Impacts of pre-harvest and post-harvest treatments on reducing aflatoxin contamination in smallholder farmers' maize

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Problem and significance: Threats to food safety that are unobservable to consumers are a major challenge for agricultural markets in the developing world and sub-Saharan Africa in particular. One major contaminant is aflatoxin, a carcinogenic fungal metabolite that is commonly present in the region's staple crops (Shephard 2003). Around 4.5 billion people in developing world are chronically exposed to this toxin, with maize being one of its main sources (Abizari et al. 2016; Williams et al. 2004). Aflatoxin contaminates crops pre- and post-harvest and it cannot be eliminated through food preparation (e.g., washing, cooking). Hence, adoption of good agricultural practices to prevent contamination is key to decreasing exposure.

In order to test which technologies and practices can most cost-effectively reduce aflatoxin contamination we implemented a randomized controlled trial (RCT) in upper eastern Kenya. The objective was to test two agricultural inputs intended to increase unobservable food quality. More specifically, the study objectives were to i) identify how well a new technology used pre-harvest called Aflasafe, and a tarp for drying maize off the bare ground post-harvest reduce aflatoxin levels in smallholder farmer's maize; ii) determine if receipt of these technologies drive household's decision to sell maize vs. consume it; iii) understand if training women vs. men improves the effectiveness of these inputs.

Our work contributes to the emerging literature on control of aflatoxin contamination in staple crops in developing world. First, we assessed the effectiveness of Aflasafe through a large-scale randomized controlled trial, when used by smallholder farmers on its own and in the absence of price premiums for unobservable food quality, to reflect current local market conditions in Kenya. Previous studies employed price premiums for safe food to incentivize adoption of Aflasafe, since benefits of using Aflasafe are not directly observable to farmers (Deutschmann, Bernard and Yameogo 2020; Hoffmann et al. 2018). Second, we compared the effectiveness of a pre-harvest and a post-harvest technology, used separately and together. Recent studies focused on the effectiveness of different post-harvest technologies in reducing aflatoxin levels in crops, when used on their own and when bundled together (Bauchet, Prieto and Ricker-Gilbert 2020; Pretari, Hoffmann and Tian 2019). It is important to estimate the effects of pre-harvest technologies because significant contamination of maize occurs in the field before harvest. Third, we estimated the cost-effectiveness of Aflasafe under smallholder farmer conditions. Fourth, we gathered evidence on the intention to use maize treated with Aflasafe and/or dried on a tarp for household consumption or sale. Previous research documented a difference in farmers' adoption of agricultural practices depending on their intention to use crops (Kadjo et al. 2020). These behaviors create information asymmetries characteristic to market for lemons problem, that could ultimately inhibit market participation of smallholder farmers (Akerlof 1970). Fifth, we studied if training and distributing inputs to female farmers increased the effectiveness of these inputs, since women oversee household food safety and food security.

Data: First, a sample of 240 maize-producing villages was randomly drawn from two aflatoxin-prone counties in Kenya. Second, we selected randomly 8 dual-adult households from each village to participate in the study. This yielded a total sample of 1,920 households. Then, we randomly assigned four experimental groups at the village level: (T_0) Control group that did not receive any inputs; (T_1) Aflasafe only group that received 4 kg of Aflasafe, enough to treat 1 acre of land; (T_2) Tarp only group that received 12m^2 tarp, enough to dry harvest from 1 acre; (T_3) Aflasafe and Tarp group that received both inputs. Each group contained 480 households across 60 villages. In each participating household we randomly trained either male or female principal decision maker in the household. The data will be collected in three waves and will include two types of data. First, the baseline data and intervention were completed in October and November 2021. We trained and distributed inputs to 1,440 maize farmers during baseline data collection. Second, two follow-up surveys, one at harvest and one during storage will be completed in the first half of 2022. The baseline survey collected data on demographics, production, awareness of aflatoxin, and awareness and previous use of the inputs that were given out. The follow-up surveys will collect data on aflatoxin levels.

Methodology: We tested the effectiveness of distributed inputs on aflatoxin levels in maize, using a linear probability model. We estimated the intention to treat effect of being randomly assigned to one of the treatment or control groups on the incidence of aflatoxin in maize above 10 ppb (the Kenyan regulatory limit), for household i in village j at period t (harvest or storage):

$$A_{ijt} = \alpha_0 + \alpha_1 T_{1j} + \alpha_2 T_{2j} + \alpha_3 T_{3j} + \alpha_4 S_{ij} + \alpha_5 T_{1j} * S_{ij} + \alpha_6 T_{2j} * S_{ij} + \alpha_7 T_{3j} * S_{ij} + \boldsymbol{X}'\boldsymbol{\gamma} + \mu_{ij} \quad (1)$$

where $A = 1$ if the level of aflatoxin in the sample taken at period t was above 10 ppb and $A = 0$ otherwise. Variables T_1, T_2, and T_3 equal to 1 if a household was assigned randomly to the respective experimental groups as described in Data section above, and equal to 0 otherwise. The coefficient estimates $\hat{\alpha}_1$ and $\hat{\alpha}_2$ test if being offered Aflasafe or Tarp only, respectively, lowered the incidence of maize samples testing above 10 ppb. Coefficient estimate $\hat{\alpha}_3$ tests potential complementarity between the two inputs. The variable $S = 1$ if maize sample came from a batch intended for sale, and $S = 0$ otherwise (i.e., for consumption, seed). The vector $\boldsymbol{X}$ includes household-level variables, and the household-level error is given by μ. Standard errors are clustered at the village-level, to match the level of randomization of the treatments.

Next, to infer the impact of gendered allocation of inputs on their effectiveness we estimate:

$$A_{ijt} = \alpha_0 + \alpha_1 T_{1j} + \alpha_2 T_{2j} + \alpha_3 T_{3j} + \alpha_4 F_{ij} + \alpha_5 T_{1j} * F_{ij} + \alpha_6 T_{2j} * F_{ij} + \alpha_7 T_{3j} * F_{ij} + \boldsymbol{X}'\boldsymbol{\gamma} + \mu_{ij} \quad (2)$$

here $F = 1$ if a household member that was trained and given inputs was a female and $F = 0$ if it was a male. All other variables remain as explained for equation (1).

Preliminary and expected results: Our baseline data indicates that more than 80% of all respondents were aware of aflatoxin, but only 22% had very good knowledge of it, as they knew what aflatoxin was, what caused it, what indicated its presence, and at least one preventative measure. Male respondents had significantly higher awareness (by 12.7%) and higher knowledge about aflatoxin (by 12.5%) compared to female respondents on average. 97% of those who reported taking some measures to prevent aflatoxin contamination also reported drying their maize to moisture content level safe for storage, and 31% stored maize on an elevated surface to avoid direct contact with ground. However, these are considered general good storage practices. Only 6% of respondents reported checking storage for mold suggesting that, on average, respondents did not employ other measures that are more relevant for prevention of aflatoxin contamination. Lastly, 49% and 4% of all respondents were familiar with tarps and Aflasafe, respectively.

We expect to find that the use of Aflasafe and tarp reduced the incidence of maize samples testing above 10 ppb at harvest and storage, respectively. We also expect to find lower aflatoxin contamination in maize intended for household consumption compared to maize intended for sale on average, and we expect to find a difference in input effectiveness across gender of the input recipient.

Implications and ability to generate discussion at the meeting: An analysis on the effectiveness of a novel technology that is intended to improve unobservable food quality, and the role of gender in enhancing the effectiveness of such technologies is important for economic development policy. Our findings will be significant for policymakers looking to increase food safety throughout the developing world and should be of interest to applied economists attending the meeting.

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