AGRILINKS WEBINAR: SOIL VARIATION AND WHY IT MATTERS

PRESENTATION TRANSCRIPT

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Julie MacCartee: All right, everyone. We are going to go ahead and get started with our webinar this morning. Good morning, afternoon, or evening, everyone and thank you very much for joining today. On behalf of the Agrilinks team, I would like to welcome you to the June Agrilinks webinar on soil variation and why it matters in the agricultural development space. Our speakers today are from the Feed The Future Innovation Lab for Assets and Market access, which is also known as the AMA Innovation Lab.

This innovation lab is managed by the Bureau for Food Security's Markets and Partnership Innovation office in order to support research on inclusive market access and risk management. And the results of this Feed The Future innovation lab and other innovation labs, the results support the goal and objectives of the global food security strategy which as you all know is a very important guiding principle for the government's agricultural development programming moving forward. And as such, we are very excited to be able to disseminate research findings from the AMA innovation lab through today's webinar.

Before we get started with the content, I'd like to provide just a couple of reminders. First, the chat box is your main way to communicate today and I see that many of you have already taken advantage of the chat box on the bottom right of your screen. Thanks to everyone who's introduced yourself. It's always really fun to see that we've got a global audience for these webinars. And throughout the webinar, we encourage you to use the chat box to network, to share links and resources and to ask any questions about the presentations.

We will hold most of those questions until after the presenters have presented today and then ask them during a Q and A portion of the webinar. Next, you'll see on the left of your screen, a variety of recommended resource in the resources box and the links box at the bottom left. So we encourage you to download throughout the webinar today. And we are also recording this webinar and will post the recording, a transcript, and other resource to Agrilinks within two weeks. If you are watching the webinar right now, that means you're already on the email list to receive a link to the recording so be on the lookout for that.

And I believe I forgot to introduce myself. My name is Julie McCarty and I'm a knowledge management specialist with the USAIB Bureau for Food Security and I'll be facilitating the webinar today, kind of keeping things moving and collecting your questions. And I also wanted to mention that Agrilinks webinars are produced and managed by the Feed the Future KDAD project, which stands for Knowledge Driven Agricultural Development. So thank you very much to that team for helping to make these webinars happen.

All right. It is time to dive into the content and discuss a topic that is very fundamental to all agriculture and food security activities, which is soil, soil types, soil variability, and the various inputs that can help improve a soil prospect for smallholder farmers. So I'm gonna go ahead and introduce our three speakers today and then pass it off to them. All right.

So we have a great panel of speakers during this webinar today and first up is Emilia Tjernström from the University of Wisconsin in Madison and she is an assistant professor of public affairs and agricultural and applied economics. Her research draws on insights from behavioral economics and employ the econometrics field and lab experiments to study technology diffusion. So she will kick us off today and then next up will be Hope Nicholson who is an assistant professor in the_____ Agricultural and Consumer Economics at the University of Illinois, Urbana Champaign. And she has her Ph. D in applied economics from Cornell and her research in the developing world tend to find relationships among agriculture, poverty, and market institutions.

She will be our second presented and Carolina Corral will be our third presenter. She is with the Precision Agriculture for Development, Kenya project which is also known as PAD. And she has … or she has her MSD in economics from the University of Montreal and more than ten years experience in applied economic research managing projects in Latin America, Africa, and many other locations. And PAD, her organization, is a non-profit with the mission to support smallholder farmers in developing countries with personalized agricultural advice through their mobile phone.

So that is our panel but kicking off with a few introductory remarks is Michael Carter with the University of California Davis. Professor of Agricultural and Resource Economics and the director of the Feed the Future Innovation Lab for Assets and Market Access or the AMA Innovation Lab. So we would love to have Michael unmute his line and kick us off for this webinar.

Michael Carter: Okay. Great. Thank you, Julie, and thank you to everyone. I'll say just a very few words by way of introduction for what we're about to hear. So the way I think about this event is in a sense, what we're talking about is the green revolution that was not. So I suspect most of us have seen data on cereal yields and fertilizer use stretching 1960 forward. And if you look at that kind of data, what you see is South Asia, East Asia, Latin America, Sub-Saharan Africa were on a very similar level 1960 and then

as you roll the clock forward, the other regions of the developing world showed very sharp rates of increase in cereal yields matched by very sharp rates of increase in the use of inorganic fertilizers.

And so one of the questions is these fertilizer revolutions. Sub-Saharan African, why didn't it happen in the same way that it seems to have happened in most other parts of the world? Economists, amongst others, have their own sort of favorite explanations. Economists might focus on liquidity constraints or risk. I've always thought it's important to ask ourselves, "What's different? Why this sort of Sub-Saharan African exceptionalism?"

One kind of perspective that's emerged from people who study this intensively is that there's something different about African soils. So an extreme version of that hypothesis would be that African soils just are not very fertilizer responsive, organic matter is perhaps really low. There simple are not the preconditions, the biophysical preconditions, the agronomic conditions for the seed fertilizer revolution to work.

Another possibility, and this really gets us to what we're gonna talk about is it's perhaps not so much the average level of fertilizer responsiveness of soil but rather the variability of soils is the issue. So the studies were [break in audio] at today share a common characteristic in that they all look at hyper, I'm gonna call it hyper local variation in soil quality. And they're really looking at a series of inter related questions. So the first is how much of that sort of hyper local soil variation is there and does it matter in the sense that a farmer in one location really has – soils are sufficiently different than a nearby farmer such that a standardized green revolution recommendation needs this much nitrogen, use this seed variety's maybe just not going to work.

So that's the first element I think all three studies are going to talk to us about today and the next thing is what do you do about it if there is this kind of hyper local variation? What are the kinds of interventions that might be possible? Is simply the provision of information sufficient or are there other kinds of matching interventions that need to be made such that farmers can actually profitably adopt their own particular, if you will, variation of the seed fertilizer variation.

So Emilia's going to be sharing information with us on a study in Western Kenya, Caro's talking about some work initially in Mexico which is now spilling over into Eastern Africa, and Hope will talk to us about work she and her colleagues have been doing in Tanzania. And I think our job here as an audience is as we go through

this material with them is to sort of ask ourselves, "What, if anything, can be done to promote the uptake of the technologies which are there and would seem to hold out such promise and yet, which seem not to have been adopted in this environment of, as we'll see, a fairly extreme soil heterogeneity. So without further ado on my part, Emilia, why don't we pass it over to you? And I look forward to the conversation with all of us who have joined.

Emilia Tjernström: All right. Thank you, Michael. Good morning everyone or good evening depending on where you are in the world. I've been asked to just remind participants that if you want to see the presentation up on the full screen then you can click the four arrows in the top right hand corner of your presentation display and that'll make it a full screen window. And so I wanna start off the morning with talking about some data that we collected in Kenya together with Tigamu Institute in Nairobi and I'm really excited to see some of them present in – and I don't know why this screen is moving – in the chat today.

Anyway, so what I wanna do is talk a little bit about what I think the data has taught us about the level at which soil quality characteristics vary and what that variability means in terms of both how to think about what the optimal input package looks like. First of all, holder farmers in terms of how farmers' ability to learn about what is optimal for them as Michael mentioned, sort of varies with the extent of soil variability. And also, in terms of the extent to which this variability slows adoption of improved input for farmers. Now, I think that will set up Hope and Caro really nicely because they're then going to talk about ways in which we can sort of leverage information about soils to maybe increase adoption of improved materials.

So some of the reasons that we might care about soil heterogeneity, I think many of you listening would agree that increasing the use of improved germplasm and fertilizer could boost the yields and the welfare of rural households. And there are lots of smart and passionate people who work in the governments here, researchers, NGOs who work on ways to increase adoption of these inputs and common approaches include things like input subsidies, extension services, and government issued input recommendations. But it's really hard to provide good recommendations and trainings when soils vary a lot. Right?

So one important question becomes sort of how low do we go? Right? How low do we need to go? At what level do we have enough similarity that providing a single recommendation should suffice? So for a country like Kenya, are we talking about ten agroecological zones for which we might want to make different

recommendations? Are we talking about 100? More?

And so I wanna start by looking at some maps and thinking a little bit about this issue because at least, I was quite surprised when we started digging into this data and then, uh, I'll move to talking a bit about what the consequences might be for farmers of this type of variability. So to give you a sense, let me show you some maps. So on the left hand side is Kenya. The red zone there is the former province of Nyanza. It was an administrative unit.

And the right hand side sort of zooms in on the part of this province that lies south of Lake Victoria, so South Nyanza, and this colorful map comes from the 2009 version of the farm management handbook of Kenya. And so you can see that there's been a lot of careful work here going into defining different agroecological zones based on rainfall, the length of the growing season, et cetera. Right? I'm gonna show you another map of the same region where the different colors and these different rectangles show different areas within which different fertilizer recommendations have been made. Okay?

And so within these different sections, you can sort of pull up a zoomed in version and find a table within this handbook and look up fertilizer recommendations for that specific zone. Okay? So this is partly to say that it's not as though local variability in the environment hasn't been considered before but what if these are still not local enough? Right? Note, the scale here that this rectangle on the right hand side is sort of 10 to 20 kilometers across. Okay? And so we're gonna look at our data to kind of think about whether or not there's important variability even within these types of zones.

And so our data, these maps show the GPS locations of our example farmers and they were collected for a study on the socioeconomic impacts of a new maize hybrid, but as part of the data collection, we sampled the fields of 1,800 farm households and sent them to be tested, sent the soil samples to Cropnuts, which is an ISO certified lab in Nairobi, and we obtained over 20 different measures ranging from pH, organic matter, a bunch of different nutrients and micronutrients, and the cation exchange capacity which I'll come back to in a second.

So as you can see, we have a pretty broad geographical spread in our sample but let me, for the sake of comparison, zoom into South Nyanza and roughly. This map here shows the GPS locations of our different households in this area and shows the distribution of cation exchange capacity. It's often used as a measure to gauge soil

fertility and – sorry. My presentation is moving so someone else is moving that. Maybe avoid doing that [laughs].

But so cation exchange capacity is important because it affects farmers, it affects optimum practices and this is just one example. But for example, liming recommendations, fertilizer efficiency and even the optimal timing of fertilizer applications all vary with a soil's CEC. Okay? So I'm gonna zoom in even more and look at a couple of villages' in our sample. And so the different dots, the colors of those dots represent different ranges of cation exchange capacity and this correlates with, as I said, different soil types, different optimum practices.

And so note that across just a couple of villages here, we have fields that fall into both very low range, low, medium, and high ranges of CEC. And so even within a village, soil quality can vary quite a bit and so if you note the scale, it might actually be difficult because my presentation, we have some technical difficulties and so it's a little bit wonky but bare with me. That bar in the lower right hand side corner in that red rectangle shows a 1 kilometer scale. So this scale here is basically incredible variation within just a few kilometers of each other. All right?

And so even within a village, as I said, soil quality can vary quite a bit. I'm gonna show some other examples of this. This is across all of our 100 plus villages, the variation cation exchange capacity again. And so each bar on this grass a box plot and if you can see it, there's a white line in the middle of each bar which shows you the median CEC value in that village. While the height of the bars represent the amount of variability within that village essentially. Okay? But there's also big differences between different villages in terms of how much variation there is.

So if we zoom in on the two villages that have the same median CEC, you can see that in one of these villages, 25th percentile farmer looks very different from a 75th percentile farmer, whereas in the other village, the distribution is sort of much more compressed. And we can see the same thing for other soil characteristics. For this graph shows pH. This graph shows organic matter and so you see lots of both between and within villages and in the extent of variability.

So the logical next question here is obviously whether this matters for input recommendations and for optimum practices. And so in particular, does the optimal fertilizer recommendation vary at this sort of hyper local scale? And might recommendations for a median farmer in a village potentially be misleading for other farmers and is certainly at the sort of 20 kilometer or regional scale? And so the short answer to the first question is that yes, it seems like the optimal input

varies quite a lot within village.

Our soil testing lab also provided each of our farmers with a recommendation for the optimal input application for a variety of fertilizers and there's substantial difference within villages. These graphs show 20 random villages and the recommended level of DAP per acre for those samples. And so the two blue circles here show that for some farmers, the ideal application rate might be 20 kilograms per acre and for others, it might be as much as 40 which may not sound like a lot but it can have very important profit implications if you're a small holder and you're deciding how to allocate a limited budget. Okay?

So we can also see this … we have the same graphs for a variety of fertilizers but I don't want to bore you with that so we can also look at this in a different way by estimating production function and slightly more advanced economic techniques and trying to estimate, based on a panel of three rounds of survey data, what the returns to fertilizer look like and how they change with the underlying soil qualities and types. On the right hand side here, the graph – so we use generalized quadratic for those who are econometric geeks. We have household, fixed effects and so you can see that on the left hand side of certain levels of CEC, the average marginal benefit of adding another kilo of nitrogen is substantial whereas for other ranges of CEC, it seems like on average, the returns to more nitrogen are quite low.

We have these graphed again for a lot of different soil conditions but it seems like the returns to an additional kilo of nitrogen vary markedly with the soil conditions. Now, this could be because – and as I think Hope will talk about, other nutrients are more limiting in certain contexts or because of acidity or because of a variety of different issues but in general, it does seem like the ideal fertilizer recommendation varies with soil quality. Okay?

So to kind of loop back to the things we really care about, we sort of think about whether this could be part of the reason that the adoption of improved inputs is so low in Sub-Saharan Africa. And so I have some other work showing that learning through social networks by farmers, basically learning from their neighbors is substantially weaker in villages with more soil quality variation. So this is somewhat logical, right? Because when soils vary more, the experience that one farmer has with improved inputs doesn't necessarily provide a good example for other farmers who may have a different soil type as I showed you earlier.

And it does seem like farmers are acutely aware of this issue. Because of the fact that they learn worse in more heterogeneous villages, we can sort of infer that one of the

reasons for this reduced learning ability is that soils vary so much. And so this really suggests that the types of localized interventions and recommendations and very specific information that the next presenters are going to talk about can play a really important role. And with that, I think I'm going to hand it over to the next presenter.

Hope Michelson: Hi. Hello? Thanks, Emelia. So this is Hope Michelson. I'm from the University of Illinois and so it's lovely to follow Emilia and Michael because they set up our work, I think, so well and I think some of the things that we're doing can really complement Emelia has just talked about. So as Michael noted, this is work that's been done in Tanzania. We're just finishing up. And it's a really big group of people that I wanna acknowledge so a whole team of soil scientists at Caplona University in Marlboro as well as folks at Columbia, University of Florida, and now we have one researcher who's at McGill.

So as Michael noted and –

Adam Schrecengost: Hey, Hope. This is Adam in DC. Can you just speak up a little bit please? You're a little bit faint.

Hope Michelson: Sure.

Adam Schrecengost: Thank you. Sorry to interrupt. Back to you.

Hope Michelson: Yeah. Okay. All right. Wait. Let me turn one thing off. There's a background air conditioner that might be making things worse. Okay. All right. Let me know if this doesn't sound better. Okay?

Adam Schrecengost: Well, we could use a little more oomph if you got it but if not, that's fine. We can live. Folks, Hope is presenting in a different location from us. You might just need to turn up the sound on your computer. Thank you.

Hope Michelson: Okay. So as Michael noted and as Emilia stressed, there's this problem that many people have been thinking about for a long time which is that mineral fertilizer use as well as other sort of advanced inputs and cultural inputs has really lagged in Sub-Saharan Africa and we've seen associated lag in crop yields, especially amongst small farmers. And so just to reiterate, there's sort of three reasons that we think soil variation can be important here if we find that it's significant enough. That there's enough variation. And the three reasons that we think about a lot, is that you're gonna need sub regional calibration of fertilizer management recommendations.

So Tanzania in particular, is not like Kenya where you've got these sub-regional kind of carefully calibrated recommendations. Tanzania's making broader recommendations for the whole regions for maize cultivation and there's a number of countries in Sub-Saharan Africa that have that kind of a strategy. And so if we find that there's enough soil variation and that that soil variation is meaningful economically, we really need to think about how we're gonna get recommendations to people that are appropriate.

So the second point is related to something that Emilia has talked about and also thought about a lot which is that if you've got this within village farmer heterogeneity, variation in soil, learning about technology is gonna be compromised in some way. They're gonna be a bit different. And that's something that if you have an extension system, you're gonna wanna think about pretty carefully. So if you're in a place where you've got very similar soils, you might expect different kinds of learning dynamic, different kinds of spillovers going to farmers. Whereas, if you're in a place where you've got a lot of variation, that process may not happen or it may not happen as quickly.

And the third piece which I think about in an associated project is if you've got all of this important variation, you're gonna have a demand for a wide variety of agricultural input. Right? So in particular, fertilizer blends. And you're gonna need well capacitied agricultural input supply chains to actually meet those needs. Right? So they're gonna have to be well resourced. They're gonna have to be able to supply the blends to the right places, to the right people, and so some work that I have suggests that at least in Tanzania, we may not be there quite yet.

Okay. All right. So the three questions that I'm gonna talk are thinking about this localized variation. So I'll show you in Tanzania what we're seeing in this one region where we're working and I'll show you that in a slightly different way than Emilia was talking about it. And then we, as a part of the intervention for this project, are providing information to farmers about their soil and specific management

recommendations based on that. And then we're looking at what the effect is of that of providing them information in a couple of different ways on what farmers decide to buy and then the yields that they're getting from me.

Okay? And then, I'll also … we're beginning to think about the third question that Emelia's also talked about which is the how low should you go question. So what's the optional scales for soil testing. And the reason we're thinking about that is that in conversations with people that were having to think about this on the policy side, that's the first question we get. So do we need to test at the field level? Do we need to test at the village level? What's the right way to think about providing this information to farmers?

So just to explain the experiment that we're doing before I show you any of the results. So we're working in Eastern Tanzania in Morogoro and we tested the primary maize spots for 1,100 farmers, small scale maize farmers. So we randomly selected the villages and there's two components to the treatment. So there's a plot specific management recommendation. So we tested their primary maize spot and I'll tell you how we did that on the next slide. And then, we had management recommendations based on those test results.

And there's also a voucher with $40.00, which was redeemable for agricultural input and that is the amount that it costs to buy the input currently recommended by the government for maize production in that research for half of the maker. That's how that number came about. So we took those two components of the treatment and we have three treatment arms. So farmers either received the soil management recommendation.

They got their management recommendations and the voucher or they only got the voucher. Right? So you can think about that as information only – information plus liquidity or liquidity only. And then, we had a control group that's both within the villages and also separate villages that were control villages. So we can look at spillovers and they received the management recommendations as well. We tested their plus as well but they received, so you can see what happens to folks that did get those things as opposed to people that didn't.

So just a moment explaining what we're using to do the testing. So this is called the soil dot kit. It was developed by Ray Wild from the University of Maryland and the cost of the test using this kit which gives you measures of CEC, pH, and PKS as random other parameters, is about $5.00 right now. Although, that doesn't include the time associated with the testing. So it's significantly less than sort of what lab

measure. Also this is designed to be able to be done in the field with the farmer. So you also don't have that time lag that you often have between the testing and the provision of the information.

We didn't do it like that because we wanted to have scale and so we used the soil dot protocols that we used in the lab at … University. So if people have questions about that, I can answer it at the end. This is where our farmers are located. So the blue dots are treatment fields, our treatment farmers and our red dots are control fields. As I said, we're in Eastern Tanzania in the Morogoro region and you can see that the maize kind of coincident coverage of the treatment and control group.

So I'll also show you, so this is our recommendation sheet. You're getting the details right on this kind of intervention is really important. So this was a recommendation sheet given to farmers who were efficient in sulfur and nitrogen and it's in Swahili. Recs were provided to each farmer for both 1 acre and half of an acre. For the cost of this packet was about £65,000.00 shillings at the time. And then, here's a picture of what the voucher looks like. It was an £80,000.00 shilling voucher. And one thing to note that people can ask about later is that they were allowed to just turn it in for cash. So if they turned it in for cash, they got 85 percent as the value of the voucher.

So let's talk about some results then. As I said, I'm gonna s how you things in a slightly different way than Emilia and it's related to the way that we did the management recommendations from the soil testing. So I'll show them to you spatially and then I'll show them to you in a table form. So this is similar to the map that Emilia showed you with one difference. So each dot is a field and then in the right side, the lower right corner key, what we've got are the management recommendations according to specific combinations of nutrient deficiencies that came out of the soil testing.

So the top one is farmers that were only deficient, only limited in nitrogen, and then farmers that were limited in nitrogen and potassium and then you can go down from there. You can think about as you get lower, those field are deficient in more nutrients. This is within 120 square mile area. You see that fields exhibit eight different combinations of nutrient limitations and you can also see that within the villages, which are these sort of clusters of points, they're marked by triangles that's difficult to see, I think.

But there's a lot of variation in what those specific combination of nutrient limitations are and that's very important because these nutrient limitations are

related to the kinds of fertilizers you need to buy, the kinds of applications you need to make, when you make those applications, and the blends that you need to purchase. So if you're thinking about what an extension service needs to think about, what an input dealer needs to have on hand, that's a lot of variability in a practical sense to be trying to better meet the demands of.

Okay. So the other way to think about this, the other way to present this is at the table. So there's 1,000 fields here in the table and it's the same information but what I'm showing you is the nutrient deficiency and then the number of farms and the share of farms in the far right column. And what I want you to note, the additional piece of information here is – well, first just a breakdown across the different limitations and you can see sulfur is highly limiting for the majority of farmers in our sample.

What's interesting is the government recommended application for maize grow in the region is NP, which I highlighted in red. And so that means that's appropriate for the nutrient limitation of only five farmers in our sample And in particular, the government's not saying anything about sulfur and that's a very highly limiting nutrient for nearly all of the farmers in the sample so an important thing to think about.

Okay. So what I'm showing you in this graph then is we're gonna get into the results of the affects of the intervention. So remember, there's three treatment groups. Voucher, so getting some liquidity, the recommendation, and then the combination of those then. Okay? So what this is showing you is just in a discreet way, what did people buy if they got those different – if they were assigned to those different treatment on.

So one thing to note, so the first bullet point there is that only eight of the farmers in our sample had a five mineral fertilizer at baseline. So extremely low baseline usage rate and that was surprising even to us. That was lower rates than we expected to see. But got about 250 farmers buying fertilizer and farmers who were receiving the vouchers or the recommendations for the vouchers are the ones where we're seeing some movement. Right? So the ones who just got the information alone without that liquidity infusion, we're not seeing making any purchases … at least yet.

So this is the thing Michael and I talked about a couple days ago. So you could look at that and you could say, "Okay, well, it looks like farmers are buying either urea and sulfur or urea and DAP or only urea and a lot of farmers are buying only urea.

So if you're giving these information on these vouchers to farmers and they're just going out and buying urea, how important is that? How useful is that to actually solving the nutrient limitations that they have on their field?

And so one thing to note here which is interesting and important is that there is a special value of the information. So farmers that got the vouchers and the information were much more likely to buy fertilizers that related to their nutrient deficiency. So in particular, as I said before, sulfur was a primary limitation for a majority of these farmers and so what I have down here in the small table is just a linear probability model regressing the interactions of being sulfur deficient with your treatment status and you can see that the big effect here – so you're much more likely to actually buy ammonium sulfate fertilizer if you were given information that you were sulfur deficient and you had the voucher and recommendation treatment. Okay?

So that's telling us potentially, its own information that information can help close those farm specific nutrient deficiency gaps. So I think that's important to note. Okay. So now, I'm gonna show you two graphs that are the effects. So we talked about what the sort of discreet effects are on buying or not buying fertilizer. So this is how much fertilizer you bought if you were the different treatment arms of the invention and then the next graph, I'll show you yield effects.

So here, what you're seeing is on the Y-axis, it's the kilos of mineral fertilizer. So we're just lumping all the mineral fertilizer together here. And on the X-axis, the different treatment arms. And so you can see that the big effects that we're seeing, so people who received the recognize and the voucher got about 12 to 13 kilos of mineral fertilizer. We also see an effect on the voucher only. They've got about seven. Those are statistically different from each other. But you can expect from the previous sides, there's almost nothing on recommendation only.

And then correspondingly, we see an effect, although it's a small effect, on the yield, the maize yields of the group that got the recommendation and the voucher. Their yield measures pretty noisy and we're doing some work to see if we can control for some of that variation in a better way. But so right now, we're only seeing that effect mapping to that group.

So in terms of preliminary conclusions, there's a few things that I wanna stress. So we do see considerable variation, I would say, in soil nutrient deficiencies in nitrogen, phosphorus, potassium, and sulfur. And our results clearly demonstrate that the national level of fertilizer recommendations are not serving a number of

farmers, at least in this region.

So vouching the loan seemed to move farmers to purchase mineral fertilizer but it's information plus vouchers that seem to be important for closing farm specific nutrient gap. It's important to note also that the financial constraint is significant. So information provisional loan is not yet changing investments. That doesn't mean that it wouldn't in the future. Farmers could be holding back and waiting to see what's happening but we don't see that at the end line just the year after the information's provided.

We obviously have pretty limited information so I didn't present these results but control farmers living in the treatment villages. Right? So looking to see whether or not those guys are different from control farmers living in control villages. We don't see any difference for them. So it's not that farmers yet are sort of swapping this information around. Part of that could be related to what Emilia has suggested and what Kyla Moonshy has found that there's a lot of – that learning can be really limited and highly variable villages. We don't see a lot of an effect on yields. There's something to take about here in terms of fertilizing maize and the profitability of doing that.

And I wanna stress this idea that areas of evidence of agroeconomically important variation in soil quality, it may be important to think about farm level soil testing and management recommendations. So that brings me to my last point and the last slide I'm gonna show you. I'm sorry. In terms of future work, I think there's interesting questions about how these dynamics change over time, what learning looks like across farmers, and whether effects stay, whether they increase, attenuate. So Cara's gonna talk about some of those questions in her …

So the last slide that I wanna leave you with is we're also thinking about this question of the optimal scale for soil testing. We're thinking about it at this point in more of a … in sort of like a statistical way where we're just trying to think about, "Okay, what are the places that have the most variation and can we predict which places have the most variation based on observable sort of structural characteristics that we can get from publically available data?" So that's what we're thinking about.

The idea being that there's variability in the variability and understanding that variability can be very important for figuring out where to deploy the resources from our field level testing versus where to maybe send less resources and to do testing at the village level or the cluster level. So this is some initial work that we're doing where we're looking at the electrical connectivity and what this is suggesting, so on

the left, we've got the actual measures similar to the box plots that Emilia was showing you of soil electrical connectivity.

On the right, we've taken our data and just randomly put the farmers into villages and then we're comparing what those distributions look like. So what this is telling you and what we're seeing across a number of the measures is that there is something structural at the village level. So the values tend to be tighter. The variability tends to be smaller at the village level in our data than it is if you just randomly group the villages together. But I think that's hopeful in some sense because it suggests that there's some kind of structure that might allow us to, in some places, not have to do the expensive kind of field level testing for assessing variability. So I'm gonna pass it off to Caro and thanks very much.

Carolina Corral: Good morning, good afternoon, everyone. So thank you so much to Emilia and Hope. You have done half of my presentation so I can … now. So thank you for you that. I'm going to present to you our research on Mexico and the work of one which whether we cherish need from the world bank _____ _____ from UC Berkley and … Carmen, Mexico.

I want to mention two very important actors that I not mention in the beginning. One is Javier Castashano. He's our full time scientist. He has been working for us for about three years. He's now helping me in our work with petitioner, Cadro fordevelopment in Kenya and at the same time, you will see how important what the role of the rocata extension work is and also the agro dealers.

So our work start very similar from very similar grants, that the _____ _____ _____ in. Basically, we start with this question about we have all these amount of alpha omega at the beginning but all these technology that we'll develop in different reasons _____ that it's working to increase yield but however, it may need happen and we don't see that it's more farmers that have opened this technology. So one of these reasons could be what we are discussing today which is _____ _____ on the soil.

So we wanted to focus in Mexico because although there are many regions in the country that they have yields comparable to the US standard, there are many other regions in the country that are actually are very close, similar to the productivity that we observe in Africa. Maybe not so much higher. For example, in Tlaxcala where we did the study, the agro productivity of our farmers is about 2 tons per acre, which is not that far away from Africa.

So what is our project? We want to better understand what where are the causes of heterogeneity and we want to focus on soil quality. We want to yield very high quality data on soil analysis and we'll talk very briefly about what are the considerations we need to think on when we are talking about soil analysis. There's a whole world behind that. And also, using this information from some analysis and high quality data from and on surveys from these farmers, we want to develop interventions that are actually from the beginning, from the design, they should be successful.

Basically, we try to develop interventions so well founded on agricultural theory but also behavioral theory that from the beginning, we expect that if farmers try them, they are going to be successful. So what are we focus on is you have self-seen like evidence from other countries in Africa. We see the same. We perform 3,000 chemical analysis using wet chemistry and with a very renowned laboratory in Mexico. We see exactly same that Hope and Emilia saw.

And large variation both we seen on across. We have 27 _____ of localities in Tlaxcala and we see high variation in micronutrients so far, nitrogen, potassium, and phosphorus. We don't see that much variation in micronutrients and we think that's interesting and probably there's someone in the audience who has expertise on that. Maybe that person could put comments about. And we know that if we have high soil variation, we cannot expect that info packages will preform the same. Okay? Same problem we have something. Okay?

So now, I will tell you what we did to stop the problem. Like from implementation, it's just that we have started this problem so what we did is we perform thousands of soil analysis and based on the results of those soil analysis, we provided individual _____ recommendation. I'm going to talk a little bit more in deeply in a second about what is _____recommendation. But we also provided income grants and we provided flexible and un-flexible.

So in the un-flexible grant, basically, we told the farmers that they could pick an info package that was a fertilizer recommendation but also we provided them machinery. And we said, "First, you have to get your planting package right and then move forward into second package." And one of the things, the reason for that is like especially Tlaxcala, only 10 to 12 percent of our farmers were applying fertelizers of planting. And the reason for that is because Tlaxcala has a lot of different, weather risk so they say, for example, drought. They say, for example, frost and so a way the farmers have … for that is to wait until the first round of fertilizer.

Where that happens is like for the first 30 days, the plant is not receiving the right nutrient and obviously, that have a high impact in the total yield. And the third part of implementation was provided agricultural extension services to the farmers. We combined these things to four treatments and _____ _____. I'm not going to talk about the treatment now. I want to actually go more in detail to explain you where we're like the different parts of intervention that we have to solve at each step and then when I show you a agricultural production I will explain you a little bit more of why we did that itolation this time.

So for the implementation, we did something that is different that I haven't seen that much in the literature. In order to typolate this input recommendation, we actually, we set up a yield target and the reason for this is a target, it was because sometimes when you are thinking what input recommendation you should work with, the first question is how much do you want to produce? And then in order to get to that optimal, then you subtract the amount of nutrients there are supplied by the soil and then you provide the recommendation out public.

So the oldest calveration model was done by Fertilab and which is a renowned on the lab that I was talking in Mexico using wet chem and for the people that are from economics, basically when we was talking to economists was we find all these recommendations, it's just like production model or economists, this is like idea flow of minimal which mean that your expected productivity depends on the nutrient that you are lacking the most. We also recommend dosage for urea, DAP, potassium chloride, and also include micronutrients because we are … high deficiency.

There's a lot of study of literature from their agricultural scientists that basically are talking about these micronutrients. You don't seem to need that many amount of kilo but actually they have high in that on yields at the end of the day. We also provided information about piesisis, quanticists, and total costs for each input package. That was called the _____. In the recommendations, we also provide information about how much and the size that you should use but we also compare that information to their own use of fertilizers.

So I did that one and she moved something. Okay. Let me – what happened? Okay. Please don't move. So one thing that is very important about fertelizer application, as she said a second ago, is the timing of the fertilization. That's something that we found evidence. I'm not going to present any here. So what's happening is the plant really needs the fertilizers to reapply at different growth stages. If the farmers don't

do that and they apply it maybe later, they are not going to see any impact.

So we were talking a lot about the timing of the fertilization and we were talking about it in terms of the number of leaves the plant has and the number of days after planting. So another part of the recommendation were to provide – actually we were commending the use of precision sowing fields and we explained to farmers that it was very important that they were the right space in between seeds. We wanted to guarantee that once the fertilizer is applied, actually the plants can – try to avoid the plants competing within each other.

And the second thing that – the last thing that we were to recommend, we didn't support with the grant also use of herbicide. I think it's very important to mention is sometimes when we're talking about all this product, we forget to mention what could be negative is externalities of the use of fertilizers and which is one of them. So the nutrient fertelizer recommendations, we saw that it's the kinds of variation both in the fine analysis and depending in which locality that was translated in a variation to recommendation. In some other localities, this was not because it depends on many different factors that we took into for the calculation.

Once we have the translation into the fertilizer recommendation, one of the things that we realize is that farmers that were using with the same amount of money that were investing in urea, they could be doing much better if they were to apply a more diverse fertilizer package. So when I was talking about this other soil analysis, so we have this situation where the government, for example, in Kenya, they're offering blanket recommendations The same is with in Mexico. The government is offering blanket recommendations to the farmers.

So what we were trying to do is try to improve this blanket recommendation and trying to be more precise about what is the level of aggregation of soil analysis. So what we did is out of clusters that they would have depend in size or like about between 5 to 10 kilometers per kilometers, we were going to – first, what we did is basically we calculate the other soil analysis for that particular cluster and then we provide other combinations based on this other soil analysis.

So what do we find from out of that is that the blend end up being a little bit cheaper than the customized that the individuals that take the blend based on the individual soil analysis. The reason for that is because DAP, which is one of the main components of the blend and it's more expensive than there was variation was calculating that. And then finally, we work with agro dealers to actually mix … perform this difficult mixes. In theory, you don't need that. You could have farmers

actually … farmers can do their own blends just by buying the different fertilizers.

The reason why we did it is because we wanted to be sure that the blend was performed in the right amount and because we're trying to see where we were trying to calculate where were the returns to these mixes. So this is a map of Tlaxcala. So those guys are a very small state is close to Mexico City and one of the things that is very interesting about the soil in Tlaxcala is that it has this big long time called the Malinche, and all of our localities that are planting maize are actually around the – you cannot see it in the map but it's this small white area in between the green area. And depending on the size of the mountain that your plot is located, the soil is actually expected to change a lot and the same is true for the high where these plots are located.

So this is one of the poorest states in Mexico. 88 percent of these is rainfall dependent and in our sample, farmers, 40 percent of our sample have not finished primary school and they _____ _____ more than regions. But what are talking about. We make all these efforts to try to understand all these agricultural yearly. We got the economy to think to all this _____ shopping list. Prices. We're talking about efficiency to farmers. We're talking about the quality of the fertilizers to farmers. So what do we see?

And we see that for 2016. That was the year that the intervention took place. We see the farmers did what we asked. So for example, what we see is we recommended less urea. Yes, they did less urea. We recommended less of DAP. Yes, they did a little bit of DAP. We see that they have option in potassium chloride that they were not using before. We see adoption on the potassium chloride. And overall, we see that they use less fertilizer. No more. And however, when we look at sub proportions, yeah, we see actually … there were increases between 16 and 22 percent.

So the first question that you will have about this table is yes, you didn't reach the 4.5 ton yield. Yes, it's true because after all that effort, we got a drought that lasted about 30 days so these results show that even under a very bad drought, all the systems were performing better. So what is the difference between treatments that I have not explained and I promise to explain you now is so treatment one is the treatment that worked first to use precision machinery as planting but we provided personalized recommendations and blends for that particular plot. People who were in treatment two were people who were forced to use the precision machinery in planting but they were provided with average input packages. Okay?

That was support for them. Actually, our grant only cover the machinery, the first

package, and a small part of the second package that they use for top dressing. Treatment three is the most interesting one for us because in treatment three, we provided information to farmers that they could do whatever they wanted. So they could use the precision machinery for planting plus the fertilizer recommendation for planting or they could use the money to exchange it for only fertilizer blends or they could even go and change it for whatever they want at the agro. So it could be just urea, just DAP, just whatever they wanted.

And in treatment four, they had all the training the rest of the farmer had. They had recommendations that were average, but they didn't receive any financial support. So what we see is that although the impact is coming from … it seems to be the case of grant is helping for people for adoption and that also that is translated into yields, separate yields at the end of the year. Yeah. What is important in here and that's something that we want you to know more is like, well, yeah, so in the first year that we provided all this support, we were helping them to get these mixed plants. We were doing all this calculations to get the right plant for them. This actually, all these stuff were translated into practice … because that's one of the main questions is like do we care about what they do the first season by trying or do we care about them maintaining these practices in the future?

So in the second year, they did not receive any grants. They did not receive more information than they wanted to receive it. However, we keep following them to try to understand the investment. And we collected information of practices. So then next is what I'm going to show you is the results for the year after intervention. So what do we see?

The first thing that we see is that the people who were allowed to choose, they actually seek – we see a … significance of a higher … significance in variance to practices so which we thought it was very interesting. So not only we see higher take up of our recommendations the first year meaning they follow … even when they didn't have to. But in the second year, only one they are adopting in this technology. So that, for us is more like a sign that it's something part of behavioral and behavioral like we might have, by just allowing people to choose whatever they want. For all, instead of forcing them like if it were the government _____ package, we see that's a sign of actually choosing makes a difference for adoption.

And this is beyond agricultural theory because the packages was a thing. So we see that for example, that we see adoption of these sewing machinery that is quite extensive. We see they keep having adoption in that. We see adoption in our fertilizer at sewing is higher for this group and also, we see higher adoption. All the

treatments are using more herbicides but we see the higher impact in treatment three, the ones who were able to choose.

And then the next slideshow, for example, we don't see any change in fertilizers used but we do see change in smaller practice that actually make the use of the fertilizer more efficient as covering the fertilizers up right after. And all the treatment groups, they have several important information that they tried to follow our recommendations and keep them and they keep using them. And also, they desire to use this brand that is called Yara. The reason why we were using this brand in particular is because we were very worried that the recommendations itself _____ _____. We wanted the recommendations to actually – we think they might or might not be successful as the quality of _____ fertilizers. So we wanted to control that using a renowned brand of fertilizers that we could guarantee that the concentration was there.

So our conclusion is yes. So we see that all these efforts are providing farmers with localized information, agricultural services, _____ _____ and income grants. This helped for adoption. We see high tech capping grants within an arm, which means things like especially of help with them. And it's like yes, probably farmers are still in support.

So it's not only about information. And that's something very interesting is that we don't see difference in take up of these packages because we are now the farmers. This is the package based on your individual soil analysis and then we were very honest with the farmers who receive the recommendations. We don't see any differences for farmers didn't seem to matter to try.

And we also provide … so yeah. Income grants are still a problem but what we think that is very important is some farmers saw the results of all these efforts we did to try to get their recommendation that will work for them to see these results, these yields actually help them to be more convinced on adoption these practice the next year. And the good thing about this recommendations is that we were trying to move them from efficiency because all the recommendations I said because we based on we collected all this information on how much the farmers were spending on … fertilizers and using that money, we raise these recommendations to say you should buy something different.

And now, we are doing our last run of the race to see if we on top of same adoption on the second year. We also, we would like to see results on yield but we don't have those results yet. And that's the end. Thank you very much.

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