Farmer uncertainty and demand for rice varietal identity information: DNA fingerprinting of smallholder rice varieties in Côte d'Ivoire

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Abstract: Information asymmetry is a key challenge facing farmers in sub-Saharan Africa, particularly regarding the identity and quality of crop varieties and other agricultural inputs. In this research, we contribute to a recent economics literature that uses advances in DNA fingerprinting technology and affordability to directly measure the identity of crop varieties, allowing this variable to be compared with farmers' beliefs about the varieties that they cultivate. In our study, we additionally utilize a novel approach in which we elicit the demand of rice farmers in central Côte d'Ivoire for information about the variety they cultivate as well as their own beliefs about how sure they are of the variety's identity. We connect our DNA fingerprinting analysis of producer seed samples to survey questions related to producer beliefs and demand, and find that the majority of the farmers in our dataset are not certain about the identity of the variety they cultivate. We further find that around 98 percent of producers in our dataset are willing to pay to obtain the results of DNA fingerprinting analysis of the variety they currently cultivate, from a minimum of around \$0.20 to a maximum of ~\$36 USD.

Keywords: DNA fingerprinting; information asymmetry; measurement error; farmer perceptions

1. **Introduction**

Adoption of new, higher-yielding crop varieties (among other agricultural technologies) is seen as an important channel to improve agricultural productivity (Evenson & Gollin 2003) as well as the economic wellbeing of agricultural producers. For example, adoption of improved NERICA rice varieties has been shown to help increase producer incomes (Kijima *et al.* 2008; Arouna et al., 2017), while improved chickpea varieties have been shown to improve producer profits in Ethiopia (Michler *et al.* 2018).

However, farmers in developing countries face a key dilemma when deciding to choose a new variety: information asymmetry regarding the identity of new seed they obtain, and even that of the seed they are growing. For example, Bold *et al.* (2017) find that a large proportion of hybrid maize seed sold in stores in Uganda is frequently not genuine; and indeed, a number of studies have shown that DNA fingerprinting of varieties collected from farmers revealed that producers were misinformed as to the variety that they are growing. In Ethiopia, Jaleta *et al.* (2020) find that only 28-34% of farmers in their sample correctly identified their wheat varieties, while Floro IV *et al.* (2018) report that Colombian cassava farmers over-estimate the extent to which they cultivate improved varieties. This mis-match between perceived and actual adoption can impact both economists' measurement of adoption and its benefits, and also farmers' behavior, which is likely to be contingent upon their beliefs of whether the variety they are cultivating is improved or not (Euler *et al.* 2022).

In this research, we couple data collected through a farmer survey with the results of DNA fingerprinting analyses conducted on seed collected from the farmers, to identify the extent of misclassification of varieties. In addition, we also ask farmers how certain they are of the variety they cultivate and how much they might be willing to pay to receive the results of the DNA fingerprinting analysis of their variety, providing interesting additional insights regarding the beliefs of farmers themselves. Indeed, although there have been a series of recent articles that use DNA fingerprinting to identify the true nature of varieties grown by farmers (Jaleta *et al.,* 2020; Floro IV *et al.* 2018;), there is to our knowledge no study to assess farmers' willingness to pay to know the true identity of the varieties they cultivate.

2. Methodology

This section describes our sample selection and data collection procedures; how we elicited farmers' beliefs about the identity of the rice seed they cultivate; and the methodology used to fingerprint the rice seed samples we collected.

2.1 Data collection and sample selection

We collected our own experimental data through fieldwork in central Côte d'Ivoire in October 2020. A recently published "e-registration" of about 8,000 rice farmers in Côte d'Ivoire was used to plan the sampling strategy (Arouna and Aboudou, 2020). Villages with a higher ratio of female to male farmers were targeted. We aimed for universal sampling in each village, targeting all rice farmers who make the decision regarding what rice variety to cultivate on their plots. The final sample consisted of 585 farmers, of which around 80% were male and 20% were female. On average, each farmer cultivated rice on around 0.8 hectares, with around 70% farming upland plots and 30% farming lowland plots.

The dataset includes farmers across the twelve villages (six in Hambol, six in Gbeke), with the number of rice farmers per village ranging from just over ten to just under 100 rice farmers in some villages. We aimed to survey as many farmers as possible given budgetary constraints (and in particular reach as close as possible to full coverage of all rice producers in each village), and also to survey a diverse set of farmers through our sample selection. Figure 1 illustrates the villages' locations on a map.

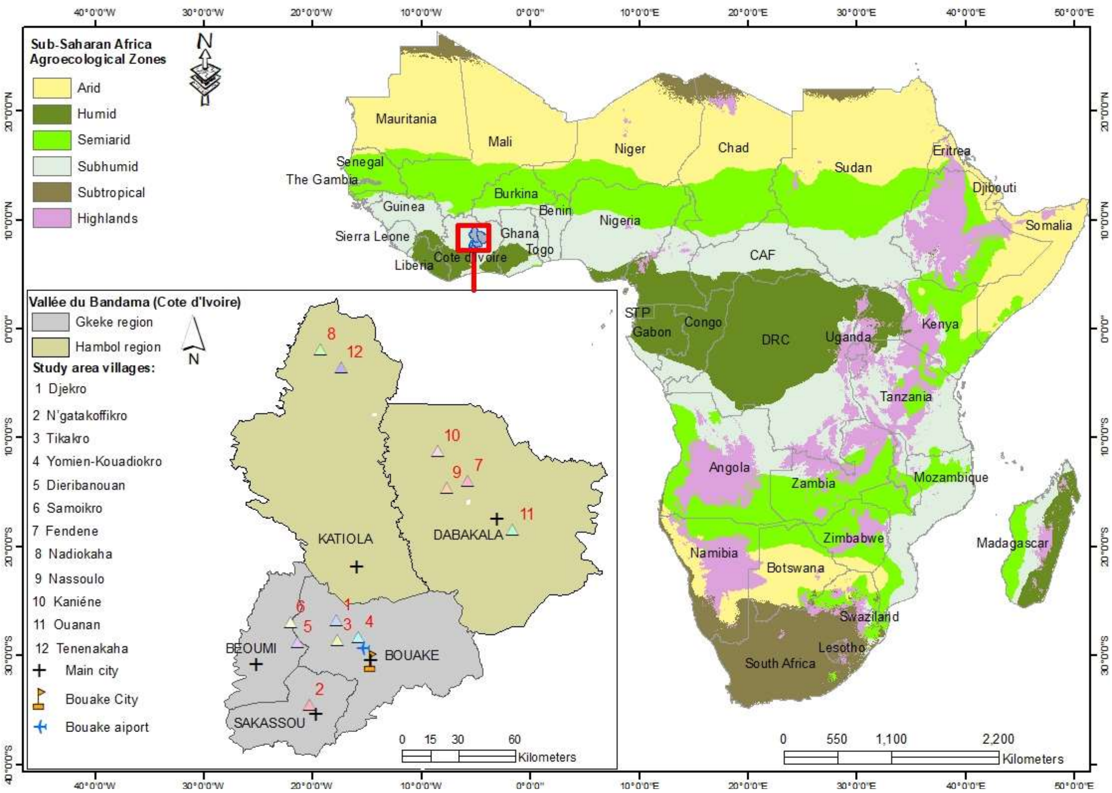

Figure 1. Map of the study villages.

An ethics approval was obtained at the Graduate Institute of International and Development Studies following the internal regulations of the institution, and respecting the measures taken by AfricaRice. Safety precautions to COVID-19 including social distancing measures were taken during surveying activities, which were conducted using electronic tablets in outside locations. Masks and disinfectant were purchased for enumerators. Travel occurred strictly within the Vallée du Bandama area around Bouaké with local staff in small groups. Farmers were asked for their consent before being surveyed, with none being forced to participate against their will. During the two periods of data collection, the epidemiological situation of COVID-19 was stable and at a low-risk level (around 0.1 cases per 100,000 per day) with active cases clustered in the greater Abidjan area. Survey enumerators were first trained in Bouaké, and then prepared further for the survey implementation through a pilot conducted before the launch of the main wave in a village nearby Bouaké.

2.2 Elicitation of farmer beliefs and demand for DNA fingerprinting

As part of a larger survey, we asked the producers to answer the following questions:

- "How interested would you be in having your rice seed tested using DNA analysis to know the exact variety you are growing?"
- "How sure are you of the exact identity of the rice variety that you currently cultivate?"
- "What is the main reason you would like to receive the results of the DNA test of your rice variety?"

In addition, we asked the surveyed producers to state how much they would be willing to pay to receive the test results regarding the true identity of the rice variety that they cultivate:

- "How much would you be willing to pay (in FCFA) to receive the test results regarding the true identity of the rice variety that you have been cultivating?"

Last, we also collected a small seed sample from each of the surveyed producers for the purposes of verifying the varietal identity using DNA fingerprinting.

2.3 DNA fingerprinting of producer varieties

The seed samples collected from farmers were brought back to AfricaRice headquarters near Bouaké and regrown. Three tissue collections from each cultivated seed sample were collected for DNA fingerprinting, to allow the analysis of any heterogeneity in the farmer seed (cultivation of seed mixture). DNA samples were prepared by Intertek ScanBi Diagnostics AB, and sent to DArT (Diversity Arrays Technology) for analysis.

3. Results

In this section, we first describe our survey results related to producer beliefs about how certain they are about the identity of their rice variety, and then present the results related to the producers' stated demand for information about the variety they cultivate. The DNA fingerprinting results, when received, will also be presented in this section.

3.1. Producer beliefs and demand for verification of varietal identity

Figure 2 presents the breakdown of how sure producers stated they were of the rice variety they currently cultivate. We find that more than half of producers in the sample (~56%) state that they were unsure or not sure at all of the identity of the variety that they are currently growing.

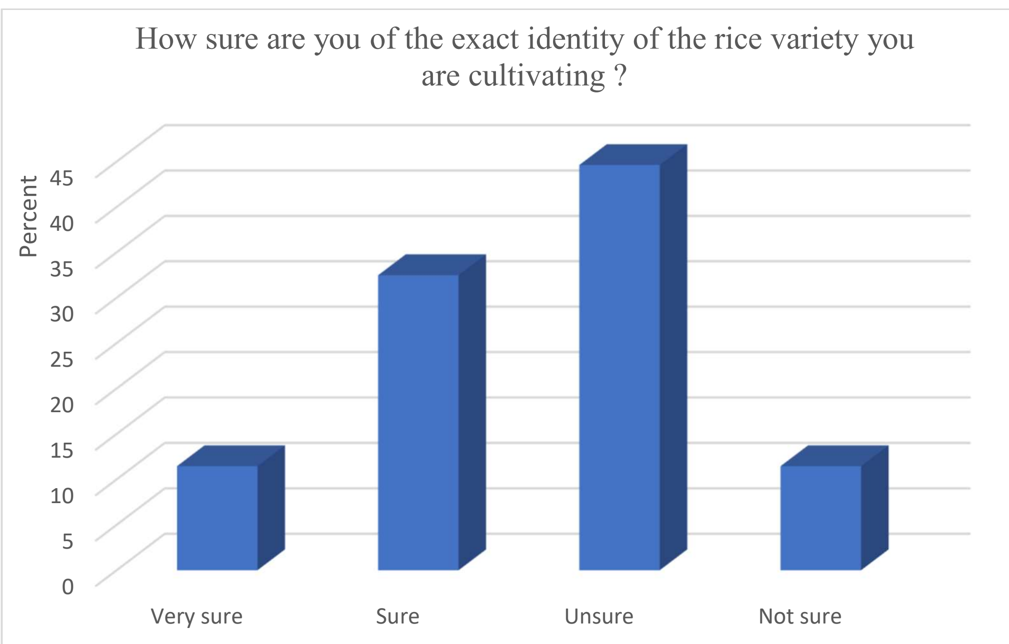

Figure 2. Producer certainty regarding the variety they cultivate.

Next, we asked farmers to express their level of interest in having their rice seed tested to verify the identity of the variety. We find that more than three quarters of farmers were interested or very interested in the results of the testing (see Figure 3).

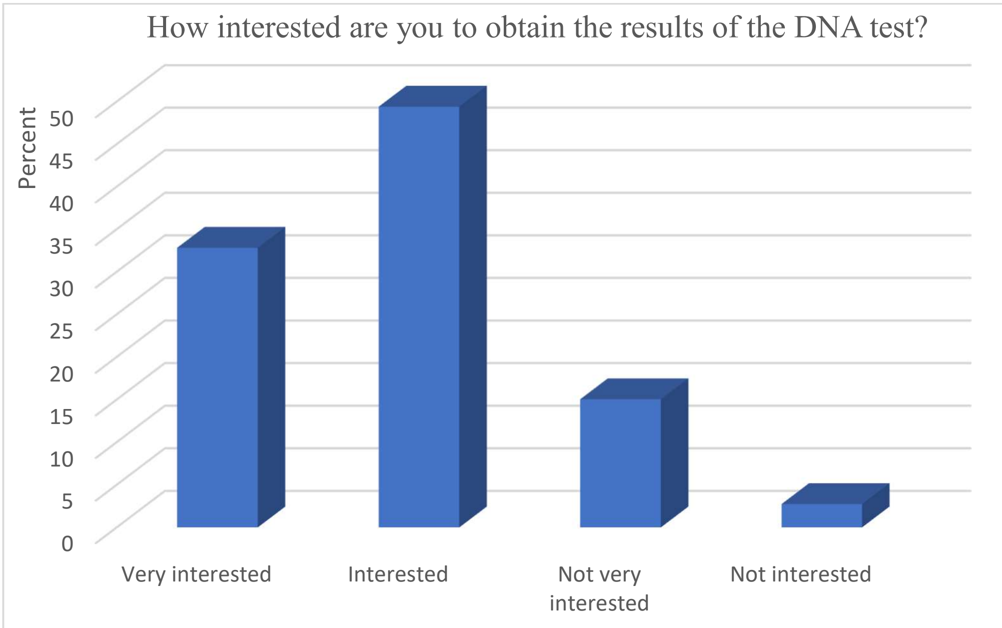

Figure 3. Producer interest in obtaining the results of the DNA fingerprinting analysis.

In terms of the results of our willingness-to-pay question, we find that 98 percent of farmers were willing to pay at least something to receive the results of the DNA fingerprinting analysis, between around \$0.20 to a maximum of around \$36, and an average of around \$5.70 (quite substantial sums given the context of the study) – indicating that farmers (the majority of which received their rice seed from other farmers) are concerned about the extent to which they are certain of the identity of the variety they currently cultivate, and are willing to pay for information about their variety's identity. Figure 4 presents a histogram of farmer WTP for the results of the DNA fingerprinting analysis.

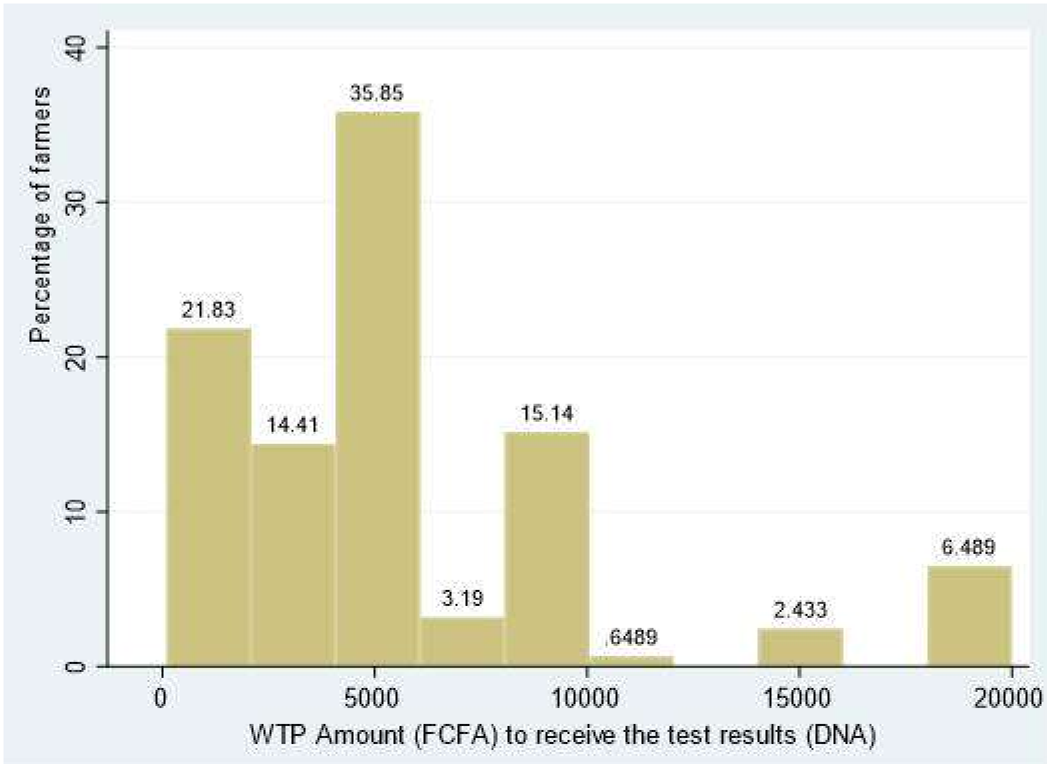

Figure 4. Distribution of farmer WTP for DNA fingerprinting results

In Table 1, we provide summary statistics for the data both disaggregated by gender and pooled together. We find that on average, male farmers were willing to pay more for the DNA fingerprinting analysis (average of around 3300 FCFA, or around $6 USD), while female farmers were willing to pay around 20 percent less (average of around 2600 FCFA, or around $4.6 USD).

Table 1. Comparison of WTP values (FCFA) to receive the test results regarding the true identity of the rice variety that you have been cultivating by gender

Number	Median	Percentile 70	Mean	SD	Min	Max
Male (n=484)	2000	5000	3283.57	3119.89	0	20000
Female (n=101)	2000	2500	2574.25	2619.87	0	15000
Pooled (n=585)	2000	5000	3161.11	3049.21	0	20000

In Figure 5, we provide two, gender-disaggregated histograms of producer WTP for DNA fingerprinting results.

Histogram for Male farmers	Histogram for female farmers

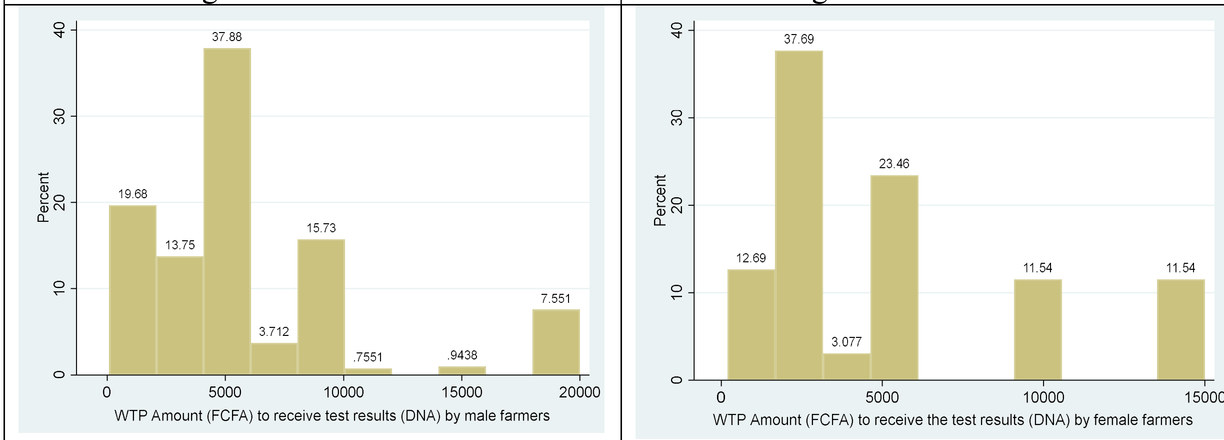

Fig 5. Gender-disaggregated histograms of WTP for DNA fingerprinting results

Last, we also present the producer responses to the question of why they would be interested to obtain the results of the DNA fingerprinting. We find that more than half (around 64 percent) of producers would like to know more information about the performance and characteristics of the variety, beyond just the name. The second most common reason was to know the exact ecology to which the variety was adapted (around 23 percent of farmers), followed by those (around 8 percent) who wanted to know the name of the variety.

Table 2. Main reason to obtain the result of the DNA fingerprinting.

Variables	**Frequency**	**Percent**
To know the performances of the variety	372	63.59
To know the ecology adapted to the variety	134	22.91
To know the name of the variety	47	8.03
To know the origin of the variety	16	2.74
To know the type of variety (improved or traditional)	9	1.54
Other reasons	7	1.2

Other reasons, cited less frequently by producers in our sample, included the desire to know the origin and/or type (improved vs. traditional) of the variety.

3.2. DNA fingerprinting results

At the moment, the samples are in the process of being analyzed. Unfortunately, due to unforeseen circumstances, this process has been delayed. However, we expect to receive the results in the next few weeks, and by the time of the conference, both the DNA fingerprinting and our analysis should be complete and available for presentation.

4. Conclusion

Our research and anticipated results contribute to a recent economics literature that uses advances in DNA fingerprinting technology and affordability to directly measure the identity of crop varieties, allowing this variable to be compared with farmers' beliefs about the varieties that they cultivate. Our DNA fingerprinting approach also allows us to identify the extent to which farmers are cultivating mixtures of rice varieties as opposed to pure seed of a single variety.

Additionally, we utilize a novel approach in which we elicit farmers' demand for information about the variety they cultivate as well as their own beliefs about how sure they are of the variety's identity. We connect our DNA fingerprinting analysis of producer seed samples to survey questions related to producer beliefs and demand, and find that the majority of the farmers in our dataset are not certain about the identity of the variety they cultivate. These new variables allow for deeper analysis about which farmers are unsure of the variety they are growing, and enables these variables to be matched to information about whether farmers incorrectly name their variety.

While our DNA fingerprinting results are unfortunately not yet available, we anticipate that the fresh results will provide interesting evidence to contribute to this growing area of literature, and help stimulate discussion at the 2023 AAEA meetings (alongside the results of the questionnaire, which are presented in this document).

References

Arouna, A. and R. Aboudou. 2020. Dataset of the survey on e-registration and geo-referenced of rice value chain actors for the diffusion of technologies: Case of Benin and Côte d'Ivoire. Data in Brief 30, 105642.

Arouna A., Lokossou J.C., Wopereis M.C.S., Bruce-Oliver S., Roy-Macauley H. (2017). Contribution of improved rice varieties to poverty reduction and food security in sub-Saharan Africa. *Global Food Security, 14: 54-60.* http://doi.org/10.1016/j.gfs.2017.03.001

Bold, T., Kaizzi, K.C., Svensson, J., & Yanagizawa-Drott, D. 2017. "Lemon technologies and adoption: Measurement, theory and evidence from agricultural markets in Uganda." The Quarterly Journal of Economics 132(3):1055–1100.

Evenson, R.E.; Gollin, D. 2003. Assessing the Impact of the Green Revolution, 1960 to 2000. Science 300: 758-762.

Floro IV, V. O.; Labarta, R.A.; Lopez-Lavalle, Becerra L.A.; Martinez, J.M. ; Ovalle, T.M. 2018. Household determinants of adoption of improved cassava varieties using DNA fingerprinting to identify varieties in farmer fields: a case study in Colombia. *Journal of Agricultural Economics* 69(2) : 518-536.

Jaleta, M.; Tesfaye, K.; Kilian, A.; Yirga, C.; Habte, E.; Beyene, H.; Abeyo, B.; Badebo, A.; Erensetein, O. 2020. Misidentification by farmers of the crop varieties they grow: Lessons from DNA fingerprinting of wheat in Ethiopia. *PLOS One* 15(7): e0235484.

Euler, M.; Krishna, V.V.; Jaleta, M.; Hodson, D. 2022. Because error has a price: A systematic review of the applications of DNA fingerprinting for crop varietal identification. *Outlook on Agriculture* 5(4): 384-393.

Kijima, Y., K. Otsuka, and D. Sserunkuuma. 2008. Assessing the impact of NERICA on income and poverty in central and western Uganda. Agricultural Economics 38 (3), 327–337.

Michler, J.D.; Tjernstrom, E.; Verkaart, S.; Mausch, K. 2018. Money matters: the role of yields and profits in agricultural technology adoption. *American Journal of Agricultural Economics* 101(3): 710-731.