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Farmers' perceptions of crop pest severity in Nigeria are associated with landscape, agronomic and socio-economic factors

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ABSTRACT

Insect pests are a major cause of crop yield losses around the world and pest management plays a critical role in providing food security and farming income. This study links Nigerian farmers' perceptions of pest severity to the landscape, agronomic, biophysical, and socio-economic context in which agricultural production takes place. A farm household survey was conducted during 2012–2013, collecting data on household characteristics, cropping systems, pest severity and pest management from 805 households in 12 states of Nigeria. Village characteristics and land use information were collected from an accompanying semi-structured village survey. Reported pest severity was negatively associated with the proportions of forest and unused land at the landscape scale. This finding suggests the existence of pest suppressive effects of a diverse landscape under African smallholder agriculture settings, confirming findings of more industrial and larger scale agroecosystems in the temperate zone. Application of fertilizers (chemical and manure) was negatively related to reported pest severity. Moreover, reported pest severity was lower in mixed-cropping systems than in mono-cropping systems, reinforcing the idea of a pest suppression benefit of diverse cropping systems. In conclusion, our findings suggest that the presence of non-crop areas in the landscape and the diversification of agroecosystems may be a viable strategy for smallholder farmers to manage pests with limited reliance of chemical insecticides in Nigeria, but that actual pest management decisions are influenced by a wide range of context-specific factors. The paper adds new evidence on the relationship between different production situation characteristics and pest severity for Nigeria, based on which policy implications are discussed.

1. Introduction

Insect pests are a major cause of crop yield losses around the world (Oerke, 2006) and an important cause of food insecurity in developing countries (Zakari et al., 2014). Farmers make crop and pest management decisions within the realm of their production situations, i.e., the physical, biological, technical, social, and economic context in which production takes place (Penning de Vries, 1982; Savary et al., 2006a,b), and their decisions in turn shape their production situations. While the interdependence between the susceptibility to pest infestation and the production situation has been demonstrated before (Allinne et al., 2016; Avelino et al., 2006; Savary et al., 2006a,b; Savary et al., 2017), little is known about the relationship between production situations and farmer reported pest severity on common crops in Nigeria. Analyzing the perceptions of farmers on pest severity within the context of their production situation can provide important new insights in the ways to encourage ecologically-based pest management attitudes and practices.

The management of pests has important implications for African agriculture where the majority of the farmer community consists of smallholder farmers with low agricultural productivity (Bature et al., 2013). In Nigeria, insect pests and plant diseases are major yield reducing factors, threatening food security and farmers' incomes. For example, insect pests and diseases in yams resulted in a 25% mean annual yield loss (Tobih et al., 2011; Amusa et al., 2003) and 25–30% of yield loss of cocoa was attributed to the brown cocoa mirid alone (Ndubuaku and Asogwa, 2006). While Nigerian farmers are aware of the availability of several methods of pest control, including chemical, biological and traditional cultural control methods, farmers commonly do not actively control pests in their field crops (Alghali, 1991; Bottenberg, 1995; Banjo et al., 2003; Ofor et al., 2009). Farmers who actively manage pests rely primarily on chemical insecticides, but can

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be constrained by the cost and availability of insecticides (Banjo et al., 2003). Traditional and cultural pest management methods include sprinkling of wood ash on plants, manual removal of pests, beating the crop with branches, application of kerosene/ash sprays, crop rotation, intercropping, and leaving land fallow are cheap and readily available, but their impact may be limited and some of these methods are labor intensive (Bottenberg, 1995; Alghali, 1991; Amusa et al., 2003; Banjo et al., 2003).

The ecosystem service of pest regulation provided by natural enemies has been estimated to represent a worldwide value of 100–400 billion USD per year (Costanza et al., 1997; Pimentel et al., 1997). The effectiveness of natural enemies in suppressing pest populations relies on both agricultural management at the field scale, and the structure, composition, and functioning of the surrounding landscape (Tscharntke et al., 2005; Bianchi et al., 2006; Chaplin-Kramer et al., 2011; Veres et al., 2013). However, little information is available on the effect of landscape factors on natural pest control in developing countries, and Africa in particular. Ironically, natural pest regulation is a critical ecosystem service for poor smallholder farmers who have limited economic access to external inputs and therefore rely on ecosystem services provided by agroecosystems and their surrounding landscapes. Promoting natural pest regulation may not only improve productivity and profit, but may also reduce farmers' dependence on the use of chemical insecticides, which can have negative impacts on human health and the environment (Pimentel et al., 1997; Naylor and Ehrlich, 1997; Antle and Pingali, 1994), and negatively affect natural enemies that suppress pest populations (Eveleens, 1983; Hansen, 1986). The extent to which the natural enemy community is conserved and utilized to substitute or complement chemical insecticides-based pest management has important implications for the socio-economic and environmental resilience of farming systems in developing countries.

The development of effective policies to support more sustainable pest management requires a better understanding of the factors that determine farmers' pest management decision making within the landscape, agronomic, socio-economic and biophysical context of farming systems (Savary et al., 2017). Previous studies have examined the effects of socio-economic factors on the likelihood of using production inputs such as fertilizers and insecticides (e.g., Nkamleu and Adesina, 2000; Zhou et al., 2010; Waithaka et al., 2007), but studies that also incorporate agronomic and ecological factors in a household analysis are scarce. The aim of this paper is to assess the ecological, agronomic, and socio-economic factors that are associated with farmer perceptions of the severity of pests in their field crops in Nigeria. The study comprised three agro-ecological zones spanning a 1000 km North-South gradient, 102 villages and 805 households. Factors associated with reported pest severity are identified and policy implications are discussed.

2. Materials and methods

2.1. Agro-ecological and socio-economic context

Nigeria encompasses semi-arid savanna ecosystems in the north and tropical forest ecosystems in the south (Aregheore, 2009). Amidst these diverse agroecological conditions there is also heterogeneity in ethnicity and cultures (Aregheore, 2009), as well as vast economic disparities between different regions of the country (Oxford Poverty and Human Development Initiative, 2015). After a period of marginal expansion from 1997 to 2007, the area of arable land is now declining (FAOSTAT, 2016a). Land degradation has been recognized as one of the most important natural resource management problems in Nigeria, constraining agricultural and rural development (FAO and ITPS, 2015; Odemerho, 1992; Titilola and Jeje, 2008). Meanwhile, the population has been steadily growing at an annual rate of around 2.8% (FAOSTAT, 2016a) and there has been a robust economic growth in the last decade (African Development Bank Group, 2015). Nevertheless, the proportion of the population that is multidimensionally poor is 53.3% nationally and 70% in rural areas, with remarkable regional variation (Oxford Poverty and Human Development Initiative, 2015).[1]

Nigeria's agricultural sector has a relatively high insecticide use as compared to other African countries. For instance, insecticide import by Nigeria accounted for 11% of the total import value for the whole of Africa in 2011 (FAOSTAT, 2016b). Despite a seven-fold increase in net pesticide imports from US$31 million to US$221 million between 1997 and 2012, progress on increasing cereal production (which is mainly used for domestic consumption) and per capita food supply has stagnated (FAOSTAT, 2016a). While the increase of pesticide inputs has contributed to the productivity growth of agricultural workers (FAOSTAT, 2016a), this has not been translated into significant food security gains. These findings question the effectiveness of strategies that are solely based on pesticides, and highlight the need for more sustainable pest management strategies that go beyond pesticide-based pest management.

2.2. Data collection

2.2.1. Sampling

Survey field work for this study was carried out in Nigeria during late 2012 – early 2013. The design of the field work was linked to the midline survey of an impact evaluation study conducted for the Nigeria Third National Fadama Development Project ("Fadama III" project) which covered all 37 Nigerian states (Appendix A). Using the sampling framework established for the Fadama III project, we adopted a stratified sampling approach by first selecting 12 states that covered the three primary agro-ecological zones (AEZs) in Nigeria: Sudan Savannah, Guinea Savannah, and Humid Forest (four states for each AEZ). These states have relatively high poverty rates based on the 2010 Nigeria poverty profile (National Bureau of Statistics, 2012) and a high incidence of conflicts over the use of common natural resources (Nkonya et al., Unpublished data). Northeastern states were excluded from consideration due to security concerns. In each of the 12 states, 6 to 10 villages were randomly selected from the midline survey sample (Appendix A). Finally, we randomly selected households from each of the villages, giving us a sample consisting of 851 households from 102 villages, with 34 villages in the Humid Forest zone, 36 in the Guinea Savannah, and 32 in the Sudan Savannah (Fig. 1). Village and household surveys were conducted in each selected village. After removing missing values, outliers and inappropriately measured responses, the final dataset used in the regression analysis contained data from 805 households. While this sampling strategy was not fully random across Nigeria (Appendix A), the sample provided comprehensive geographic coverage of the country and covers all three primary AEZs.

2.2.2. Survey instruments

In the farm household survey (see Appendix B for the household survey questionnaire), respondents were asked information on households' social and demographic characteristics, such as ethnicity, age and gender of household head, family size, and farm size, as well as detailed information on pest management. Each household was asked to report up to three main crops that were grown in the previous growing season, and to list up to two important insect pests for each crop. A field guide for insect pests, natural enemies, and pollinators in 15 main crops of Nigeria was developed to assist farmers identifying insect species. Perceived pest severity was expressed at a 3-level scale (1 = significant yield reduction, 2 = moderate yield reduction, and

[1] The global Multidimensional Poverty Index (MPI), developed by the Oxford Poverty & Human Development Initiative (OPHI), is an international measure of acute poverty covering over 100 developing countries. It complements traditional income-based poverty measures by capturing the severe deprivations that each person faces at the same time with respect to education, health and living standards (Alkire et al., 2016; OPHI, 2007–2016).