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Research paper

Feeding the world while reducing farmer poverty? Analysis of rice relative yield and labour productivity gaps in two Beninese villages

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A B S T R A C T

Improvements in agricultural land and labour productivity are needed to meet the growing food demand and reduce farmer poverty in sub-Saharan Africa. The objectives of this study were to (i) quantify variation in labour inputs, yield and labour productivity among rice fields; (ii) elicit factors associated with this variation; and (iii) identify opportunities for improving yield and labour productivity. The study was carried out in two contrasting Beninese villages: Zonmon in the south and Pelebina in the north-west.

In Zonmon 82 irrigated rice fields were surveyed during the 2013 and 2014 dry seasons. In Pelebina 50 rainfed lowland rice fields were surveyed over three rainy seasons (2012–2014). Data on farmer field management practices and field conditions were recorded through interviews with farmers, on-farm observations and measurements. Stepwise regression analyses were used to identify variables associated with variation in yield, labour inputs and labour productivity.

Average yields were 4.8 ± 2.0 t ha^{-1} in Zonmon and 2.3 ± 1.2 t ha^{-1} in Pelebina. Average labour productivity, however, was larger in Pelebina (17 kg of paddy rice person-day^{-1}) than in Zonmon (8 kg of paddy rice person-day^{-1}). Relative yield gaps (43–48%) and labour productivity gaps (59–63%) were similar in the villages. There was no trade-off between yield and labour or labour productivity within the villages, suggesting that in many cases rice yields can be increased without additional labour inputs. The major labour-demanding farming operations were bird scaring in Zonmon and harvesting and threshing in Pelebina.

We identified opportunities to improve rice yield and labour productivity, given current farmer knowledge and resource endowment. Based on the statistical models fitted per village, increasing the average hill density would result in up to 1.2 t ha^{-1} more yield, and up to 4 kg person-day^{-1} greater labour productivity for Zonmon. Increasing the average field size and avoiding rice shading would result in up to 0.8 t ha^{-1} more yield, and up to 17.1 kg person-day^{-1} greater labour productivity for Pelebina. Further enhancing yield and labour productivity will require (i) introducing small-scale mechanisation and other labour-saving innovations, in particular for labour-demanding farming operations such as bird scaring in Zonmon and harvesting and threshing in Pelebina; and (ii) combining analyses of yields and labour productivities at field level with detailed analyses of labour use and labour productivity at farm level. We found that, on average, one hectare in Zonmon contributed twice as much to Beninese rice production than one hectare in Pelebina but with a two times smaller reward for farmer labour. This paradox of higher yields but lower labour productivity in such different rice growing environments and farming systems should be addressed in elaborating development policies.

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1. Introduction

The first and the second Sustainable Development Goals address eradicating extreme poverty and achieving global food security by 2030. Achieving these goals requires improvement in agricultural land and labour productivity as a source of growth based on agriculture and improvement of farmers' livelihoods (Byerlee et al., 2008; Thirtle et al., 2003; UN, 2015a). This is especially the case for sub-Saharan Africa, which was identified as particularly affected by extreme poverty and undernourishment (UN, 2015b). Many recent studies focused on land productivity, i.e., crop yield gaps (Anderson et al., 2016; Beza et al., 2017; Hengsdijk and Langeveld, 2009; Ittersum et al., 2013; Silva et al., 2017; Stuart et al., 2016), while largely ignoring labour input and labour productivity. With growing land scarcity, increasing yield is needed to meet the growing food demand (Conceição et al., 2016; Koning et al., 2008; Nonhebel and Kastner, 2011). Increases in land productivity should, however, be accompanied by and may in specific cases be subsidiary to increases in farmer labour productivity as a key to reducing farmer poverty.

Labour productivity is commonly measured as the gross margin per worked hour or person-day (8-hour day) or approximated as the gross margin per worker (Byerlee et al., 2008; Freeman, 2008; ILO, 2015). In sub-Saharan Africa, 65% of the labour force is involved in agriculture (ILO, 2008) and agricultural labour productivity is the lowest in the world (Byerlee et al., 2008; Haggblade and Hazell, 2010; Thirtle et al., 2003; van den Ban, 2011). Low labour productivity in this region was attributed to low yields (Tittonell and Giller, 2013) and high labour requirements due to lack of use and access to animal or fuel-based mechanisation (Ashburner and Kienzle, 2011; Diao et al., 2016, 2014; Fonteh, 2010; Houmy et al., 2013; Onwude et al., 2016).

Increasing labour productivity may have several impacts. When labour rather than land is a major limiting factor for crop production, improvement in labour productivity may allow (i) an increase in the cultivated area by the family as a whole, which is an important determinant of farm income and food security (Sender and Johnston, 2004; Tittonell and Giller, 2013); (ii) an increase in area cultivated by individual household members, which determines individual development opportunities (Paresys et al., 2016); and/or (iii) a decrease in casual labour use and its associated costs (Diao et al., 2016; Leonardo et al., 2015). In a context of lack of good off-farm job opportunities, increased labour productivity may allow poor farmers not to sell their labour to other farms, getting them out of 'poverty traps' (Tittonell, 2014). Improvement in labour productivity may also simply free up time and improve farmer health and quality of life (De and Sen, 1992; Netting, 1993). Finally, it may free children from labour in favour of schooltime thus improving their future opportunities (Byerlee et al., 2008; Ellis and Freeman, 2016; Frelat et al., 2016; van den Ban, 2011; van der Ploeg, 2008; Woodhouse, 2010).

Rice is the most important food crop of the developing world and the staple food of more than half of world's population (Seck et al., 2012). In sub-Saharan Africa, rice consumption is growing fast and rice production needs to be increased in order to decrease or at least halt the increase in country dependencies on food imports (Demont, 2013; Saito et al., 2014). Increasing rice production is possible through increasing rice yield and through expansion of the area cultivated in wetlands, which are currently underexploited (Saito et al., 2013). This is the case for Benin, where by 2009 only between 12 and 15% of arable wetlands were under rice cultivation (Diagne et al., 2013; Gruber et al., 2009). Benin has one of the largest untapped potentials for irrigation in sub-Saharan Africa (Saito et al., 2013; Seck et al., 2012; You et al., 2011).

Wetland crops, rice included, are labour-demanding (Balasubramanian et al., 2007; Guirkinger et al., 2015; Selim, 2012). A recent study in two villages in Benin showed that labour availability constrains farm expansion in wetlands (Paresys et al., 2017). Land was not a limiting factor in these two villages. Consequently farmers tended to adopt land-demanding and labour-saving production activities: they maximized labour productivity by giving priority to upland crops rather than to wetland crops. Improving labour productivity on rice fields would stimulate the expansion to wetlands (Paresys et al., 2017). In order to understand the main causes of variability in yield, labour input and labour productivity among rice fields, and to identify opportunities for improving yield and labour productivity, we collected and analysed detailed survey data from rice fields of two Beninese case-study villages contrasting in terms of rice growing environments.

2. Materials and methods

2.1. Case-study villages

The selection of villages was based on a rapid regional assessment of the various wetland agro-ecosystems from south to north in Benin. Two case-study villages were selected that were close to an urban market and experienced markedly different agro-ecological and socio-economic conditions; Zonmon in the south and Pelebina in the north-west (Paresys et al., 2017). Farming systems and types of farms differed greatly between villages.

In Zonmon, food production mainly involved maize and cash crops included groundnut and rice. Based on data from a random sample of 38% of farms, rice accounted for 14% of the total farmed area during the 2012–2013 agricultural season (Paresys et al., 2017). Area under rice was a key distinguishing factor among farm types. Larger areas were found in the wealthier farms, i.e., in farms with larger labour availability, particularly due to hired labour.

In Pelebina, food production involved tubers (yam and cassava) and cereals (maize and sorghum). Cash crops mainly included cotton, soya and groundnut. Based on data from a random sample of 34% of farms, rice accounted for 1% of the total area farmed during the 2012–2013 agricultural season (Paresys et al., 2017). The area under rice was not a key distinguishing factor among farm types.

The access to inputs for rice cultivation and the rice growing environments differed between villages (Fig. 1). In Zonmon, agricultural services provided farmers with improved seeds (IR841) and credits for fertilizers and casual labour. Rice was mainly cultivated in the bottom and lower fringes of one lowland with a mixed flood regime, i.e., subjected to both rainwater runoff and floodwater of the Oueme river (Fig. 2). The rice cropping season started at the end of January, i.e., in the middle of the dry season and ended in mid-May, i.e., in the middle of the long rainy season. An irrigation scheme had been developed in 1975 under the Benin-China cooperation (Djagba et al., 2014). Although operated and maintained with difficulty by farmers (Totin et al., 2012), this scheme allowed intermittent irrigation from stream water on rice fields.

In Pelebina, rice seeds were either bought on local markets or self-produced. Original variety names could not be identified. Rice fields were scattered across 11 different lowlands. The rice cropping season started at the end of June, i.e., at the beginning of the rainy season and ended at the beginning of December, i.e., at the beginning of the dry season. Water on rice fields was not controlled.

2.2. Field survey

We determined the total number of farms for each village with the help of village authorities using social mapping (Rim and Rouse, 2002): 134 farms in Zonmon and 146 farms in Pelebina (Paresys et al., 2017). In Pelebina, we surveyed all rice fields found in the village during the 2012, 2013 and 2014 rainy seasons. In Zonmon, we surveyed all rice fields in a random sample of 21 farms during the 2013 and 2014 dry seasons. In total, we surveyed 50 rice fields found in 26 farms in Pelebina and 82 rice fields found in 21 farms in Zonmon (Table 1).

At the start of the growing season, we conducted semi-structured interviews with farmers to (i) identify whether rice fields were family rice fields, i.e., fields controlled by the family management unit to