NAFAKA Project – Tanzania

STTA Report

Consultancy Report on Urea Deep Placement Technology

Venue: Morogoro, Tanzania

Period: 10-20 June 2012

Prepared by Dr. B. FOFANA

Regional Coordinator Urea Deep Placement

IFDC North and West Africa Division

June 2012

List of Acronyms

CRS	Catholic Relief Services
IFDC	International Fertilizer Development Center
IFDC-ESAFD	International Fertilizer Development Center East and Southern Africa Division
IFDC NWAFD	International Fertilizer Development Center North and West Africa Division
FDP	Fertilizer Deep Placement
FIPs	Farm Input Promotions-Africa
ISFM	Integrated Soil Fertility Management
KATRIN	Kilombero Agricultural Training and Research Institute
PU	Prilled Urea
SRI	System for Rice Intensification
STTA	Short-Term Technical Assistance and Training
ToT	Training of Trainers
UDP	Urea Deep Placement
USAID	United States Agency for International Development
USG	Urea Supergranules
VBAA	Train Village Based Agriculture Advisors

Introduction

The dominant nitrogen fertilizer used in rice production is urea. With a plant nutrient content of 46% nitrogen, urea fertilizer has the highest nitrogen content of all solid fertilizer products. The typical method of urea application in rice cultivation is to hand broadcast the fertilizer (i.e., surface application). This process of surface application of urea is the major contributor to the extremely low (i.e., 35%) efficiency factor in crop uptake of applied nitrogen. Ammonia volatilization, denitrification, and runoff are the three main nitrogen loss mechanisms when urea is surface applied to flooded rice.

IFDC has been engaged in research to improve efficiency of urea for rice production. One product that has emerged from the IFDC research and development program is a simple and low cost technology that is extremely well suited to small-scale rice production. The technology is comprised of urea supergranules (USG) and urea deep placement (UDP) application. It involves an approach to managing urea in flooded rice systems based on the deep placement of USG into puddled soil shortly after transplanting rice. Within 1-2 days after transplanting rice, the USG are inserted into the puddled soil by hand and placed to a depth of 7–10 cm in the middle of alternating squares of four hills of rice. UDP improves N use efficiency by keeping most of the urea N in the soil close to rice roots and out of the floodwater, where it is more susceptible to loss as gaseous compounds or runoff.

This assignment is a follow up of the previous one that has been executed on request of NAFAKA ACDI-VOCA in mid-January, 2012. The main purpose was to organize and conduct a training of trainers (ToT) program on Urea Deep Placement (UDP) for national experts and staff directly involved in NAFAKA's implementation in Morogoro. The expected output was to strengthen national expertise in UDP fundamentals and elaborate a strategic action plan for its deployment in Tanzania focusing on NAFAKA's target districts including Kilombero, Mvomero, Kiteto and Kongwa.

UDP has been deployed in Tanzania in the aforementioned target districts. The main objective of this second Consultancy Work was: *(i)* to gauge the progress being made in its deployment in Tanzania; and *(ii)* in collaboration with involved public and private partners and various training centers, to develop a follow-up strategic work plan for its sustainable expansion, addressing both demand and supply.

The expected net result is the development of strategic public-private partnerships in order to raise awareness of UDP existence and its performance to stimulate its demand while improving participating farmers access to quality inputs (particularly USG) and their timely availability.

Scope of Work

The scope of work specifically focused on the following activities:

- Visit to demo plots in Morogoro Region and evaluate the field performance of UDP.
- Follow up on recent results and progress and develop strategic public-private partnerships for UDP site expansion.
- Train NAFAKA staff in the use of UDP in crops other than irrigated rice.
- Train Village Based Agriculture Advisors (VBAA) and government extension workers in the use and benefit of UDP in Kilombero, Mvomero, Kongwa and Kiteto districts.
- In collaboration with the NAFAKA team and local input suppliers, develop a plan for UDP manufacturing in Tanzania.
- Review data from past season and formulate recommendations for future activities.
- Develop local UDP training materials.
- Introduce UDP use and benefits to Sokoine University of Agriculture and Kilombero Agricultural Training and Research Institute (KATRIN).
- Meet with YARA-Tanzania Limited and NAFAKA to explore the possibilities of a joint effort in developing a grassroots network for UDP production and distribution in Morogoro.

Description of the Activities Conducted

The Scope of Work (SoW) was jointly developed with Mme. Mary Nyaoso, Project Coordinator, IFDC. Subject matter for the program was determined after discussions with Mr. Mzee Filbert (IFDC's Seed Specialist) and Mr. Martin Mason, Deputy Chief of Party for the NAFAKA Staple Value Chain activity in Morogoro (Appendix I).

Visit to Dakawa Irrigation scheme

We visited Dakawa irrigation scheme where UDP demonstration is being conducted in collaboration with the Uwawakuda Water Users' Cooperative.

Dakawa irrigation scheme is a model farm that was established with the support of the NAFAKA Feed the Future Initiative with the assistance of USAID. The model farm is a training

site designed to increase productivity, competitiveness and incomes of smallholder rice producers in Dakawa. The Uwawakuda Water Users' Cooperative, which represents 954 of these rice producers, is responsible for managing water flow to member farms. The Dakawa Irrigation Scheme supports over 2,000 small holder rice farmers and their families. YARA-Tanzania is testing its newly released compound fertilizers at the model farm (YaraMila, YaraMira Nitrabor) and others single fertilizers (Figure 1 D).

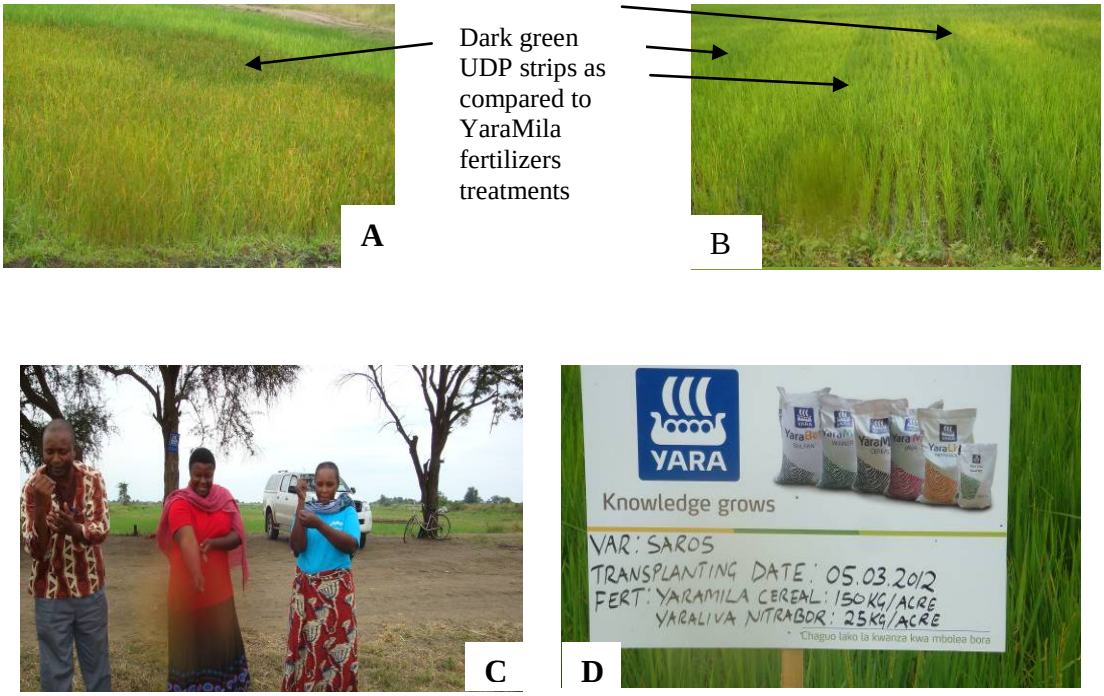


Figure 1: Field Demos and UDP-Practitioners at Dakawa Irrigation Scheme, June 2012.

UDP demos are being conducted by 100 lead farmers out of the 954 members of Uwawakuda Water User's Cooperative. The on-going field demo plots compare yield performance of irrigated rice using YaraMila compound fertilizers broadcast applied at 250 kg ha^{-1} with UDP (2.7 g USG) at 175 kg N ha^{-1}). Madams Chetu KOROGO and Nuru MBONGA are rice farmers actively participating in the UDP demos (Figure 1 C). They are very impressed seeing the dark green color of UDP strips lasting longer than those of YaraMila treatments (Figure A, B), and already well- acquainted with different USG spacing methods (≈ 40 cm apart) between rice rows (Figure 1 C). According to the rice farmers, it is likely that UDP strips will perform better than the

YaraMila treatments. Yield-monitoring is on-going and will confirm whether UDP outperforms YaraMila treatments or not.

Visit to Kilombero Agricultural Training and Research Institute (KATRIN)

Courtesy Visit to KATRIN

We were received by Mr. Joshua Mganga Kitilu, the agronomist in charge of overseeing on-station research activities of the center. KATRIN is a government institute located in Ifakara (Kilombero District). It operates under the department for Research and Development of the Ministry of Agriculture Food Security and Cooperatives. Most of KATRIN Research infrastructure and facilities are under renovation. It is mandated to *(i)* co-ordinate rice research activities, *(ii)* implement research on various crops with particular focus on rice, *(iii)* conduct training to farmers and extension officers, and provide extension services.

In 2008, KATRIN was chosen to be the headquarters of the Regional Rice Center of Excellence of the Eastern Africa Agricultural Productivity Program. This program is financed by the World Bank on loan basis under the agreement signed between the Government of Tanzania and the World Bank. The program was officially inaugurated in April 2010.

Visit to the KATRIN Research Station in Ifakara

The station we visited has about 1600 ha of land, of which 150 ha is used for research activities. Lumemo river which is bordering the station is permanent and potential for irrigation. For the past twelve years, KATRIN research activities have mainly concentrated on Rice and Spices. Rice research activities are focused on improving varieties with best response to production attributes and more specifically on selecting breeding lines resistant to rice yellow mottle virus (RYMV) to meet farmers' priorities. Activities being conducted are among others as follows:

- ✓ Development of blast resistant rice genotypes in East Africa
- ✓ Promotion of NERICA varieties to increase rice production and productivity of rice in Tanzania and Kenya
- ✓ Seed multiplication for recently five released upland rice varieties including NERICA1 to 7 and TXD 306, 88 and 85
- ✓ Germplasm collection and maintenance
- ✓ Evaluation of Green Super Rice

- ✓ Production and blast evaluation of upland and lowland NERICA varieties in collaboration with Africa Rice Center

Major Research Partner Institutions involved in Rice Research in Tanzania include among others JICA, IRRI, Africa Rice Center, ARI-Dakawa, Sokoine University of Agriculture in Morogoro.

Visit to Kilombero Plantation Limited (KPL) and Conducting Training of Trainers in UDP

KPL is the Tanzania subsidiary developing about 6000 ha Mngeta farm situated in the fertile Kilombero river valley, one of the best agro-eco zones for rice farming in East Africa. It aims at developing model sustainable agribusiness in Tanzania through the introduction of both modern and commercial agriculture and innovative smallholder technology to achieve food security. KPL is funded by Norwegian Investment Fund for Developing Countries (NorFund), Capricorn and African Agricultural Capital. It has introduced the System for Rice Intensification (SRI) to about 250 farmer families in impoverished villages near the farm that rely on rice for their annual income.

Highlights of the Training Program in KLP Compound in MNGETA

Training materials elaborated are comprised of 11 modules and 13 PowerPoint presentations, embracing the above-mentioned topics (Appendix II). The program concentrated on *(i)* scientific principles governing the combined management of urea and water management, *(ii)* understanding of UDP-fundamentals and its agronomic and economic benefits, *(iii)* UDP success stories in West Africa *(iv)* and case studies of the applicability of UDP to other ecologies (rainfed lowland and upland) and crops (maize, tomato and banana). Field training sessions were also conducted to expose participants to the application techniques for urea briquettes, specifically their geometric hand placement in line and random transplanting methods

Attendance and Training Program

Seventeen participants from different ACDI/VOCA consortium member organizations (IFDC, CRS and FIPs-Africa) and KPL attended the program. Details of the participants in attached in Appendix III. The training program was jointly elaborated with Mr. Mzee Filbert. The objective was to train Village Based Agriculture Advisors (VBAA), KPL and government extension workers in the use and benefit of UDP in Kilombero district. A detail of the attendance is attached in Appendix III.

Soil Pit Profiling and Field Visit

On our way back from Mngeta to Ifakara, we spent some time visiting demos that compare rice performance using YaraMila compound fertilizers broadcast applied at 250 kg ha^{-1} with UDP (2.7 g USG – 175 kg N ha^{-1}). Again, it is likely that UDP plots perform better than the YaraMila treatments. Yield-monitoring is on-going and will confirm whether UDP outperforms YaraMila treatments or not.

We also visited a farm family nearby the road. The piece of land was a narrow swamp and only about 0.25 ha area under maize and cassava mixed cropping (Figure 1). Most of the soils in Kilombero District are developed in alluvial deposits along the Kilombero River and have *fluvic* soil properties (*Fluvisols*). I dug a pit on the upper slope position and observed a likely Ah-horizon which was dark in color (0-30cm) with organic matter (6%) deriving from fresh sediments during regular floods of Kilombero River (Figure 2). This layer had a sandy loam to clayey texture and lot of fine structured organic matter. At 30-50 cm depth there was a C horizon which was a yellow/reddish very distinct layer with a sandy texture (about 90% sand). Where the vegetation has been cleared the topsoil is lost, exposing the subsoil, there is a greater risk of runoff and erosion. Most of these soils mainly show N and P deficiencies (Table 1).

Figure 2: Photos Showing the Color and Physical Properties of Upper and Lower Layers of Cultivated Soils (*Fluvisols*) in Mngeta Tanzania, June 2012

Despite their low nutrient status, they are suitable for the cultivation of trees in the steep hill slops, and arable crops (rice, maize and vegetables) in the bottomlands. UDP is well appropriate for this soil types but needs to be combined with basal application of compound fertilizers in combination with soil amendments using liming or Minjingu Rock Phosphate (easily soluble on acidic soils of Kilombero District) to raise the pH to between 5.5 and 6.0 and prevent potential Al toxicity.

Table 1: Chemical and Physical Properties of Cultivated Fluvisols in Mngeta Village (B. H. J. Massawe and N. A. Amuri, 2012)

Village name:	Mngeta	
Latitude	-8.35130	
Longitude	36.13032	
Soil texture	Sandy Clay Loam	
Parameter	**values**	**Interpretation**
pH(water)	4.9	very Acidic
Ec (mS/cm)	0.08	salt free
CEC (cmol(+)/kg)	37	high
Organic carbon (%)	6.25	very High
Total nitrogen (%)	0.51	high
Nitrate N (ppm)	56.00	low

Meeting with Pr. Semoka M.R. Johnson, Sokoine University of Agriculture, Department of Soil Science

We met Pr. Semoka to discuss about UDP deployment in Tanzania using student training program to develop science-based strategies for its dissemination. The Sokoine University of Agriculture is the only and well-renowned agricultural university in Tanzania. It has the nationwide mandate of training, conducting research in agriculture and related fields and disseminating technologies. Particular emphasis is put on scaling up the adoption of suitable fertilizer technologies by farmers and establishing a basis for updating the integrated soil fertility management (ISFM) technologies.

Having participated in many IFDC's training programs, Pr. Semoka knows well IFDC and is well-informed about UDP Technology and its performance. He expressed the strong willingness of the University to support UDP deployment in Tanzania in collaboration with NAFAKA and IFDC. Sokoine University will play a critical role in adapting UDP to local agricultural practices and agro ecological conditions in Tanzania. Students and graduates will therefore be deployed to conduct adaptive research trials and demonstration plots in the public and private training centers. In addition to UDP, the University is keen to promote the overall efficient use of other fertilizers in Tanzania using ISFM.

Meeting with YARA-Tanzania Limited and ACDI-OCA NAFAKA-Project at the Main Office in Dar Es Salam

YARA-Tanzania Limited closely collaborates with NAFAKA to facilitate fertilizer supply and use in NAFAKA target districts. Main objective of the meeting was to get YARA-Tanzania Limited and NAFAKA staffs well-acquainted with the UDP fundamentals and highlight its agro economic performance, and the profitability of USG business. The participants included the Regional Director (Mr. Paul), the Commercial Manager Mr. Julien Camaléonte of YARA-Tanzania-Limited, the NAFAKA-COP Mr Lee and the Access to Finance Specialist (Mr. Silas).

The Powerpoint presentation specifically addressed the UDP-fundamentals and the soil and plant factors that make its use more beneficial and attractive to farmers and entrepreneurs. Emphasis was also put on the overall potential of UDP and fertilizer deep placement (FDP) and their use on other crops than the classical irrigated rice (maize, vegetables and other various high-value and commercial crops) in different ecologies (rainfed lowland and upland).

YARA-Tanzania was particularly interested to know more about the potential of deep placement technology in terms of its extension to other YARA single and compound fertilizers - Fertilizer Deep Placement (FDP), various high-value commercial crops under lowland and upland conditions, and to which extent the conversion of PU into briquettes could be industrialized. The Regional Director of YARA-Tanzania underlined the current system of USG provision which is community-based and limited in area (demo sites) and the small scale UDP deployment in Tanzania at least for the time being. And all these are not yet conducive to the development of fertilizer briquetting industry in East Africa. To make UDP/FDP more commercial and attractive to the fertilizer industry, immense effort needs to be made on the demand side through mechanizing USG application methods and the extending UDP/FDP use to various high-value and industrial crops.

Despite the fact that UDP deployment in Tanzania is in its incubating period, the Regional Director clearly expressed YARA's willingness in collaboration with NAFAKA and IFDC to jointly support its deployment together with the PU-briquetting business in Tanzania. The collaboration will consist of a joint production of USG as to avoid any shortage in the course of the participatory demonstration and the projected large-scale dissemination of UDP in Tanzania. To this end, NAFAKA intends to purchase a briquetting machine while YARA-Tanzania will be hosting and taking care of its maintenance and use for production and distribution of USG. In collaboration with NAFAKA and IFDC, YARA is willing to give fertilizer subsidies up to 10 tons urea/year and

other fertilizers (CAN, YaraMila etc.) for demos, and eventually sponsor students for monitoring fertilizer deep placement trials in selected areas showing great potential for profitable fertilizer use.

Being aware of the effort made by IFDC to promote UDP in East- Africa, the Commercial Manager of YARA Mr. Julien Camaléonte is proposing to harmonize and extend the collaboration perspectives into East African countries (particularly Rwanda and Burundi) where UDP deployment is well-advanced.

Development of a Business Plan for the Briquetting Machine

On request of NAFAKA-Project, a UDP brochure was elaborated to guide USG dealers willing to invest funds in briquetting machines. It contains technical information on the manufacturing process including the safe operation and maintenance of the briquetting machine. It also provides USG dealers with information about the profitability of USG business and factors influencing crop performance under UDP. This is expected to build USG-entrepreneurs' capacity to know better the product and advise farmers on its proper use. The details are in Appendix IV

Participants' Evaluation of the Training Program

All participants opined that their expectations were met and most of the UDP-related subjects were clearly treated and discussed. Out of the 16 participants, 9 rated the training as excellent, 5 as very good, and 2 as good.

Recommendations

Public & Private Partnerships to Promote a Sustainable UDP/FDP Site Expansion in Tanzania

- There is a growing need to develop a step-down training scheme in close collaboration with KATRIN and KPL as to get more farmers and field officers well-acquainted with UDP fundamentals and use. Both village based Agricultural research (KATRIN) and extension (KPL) centers should serve as training centers for future specialists in improved fertilizer technologies including UDP/FDP and other related topics. The net expected result of this institutional arrangement is to facilitate the emergence of a training network at grassroots level that could contribute to improving knowledge sharing and exchange among partner institutions, increasing awareness-creation, resulting in an extensive demand for UDP within Morogoro region and beyond.

- In collaboration with Sokoine University, IFDC and NAFAKA will conduct adaptive research to jointly develop UDP - technologies for diverse commodities under different growing regions in Tanzania by *(i)* establishing for each district-growing environment (soil type, water management etc.) the variety with highest yield under UDP and *(ii)* assessing through a series of trials and agroeconomic surveys in selected pilot-districts how cultural practices and socioeconomic conditions may affect acceptance of UDP and consider, how they could be modified to facilitate adoption

- Rice farmers in Dakawa irrigation scheme and NAFAKA staffs expressed their satisfaction with UDP performance. Hence, the potential demand for USG will steadily increase. The challenge in the near future is to locally develop an input marketing strategy that will stimulate a distribution system of USG with a strong involvement of the private sector. YARA-Tanzania Limited in partnership with NAFAKA, KPL and IFDC is already giving fertilizer subsidies to illustrate crop response to various fertilizers using demos, and train farmers and extension agents in the efficient methods of fertilizer use. This public and private partnership with YARA-Tanzania should be strengthen in order to stimulate the emergence of a USG distribution system at grassroots level while fostering incentive for UDP use and adoption.

- For widespread acceptance of UDP, research should also be conducted to develop ways to reduce the high labor cost related to the deep placement of urea. Hand placement of USG is likely to be acceptable only where labor costs are low and/or individual farm size is small (≤ 1 ha). One way to reduce substantially labor costs is the development of an efficient low-cost applicator for manual placement of urea briquettes

- Organizing a study tour to expose Tanzanian experts from partner organizations (NAFAKA, KPL, KATRIN, Sokoine University etc.) to UDP and ISFM promotion in West Africa will be useful for improving technical knowledge of local experts and NAFAKA staffs, and beneficial to the overall UDP deployment in Tanzania.

Partner Role in Designing and Implementing UDP/FDP Expansion Strategy in Tanzania

The expansion strategy will require two approaches addressing both the demand and supply side issues.

Demand Side

The participatory demonstration and the adaptive research will focus on assessing the potential productivity gains and the profitability of the technology, and on finding alternatives to overcome biotic and socio economic constraints to the site expansion of UDP Technology

IFDC' role will be instrumental in strengthening the local expertise in UDP and ISFM fundamentals. Thus, there is an evident need to embark on an academic training and applied research program in collaboration with Sokoine University in Morogoro and KATRIN in Ifakara as to adapt UDP/FDP to diverse soil, water and plant management methods in the rice-growing areas of Morogoro.

NAFAKA project with assistance of its agricultural productivity program will play a critical role in the development of a well-thought step-down training scheme involving field officers from different partner institutions and programs including KPL, KATRIN and other public training centers in charge of strengthening technical capacities of national field officers and nationwide extension services. NAFAKA productivity program in collaboration with KPL will therefore appoint field officers to coordinate and monitor an extensive demonstration program of UDP and

ISFM Technologies to illustrate various crops' response (including irrigated and lowland rice and maize) to UDP - in combination with other nutrient sources- both organic and inorganic (ISFM).

The above-mentioned partnership building is very crucial for the participatory demonstration, the awareness raising and the large-scale expansion of UDP. And by doing so, the public sector stimulates the demand for USG and briquetting machines, creating an enabling environment for the private sector to invest in the USG business which is favorable to rural employment.

Supply Side

On the supply side, meeting the increasing demand for USG requires the development of a progressive and dynamic USG supply and distribution systems at community level, involving many actors from the private sector including empowered Farmers' Cooperatives, YARA-Tanzania Limited and other input dealers and retailers active in the pilot-districts. The current system of USG provision is limited in area (trial sites), scope (equipment for processing PU into granules) and time (trial period). NAFAKA and IFDC should contractually partner with the private sector to provide the necessary and quality inputs (seeds, pesticides, USG, compound and single fertilizers etc.) and equipments along with the technical backstopping to the participating UDP-farmers.

The private sector is to play a crucial role in meeting the increasing demand for USG and required equipments spurred by the awareness-raising and demonstration activities conducted by the public sector.

Conclusion

Preliminary results are similar to those in the West African UDP target countries and are likely to show lowland rice performing better with UDP than the conventional broadcast application methods. Fertilizer Placement Technology fits well into small-scale rice farming systems of Morogoro as it saves fertilizers while increasing crop productivity. Both, total crop area under UDP and demand for USG will steadily increase in the near future.

To stimulate the demand for UDP, NAFAKA project should develop a well-thought step-down training scheme and an extensive demonstration program using field officers from KPL, KATRIN and other public rural training centers. IFDC will develop a training program to technically backstop and support the site expansion process through strengthening local expertise and adapting UDP and ISFM options to the local agricultural practices.

The private sector, particularly YARA-Tanzania Limited and other input dealers and retailers active in the pilot-districts, will play a crucial role in developing an input supply and distribution systems at grassroots level in order to meet the expected growing demand for USG and required equipment in the course of the site expansion.

Implementing the proposed strategic public-private partnerships will be instrumental in paving the way for both a sustainable site expansion of UDP together with a client-oriented and dynamic input supply and distribution system at grassroots level. These will improve the fertilizer use efficiency; bolster up fertilizer consumption while increasing crop productivity and food security in Morogoro and beyond.

Appendix I

Itinerary From 11th June to 20th June 2012

Date	Location	Activity	Stakeholders to meet	Remarks
11th June 2012	Morogoro	Arrival of Dr.Fofana		
12th June 2012	Dakawa-Morogoro-Ifakara	Visit demo plot where UDP was used. Business plan	Farmers in Model farm and other farms Silas	
13th June 2012	Ifakara-Kpl	Katrin research and District agriculture office.	Researchers, Extension officers	
14th June 2012	KPL	KPL training of extension staffs. Visit UDP Demo plot.	Farmers and KPL Extension staffs.	
15th June 2012	Mlimba-Ifakara	Train on the UDP Mlimba staff	Mlimba staff training	
16th June 2012	Ifakara-Morogoro	Travel		
17th June 2012	Morogoro	Report Business plan		
18th June 2012	Morogoro	Sokoine University of Agriculture –Soil science introduction on use of UDP. Report	Soil scientist Sokoine University of Agriculture.	
19th June 2012	Morogoro-Dar.	UDP supply.	YARA Dar Es Salam with Silas	
20th June 2012	Dar-Nairobi.			

Appendix II

List of Training Modules Prepared and Presented

1. Balanced Fertilization for Sustainable Use of Plant Nutrients
2. Benefits of Deep Placement of Urea Supergranules
3. Conditions That Make Urea Deep Placement Highly Beneficial
4. Factors Affecting the Agronomic Efficiency of Urea Deep Placement Technology
5. USG: A Handbook For Entrepreneurs
6. More Rice With Improved Nitrogen Efficiency
7. Myths and Facts on Urea Deep Placement Technology (UDP)
8. Estimating Application Rate of Urea N and other Compound Fertilizers
9. Converted into Fertilizer Briquettes
10. Trainers Training Manual and Exercises
11. Potentiality of Using Applicators, Advantages and Challenges

List of PowerPoint Presentations Prepared and Presented

1. Importance of Balanced Fertilizer for Better and Sustainable Soil and Crop Performance
2. UDP Technology: what is UDP and how to do it? (Technology Video Show [Hand Placement and Briquetting])
3. Conditions that Make UDP Highly Beneficial: Selection of Appropriate Sites and Pilot-Farmer Groups
4. Experience in West Africa: UDP Initiative Program, Results of Demonstrations Trials and Farmers Reactions
5. Video Show (Hope for Food Self-Sufficiency in West Africa)
6. Benefit of Using UDP, Its Advances to Farmers, Dealers, Government and Industries
7. UDP Applied to Other Crops and Ecologies

8. Calculation of Application Rate of Urea N and other Compound Fertilizers (N, P and K) Converted into Briquettes

9. Myths and Facts on Urea Deep Placement
10. Video Show: Advantages of UDP, Geometry of Deep Placement of Urea Supergranules (USG)
11. Potentiality of Using Applicators, Advantages and Challenges
12. Different Major Parts of Briquetting Machine and Engine/Motor Maintenance
13. Trainers Training Manual and Exercises

Appendix III

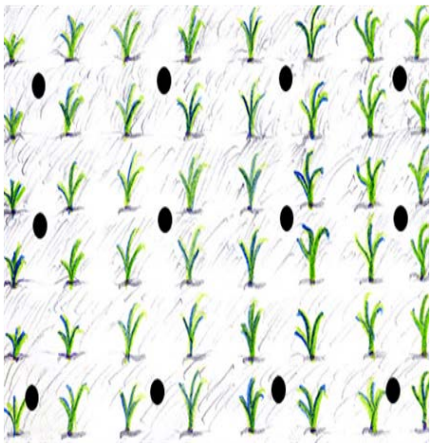
UDP Training Participants List

Morogoro, Mngeta at KLP Compound, Tanzania, June 10-20, 2012

Name		Function	Organization
1	Faphari S. Kasuhura	Agronomist	NAFAKA
2	Flora F. Mbala	Assistant Development Officer	NAFAKA
3	Deogratius Cosmus	Agronomist	NAFAKA
4	Filbert Mzee	NAFAKA Seed Specialist	NAFAKA
5	Salim Sarai	Agronomist	NAFAKA
6	Robert Kuuyo	Extension Officer	KPL
7	David Josich	Extension Officer	jtindwa@nafaka-tz.org +255 786 403 568
8	Stanley S. Kalalasy	Extension Officer	KPL SRI
9	David Lukindo	Human Resources Manager	KPL
10	Ibrahim John	Extension Officer	NAFAKA- SRI
11	Remidius Ruhinduka	UDSM	Assistant lecturer
12	Hüken Eggert	University of Gottenburg	Assistant Professor
13	Datius K. Domissian	Agronomist	NAFAKA
14	Angel A. Livipa	Farmer	NAFAKA
15	Anthony Mavere	Agronomist	NAFAKA
16	Raphaela Chenolo	Farmer	NAFAKA
17	Murray Dempsey	Crop Production Manager	KPL

Appendix IV

Urea Deep Placement (UDP): Guide Lines for Entrepreneurs



June 2012

Prepared and Presented by
Bidjokazo FOFANA (PhD)
Regional Coordinator - Urea Deep Placement
IFDC-North and West Africa Division
Bamako/MALI

Introduction

Rice is the staple food for many Africans and constitutes a major part of the diet for many others. In Africa, it is the fastest-rising food source; even though production in Africa has been increasing at a rate of 6.0 percent per annum, this has been inadequate to keep up with rising demand. And this increased demand for rice plays a major role in the strategic food security planning policies of many African countries. Africa has large gaps between potential and actual rice yields, much avoidable yield losses and huge scope for improved nutrient and crop management technologies that could lead to increasing locally rice production and productivity.

The main constraint to achieving high rice productivity in Africa is the increased deficiency and the inefficient management of major nutrients and particularly nitrogen (N). Urea Deep Placement (UDP) is proven to significantly increase rice productivity while improving nutrient, and particularly N, use efficiency. It is a low cost technology, well suited to small - scale rice production. The technology is comprised of production of urea supergranules (USG), compacted prilled urea (PU), and hand placement of USG in the puddled soil between each set of four hills of rice at a depth of 7-10 cm seven day after transplanting. It's a single basal deep placement of USG that matches more favorably the N requirement of the plant throughout the duration cycle.

In 2009, IFDC initiated a UDP program in Africa aiming at increasing crop productivity, improving food security and alleviating poverty among small-scale rice producers. The target countries include Burkina Faso, Madagascar, Mali, Niger, Nigeria, Senegal and Togo in West Africa, and Madagascar and Rwanda in East Africa. The UDP Initiative Program is expected to significantly increase rice yield and net income for African farmers while reducing the need for costly imported fertilizers and rice. Small-farm-level demonstration of UDP was therefore undertaken to introduce UDP into the target above-mentioned African countries. The objective was to raise awareness of its existence, use and profitability, and develop a sustainable supply chain for urea Supergranules (USG) and required equipments.

This brochure will guide USG dealers willing to invest funds in the briquetting machines. It contains technical information on the manufacturing process of USG, including the safe operation and maintenance of the machine. It also provides USG dealers with information about the profitability of USG business and the environmental factors influencing crop response to UDP. This is expected to build USG-entrepreneurs' capacity to know better the product and advise farmers on its proper use.

Improving Nitrogen Efficiency in Rice Production

Nitrogen (N) is one of the three primary nutrients required in crop production. Urea fertilizer contains 46% N and is the most concentrated source of nitrogen available in a solid fertilizer. Nitrogen is considered quite mobile once the fertilizer particle is dissolved. In flooded rice cultivation, N mobility allows for up to two-thirds of the applied N to be “lost” and “unavailable” to the plant. Incorporating the urea in the soil is the key to minimizing N losses.

Urea deep placement (UDP) is a method of fertilizer application that substantially increases nitrogen uptake efficiency in rice. As a result of placement of fertilizer near the root zone of the plant, N losses that occur from surface-applied (broadcast) methods are substantially reduced and the efficiency of N fertilizer increases more than 100% over broadcast urea application.

Urea Deep Placement (UDP) Technology

Urea Supergranules (USG) - The Product and its Use

USG is a modified urea fertilizer product. It contains 46% nitrogen. That is the same nitrogen content contained in conventional urea fertilizer. The only difference between USG and conventional urea fertilizer is the particle size. The particle size for recommended USG varies depending upon the inherent soil fertility status, the recommended fertilizer N rate, cropping season and rice crop under cultivation.

USG ranges in size from 1.8 grams (g) to 2.7 g in weight with about 1 to 2 mm diameter. It is developed specifically for deep placement in irrigated rice production, but is also used for other crops rather than the classical irrigated rice including lowland rice, irrigated maize and vegetables. Each USG briquette is inserted 7–10 cm below the soil surface, near the root zone 7 to 10 days following seedling transplanting. One USG particle contains enough nitrogen needed for four hills of rice plants. But its efficiency is partly a function of duration cycle of crop varieties and its response to fertilizers, and soil physical and chemical properties. Short duration cycle varieties and clayey soils are critical for the efficiency of UDP. For best results, the USG should be applied within 7 days following seedling transplantation.

The application of USG through deep placement reduces nitrogen losses as it is placed close to the crop rooting zone, yield increases from 20% to 50% can be attained due to efficient uptake of

nitrogen by the crop. This phenomenon represents a clear “win-win” situation for farmers - higher yields, fertilizer savings and less air and water pollution.

The Manufacturing Process

Manufacture of USG is done by compaction. Standard sized of prilled urea or small granules are compacted under pressure in a mold to form the large USG particles. The process, in simple terms, is the physical transformation of conventional urea fertilizer. There is no chemical interaction and no additives incorporated to change the chemical composition of the urea fertilizer. USG and conventional urea both contain 46% N.

Currently, prilled urea is converted into USG using small-scale equipment. The briquetting machine is a stand-alone unit, weighing from 300 to 460 kg. The weight of one high-capacity machine producing 1,000 kg/h is about 700 kg. The photographs below are of an actual USG briquetting machine. It is shown as a complete unit.

Electrically (left) and Diesel (right) Operated Briquetting Machines

The manufacture of USG is a simple process that involves a limited number of moving parts, driven by either a diesel or electric powered motor. The motor size may vary from 7.5 horsepower (450 kg/h) up to 20 horsepower (1,000 kg/h) depending upon the size and capability of USG machine. The production/briquetting capacity of the machines is in the range of 250–1,000 kg/h; most of the machines have the capacity to produce 450 kg/h.

The USG briquetting machine and the manufacturing process are briefly described as follows:

- The small metal frame for housing a small hopper, mounted at the top of the unit, allows for gravity flow of the standard urea.
- At the base of the hopper is an opening to allow the urea to freely flow to a pair of feed rollers to push to the compaction rollers, designed with a concave mold that compacts the urea under pressure.
- The rollers discharge the granules into a small cone-shaped trammel that channels/further discharges the granules to a pan or bucket.
- Urea supergranules are then placed in the same 50-kg sack of urea for the farmer to take to the field for application.

Major Component Parts of the Briquetting Machine

To facilitate the use and maintenance of the briquetting machine owners, some major parts of the machines are shown below:

1. Compacting rollers

2. Feed frame with feeding rollers

3. Gear box

4. Spur gear

5. Feed roller and shaft

6. Compacting roller shaft

7. Compacting production area

8. Diesel engine 12 HP

9. Electric motor 7.5 HP

10. Roller adjustment system

11. Belt tightening system

12. Trammel

Location and Installation of the Briquetting Machine

A suitable site must be identified and used for locating the briquetting machine. It should be located in a secure, safe area that provides farmers convenient access. It should be in an area that is not easily flooded. The following should be considered when locating and positioning the machine.

- The USG manufacturing equipment should be installed and operated in an area that is secure from theft, dry and completely free of moisture, and away from human traffic. In other words, the area should be fully dedicated to the making of USG; it should be under a roof in a walled building/shop that can be well secured at night.
- Select a location that is convenient to farmers.
- The room where the machine is positioned must be well ventilated to allow the exhaust fumes to exit the enclosed area.
- The machine should be placed in an area that allows for limiting access to only the machine operator(s).
- Select a location that is sufficiently spacious to allow for the machine to be located without touching any walls. The space should be adequate for two operators to work in the operation and for storage of up to 20 bags of urea.
- The area should be well drained so that any water leakage from water-cooled motors, rainfall, etc., can be easily channeled from the area where the machine is located.
- Install the machine on a level and stable surface, preferably with a concrete base.

- Anchor the machine firmly at the base by anchor bolts through the holes of the machine base. It will help to keep the machine firmly fixed from any movement and vibration.
- For electric motors, a three-phase electric line with 440 voltages should be connected, checked, and grounded prior to starting the machine. A three-pin socket has been attached for grounding by wire to avoid any electrical accidents.

Operating the Equipment

Operating the USG briquetting machine requires proper training and close attention to detail. The moving parts can be dangerous and cause serious injury and even death if not well operated. The following operating instructions supplement those provided by the equipment supplier.

- Check the hopper and ensure that there are no dirt materials inside it. It is recommended to use clean urea without any hard or metallic substances; otherwise, the rollers will be damaged.
- Rotate the machine manually to check correctness of alignment of rollers.
- Check by putting a white paper sheet (3 inches wide, 1 foot long) between two rollers. Then rotate the rollers manually so that the paper sheet is pressed by two rollers. See the pressed impression on the paper, which will indicate the correct alignment of the rollers.
- First, start the machine, and then pour prilled or granular urea into the hopper.
- Once the briquettes are achieved with a suitable size and shape, proceed to fill up the hopper with urea for continuous production.
- The broken particles/dust urea coming out from the trammel are to be mixed with fresh urea and put again into the hopper.
- When production is completed, press the switch off with your finger. Keep the machine covered with a sheet of polyethylene or cloth to keep the machine free from dust, etc.

Maintaining the USG Briquetting Machine in Good Condition

All machines that have moving parts must be properly maintained for safety, operational performance, and economic reasons. All safety components of the machine must be maintained in good order.

- The machine has an oiling unit for the gear box. Care should be taken to maintain the gear box oil at the required level.

- Urea fertilizer is corrosive, and it is important each day to clear the machine of any urea fertilizer particles/dust to the extent possible. During periods when the machine is idle, it should be fully cleaned of urea residue and greased to avoid corrosion/pitting of the metal.
- Clean the feed and compacting rollers and ensure that the compacting roller pockets are free from dust.
- Grease the bearing case and gears with a grease gun/nipple and remove all used grease.
- Gear Oil Shell Spirax 140 EP or similar oil should be used.
- Gear oil should be checked before starting the machine and, if necessary, refilled to the optimum level as shown in the measuring gauge.
- If the machine is idle for more than 72 hours, clean and apply grease to the feed rollers and compacting rollers to avoid rusting. Before starting, clean the rollers with a soft cloth. In case quality grease is not available, enamel painting of the pressing rollers may be done to protect these parts.
- After every season of operation, the entire machine should be painted with enamel paint. In order to maintain the diesel engine in good condition, the engine oil filter, along with oil and diesel filter, should be changed after an operation time of 1,000 hours. A simple test may be performed to verify the oil thickness. This can be done by using your fingers to examine the gear oil thickness or viscosity. If the oil is very dark and has lost its thickness, it should be changed. At all times, the necessary level of gear oil should be maintained by filling. Always use quality engine oil and fuel to increase the useful life of the engine.

Quality Control

Providing farmers with a high-quality USG is absolutely essential for success of the USG business. The key factors that determine quality are as follows:

- Accurate nutrient content: USG must contain 46% N. The manufacture of USG is controlled by the shop owner, and the process involves only changing the size and shape of the urea particle. In order to maintain an accurate nutrient content of USG, there can be no additives or other materials included with the urea that passes through the machine.
- Dry and free flowing: Urea, due to its chemical composition, is hygroscopic; that means it rapidly absorbs moisture. It is important that the USG remain dry and moisture free. This is best achieved by (1) operating the machine in an area that is protected from rainfall and is free from

water on the floor and (2) placing USG in a closed container/bag with polyethylene lining soon after it is made.

- Uniform in size/shape: The USG manufacture will involve some broken particles and some dust. It is important that any less than full-sized particles be recycled through the compaction process so that only full-sized USG particles are provided to farmers.

Safety and Precaution

Human safety is a top priority in the operation of any machinery and equipment. The following guidelines are applicable to the operation of the briquetting machine.

- One operator has to be assigned to manage the machine, so that he/she develops the needed skills for proper operation, safety, and maintenance of the machine.
- When the machine is in "running condition," all body parts — hands and limbs — must be kept away from moving parts of the machine, including the motor, gear, feed roller, compacting roller, drive belts, etc.
- Do not push urea inside the feed rollers from the hopper by finger or hand; otherwise, there is a great possibility of severe injury or damage to your finger or hand caused by the feed rollers.
- Do not touch live electrical connections or wires.
- Avoid wearing loose clothing as it may tie up with moving parts of the machine, which could cause an accident.
- After any long gap of every production, clean the feed and compacting roller by cloth, air blower, or fiber brush — not by wire brush. The pockets of the two compacting rollers should be cleaned thoroughly. This will ensure uninterrupted and quality production.
- Keep water away from the working area. Water falling onto the motor can cause fire, damage to the machine, and electrical shock if water comes into contact with wires of the electric motors.
- Always keep the working area clean and non-slippery for the advantage of the operator. Every day after operations, all dirt and urea material should be cleaned properly and dried from the floor and machine's body; otherwise, due to the hygroscopic characteristic of urea, the floor as well as machine will be moist and slippery.
- Storage of other items should be segregated from USG.
- Although USG is not toxic and creates no known health hazard, the machine operators should wear gloves, gum boots, and a mask to avoid excessive handling of urea to protect the skin of

hands and feet and to avoid prolonged breathing of urea dust that may result from the briquetting process.

Good Business Management is Important to Success in USG Supply

Many factors will determine the success of your USG business. This handbook discusses product quality, production efficiency, good care and maintenance of the machine, keeping the machine in a secure location, the importance of a good shop location that farmers can conveniently visit, and the proper use and handling of USG. Each of the aforementioned is important to the success of your business and must be well considered for good business management. But there are many other factors that you will need to consider as you begin to operate and seek to expand your USG shop. Some of the important elements of *good business management* follow.

- Be customer (farmer) oriented - that means to treat each farmer/customer with respect. Be fair and honest in dealing with the farmer. Give the farmer good quality USG with the correct weight in the bag. Your prices should be fair and reasonable to you and the farmer. Give good advice to farmers on how to apply USG.
- Understand the basic elements of marketing and give attention to each on a regular basis:
  1. *Product* - Three aspects are particularly important: (a) achieving high quality USG that is consistent in shape with few broken pieces, the correct weight, and free of moisture; (b) understanding how to apply USG for maximum benefit; and (c) understanding both the agronomic and economic benefits that the farmer should get from using USG. *KNOWING YOUR PRODUCT is paramount to success*.
  2. *Place* - Selection of a good location is important to give farmers convenient access to your shop. The shop should be in a secure location and on high ground to avoid normal flooding. The hours of operation should be convenient to farmers for buying USG.
  3. *Promotion* - USG supplier (along with the extension services) can greatly influence farmer demand for USG. Effective methods include using wall hangings, handing out technical brochures, posting signboards, and holding educational sessions for farmer groups. Hosting field demonstrations for USG is highly effective; it should be done with lead farmers and involve IFDC, NAFAKA, KPL and other private dealers and input stockists operating in the proximity of UDP practitioners - In deciding the price to charge for USG, you should consider such factors as costs of manufacture of USG, farmer demand for USG vis-à-vis prilled urea, and competition. Ultimately, the USG supplier will have to cover all of the

costs of doing business in order to stay in business. Charging a fair price to farmers — that is achieving a reasonable return on investment - will help to improve the chance of success.

- Planning is a key to success, so do not underestimate its importance. Planning applies to:
  1. *Budget* - Each year and each quarter you should develop a budget of all expected expenses and revenues by cost category. This will help you to manage your finances.
  2. *Finances* - It is important that your shop make a profit and that you meet your daily expenses. Cash flow management is essential so that you can pay your obligations and buy needed supplies and materials as well as cover operating costs.
  3. *Asset management* - It is necessary to keep accurate records of inventory, both of conventional urea so that you can have enough supply to make USG and also to maintain a reasonable supply to meet demand.
  4. *Promotion campaign* - Promoting USG requires advance planning to ensure your wall hangings are in place before the season, to arrange a good-quality demonstration plot, and to coordinate with specialized public or private extension service providers such as IFDC for educational programs for your customer farmers.
  5. *Growth of your business* - That growth applies to (among others) (a) making arrangements for adequate physical space and additional shop locations; (b) holding employee trainings to better educate and improve the knowledge of your workers; and (c) increasing the scope of your business to include other fertilizer products (remember that USG contains only N, but farmers also need other fertilizers [e.g., those containing phosphorus, potassium, and sulfur] as well as complementary goods).
- Recordkeeping provides the foundation for good planning and overall business management. You should give much attention to keeping good records on a daily basis. That would include, at a minimum, the following types of records:
  1. Financial records to record daily costs by category — e.g., rent, utilities, briquetting machine maintenance, promotion, fuel for the machine, taxes, labor, etc.
  2. Cash flow record - Record daily cash received, cash paid to others, and a running balance amount.
  3. Sales records for each day - Quantity of USG sold, name of farmer.
  4. Production records for each day-How many bags of USG were produced with a running balance for month and year-to-date.

5. Inventory record with amount of USG in stock and amount of prilled urea in stock with a running balance.
6. Briquetting machine maintenance records.
7. Build business linkages (backward and forward) to strengthen your competitive position. You should develop good business relations with the suppliers of the briquetting machine and the suppliers of prilled urea. That will help prevent any “lost production” time due to lack of urea and mechanical breakdown of equipment. Also, build good linkages with NAFAKA and organizations such as IFDC to get the benefit of joint promotion and training programs.
8. Put great emphasis on financial management to protect your assets, control costs, and accurately record the returns that you are getting from your USG enterprise.
9. Know the *total cost of your business operations - the total cost of doing business*. Recordkeeping will give you the information that you need to understand the total cost of doing business. This is the key to making a profit and fair return on your investment. Many entrepreneurs fail because they do not know the total costs of the business and thus do not recover all of their costs.

Returns to Briquette Producers in Bangladesh

The cost and return data on investment for urea briquetting machines are presented in Tables 1 and 2 for electric-driven and diesel-operated machines, respectively.

Table 1. Return on Investment Per Machine—Diesel Operated

Item	Unit	Unit Price	Total Unit	Total Cost/Return
		(US $)		(US $)
COST				
Initial Investment Cost				
Briquetting machine	Number	1,060.00	1	1,060
Other spare parts	Lump sum	35.72	1	36
Total Investment Cost				**1,096**
Operating Cost				
Office and factory rent	Per month	10.14	5	51
Maintenance	Per month	3.51	5	18
Urea	Bag	3.84	739	2,838
Storage	Per month	6.62	5	33
Labor	Per person	40.8	7.2	294
Diesel	Liter	0.59	211	125
Packaging	Per 50-kg bag	0.02	694	16
Management expenses	Per month	8.32	5	42
TOTAL OPERATIONAL COST				**3,416**
INCOME				
Sale of USG during Boro 2008	Bag	5.04	739	3,727
Fee charged to produce USG from urea carried by other	Bag	0.62	440	274
TOTAL RETURN				**4,001**
NET RETURN				**585**

All respondents provided information on the initial investment for purchasing one urea briquetting machine and other related expenses including operating expenses during Boro 2008 in Bangladesh.

Table 2. Return on Investment Per Machine—Electrically Operated

Item	Unit	Unit Price	Total Unit	Total Cost/Return
		(US $)		(US $)
COST				
Initial Investment Cost				
Briquetting machine	Number	1,212.65	1	1,212.65
Electric line installation	440 volt double phase	168.23	1	168.23
Other spare parts	Lump sum	25.26	1	25.26
Total Investment Cost				**1,406.14**
Operating Cost				
Office and factory rent	Per month	11.16	5	55.8
Maintenance	Per month	4.06	5	20.29
Urea	Bag	3.84	1,190	4,570.29
Storage	Per month	6.88	5	34.42
Labor	Per person	40.8	8	330.46
Electricity	Per month	16.99	5	84.93
Packaging	Per 50-kg bag	0.02	1,146	24.91
Management expenses	Per month	6.59	5	32.97
TOTAL OPERATION COST				**5,154.07**
INCOME				
Sale of USG during Boro 2008	Bag	5.04	1,190	6,001.74
Fee charged to produce USG from urea carried by other	Bag	0.46	429	198.72
TOTAL RETURN				**6,200.46**
NET RETURN				**1,046.40**

The respondents were also asked to provide information on USG production and sales. It may be noted that in Bangladesh, farmers use USG in all three paddy seasons, with Boro being the principal paddy crop for the UDP technology use. Therefore, the operating costs of a machine for one Boro season is calculated based on 5 months.

Both Tables 1 and 2 indicate that, on average, one diesel-operated machine produced 1,179 bags or 58.95 tons of USG and an electric-driven machine produced 1,619 bags or 80.95 tons of USG. Thus, 229 machines produced 15,833 tons of USG.

The data in Tables 1 and 2 show that, on average, owners of briquetting machines earned a net profit of US $585.00 from diesel machines and US $1,040 from electric machines. The reason for lower profits from diesel machines is attributable to the cost of fuel during Boro 2008. It is clear from the tables that if one machine can produce 60 tons or 1,200 bags of USG in two seasons, the machine owner can recoup the investment in less than 1 year. If urea is easily available and of good quality, there is little doubt that the USG business can be lucrative.

Returns to Briquette Producers in West Africa

The briquetting machines are manufactured by MARKET INDUSTRIES in Bangladesh. Almost all the briquetting machines that are being use for UDP deployment in West Africa are imported from Bangladesh. The total investment costs including one diesel operated machine, an additional set to produce 2 urea granules sizes (1.8 and 2.7 g) and the transportation (by ship) average $7000 (Table 3).

Table 3. Investment Per Machine – Diesel Operated

Item	Unit	Unit Price
		(US $)
COST		
Initial Investment Cost		
Briquetting machine	Number	2900
Extra Set	Number	900
Transportation Cost by Ship		3000
Total Investment Cost		6800

Most of the briquetting machines in West Africa are hosted and maintained by well-organized and empowered farmer-based organizations (FBOs). And the economic analysis of urea granulation is being monitored by IFDC in West Africa. The cost and return data on investment for urea briquetting machines and other related expenses are being collected in close collaboration with FBOs-members and partner extension services in the respective pilot-countries. Preliminary data

indicate that the briquette production capacity including packaging is about 250 kg urea per hour. Labor, storage, maintenance and fuel costs are being monitored to evaluate the total production costs and determine the average price of 1 kg briquette and returns to entrepreneurs.

END FOFANA