Fertilizer Deep Placement Technology
A Useful Tool in Food Security Improvement

Presentation Transcript

April 24, 2013

Presenters

Samba Kawa
USAID/BFS

Upendra Singh
IFDC

John H. Allgood
IFDC

Sponsor
United States Agency for International Development

Zachary: Good morning. Thank you for joining us today for today's Ag Sector Council. My name is Zachary Baquet. I'm the Knowledge Management Specialist for USAID's Bureau for Food Security. This even is brought by the Feed the Future initiative and sponsored by the Bureau for Food Security and implemented through the Knowledge-Driven Microenterprise Development project. With that I'm going to try to keep it brief. If you've got a cell phone please put it on silent or vibrate.

Please hold questions until the end when we do the Q&A because otherwise the people joining us online (and welcome to you joining online) can't hear your question. Also when asking a question please state your name and organization before asking a question during the Q&A. With that I would like to introduce a colleague from PPL who's going to be talking about – Hold on. One thing I forgot – sorry. Upcoming events: we've got e-consultation for Innovate which is going to be talking about capacity building which is headed up Virginia Tech.

This will be taking place May 7th and 8th. You can look for more information on Agrilinks. And the next agriculture Ag Section Council will be May 29th. We're looking to have it on horticulture. With that I will now turn it over to PPL about the Learning Lab.

Zan: Thank you Zachary. Hi. My name is Zan Larsen and I'm from the Bureau of Policy, Planning, and Learning – the Office of Learning Evaluation and Research. If that's enough of a mouth full for you then I apologize. I'll try to do better next time. And I wanted to say thank you for letting me come here. I actually come from farming family. My father and my grandfather were cattle ranchers. And I think they were a little bit sad that I didn't follow them down that path. So when I let them know that I was here today they feel a little bit better that I at least sometimes get to rub shoulders with other people in agriculture. They'd be very happy.

I wanted to tell you today about a new web site that PPL has just released. And it's in the same family of the Knowledge-Driven Microenterprise Development platform with Agrilinks sits on. Now the difference between Agrilinks and Learning Lab is that Learning Lab doesn't have a sector-specific focus. So unlike Agrilinks that focuses on agriculture, we focus on providing adaptive learning approaches and collaboration models for anyone in any sector.

We're trying to help people have a more collaborative approach to the development work that they do. And we have resources and tools that help people think through how to have that model of approach. The second thing we offer on Learning Lab is change management tools to respond to the major reforms that are happening around the Program

Cycle. How many of you guys have heard the term Program Cycle and are really sick of it already? A few hands in the audience for sure.

And those of you who haven't, I'm sure you'll start to hear about it. Basically it's just USAID is trying to standardize development processes across the agency and that is reflected in the Program Cycle. Their trying to standardize the way we use the term project versus activity or the way that we choose to engage in government to government exchanges, etc., and our strategic planning processes and our project design processes – all of these to be more standardized and to use common language.

And that's reflected, as I said, in the Program Cycle. There are a number of tools on Learning Lab that can help you familiarize yourself with these reforms and changes. That's about all I have to say about the Learning Lab. And I've got little bookmarks for you all. Thank you again for your time. Thank you.

Zachary: Thank you. I recommend checking out Learning Lab. Learning Lab is http://www.usaidlearninglab.org.

Female: *[inaudible comment]*

Zachary: And with that I'd like to introduce Samba Kawa who's an Agricultural Officer with USAID in the Bureau for Food Security. He works with IFDC, our main presenters today, and he's going to be doing the introduction. Samba?

Samba: Thank you sir. Good morning everyone and welcome to today's seminar: Fertilizer Displacement by John Allgood and Upendra Singh. As you just heard I am managing the portfolio here with USAID. I'm managing a portfolio here with USAID. IFDC has their headquarters in Muscle Shoals and they work all over the world. It's a global non-profit PIO. And their mission is to enhance – enable farmers to actually manage fertilizers to be able to use them profitably as well as in a very responsible way to avoid environmental contamination or degradation.

So they do this as a way to also improve food productivity and to achieve food sufficiency and food security. IFDC has these two gentlemen here. I will just read a little bit to introduce them and I will talk a little bit about what we will be hearing from them. John Allgood has over 35 years of global experience in fertilizer sector development. He is the Director of the Eurasia Division. He has completed technical assistance missions and capacity building assignments on a wide range of growing food market development issues including fertilizer distribution, strategy planning for green food market development, management information system development, fertilizer supply analysis, and international procurement.

All this he has done in various countries in Africa, in Latin America, and in Asia. During the early 90's John served first as dealer development and training advisor and later as chief or party for a major policy reform and technology transfer project in Bangladesh. This was a fertilizer development improvement program, which may leave very little doubt for us for his active and successful management of one of USAID's sponsored programs in Bangladesh, the Accelerating Agricultural Productivity Improvement agricultural improvement project - the AAPI. John will give more about this when he talks.

Dr. Singh is IFDC's Senior Scientist. He has extensive experience in all aspects of soil fertility improvement including quantification of soil and neutrodynamics development and application of crops and relation models. And decision supports this stance in Ag research, extension, and decision making.

His experience spans from his current work in coordinating the IFDC area collaborative program at the International Rice Research Institute in the Philippines, which include research on improving new trends on water use efficiency, reducing losses and preventing ecosystem degradation and rice based cropping systems and the development of the low land nitrogen model, phosphorous model crop growth models, and the phosphate rock decision support system. Dr. Singh is leading the IFDC research activity to assess the environmental consequence of fertilizer displacement technology.

What we'll hear from them today is very pertinent to the role fertilizers play in food production as well as in poverty reduction. It will also be very pertinent to the role of fertilizers and fertilizer management play in many healthy environments in the soil, be it water, and air. Then they will also tell us about the where, the how, and why of fertilizer placement for sustainable benefits to the farmer as well as to other forms of life be it fish and other animals as well as the other people around the farmer. They will tell us how fertilizer deep placement contrasts with fertilizer broadcasting.

Without much ado I want to say thanks again to all of you who came and we look forward to a very successful and exciting presentation. Thank you.

John: Well good morning everyone. Thank you for coming this morning. But also thank you for allowing IFDC to take part in this event. I think the introductions were really nice and I think you've been kind of oriented to what we're going to talk about. Dr. Singh and I hopefully will give you an idea that when you leave you'll have a good understanding of the science behind this technology and also what it takes to move it from a research

lab into the field. To give you a little bit of a history this technology is not something that's new.

It's something that we developed at IFDC over a number of years with the intent of coming up with a fertilizer product that would improve agricultural productivity, that has increased yields per hectare with a more efficient fertilizer product. And that's what we've done. We've carried out extensive agronomic research looking at different types of products that would improve nutrient management, various types of coded products, and other additives that would improve the efficiency.

But we wanted something that would be affordable to small holder farmers. And this product is affordable. So based on years of agronomic research we know that the product works in the field and we know that it doesn't add much to the cost of the fertilizer. We'll talk about that in just a minute. We did a lot of engineering research because the product that we're talking about is not available commercially. There is no factory in the world that produces this product. It's only made through small machines that are basically briquetting machines.

We did a lot of engineering research to come up with a machine that would make this product of good quality. And then we're doing other research as well to develop devices to help the application of this product. The technology works. We have seen that applied fertilizer losses, or the losses from applied fertilizer can be extremely high, particularly with surface-applied or broadcast by hand fertilizer in flooded rice fields. The losses can be up to two-thirds of the applied nitrogen and that's huge.

We are seeing that with this technology farmers are using about one-third less fertilizer and they're realizing yield increases of 15 to 18 percent. So on both ends we're seeing higher yields with less fertilizer use – extremely significant in terms of income to the farmers. And there are other aspects in terms of overall fertilizer production being reduced. We are seeing that while this is perfect for rice a number of farmers are adapting the technology in other crops.

In Bangladesh we're seeing it used on cauliflower, cabbage, and eggplant which good results. So this morning at our presentation as Samba and Zachary have already told I will talk about the experience in Bangladesh and then Dr. Singh will talk about the science of how it works, why it works, and some of the environmental consequences of the technology. You can see that this project that we're working in Bangladesh is a five-year program. The budget for the project is about $24 Million dollars.

The goal and objectives are – particularly the goal is consistent with the Feed the Future food security and poverty alleviation initiatives. Our

objectives are focused around building demand for a product when there is no demand among farmers. Changing the farmers' mindset: why should they come to use a different fertilizer method than their families have used and that have been passed down by generation? At the same time there's no supply of this product worldwide.

So we had to address both supply side issued and demand side issues. Our strategic approach was that we wanted something that would support sustainability and basically would put us in a position that we could rely on the market to perform. On the supply side we're working through small entrepreneurs – independent entrepreneurs that have no relationship to the government. But basically they're dealers that either emerge or they're integrated past management groups or farmer groups.

They wanted to buy a machine that would make the larger particles. We also worked with the private sector to make these machines. These machines don't exist anywhere in the world. But our engineers did the engineering design and then provided that to some metal workshops in Bangladesh to make the machines. So everything from the supply of the machines to the manufacture of the product is all private sector driven.

To create awareness we have a very aggressive promotion program. We do the typical things like farm level demonstrations, technical leaflets, and things like farmer field days. But we also do sign boards. We do billboards. We do all type of media events to promote the technology. Stakeholder participation in any country, but particularly in countries where you have a larger or high level of government involvement; it is a process to get a fertilizer product approved.

We did that by working with and through the National Ag Research organizations with the universities. Dr. Singh will talk about some of that work. But basically we wanted the researchers in the country to endorse what we're doing, so a very high level of research and technology validation through our stakeholders. Farmer education – Any USAID project has limited resources. We knew that we could get more value for our investment by engaging the Department of Agricultural Extension.

And for those of us who have worked overseas you know the limitations of Ag Extension. But they can be a valuable partner. So we signed a MOU with the Department of Ag Extension which basically helps us to leverage our resources and get that government support in building the system that will contribute to longer-term sustainability. Policy constraints I've alluded to. A new product coming into the market; there are limitations in Bangladesh on who can buy fertilizer and who can sell fertilizer.

So we had to work with the government to be able to break down some of the policy barriers. And of course design of an M&E system to help us monitor where we're going and what progress we've achieved. And always building from lessons learned to make sure that after each year or each period we're able to reflect on what we've done, what our deficiencies are, and then adapt to those lessons learned. There are several cross-cutting dimensions. I've mentioned capacity building, gender dimensions, environmental, public sector, working with the National Agricultural Resource organizations, private sector.

We work with the National Association, which is a private sector group, and we work with the people that make these machines to give them not only engineering design information but to help them troubleshoot and also to make improvements: safety improvements and performance improvements. We target a 20 percent women participation in every aspect of this project, which is really good. But Paul Weisenfeld was in Bangladesh in August and one thing he said was, "You're exceeding 20 percent. Why don't you go for 50 percent?"

And we said, "Wow, we can try, but this is a different situation." We are very much aware. Women make excellent fertilizer dealers. They're at their shop. They're very conscientious workers. There's also the gender dimension of the increased yield of rice. That gives more labor opportunities for women and that's pretty significant too.

And the environmental dimensions: we are measuring some of the environmental consequences and right now Dr. Singh will talk about that. But things like ammonium in concentrations in floodwater. We're working with the National Agriculture Research organizations to measures that and we're seeing some really significant benefits from the technology.

And this is the way you make it. You take prilled urea which is commercial available in the world. That product is placed into a hopper with gravity flow. It rolls between two rollers which basically have indentations, compressed the smaller particles into a larger particle. Gravity flow – it comes into this wire shoot that's rotating. And the fertilizer product then comes out as urea-supergranules. I'm not aware of any process commercially that can make this product other than through a compaction or a briquetting process.

Most of the urea factories in the world make this prilled urea or a granular product, but nothing of the 1.8 to 2.7 gram size that's needed for deep placement. And this shows you a graphic just simply showing the difference in size. Bangladesh has the capacity to product about 2.3 million tons of this stuff – 2.3 million tons. The factories, the investment costs can easily be almost $1 Billion dollars because it's a heavy chemical

complex. To make these products the machine costs $2,300.00. The capacity of a normal factory is about 2,500 tons per day.

The capacity to produce these particles from one machine is less than 12 tons a day. So order of magnitude it kind of gives you an idea that what we're doing is basically transforming the physical properties from this to this to provide a convenience for the farmer. This is a typical shop for a fertilizer dealer. This is the machine showing him pouring that smaller particle into this hopper. It flows through compression where the larger particles are made and then through this rotating discharge shoot into a bucket where the particles are then put in a bag.

There are a lot of ____ *[sounds like fines]* and a lot of broken product. They fall into this area and they can be recycled. So losses are basically nothing. If you put in a 50 kilo bag you get 50 kilos out – very low losses. Urea is extremely hygroscopic which means it will draw moisture from the atmosphere. It will draw moisture from the ground. So care and handling is really important to get a good quality product. A lot of training goes into helping these dealers make sure that they know how to handle, what to do after you make the product, and how to store it to make sure it doesn't deteriorate.

But to give you an idea, if you take urea and if you put it outside the building and come back this afternoon it will be water because it draws the moisture from the atmosphere. It involves a lot of training. If this product is put on the shelf in a bag the shelf life doesn't have a limit. It could be six months. It could be year and it still retains its integrity. So the key is proper handling and a lot of training goes into that. This is just to give you an idea of some of our end of project indicators.

One that's very important to us is the increased income per farm, which is about $260.00, and also the increase in rice production –in over a 5 year period over three million tons of additional rice. This gives you an idea of some of our promotional activities. We mentioned demonstrations, workshops, some _____ cuts and so forth. These are numbers that – just to give you an idea of the complexity. Farmer training – this is in one season – we'll train 113,000 farmers – 113,000 farmers in one season only.

And all these activities are for one season. The boro season is the dry season in Bangladesh. It's the most productive season. It's the season when the farmers can control and manage the water through irrigation. The incremental yield that we have registered during that year was 619 kilos of rice per hectare. The urea savings is approximately two bags of urea per hectare – 50 kilo bags. Bangladesh heavily subsidizes fertilizer. Right now the subsidy level is about 50 percent, which his pretty significant.

But even at that level the farmers are able to save about $20.00 per hectare. Bangladesh uses about 2.5 to 3 million tons of urea. So the cost to the government from subsidy is huge. And that's one of the reasons that the government is very interested in seeing this technology expand. Food security is there. Increasing farmer incomes is an issue. But reducing the government's expenditure on fertilizer is a huge factor.

This gives you an idea of the growth and the demand cumulative. Right now the area is in excess of 1.3 million hectares under the technology. And the number of users is already exceeding 3.5 million. And the supply growth pretty much mirrors the demand growth because we worked on both concurrently. Right now those little machines that we talked about; there are about 900 of them in operation. This gives an idea about the geographic dispersion. The one thing that we wanted to make sure is that farmers had access.

So by having as widely dispersed entrepreneurs as we can achieve, that give the farmers increased access to the product. These are all independent. There is no relationship between these guys and higher up suppliers of fertilizer other than it's an independent business relationship. This is in the northern part of the country in
Sherpur and Mymensingh area. The number of dealers is much less because we really haven't put as much emphasis on developing the dealers there as we have in the southern part in the Feed the Future zone.

Again, a typical dealer shop. Ventilation is required because these machines are run by either gas which creates a lot of exhaust or they could be electricity. But electricity supply is so sporadic that most are gas powered. You can see the discharge shoot. The farmers will actually bring the urea that they buy into these dealers and pay about $1.00 per bag to have it converted to the bigger product. These machines are stable. They weigh probably about half a ton. Our engineers are working with the people that make them to come up with some features that will allow some mobility – put them on rollers and that kind of thing.

We're also working on some safety issues and some other issues to improve the functioning of the machines. Profitability is important on the supply side – definitely on the demand side, but to give you an idea the total variable cost for operating the machine is about $262.00 a ton. Of that total $250.00 is just for the fertilizer. So to make that conversion it comes to about $12.00 a ton for labor, power, fuel, supplies, and so forth. And the typical selling price is about $275.00. The contribution that's being made for each ton to the fixed cost is $13.00 with the total cost of the machine at about $2,300.00.

And that's the total cost of the machine. Based on our experience in two and a half years it only takes 18 to 24 months for the people that invest in the machine to recovery their full investment cost. And that is really, really good because the machines have a life of seven to eight years. Two years they've recovered their full investment cost. But what we did with the project; knowing that there was no demand when we started and knowing there was high risk we had a phased cost-share program where the project paid 75 percent of the cost in the first year and then it gradually will be phased out.

In year five the dealers will pay 100 percent of cost. From an investment standpoint we mitigated the risk to the entrepreneurs by helping them to reduce their investment cost. We mitigated the risk to the entrepreneurs by helping to build demand, build the market. And we mitigated the risk by training the entrepreneurs so they would be efficient. This gives you an idea of the project achievement. I won't spend any time here other than we are pretty much on target in all aspects of our results indicators.

Here we're also – Considering we're now in our third year we're pretty much on target everywhere. We're a little low on incremental rice production and the increased value of the rice. Of course those are related. We recently conducted a rather extensive survey to identify the factors that we think might be the most critical to adapt those lessons learned to the last two and a half years of the project. And these are the key areas on the demand side and supply side. A lot overlap but the one thing that we are trying to make sure that we don't do is to create undue project dependence.

We want to link these on the supply side. We want to link the entrepreneurs back to the suppliers of the equipment so when repairs are needed the idea is not to come to the project but to come to the local industry that made the machines. We want to link these small entrepreneurs to the Bangladesh Fertilizer Association so there becomes more of a network type relationship. Rather than independent suppliers we would like to see that network develop. And that's really important because of policy related issues impacting who can buy and sell fertilizer.

The more we can show that chain is linked the greater the chance is that the government will not stop the small entrepreneurs from buying urea, making the larger particles, and selling it in the market. And of course for the demand side these factors. By working with the Department of Agricultural Extension we have helped the Department of Ag Extension to strengthen their curriculum. They have adapted in 14 training institutes this technology as a core technology for educating the extension staff.

That's really significant to get the Department of Ag Extension to modify their curriculum to introduce this as part of their core ____ fertility management program.

Ease of application: we brought with us a device that some of our people developed. There's a gentleman that some people here will recognize his name: Ahmshad Chotery. He has taken it and has created molds to make this device which provides ease of application of these particles. I will show you on the next slide this is the device. This funnel holds the larger particles. Gravity flow into this chamber, where there is a chamber here that only lets one particle flow at a time down through this tube.

And through a plunging mechanism with this lever action you can see the placement depth is typically three to four inches in the soil. And you can see a plunger come down. That basically inserts the particle in the soil. We tested it earlier. We didn't have any fertilizer so we used a grape. That's why it's a little sticky. *[Laughter]* That was just to demonstrate it. You can see the farmer. Remember fertilizer, urea, very hygroscopic. He keeps his pasture fertilizer here in a dry hand. You can load enough particles in this to basically go the distance of one row. So he's constantly feeding and walking through the field applying the particles.

We've also developed a push type machine which is still under development. This plunger is about 99 percent accurate in placement. This is about 98 percent accurate. This costs about $7.00 – this plunger type. This costs almost $30.00. So it's like the options we have as consumers you can either go with a smaller device – hand held if you have a smaller plot. For larger plots this is available. It's the same type of mechanism with a chambering mechanism. This is skid mounted. One person can pick it up fairly easily but it's long and cumbersome.

We've modified this. This can be broken down into two sections and it's simply pushed through the field. The next slide will show it moving through the field. It's also quite an interesting device but it's still under development. We're not yet satisfied. This is a priority of the Minister of Agriculture so we're giving it a priority as well. I think that gives you an idea of what we're doing in Bangladesh. Hopefully you'll have an idea of how we make these bigger particles and what we're doing to make sure that getting into the market is not only effective but it will be sustainable.

Now Dr. Singh will talk about the science behind it and some of the research activities that are ongoing.

Upendra: Good morning everyone. Can you all hear me? Good, thanks. As John mentioned I'm going to talk on the technological aspects of deep placement or subsurface application of urea. Recalling what the goal of

the project is one thing that we do have to realize that there are many issues that influence food security including weather, climate variability, degraded soils, and then persistent poverty. We would like to use a technology that can operate under wide range of biophysical as well as socioeconomic conditions.

And during this presentation you see from what John has presented that deep placement is one of those technologies that does allow poor farmers to take advantage of a technology and alleviate themselves and increase their income. We'll look at the other side in terms of how this technology is able to operate under a wide range of climatic variabilities. Here I'm going to show how deep placement works. Basically this chart shows a section of a rice field. There is floodwater. There is a then a layer of oxidized soil and then reduced soil layer.

The majority of the soil under the paddy condition is reduced because of water seeping there and therefore allowing very little oxygen in the soils. As John illustrated the deep placement of fertilizer is done at about seven to ten centimeter depth. This is where your urea briquette is placed. While it does not change the chemistry urea still hydrolyzes. It doesn't matter whether urea is put here or on the surface _____ cost application. Urea will hydrolyze. And during the hydrolyzes process you have urea converting into ammonium and ammonia and also some CO2 is released during that conversion because the urea molecule contains carbon which is released during the hydrolyzes process.

I will not go into all the detailed chemistry but basically the key thing I want to emphasize is the fact that we are about ten centimeters or so inside the reduced layer there is a diffusion process that slows down the diffusion of ammonia from where urea is placed to the floodwater. So we end up with very negligible amounts of nitrogen in the floodwater. Likewise this ammonium and ammonia include _____ such that ammonia is not quickly diffusing out.

If we're applying at the surface with a broadcast application it will be very easily lost to the environment. But the fact that the urea is deep placed means that ammonia is diffusing very slowly or none at all. Ammonia fertilization loss, which is a major loss mechanism for nitrogen in flooded soil, is almost totally reduced with deep placement – with good deep placement. The other component that's of interest is the fact that we will have high concentration of both ammonia that allows good results in some degree of inhibition, which means the enzymes that break down urea is somewhat slowed down.

Under normal conditions urea would be converted to ammonia in about less than five days the total conversion takes place. Here we slow down

that process. The other thing that occurs – the fact that we are in the reduced soil means that ammonium does not get oxidized since there is no oxygen. So you don't form the nitrate. And nitrate is the major culprit in terms of groundwater pollution. Nitrification: also during that process when nitrate is formed we also have N2O and NO forming. And again if nitrate is formed in the field conditions it can be leached.

Or if there is too much water in the field the nitrate can be denitrified which would be the case in the flooded field. But the fact that this reaction doesn't even take place or is slowed down to various factors first that we are in the ____ reduced layer and the high ammonia concentration; all of those explains why deep placement technology performs the way it does. If you look at a comparison of the two methods where we have a split application of urea, conventional, and then the deep placement of urea briquette you can see that almost two-thirds of the nitrogen that's applied through deep placement is captured by the plant in contrast to about a third with the split application.

The soil component has not changed that much. But the key component that is happening here is this four percent loss – about four percent compared to about 35 percent in the split application. And this directly translates to what John mentioned, why there is a nitrogen fertilizer savings. Farmers are applying less urea with the deep placement and still getting yields, and sometimes higher yields than through the split application. I will not go into any more chemistry hopefully. We'll go back and check on a couple of things.

John has already talked about productivity gains, the yield increases, and farmer profits so I will not dwell too much on that. The other component of course of economics is the labor cost involved and I'll discuss that to some extent. Here's an example of another applicator which does two rows at the same time. I'm going to show some results on ___ [sounds like eel or EL] increases. And this was done by the Bangladesh Research Institutions, or done by BRRI which is the Bangladesh Rice Research Institution. BARI is the Bangladesh Agricultural Research Institute. And BINA is the Bangladesh Institution for Nuclear Agriculture.

This is independent research done by their scientists which shows again the benefits of deep placement giving high yield across a different range of applications. This is the result from demonstration plots. I'll take a couple of minutes to explain this graph. If there was no difference between yield from broadcast and through deep placement will be seeing most of our points lying along this one-to-one line. There will be scatter on both sides of this one-to-one line.

But we clearly see in this example that all the points are clearly above the one-to-one line. There isn't any below. That tells us that for all these 315 examples the yields from deep placement are always higher than from the broadcast application. And this intercept here of .9 or close to one ton tells that independent of whether it was low yielding environment or high yielding environment there's roughly one ton higher yield obtained by deep placement – the intercept of .9 and .98.

These are some examples from a deep placement ___ that has been recently done in Sub-Saharan Africa. Again the black box – so the yield with UDP grain with urea broadcast application and incorporation. You can see on average we are getting close to a ton – again increase in yield across the different environments in Sub-Saharan Africa. This is an example from work done in Afghanistan in the USAID USDA project that shows increases again with UDP. In this case urea application was done using the best management practice, in this case the leaf color chart so that urea was only applied when the plant really needed it.

In the conventional tillage you can see there's still advantage of deep placement. When you go to zero tillage particularly for one variety there is a huge advantage with deep placement. And one could understand that in a zero tillage situation if you are applying and broadcasting the urea your urea will be exposed to the surface. It will not be able to penetrate into the soil. So the losses could be high. This technology would also work with zero tillage systems. Gain we can see the adaptability of deep placement technology and a wide range of conditions.

As I mentioned the labor issue – there is labor in terms of requirement for deep placement. But when you look at some of the other benefits that come from deep placement (this is looking at weeds) because the nitrogen is deep placed at ten centimeters or so below the surface, the weeds which have to germinate do not get access to nitrogen because the nitrogen in the floodwater is negligible. There is generally less weed growth in deep placed fields. And as you can see if we look at the median here, the 50 percent dial, the labor cost is almost half that of broadcast application.

So there are some gains also coming to a farmer in the fact that he will not have to spend that much money on weeding with the deep placement technology. Next I'm going to look in terms of gains from deep placement, what's the improved nitrogen efficacy. In this chart we're combining two aspects of deep placement: the yield gains that we talked about and the nitrogen fertilizer savings that John talked about.

Here when we look at the parcel vector productivity, which is grain yield per kilogram of nitrogen applied, we can clearly see that again there is hardly anything on the one-to-one line. Everything is shifted by about

close to 40 kilograms. There is a 40 kilogram extra grain yield produced per kilogram of nitrogen applied using deep placement. And that's a very significant increase in terms of increase in the use efficiency.

Some more examples in terms of improved efficiency with urea briquette we see (and this an example again from some of the work that was done by our colleagues in Sub-Saharan African, particularly West Africa and Madagascar and Rwanda) that the ergonomic use efficiency is again higher with deep placement and so, as expected, is the VCR that you get, the value:cost ratio.

The apparent recoveries of applied fertilizer, meaning that the fertilizer recoveries are much greater in deep placement, you can again see this is an example of the NPK briquette where instead of just deep placing urea this particular briquette also contains phosphorous and potassium. Again you see that the recoveries on average have increased from about 35-40 percent on average of about 70 percent. So much of our applied fertilizer is recovered and as expected there are less losses.

I'm going to take a couple of minutes and talk about the environmental gains with deep placement. And to remind you, again when we talk about deep placement we are talking about placing the (particularly in the flooded condition – rice conditions) fertilizer in the reduced zone of the soil where there is little or no oxygen. And then it is also point placement because we are putting all the urea in a compact tablet or a briquette. Combinations of these conditions result in less loss of nitrogen because we have high concentrations which are acting as inhibition of nitrification and losses are reduced.

So the nitrogen fertilizer savings that we're getting has consequences because to produce one ton or urea, in terms of energy _____ will require four barrels of energy as well as a feed stock. So if we can save on the use of urea by 20 percent then that means there are direct savings also on the production side. And the other thing to note is if you want to convert that in to CO2 equivalence one ton of urea production emits about 980 kilograms of CO2 for the greenhouse gas emission equivalence.

Recapping on our loss we've discussed this and you can see the results. These results have been obtained from several places. Here's one example of when we look at the floodwater nitrogen content. If you look at the data here the floodwater nitrogen content with deep placement is similar to what we have when we didn't apply any fertilizer. So basically there is no leakage of nitrogen into the floodwater whereas when you look at the broadcast application or incorporated application of prilled urea you see there is a high range of floodwater and nitrogen.

And then has consequences in terms of both runoff losses – if the water flows off from the field you will have nitrogen flowing off – nutrients flowing off likewise. The nitrogen that's in the floodwater is also prone to volatilization laws. So you're cutting down both the volatilization laws (as we'll see in the next slide) with deep placement with normal urea application. And then using a very widely-used _____ innovator that's marketed as Agrotain. It's used very widely.

Agrotain does work quite well. It has reduced significantly the volatilization laws. But when you compare that with deep placement you can see that volatilization laws have been almost totally wiped out. There's no loss from volatilization with the deep placed urea. Next I will talk about N2O emissions. On average the numbers are saying that is one percent of applied nitrogen is lost as N2O emission. So not very significant in terms of economics but when we look at the climate side, on the environmental side, we'll find out how important that is.

N2O contribution to global warming was about six percent in 2007. One component that we have to understand is that N2O has a global warming potential if you express in terms of CO2 equivalence of about close to 300 – 298 or so. That one percent that I mentioned – one kilogram and it would be 300 kilogram of N applied is a small number, but when you multiple that by 300 that's a 300 kilogram C02 equivalent. In terms of the total N2O emission agriculture comes from 10-27 percent. This wide range again tells us that we having a lot of guestimates and estimates and back of envelope calculations in terms of coming up with what the actual emissions are.

If you look at the anthropogenic N2O emissions (man-made) and you see that agriculture contributes to about close to 80-85 percent of anthropogenic emission comes from agricultural sources. The other side of the N2O story is that N2O also reacts with ozone in the ozonosphere. It destroys the ozone. When you look at its impact following the Montreal Protocol the use of ozone destroying substances have been markedly reduced. If you look at the CFC's compared to 1987 to 2008 there's been drastic reduction.

With that now N2O has become the largest threat to destruction of the ozone layer. That also tells the importance of why we need to quantify the N2O emission. I will not go into the details here but this is some work that we have already started, also with the USAID and climate and initiative funding we've started a project that will begin in May of this year in Bangladesh to quantify the N2O emissions. But very briefly this is a continuous system that will measure the N2O emissions throughout the growing season, not only when the rice is growing but also during the pre-plant and the post-harvest periods.

This is just a snapshot of some of the measurement that we have taken. One thing that you can clearly see is that the emissions were higher during the pre-flooding stages. Once the field was flooded we didn't see that much emission. There was a bit more for urea compared to deep placement. The pre-plant dominated. And this is for nitrous oxide emission, NO. During the cropping season there was definitely much lower emissions from UDP compared to crop cost urea, and likewise you see the similar trend for N2O emissions.

Pre-plant, pre-flooding stages, more emissions, and then after flooding less but still more for urea application than deep placement. And the last part that I will talk about will be looking at the long-term effect of UDP. How had it affected soil health? From this slide you can see this is the broadcast field and this is the deep placed field. You can see a lot more algae growing here. And yet I mentioned that there is less floodwater nitrogen in the UDP plots. So what we have here is mostly blue-green algae which is the nitrogen fixing algae.

While growing here they're also fixing additional nitrogen from the atmosphere. So that provides additional source for nitrogen whether it's taken up by the plant or it builds up in the soil. It is a component that we still have to quantify. The other thing that I mentioned was that urea, when it hydrolyzes it not just releases ammonium but it also releases CO2. On _____ *[sounds like seffer or seffner]* supplied CO2 you would expect a whole lot of that to be diffused out into the atmosphere.

But when it's deep placed the CO2 emission or diffusion from the soil will be slowed down but also allow opportunity to capture that CO2 as well. That is the other aspect that we would like to quantify at some point. Going back to a long-term effect these were field where farmers had been applying deep placement for more than ten years. And the neighboring fields where the normal conventional application of urea was done. We see that the organic matter content had increased by more than a ten in the top ten centimeters.

Just as a rule of thumb a one percent increase in organic matter is equivalent to ten ___ _____ of organic matter increase. Similar results for nitrogen changes in the soil. In summarizing the deep placement results I'm going to quickly go through and say that we've talked about the significant reduction in losses. There have been improved rice grain yield, high yields, and similar types of range for yield has also been recorded for our plain crops. There is generally less nitrogen fertilizers used anywhere from 25-40 less nitrogen.

In terms of efficiency there is up to 50 kilogram additional rice grain per kilogram of nitrogen applied with deep placement. We have a significantly higher recovery if you're looking at the NPK briquette or phosphorous also. And looking at the soil organic matter build up we have increased carbon sequestration. The explanations for that could come from the fact that we are producing higher yields, higher biomass, and naturally we should also have higher root biomass with the UDP plots.

And also the fact that there is undergrowth – more undergrowth in the UDP plot. All of this could combine to help sequester more carbon. From the preliminary results that we have obtained we see that there is much more – much of N2 and NO emission during the pre-plant stages compared to the actual rice growing periods. So this has implications in terms of how management of N2 and NO in rice based cropping systems. But when you compare the two sources: UDP versus urea broadcast incorporation there is still significantly lower emissions from UDP.

And finally we talked about the weeding impact. So this has implications for the clean development mechanisms, first in terms of fertilizer savings, reduced N2O and OX emissions, and increased CO2 fixation. This is my last slide. When we apply urea – I'm not talking about the urea production side this time – to the field with the current practices – not deep placement but current practices – you lose about – There are 100 kgs of CO2 equivalent of greenhouse gas emission taking place per ton of rice that's produced.

Some of that is from CO2. Others are from N2O emissions. That's what our current situation is. And we believe this number can be significantly reduced with the deep placement technology. In terms of what we'd like to do for our future research (and this has already started I mentioned) is to have a better estimation of N2O emissions so that this information can be used for carbon development for clean development mechanisms or for carbon credits. We'd also like to quantify CO2 capture from deep placed urea briquette and get a better estimate of how much more CO2 is fixed when you deep place urea than broadcast application.

The fact that we are increasing the soil carbon, etc., we need to quantify that and also perhaps revise recommendations for the future and then look at increase options for applicators. We looked at the very simple one. That may be appropriate for Bangladesh but when you go to other countries where labor is still a major constraint, where farmers are shifting to transplanting rice using mechanized translators who like to incorporate the deep placement technologies – the plungers here – so that as the rice is transplanted, at the same time deep placement also takes place.

That's all I have. Thank you very much. *[Applause]*