in the 2010 and 2011 research also indicated that traditional mechanisms of reciprocity and gift giving would allow those who owned vehicles to share them with other community members (Bellwood-Howard 2012). However, issues of equity emerge: This option is, of course, more available and more advantageous to richer farmers, reminiscent of the economic differentiation that resulted in some instances immediately after the first Asian Green Revolution (e.g., Dhanagare 1987; Jayatilaka 1989; Webster 1990; Harriss-White and Janakarajan 1997).

The state also has a role to play in such a situation: for reasons of scale it is usually held responsible for the infrastructural improvements essential for well-functioning transport systems (Morris et al. 2007). In Yong, the government, in the spirit of the AGR, brought in private Chinese contractors to grade and tarmac the road to the local town. In Ypilgu, however, the local authority had delayed for five years in making improvements to the feeder road, so motorized transport came to the village less than once a month. This was less of a constraint on the operation of the bullock hire market than on farmers' access to inorganic fertilizer. High transport costs are one major reason for high fertilizer prices on the continent (Jayne et al. 2003) and the Ghanaian government, like others, has responded with the fast and visible solution of fertilizer subsidy, alongside the ongoing development of transport infrastructure. There have also been suggestions that such a structural solution as subsidy could be used to overcome, for example, the high import costs of cart axles (Reddy 1988). Agroecologists and technologists, therefore, both acknowledge that transportation and import tariff infrastructure is essential for environmentally as well as economically sustainable SFM (see, e.g., Toenniessen et al. 2008; but also Altieri 2009). Public investment, thus, has a role to play as well as the private capital that can provide ownership and hire of the vehicles that are used on public roads.

Implications of the study: State and private infrastructural investments are necessary for sustainable SFM.

2010: INTEGRATED SOIL FERTILITY MANAGEMENT AND COMPOST

In 2010, a further study compared the effects of compost and fertilizer application on maize performance. Twenty-nine men and one woman participated across two villages, Ypilgu and Zaazi. Each allocated an area

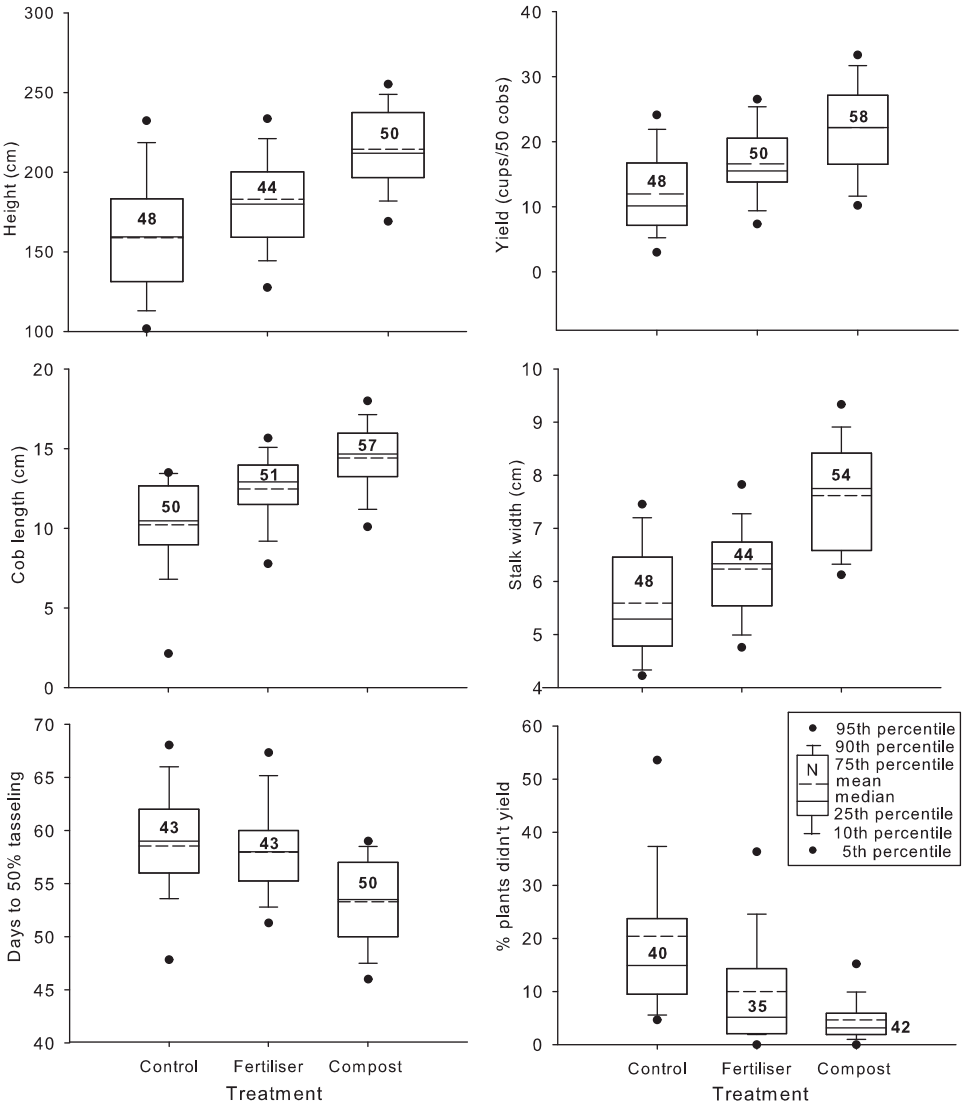

FIGURE 2 Selected growth parameters and yield of maize plants in control, inorganically fertilized and composted plots (N = sample size).

within one of their fields to be fertilized only with compost, an area to be fertilized only with inorganic fertilizer and a control area that received no organic or inorganic amendments in the experimental year. Farmers used these inputs at the rates that they were able to manage given their resource endowments. Maize was planted on the plots and the yield and growth parameters indicated in Figure 2 were measured. Soil was tested for C, N, P, K, and pH. The experiment did not use a combined treatment, because the aim was to ascertain whether farmers with a limited capital endowment

could use compost or inorganic fertilizer most effectively within the larger matrix of their SFM practice, and hence where the emphasis should lie. A further aim was to explore the mechanisms by which the fertilizer and compost influenced maize growth. Of course, the effects of the multiplicity of SFM methods that farmers use do endure over more than a single cropping season, so the experiment could not be said to be controlled, as control plots were likely to have retained residual fertility from previous years. In addition, as different farmers' fields were used, factors such as weed control regime varied widely. These conditions were tolerated because the experiment aimed to relate to farmers' real resource allocations, and this was held to be a more valid concern than which treatment performed better in a controlled experiment. SPSS was used to perform Mann Whitney U tests on the data.

The results were unequivocal: At farmers' application rates, maize plants treated with compost yielded better and also outperformed those treated with inorganic fertilizer for five other growth parameters.

Soil nutrient tests showed that this was unlikely to be as a result of better macronutrient provision. Mann-Whitney U tests on the data shown in Table 1 showed that there were no significant differences in macronutrient levels between the compost and inorganic fertilizer treatments, although pH was higher for the compost treatment at tasseling.

This similarity between the nutrient levels provided by compost and inorganic fertilizer resonates with results from the literature. There is no universal trend; whether organic or inorganic amendments give higher nutrient levels is context dependent. For example, Ouedrageou et al. (2006) found that, in Burkina Faso, the extent of tillage determined whether compost or inorganic urea resulted in higher soil nitrogen. For Eghball and Power (1999) in the temperate context of mid-western America, application of ammonia fertilizer gave higher soil N levels than application of compost, but only in drier years. The importance of such context-specific non-nutrient factors serves to emphasize that, in the heterogeneous African environment, appropriate management techniques vary between sites. In the study sites, this was confirmed by qualitative data collection.

In the 2010 farming season, farmers were interviewed in their fields once before and once after the experiment. Participant observation also took

TABLE 1 Nutrient concentrations in compost and fertilizer amended plots at tasseling stage

Parameter	Fertilizer	Compost	Mann-Whitney *p*
C (%)	1.12	1.13	0.804
N (%)	0.11	0.13	0.823
P (mg/kg)	9.73	9.15	0.354
K (mg/kg)	135.23	128.64	0.725
pH	7.71	6.76	<0.001

place during compost preparation, transportation, and application. These data indicated that the superior performance of organic amendments in this setting resulted from their ability to increase soil water retention capacity. In interviews, as well as informal conversations, farmers described how compost improved soil structure. Four farmers demonstrated how they could recognize the high water retention capacity of soil amended with compost when their foot sank into it, in contrast to the hard, compact soil treated with inorganics. Maize yields can be affected after 5–15 dry days (Fischer et al. 1982; Eck 1986; Barron et al. 2003; Recep 2004), and farmers in the study site agreed that the enhanced ability of compost-amended soil to retain moisture became beneficial to maize after a week without rain.

A quantitative assay was, therefore, performed to test this property. In Ypilgu village, thirty infield compound farm sites fairly high in organic matter and thirty outfields or "bush farms" with lower organic content were selected, using Munsell color as a proxy for organic matter (see Wopereis et al. 2006). Soil water content by weight was measured immediately after a heavy rainfall event and then 6 and 11 dry days later. To avoid destroying soil structure by removing samples from the field, the assay was performed in situ. It was, therefore, necessarily carried out in March, before the rainy season began in earnest, so that dry spells between rainfall events were likely to last a week or more. The practice of preferential organic matter application to compound farms pertains in the study sites (Karbo and Agyare 2002), and in March farmers had not yet carried compost to their bush farms, hence why compound infields and bush farm outfields were used as proxies for sites with and without organic matter amendments. The farmers' contention that fields with historic compost application retained more water was borne out: infield soils as a group retained significantly more water both initially and after 11 days (see Figure 3).

The main advantage of compost in this site, its ability to enhance water retention capacity, is a function that inorganic fertilizers cannot perform. This resonates with Ekins et al.'s (2003) concept of strong sustainability: some functions of natural capital cannot be substituted for (Neumayer 2003). As fertilizer cannot serve moisture retention functions, indications are that within an ISFM strategy for the savanna, the emphasis should rest upon organics. This consideration resonates with Sanchez's (1994) "second paradigm" (68), the forerunner to ISFM, which advises farmers to rely more on biological processes by adapting germplasm to adverse soil conditions, enhancing soil biological activity, and optimizing nutrient cycling to minimize external inputs and maximize the efficiency of their use.

It is important to contextualize these results within the matrix of ISFM practices and their associated resource requirements. The field experiment was limited to testing amendments, yet any one of the techniques that raise soil water retention capacity could play a valuable role here. Farmers in the

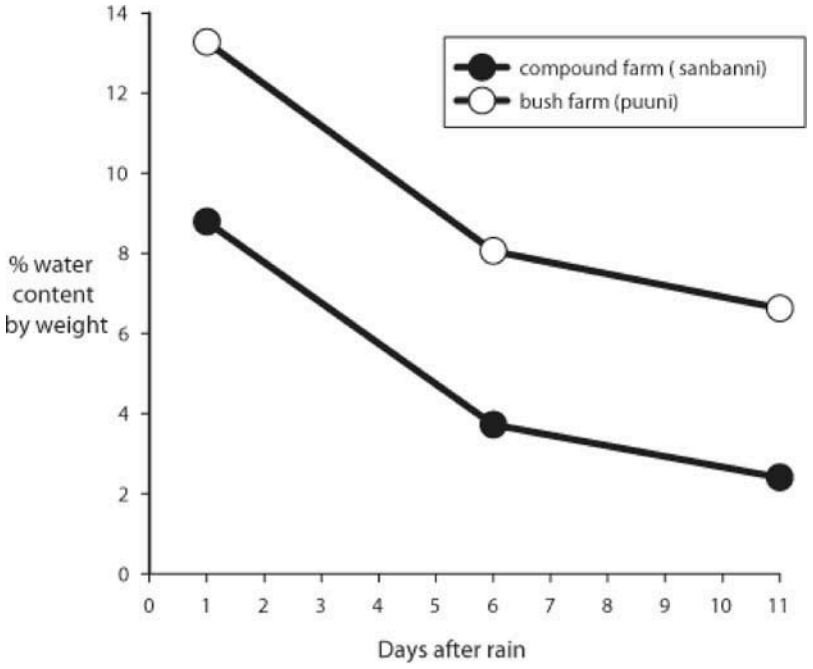

FIGURE 3 Mean water content of 30 compound and 30 bush farms up to 11 days after rain. Differences between compound and bush farms were significant (Mann-Whitney $p < 0.001$) at each sampling date.

study sites did practice such strategies, including annually rotating the portion of the field that compost was applied to, incorporating stover and double ploughing with bullocks. The last method involves ploughing once, allowing grasses to grow back, then four weeks later using bullocks to plough those grasses 15 cm into the topsoil, rather than 30 cm deep as a tractor would do. Farmers' use of such strategies shows that over time they have developed SFM methods that meet their needs for organic amendments. Furthermore, whereas organic treatments have high labor costs, fertilizers are expensive. For most farmers in this site, the cash required for fertilizer application had hitherto been more limiting than the labor costs of composting, and this plays a role when famers evaluate the relative costs and advantages of each technique.

However, although organic amendments are generally the most appropriate soil treatment in the study site, this cannot be taken as an indication that the same is true all across the region. Some farmers were observed performing mixed application, the strategy advocated within ISFM. In interview, one farmer from Ypilgu explained that this would be his preferred practice, as it would improve water retention capacity as well as raising absolute nutrient content to superlative levels. Nevertheless, limited availability of

both organic and inorganic fertilizers constrained him from applying this treatment to every field. When the realities of variable resource availability meant farmers had to choose between the two, organics were preferred. This study did not implement a combined treatment that would facilitate a conclusion about the agronomic efficacy of mixed application, as the aim was rather to observe how farmers' ISFM decisions interacted with their ability to use different resources. However, it is those same issues of resource accessibility that imply a role for inorganic fertilizer within a regional SFM strategy. The importance of site specificity has been emphasized: Different soils do respond to organic and inorganic amendments in various ways, and the availability and transportation of organic materials can be more or less problematic between locations (Bationo and Mokwunye 1991b). At the moment labor seems less limiting than cash for these particular farmers. However, before the introduction of bullock carts, compost transportation was, indeed, a challenge in the study site. Fertilizer is, therefore, potentially useful in situations where compost may be less accessible or of poorer quality than that applied by the farmers in these villages.

The real value of these results is to illustrate that ISFM is most usefully interpreted not only as mixed application of organics and inorganics, as the AGR emphasizes, but the ability to apply whichever combination thereof suits the resource availability and crop demand context. This could include sole organic addition, as seemed the best choice here.

Fertilizer subsidy may, therefore, be helpful in the contexts where inorganic amendments have a role to play. However, considering these results, it is worth considering whether the funds allocated to mineral fertilizer subsidy could usefully be diverted toward promoting development of organic sources, for example by subsidizing their transportation.

Reflecting on the type of germplasm that farmers use, it should also be noted that the experiment was performed on the high-yielding improved 'white' maize varieties that most farmers in the villages have adopted. These are the strains that are shown performing best under compost in Figure 2.

Implications of the study: ISFM should be interpreted as a range of possible practices, which may include sole organic application. Organics should be emphasized for their soil water retention properties.

2012: INPUT MARKET ACCESS AND CREDIT

The final study in this trio examined the impact of fertilizer credit schemes, including the MiDA scheme and its government and informal parallels, on farmers' SFM and commercialization strategies. It compared socioeconomic characteristics and fertilization practices of 104 farmers who had borrowed fertilizer credit and 101 who had not, across five villages: Ypilgu, Tarakpaa,

Zugu, Satani, and Yirikpani. Credit group members were identified from lists provided by the chairman of their farming group and invited to participate in a structured survey with a qualitative component. They then self-selected, and those who agreed to participate were interviewed until the sample size reached 5% of the population of the settlements. Non-credit borrowers who matched them were then selected by a method similar to the nearest neighbor technique (Kennedy and Cogill 1987), in this instance matching farmers on the basis of their household size, their approximate age and their position within their household. These farmers guessed their ages to be from about 16 to about 70 years old. Only two were women. Descriptive and inferential statistics were performed on the data using SPSS.

The results of the survey showed that credit group members generally applied more fertilizer, achieved higher yields and sold more maize. Crucially, they were also more likely to use compost (see Table 2).

Across Africa, richer farmers often do use more compost than the less well off (Vanlauwe and Zingore 2011). Indeed, there were six wealthier farmers who illustrated this. They had large herds of cattle that fertilized their fields. They could afford all the fertilizer they needed, and were engaging in markets to some extent: one even owned a tractor with which he drove a mechanized sheller, processing his neighbors' grain, collecting a tenth of their harvest as payment and selling some of it when the price peaked. However, these farmers had not joined credit groups, because they didn't need to: the son of one explained that he considered entering the market on 'your own strength' preferable. To some extent these results bolster the AGR rhetoric: These farmers have exceeded the need for credit mechanisms and are also able to pursue more sustainable SFM. If credit were to facilitate such wealth for their peers, they could also ostensibly attain such an achievement. Two factors, however, disrupt this reading.

TABLE 2 Differences between credit group members and non-members

Parameter	Group members' mean	Non-members' mean	Mann Whitney *p*
Number of 50 kg bags of fertilizer used	5.90	4.41	0.000***
Fertilizer application rate (bag/acre)	1.61	1.41	0.167
Bags of fertilizer bought	2.06	4.02	0.000***
Bags of fertilizer borrowed from sources other than the credit group	0.11	0.36	0.333
Yield (50 kg bags maize/acre)	5.05	4.79	0.316
Yield per household member	0.37	0.31	0.028*
Bags of maize sold	1.70	1.05	0.000***
Percentage of maize sold by bag	8.37	7.89	0.082
Income received from maize sales (GhC)	124.42	91.62	0.021*
Income per bag of maize	52.3	51.3	0.794
Percentage of farmers using compost	34	27	

***=significant at 0.000 level; *=significant at 0.05 level.

The first explains the association between credit group membership and compost application. A disproportionate number of household heads were credit group members, and a higher percentage of them than of the younger men used compost: 41.3% as opposed to 17.7% (X^2 $p < 0.001$). This relationship was more statistically significant than that between group ownership and compost application, and has more important implications. The fact that household heads were more likely to use compost and, on average, used more of it, points to an aspect of agriculture the AGR deals less well with. It is the traditional responsibility of the Dagomba household head to feed his family, and several respondents described the pride they felt if able to use their own maize do so for much of the year. This could be seen as expressing the cultural meaning of subsistence, but risk avoidance is another contributing factor. Maize is more nutrient-hungry and water responsive than the groundnuts that young men traditionally cultivate for cash, and household heads, generally better endowed with cattle and with access to more labor, are often better able to supply manure and compost to this cereal crop. This is why subsistence maize is grown in compound farms, to which the landlord organizes the application of compost. Their responsibility to feed their dependents also drives their uptake of fertilizer credit, and the confluence of these two household food security mechanisms is responsible for the association of credit and compost use. The current generation of household heads has not replaced organic-subsistence maize cultivation with practices that represent a market route to food security. Whether the next generation will do so remains to be seen, but farmers' responses to the question of whether maize was a commercial or subsistence crop, shown in Table 3, give some indication.

Farmers' preference for organic, subsistence maize cultivation is a response to their specific context of agroecological risk. It is, therefore, a knowledge resource that strategies like the AGR could usefully learn from rather than undermining.

The second factor that sits uneasily with the AGRs promotion of credit is the complaint of a minority of farmers about the schemes examined here.

TABLE 3 Farmers' responses to the question of whether maize is a commercial or a subsistence crop

Farmer response	Percentage of 205 farmers giving this response
They would sell maize only if some remained at the end of the year	70.2
Maize can be sold as well as eaten	52.9
Maize is a subsistence crop	3.4
Maize is a commercial crop	0.5

Note. Many farmers gave multiple responses to this open question. As answers in the first two rows are not mutually exclusive the total exceeds 100%.

Some saw the terms of access as unfavorable, to the extent that in 2012 a group in Tarakpaa declined participation in the MiDA-funded group they had formerly been part of. They were aware that by repaying fertilizer loans in maize at harvest time they received the minimum price for their produce. This meant that in effect they paid up to twice as much for fertilizer as they would if they had bought it with cash. Farmers generally borrowed one 50kg bag of compound fertilizer and one of ammonium sulphate top-dresser per acre, worth subsidized prices of 30 and 25 GhC, respectively, in 2011 (1 GhC = approximately 0.6 USD in 2011). Repayment rates were 1–1.5 bags of maize per bag of compound fertilizer and 1 bag of maize per bag of top dresser. At harvest time, a bag of maize cost around 30 GhC. Six months later it could sell for up to 60 GhC. Both NGOs and private lenders took advantage of this to cover costs or make profit. Twenty five percent of the farmers who had opted out of the MiDA-funded scheme explained that they would only join another group in future if it offered them credit on fairer terms. Forty eight of the 104 group members, when asked, made negative comments about what they perceived to be the inequitable effects of the credit schemes. These are listed in Table 4.

Nevertheless, despite the opinions of these particular farmers, the majority appreciated the help (*suŋsim*) fertilizer credit afforded them: 94 of the 104 group members sampled said that, despite their few concerns, group membership was advantageous overall.

For most Dagomba farmers, both household heads and young men, some access to input as well as output markets is better than none. The

TABLE 4 Farmers' concerns about fertilizer credit schemes

Statement	Number of farmers	Percentage of entire sample	Percentage of group members
Concerns related to credit provision			
Inputs are delivered late	19	9.3	18.3
Repayments are expensive	10	4.9	9.6
They prefer self-sufficiency	10	4.9	9.6
They would be unable to repay in the event of drought and crop failure	10	4.9	9.6
MiDA profits more than farmers	5	2.4	4.8
Some have not harvested when repayments are due	3	1.5	2.9
Market prices are low when repayments are due	3	1.5	2.9
Concerns related to fertilizer			
It is problematic in case of drought	55	27	
There is low soil fertility in years following application	24	12	
Weeds thrive in years following application	10	5	
It has negative health effects	7	3	

AGR rhetoric promotes the linked input-output market mechanisms of contract farming and outgrowing over government and informal credit routes, and the problem of a lack of sanctions for non-repayment in government schemes certainly was observed in this case. Credit does, however, need to offer access at minimal cost and risk. If commercial schemes increase risk and make farmers worse off, they are a high price to pay for fertilizer that, as has been seen, is in any case a second best option after organic matter in this particular situation. Indeed, none of the farmers in this sample were members of outgrower credit initiatives, even though two of the communities were in district where a Ghana Grains Partner, the Masara N'Arziki association, was operating. Some did not have the five acres required to join that organization. However, larger scale farmers who were asked in the qualitative section of the survey about their reasons for not joining the cooperative cited discomfort with the requirement that all maize be sold back to the creditor. The high fertilizer levels Masara N'Arziki asked outgrowers to apply to their fields were also problematic for some, with 91 farmers mentioning at least one of the concerns relating to fertilizer use in general listed in Table 4. In sum, the farmers in this sample preferred to satisfy their subsistence needs using largely non-marketized transactions and organic soil amendments.

Implications of the study: Credit and market access are only helpful when they are optional, low risk and not tied to conditions.

DISCUSSION

This article has seen that the AGR incorporates some appropriate elements of farmers' practice. Yet, it combines them with other, less advantageous schemes and, despite the rhetoric of choice and site specificity, applies them as a package in a hegemonic fashion that means the approach as a whole does not meet all farmers' needs.

With respect to ISFM, organic matter was shown to be of paramount importance in this particular location because of its ability to enhance water retention capacity, indicating the validity of Sanchez's (1994) second paradigm. This does not mean that fertilizer is always irrelevant: There could be a case in some areas for mixed application, a treatment that was not tested here but has been widely endorsed in the literature. However, as well as the agronomic advantages of each treatment, it is essential to consider the availability of the resources necessary to apply them. The financial cost of fertilizer as well as the fact that it does not provide a soil water retention function means that in this site, organic amendments comprise a more useful resource. This is a good explanation for why richer farmers chose to invest in bullock carts that facilitated a market in compost transport, rather than purchasing fertilizer. What is most significant about this result is that it demonstrates the importance of context specific solutions. Indeed, the

importance of organic matter additions to the soil in these Northern Ghanaian villages does not imply that compost is always necessary here: A farmer may equally implement any other strategy compatible with their resource capabilities that integrates organic matter into the soil, such as double ploughing. Similarly, sole fertilizer application could be the best solution in other sites, and combined application has been shown to be most effective in many others (Bationo and Mokwunye 1991b; Chivenge et al. 2011; Tittonell et al. 2011). Although the AGR nominally recognizes that various SFM systems are appropriate for different sites, it largely interprets ISFM as combined application. It does not support the idea that that organic amendments or agroecological techniques promoting generation of soil organic matter could potentially be sufficient in sole application, as has been shown to be the case in these particular villages. This results from an emphasis on nutrient rather than soil water provision (Bationo and Mokwunye 1991a). This is not necessarily universally relevant, especially in terms of the resources farmers are able to access. The AGR, therefore, struggles to reflect the holistic approach that farmers develop through a working familiarity with their agroecosystem and knowledge of available resources. Its claim to recognize the importance of context specificity is thus not borne out, because it deals less well with sites requiring strongly sustainable characteristics like soil water availability that cannot be purchased as an input.

The same idea of choice is applicable to market strategies. Farmers use a range, involving commercialization but also subsistence and reciprocity, as a hedge against market as well as agroecological risk. Credit can, therefore, be useful as it can facilitate market access if and when farmers need it. However, absolute market integration, of the type that Masara N'Arziki advocates, is just as risky as none. In addition, harvest-payment credit mechanisms like the one encountered in this study are a sure route to inequality. In contrast to the idea that the AGR gives farmers access to multiple livelihood options, they lock farmers into arrangements that, ironically, disadvantage them in the marketplace, because they are designed to make profit for another agency such as an NGO or outgrower association.

The systems and mechanisms that farmers have developed autonomously, such as organic matter incorporation and subsistence farming, are generally attuned to their own agroecological and market conditions. The most useful function the AGR could perform would be to provide low risk entry routes to techniques that farmers do want but have hitherto been unable to access. The problem is that, despite advocating farmer choice, it deals less well with site-specific demands that fall outside its overall objectives of marketization and combined application. Farmers are encouraged to access the market in any way they like, as long as they would like to access the market. Likewise, they are encouraged to practice any sort of combined application of inorganic and organic amendments they like, as long as they practice combined application. As long as the options of the

AGR are presented to farmers as part of such a package, they are beneficial to only a section of the population.

This is especially the case if those options themselves run the risk of accentuating socioeconomic differentiation. This is the case with almost any change to agrarian systems: the bullock cart hire market that farmer themselves instigated did so. Land titling is similar: in the 20th-century GR it resulted in some land consolidation (Niazi 2004). The evidence presented here indicates that some such innovations may be of dubious utility and it is, therefore, questionable whether farmers need to take the risk of implementing them. Having a title to land, for example, is not a prerequisite to investing in it: farmers in the study situation do not have legal titles to their land but are already using strategies to enhance its soil organic matter content. Similarly, they are already able to access credit without using land as collateral. Warrantage systems, where farmers are able to store produce in warehouses in order to wait for a higher price (Tabo et al. 2011) pose another, potentially less risky, alternative to the types of credit schemes described in this study. In warrantage, the produce acts as collateral, making land titles unnecessary. Warrantage has been implemented on a small scale in Ghana (e.g., Ghana News Agency 2010) and a warehouse receipt system began in Northern Ghana in 2013 (ACDI/VOCA 2013). Such initiatives seems to hold more potential than land titling exercises for rural areas like the study area, where land is owned by chiefs in trust for families.

These studies indicate that basic infrastructural support would do more than targeted input schemes to enable farmers to perform the management strategies that they have developed over time, such as compost application, and take advantage of new opportunities that present themselves. Warrantage, for example, requires warehouse facilities. Such investments point to the involvement of large organizations like government, with extensive capacity to provide background services and less imperative to make profit than private sector bodies.

Almost all commentators on the AGR nominally agree that single solutions cannot work across the smallholder spectrum. However, whereas the movement's advocates consider that the multiple pathways available within the package are sufficient to meet the needs of all, critics are of the opinion that non-commercial alternatives must be retained, so that farmers in different sites may choose subsistence, organic and landrace as well as market, ISFM and improved variety options (Amanor 2010). The farmers encountered in these studies preferred inputs and markets over which they had more control, which for them meant organic amendments and subsistence mechanisms. These must, therefore, be conserved, and external tools like subsidy can potentially support such activity. There is little need for farmers to risk getting involved in mechanisms such as unfair credit, fertilizer application and land titling when they already have developed the agroecological strategies they need to lead sustainable agricultural livelihoods.

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