Adoption and Economic Impact of Water Conservation and Intensification Methods on Input Demand, Output Supply, and Net Returns in Lowland Rice Production of Northern Ghana

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The adoption of new agricultural technologies still plays a key role in increasing agricultural productivity and food security in developing countries. Rice is an important cereal to Ghana's economy and agriculture. While a huge potential for lowland rice cultivation has been identified for northern Ghana, the self-sufficiency rate of rice has been very low in the country. Rainfed lowland rice production is characterised by low productivity, erratic rainfall, and degrading soil fertility. Soil bunds for water and soil conservation and dibbling as seed sowing and fertilizer application method have been introduced in smallholder rice cultivation in the study region as part of a project to intensify lowland rice production.

The present study contributes to the literature by analyzing the impact of dibbling and bund technology on fertilizer demand, output supply, and net returns by explicitly taking account of selection bias. Methods used for impact evaluation are the non-parametric matching approach and the parametric endogenous switching regression model. Without controlling for selection bias, the estimated technology effect would be biased and result in wrong policy implications. The data set used consists of 342 smallholder rice farmers and was collected in 24 communities across three river valleys around the regional capital of Northern Region, Tamale.

The adoption decisions of dibbling and bund technology were estimated employing a seemingly unrelated bivariate probit model. The results suggest that the adoption decisions should be estimated jointly. Adoption decisions are found to be related to economic constraints, particularly of labor and capital. Furthermore, adoption is influenced by the perception of technologies, and the participation in technology-related projects and farmer groups. In addition, the use of interrelated technologies, such as the use of improved varieties, plot-level characteristics, and the geographic location appear to be significant factors. Results suggest that bunds are more likely to be constructed on marginal land (in terms of soil quality) as a preventive technology, while dibbling method seems to be used complementary on productive plots.

While most empirical studies use matching approaches that are based only on the propensity score, this study applies the Mahalanobis metric matching with the propensity score as additional variable. This method has been rarely used in the agricultural economics literature, but is particularly useful in the present analysis with multiple treatments. To check for the robustness of results, kernel based matching and nearest neighbour matching methods are applied in addition. Balancing tests clearly indicate the significance of matching in reducing bias in the distribution of relevant variables between the treatment and control groups. Sensitivity analysis is undertaken by employing the Rosenbaum (2002) bounding approach. Results suggest that the estimates are quite insensitive to hidden bias. Results of the Mahalanobis metric matching indicate that the use of bund technology has a positive and significant effect on fertilizer demand, as well as a positive, but insignificant impact on rice yields and net returns. Adopters of dibbling technology appear to have higher rice yields, while no significant difference between the net returns of adopters and non-adopters was found. However, the data reveal a positive and significant effect on productivity and net returns when dibbling method is combined with intensified weeding. Furthermore, if dibbling is used not only as seed sowing but also as fertilizer application method, nitrogen demand is significantly higher.

Estimates of the endogenous switching regression model suggest that self-selection occurs and that different variables are significant in explaining the farm outcomes of adopters and non-adopters. In particular, capital and labor constraints, and the availability of land preparation equipment are important factors in determining farm outcomes. Furthermore, social networks such as farmer groups, the use of interrelated technologies, and learning effects through the dissemination of interrelated technologies turn out to impact on farm outcomes. However, the effects vary in the level and significance according to the type of technology and outcome.