

Rapid Introduction
and Market
Development for
**Urea Deep
Placement
Technology**
for Lowland
Transplanted Rice

A REFERENCE GUIDE



Rapid Introduction and
Market Development for
Urea Deep Placement
Technology for Lowland
Transplanted Rice

A Reference Guide

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Foreword

As climate change impacts global harvests, agricultural systems must continue to increase food production and farmer incomes, decrease environmental degradation, and become more resilient under a changing climate. Technologies and practices, including stress-tolerant varieties, improved water management, increased nutrient use efficiency, and balanced fertilizer use, are central to meeting these challenges. Designed specifically for resource-poor farmers cultivating lowland rice, urea deep placement (UDP) is one example of a nutrient management technology that accomplishes what agriculture must do in a changing climate: increase yields and profitability and reduce pollution.

Deep point placement of urea briquettes delivers more nitrogen to the plant and reduces fertilizer use, water contamination, and greenhouse gas emissions. Additionally, farmers experience about 15-20% higher yields. More than 2 million farmers and retailers in Bangladesh are experiencing increased production and income using this technology. These results are being replicated in several countries in sub-Saharan Africa.

IFDC has validated UDP under various research and field environments, including in greenhouse and research trials and under farmer field conditions. This manual provides the scientific basis for UDP technology and outlines the steps necessary for the successful introduction and commercialization of UDP into developing agriculture systems. The process is complex – both demand creation and supply system development must occur simultaneously. On the demand side, farmer adoption requires ongoing education and demonstration of improved livelihoods. On the supply side, farmers must have affordable and convenient access to high-quality UDP products. Approaching UDP as a new fertilizer product on the market, the manual guides users through each phase of UDP project planning and implementation.

The manual is intended for IFDC project implementers and partners who aim to strengthen food security, improve rural income, and reduce agriculture's environmental footprint. We consider ourselves a partner to each organization utilizing this manual. As such, the guide outlines support that can be expected from IFDC.

We hope that this publication will be a valuable tool in expanding fertilizer nutrient management technologies that ultimately strengthen agriculture systems and the environment.

J. Scott Angle
IFDC President and CEO

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Acronyms

ANOVA	analysis of variance	IFAD	International Fund for Agricultural Development
CEC	cation exchange capacity	IRR	internal rate of return
cm	centimeter	K	potassium
CP	Collaborating Partner	kg	kilogram
DAE	Department of Agricultural Extension	m	meter
DAP	diammonium phosphate	M&E	monitoring and evaluation
DGIS	Directorate-General for International Cooperation (Netherlands)	mm	millimeter
DQA	data quality assessment	MOA	Ministry of Agriculture
FAO	Food and Agriculture Organization of the United Nations	MOP	muriate of potash
f.o.b.	free on board	mt	metric ton
g	gram	N	nitrogen
ha	hectare	NARO	national agricultural research organization
HYV	high-yielding variety	NGO	non-governmental organization
IA	Implementing Agency	P	phosphorus
IARC	international agricultural research center	RCBD	randomized complete block design
ICT	information and communication technology	SSP	single superphosphate
IFA	International Fertilizer Association	TSP	triple superphosphate
IFDC	International Fertilizer Development Center	UDP	urea deep placement
		USAID	U.S. Agency for International Development
		USG	urea supergranule

Rapid Introduction and Market Development for Urea Deep Placement Technology for Lowland Transplanted Rice

A Reference Guide

"To have a positive and long-term impact on fostering food security and to be broadly accepted by stakeholders, technologies need to be introduced with care, be readily adaptable to the demands of a particular setting and be easy to understand and to use."

Source: Global Forum on Food Security and Nutrition

Introduction

Urea deep placement (UDP) technology is a relatively simple, field-proven technology developed and validated by the International Fertilizer Development Center (IFDC) and more than a dozen research organizations in Asia and Africa. It is a soil nutrient management technology ideally suited for smallholder farmer agriculture production systems. With UDP, rice farmers consistently achieve yield gains¹ of 15%-20% while using one-third less fertilizer. To a lesser extent, vegetable farmers realize attractive yield increases with UDP compared with conventional fertilizers.

UDP technology involves "point placement" of large fertilizer granules (1 to 3 grams each, in the shape of briquettes) 7 to 10 centimeters (cm) below the soil surface in close proximity to the root zone of the plant. Urea briquettes are applied only once during the crop growth season, compared with two to three fertilizer applications needed for surface-applied prilled or granular urea. UDP technology makes nitrogen available to the crop throughout its growth cycle. Plants are able to absorb more of the applied nutrients, resulting in higher crop yields and lower production costs for farmers.

IFDC developed UDP technology through its research and development programs, which include emphasis on reducing losses and increasing crop uptake of applied nitrogen fertilizers. Following more than two decades of in-house research and development, the technology is now being introduced and promoted on a large scale in selected countries.²

UDP technology is appropriate for most rice-producing countries in Africa and Asia and many in Latin America. It performs best in clay and silt soils and in rice production systems in which fields are subject to surface water runoff and line sowing is practiced. While much research was conducted in southeast Asia, particularly in Bangladesh, the technology requires adaptation for use in lighter textured soils. While there is considerable desire to quickly adapt new technology to local conditions, it is important to validate the UDP technology via research and on-farm field trials in the zones targeted for introduction. The research trials should be done in collaboration with private enterprise, national agriculture research organizations, non-governmental organizations (NGOs) and/or international agriculture research organizations with an endorsement (collaboration where possible) of the host Ministry of Agriculture.

Traditional fertilizer application by smallholder farmers involves "broadcasting" by hand. In some cases, the fertilizer is "worked into the soil." In growing rice, fertilizer is "surface-applied" two to three times during crop growth. Nitrogen losses of surface-applied urea are estimated to be up to 66% of the applied nitrogen.

¹ Incremental yield attained with UDP over conventional surface applications of commercial fertilizer.

² Funding for the rollout of UDP technology has primarily been from the U.S. Agency for International Development (USAID), International Fund for Agricultural Development (IFAD) and the Netherlands' Directorate-General for International Cooperation (DGIS).

The introduction and market development for UDP technology require concurrent attention to demand- and supply-side issues. On the demand-side, changing farmer behavior from traditional practices to an improved method of soil nutrient management is a key challenge. It is our experience that farmers are interested in adopting improved technology when they are convinced of improved yields and a favorable return on their investment. Farmer access to high-quality UDP briquettes at an acceptable price and knowledge of proper use and benefits are key factors that impact demand growth and market expansion.

UDP technology involves a significant labor requirement at the time of fertilizer briquette placement in the soil.³ This furthers the challenge of creating and sustaining farmer demand for the technology. Efforts to develop a mechanical applicator for fertilizer briquettes have yielded favorable results. Work to improve the performance and availability of applicators is continuing, and achievement of a quality push-type or self-driven applicator is critical to diffusion of the technology.

On the supply side, there is no large-scale commercial manufacturer of UDP products. Supply is currently derived from fertilizer briquetting machines that are a “village-level operation.”⁴ Standard commercial urea fertilizer (prills/granules) is the raw material used to make the UDP briquettes through a high pressure “compaction” process.

There is no need to establish a separate channel system (e.g., dealer network) for UDP fertilizers. Rather, UDP briquettes will be a “new product”⁵ in most fertilizer markets and should be treated as an enhancement to the existing fertilizer product options available to farmers.

The introduction of UDP fertilizers may be successful in either a public or private sector system. In the case of private sector fertilizer marketing systems, a dealer’s decision to invest in a fertilizer briquetting machine and/or include UDP fertilizers in their product mix will be based upon the dealer’s expectation of return on investment. While UDP fertilizers will, to some extent, cannibalize sales of standard prilled/granular urea, the technology will deliver improved financial returns to dealers and farmers, creating a win-win situation. Moreover, as with any improved technology, dealers may realize increased margins with UDP products through a value-based approach to pricing.

Success in UDP briquette manufacture is volume sensitive. As a general guide, the threshold annual sales volume needed to support a urea briquetting machine (full cost basis) is about 100 metric tons (mt) of UDP fertilizer.⁶ Many agro-input dealers in Africa, and to a much lesser extent in Asia, will not have sufficient fertilizer sales volume to justify an investment in a briquetting machine. In the cases of weak fertilizer markets and low volume dealers, market entry will require attention to entry upstream in the marketing system (e.g., larger fertilizer dealers, wholesalers/distributors), or through large farmer member organizations and NGO-supported enterprises. A strategy employing a cost-share element may be needed in the initial stages of supply system development to offset the initial equipment cost and mitigate the investment risk in a technology with low initial demand.

National policy and regulatory system issues may impact the manufacture and sale of the briquettes. Proactive attention to identifying, fully understanding and addressing issues such as agro-input dealer licensing, fertilizer stock holding, fertilizer pricing, fertilizer product registration and fertilizer “manufacture” is essential to private sector investment in the manufacture and sale of fertilizer briquettes. To illustrate, urea briquette manufacturers/dealers require flexibility to set prices for fertilizer briquettes that allow for an acceptable gross margin. And, while fertilizer briquettes are manufactured through compaction of standard fertilizer products, in some environments government regulatory system provisions may treat the briquettes as a “new” product, requiring a separate product registration.

It is clear that UDP technology introduction and market development is a complex process, with many variables at play that impact initial success and sustainability of gains. This reference manual provides guidance for successful planning, introduction, commercialization and management of the technology. **It is essentially a “cookbook” approach to the introduction of a new fertilizer product into a developing country’s agriculture system wherein both demand creation and supply system development must occur concurrently.**

³With UDP technology, the labor requirement for split applications of urea fertilizer topdressing is eliminated and the labor required for weeding is substantially reduced. Labor at harvest is increased due to increased crop yields.

⁴Fertilizer briquetting machines are available from private suppliers in Bangladesh. The export price is approximately U.S. \$2,500-\$5,000 per unit. Based upon the IFDC design, briquetting machines may be fabricated in any well-equipped metal fabrication shop with proper technical staff. Local fabrication of briquetting machines is a preferred option to support market growth. An example is Myanmar where two engineering firms are making briquetting machines for the local market.

⁵UDP is formed entirely from urea fertilizer, commonly available in most countries. The characteristic of being “new” is related to urea granule size and associated deep placement technology, not its composition.

⁶Based upon IFDC experience in UDP market development where price competition is intense and UDP price markup over conventional urea fertilizer averages about 10%.

Incorporating lessons learned and knowledge gained from IFDC's experience in UDP technology and diffusion in Asia and Africa, the strategic approach to UDP technology diffusion captures elements of the "franchise business model," namely standardization of systems and a systematic approach to supply management (with emphasis on product standardization and quality control). Elements of a public-private partnership approach are incorporated to achieve synergies that may accelerate UDP technology diffusion.

This manual is intended for use by an IFDC project leader (i.e., in cases in which IFDC is performing the role of Implementing Agency) and/or a Collaborating Partner (e.g., an international development assistance organization, developing country national government, or NGO) that seeks to improve food security and increase economic returns to smallholder farmers through improved agricultural productivity.⁷

The Collaborating Partner (CP) will be responsible to provide the required funding for UDP project planning and implementation in a timely manner. The CP will either directly implement the UDP project or select an Implementing Agency (IA) for that purpose. The IA may be a government entity in the host country, an international organization (e.g., IFDC) or an NGO experienced in fertilizer sector development. Various stakeholders will be involved in the UDP project; the respective roles of each are defined herein.

The manual is divided into four sections:

- **Agronomic Overview of UDP: The Science Behind the Technology**
This section provides a summary of the problems of nitrogen fertilizer management that are inherent in lowland rice production systems. It introduces the science behind UDP technology and the evolution of UDP as a highly suitable nitrogen fertilizer management technology for smallholder farmers. Soil- and crop-related factors that impact UDP suitability are presented. A summary review of research conducted by IFDC scientists and others on the technology is included. Attention is given to the economic returns to farmers from UDP technology use. The environmental consequences of UDP technology are identified.
- **UDP Project Initiation Phase**
This section presents factors that impact UDP technology success and affect UDP fertilizer entry into the market. An outline for the Target Market Assessment is presented. The UDP Strategic Plan will flow from the Target Market Assessment. Based upon and tailored to the specific conditions in the target market, the assessment will guide project implementation. Both the public and private sector will have important roles to play in UDP market development; their roles are indicated in this section.

Developing the market for UDP technology is **a new product introduction**. The process involved in any fertilizer product introduction will apply. To some extent, urea briquette sales will displace sales of prilled/granular urea fertilizer. **Significant complexities are involved due to the need to concurrently address demand- as well as supply-side issues, including a change in farmer behavior from traditional agricultural practices, and UDP technology entry in small and underdeveloped fertilizer markets.** Due to the complexity involved and the long duration to achieve market development, the initiative to commercialize UDP technology is referred to as a "project" in this manual.

⁷ In this manual, Collaborating Partner (CP) refers to the sponsoring entity (i.e., provider of funding and contracting entity) that is concerned with advancing food security improvement and smallholder farmer poverty alleviation/livelihood improvement through rapid diffusion of UDP technology. The CP will typically be a global/regional development organization (e.g., USAID, DGIS, World Bank, Alliance for a Green Revolution in Africa, African Development Bank, Food and Agriculture Organization of the United Nations or a foundation). The CP may either directly implement the UDP project or (and more likely) arrange for an Implementing Agency (IA) to implement the UDP project under the funding and overall guidance of the CP. The IA will handle the day-to-day project implementation activities to achieve a set of pre-defined goals and objectives. The IA will typically be an NGO, international organization or national public sector agency in the target country for UDP technology diffusion. IFDC currently serves as IA for UDP market development in selected countries in Asia and Africa. For convenience, the terms CP and IA may be used interchangeably in this manual. See "Frequently Asked Questions" in Section IV for a brief description of the CA and IA.

- **Rollout Phase for UDP Technology**

This section provides guidance on developing the UDP product supply and marketing system – channel selection, manufacture of UDP briquettes, quality control and problem resolution. It addresses building farmer demand for UDP products: promotion techniques for best results, establishing collaborative linkages with key stakeholders to achieve synergies, and use of research and demonstration plots to further validate the technology and refine site-specific recommendations. Management systems to support proper management of the UDP project are addressed. Finally, the resource requirements to implement a UDP project are discussed.

- **IFDC Support**

Ongoing IFDC support to the CP will facilitate UDP market development. This section describes the support and technical guidance that IFDC will provide to the CP should the IA be an entity other than IFDC.⁸

In an effort to extend UDP technology, enhancements and research findings will continue to occur at IFDC and elsewhere. Details on research findings of IFDC scientists and others, as well as technology enhancements, will be provided through the IFDC website.

A video has been developed to accompany this reference manual. It includes segments on UDP application practices and urea briquette manufacture.

Finally, lessons learned and frequently asked questions regarding UDP technology and market development are included.

⁸ In a situation wherein IFDC is identified to be the Implementing Agency for the Collaborating Partner, the support provided by IFDC would be included in a written agreement with all terms and conditions clearly defined.

I. Agronomic Overview of UDP: The Science Behind the Technology

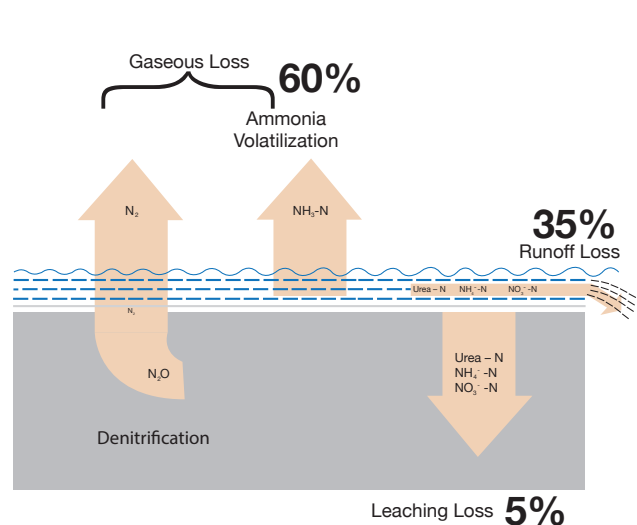
UDP products were initially developed for lowland rice production systems wherein applied nitrogen (N) losses can be very high. This section provides an overview of the agronomic factors, including a summary of IFDC’s research results related to UDP technology for lowland rice. More recent research indicates the products are also well-suited to production of high-value crops such as cabbage, cauliflower, broccoli and eggplant.

Humans rely on cereal grains (wheat, rice and maize) to provide 80% of the food energy supply. Among the three grains, rice is the staple crop for approximately half of the global population and continues to play a dominant role in the production systems and diets of Asia. Approximately 90% of the world’s rice is produced and consumed in Asia, mostly on small family farms. However, in the last two decades, changes in consumption patterns have led to a large increase in the demand for rice by consumers in sub-Saharan Africa. Demand is driven by rice becoming the staple food of the poorest urban households in sub-Saharan Africa’s rapidly growing cities. This increase in consumption has resulted in increased production, but imports still play a major role in meeting overall demand.

Rice cultivation provides most of the employment for a large sector of the rural population, particularly in southern Asia. Lowland rice production, which can be either rainfed or irrigated, predominates and constitutes more than 90% of the total rice production. For transplanting rice seedlings, the field is generally prepared first by wet plowing followed by puddling operations to facilitate easy transplanting and to reduce water losses through percolation. Following this typical wetland tillage, submerged soil conditions prevail continuously or for broken periods of varying duration from transplanting to maturity of the rice crop. These conditions differentiate lowland rice soils physically, chemically and microbiologically from upland soil conditions. Hence, lowland rice production requires special fertilizer management practices.

In most rice production systems, farmers’ practices for N fertilizer application include basal broadcasting with or without incorporation before transplanting or seeding and one or two topdressings in the floodwater immediately after transplanting up to flowering. These conventional practices are largely based on seasonal nutrient demand and/or convenience and are generally controlled by agro-climatic and socio-economic factors. Several studies have shown that these management practices for application of N fertilizer in transplanted rice are very inefficient. In general, only about one-third of the N fertilizer is used by the plants. The rest is lost via ammonia volatilization and denitrification (where gaseous losses account for 60% of total losses), runoff and/or leaching (Figure 1) or is immobilized in soil. Because rice soils in southern and South Asia and sub-Saharan Africa generally show marked responses to N fertilizer, use of N fertilizer is a must. Farmers today must respond to the increased demand for rice while simultaneously identifying means to increase N use efficiency. UDP technology addresses those needs for smallholders.

Figure 1.
Nitrogen Loss
Mechanisms in
Irrigated Rice
Production



Problems of Nitrogen Management in Rice Production

Fertilizers account for 40%-60% of increases in cereal production and will continue to play a critical role in reaching future food production targets. Generally, N fertilizer is the single most important input a farmer can provide to increase crop yields, and globally urea is the primary fertilizer used to supply this plant macronutrient. Urea is one of the cheapest commercially available solid N fertilizers. It has the highest N content (46%) which allows for considerable savings in transport and handling costs. Therefore, despite its caking tendency in humid tropical and sub-tropical countries, prilled urea is the principal N fertilizer used for rice, and its use is expected to increase in the future. When properly used, urea (prilled or granular) can be an efficient N fertilizer. Similarly, the rice plant can be an efficient user of urea fertilizer. The poor efficiency of urea fertilizer in rice can be attributed to its traditional application by farmers (Figure 2) who have limited understanding of the N losses that can occur when urea is conventionally applied to a submerged soil-plant ecosystem.

Some of the inefficiency problems associated with conventionally or split-applied urea fertilizer in rice are complex and serious. If there is floodwater flowing from field to field, as is common in rainfed areas, runoff losses of broadcast and/or slightly incorporated urea can be very significant (Wetselaar, 1985). Under non-flowing floodwater conditions without percolation, most of the broadcast or topdressed urea is hydrolyzed to ammonium and aqueous ammonia in the floodwater and particularly at the floodwater-soil interface (Savant et al., 1983; 1986; Savant and Stangel, 1990). The ammonium buildup in the floodwater can eventually lead to high ammonia volatilization losses (Vlek and Craswell, 1981). Also, if the floodwater is non-flowing and water percolation rates are high, leaching losses of urea-N and/or ammonium-N may occur. Proper incorporation of broadcast urea before transplanting or sowing is often advocated to minimize the magnitude of the N losses; however, because of unavailability of suitable implements and/or the presence of the floodwater, proper incorporation of broadcast urea into the soil is nearly impossible to achieve for most farmers (De Datta and Buresh, 1989; Goswami et al., 1984; Pillai, 1981). Some studies have shown that sizable losses of urea-N still can occur following incorporation of prilled urea with tillage implements such as an animal-drawn or single-axle tractor-drawn comb harrow or conical puddler (Padilla et al., 1990). Draining of the floodwater before incorporation or before topdressing is another suggestion for decreasing losses of applied urea (De Datta et al., 1987; Sudjadi et al., 1987). This practice, however, is impractical for many farmers because there are no separate outlets to drain water for individual paddy fields, and their fields are often surrounded by fields of other farmers. In irrigated areas, water is an expensive input and farmers have very little control on irrigation schedules in a given area. In rainfed areas, because of the unpredictable nature of rains, farmers simply are not able to control the rainwater flowing through their fields and also cannot afford to lose standing floodwater just for the purpose of applying urea. Therefore, many farmers continue to lose up to 60%-65% of conventionally applied urea due to ammonia volatilization, denitrification, runoff and/or leaching (Sudjadi et al., 1987; Vlek and Byrnes, 1986).



Figure 2.
Conventional
Method of
Broadcasting
Prilled Urea in
Rice Fields

Urea Deep Placement Technology

One effective method to reduce N losses and improve fertilizer efficiency is UDP technology, which was developed by IFDC and collaborators with funding from the U.S. Agency for International Development (USAID), the International Fund for Agricultural Development (IFAD) and the Government of Bangladesh. UDP is a simple, farmer-friendly technology that enhances the efficiency of applied N fertilizer. There are two elements to the technology: (1) a large-sized fertilizer particle of 1-3 grams (g) by weight, referred to as a urea supergranule (USG)⁹ and (2) point placement of the large fertilizer particle at 7-10 cm depth (in the reduced [anaerobic] soil layer for flooded rice) near the root zone of the crop being fertilized. Through UDP, the avenues for N losses are reduced, and improved N uptake by the plant is possible. UDP is a highly efficient soil nutrient management technology, enabling farmers to achieve higher crop yields (15%-20% higher than with broadcast application of urea) with lower use of high-cost fertilizer (about one-third lower than urea broadcast). To increase rice yields with reduced N fertilizer application and reduced N losses, UDP has been successfully adopted in Bangladesh and is being introduced in other South Asian countries and in sub-Saharan Africa by IFDC and others (e.g., International Development Enterprises in Vietnam).

UDP technology involves the deep placement application of urea briquettes. Typically, one briquette (size determined by required N application rate and planting density) is placed in the puddled soil (by hand, manual applicator, mechanized row applicator, etc.) at the center of each set of four hills of rice at a depth of 7-10 cm from one to seven days after transplanting rice. Although hand placement of the urea briquettes increased labor compared with broadcasting urea, this cost was partially offset by reduced labor required for weeding. The yield increase resulting from UDP technology more than offsets the labor cost and results in increased profitability. In Bangladesh, UDP increased yields 0.5-1.0 mt/hectare (ha) over traditional methods that used 40-60 kilograms (kg)/ha more N. The yield increases associated with the UDP technology have prompted the interest of national and international organizations to demonstrate this fertilizer technology on the fields of farmers in developing countries. These organizations recognized the technology's potential for developing country farmers who cultivate lowland rice on small plots where increased yields with improved input efficiency are of vital importance for food security.

Fertilizer Deep Placement Products

Urea supergranules (USGs) are fertilizer particles that are much larger than commercial-grade urea fertilizer prills/granules. With a particle weight of 1-3 g each, USGs are well-suited to UDP technology.

USGs may be produced through either a granulation or compaction process. The shape of the granules (spherical, pillow-shaped [briquette] or tablet) depends upon the production process.

Briquetting is a compaction process that, due to simplicity and cost- and market-related factors, is highly suited for manufacture of USGs. Through its research and development program, IFDC has developed briquetting machine technology that yields high-quality fertilizer briquettes. Albeit USG is a more encompassing term, throughout this manual, the terms "urea briquettes" and "urea briquetting machine" are used when referring to UDP products.

⁹ USG fertilizer may be in the shape of a granule, tablet, pellet or briquette. IFDC has determined that the briquette is the most appropriate shape due to production process-related factors. For that reason, the term urea briquette is used to reference the urea supergranule (see information sidebar).

The Scientific Basis for the UDP Technology

Properties of Urea Supergranules

Basically, the urea briquette is a simple physical modification of ordinary urea fertilizer. It consists of large discrete particles of urea containing 46% N as NH_2 , an amide form. Weight may vary from 1 to 3 g per particle. Their shape depends on the production process used (Figure 3). Briquettes prepared by any one of the melt-type granulation processes are nearly spherical and without edges, but they may vary substantially in size and weight. Those prepared by briquetting are pillow-shaped, oblong or oblate, with broken edges due to webbing, and they are reasonably uniform in size and weight. In 1985, IFDC evaluated physical properties of UDP materials as determined by the methods described by Hoffmeister (1979). These materials were prepared using (a) TVA's falling curtain process, (b) Norsk Hydro's pan-granulation process and (c) the briquetting process. The information on their storage and handling properties suggest the following:

- The absence of formaldehyde (as a conditioning agent) in urea briquettes was apparently detrimental to their handling properties.
- Urea briquettes were more prone to excessive fines and dust formation even with formaldehyde.
- The larger urea particles produced by the pan-granulation process exhibited the best handling and storage properties.
- Caking tendency was higher for urea briquettes (with or without formaldehyde) prepared by the falling-curtain process; most of the crystal-bridge formations were weak to moderate and could be broken apart by hand.

Following this evaluation, the physical properties of briquettes produced recently have been tremendously improved.

Figure 3.
Prilled Urea and
Urea Briquettes of
Various Shapes



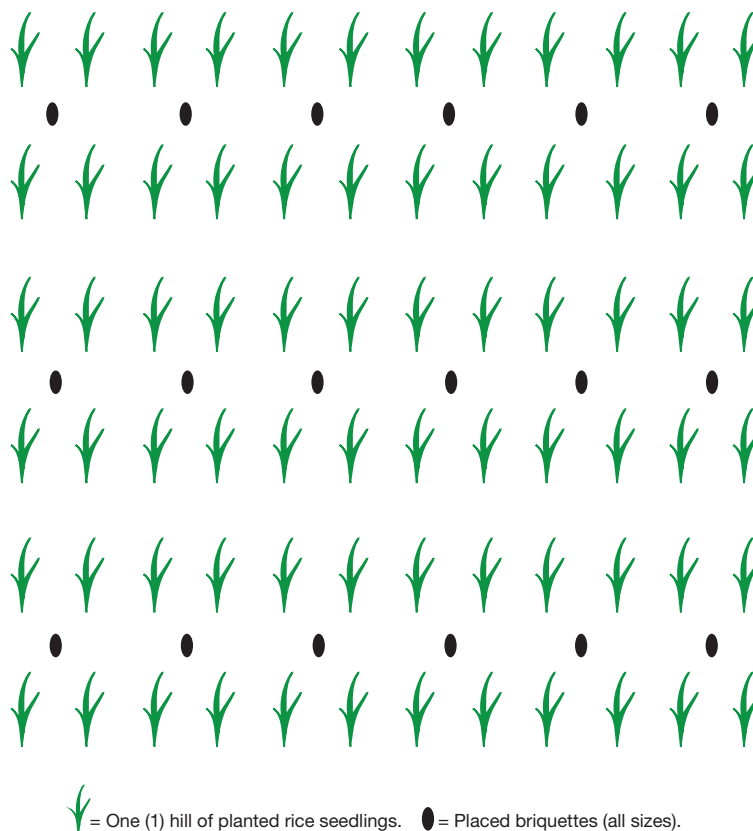
Application of UDP Briquettes

The UDP technology requires trained farmers and extension agents who can correctly apply the technology under transplanted and, most recently, direct seeded rice-growing systems. The amount of N fertilizer applied with UDP depends on the size of the briquette (currently briquetting machine rollers are capable of making briquettes of three sizes: 0.9 g, 1.8 g or 2.7 g) and the spacing of briquette placement (Table 1). Placement of briquettes should be either at the center of alternate four rice hills (Figure 4) or on a 40 cm grid for direct seeded rice fields. Thus, for line transplanted rice, each briquette is placed in the center of four rice plants at a depth of 7-10 cm below the soil surface.

Table 1.
UDP Application
Rate Based on the
Size of Briquettes
and Plant Spacing

USG Size (One Briquette)	Spacing (cm)			
	15 x 20		20 x 20	
	N	Urea Equivalent	N	Urea Equivalent
(g)	(kg/ha)			
0.9	35	75	26	56
1.0	38	83	29	63
1.2	46	100	35	75
1.4	54	117	40	88
1.6	61	133	46	100
1.8	69	150	52	113
2.0	77	167	58	125
2.7	104	225	78	169.5

Figure 4.
Urea Briquettes are
Deep-Placed at 7-10
cm Depth at the
Center of Alternate
Four Rice Hills



Transformation of Nitrogen in UDP at the Placement Site

The submerged soil environment at the UDP placement depth can play a marked role in influencing transport and transformations of N in UDP. The physical, chemical and microbiological properties of the submerged rice soil at the placement depth are highly complex, heterogeneous and dynamic (IRRI, 1978; Ponnampereuma, 1965). The field soil-water regime varies from near saturation to submergence because the floodwater overlying puddled soil varies in depth and time periods. The soil at the placement depth is characterized by anaerobic conditions with nearly stabilized pH ~7 and generally decreased soil redox (Eh) potentials (reduced conditions). Considerable spatial variations in soil bulk density and volumetric water content are common in a submerged soil profile (Savant and De Datta, 1980). For one to three weeks after rice transplanting, the soil at the placement depth is generally reduced, but as roots develop, the rice rhizosphere may become somewhat oxidized because of diffusion of oxygen from rice roots (Armstrong, 1971). However, conditions favorable to denitrification may also develop in some parts of the same rhizosphere (Garcia, 1975a, and Garcia, 1975b), presumably due to root exudates containing soluble organic substances and dead cells of roots (Kimura et al., 1979; Russell, 1977). In other words, the rice rhizosphere is considered another site for simultaneous nitrification-denitrification (Reddy and Patrick, 1986; Savant and De Datta, 1982).

Urea briquettes generally dissolve gradually after their placement, producing very high localized concentrations of urea at or very near their placement sites. Most of the urea in this reaction zone stays in solution, but some of it may be weakly sorbed by the reduced soil complex (IFDC unpublished data). The ammonium, formed as a product of urea hydrolysis and stable in a reduced soil environment, tends to accumulate at the placement sites. With submergence time, the ammonium is transported mainly through diffusion and interacts with more soil. Eventually, its fixation by clays and/or microbial immobilization with time may increase. Thus, a steep concentration of gradients of ammonium exists in the proximity of the placement sites. This unique N transformation occurs at the placement site, and thus minimizes N losses from the applied briquettes and increases plant uptake. The reduction of N losses from applied briquettes is depicted schematically in Figure 5.

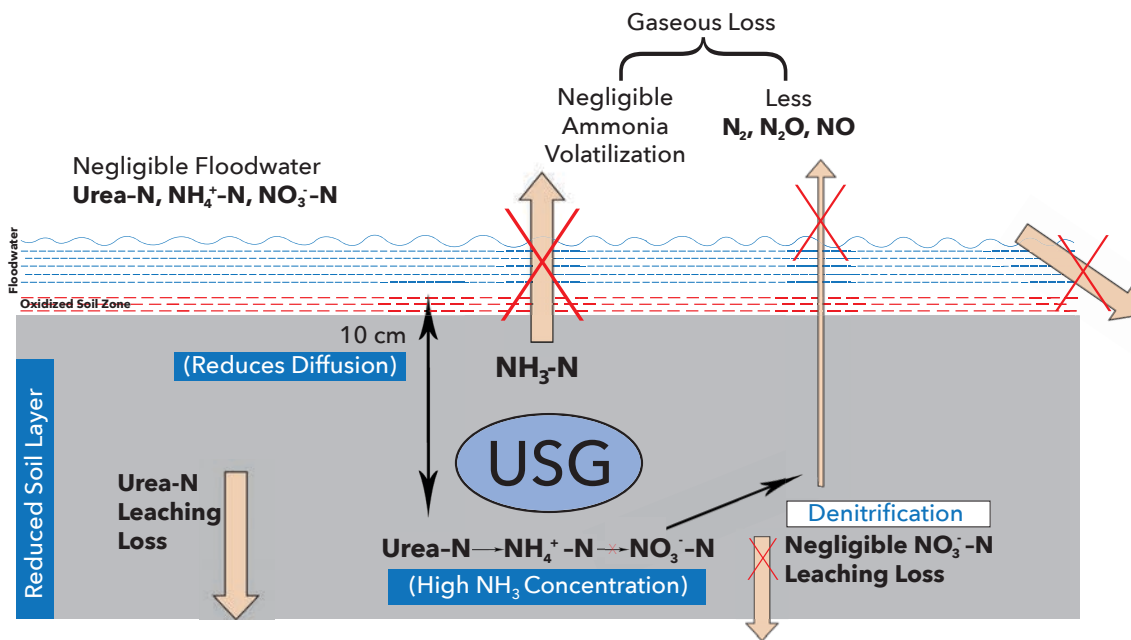


Figure 5.
Effect of UDP in
Reducing Losses
and Increasing
Soil N Status

Plant Availability of Nitrogen Contained in UDP Briquettes

The transport of ammonium from the placement site is slow because it is mainly a diffusion process influenced by ion-exchange. As a result, the spatial concentration gradients of available ammonium tend to exist in a restricted soil volume (Savant and De Datta, 1979; 1980; Panda and Patnaik, 1989). The rice plants may take about one to two weeks for establishment and root development, and therefore there is a “lag period” before the N contained in UDP briquettes (referred to as UDP-N) starts becoming spatially available to the rice plants. In general, increases in the distance between the placement site of the briquette and the rice hills result in an increase in the lag period before UDP-N becomes spatially available to the rice plants. The lag period for the initial availability of ammonium to the rice plants also seems to be increased with an increase in the depth of briquette placement.

After the lag period, as the rice roots reach the placement sites, N absorption begins only from the periphery of the soil-urea reaction zones that are below the toxic concentration of ammonium (Savant and De Datta, 1980; Gaudin et al., 1987). An ammonium concentration of 0.45 millimoles seems to be a concentration threshold below which rice root uptake becomes highly efficient (Gaudin, 1987; 1988). A tendency of rice roots to avoid high toxic concentrations of ammonium near the placement site of 1-g briquettes has been observed in root-box studies. As the ammonium concentrations at the placement sites decrease with time, presumably due to continued diffusion and/or plant uptake, the rice roots may slowly proliferate through the placement sites.

At this point, the spatial availability of UDP-N may reach its peak, and it will then decline with time. Thus, the spatial concentration gradients of ammonium existing at the placement sites control rate and duration of availability of UDP-N to the rice plants (Gaudin, 1987; Savant and De Datta, 1980). This type of spatial availability of N seems to result in an improved relationship between deep-placed briquettes and the rice plants as compared with that between traditionally applied prilled urea and rice plants (Chen et al., 1983).

From the above discussion, it is apparent that UDP briquettes per se are not slow-release N fertilizers. However, briquettes that are properly deep placed (unlike broadcast or broadcast-incorporated urea) can be considered a slowly available N fertilizer.

Agronomic Performance of UDP Briquettes

Since 1975, several thousand field trials to evaluate the agronomic performance of UDP briquettes in transplanted rice have been conducted in South Asia and sub-Saharan Africa by IFDC, rice agronomists from national institutions and by national and international networks. A summary of the results are as follows:

- In general, the agronomic performance of deep-placed UDP was found to be superior to that of two or three split-applications of prilled urea in 75%-80% of the trials. In non-typical rice paddies with coarse-textured soils and a high percolation rate (100-120 mm day⁻¹), deep-placed UDP was inferior or similar to split-applied prilled urea.
- Agronomic efficiency (kilogram of brown rice produced per kilogram N applied) of deep-placed briquettes tended to be much higher at low rates of N than the other rates shown in Table 1.
- The yield response of transplanted rice to increasing rates of urea-N showed more tendency to be curvilinear (quadratic) for deep-placed UDP than for split-applied prilled urea in the range of 30 to 120 kg N/ha.
- In general, depending on agro-climatic conditions, deep-placed UDP vis-à-vis split-applied prilled urea resulted in saving up to 66% of the urea fertilizer, with an average saving of about 33%, or gave an additional grain yield up to 45% depending on N rate applied, with **an average additional yield of 15%-20%**.
- UDP was found to be agronomically efficient in calcareous soils and in problem soils such as acidic, sodic, alkali, coastal saline and poorly drained soils.
- Deep placement not only was effective in increasing the grain yields of irrigated transplanted rice, but also showed considerable promise in increasing yields of rainfed transplanted rice and deep-water rice.
- Agronomic efficiency of UDP was, in general, equal to or (at times) better than that of other modified urea (sulfur-coated urea, neem-amended or coated urea, rock phosphate-coated urea, urea amended with inhibitors [urea + NBTPT,¹⁰ urea + PPDA,¹¹ and urea + DCD¹²]).
- Additional grain yields with UDP are attributed to increasing the number of panicles per square meter and the number of filled grains per panicle.

¹⁰ NBTPT = N-(n-butyl) thiophosphoric triamide.

¹¹ PPDA = Phenylphosphorodiamidate.

¹² DCD = Dicyandiamide.

- UDP increased protein yield of rice over that with split-applied prilled urea.
- Besides providing direct agronomic benefits, UDP-N has other indirect agronomic benefits. UDP briquette N is less subject to algal immobilization and uptake by aquatic weeds than conventionally applied prilled urea. Also, by not disturbing the natural algal N₂-fixing system, UDP provides a bonus of N to the wetland soil-rice plant ecosystem.

Summary of Benefits Associated with UDP Technology

UDP technology makes N available to the crop throughout its growth cycle, thereby drastically reducing losses to the atmosphere, groundwater and waterways. Consequently, plants absorb more N, resulting in higher crop yield and lower production costs. To summarize, UDP has the following benefits:

- Increases efficiency of N fertilizer use in flooded rice due to reductions of N loss through gaseous emissions and floodwater runoff. With broadcast application of urea, volatilization losses alone can result in losses of 30%-50% of the applied N.
- Encourages algal biological N fixation because of low floodwater N concentration.
- Reduces weed competition because fertilizer is centered among four rice plants and away from the weed root zone.
- Encourages better water management and line transplanting (vs. random transplanting); thus, weeding and pest control are easier.
- Reduces phosphorus (P) runoff when multi-nutrient NP (urea-diammonium phosphate [DAP]) briquettes are deep-placed as opposed to broadcasting urea and P fertilizers (i.e., triple superphosphate [TSP], DAP).
- Reduces ammonium and P fixation and immobilization.
- Reduces the number of ineffective tillers in rice plants and results in larger panicles.
- Ensures N availability beyond the flowering stage when applied at the proper rate without the danger of N fertilizer overuse.

Analysis of the research data collected between 1999 and 2002 validated the additional economic benefits associated with UDP use as opposed to broadcast/incorporated urea including: N fertilizer saving of up to one-third, weeding costs reduced by 26%-35% and paddy yield increased on average by 15%-20%. Environmental benefits included negligible amounts of N in runoff water and reduced levels of nitrification-denitrification and nitrous oxide emissions (Gaihre et al., 2015) from the UDP treatments compared to the broadcast/incorporated treatments due to deep placement of the N in the anaerobic zone of the soil. Preliminary results from fields where UDP has been used for an extended period of time suggest that in addition to higher yields and plant N uptake, there is also an increase in root biomass which supports maintenance of soil organic matter content and improves overall soil fertility.

The UDP technology has recently enjoyed successful upscaling and adoption in Bangladesh, following years of extensive research and trialing by IFDC and various partners in-country (i.e., International Rice Research Institute, Bangladesh Agricultural Research Institute, Bangladesh Rice Research Institute). Currently, over 28% of rice growers in Bangladesh are using UDP on more than 1 million ha of paddy rice for the combined seasons. Fertilizer partial factor productivity in Bangladesh has increased by over 50% (Miah et al., 2016) due to average yield increases of 15%-20% and **fertilizer use reduction of 33%**; this, in turn, has resulted in increased farmer income, new local non-farm employment, greater national rice self-sufficiency, reduced government fertilizer subsidy costs and enhanced environmental performance of paddy-rice farming.

Considerations to Ensure Agronomic Efficiency of the UDP Technology

In spite of the well-documented benefits, the agronomic performance of the UDP technology has shown considerable variation under different agro-climatic field conditions. Early in the research phase, it was recognized that to achieve maximum benefits from UDP technology, soil, plant and management factors must be taken into consideration (Savant et al., 1983).

Soil Properties to Consider

The type of soil has enormous influence on the success of UDP technology. Soil factors that need to be considered include the texture, N status and cation exchange capacity (CEC) (Mohanty et al., 1998). Texture can be the most influential soil factor. There is a positive relationship between transplanted rice yield response to the N available through UDP and the clay content of the soil (De Datta and Gomez, 1981). After deep placement of briquettes, high amounts of urea during the first four days and high amounts of ammonium thereafter, due to urea hydrolysis, tend to exist in soil solution at or near the placement sites (Gaudin, 1988; Savant and De Datta, 1980). In a coarse-textured soil with a high percolation rate, urea and ammonium in such high localized amounts in soil solution are very susceptible

to serious leaching losses from the rice root zone (Vlek et al., 1980). On the other hand, in fine-textured soils with low percolation rates, and with a higher proportion of urea and ammonium existing in the sorbed phase, leaching losses of deep-placed UDP-N could be negligible. Therefore, it can be concluded that to ensure the agronomic efficiency of N deep-placed, UDP should be used only in medium- to fine-textured puddled soils with low percolation rates. Conversely, the practice of UDP should not be used in coarse-textured soils with high percolation rates.

Again, soil N status can have an indirect influence on the agronomic efficiency of UDP. Transplanted young rice seedlings cannot start absorbing deep-placed UDP-N, mainly because it is spatially unavailable to them. For a given agro-climate, this “lag period” may extend up to four weeks after transplanting depending on the depth of UDP placement, seedling age and the transplanting geometry. During the lag period, the young transplanted rice seedlings therefore have to largely depend on the soil N status (or applied fertilizer N). This means that the initial soil ammonium status will determine the initial plant growth and can have significant impact on yield (Bhuiyan et al., 1984; Mengel et al., 1986; Schon et al., 1985).

The CEC of soils is positively related to the agronomic performance of UDP-N in transplanted rice (Tejeda et al., 1980). This positive relationship can be explained as follows. The CEC of soils, which is positively related to clay content (texture), helps to retain more ammonium in an adsorbed phase than in a solution phase (Ponnamperuma, 1965) and to slow down ammonium transport (movement) via diffusion and convection (mass flow) in soil. Therefore, when briquettes are deep-placed in fine-textured soil with high CEC, relatively more ammonium tends to exist in the adsorbed phase than in the solution phase in a very much restricted volume of soil-urea interaction at briquette placement sites. This eventually results in decreased downward movement and therefore negligible leaching losses of deep-placed UDP. On the other hand, when UDP is applied to coarse-textured soil with low CEC, more ammonium stays in the solution phase and is highly susceptible to serious leaching losses (Katyal et al., 1984; 1985a, 1985b). Thus, the CEC of soil plays a definite role in determining leaching losses of UDP-N, and higher CEC certainly helps to ensure its agronomic efficiency.

The CEC of soils also appears to play another beneficial role by maintaining relatively more ammonium in the adsorbed phase at a given time (Wetselaar, 1985). As a result of this retention, concentration gradients of ammonium near the briquette placement sites tend to persist longer, and spatial availability of UDP-N (as ammonium) to the rice plants, therefore, may tend to last relatively longer in soils with high CEC than with low CEC. A high CEC therefore can help in decreasing leaching losses of UDP-N and in prolonging the duration of N availability to the rice plants.

Plant Factors to Consider

The most important plant factor that can influence the agronomic performance of UDP technology is the plant growth duration. In several studies, it is observed that UDP technology was much superior to split-application of prilled urea when short- to medium-duration (~ up to 120 days) rice varieties are used (Yamada et al., 1979). These observations suggest that the rate and duration of spatial availability of the deep-placed UDP-N to the rice plants probably match more favorably the N requirement of a short- to medium-duration variety than that of a long-duration variety. It seems that, for long-duration varieties, the finite amount of UDP-N can be exhausted and used in early vegetative growth while the N requirement for other yield components may continue. Therefore, it is desirable to use rice varieties of short- to medium-duration to ensure agronomic efficiency of single deep placement of N. In order to ensure agronomic efficiency when a long-duration variety is grown, some results indicate that it helps to supplement the basal deep-placed N by topdressing with prilled urea (CRRI, 1987; Prasad and De Datta, 1979).

Management Practices to Consider

Besides the soil and plant factors, the following management factors can markedly influence the agronomic efficiency of deep-placed briquettes in transplanted rice and therefore warrant adequate consideration. Placement depth of the briquettes is one of the key management factors that influence agronomic efficiency of UDP-N. Although adequate agronomic efficiency for UDP placed at a 3-4 cm depth has been demonstrated on experimental farms (Singh et al., 1989), this shallow placement practice is considered highly risky for farmers to follow. Under farmers' field conditions, if briquette placement depth is 5 cm or less, part of the UDP-N (as urea or ammonia) can diffuse to the soil surface and into the floodwater and will be prone to ammonia loss and/or runoff loss. On the other hand, if the placement depth is more than 10 cm, the availability of UDP-N may be delayed so much (due to the “lag period”) that the initial plant growth is likely to be adversely affected. Also, deeper placement will increase the drudgery of the operation and will require more labor. Therefore, from the practical considerations, the UDP briquette placement depth of 7-10 cm is a good compromise and adequately ensures high agronomic efficiency of UDP technology.

Disturbance of the soil after briquette application also affects the agronomic efficiency of the UDP technology. Pest control and weeding operations are likely to disturb the placement sites of briquettes and eventually the ammonium

concentration gradients. Such disturbances may adversely affect the rate and duration of UDP-N supply. It therefore seems apparent that once briquettes are deep-placed, there should be minimum disturbance of the placement sites in order to ensure efficiency of the product. This easily could be achieved by adoption of a modified spacing that provides a “traffic lane” to be used for walking during weeding and pest control in order to automatically protect the briquette placement sites (Exhibit 5-1).

Water management is also critical for the success of the UDP technology. Under irrigation, where water supply can be easily controlled, maintaining adequate water supply to the fields ensures effective dissolution and distribution of the UDP-N to the rice plants.

Economic Returns to Farmers and Other Benefits with UDP Technology

UDP technology consistently delivers improved yields and superior economic returns to farmers when compared to traditional fertilizer management practices and use of conventional urea fertilizer. Economic benefits from the use of UDP compared to traditional use of urea broadcast applications arise in four areas, namely, at the farm level, at the national level, at the supply chain level and at the environmental level.

Farm Benefits

UDP technology consistently delivers improved yields and superior economic returns to farmers when compared to traditional fertilizer management practices with use of conventional urea fertilizer and equal yields to larger applications of urea applied in split applications guided by leaf color chart comparisons (Khan et al., 2009).

The high agronomic efficiencies derived from UDP technology translate to improved economic returns to farmers. Two factors are at play: “yield improvement” and “lower expenditure” on fertilizer, both due to improved crop uptake of applied nutrients (agronomic efficiency). While UDP requires a higher labor cost for fertilizer application, this is offset by lower labor requirements for weeding. Developments in mechanized UDP application will reduce the current UDP application cost and further improve the farmer benefit from using UDP. This development is important because reduced labor availability and its higher cost are realities faced by many rice farmers. The average net benefit from UDP use compared to traditional urea applications in southern Bangladesh in the three rice seasons of 2009 and 2010 was U.S. \$221/ha (Miah et al., 2016). These benefits were recorded under circumstances in which urea in all forms is subsidized by 50%. At unsubsidized urea prices, the benefits are substantially increased.

In a further study (Alam et al., 2013), it was shown that yields arising from the use of leaf color charts were better or the same as UDP use in most cases, again using subsidized urea costs. The use of leaf color charts with conventional prilled/granular urea requires much higher application of urea fertilizer (compared to UDP) due to high N-loss mechanisms of surface-applied urea.

National-Level Benefits

National benefits arise from the reduced N application rates resulting from the use of UDP, especially when urea is subsidized, but also in cases where either urea imports and/or local production are at play.

In order to illustrate, in the case of countries wherein urea fertilizer is subsidized, when rice farmers use UDP at approximately two-thirds the application rate of traditional broadcast application, there is a direct saving in subsidy cost to national governments. In the case of unsubsidized conditions, use of UDP either results in a reduction in the import requirement for urea fertilizer (e.g., resulting in a reduction of foreign exchange expenditures on imports) or a reduction in the urea requirement from local factories. In some instances, due to the reduced urea fertilizer requirement, the raw material needed for indigenous urea manufacture (e.g., natural gas) may be diverted to non-fertilizer manufacture purposes. An additional benefit is the reduction of rice imports due to increased rice production.

Supply Chain Benefits

The small-scale production and sale of urea briquettes can be very profitable for fertilizer dealers.

An IFDC survey in southern Bangladesh in 2015 of small-scale briquette producers showed that those producers fully utilizing their briquetting machine capacities were realizing gross margins of up to U.S. \$10,000 during a single season, representing a very high internal rate of return on their investment; small-scale producers utilizing 50% of the machine capacity were also profitable. Retailers selling urea briquettes, due to higher markup associated with the more efficient UDP, were also making a higher gross margin compared to selling the equivalent market demand as prilled urea.

Small-scale briquette production generates village-level employment as it takes two to three workers to properly operate and maintain the briquetting machine.

Environmental Benefits

The carbon footprint of urea is quite substantial from both a production and use viewpoint; urea is a contributor to global warming.

The total CO₂ equivalent emission from urea production is 1.7 kg CO₂/kg urea. The total CO₂ equivalent emission from traditional urea application to rice is 1.96 kg CO₂/kg urea composed of 0.73 kg CO₂ + 1.23 kg of CO₂ equivalent NO₂ emission. The total CO₂ equivalent emission from urea production and application is approximately 3.7 kg CO₂ equivalent/kg urea. For every kilogram of urea savings due to UDP, the CO₂-equivalent emission is reduced by almost a factor of four.

In addition, compared to broadcast urea application, UDP at 7-10 cm depth reduced N₂O emissions by between 61% and 84%. The global warming potential of N₂O is about 300 times higher than CO₂. UDP use substantially reduces environmental degradation resulting from ammonia losses from traditional urea broadcast applications to the atmosphere and to groundwater runoff.

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II. UDP Project Initiation Phase

Proper planning, allocation of adequate resources and establishing mutually beneficial relationships with key stakeholders are essential to UDP project success.

The project initiation phase will set the stage for early and sustained UDP project success. Three main tasks will be performed during this phase, which is expected to be about four months in duration:

- **Target Market Assessment completed and Strategic Plan developed:** Proper planning for the UDP project requires understanding the specific conditions and many factors that may impact the local manufacture and introduction of a new fertilizer product and changing farmer behavior to adopt a new application technique.

The Target Market Assessment (called “initial rapid appraisal” in some areas), to be conducted within the first 60 days of the initiation phase, is designed to provide a thorough understanding of all factors that may potentially impact UDP project success, including: (1) soil and cropping conditions; (2) policy-related issues that impact new product introduction and agro-input dealer operations; (3) the fertilizer market structure (e.g., public/private/marketing channels/dealer networks) and efficiency in servicing the fertilizer-related needs of farmers; (4) the suitability and interest of agro-input dealers (and others such as fertilizer wholesalers/distributors and non-governmental organizations) to engage in UDP briquette manufacture and include UDP fertilizers in their product mix; and (5) macro-environmental factors (e.g., farmer literacy rates, dealer access to financing, cropping seasons) that influence new product introduction.

The UDP Project Strategic Plan will flow from the Target Market Assessment; it will be tailored to the specific conditions that prevail in the target market. Note that each market targeted for UDP technology introduction and market development will differ, and the Strategic Plan will be specifically developed for and adjusted to the prevailing and changing conditions. The plan will include: (1) specific quantifiable objectives; (2) a detailed list of project activities and performance schedule by quarter (supported by a Gantt chart); (3) a detailed list of resource requirements (including staff requirements and an asset list for full project budget); and (4) metrics for performance measurement. The Strategic Plan will include the UDP project organogram and the role and function of each unit identified in the organogram.

- **Collaborating Partner commits the needed resources for the project:** The Collaborating Partner (CP) is ultimately responsible for the success of the UDP project. The CP must make a firm commitment to provide the financial resources needed in planning and project implementation in a timely matter. For illustrative purposes, there must be a firm commitment of financial resources for: (1) recruitment of staff to implement and manage the UDP commercialization program and (2) the ongoing strategic activities needed to (a) further evaluate and refine UDP recommendations for various crops and agronomic conditions; (b) create farmer awareness of and demand for UDP products; (c) facilitate policy reforms to alleviate constraints to UDP entry in the market; (d) stimulate the development of a supply system to ensure farmers access to a convenient and timely supply of high-quality UDP products at a reasonable price; and (e) design and implement management systems for tracking and reporting progress against objectives and targets. UDP project implementation may be handled directly by the CP or through an implementing agent (e.g., consulting firm, international organization/NGO) selected by the CP.¹³
- **Public and private linkages that will impact UDP market established:** Both public and private sector entities will impact the success of the UDP project. Key areas for building linkages will be in research and testing of UDP products, creating/improving farmer access to UDP products, building farmer knowledge of UDP product use and benefits, identifying private sector agents interested in and ready to engage in UDP input and equipment production and distribution and linking private investors to farmers and to funding sources. During the initiation phase, the CP/IA will identify (through the Target Market Assessment) and appraise the impact potential of those entities (research and extension, farmer organizations, input dealers, financial institutions, etc.). When feasible, written agreements in the form of a public-private partnership will be developed to indicate roles and responsibilities of each party.

¹³ IFDC will provide technical support and guidance during the project initiation phase and potentially thereafter, subject to needs and agreement with the Collaborating Partner.

Chapter 1. Target Market Assessment

The Target Market Assessment is a key initial step in building the foundation for a successful UDP commercialization program.

To be completed within the first 60 days of the Initiation Phase, the assessment will be conducted by the Collaborating Partner/Implementing Agency (CP/IA). The objective will be to identify fertilizer demand and supply-side opportunities and threats that may impact UDP technology diffusion. Included will be an evaluation of the agriculture sector (e.g., soil map, cropping systems map, farmer profile, on-farm production efficiency, yields), an assessment of potential farmer demand for UDP and an appraisal of agriculture input and output markets within the target region. The fertilizer supply and marketing system will be evaluated in a broad context to gain a better understanding of the roles of various public and private sector entities, the functioning of the marketing system and performance factors that may impact the UDP market. In addition to assessing supply/marketing channels (e.g., agro-input dealers, non-governmental organizations (NGOs), cooperatives, farmer groups, agriculture parastatals, estate crop sector) and the fertilizer policy environment, the assessment will evaluate dealer networks and the potential for expansion to include the supply of UDP products in their fertilizer product mix. The assessment also will address the potential supply options for local fabrication of briquetting machines and UDP product applicators. The extension service has a key role to play in knowledge transfer and technology introduction; the availability of farmer advisory services – including the potential to fully engage the public extension service and the opportunity to utilize the private sector in UDP technology dissemination – will be appraised.

Design and Conduct of the Assessment

The Target Market Assessment will provide the foundational information for the Strategic Plan. It will be conducted by the IA. Proper advanced planning and allocation of sufficient resources and staff time are essential. The following general guidelines apply:

1. **Goal of the Assessment:** To provide a thorough understanding of all factors that are relevant to UDP market development and support development of a Strategic Action Plan for the UDP project.
2. **Objectives:**
 - a. Assess the fertilizer market and fertilizer promotion and policy-related issues that impact the fertilizer market. This includes evaluating the fertilizer product mix used by farmers, physical distribution systems from point of production/import to farmer access points and pricing issues (costs and margins).
 - b. Assess agronomic potential for UDP by agroecological zone and crop in the target market. (Note that the significant response to UDP has primarily been on lowland rice. Current and future research on direct-seeded rice and other crops may greatly expand the potential for UDP.)
 - c. Identify and assess demand-related factors of UDP and fertilizer in general (e.g., economic returns from fertilizer use on targeted crops, farmer access to and use of fertilizers, availability and cost of seasonal labor, access to affordable credit, crop marketing factors, farmer attitude toward change).
 - d. Identify and assess UDP supply potential (including assessment of market entry at various channel levels and potential for local fabrication of briquetting machines).
 - e. Identify and assess fertilizer regulatory and policy-related factors that may impact UDP market development (e.g., fertilizer product approvals, pricing policy, licensing, input subsidy and taxation policies, fertilizer regulations, quality control).
 - f. Assess the capacity and reach of extension services (public and private) that may be engaged in technology dissemination.

- g. Identify and assess potential collaborative linkages to further UDP technology diffusion and leverage resources.
3. **Expected Result:** The Target Market Assessment report will provide a thorough understanding of the factors that may impact success in the introduction and development of the UDP market.
- a. The report must be a well-written, professional document that is presented in a well-structured format.
 - b. All relevant factors that may impact the successful introduction and development of a fertilizer-related technology (e.g., UDP technology) must be fully assessed from three perspectives:
 - **Farmer:** Is the technology suited to the farming conditions (soil, water, crops and farmer characteristics) in the target market?
 - **Market:** Is the technology sufficiently attractive from a business perspective to stimulate investment in the supply system and market development? The size and stage of development of the fertilizer market will impact channel-related decisions on market entry.
 - **Public Sector:** Is the technology consistent with the national interests of the country wherein UDP is targeted? The fertilizer regulatory system and policy framework will impact the development of the supply and marketing system.
4. **Methodology:** The assessment team will be organized by the IA. The study should be guided by standard market research methodologies. An effective technique that may be used to conduct the market assessment is the SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis approach. This includes the use of secondary data (published and unpublished) to the extent possible; secondary data will need to be supplemented by the collection and analyses of primary data.

At the assessment planning and design stage, the team should discuss the specific data requirements in order to understand various secondary data sources and to identify the need for (and best approach to collect) primary data. Secondary data sources will vary by country/target market. For illustrative purposes, secondary data sources may include the following:

- Data on crop agriculture and the fertilizer sector, derived from the Ministry of Agriculture (MOA), Bureau of Statistics and other authorities responsible for statistics related to land use by crop and variety, crop production and yield, gross margins and fertilizer supply/demand/imports.
- Planning documents that target crop sector performance and land use (e.g., Ministry of Planning and MOA).
- Reports of international organizations and development agencies that address the agriculture sector and/or fertilizer market development issues.
- Statistics available through international organizations such as the Food and Agriculture Organization of the United Nations (FAO), International Fertilizer Association (IFA), IFDC, World Bank, specific country-related fertilizer associations and others.
- Reports available through national agricultural research organizations (NAROs) and international agricultural research centers (IARCs).
- Reports available through NGOs and national and multinational organizations (e.g., national fertilizer association, national farmers' association).

In many cases, secondary data on important variables may not be available from secondary sources. For example, primary data may be needed on assessment of dealer networks, fertilizer pricing, policy-related issues that impact the fertilizer market and agriculture labor availability/costs, economic returns by crop and fertilizer use by crop. The strategy for collection of primary data must be carefully planned to achieve desired results in a timely manner. Sources of primary data may include: (a) fertilizer importers/wholesalers/retailers, (b) farmer-based organizations, (c) commercial banks, (d) farmers, (e) central and decentralized government technical offices, (f) agribusiness enterprises, and (g) NGOs.

The resource requirements for the Target Market Assessment will vary by the characteristics of each target market, the availability of quality secondary data and the need for collection of primary data.

5. **Study Team Composition:** The study team should be composed of specialists knowledgeable about agriculture and the fertilizer sub-sector. The following disciplines are appropriate in the team composition:

¹⁴The team leader also should have thorough understanding of fertilizer policy issues and impact on market development.

- Agricultural economist/fertilizer marketing specialist (team leader).¹⁴
 - Soil scientist/agronomist.
 - Fertilizer production engineer.
6. **Timeframe:** The Target Market Assessment should be completed within the first 60 days of the UDP market development initiation phase.
7. **Market Assessment Report (report structure):** As indicated above, the assessment must be a well-written and well-structured document. The following general structure will ensure that the assessment is sufficiently comprehensive to support the Strategic Plan.
- a. **Agriculture Sector:** The agriculture sector assessment will identify and appraise the key factors and issues that may impact fertilizer market development in general and market development for UDP products in particular. This section will (at a minimum) address the following:
- Soils (characteristics) and cropping pattern by geographic zone in the target area:
 - Soils profile.
 - Area planted (hectares planted by crop and by agriculture zone): This should be presented in a table format with a brief narrative describing any significant characteristics and trends.
 - Crop seasons: Identify planting/harvest periods by crop; indicate cropping intensity. Seasons should be presented in a calendar format by crop.
 - Profile of crop production systems: Identify crops and varieties that may be targeted for UDP market development. Rice is particularly well-suited. Indicate areas/trends in high-yielding variety (HYV) seed, area and method of irrigation, planting method (e.g., direct seeding versus transplantation), extent of mechanization, use of labor and availability of labor during planting seasons.
 - Yields per hectare by crop and by geographic area: Estimate crop yield and trends by target zone.
 - Existing cost and return estimates of rice and other crops in UDP target zones.
 - Fertilizer use by product type and by crop.
 - Summary of key constraints to bridging the yield gap: Identify all factors that are contributing to the yield gap and rank them based on significance of impact.
 - Government policy and/or national strategy on agriculture. This includes productivity/yield improvement targets, export targets, government estimates of crop area by zone and other factors that may impact UDP technology use to advance agriculture.
 - Farmer profile:
 - Average size of farm: Estimate the household cropped area based on categories of farmers – smallholder, medium, large, commercial and estate.
 - Farmer income: Estimate farm income by farm size.
 - Labor availability and use at various stages: Land preparation, production-related activities and harvest.
 - Literacy level of farmers (estimate for farmers in the UDP target zones).
 - Source of agriculture/technology information available to farmers: Determine the information sources for farmers targeted in the UDP zones (e.g., personal contact with government extension agents, NGO extension agents, fertilizer dealers, private seed companies, television, radio, print, information and communication technology).
 - Farmer access/use of production credit in farming: Describe farmer access to finance in the targeted zones.
 - Post-harvest:
 - Estimated portion of crop that is sold in the market: What quantity of the harvested crop is used in on-farm household consumption and what quantity is sold in the market by season? Estimate the portion of incremental production (that may result from UDP) that would be sold.
 - Crop marketing at the farm level: Describe the various methods that farmers use in selling their crop (e.g., village market days, through public sector, contract farming).
 - Crop pricing: Indicate crop pricing methods and prices received by farmers by crop.
- b. **Fertilizer Market:** Assess fertilizer market-related factors that may impact farmer demand for UDP technology and farmer access to a supply of high-quality UDP products in close proximity to farms. An overview of the fertilizer market should include the following:
- Market size: Identify annual sales of fertilizer (by product) for the past five years. Identify trends in fertilizer use by volume (metric tons) in the targeted country/zones. Estimate intensity of use (kilograms

per hectare) by primary nutrient and product mix (urea, other N fertilizers, DAP, muriate of potash [MOP], etc.).

- Estimated fertilizer use by market segment: Estimate fertilizer product use and kilograms of nutrient per hectare for each category of farmer: (smallholder, medium, large, commercial and estate).
 - Estimated fertilizer use by crop/geographic region (kilograms of nutrient per hectare).
 - Fertilizer pricing overview: Identify factors that impact farm-level prices of fertilizers (e.g., methods of setting fertilizer prices, estimated cost-buildup to retail-level prices – by fertilizer product).
 - Market structure: Identify the role of the public and private sector in the fertilizer market. Develop diagram of the market structure and physical flow of fertilizers from the source of origin to farm-gate via various channels (e.g., private agro-input dealers, cooperatives, NGOs, farmer groups, government agencies).
 - Supply sources: Identify local manufacture/imports by product volume and source.
 - Marketing network: Identify wholesalers and dealer network (number of wholesalers, dealers, estimated sales volume by dealer and relationships among value chain members).
 - Role of fertilizer dealers in new product introduction and in provision of advisory services to farmers: Do fertilizer dealers advise farmers on soil nutrient management and/or product use? Also identify the role of dealers in technology promotion (e.g., through wall hangings, technology demonstrations, field days).
 - Credit: Identify and appraise agro-input and fertilizer dealers' ease of access to credit (bank credit, supplier credit and terms).
 - Fertilizer promotion: How do farmers gain awareness and knowledge of new technologies and farming methods? Farmer education methods (public sector extension services) include fertilizer demonstrations/field days (key actors – NGOs, public sector/private sector), radio and TV messaging, farmer groups/clubs and advertising (billboards, shop signs and/or signboards)?
 - Fertilizer policy and regulatory issues: Identify policies and provisions of the national regulatory guidelines that pertain to fertilizers and may impact UDP products and availability to farmers (e.g., product approval, fertilizer product registration, dealer registration/licensing, pricing, fertilizer stock holding, fertilizer procurement).
- c. **Cross-Cutting Issues:** Assess cross-cutting issues that may affect market development for UDP products.
- Information and communication technology (ICT): Determine status of ICT and potential to engage ICT in providing farmer advisory services, linking members of the fertilizer marketing system and linking farmers to markets.
 - Briquetting machine fabrication at local level: Identify local metal works shops and capacity (e.g., for fabrication of briquetting machines and UDP product applicators). Complete a general assessment of the number and capacity of local metal works shops in fabrication of briquetting machines. Include contact name and address of shops with high potential and interest to deliver high-quality machines. Assess capacity to import or source high-quality bearings and brass fittings/high-quality steel.
 - Agriculture extension service:
 - Determine its role in technology introduction.
 - Conduct a general assessment of the efficacy and capacity to include advisory services to farmers on UDP technology use/benefits.
 - Assess the need/opportunity to include UDP technology in education curricula of the MOA/ Department of Agricultural Extension (DAE) and/or other training institutes.
 - Non-governmental organizations:
 - Determine the roles and geographic focal areas of those with agriculture-related programs.
 - Assess interest to support UDP technology diffusion through use of UDP products in farm-level fertilizer/technology trials, investment in fertilizer briquetting machine as a service to farmer groups and inclusion of UDP technology in recommendations for farmer beneficiaries.
 - Agricultural development programs of donors/development organizations:
 - Explore opportunities to establish linkages with various development programs that may be in progress and/or the planning stage. Included may be projects/programs that concern:
 - Agriculture productivity improvement.
 - Food security improvement and poverty reduction.

- Agribusiness development.
- Fertilizer market development.
- Role of women (in areas that may impact UDP technology and opportunities for women empowerment):
 - In agriculture – production, harvest and post-harvest activities.
 - Ownership/operation of micro-enterprises.

Strategic Action Plan for UDP Market Development

It will be the responsibility of the IA to develop the Strategic Plan. The plan must be a written document. IFDC will provide assistance (in review of and guidance) on plan details.¹⁵

The Strategic Action Plan will flow from the Target Market Assessment. It will incorporate elements of a conventional business plan and serve to guide the UDP project. The plan should cover the project duration (typically four to eight years) as determined by the scope and complexity of the market development effort and the availability of funds. It will be a “living document,” meaning that it should be sufficiently flexible to allow modifications as opportunities and/or threats to progress materialize. For example, the initial focus will be on UDP with emphasis on lowland rice production. As the technology becomes established, it may evolve to include production of multi-nutrient fertilizer briquettes and application on various high-value crops where research and field trials yield favorable results.

The Strategic Action Plan will include a narrative on the strategic approach to farmer education, capacity building of UDP product suppliers (e.g., in manufacture of high-quality UDP products and provision of advisory services to farmers), policy reforms needed for supply and marketing system development and the UDP promotion campaign to create farmer awareness/build demand. The narrative will address building public-private partnerships to leverage resources and achieve synergies that will accelerate progress in UDP technology diffusion and contribute to sustainability. It also will stipulate the research activities needed to continue to refine UDP use recommendations.

Building upon the SWOT analysis, the Strategic Action Plan will identify:

- Specific project goals and objectives.
- The specific target market for UDP technology introduction and market development (e.g., geographic area, types of farmers targeted, number of UDP supply points by area, source points for UDP briquetting machine fabrication).
- A detailed list of the time-sequenced performance activities needed to concurrently stimulate farmer demand for UDP products and nurture a supply system to provide farmer access to high-quality products.
- Specific scheduling and protocols for UDP research activities, collaborative linkages and dissemination of results.
- Specific policy and regulatory system issues and reforms needed to allow UDP technology introduction/market development.
- Metrics appropriate to measuring progress in UDP market development – progress in performance activities, achievement of specific quantifiable objectives and results achievement.
- Project organizational structure, including staffing detail requirements.
- Physical assets needed for project implementation.
- Detailed financial resource requirements (by quarter) to implement the project.

The remaining chapters in this manual identify numerous activities that will need to be included in the Strategic Action Plan.

¹⁵ As indicated earlier and throughout this manual, IFDC may be contracted by the Collaborating Partner to serve as the Implementing Agency for the UDP project; in these cases, initiation and roll-out phase activities would be performed by IFDC on a cost-reimbursable basis.

Chapter 2. Public and Private Linkages Impacting UDP Market

Understanding the respective roles of the public and private sectors, as well as the potential for engagement of international agricultural research centers (IARCs) and non-governmental organizations (NGOs), will allow for effectiveness and efficiency in developing, managing and controlling the UDP market development strategy.

The public and private sectors will impact UDP technology demand- and supply-side development. For example, stakeholders from the public sector¹⁶ and private sector¹⁷ impact demand by facilitating knowledge transfer and changing farmer behavior through education and advisory services. Demand also is influenced by farmers' ability to access markets (e.g., through agribusiness processors and public/private buyers in the domestic market) to sell their incremental yield achieved using UDP technology. On the supply side, UDP technology introduction and market development may involve government clearances for "new" products (such as UDP briquettes) to be on the "approved" list of fertilizers and for dealers to manufacture/market UDP products. National agricultural research organizations (NAROs) often play a key role in new product testing to validate performance of UDP under local conditions. It is essential to fully understand the roles of the relevant public and private sector entities that may impact the fertilizer market, and more specifically UDP technology.

Role of the Public and Private Sectors

The role and capacity of actors in the fertilizer sub-sector vary across countries. In some cases, both the public and private sectors engage in activities of a similar nature. For example, in some areas, state agencies are engaged in fertilizer marketing to farmers in competition with private agro-input dealers. The Target Market Assessment will identify the various roles of each sector and instances in which the sectors have common roles. The SWOT analysis will be useful to assess the relative strengths and weaknesses of each.

For illustrative purposes, the roles of the public and private sectors in the fertilizer sub-sector may include the following:

a. **Public Sector:**

- Policy formulation and enforcement influence:
 - Fertilizer supply and marketing functions (e.g., fertilizer regulatory system, dealer licensing, fertilizer import procurement, elements of UDP manufacture, stockholding, fertilizer pricing, monitoring quality of products).
 - Introduction, approval, testing and evaluation of new fertilizer products.
- Information collection and dissemination regarding fertilizer supply (local production/imports/stocks), farmer demand/use, prices and technology adoption rates.
- Farmer education (including problem resolution on soil fertility management issues, technology awareness/introduction and knowledge building). In some cases, the role of the government may extend either to performing or substantially controlling various fertilizer marketing functions, even to the retail point of fertilizer sale to farmers. The government also may be directly involved in planning/approving the fertilizer supply to ensure that it meets farmers' needs.

b. **Private Sector:**

In most developing countries, the private sector has become increasingly involved in the performance of fertilizer supply and marketing functions. The role of the private sector may typically include the following:

- Fertilizer supply and marketing functions:
 - Developing and managing the supply of fertilizers – importation and/or procurement from domestic manufacturers. Domestic marketing activities – at the wholesale/distributor and retail levels, these include product selection, promotion of fertilizer products, fertilizer pricing, provision of credit at various levels, briquetting machine fabrication, physical distribution and dealer network development, quality control, information collection/analysis for planning and control of supply/marketing activities, etc.

¹⁶ Ministry of Agriculture, Department of Agricultural Extension, etc.

¹⁷ Agro-dealers associations, farmer groups, NGOs, etc.

- Introduction of new/improved fertilizer-related technologies.

A thorough understanding of the roles of the public and private sectors in the fertilizer market is essential to planning specific activities and interventions to achieve orderly development of the market for UDP products.

Collaborative Relationships to Accelerate UDP Technology Diffusion

The Collaborating Partner/Implementing Agency (CP/IA) will build linkages with both the public and private sectors in order to rapidly advance and sustain the UDP market. Within the public sector, initial engagement of the Ministry of Agriculture (MOA) and Ministry of Environment will be essential to gain participation in UDP technology evaluations and to complete environmental scans. Such linkages also will facilitate alleviation of possible policy barriers that may impact market development. Within the private sector, building linkages with the input suppliers, metal works fabrication shops, the banking community and even local media (radio, newspaper and TV) will contribute to private sector investment in the supply system for UDP products. NGOs often play a key role in development; through the initial Target Market Assessment, NGOs that may be relevant to UDP technology diffusion will be identified. To the maximum extent possible, the collaboration should:

- Be based on a structured relationship with clearly defined plans – activities, inputs, expected results and deliverables. If the collaborator is an NGO or donor-funded initiative, a written agreement (e.g., memorandum of understanding or letter agreement) may be appropriate.
- Involve multiple collaborators concurrently.
- Be dynamic in nature to adjust to changing conditions in the target country.
- Be actively managed, with emphasis on information dissemination.

As indicated above, it is important (to the extent feasible) to involve multiple collaborators simultaneously. For example, engaging NAROs to conduct UDP research trials may be done at the same time as collaborative activities are in progress with the MOA or agriculture extension service to train extension officers on the proper use of UDP technology. This may occur at the same time as collaborative activities are implemented with NGOs (as well as IARCs) to include UDP technology in their interventions to improve agriculture productivity.

The conditions that prevail in the target market will influence how best to proceed to achieve results in a timely manner. This includes the establishment of collaborative relationships. For illustrative purposes, in some cases it may be advantageous for the IA to establish its own UDP trials in the first season and use the trials to draw the attention of the MOA to the technology and associated benefits.

Functional areas in which the IA should explore/pursue linkages include the following:

- UDP Product Approvals** – UDP fertilizers may or may not require approval by the MOA and/or other government authorities prior to sale to farmers.¹⁸ In cases in which the UDP product approval is required, the CP/IA should pursue the approval through research linkages with NAROs and university agriculture systems. While each situation may differ, some (or all) of the following steps may be involved in the approval process:
 - Identify the relevant authorities with jurisdiction over fertilizer product approvals and gain an understanding of the approval process.
 - Identify the relevant authorities within the NAROs and the university system that are engaged in soil nutrient management studies.
 - Share UDP research and on-farm results with the various researchers. Extensive research results are available through IFDC.
 - Seek a collaborative relationship (documented) with NAROs and university systems to conduct trials with UDP under research protocols established by the CP.
 - Routinely visit research trials to review procedures, identify issues that may impact UDP evaluations and correct as needed. Visits should be made at the time of crop planting, during UDP application, every three weeks after application until harvest and at the harvest stage.
 - Conduct workshops to share research results on UDP technology.

¹⁸In most countries, fertilizer regulatory provisions are such that “new” products require vetting and official approval by the regulatory officials. The process of “new” product approval will vary by country. As described in this manual, UDP products are derived from compaction (under high pressure) of conventional urea fertilizers (prilled or granular) to achieve a larger sized product. The larger sized particles (up to 2.7 grams in weight) are of the same chemical composition as conventional urea fertilizer. In discussions with fertilizer regulatory officials regarding UDP fertilizer market entry, the IA should be able to achieve approval for the manufacture and sale of UDP on the basis that urea is already on the list of approved products.

b. **Fertilizer Sector Policy Issues** – Fertilizer policy issues that may impact UDP introduction and market development include: (i) fertilizer procurement and stock holding; (ii) pricing of fertilizers; and (iii) dealer licensing to allow dealers to manufacture and/or market fertilizers. Fertilizer sector policy reforms to achieve a market-friendly environment that will allow for UDP manufacture and sale and pricing flexibility may be needed. Establishing fertilizer-related policies would typically be under the authority of the MOA and/or the Ministry of Industries. The IA must have the capacity to interact directly with the concerned policymaking authority to alleviate policy-related constraints. Collaboration with an international organization (e.g., International Food Policy Research Institute, IFDC, Alliance for a Green Revolution in Africa) or a donor-supported initiative concerned with policy analysis and reform may be appropriate to identify needed reform measures and advance those measures.

c. **UDP Briquetting Machine Fabrication** – UDP manufacture is well-suited to small-scale enterprises, based on relatively low-cost briquetting machines. The fabrication of briquetting machines requires: (i) the use of high-quality component parts (e.g., hardened steel, rollers, bearings) and (ii) a high degree of precision (e.g., in “machining” the metal components of the briquetting machine and assembly). The machines can be fabricated locally in most areas. The capacity for local fabrication of the machines should be assessed as described in Chapter 1.

Local agriculture machinery enterprises are an appropriate contact point to explore the potential for UDP briquetting machine fabrication. The IA should explore collaborative relationships with those NGOs and/or donor-assisted programs that are involved in manufacture/distribution of agriculture equipment.

d. **Building the UDP Supply System** – The supply of UDP products will be made available to farmers through a network of various channel members and farmer-based organizations. Typically, the existing fertilizer dealer/retailer network is often best positioned to be the supply point for farmers and, if successfully engaged, will contribute to sustainability of the market. Emphasis must be on providing dealers with information and support in developing their technical capacity and marketing, including building farmer demand.

The IA should engage with the relevant donor-assisted programs and NGOs that may be involved in the introduction of UDP technology to ensure that their respective programs complement, rather than compete, with the private dealers in sourcing UDP products.

e. **Creating Demand for UDP Technology** – Creating farmer demand for UDP technology should be a high priority and pursued concurrently with developing a supply system to meet demand for UDP products. The potential for collaborative linkages to accelerate farmer awareness/demand creation programs for UDP technology will be high in most countries. Collaborative linkages should be established with the following:

- MOA/Department of Agricultural Extension – Emphasis on inclusion of UDP in extension staff training curricula, agriculture research trials and demonstrations and field officer farm visits/farmer training programs.
- NAROs/agriculture universities – Emphasis on inclusion of UDP in research trials and farmer/student education materials.
- IARCs – Emphasis on inclusion of UDP technology in research and demonstration activities designed to increase rice productivity.
- NGOs – Emphasis on inclusion of UDP technology in fertilizer dealer development initiatives (e.g., trainings, technology demonstrations, advertisements, other promotional activities) and in activities that target improved food security and rural income growth.
- International development agencies/donor-funded programs – Emphasis on inclusion of UDP technology in all programs that involve fertilizer sector development and improve the productivity of agriculture.
- Private sector companies/associations – Emphasis on the inclusion of UDP technology in private sector companies’ technology demonstrations/field days and dealer training events. These include multi-national firms as well as national fertilizer and seed associations.
- Local media – Emphasis on inclusion of UDP technology in radio and TV programs in local languages to carry promotional and technical messages and benefits to farmers and other stakeholders.

f. ***Cross-Cutting Issues***

- Women and youth empowerment – UDP technology influences income generation potential at the fertilizer dealer level, during on-farm production and during post-harvest activities. In many cases, UDP increases micro-enterprise and labor opportunities for women and youth. The CP should explore such opportunities and develop collaborative linkages with NGOs and donor-assisted programs that target empowering women and youth groups through agriculture and agribusiness development.

III. Rollout Phase for UDP Technology

In order to achieve success in market development for UDP products, supply-side and demand-side interventions must occur concurrently. The Strategic Action Plan will guide the Rollout Phase interventions that will proactively address policy-related barriers to UDP market development, further refine UDP application rates through research and field trials, build farmer demand, and establish a supply and marketing system that will afford farmers access to high-quality UDP products on a timely basis.

The **Rollout Phase** will build on the information developed, knowledge gained and systems initiated during the initiation phase. It will begin about four months (~120 days) into the initiation phase. By this time, (a) the Collaborating Partner (CP) will have organized the resource requirements for the project and selected the Implementing Agency (IA); (b) the Target Market Assessment and Strategic Plan will be completed by the IA and approved by the CP; (c) the IA's project staffing will be sufficiently advanced to begin full-scale implementation of strategic plan activities; and (d) arrangements will be made to ensure an adequate supply of urea briquettes to "seed the market" and support research and development purposes.

As indicated throughout this manual, in order to achieve success in market development for UDP products, supply-side and demand-side interventions must occur concurrently. On the demand side, rapid diffusion of UDP technology requires creating farmer awareness and interest and stimulating change in farmer behavior to adopt a new technology. A series of concurrent demand-influencing activities (knowledge building/awareness creation) at the farmer level are required. An aggressive UDP promotion/advertising campaign will complement farmer training programs and workshops to create awareness of UDP technology and build farmer knowledge. In order to achieve a "train the trainer" effect, the IA will collaborate with the Ministry of Agriculture/Department of Agricultural Extension (MOA/DAE) to include UDP technology in the training and farmer education materials used to train MOA/DAE staff. The IA also will collaborate with relevant non-governmental organizations (NGOs) to provide appropriate farmer training materials on UDP technology. The following are key activities to create awareness and build farmer demand for UDP:

- Farmer training (classroom and field).
- MOA/DAE staff training (classroom and field).
- Technology demonstrations/field days.
- Use of roadside sign boards/billboards.
- Use of mass media – television/radio/newspaper/agriculture bulletins.
- Farmer meetings.
- Agriculture fairs/trade shows.
- Training of relevant NGO staff.

Research and field trials with UDP products will be intensified and continue throughout the Rollout Phase. They will continue throughout the project to further refine recommended UDP application rates and reinforce UDP technology and associated benefits.

On the supply side, it is essential to nurture an orderly development of the supply and marketing system so that farmers have timely and convenient access to a ready supply of high-quality UDP products. Based upon the current status of UDP production technology and the fact that urea briquettes will be a new product in the marketplace, the supply and marketing system may be based upon small-scale fertilizer briquetting machines, ideally to be located at the village level and in close proximity to farmers' fields. In the event local demand for fertilizer is in a very early phase of development, it may be best to focus on fertilizer suppliers at the wholesale level as the entry point for briquette manufacture. Concurrent attention will be given to building the foundation for a UDP product supply and marketing system that can sufficiently expand to meet anticipated growth in demand. This will include proactively addressing policy-related issues that may impact the urea briquette manufacture, establishing domestic capacity to fabricate fertilizer briquetting machines based upon the IFDC engineering design, and developing a network of dealers that invest in the capacity to extend their product mix to include UDP products. IFDC may provide the CP/IA guidance on policy reforms that may be needed to enable local manufacture and sale of UDP products. The IA capacity-building support to both (a) machine shops that fabricate the briquetting machines and (b) dealers

interested in adding UDP products to their fertilizer product mix will be extensive and ongoing throughout the life of the project. The support may be varied and include capacity-building training of dealers to extend their product knowledge in UDP manufacture and best use practices, establishing linkages between dealers and briquetting machine suppliers and improving dealer access to finance. In some cases, a subsidy element may be needed to provide adequate incentive to dealers to invest in UDP briquetting machines. Quality control in urea briquette supply is essential to dealer success; it must be emphasized throughout the project to ensure farmers have access to high-quality UDP products.

Chapters 3-7 will guide the IA in local fabrication of fertilizer briquetting machines and UDP briquette manufacture, development of a UDP dealer network, design and implementation of the UDP promotion program and research protocols, and management of UDP field demonstrations. Attention is also devoted to management of the UDP project to achieve sustainable progress in UDP market development.

Chapter 3. UDP Briquetting Machine Operation and Maintenance

A consistent supply of adequate quantities of high-quality fertilizer briquettes is essential to UDP market development. The briquettes must be competitively priced against conventional fertilizers and conveniently available to farmers.

There is no global supply system for urea briquettes. Supply is based upon local, small-scale fertilizer briquetting machines that have been designed by IFDC. This chapter provides details on the fertilizer briquette manufacturing process, including machine operation and maintenance and the process for fabrication of briquetting machines. This chapter also covers key elements that must be addressed to ensure that the UDP fertilizer supply system is established concurrent with the growth in farmer demand for the product. In turn, Chapter 4 provides guidance on developing the marketing system so that farmers will have access to UDP products.

As a first step in securing a supply of urea briquettes (i.e., during the Initiation Phase), the Implementing Agency (IA) should import two fertilizer briquetting machines. The delivered cost of each machine will be approximately U.S. \$2,500-\$5,000 (2015). The IA will operate the briquetting machines as necessary to manufacture adequate quantities of urea briquettes to initiate research activities and UDP trials to be conducted in cooperation with the Ministry of Agriculture/Department of Agricultural Extension (MOA/DAE), national agricultural research organizations (NAROs) and selected non-governmental organizations (NGOs).

IFDC may support supply system development through provision of information and technical support to the IA.

The market assessment, to be completed in the Initiation Phase, will provide a complete understanding of the current fertilizer supply and marketing system in the target region. This will be needed to understand opportunities and potential threats to dealers securing a supply of raw materials for UDP manufacture. UDP fertilizer will become a “new” product addition to the fertilizer product mix in the existing supply system.

The market assessment, to be completed in the Initiation Phase, will provide a complete understanding of the current fertilizer supply and marketing system in the target region. This will be needed to understand opportunities and potential threats to dealers securing a supply of raw materials for UDP manufacture. UDP fertilizer will become a “new” product addition to the fertilizer product mix in the existing supply system.

Getting Started: A separate supply system for UDP fertilizer is not needed. Rather, **UDP should be introduced through the already established fertilizer/agricultural input supply and marketing system** (e.g., agricultural input dealers, including private dealers, cooperatives, agriculture input supply parastatals, NGOs and others).

UDP Fertilizer: Commercially available urea fertilizer (in either the prilled or granular form) is the basic fertilizer (i.e., raw material) used to make UDP fertilizer. A simple transformation of commercial urea fertilizer (46-0-0) to a larger particle size is achieved through a compaction process. The resultant UDP product is referred to as a “briquette” and has the same chemical analysis as commercial urea fertilizer. The quantity of nutrient supplied by each briquette will be determined by multiplying the weight of each briquette times the nutrient content of urea (e.g., 46% N).

Fertilizer Briquetting Machine: A specially designed briquetting unit facilitates the formation of the UDP fertilizer briquettes. The briquetting unit is well-suited to small-scale production and designed for village-level operation (see Exhibit 3-1).

IFDC holds the legally registered patent protection for the UDP product briquetting units.

Sourcing the UDP Briquetting Machine: The UDP briquetting machines are low technology, but they require high-quality component parts and high precision in design and operation to ensure consistent delivery of high-quality UDP fertilizers (see Exhibit 3-2).

- **Import of Units for Quick Supply System Startup:** Bangladesh is the only country that currently fabricates and exports UDP briquetting machines. The machines have been exported to more than 20 countries in Asia, Africa

and Latin America at a cost of about U.S. \$2,500-\$5,000 per briquetting unit.

- **Local Fabrication:** Fertilizer briquetting machines may be fabricated in metal works shops in any country.¹⁹ Ideally, as UDP demand levels grow, local fabrication of the UDP units will materialize through the efforts of the IA and key stakeholders.²⁰

UDP Supply and Integration in the Fertilizer Supply System: The Strategic Plan will guide the introduction of UDP in the fertilizer supply and marketing system. At a minimum, the Strategic Plan section on UDP Product Supply and Physical Distribution System should include:

- ✓ Goal and specific objectives.
- ✓ Sourcing of briquetting machines: local fabrication versus import of machines and identification of metal works shops.
- ✓ Entry into market
 - Selection of targeted actors in the market for UDP introduction: input wholesalers/dealers, NGOs, others.
 - Establishment of metrics for dealers that will manufacture UDP.
 - Establishment of metrics for dealers by geographic region that will include UDP in product mix.
 - Establishment of rolling three-year sales targets by crop and by season for UDP.
- ✓ Training
 - High-quality manufacture of briquettes.
 - Proper storage and handling of UDP.
 - Proper use/application under various crops/cropping conditions.
 - Briquetting machine assembly, installation and maintenance.

Description of the Briquetting Machines: As previously noted, the briquetting machines have been designed to produce urea briquettes using prilled or granular urea as raw material. The basic design includes a standard stand-alone, self-powered machine that is equipped with (1) two pocketed rolls (referred to as “briquetting” rolls) for forming the briquettes and (2) two pre-pressing rolls (referred to as “feeding” rolls) located on top of the briquetting rolls to feed the urea raw material into the briquetting rolls. The briquetting rolls may have two rows or three rows of pockets depending on the briquette size and weight to be produced. The briquetting rolls are 245 millimeters (mm) in diameter by 42 mm wide to produce 1.8-gram (g) urea briquettes, or 245 mm in diameter by 53 mm wide to produce 2.7-g urea briquettes. The difference in width depends on the number of pocketed rows. The briquetting rolls used to produce 1.8-g urea briquettes have three rows of 44 pockets in each row for a total of 132 pockets. The briquetting rolls used to produce 2.7-g urea briquettes have two rows of 40 pockets per row for a total of 80 pockets. With proper adjustment, the pockets on both briquetting rolls are aligned to produce briquettes. The shallow, half semi-spherical pockets produce oblate (semi-flattened) spheres. The conventional urea fertilizer is fed into the briquetting rolls by means of two small corrugated rolls located above the briquetting rolls inside on the bottom of the feeding hopper. A plate (located above and between the feeding rolls) serves as a seal to prevent overfeeding and also to prevent material from being forced up into the feed hopper. All rolls, briquetting and feeding, are driven by gears. The belt-driven briquetting machines are operated by an electric or diesel motor. The motor is connected to a gear box that acts as a speed reducer. From the gear box, a shaft drives one briquetting roll (driving roll). The other briquetting roll (driven roll) is run by the driven roll gear. Each feeding roll is gear-driven by its corresponding briquetting roll.

A feed hopper is located above the briquetting rolls. The hopper is supported by the cheek plates, which in turn support the feeding rolls shafts. The briquetting machine is equipped with a truncated cone-shaped trommel screen driven by a pulley located underneath the briquetting rolls and receives the briquettes discharged from the briquetting rolls. The rotating action of the trommel screen should separate the briquettes that are joined together and break most of the remaining webbing on the briquettes. The briquettes discharge from inside the trommel screen; the urea fines and urea dust fall through the trommel. The urea fines are captured and recycled through the briquetting machine. Losses in the process are negligible due to recycle.

- a. **Diesel Engine Driven** – The typical diesel engine used to drive the briquetting machine is a single cylinder, four-stroke, horizontal type, 16 horsepower, 2,200 rpm.
- b. **Electric Motor Driven** – The typical electric motor used to drive the briquetting machine is 440 volts, 10 or 14 horsepower.

¹⁹ Requires basic metal working equipment (e.g., lathe, drill press, welding equipment).

²⁰ In larger markets with indigenous urea manufacturing facilities and where UDP demand growth is robust, large commercial-scale UDP manufacture is possible through factory modifications. Bangladesh is currently pursuing factory modifications to include a manufacturing unit with a capacity of more than 100,000 mt per year of UDP products.

Briquetting Machines Operation:

- a. **Operating Location** – The briquetting machines may be set on concrete, steel or any solid flat surface constructed to support an operating weight of about 350 kg without deflecting or vibrating. The location should be free from flooding and protected from rain. Good ventilation is needed for proper venting of engine gases. The space required is a minimum of 4 meters by 5 meters with a height of 2.5 meters for briquetting machine installation and operation.
- b. **Startup/Operation** – Before connecting the power supply (for an electric-driven briquetting machine) or before cranking the engine (for a diesel-driven briquetting machine), check the following:
- Make sure that there is no foreign material inside the feed hopper.
 - Manually operate the briquetting machine to see if the machine turns freely with no obstruction anywhere in its moving parts.
 - Install the scalping screen on top of the feed hopper to keep lumps and foreign material out of the hopper.
 - Check the oil level in the gear reducer. The gear reducer should be filled with oil to the level indicated by the vendor.
 - Check the gap between the rolls with a large feeler gauge and make sure that the rolls are aligned (same distance [gap] all along the surface of the rolls). If the gap is not correct, or if the rolls are misaligned, loosen the mounting bolts and the retaining bolt and adjust as necessary. After adjusting the gap, make sure to properly tighten all bolts. If the bolts become loose, the gap will increase while the briquetting machine is in operation, resulting in poor, weak product.
 - With the feed hopper empty, start and immediately stop the briquetting machine to check the direction of rotation of the rolls and to listen for any abnormal noise. The briquetting machine rolls should turn toward the discharge chute. If the rolls rotate toward the feed hopper, disconnect the electric power (in the case of an electric-driven briquetting machine), and change the polarity of the electric motor to obtain the proper direction of rotation.
 - Once the rotation of the briquetting machine has been checked, proceed to start the motor and leave it running with no material for about a minute. To make briquettes, fill the feed hopper with the fertilizer material while the briquetting machine is in operation. Make sure that the hopper remains filled at least about 80% of its capacity while operating the briquetting machine.
 - Place a container at the trommel discharge to collect the briquettes.
 - Place a tarpaulin/plastic sheeting beneath the trommel screen to capture broken/fines for recycling through the briquetting machine.
- c. **Shutdown** – To shut down the briquetting machine:
- Stop feeding material into the feed hopper, and let it run empty.
 - When the feed hopper is almost empty, the briquettes produced are weak and often have a broken edge. Therefore, be sure to separate the last briquettes made from the rest of the briquettes.
 - When the feed hopper is completely empty, keep the briquetting machine in operation to allow the trommel screen to empty as much as possible.
 - Turn off the power or shut down the diesel engine to stop the briquetting machine.
 - Once the briquetting machine is not in operation, empty by hand the trommel screen of any briquettes left inside.
 - Proceed to clean the briquetting machine. Most of the briquetting machine can be washed with water. Avoid getting water on the electric motor or on the hot diesel engine. After washing with water, it is recommended to dry the machine as well as possible. Drying can be done with compressed air, if available, or with a clean piece of cloth.
 - If the briquetting machine is not going to be used for a long period of time, it is recommended to put grease on the rolls to mitigate corrosion.
- d. **Safety**
- Never touch any rotating parts (e.g., briquetting rolls, feed rolls, gear, pulley) of the briquetting machine while it is in operation.
 - Do not attempt to clean the briquetting rolls with a screwdriver or any type of metal object while the briquetting machine is in operation. This action could result in severe damage to the machine and serious injury to the operator.
 - Do not remove the screen of the feeding hopper. This screen is to protect the machine from damage caused by foreign objects, but most importantly, it ensures that no one puts his or her hand inside the feed hopper.
 - Ensure that the machine area is dry and that the engine is never in contact with water.
 - The machine operator should wear appropriate clothing and closed-toe shoes.

Briquetting Machine Maintenance – The briquetting machine durability depends on proper maintenance. Major maintenance should be minimal as long as the machine is kept clean and stored in a dry, protected area when not in use. It also should be well-lubricated when in operation and not abused by briquetting materials other than those for which it was designed. Maintenance of the briquetting machine can be divided into three categories:

a. Maintenance Before Production

- The operator should check to see whether there is any problem continuing from the previous operation and check machine settings, belt, level of engine, position of the hopper, radiator water, etc.
- Briquette quality and quantity and machine durability and safety highly depend on the cleanliness of the machine area. Therefore, keep the area neat and clean.
- Frequently grease all parts of the briquetting machine, such as briquetting rolls, feed rolls, spur gear, etc.

b. Maintenance During Production

- During production, make sure that briquettes are the proper size and shape; otherwise, turn the machine off, clear all remaining raw materials and adjust the compact roller properly. Particle “hardness” is also important to product quality.
- The roller pocket should be cleaned during production.
- During production, make sure there are no unusual sounds in the engine and no excess heat in the gear box.
- After every four hours of continuous operation, the briquetting machine should be shut down and not operated for a period of at least one hour.
- Never run the briquetting machine without urea for more than one minute.

c. Maintenance After Production

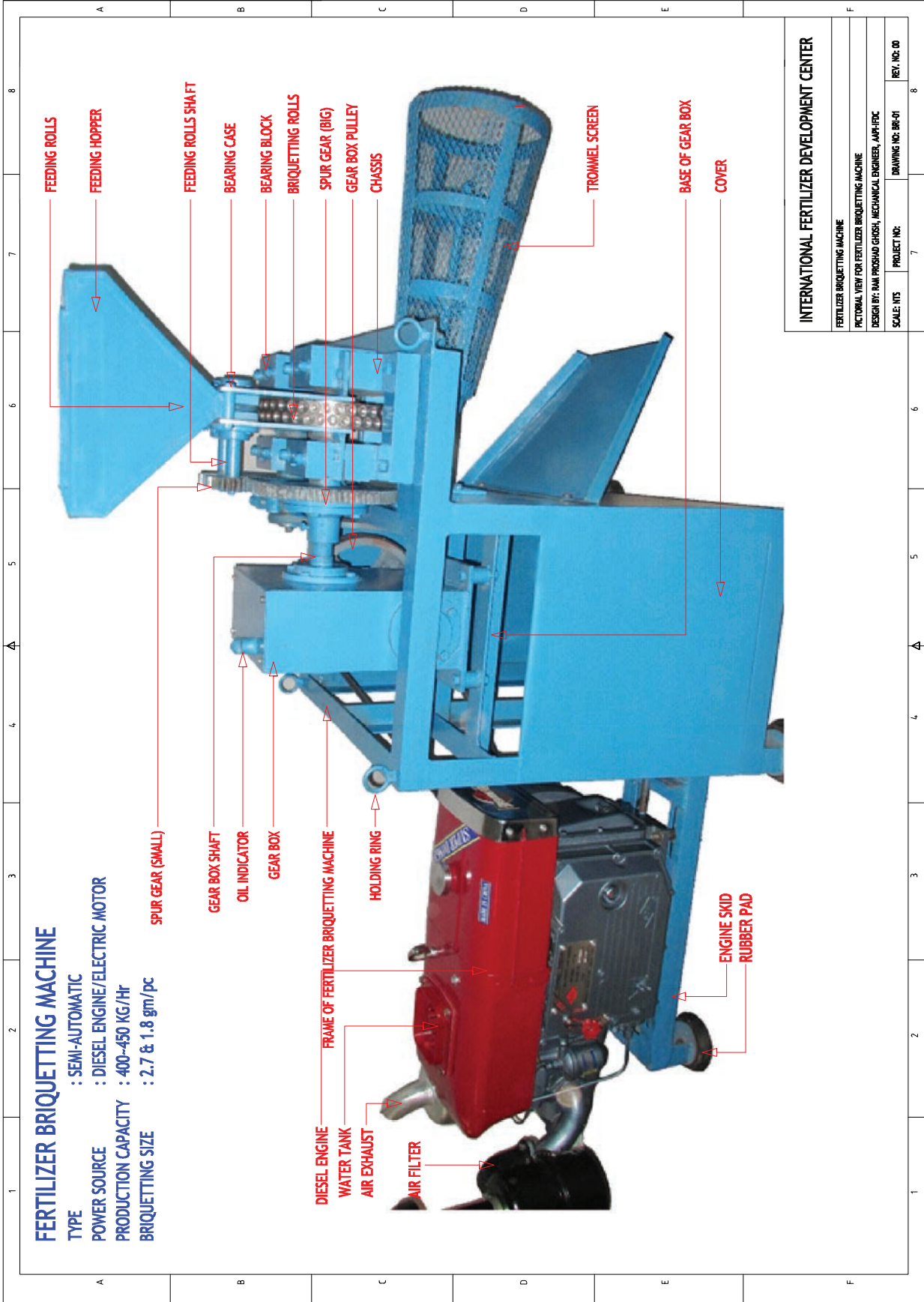
- After successful completion of production, wash the machine with water and dry it using a blower or dry cloth.
- Refill the spur gear with new grease after removing the old grease every seven days. Put grease in the bearing case with the help of a grease gun after producing every 50 mt of briquettes.
- Change the old gear oil and put in the new gear oil (SAE-90 or 120) after producing 50 tons of briquettes.
- After a certain time, completely flush out the cooling water of the diesel engine and refill it with clean and soft water that does not contain iron.
- When the briquetting machine is expected to be out of operation for a long period of time, it is recommended to lubricate all its moving parts and to cover the rolls and shafts with a metal-protecting compound or with a thin layer of grease to avoid corrosion. If the pockets or indentations of the rolls start to corrode, the briquettes will not release easily and will probably break in half. It is very important to have the internal surface of the indentations as smooth as possible to avoid release problems.

The UDP briquetting machines are designed to manufacture high-quality products of a consistent shape and size. Problems in machine operation and quality control may occur at any time. Some of the most common problems and troubleshooting solutions are shown in Table 3.1.

Table 3.1
Common
Problems and
Troubleshooting

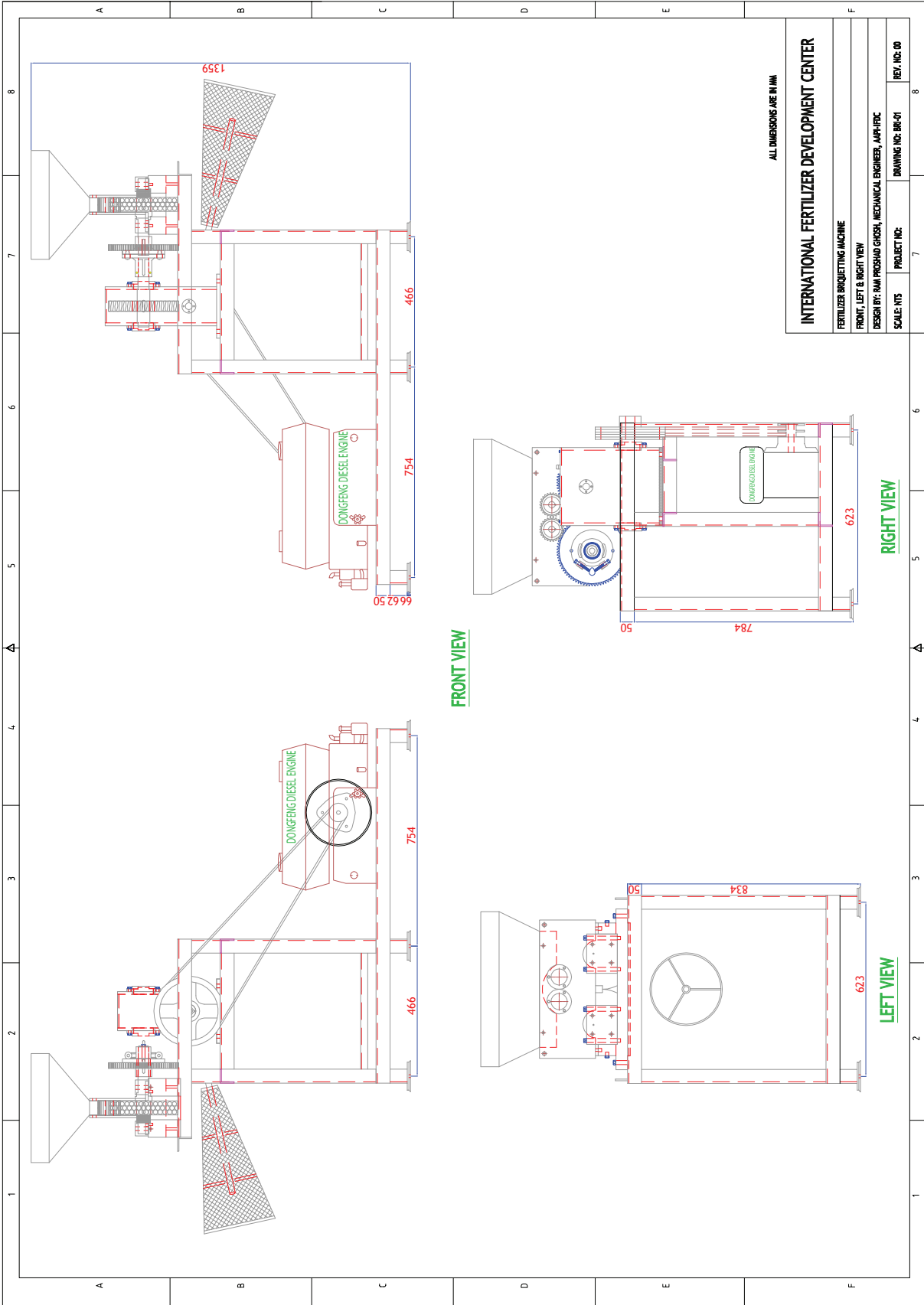
PROBLEM	SOLUTION
Uneven size of briquettes	Time the pockets of the briquetting rolls after loosening the two bolts that are fitted in the spherical groove of the spur gear. First, loosen the right side bolt slightly and tighten up the left side bolt. After this adjustment has been made, make some briquettes. If better briquettes are produced, continue adjusting the bolt as instructed above until the shape is perfect. If the briquettes produced are worse than before adjusting the roll, then adjust the bolt combination process in reverse.
Excess powdered urea from the briquetting rolls	There should be a required space between the two feed rolls. If it is not there, then use a wrench to loosen the two L-end bolts and tighten the two front side bolts equally. Then tighten the two L-end bolts again.
Fertilizer gets stuck in the pocket of the briquetting rolls and in the feed rolls	Stop the machine and clean the feed rolls and the pockets of the briquetting rolls with the help of a soft brush. Urea sticking on the rolls is typically caused by the use of wet urea. Try to mix good dry urea with the wet urea or use recycled material with the wet urea to reduce the stickiness of the material. Another possible issue is with the feed urea. Urea of small particle size/fines may cause blockage. Use of granular urea will improve flowability from the hopper to rollers.
V-belt gets loosened	With a wrench, tighten the belt. If it does not perform well after tightening, then change the belt.
Gear box becomes overheated (more than 60°C)	Release the oil level and examine the oil level and viscosity. If the level is low, then change the oil or refill as needed.
Broken briquettes	Shims (4) of 1 millimeter thick should be placed under the feed rolls frame to increase the distance/gap/space between the feed rolls and the briquetting rolls (the size of the shims depends on the adjustment required).

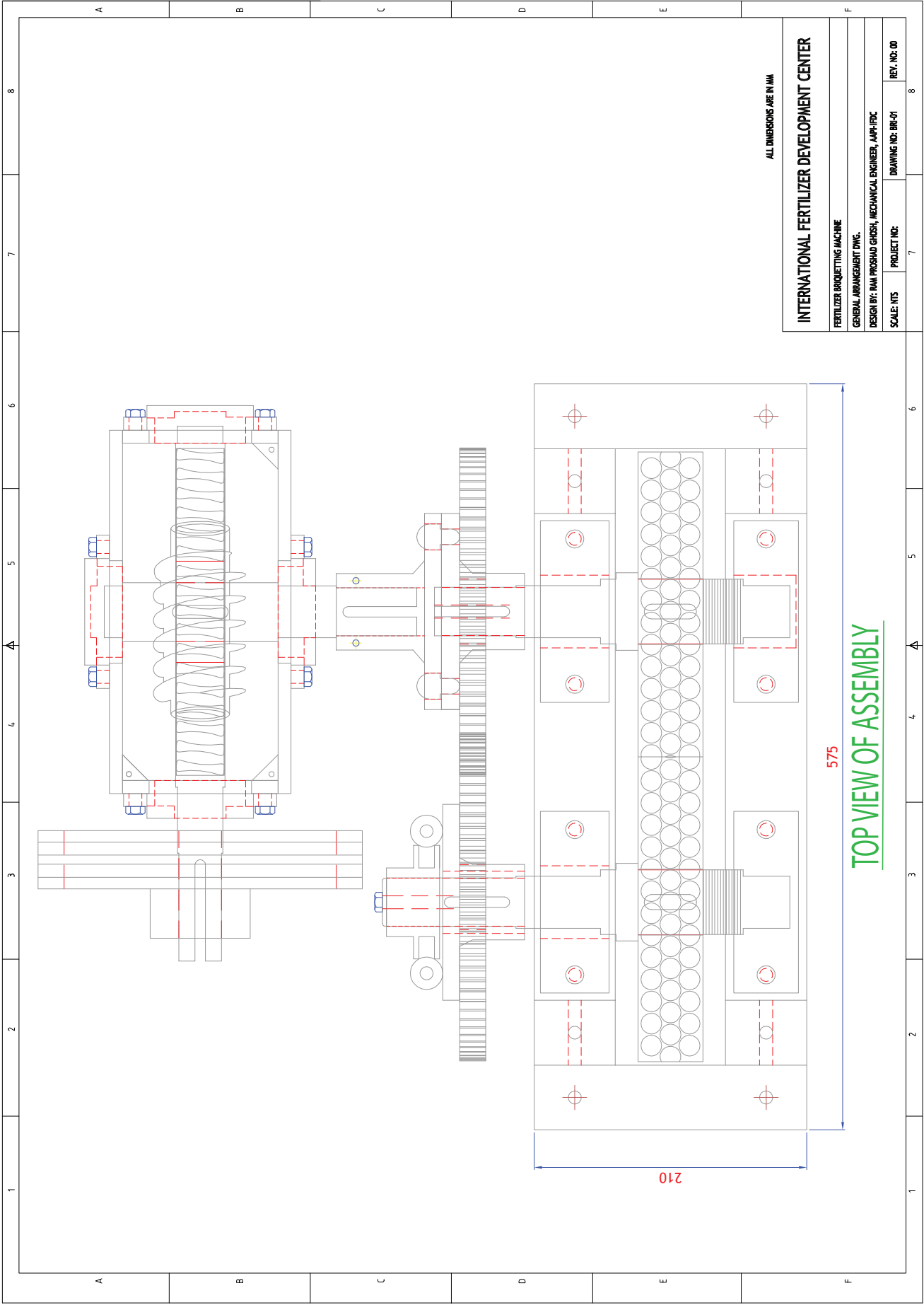
Exhibit 3-1
Fertilizer
Briquetting
Machine



INTERNATIONAL FERTILIZER DEVELOPMENT CENTER	
FERTILIZER BRIQUETTING MACHINE	
PICTORIAL VIEW FOR FERTILIZER BRIQUETTING MACHINE	
DESIGN BY: RAM PRASAD GHOSH, MECHANICAL ENGINEER, IAP-IFDC	
SCALE: NTS	PROJECT NO: BR-01
DRAWING NO: BR-01	REV. NO: 00

Exhibit 3-2
 Fertilizer Briquetting
 Machine Engineering
 Drawings





ALL DIMENSIONS ARE IN MM

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FERTILIZER BRIQUETTING MACHINE

GENERAL ARRANGEMENT DWG.

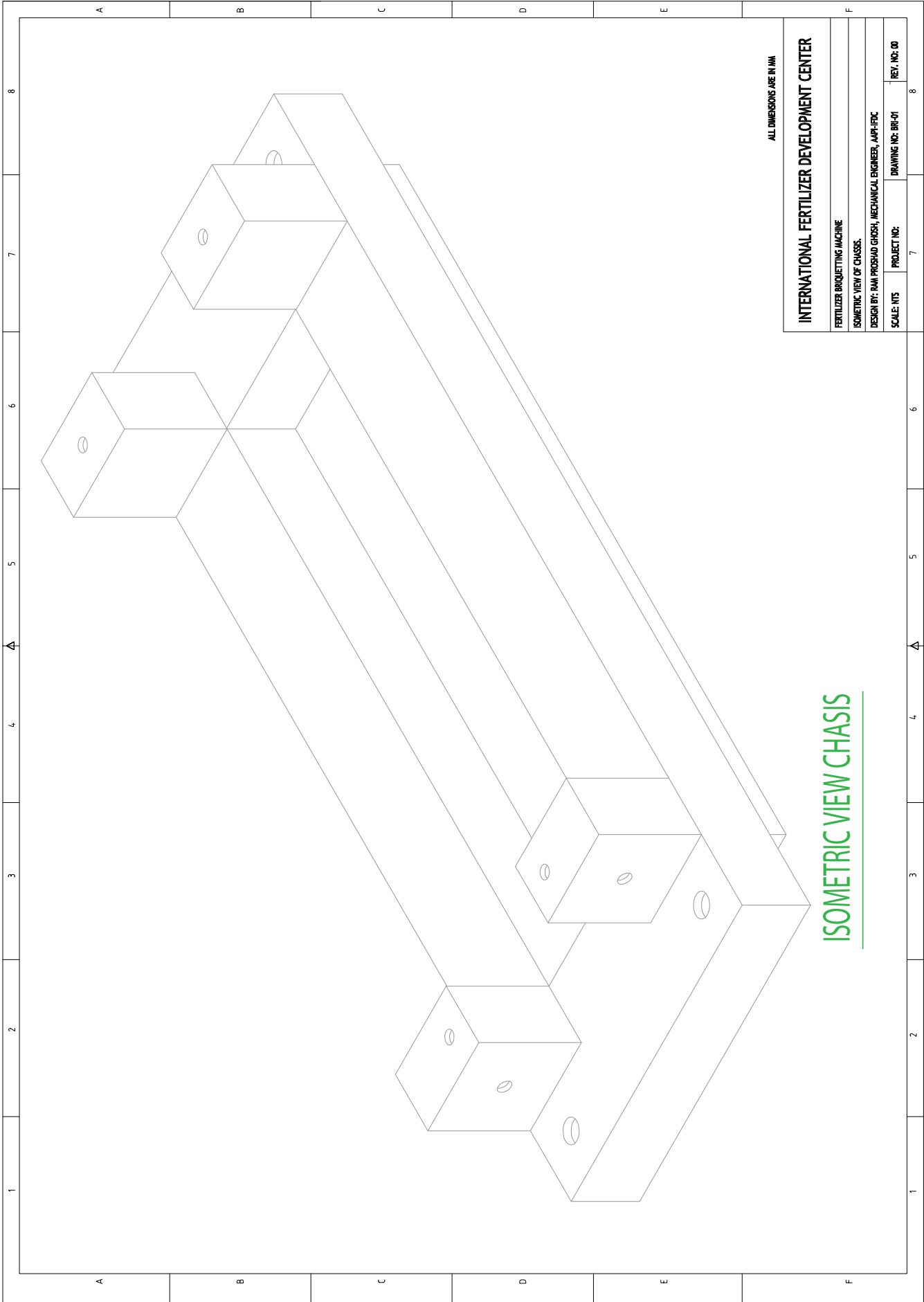
DESIGN BY: RAM PROSHAD GHOSH, MECHANICAL ENGINEER, AMP-FDC

SCALE: NTS PROJECT NO: DRAWING NO: BR-01 REV. NO: 00

TOP VIEW OF ASSEMBLY

575

210



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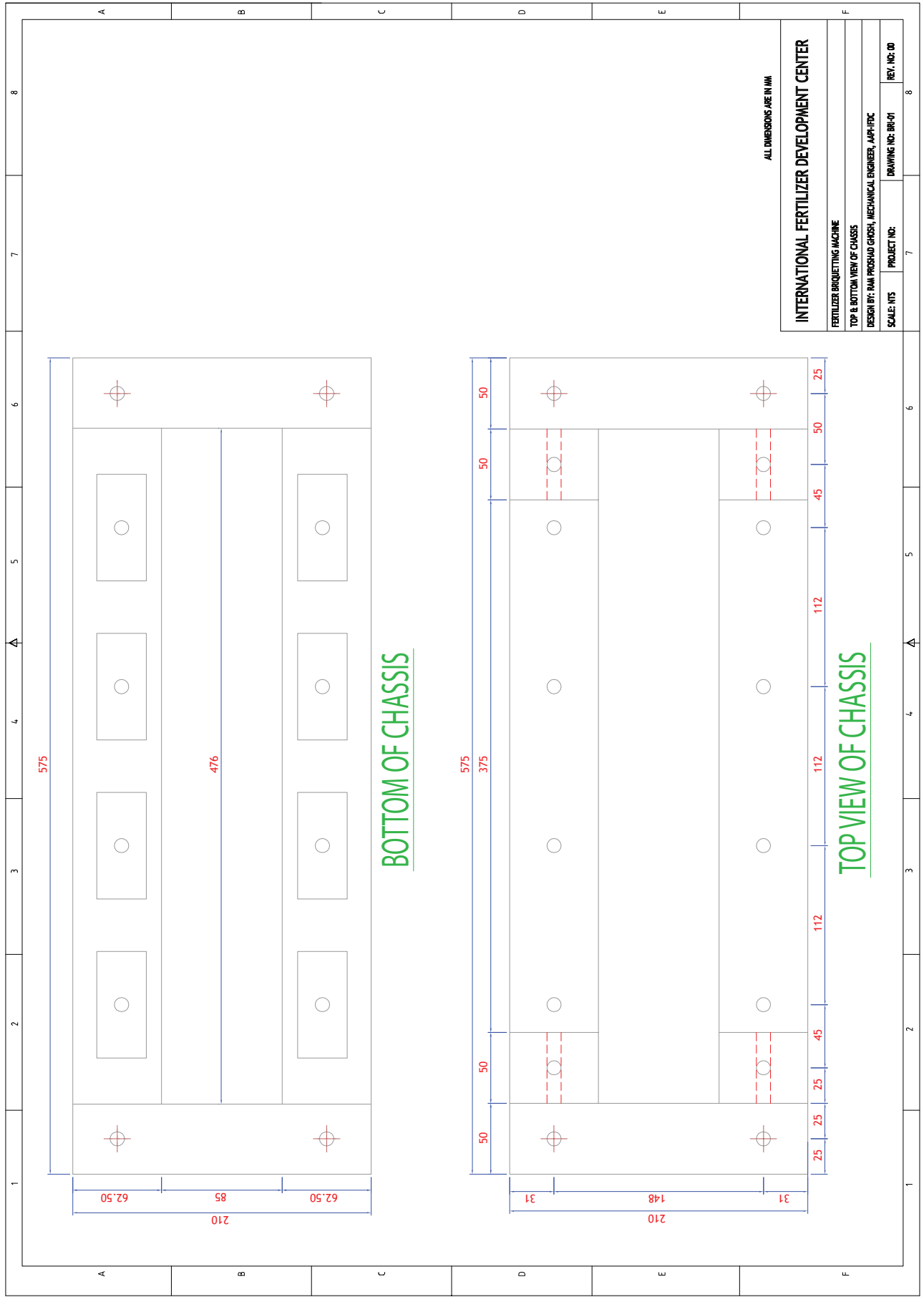
FERTILIZER BRACKETING MACHINE

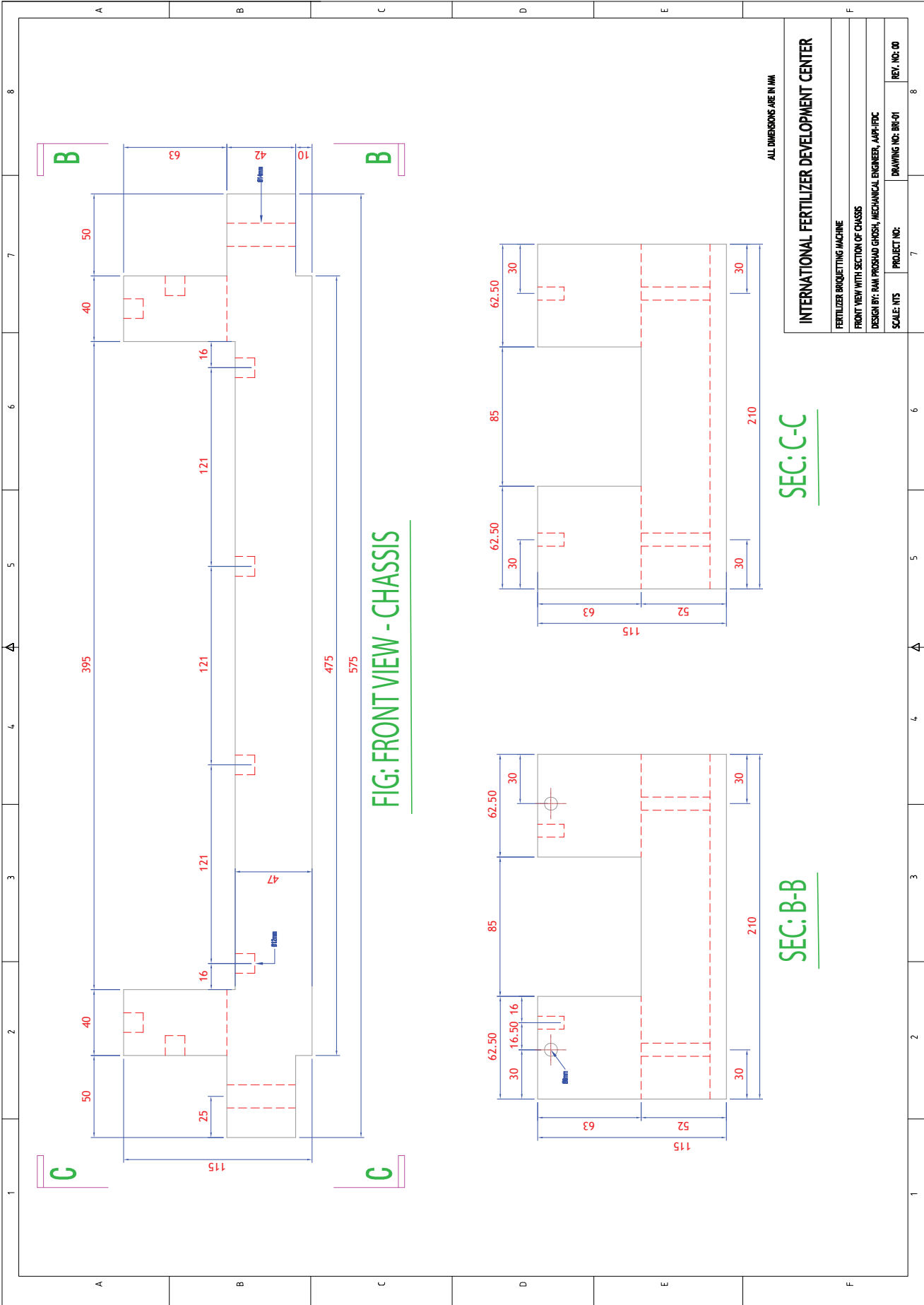
ISOMETRIC VIEW OF CHASIS.

DESIGN BY: RAM PROSHAD GHOSH, MECHANICAL ENGINEER, IITM-FCI

SCALE: NTS PROJECT NO: DRAWING NO: BR-01 REV. NO: 00

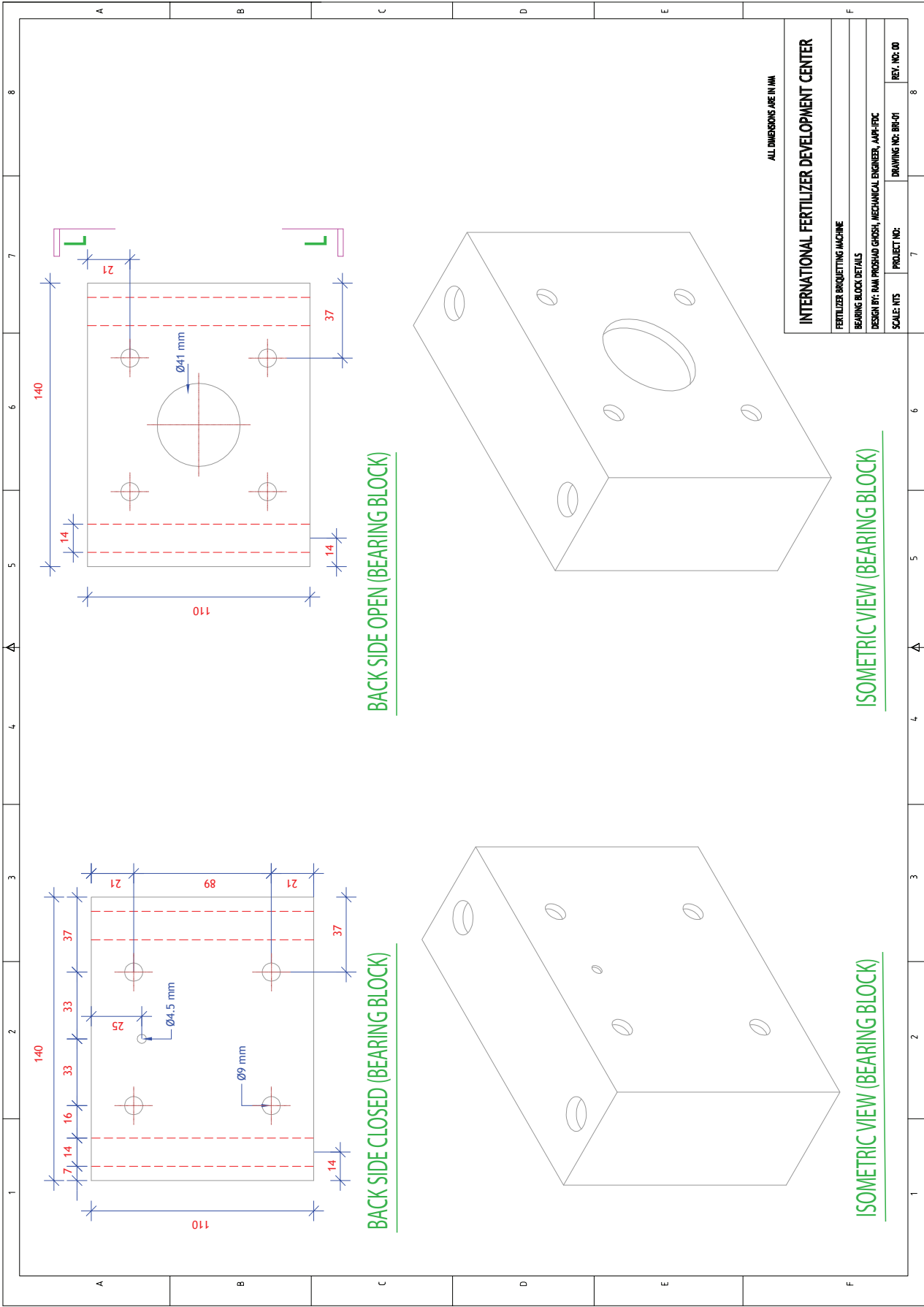
ISOMETRIC VIEW CHASIS

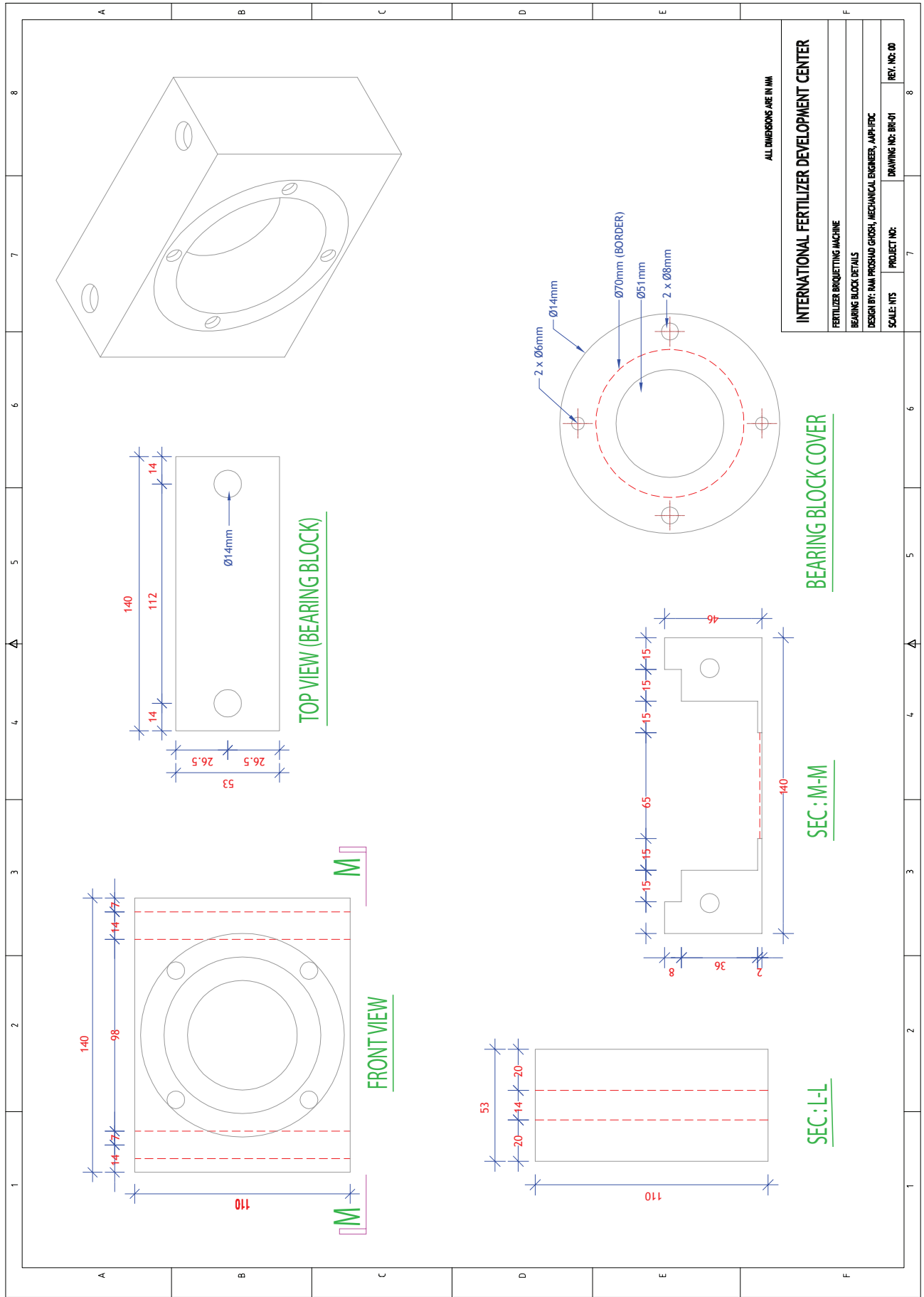




INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

FERTILIZER BROQUETTING MACHINE
 FRONT VIEW WITH SECTION OF CHASSIS
 DESIGN BY: NAM PROSHAD GHOSH, MECHANICAL ENGINEER, IAPF-IRC
 SCALE: NTS PROJECT NO: DRAWING NO: BR-01 REV. NO: 00





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FERTILIZER BRACKETING MACHINE

BEARING BLOCK DETAILS

DESIGN BY: RAM PRASHAD GHOSH, MECHANICAL ENGINEER, AAP-IFDC

SCALE: NTS

PROJECT NO:

REV. NO: 00

BEARING BLOCK COVER

SEC: M-M

SEC: L-L

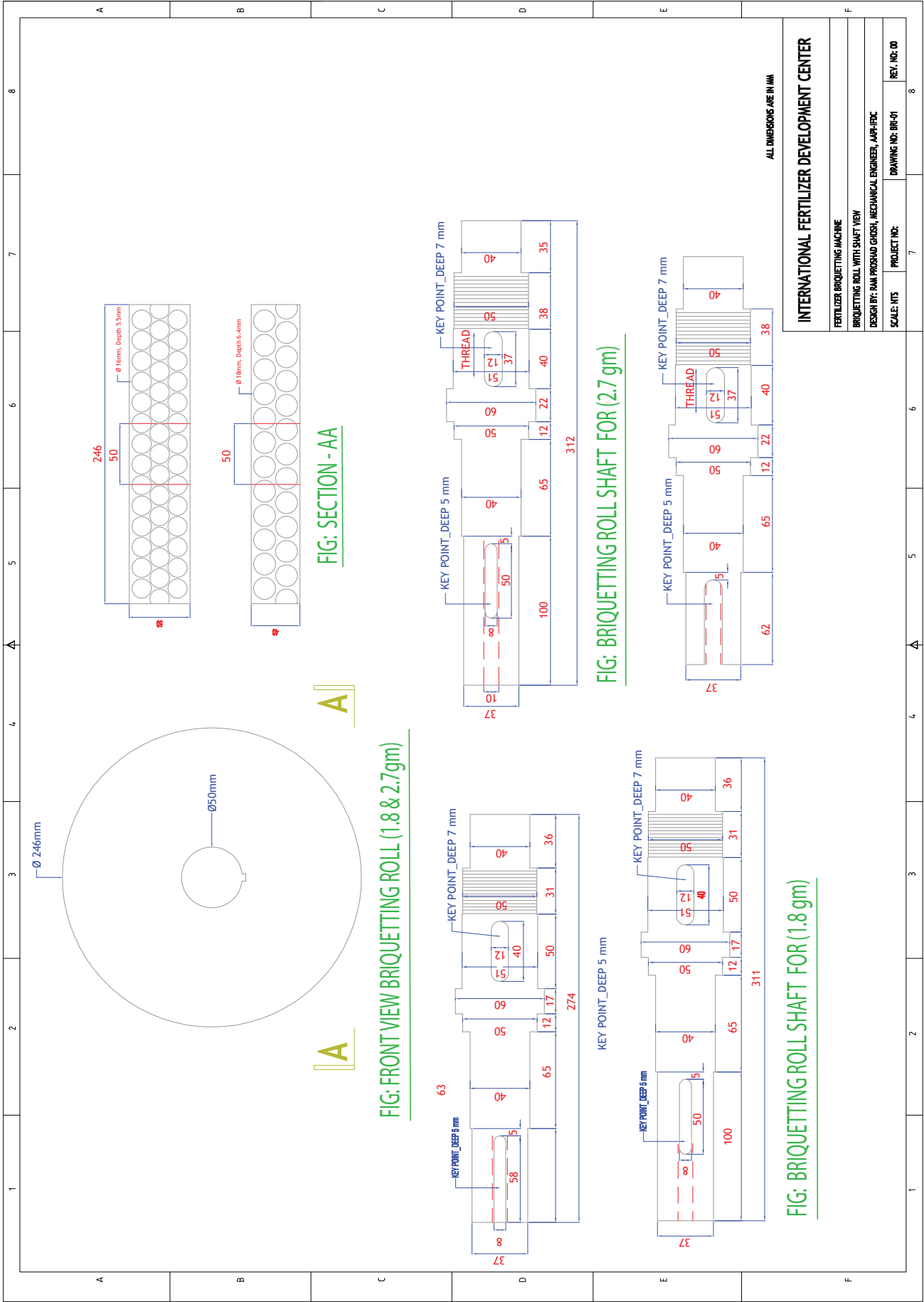


FIG: SECTION - AA

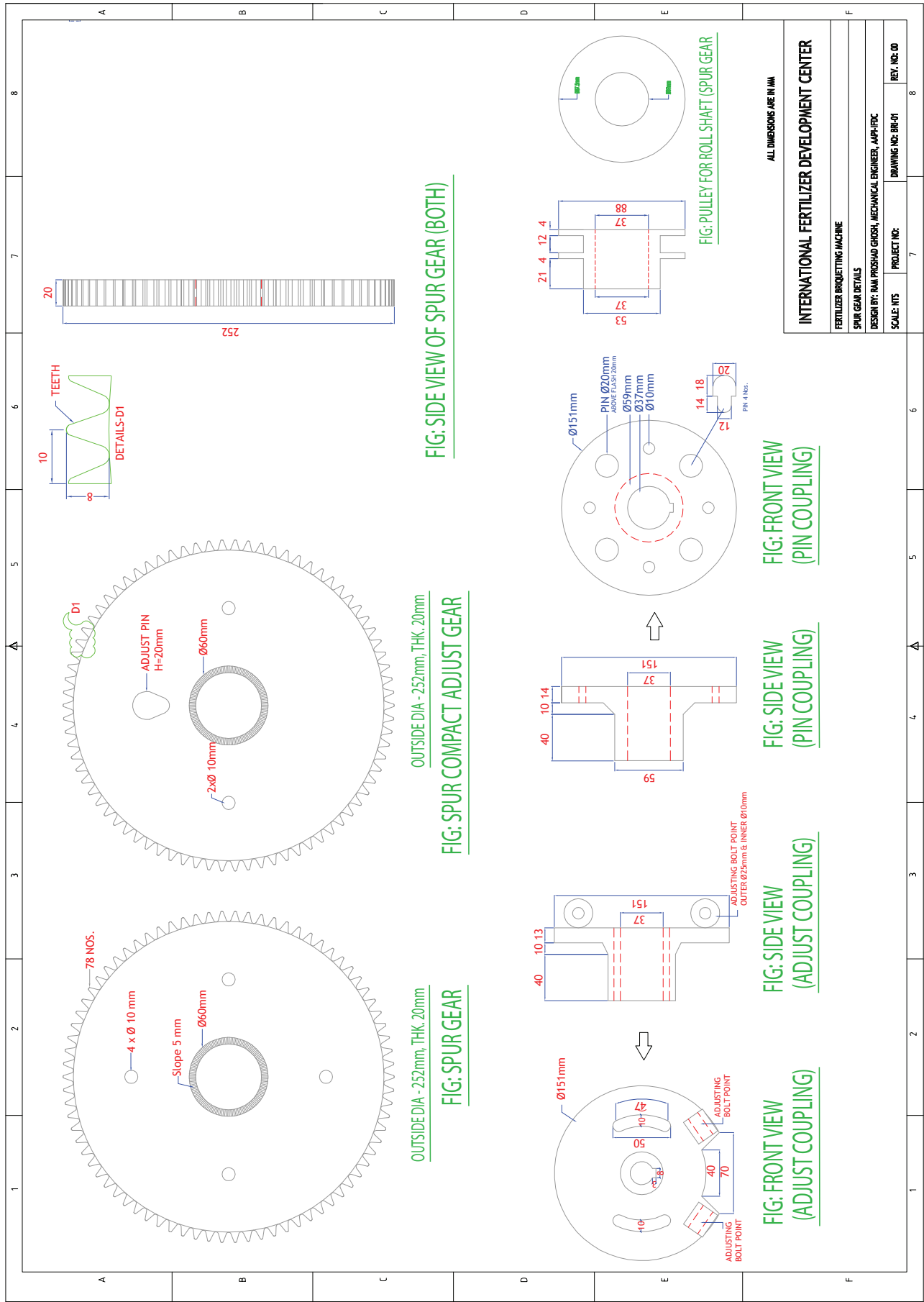
FIG: FRONT VIEW BRIQUETTING ROLL (1.8 & 2.7 gm)

FIG: BRIQUETTING ROLL SHAFT FOR (2.7 gm)

FIG: BRIQUETTING ROLL SHAFT FOR (1.8 gm)

ALL DIMENSIONS ARE IN MM

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER	
FERTILIZER BRIQUETTING MACHINE	
BRIQUETTING ROLL WITH SHAFT VIEW	
DESIGN BY: RAHIM PROSHAD GHOSH, MECHANICAL ENGINEER, AMP-EDC	
SCALE: HTS	PROJECT NO:
DRAWING NO: BR-01	REF. NO: 00



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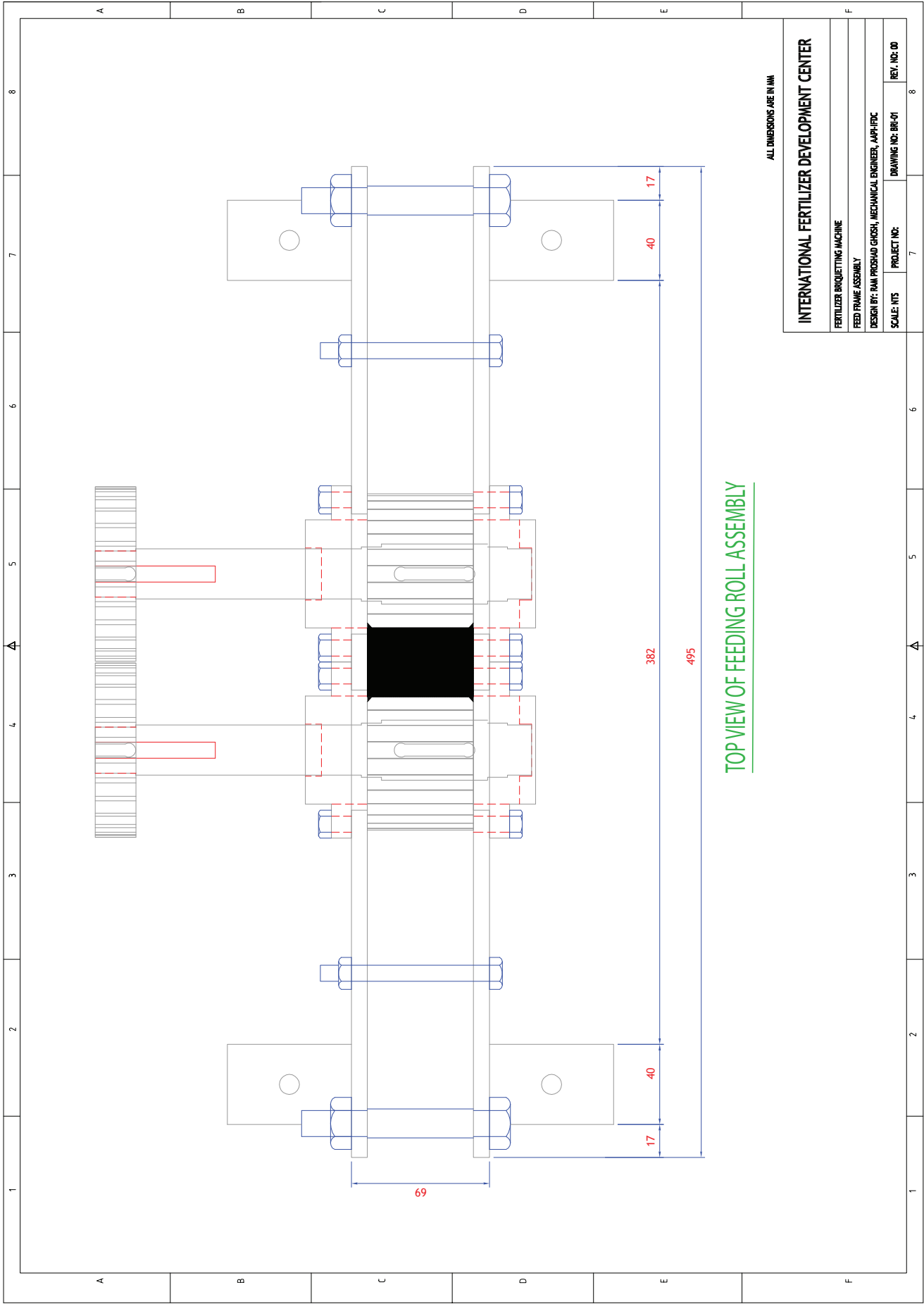
INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

FERTILIZER BRIQUETTING MACHINE

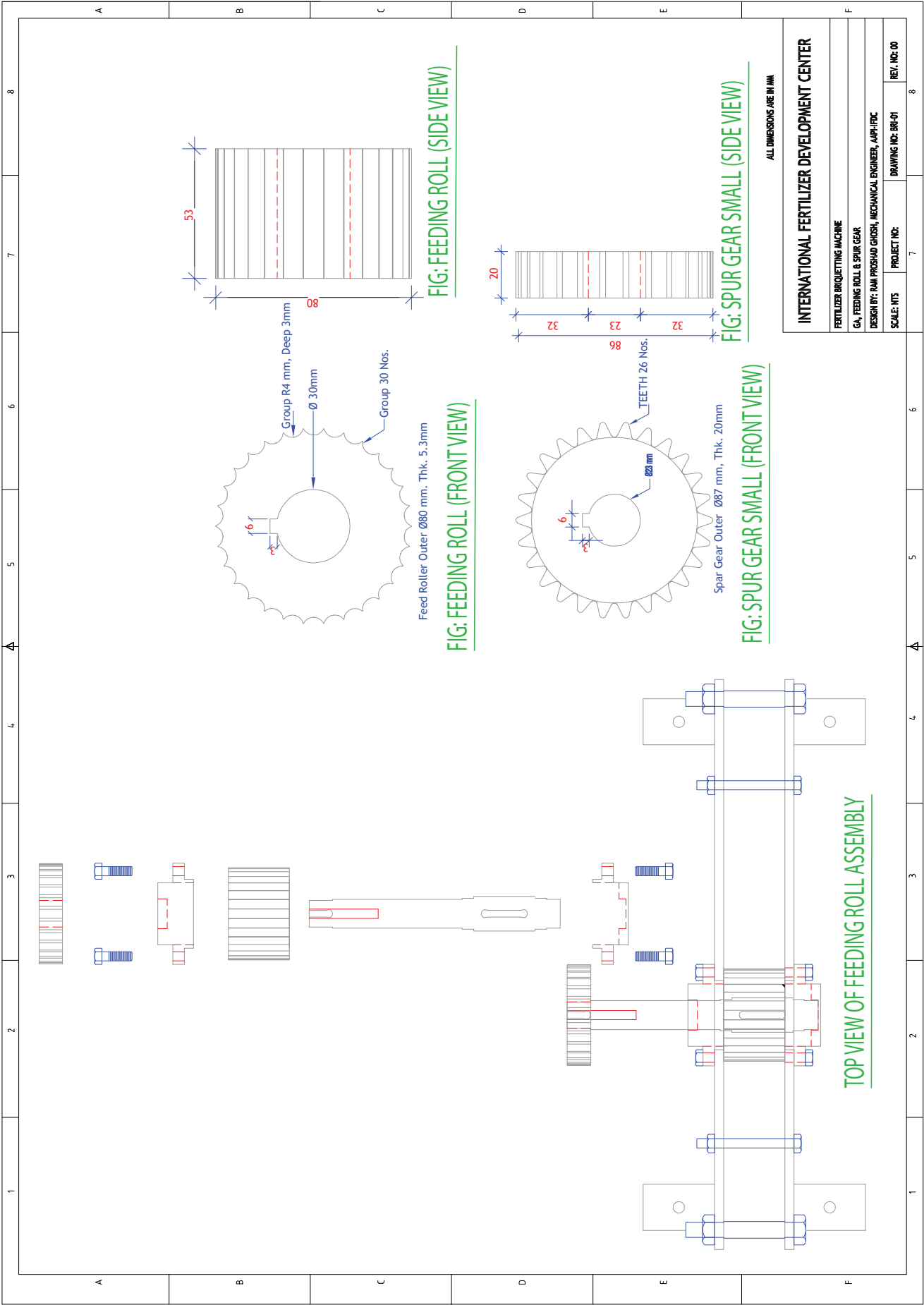
SPUR GEAR DETAILS

DESIGN BY: RAM PROSHAD GHOSH, MECHANICAL ENGINEER, AAP/IFDC

SCALE: NTS PROJECT NO: DRAWING NO: BIC-01 REV. NO: 00

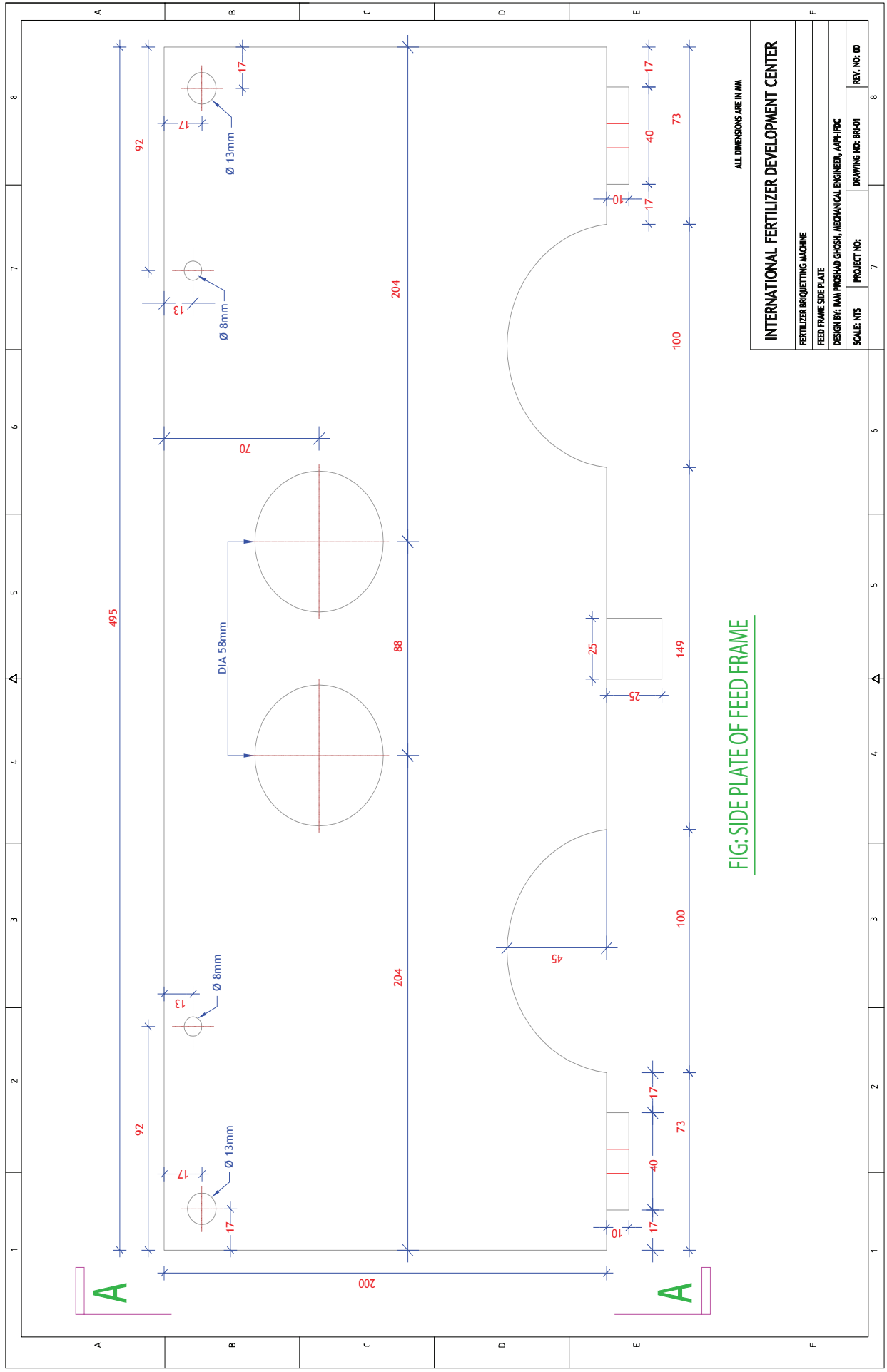


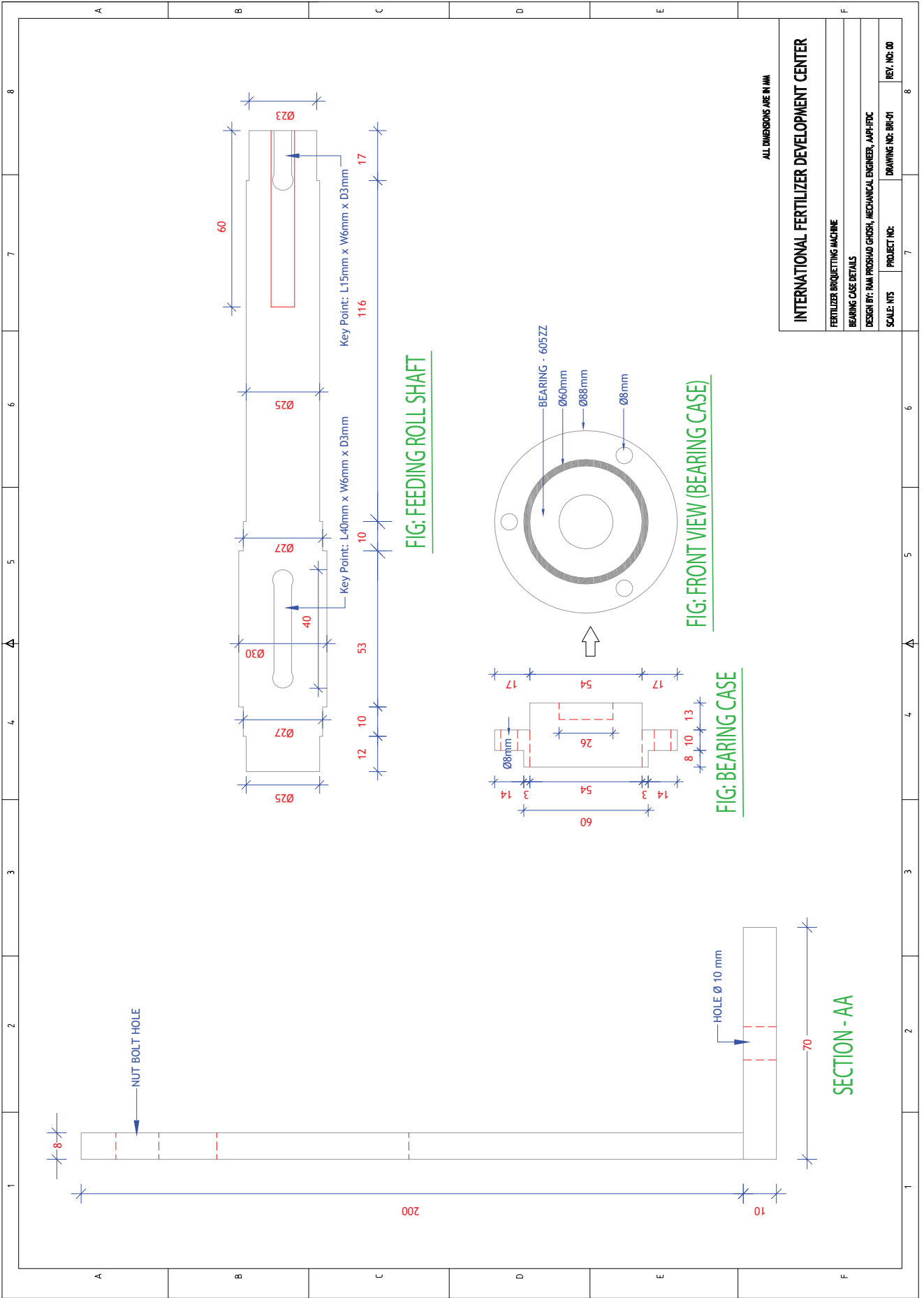
TOP VIEW OF FEEDING ROLL ASSEMBLY

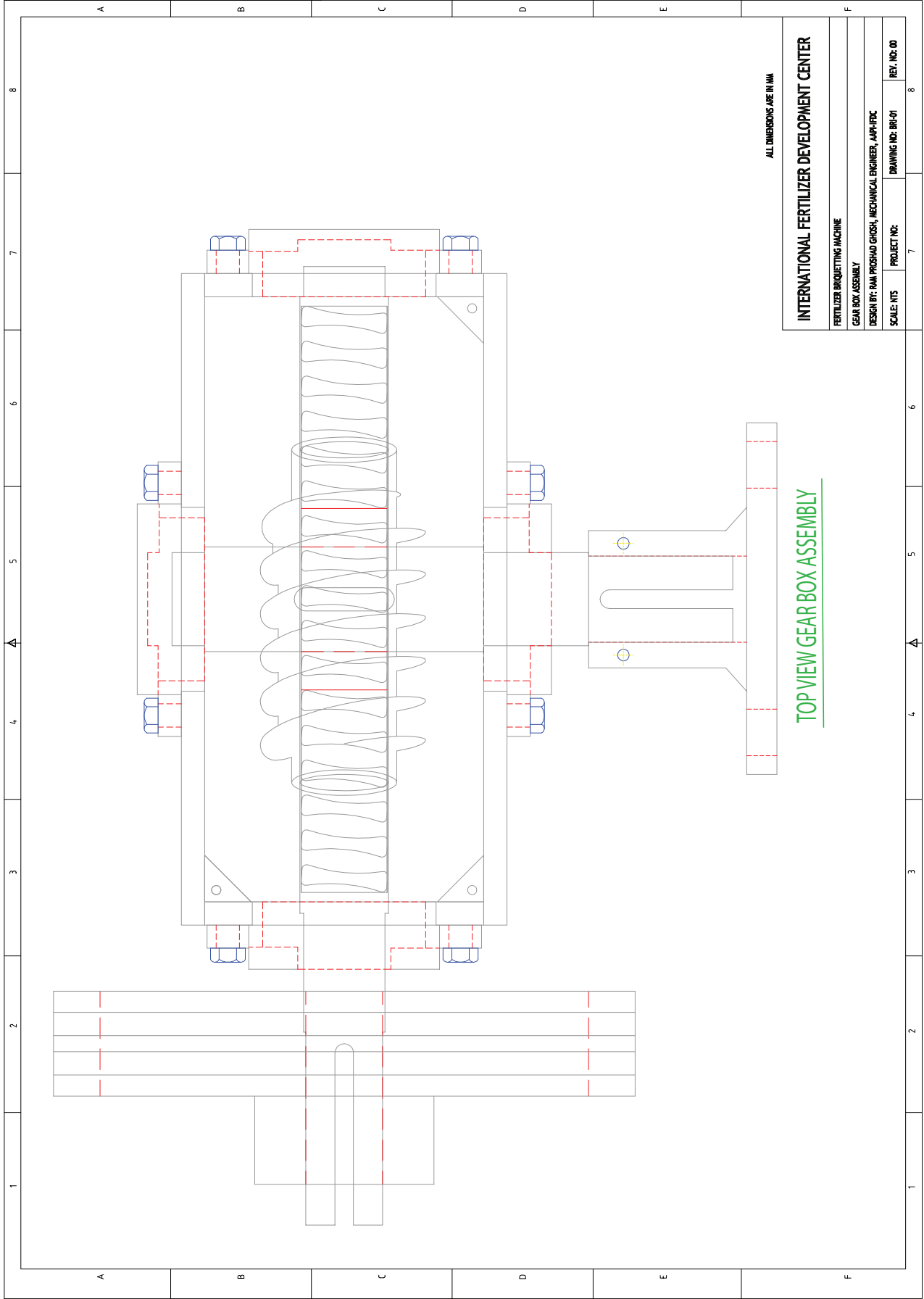


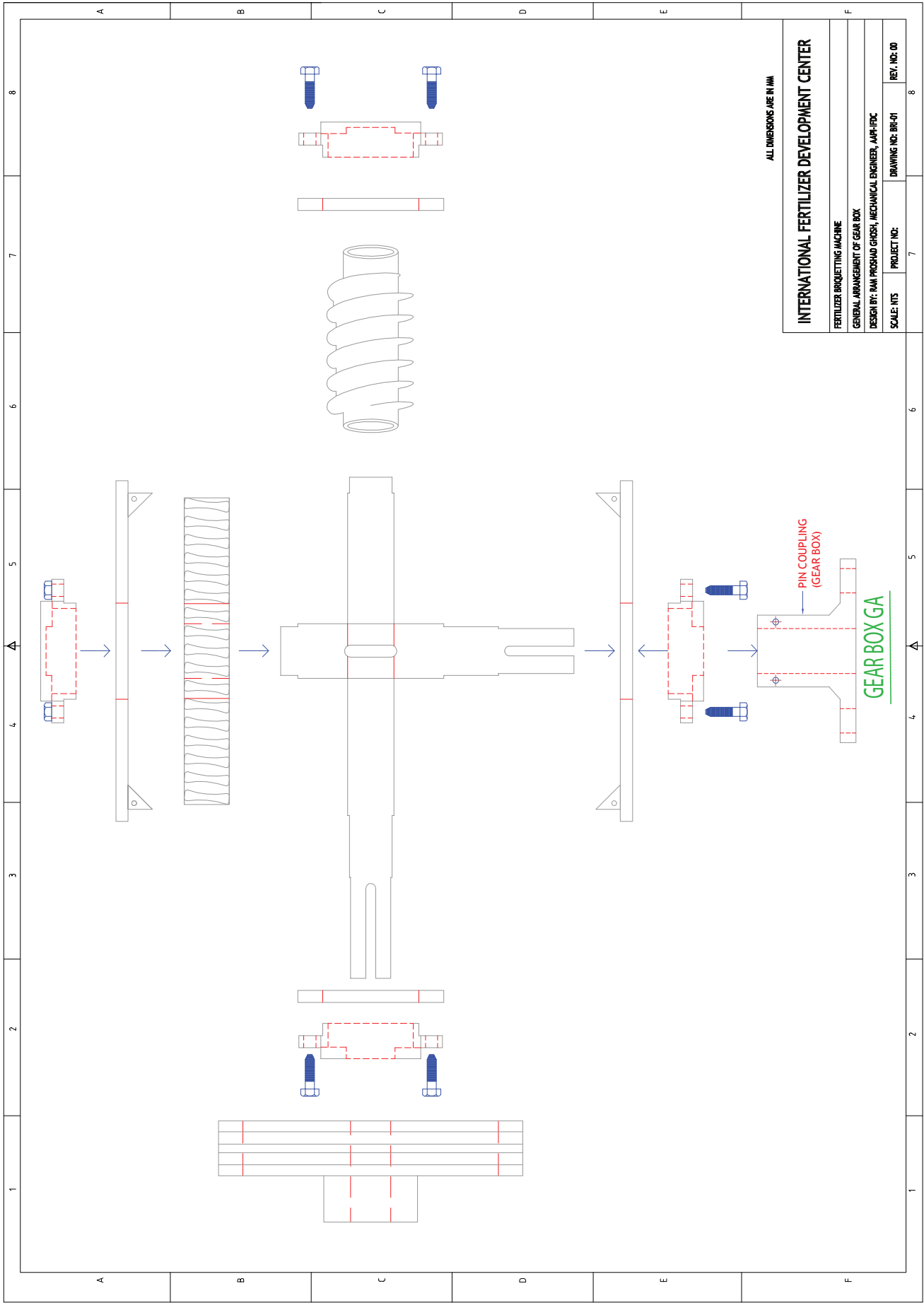
ALL DIMENSIONS ARE IN MM

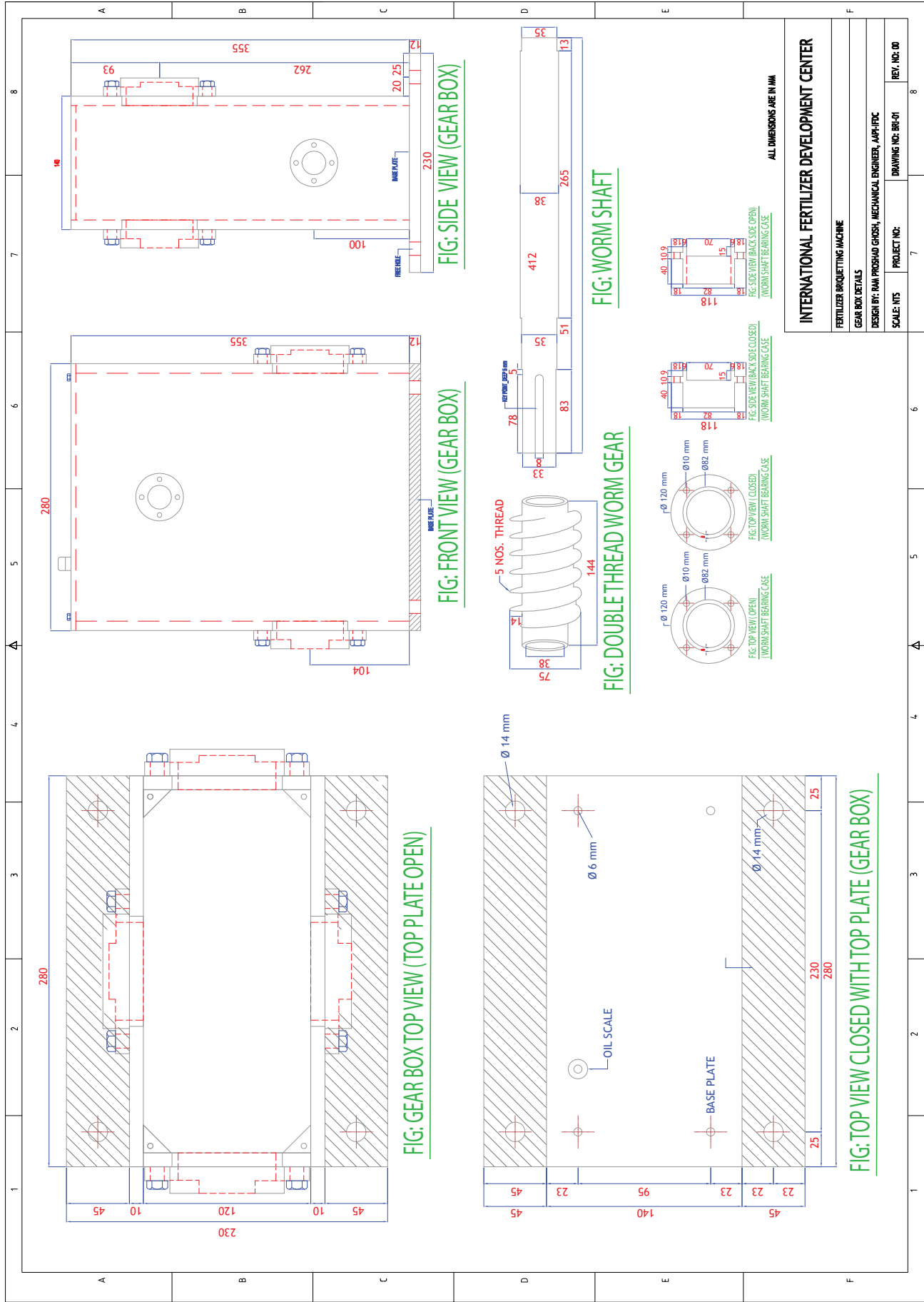
INTERNATIONAL FERTILIZER DEVELOPMENT CENTER	
FERTILIZER BRICQUETTING MACHINE	
GA, FEEDING ROLL & SPUR GEAR	
DESIGN BY: RAM PRASHAD GHOSH, MECHANICAL ENGINEER, IARI-IPCC	
SCALE: NTS	PROJECT NO: 7
DRAWING NO: BR-01	REV. NO: 00



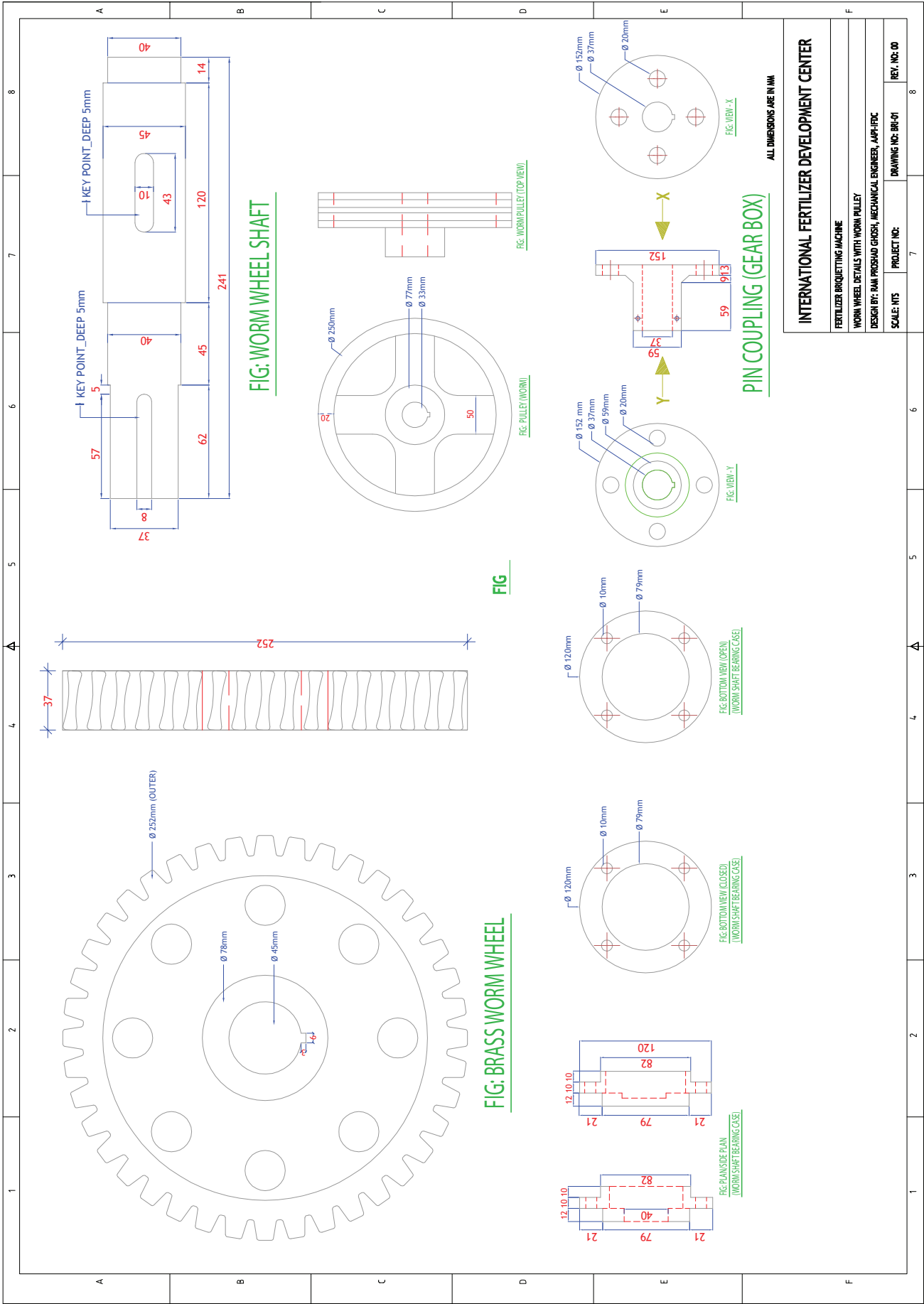




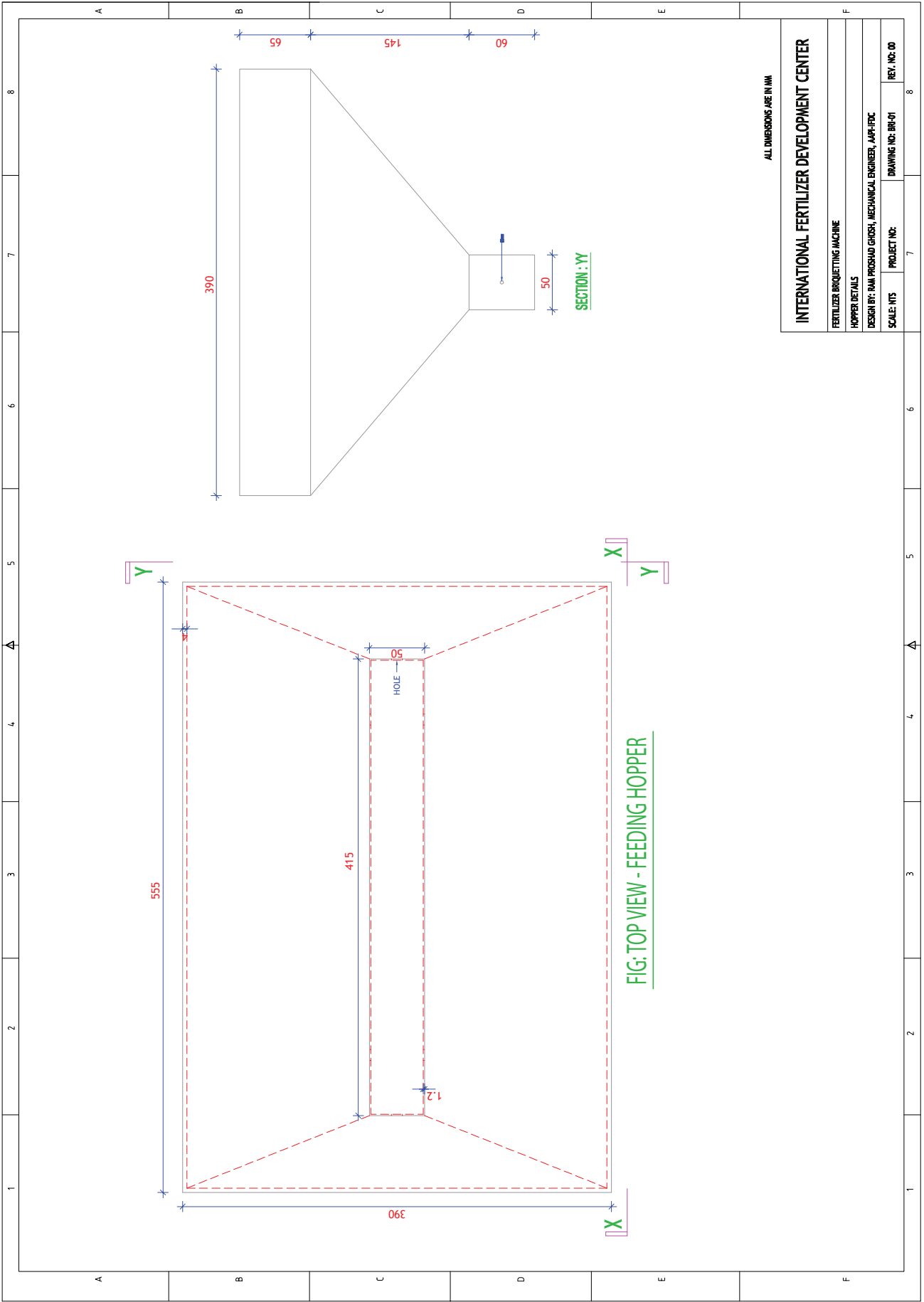




INTERNATIONAL FERTILIZER DEVELOPMENT CENTER			
FERTILIZER BROQUETING MACHINE			
GEAR BOX DETAILS			
DESIGN BY: NAM PROSHAD GHOSH, MECHANICAL ENGINEER, APM-IFDC			
SCALE: 1:15	PROJECT NO:	DRAWING NO: BR/01	REV. NO: 00



INTERNATIONAL FERTILIZER DEVELOPMENT CENTER	
FERTILIZER BRQUETTING MACHINE	
WORM WHEEL DETAILS WITH WORM PULLEY	
DESIGN BY: RAM PROSHAD GHOSH, MECHANICAL ENGINEER, AMP-HDC	
SCALE: NTS	PROJECT NO: DR-01
DRAWING NO: BR-01	REV. NO: 00

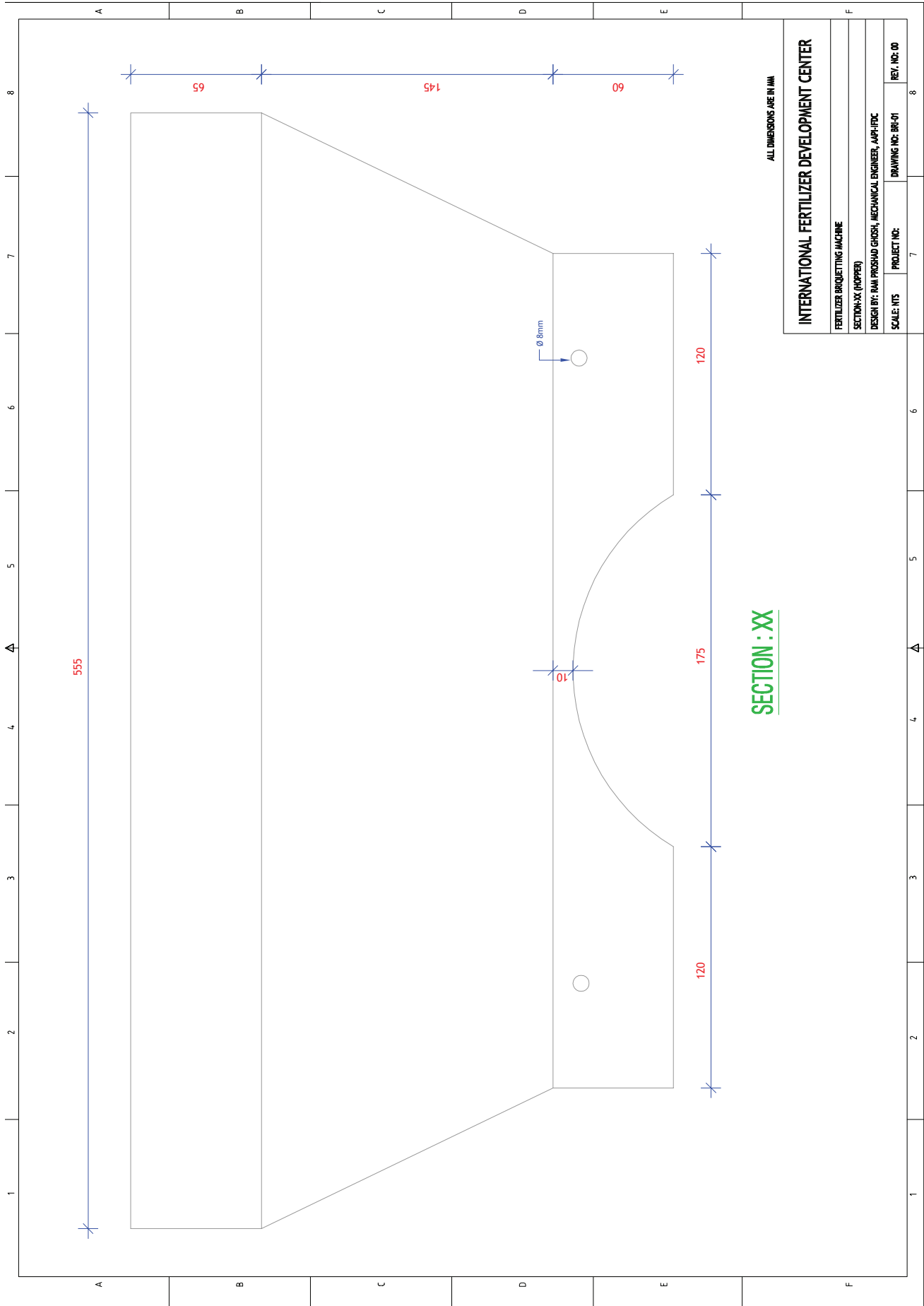


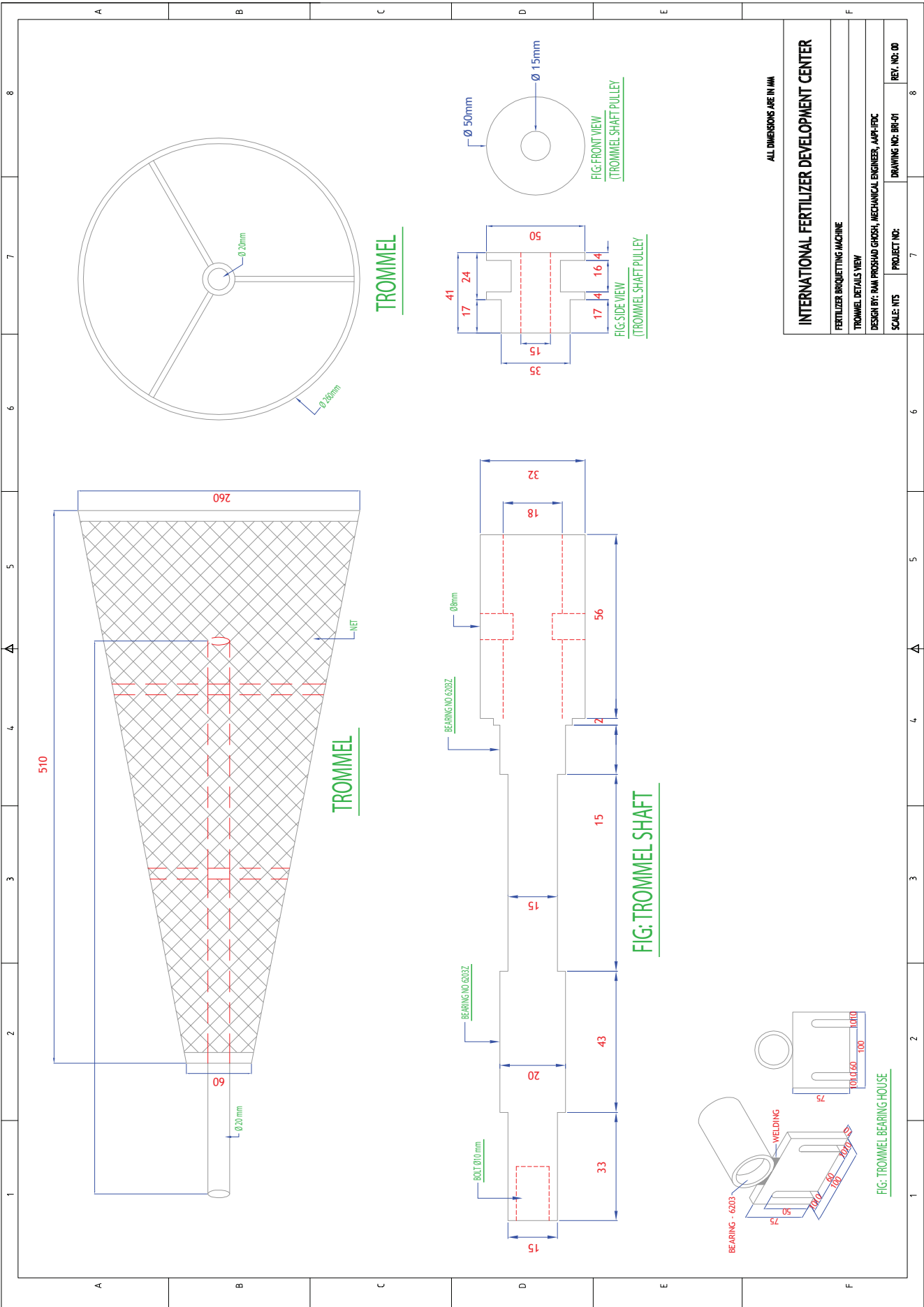
ALL DIMENSIONS ARE IN MM

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

FERTILIZER BRICQUETTING MACHINE	
HOPPER DETAILS	
DESIGN BY: RAM PROSHAD GHOSH, MECHANICAL ENGINEER, IAPF-IFDC	
SCALE: NTS	PROJECT NO:
DRAWING NO: BR-01	REV. NO: 00

FIG: TOP VIEW - FEEDING HOPPER





ALL DIMENSIONS ARE IN MM

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

FERTILIZER BROCKETTING MACHINE

TROMMEL DETAILS VIEW

DESIGN BY: RAM PROSHAD GHOSH, MECHANICAL ENGINEER, AMF-IIDC

SCALE: NTS	PROJECT NO:	7	REV. NO. 00
DRAWING NO: BRG-01		8	

Chapter 4. Developing a UDP Dealer Network

There is no need to develop a fully dedicated marketing channel for UDP products. Market entry through the existing channel members – private, public, non-governmental organizations (NGOs) – is the best approach to early diffusion and sustainability.

Matching supply with demand is an essential feature of a successful UDP technology introduction and market development project. Farmers must have timely access to high-quality UDP products that will perform in the field. And UDP product suppliers must have adequate incentive to include UDP products in their fertilizer product mix. In terms of market entry via the private sector, this means dealers must have confidence that they can achieve an acceptable return on their investment in the manufacture/sale of UDP fertilizers.

There is no need to establish a separate supply and marketing system for UDP products. UDP fertilizers should be treated as a new product entry in the fertilizer market. Market entry and development can be achieved under most situations and should be pursued through the already existing fertilizer marketing system and available channel members.²¹ The stage of fertilizer market development and the type of system (e.g., public, private, mixed) which prevails in the target market will have a major influence on the strategic approach to supply system and channel selection.

From the UDP product supply side, market entry may be under the following type of arrangements:

1. Owner/operator of a fertilizer briquetting machine: (In cases where a channel member invests in a briquetting machine and manufactures briquettes for sale, either directly to farmers or to other channel members for forward sale.) As a general rule, a throughput volume of 100 mt of fertilizer (e.g., needed to generate 100 mt of fertilizer briquettes per year) by the end of Year 3 is the minimum production level needed to achieve an acceptable return on investment.
2. Marketing channel member (including sales) to farmers: (In cases where a channel member is a non-manufacturer and sources briquettes from a manufacturer for resale to farmers.) Volume sensitivity is less of an issue as margins will reflect costs and revenues associated with each procurement and subsequent sale of the briquettes.

The current fertilizer supply and marketing system that services farmers' fertilizer needs will be appraised in the Target Market Assessment (Chapter 1). The appraisal will identify market-related strengths and weaknesses that will drive the strategic approach to channel selection.

Public Versus Private Systems: The channel system may be either a public sector or private sector system, or a combination of the two. NGOs and farmer groups also may be engaged in fertilizer supply to member farmers. While private sector systems offer cost and efficiency advantages over public sector systems, the introduction and development of the UDP market may successfully progress under any type of system. The stage of market development (see next page) will impact channel system selection.

²¹ Fertilizer wholesalers/distributors, agro-dealers, NGOs, parastatals, farmer groups, output marketing organizations and others (including estate sector) that support the fertilizer needs of farmers.

Regardless of the system targeted, adequate incentive must exist to pursue UDP technology diffusion. The nature of the incentive may include the following:

SYSTEM	INCENTIVE
Public Sector	Increase on-farm productivity, rural income growth, food security and agri-business growth, improve fertilizer use efficiency and reduce farmer waste of applied fertilizers.
Private Sector	Increase profits, improve products/services to farmers, expand market share and support national interests.
NGOs/Associations/Other	Enhance member support with improved technology, improve financial status of NGOs, contribute to achievement of internal/donor objectives.

Stage of Fertilizer Market Development: The stage of market development will have a very significant impact on the strategic approach to supply and marketing channel selection. In the case of weak/underdeveloped fertilizer markets, achieving rapid progress will be a serious challenge.²² A number of countries in Africa (to a lesser extent in Asia and Latin America) have relatively weak, under-developed fertilizer markets. In those circumstances, at least initially, (and even with a strong cost-share provision in briquetting machine procurement), it will not be possible to achieve good success in an agro-dealer based supply system. Rather, the supply system for briquette manufacture will need to target either a high-volume wholesaler/distributor or public sector/NGO/farmer organization. The low-volume agro-dealers may source UDP briquettes from the other channel members, and/or farmers may access supply from public sector supply points/NGOs/others. As the market develops for fertilizers in general, and UDP technology in particular, UDP market development may occur under various scenarios. This may include a larger private sector network at the agro-dealer level in UDP fertilizer manufacture and even larger scale production of briquettes through factory-level briquetting machines.

Understanding that each market will differ and there may be various combinations of private and public sector entities that engage in fertilizer briquette manufacture/marketing, the remainder of this chapter will deal with UDP market entry through private sector fertilizer dealers. Stimulating private sector investment in the technology will be critical to long-term sustainability.

An agro-input dealer's decision to include UDP fertilizers in the product mix will be an individual decision, determined by the dealer's own situation and expectation of the impact of urea briquette sales on their operations and profitability. The Implementing Agency (IA) will need to provide dealers with information that will assist in the decision-making process, along with technical and management capacity building.

Priority attention should be in the following areas:

1. *Stimulate dealer interest* (to invest in briquetting machines and/or add UDP products to product mix): This will entail providing dealers with information on the "business opportunity" associated with UDP manufacture and sale. The messaging to dealers should be based upon market realities in the target market and pro-forma statements to illustrate the impact on dealer finance. Tables 4.1 and 4.2 illustrate the financial returns associated with a dealer investment in a fertilizer briquetting machine.
 - a. The forecasts in Table 4.1 will be used in a template to provide a forecast of income and profit streams as shown in Table 4.2. In this example, the initial cost for the briquetting machine locally produced or an imported machine with a 50% investment grant is estimated at \$2,500-\$5,000 and additional equipment costs \$500.
 - b. Machine life is estimated to be five to eight years. In this example, a residual briquetting machine value of \$1,000 is assumed at the end of Year 5.
 - c. In the example, where annual production increases from 45 mt in Year 1 to 138 mt in Year 5, there is a positive net present value and an internal rate of return (IRR) of 39%. The payback period is estimated at just under three years.

²² For purposes of this manual, weak/underdeveloped fertilizer markets include those markets that are characterized by low levels of fertilizer sales, fragmented marketing systems with limited dealer networks, a policy environment that is not conducive to private sector development and uncertain crop markets.

Table 4.1
Market
Forecasts,
Production
and Inventory
Schedules

YEAR 1									
RICE CROP	SEASON 1		SEASON 2			SEASON 3			ANNUAL
MONTHS	1	2	3	4	5	6	7	8	
Area (ha)	500	500		300	300		500	500	2,600
Forecast UDP %	10.00%	10.00%		10.00%	10.00%		15.00%	15.00%	11.92%
UDP Area (ha)	50	50		30	30		75	75	310
UDP/ha (kg)	170	170		110	110		110	110	
UDP demand (mt)	8.5	8.5		3.3	3.3		8.25	8.25	40.1
Production (mt)	10	10		5	5	0	10	5	45
Opening Inventory	0	1.5	1.5	1.5	3.2	3.2	3.2	4.95	1.7

YEAR 2									
RICE CROP	SEASON 1		SEASON 2			SEASON 3			ANNUAL
MONTHS	1	2	3	4	5	6	7	8	
Area (ha)	500	500		300	300		500	500	2,600
Forecast UDP %	15.00%	15.00%		15.00%	15.00%		15.00%	15.00%	15.00%
UDP Area (ha)	75	75		45	45		75	75	390
UDP/ha (kg)	170	170		110	110		110	110	
UDP demand (mt)	12.75	12.75		4.95	4.95		8.25	8.25	51.9
Production (mt)	20	5		5	5		10	8	53
Opening Inventory	1.7	8.95	1.2	1.2	1.25	1.3	1.3	3.05	2.8

YEAR 3									
RICE CROP	SEASON 1		SEASON 2			SEASON 3			ANNUAL
MONTHS	1	2	3	4	5	6	7	8	
Area (ha)	500	500		300	300		500	500	2,600
Forecast UDP %	25.00%	25.00%		25.00%	25.00%		25.00%	25.00%	25.00%
UDP Area (ha)	125	125		75	75		125	125	650
UDP/ha (kg)	170	170		110	110		110	110	
UDP demand (mt)	21.25	21.25		8.25	8.25		13.75	13.75	86.5
Production (mt)	20	20		10	10		15	10	85
Opening Inventory	2.8	1.55	0.3	0.3	2.05	3.8	3.8	5.05	1.3

YEAR 4									
RICE CROP	SEASON 1		SEASON 2			SEASON 3			ANNUAL
MONTHS	1	2	3	4	5	6	7	8	
Area (ha)	500	500		300	300		500	500	2,600
Forecast UDP %	30.00%	30.00%		30.00%	30.00%		30.00%	30.00%	30.00%
UDP Area (ha)	150	150		90	90		150	150	780
UDP/ha (kg)	170	170		110	110		110	110	
UDP demand (mt)	25.5	25.5		9.9	9.9		16.5	16.5	103.8
Production (mt)	30	25		10	5		20	15	105
Opening Inventory	1.3	5.8	5.3	5.3	5.4	0.5	0.5	4	2.5

YEAR 5									
RICE CROP	SEASON 1		SEASON 2			SEASON 3			ANNUAL
MONTHS	1	2	3	4	5	6	7	8	
Area (ha)	500	500		300	300		500	500	2,600
Forecast UDP %	40.00%	40.00%		40.00%	40.00%		40.00%	40.00%	40.00%
UDP Area (ha)	200	200		120	120		200	200	1,040
UDP/ha (kg)	170	170		110	110		110	110	
UDP demand (mt)	34	34		13.2	13.2		22	22	138.4
Production (mt)	35	35		10	15		20	22	137
Opening Inventory	2.5	3.5	4.5	4.5	1.3	3.1	3.1	1.1	1.1

For resource-poor dealers, the IA may provide a dealer incentive via initial grants of 25%-75% of the initial investment cost. In this example, a 50% investment grant would result in reducing the payback period to 30 months and increasing the IRR to 55%.

The Strategic Plan will include methods of providing information to prospective dealers. Among others, regional/national workshops, meetings with agro-dealer associations, discussions with donor agencies and use of mass media and ICT messaging may be appropriate.

Table 4.2
Cash Flow
for a Single
Briquetting
Machine^a

	YEARS	0	1	2	3	4	5	6
Sales	mt		40.1	51.9	86.5	103.8	138.4	
Price/mt	US \$		600	600	600	600	600	
REVENUE	US \$		24,060	31,140	51,900	62,280	83,040	
Production	mt		45	53	85	105	137	
Losses (.05%)	mt		0.225	0.265	0.425	0.525	0.685	
Urea Purchases	mt		45.225	53.265	85.425	105.525	137.685	
Urea Cost (mt)	US \$		522	522	522	522	522	
Urea Cost (Total)	US \$		23,607.45	27,804.33	44,591.85	55,084.05	71,871.57	
Processing Cost	US \$/mt		26.00	26.00	26.00	26.00	26.00	
Bags and Bagging	US \$/mt		10.00	10.00	10.00	10.00	10.00	
Promotion	US \$/mt		10	10	10	10	10	
TOTAL COST/mt	US \$		25,061.05	29,682.73	47,715.85	58,830.85	76,863.97	
Cash Flow	US \$		-1,001.05	1,457.27	4,184.15	3,449.15	6,176.03	
Cumulative Cash Flow	US \$		-1,001.05	456.22	4,640.37	8,089.52	14,265.55	
Investment								
Fixed Equipment	US \$	-3,000						1,000
Working Capital	US \$	-1,001						1,001
Net Cash Flow	US \$	-4,001	-1,001	1,457	4,184	3,449	6,176	2,001
Cumulative Net Cash Flow	US \$	-4,001	-5,002	-3,545	639	4,088	10,265	12,266
NPV (15%)	\$4,889.27							
IRR	39%							
PBP (months)	34							

a. Based upon assumptions presented in Table 4.1.

2. *Work to alleviate policy-related constraints:* It is necessary to alleviate, to the extent possible, policy barriers that impact private sector participation in the UDP market. Key areas of concern (in most markets) are policies and regulations that deal with price controls, licensing, new product approvals, subsidies, stockholding and fertilizer manufacture. All such policies and implications will be indicated in the Target Market Assessment. The IA should alert dealers to policy-related issues and the status of progress in working with policymaking bodies to achieve reforms.
3. *Capacity building support to dealers* (business management, technical issues, farmer services and demand building): The IA will need to provide ongoing support to dealers to strengthen their capacity in the supply and marketing of UDP products. Three areas are essential:
 - a. *Technical issues:* Ensure fertilizer briquetting machine installation for safe and secure operation. Strengthen dealer capacity in briquetting machine operation/adjustment to achieve high-quality briquettes. Disseminate machine maintenance guidelines to keep equipment in good operating condition and to extend machine life.
 - b. *Farmer services:* Build dealer knowledge to provide sound farmer advisory services on plant nutrients in general and UDP use in particular.

- c. **Business acumen:** Strengthen dealer capacity in record keeping and financial management to support internal decision making and better equip dealers in linking with financial institutions to access investment and working capital for UDP market entry/participation.
4. *Facilitate dealer access to briquetting machines:* Work with local metal works/fabrication shops to locally fabricate fertilizer briquetting machines, linking dealers to the machine fabrication shops and engaging with local financial institutions to support dealer access to loans for briquetting machine purchase.
5. *Create farmer demand for the technology:* Engage in an aggressive UDP technology promotion campaign to create awareness and build farmer demand. Linking farmers to channel members that are engaged in fertilizer briquette supply is essential.

Other Issues and Considerations: A number of other issues and considerations will impact private dealer participation in UDP manufacture/marketing. The IA should be proactive in providing channel members and farmers with information in the following:

1. *Impact of urea briquettes on the sale of other fertilizer products:* As a new product in the product mix, urea briquette sales will displace (cannibalize) sales of standard prilled/granular urea. This is a normal market phenomenon with any new product entry. Since urea briquettes and UDP deliver increased nutrient recovery by the plant and higher yields, farmers will be inclined to use a lower level of urea fertilizers overall. However, three issues are at play:
 - a. Urea briquette prices should adjust to reflect costs and market/profit objectives. Overall, farmers will spend less on urea fertilizer with UDP while farming the same land area.
 - b. Additional revenue may be realized through improved sales of fertilizers containing other primary/secondary/tertiary nutrients. Value-based pricing may be appropriate.
 - c. Improved soil nutrient management will lead to greater returns to farmers, achieved through improved yields; this will improve dealer-farmer relations.
2. *Resource requirements for most village-level dealers to engage in briquette manufacture will be significant.* The following is indicative of the resources needed to pursue briquette manufacture:
 - a. *Investment capital:* The retailer should have access to sufficient capital to finance the purchase of the briquetting machine. The full cost of a briquetting machine is in the range of U.S. \$2,500 to \$5,000 depending upon local supply versus import. Due to risks associated with new product introduction, dealers may need to be provided with added incentive to invest in fertilizer briquetting machines. It is IFDC's experience that (i) a phased cost share of 75% cost paid by the IA and 25% paid by the private dealer and (ii) a commitment by the IA to provide technical support in briquetting machine operation (e.g., dealer training in briquette manufacture/machine maintenance/quality control) and engage in demand-building activities (e.g., UDP demonstrations, advertising) are adequate incentives to encourage private sector investment. In most cases, a 75:25 cost-share ratio will be needed for the first two to three project years. Beginning in Year 3 or 4, the cost share may be gradually phased out over the remaining life of the project.

The retailer must have access to sufficient dry and secure facilities in which to operate the briquetting machine and to inventory storage for the fertilizer raw materials and finished UDP products; 3.5 square meters is adequate floor space.

- b. *Working capital:* Working capital requirements will vary by situation. The following are areas wherein costs may be incurred for private dealers:
 - **Legal costs:** As a manufacturer, the retailer in most countries will have to obtain registration and register the product separately from prilled urea because of the different physical form.
 - **Labor costs:** As the demand for UDP briquettes increases, there will be a small (one or two person) day labor requirement.
 - **Raw material costs:** This will primarily be costs for procurement/inventory holding of small quantities of urea fertilizer.

- Promotion costs: The extent of dealer participation in fertilizer promotion is generally quite low. However, some dealers may seek to establish promotion activities to create demand for UDP. Technology demonstrations/field days may be relatively low-cost activities that will require some allocation of working capital.
3. *Supply*: The retailer must have reliable access to a supply of high-quality prilled urea and, if manufacturing NPK briquettes, also have access to supplies of other fertilizer products (e.g., diammonium phosphate and muriate of potash).
 4. *Power supply*: If the dealer has consistent and reliable electric power, the briquetting machine can be either electric or diesel powered. If the electricity supply is inconsistent, diesel motors are necessary to ensure meeting production goals.
 5. *Business management*: The retailer should be prepared to record all operating costs associated with UDP production and marketing. These costs will include:
 - Urea costs.
 - Processing costs including labor, power, machine maintenance, bags and bagging costs and machinery depreciation.
 - Inventory costs.
 - Overhead costs.
 - Promotion costs including field demonstrations and field days.

Important elements of good business management include:

- a. Understand and regularly address the basic elements of marketing:
 - *Product* – Three aspects are particularly important: (a) achieving high-quality urea briquettes that are consistent in shape with few broken pieces, the correct weight and free of moisture; (b) understanding how to apply urea briquettes for maximum benefit; and (c) understanding both the agronomic and economic benefits that the farmer should experience after using UDP. Knowing your product is paramount to success.
 - *Place* – Selection of a good location is important to give farmers convenient access to the product. The shop should be in a secure location and on high ground to avoid flooding. The hours of operation should be convenient for farmers.
 - *Promotion* – The urea supplier can greatly influence farmer demand. Effective methods include using wall hangings, handing out technical brochures, posting sign boards and holding educational sessions for farmer groups. Hosting field demonstrations is highly effective:
 - *Price* – To determine the price to charge for urea briquettes, the following factors should be considered: costs of manufacture, farmer demand for briquettes vis-à-vis prilled urea and competition. Ultimately, the urea briquette supplier will have to cover all of the costs of doing business in order to stay in business. Charging a fair price to farmers (i.e., achieving a reasonable return on investment) will help to improve the chance of success.
- b. Planning is key to agro-dealer success; it applies to:
 - *Budget* – A budget of all expected expenses and revenues by cost category should be developed each year and each quarter.
 - *Finances* – Cash flow management is essential to meet daily expenses, buy needed supplies and materials and cover operating costs.
 - *Asset management* – It is necessary to keep accurate records of inventory, both of conventional urea (in order to have enough supply to make briquettes) and also an inventory of briquettes to maintain a reasonable supply to meet demand.
 - *Promotional campaign* – Promoting UDP requires advance planning to ensure wall hangings and other promotional materials are in place before the season, to arrange a good-quality demonstration plot and to coordinate with extension agents and organizations to develop educational programs for customer farmers.
 - *Business growth* – Growing an agro-dealer business includes: (a) making arrangements for adequate physical space and additional shop locations; (b) holding employee trainings; and (c) increasing the scope of business to include other fertilizer products (urea contains only nitrogen, but farmers also need other fertilizers [e.g., those containing phosphorus, potassium and sulfur] as well as complementary goods).

- c. Build backward and forward business linkages. Good business relations with suppliers of briquetting machines and urea briquettes are important. This will help prevent any “lost production” time due to lack of urea or mechanical breakdown of equipment. Also, build linkages with extension agents and organizations (e.g., NGOs, farmer groups) for joint promotion and training programs.
 - d. Know the total cost of the business operation (i.e., the total cost of doing business). Recordkeeping will provide the information needed to understand the total cost of doing business. This is key to making a profit and fair return on investment.
6. *Sales records:* Record-keeping provides the foundation for good planning and overall business management. The IA should request all sales points to maintain sales records by customer and location and eventually by crop and location to compare with targets and manage corrective actions to achieve target sales. The following types of records should be kept:
- a. *Financial records to record daily costs by category* – For example, rent, utilities, briquetting machine maintenance, promotion, machine fuel, taxes, labor.
 - b. *Cash flow records* – Record daily cash received, cash paid and a running balance amount.
 - c. *Sales records for each day* – Quantity sold and name of farmer.
 - d. *Production records for each day* – Record how many bags of urea briquettes were produced and keep a running balance per month and year.
 - e. *Inventory records* – The amount of urea briquettes in stock and amount of prilled urea in stock, with a running balance.
 - f. *Briquetting machine maintenance records.*
7. *Training programs:*
- a. A comprehensive training program on operation of the briquetting machine and quality control will be given by the IA.
 - b. A comprehensive business management training program will be provided covering operational issues such as pricing, promotion, product features, quality control and inventory management. An individual business plan will be developed if required.
 - c. A comprehensive training program will be provided on the use and benefits of UDP for individual crops, economics of use by farmers and how to promote this information to farmers.

Chapter 5. UDP Promotion and Farmer Education to Create Farmer Demand

Achieving and sustaining widespread farmer demand for UDP fertilizers (urea briquettes) requires creating farmer awareness and interest and stimulating change in farmer behavior to adopt the new technology. Farmer education on the proper use of UDP fertilizers and the benefits associated with the technology is essential to increasing the UDP fertilizer market. Demand-building activities must be continuous throughout the project life and thereafter to achieve sustainable results.

The Implementing Agency (IA) will manage and control an aggressive UDP promotion campaign. The campaign will include a strategically designed “promotion mix” that creates awareness of UDP technology, stimulates farmer interest in the technology, and prompts farmers to adopt UDP in their fertilizer management practices. Thereafter, continued emphasis on carrying out promotional UDP activities to sustain farmer demand is essential. The promotional program must be tailored to the farmer conditions in the target market area.

Collaborative linkages are important in UDP promotion and farmer education; opportunities to develop suitable linkages should be considered. For example, forming linkages with a government’s Ministry of Agriculture (MOA)/ Department of Agricultural Extension (DAE) is essential to gain farmer acceptance of UDP and offers an excellent opportunity to extend farmer education programs. Non-governmental organizations (NGOs), rice development projects, farmer member groups, fertilizer dealer associations and private sector agribusiness firms may be suitable entities for collaborative linkages as they seek to improve crop yields.

This chapter provides guidelines for developing the UDP promotion and farmer education program. Included are examples of promotional and farmer education materials such as schematics of UDP application (Exhibit 5-1), videos of UDP field application, sample billboards, banners and demonstration plot signs (Exhibits 5-2, 5-3 and 5-4), templates with recommended messaging, information brochures for extension agents and farmers (Exhibits 5-5 and 5-6) and farmer training guidelines (Exhibit 5-7).

Improved Soil and Crop Nutrient Management and Stimulating Farmer Demand for UDP

Balanced fertilizer use is one of the keys to achieving high returns from agriculture production. It is essential to sustainable agriculture production systems. UDP technology will play an important role in soil fertility management by improving the efficiency of nitrogen fertilizer use with lower application of applied nitrogen and improved uptake by crops. The best results, however, will be achieved through balanced fertilizer use. Efforts to stimulate farmer demand for UDP technology should focus on encouraging farmers to include UDP fertilizer in their soil management practices based upon soil- and crop-specific nutrient requirements – nitrogen (from UDP fertilizer), phosphorus, potassium, sulfur, calcium and micronutrients. Appropriate diagnostic tools, including soils analyses, should be used to determine the best nutrient management program.

UDP Fertilizer as a New Product – As indicated throughout this manual, urea briquettes should be treated as a new product in the product mix of agriculture input dealers. **But unlike typical “new product” introduction, successful introduction of UDP, on the demand side, is much more complex. Farmer behavior must change in markets that are characterized by use of conventional inorganic fertilizer products and traditional application practices such as broadcasting (e.g., surface-applied).**

Farmer Characteristics and Understanding Farmer Behavior – Farmers have a common interest in achieving the best yields and returns from agriculture. However, limitations (e.g., availability of resources, access to markets, knowledge) often hinder farmer success in achieving improved returns. In order for the IA to design a strategic promotion campaign to stimulate farmer demand for UDP fertilizer, it is necessary to understand farmer characteristics (including limitations) and behavior.

The fertilizer market assessment completed in the initial phase will provide useful information in assessing farmer characteristics and understanding farmer behavior. It is important to be aware of the “customer adoption curve” and implications in the promotion strategy. For example, there are typically five categories of farmer customers for new products:

- a. *Innovators* – Usually the most progressive farmers with access to modern technologies.
- b. *Early adopters* – Progressive farmers with above-average education and community leaders.
- c. *Early majority* – More conservative farmers, with an average level of education, and relatively active in the community.
- d. *Late majority* – Very conservative farmers, cautious of new ideas and technologies, who have a lower level of education and are more likely to be land renters than land owners.
- e. *Late adopters* – Farmers with a low level of education who typically rent land rather than own their farm and follow long-standing traditional practices in agriculture.

Farmers that are classified as innovators and early adopters should be targeted in the initial farmer education programs for UDP market development and could serve as collaborators in on-farm demonstrations. Their endorsement of UDP will have a positive influence on the farmers in the “early majority” and “late majority” categories.

Labor Burden in UDP Application – Manual UDP application is labor intensive, similar to the burden involved in transplanting rice seedlings. The labor requirement (bending over and inserting the UDP briquette in the soil) acts as a deterrent to some farmers.

In order to alleviate the farm-level labor requirement in UDP technology, IFDC has developed a simple applicator for briquette placement. A plunger-type applicator is highly effective and conveniently available in Bangladesh. The cost is less than \$10 per unit f.o.b. basis (2015). A more sophisticated push-type applicator is also under development. Exhibit 5-8 provides details for the manufacture of the plunger-type applicator. IFDC continues to work to develop both applicators and will provide updates on the technology as advances are made.

Role of Extension Education – A government’s MOA/DAE is well positioned to play an essential role in UDP technology introduction and market development. Attention to engaging the MOA/DAE at all levels will pay dividends in farmer education and increase farmer demand for UDP products. This will include cooperation in the following areas:

- a. *Engage MOA/DAE in UDP Trials and Evaluations* – Gaining MOA/DAE support is a priority. From the beginning, collaborate with DAE (as well as other departments in the MOA and national research organizations). Collaboration should focus on the testing and validation of UDP product performance under various cropping conditions and implementation of workshops to present findings and gain stakeholder endorsement.
- b. *Build MOA/DAE Capacity and Understanding of UDP Technology* – Collaborate with MOA/DAE to modify staff training curricula to include UDP technology in field officers’ training programs.
- c. *Engage MOA/DAE in On-Farm Interventions and Other Demand-Influencing Activities* – Include MOA/DAE field officers in all UDP on-farm demonstrations, technology field days and farmer training events. This will reinforce MOA/DAE staff knowledge and convey the message that MOA/DAE supports UDP technology inclusion as an appropriate technology. Include MOA/DAE field staff and area officials in media events, agriculture trade fairs, discussions with farmer associations and similar events that offer opportunities to further the advancement of UDP awareness and knowledge building.
- d. *Link MOA/DAE to Suppliers of UDP Products* – Members of the UDP supply chain have a vested interest in building demand for UDP products. Inclusion of MOA/DAE field officers in training programs for UDP suppliers will further MOA/DAE staff knowledge of factors that impact quality control in UDP manufacture, handling and storage. It also will better equip MOA/DAE officers in their capacity to advise farmers on UDP.
- e. *Organize UDP Technology Workshops in Close Collaboration With and Full Involvement of MOA/DAE* – UDP technology workshops should be planned and conducted at key intervals in the market development program.

This should include a minimum of three national workshops, one at the beginning of the program, one at the midpoint and one at the conclusion.

Promotion Strategy and Farmer Education Programs: The promotion strategy for UDP should be well designed and tailored to the target market and farmer characteristics. As indicated above, the promotion strategy will be influenced by the profile of the farmer in the target zones. Among others, the following promotion activities may be appropriate to create demand for urea briquettes:

- a. **Farmer Meetings** – Farmer meetings offer excellent opportunities to present and discuss UDP technology: how and why it works, application practices and use benefits. The IA, in collaboration with the MOA/DAE field officers and agricultural input dealers, initially should select farmers classified as “early adopters/early majority.”
 - *Objectives*
 - ✓ Share relevant, up-to-date soil fertility management information and UDP technology information as a component of soil nutrient management.
 - ✓ Improve farmers’ knowledge in soil nutrient management and create awareness of UDP technology and best management practices that will increase crop yields.
 - *Implementing Guidelines*
 - ✓ Establish objectives and plan for the preparation, presentation (speakers/visual aids) and follow-through of the program.
 - ✓ Focus on UDP as a component of the soil and crop nutrient management program.
 - ✓ Conduct meetings in an orderly manner using knowledgeable staff, clear objectives and a focused program agenda. Provide each farmer with a notebook, pen, cap and T-shirt with UDP marketing and a technical leaflet in the local language on soil/crop nutrient management and UDP. The government extension officer should be present for all farmer meetings.
 - ✓ Schedule the meetings at a convenient venue and time that does not conflict with local events. Choose an accessible location that is comparatively quiet. In advance of the program, generate interest and enthusiasm for attendance and participation. Provide snacks/lunch as appropriate for all in attendance.
 - ✓ Have a plan for follow-up farm visits.
 - *Measurement* – At the completion of each farmer meeting, the IA should conduct a review to assess the quality of the event and to determine if modifications of future meetings are needed. Some factors that may be considered in the evaluation are:
 - ✓ Determine the level of farmer participation, including farmers’ engagement in discussions and their candor while answering questions.
 - ✓ Analyze the quality of presentations by field staff and their capacity to respond to farmer questions on soil nutrient management/fertilizer recommendations and UDP use.
 - ✓ Determine the budgeted versus actual costs and preparation time.
 - ✓ Analyze the quality of presentations by field staff and their capacity to respond to farmer questions on soil nutrient management/fertilizer recommendations and UDP use.
 - ✓ Determine the budgeted versus actual costs and preparation time.

- b. **Farm Visits** – Farm visits are critical to demonstrate interest in the farmer’s welfare. The visit is a good opportunity to provide technical information on UDP use and obtain feedback on the results of advice. This will serve as a follow-up program to offer answers or solutions to questions and problems not covered in detail during the large farmer meeting.
 - *Objectives*
 - ✓ Demonstrate interest in the farmer’s needs and assist him or her in improving farm productivity.
 - ✓ Follow up on specific soil/crop nutrient management issues and UDP in particular. This gains the farmer’s trust and confidence.
 - *Implementing Guidelines*
 - ✓ Plan the visits according to farmers’ availability.
 - ✓ Involve the female in the household if appropriate. She may do most of the work, control the family’s spending and influence the buying decision for farm inputs.
 - ✓ Encourage MOA/DAE field officers to participate in visits if they are available.
 - *Measurement*
 - ✓ Evaluate the results of each farm visit relative to attainment of objectives.
 - ✓ Evaluate the farm visit relative to improving the preparation for the next visit and/or promotional activities, thereby maximizing the visit’s benefits.

- c. **Mass Media** – The IA should conduct a media event to include representatives from various media outlets. The purpose is to acquaint the media with UDP technology and the initiation of the UDP market development program. Representatives of the MOA/DAE should attend to show government support for the technology. Recurring television or radio farm programs can overcome the communication barrier that often results from language and educational differences. Recurring agriculture sections of national newspapers reach numerous farmers, create awareness and increase farmer knowledge of UDP technology.
- *Objectives*
 - ✓ Create awareness of UDP technology and knowledge transfer to farmers on best use practices/economic returns.
 - *Implementing Guidelines*
 - ✓ Develop program materials from the IA implementation team and include accurate details on best use practices/results.
 - ✓ Present materials in a manner appropriate to the listeners' level of understanding and oriented to their economic capacity.
 - ✓ Incorporate a radio farm program into the integrated extension education strategy in combination with other field extension activities.
 - *Measurement*
 - ✓ Use feedback from farmers, MOA/DAE field staff, farmer associations and input dealers to measure the success of the media efforts.
- d. **Farmers' Training Classes** – Farmers' training classes are effective in educating farmers on UDP technology. The classes should be formal, classroom-style events. The program content will include the basics of soil fertility management for crops planted in the target area and an introduction to UDP technology for rice. Each program should be approximately six hours in duration and include 40 farmers per event. Language for the medium of instruction must be localized, simple and straightforward.
- *Objectives*
 - ✓ Increase farmer knowledge of UDP fertilizer technology and its role in improving soil and crop nutrient management.
 - *Implementing Guidelines*
 - ✓ Initially select training participants with a sufficient level of education (classified as early majority or early adopters). To the extent feasible, consult with MOA/DAE field officers and fertilizer dealers when selecting farmers.
 - ✓ Target the subject matter on UDP to crops (primarily lowland rice) in the area where classroom trainings occur.
 - ✓ Be aware of local customs and provide a schedule that allows for both women and men to participate. Snacks and lunch should be provided.
 - *Measurement*
 - ✓ Monitor participants' farm practices to determine if they are practicing what they learn from the training program.
 - ✓ Evaluate program content, structure and duration to assess the need for adjustment.
- e. **Printed Educational Materials** – UDP technology leaflets and brochures should be developed and disseminated to farmers, agro-input dealers and collaborators at all levels. These materials include wall hangings for MOA/DAE offices and agro-input dealers. All should be in the local language and include schematics and photos to illustrate proper handling and use of UDP fertilizer.
- *Objectives*
 - ✓ Provide agro-input dealers with point-of-purchase handouts for farmers.
 - ✓ Provide a simple reference guide for best UDP use practices and benefits to collaborators that interact with farmers on improving agriculture production.
 - ✓ Provide farmers with a simple brochure/leaflet on UDP technology that they can share with family and friends and reference regularly.
 - *Implementing Guidelines*
 - ✓ Present subject matter in the local language.
 - ✓ Make the presentation attractive with colorful visual aids.
 - ✓ Use farmer testimonials to support UDP technology.
 - *Measurement*
 - ✓ Analyze farmers' recall and their use of the information.
 - ✓ Determine production cost of the material and dissemination.

- f. **Field Days** – Field days are effective educational extension activities and should be a part of the farmer education and UDP promotion program. Field days provide an opportunity to showcase the results of farm demonstrations; they establish visible proof of success of a credible farmer-cooperator. Successful field days have well-planned programs, strong advance publicity, good organization before and during the event and enthusiastic participation of field extension workers.
- *Objectives*
 - ✓ Demonstrate local proof to farmers that UDP technology is profitable and applicable to their own farming situation.
 - ✓ Provide a venue for a high level of local farmer participation. Farmer-cooperators and neighboring farmers are able to observe the standing crop, participate in crop harvest, share UDP field results and exchange experiences.
 - ✓ Provide an opportunity for furthering farmer relationships with MOA/DAE and UDP dealers.
 - *Implementing Guidelines*
 - ✓ Begin planning for the field day three weeks before the visible results are apparent in the UDP demonstration treatment plots.
 - ✓ Select a date that does not conflict with other activities (market day, official holidays, religious holidays, etc.) in the community.
 - ✓ Discuss field day plans with the farmer-cooperator, farm input dealer, supplier representative and field personnel of research and extension agencies for integrated participation and involvement.
 - ✓ Prepare or secure materials in advance.
 - ✓ Use a field day checklist (Exhibit 5-9) to guide the procedure in conducting the field day.
 - ✓ Present awards and certificates of cooperation to the farmer-cooperator as part of the field day program.
 - *Measurement*
 - ✓ Have farmers complete an evaluation questionnaire (Exhibit 5-10) to measure the effectiveness of the field day.
 - ✓ Conduct follow-up visits for farmers whose questions or problems were not fully addressed during the field day program.
- g. **Farm-Level Technology Demonstrations** – UDP technology demonstrations on farmers' fields will be a key activity in UDP promotion and farmer education. Demonstrations are best conducted with farmer leaders as farmer-cooperators, and they should include involvement of the MOA/DAE and agro-input dealers. If farm demonstration plot treatments are statistically replicated in various locations per crop season, the program may also serve as adapted research to fertilizer crop response.

The working framework of this program is presented in more detail to serve as an example of the process involved in successfully planning and executing an on-farm UDP technology demonstration.

- *Objectives*
 - ✓ Demonstrate local proof of the benefit of improved farm practices.
 - ✓ Show the farmer that the practice is profitable.
 - ✓ Gather actual and factual yield data for dissemination.
 - ✓ Gather visual aid materials for advertising and promotion.
 - ✓ Provide a nucleus or “show window” for field days, guided tours, farmer meetings, farmer training classes, etc.
- *Implementing Guidelines*
 - ✓ Select the site and farmer-cooperators.
 - ✓ Conduct the program as a cooperative effort with farmer-cooperators.
 - ✓ Promote the support and involvement of government agencies and farm input suppliers involved in farm servicing.
 - ✓ Define operating procedures, policies and responsibilities of participants.
 - ✓ Provide operational training for participants on the conduct of the program and on sound agronomic management practices for targeted crops in the agroecological zone.
- *Procedures*
 - ✓ Define participants' responsibilities for the following tasks and/or requirements. (Participants include farm input suppliers/dealers, farmer-cooperators, government field services personnel, etc.)
 - ✓ Select farm sites and farmer-cooperators.
 - ✓ Demonstrate layout/plot treatment and agronomic management.
 - ✓ Install farm demonstration plot signs/billboards.
 - ✓ Collect and interpret data results/testimonials/promotion materials.
 - ✓ Determine cost of and conduct field days.

- ✓ Formulate an agronomic management guide for the crop. The guide will prescribe the recommended management practices to be demonstrated. The management guide should define and specify the following: area requirements, minimum and maximum size, soil analysis and previous cropping history, land preparation, seed preparation, rate and method of planting, cultivation, fertilizer application, pesticide application, weeding, harvesting, supervision and/or observation schedule and preparation for field days.
 - *Measurement*
 - ✓ Determine the number of farmers adopting the UDP technology and practices demonstrated.
 - ✓ Use the results of the demonstration to determine the success of the field day conducted.
 - ✓ Analyze the number and quality of promotional materials generated from the demonstration that can be used to promote the adoption of the UDP technology.
- h. **Agriculture Fairs/Trade Shows** – Agriculture fairs and trade shows present an opportunity to introduce UDP technology to key stakeholders at many levels: lead farmers in the community, agriculture input dealers, political leaders and the general public. The IA should participate, at a minimum, by organizing a booth for UDP technology that includes a UDP product display and brochures (in local language) that describe UDP technology. The booth should include the demonstration of both UDP manufacture and use.
- *Objectives*
 - ✓ Increase awareness of UDP technology as a new and appropriate fertilizer technology.
 - ✓ Encourage private dealers, non-governmental organizations (NGOs) and others to add UDP to their product mix.
 - *Implementing Guidelines*
 - ✓ Determine dates of planned agriculture trade fairs and technology shows and make staffing assignments for the management of the IA's participation.
 - ✓ Register and reserve space for a booth. Include a briquetting machine and a simple model demonstration plot for rice and other crops. Demonstrate the urea briquetting machine operation.
 - ✓ Complete planning for assembly of the booth and the organization of all materials for the booth (briquetting machine setup, model demonstration plot, samples of urea briquettes and conventional urea, technical brochures to hand out, wall hangings, parallel videos of UDP manufacture and use to show on a continuous basis, etc.).
 - ✓ Ensure that the booth and exhibits/displays are properly implemented in time for the first day of the event.
 - *Measurement*
 - ✓ Determine (registered in writing) the number of visitors that inquire about briquetting machines and express interest in being a UDP supplier/dealer or fabricator of briquetting machines and the number of farmers that express interest in having a UDP demonstration plot on their farm.
 - ✓ Use the number of brochures/leaflets disseminated to measure success.
- i. **Advertising: Roadside Signs, Billboards, Promotional Handouts, Materials for Dealer Shops, and Social Media Messaging** – Advertising through non-personal means offers an excellent opportunity to generate interest in UDP technology. While relatively high cost (vis-à-vis other signage), well-placed UDP technology billboards with a simple message and appropriate illustrations are quite effective in creating awareness and influencing demand. Billboards reach a large number of stakeholders at all levels and the general public. Roadside signs are an effective form of additional messaging on UDP. Promotional handouts (e.g., T-shirts, caps, umbrellas with UDP messaging) are valuable tools in generating farmer interest in the technology. All agriculture input dealer shops that include UDP fertilizers should be provided with wall hangings and display materials with appropriate messaging for farmers about UDP use and benefits.
- *Objectives*
 - ✓ Create awareness of UDP technology among the rural population.
 - ✓ Create awareness of UDP technology among agriculture input suppliers.
 - ✓ Mark areas where UDP plots are installed.
 - ✓ Provide further messaging on UDP technology use and benefits.
 - *Implementing Guidelines*
 - ✓ Develop a written plan with specific targets (e.g., number of billboards, number of signs, number of handouts) and planned sites/locations for the advertising program.
 - ✓ Contact MOA/DAE and other collaborating stakeholders to discuss the written advertising plan and seek suggestions to improve the plan and leverage resources.
 - ✓ Complete messaging for each advertising medium.
 - ✓ Arrange with local authorities and landowners for the placement of billboards/roadside signs.

- ✓ Arrange (with local service providers) for the production of high-quality advertising materials – billboards/assembly, signs, handouts for farmers, dealer wall hangings/display materials.
 - ✓ Periodically (bi-weekly or monthly) visit areas where advertising billboards/roadside signs are installed to verify that signage is in place and that UDP use in the area is being sustained or increasing. (NOTE: Be sure that only fields that are under UDP treatment are marked with UDP signs.)
 - ✓ Visit agriculture input dealer shops to provide updated signage/display materials as needed and verify proper placement in the dealer shop.
 - *Measurement*
 - ✓ Solicit feedback from MOA/DAE, NGOs and others regarding the appropriateness of the signs and their perceived value in promoting the technology.
 - ✓ Solicit feedback from farmers regarding their attitude/reaction to billboards, roadside signs and wall hangings/display materials in dealer shops.
 - ✓ Solicit feedback from dealers regarding the reaction of farmers to wall hangings and UDP technology displays in dealer shops.
- j. **Open Sky Show** – Open sky shows may be an appropriate advertising tool for UDP technology, depending upon the cultural environment. Typically, the shows are presented as a form of entertainment, with an underlying message of UDP fertilizer use and its benefits.
- *Objectives*
 - ✓ Create awareness of UDP technology among the population in villages/small towns.
 - ✓ Distribute further messaging on UDP technology use and benefits.
 - *Implementing Guidelines*
 - ✓ Develop a simple, attractive video production with local music and actors to illustrate UDP technology use and benefits.
 - ✓ Review video (15-20 minutes in duration) for technical accuracy on UDP technology.
 - ✓ Arrange with local village officials to show the video at a central village location at night (one night per month beginning the month before the agriculture season).
 - *Measurement*
 - ✓ Monitor attendance at each show to measure interest.
 - ✓ Discuss with farmers/family members their reception of the show and their perception of (and interest in) UDP technology.
- k. **Motivational Events** – Motivational events target farmers that have not yet adopted UDP technology. The events involve arranging for groups of non-adopting farmers to attend a technology field day on farmers' fields. The event serves as an opportunity for the farmers to observe crop health and yield improvement with UDP and discuss UDP with farmers who use the technology.
- *Objectives*
 - ✓ Create awareness of UDP technology among targeted farmers who are identified as having high potential for adoption.
 - *Implementing Guidelines*
 - ✓ Set the date of the event to coincide with the technology field day.
 - ✓ Select targeted farmers and arrange for transport by bus to the field site.
 - ✓ Recognize the selected farmers as potential adopters of UDP technology and explain their involvement in the ceremony as a learning experience.
 - ✓ Present field day results and provide farmers an opportunity to ask questions regarding their own circumstances.
 - *Measurement*
 - ✓ Assess farmers' interest in adopting UDP technology on their farms.

Management of Promotional Campaign: The IA will manage the promotional campaigns to ensure that all promotion activities are (a) high quality, (b) directed to reaching the intended target audience that will impact UDP technology market development and (c) focused to deliver consistent and appropriate technical messages to the target audience. The IA will be responsible for ensuring there is a sufficient staffing structure and funds available to implement the promotional campaign.

Proper management of the promotional campaign will help to ensure costs are properly managed, any errors in messaging are detected at an early date, and opportunities to enhance the UDP technology promotion efforts are identified in a timely manner.

The IA should focus on the following management issues, among others:

a. **Quality Control**

- *Messaging* (accuracy of technical content and use of language that is appropriate to the target audience – farmers, dealers, researchers and the public sector). All materials should be appropriate to the cultural environment of the target farmers, technically accurate and attractive in presentation.
- *Managing collaborators to ensure consistency in UDP technology promotion is essential*. Private sector fertilizer dealers, NGOs, international agricultural research centers (IARCs), associations and others should be interested in encouraging farmers to use UDP fertilizers. Ensuring consistency in farmer education on UDP is essential to demand creation and sustainability of UDP. Consistent messaging includes providing proper guidance on establishing demonstrations correctly, proper interpretation of demonstration results and presentation for field days and accurate messaging in NGOs' literature.
- *Advertising materials* – billboards, signboards, wall hangings, technical leaflets, handouts – should be high-quality materials and well-installed. For example, billboards should be installed to withstand high winds without damage and with colors that will not quickly fade from ultraviolet rays. Signboards on roadsides and in farmer fields should be made of high-quality materials and well anchored to minimize theft.

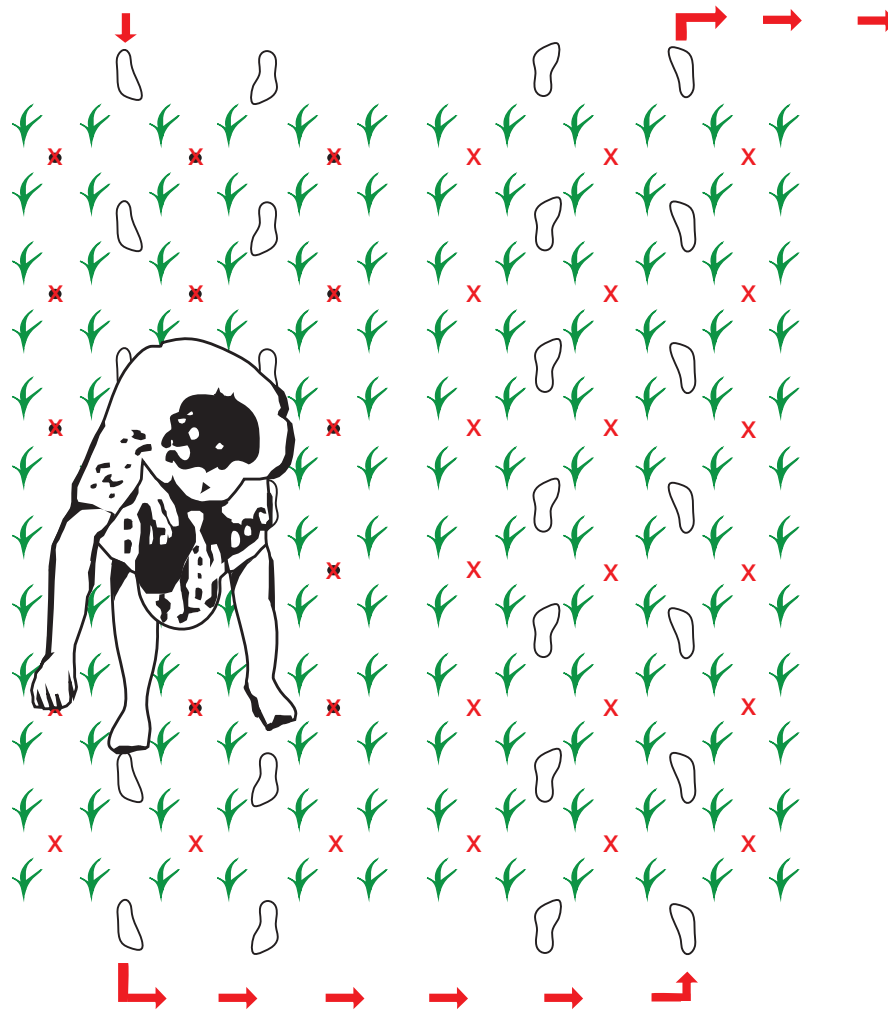
b. **Crisis Management** – It is important to be aware of and prepared to respond to various stakeholders (as well as outside groups) that may oppose UDP fertilizer. The first step in crisis management is to be proactive rather than reactive in addressing UDP issues. Several proactive steps can be taken: (1) build a solid record of science-based testing and field validation of UDP across multiple seasons, crops (rice and vegetables) and soil conditions (do this in collaboration with local and national agriculture research organizations, MOA/DAE, etc.); (2) maintain frequent and ongoing interaction with key stakeholders and collaborators to detect any issues related to UDP demand (e.g., UDP product quality and use results); and (3) include the donor community (as appropriate) in workshops, farm visits, UDP demonstrations and field days. When opposition to UDP technology does occur, depending upon the source of the opposition, the response should be measured and based upon science-based evaluations and field performance.

c. **Financial and Resource Management** – The promotion program will be a major cost item in the IA's budget. Attention to the use of funds to validate cost appropriateness and application to the intended purpose is essential. The timing of cash flow requirements will require close management to ensure funds are available in a timely manner to implement the promotion program (e.g., setting up crop demonstrations, installing billboards before the cropping season, participating in trade shows, conducting farmer training before the crop season begins).

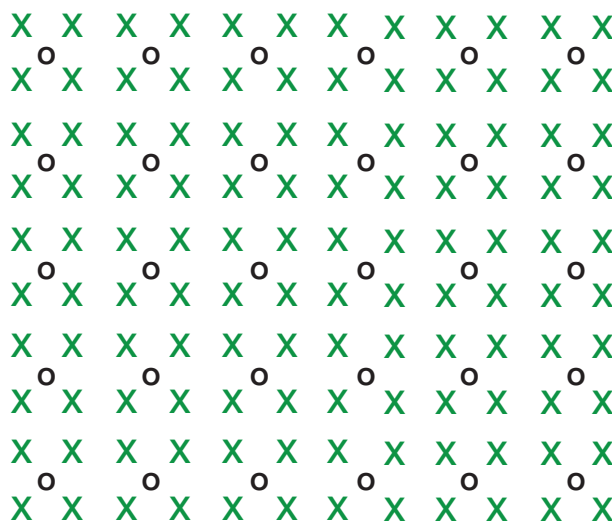
d. **Measuring the Impact of Various Promotional Activities** – It is essential to continually assess the effectiveness of the promotional activities in stimulating farmer demand for UDP. Initially, some activities may be more effective than others; however, it is important that attention is given to reinforce messaging to farmers so that the farmer does not lose interest. Continuing UDP promotion support with and through MOA/DAE and dealers will be key to sustaining the technology beyond the life of the UDP market development effort.

Exhibit 5-1
Schematic of
Urea Briquette
Application

This schematic
may be used as
a handout to
trainee farmers,
or as a sign at
both dealers'
shops and for
field days.



√ = One (1) hill of planted rice seedlings. ● = Briquettes. ✕ = Placement of briquettes. ☐ = Placement of feet between rows of rice.



X = One (1) hill of planted rice seedlings. O = Placed briquettes (all sizes).

Urea Briquettes (o) are deep-placed at 7-10 cm depth at the center of alternate four rice hills.

Exhibit 5-2
Sample
Billboards



Urea Deep Placement Less Expense More Rice



USAID
IFDC AAPI

গুটি ইউরিয়া

কম খরচে অধিক ধান

সহযোগিতায়: কৃষি সম্প্রসারণ অধিদপ্তর

Exhibit 5-3
Sample
Agriculture
Trade Fair
Banner

Agriculture Trade Fair Urea Deep Placement



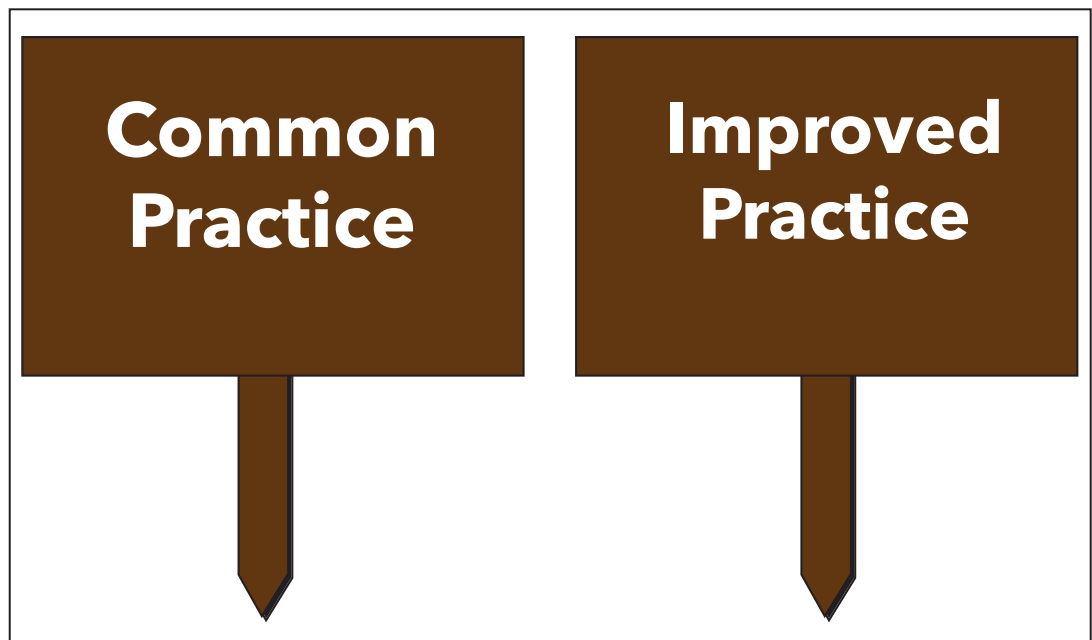
In collaboration with _____

Exhibit 5-4
Farm
Demonstration
Signage

The farm demonstration billboard and plot signs should be installed only when successful results are visible.



Farm demonstration billboard (6'x 4'), with lettering in bold type against a painted background.



Two farm demonstration plot signs (2'x4'), with lettering in bold type.

Exhibit 5-5
Information
Brochure for
Extension
Agents

Exhibit 5-5 includes content that the Collaborating Partner/Implementing Agency can use in a brochure, or other information-sharing publication, for extension agents.

Urea Deep Placement: Information for Extension Agents

Traditionally, urea fertilizer is broadcast – typically with two, three, or possibly four applications – during rice cultivation. Urea use is inefficient during split broadcast application. In this process, up to 70% of nitrogen is “lost” in three main ways. First, nitrogen evaporates into the air. Second, urea mixes with paddy water and travels to other fields through runoff. Third, due to leaching, the N moves deep into the soil. As a result, the rice plant cannot absorb the required quantity of nutrient from urea.

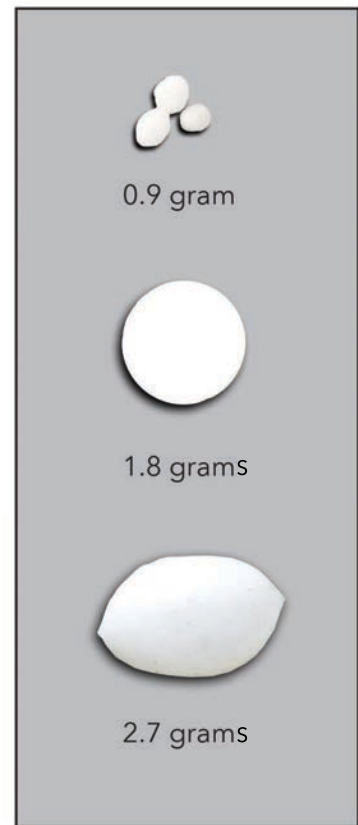
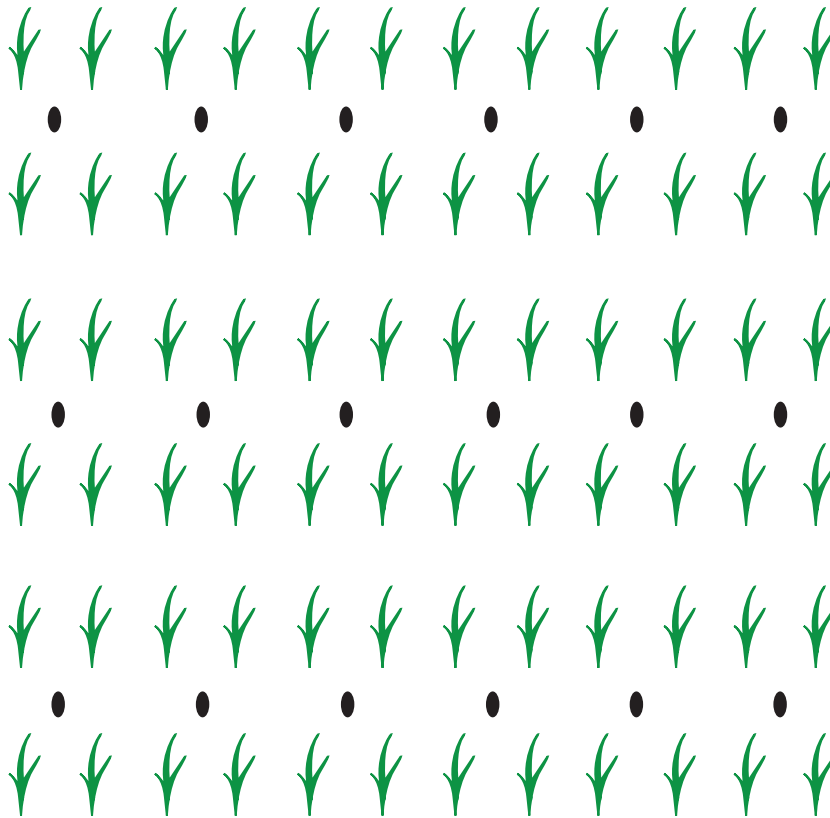
Research results of IFDC and other local and international agencies indicate that the efficiency of urea more than doubles if urea is deep-placed up to 7-10 centimeters (3-4 inches) into the soil. In addition, rice production improves by 15%-20%. IFDC has observed that if a farmer uses UDP in two rice seasons on 0.2 ha of land, the additional rice produced can provide the yearly food requirement (daily 2,122 kilo-calorie) of one person.



Urea Briquettes

Urea briquettes are produced by a briquetting machine using either prilled or granular urea available in the market. The briquetting machine produces three different sizes of briquettes.

- 0.9 gram weight: In Bangladesh, for example, three briquettes are applied in the *Boro* season and two in *Aus/Aman* seasons in the center of four hills in line-planted rice seedlings.
- 1.8 gram weight: In Bangladesh, one briquette is applied in *Aus/Aman* seasons in the center of four hills in line-planted rice seedlings.
- 2.7 gram weight: In Bangladesh, one briquette is applied in the *Boro* season in the center of four hills in line-planted rice seedlings.



 = One (1) hill of planted rice seedlings.  = Placed briquettes (all sizes).

 indicates where to deep-place briquettes

Why is UDP potentially more profitable than using prilled urea?

- **Improves nitrogen intake** – Loss of nitrogen is reduced significantly in UDP application. It does not evaporate as gas in the air. In addition, it reduces leaching and runoff to other nearby crop fields.
- **Requires less urea** – Due to increased nutrient use efficiency, about one-third less urea is required.
- **Increases crop yield and farmers' income** – Farmers increased rice yields and incomes.
- **Improves soil** – Soil texture and structure improves.

How and when to apply urea briquettes?

For paddy in line sowing method:

- Transplant seedling at a line-to-line distance of 20 x 20 centimeters (8 x 8 inches) and plant-to-plant distance of 20 x 20 cm (8 x 8 in) five to seven days before application of urea briquettes.
- Apply briquettes within five to seven days of transplantation of seedling before the soil becomes hard and compact.
- Apply briquettes when there is 2-3 cm (1 inch) of standing water in the field.
- While applying briquettes, put sufficient quantity of briquettes in the fold of the container in order to cover the last seedling in the line.
- Start application from the right side of the field.
- Deep-place briquettes in the middle of four seedlings of the 1st and 2nd line up to 7-10 cm in the soil.
- Apply three briquettes in accordance with (briquette size and number of briquettes) recommended rates of application. If the soil is soft, then cover the point of application with mud.
- After applying briquettes between the 1st and 2nd line, apply between the 3rd and 4th line in a similar manner.
- Again, apply briquettes between the 5th and 6th line following the same procedure and complete application in the whole field. Please ensure that applied points are not pressed by the farmer's feet.
- Farmers should not walk on the field within 30 days of briquette application. However, if it is necessary, farmers should be sure not to step in the points in the field where briquettes were deep-placed.
- Water must be kept in the field after UDP application so that the soil is not cracked or broken.

For paddy not planted in lines:

Urea briquettes also can be applied in paddy fields where line sowing is not followed. In that case, apply the required number of briquettes in one point and go ahead in the right and left directions, keeping 40 cm (19 inches) distance from one point of application to another. In this method, it might not be possible to deep-place briquettes at equal distance of hills/seedlings, but higher crop yield can still be obtained.

Other points to consider:

- Apply all fertilizers other than urea as per prescribed dose.
- Use good quality seeds of high-yielding variety.
- Apply briquettes in fields where water leaching is comparatively less. Do not use briquettes in sandy soils.
- For desired higher yield, apply briquettes in paddy fields where line sowing has been done.
- Take timely measures for insect and pest control.
- Apply timely irrigation.
- Control weeds in a timely manner.

Use of urea briquettes with other crops

On-farm IFDC research results show that UDP can be profitable in vegetable production, such as cauliflower, cabbage and eggplant. In this case, 10%-20% less urea is required over the recommended dose for surface application.

Advantages

Agronomic:

- Single application is sufficient until the ripening of paddy. While purchasing all of the required urea at the beginning of the season can be a constraint for some farmers, they will be purchasing only two-thirds of the rate.
- Infestation of weeds and grasses is reduced.
- Rice plants get the required supply of nitrogen in various stages of plant growth.
- UDP improves the uptake of other plant nutrients from soil.
- The nutritive value of straw is higher and can be used as high-quality cattle feed.
- In drought, rice plants cope comparatively better as roots become longer and go deep into the soil.

Socio-economic:

- UDP gives higher yield and higher profit.
- Food security improves for farm families.
- Farmers' incomes increase.
- Poverty is reduced.
- New employment opportunities are created.

Market opportunity and saving of foreign exchange:

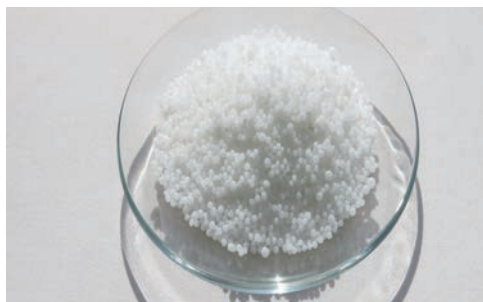
- Demand of prilled or granular urea goes down during peak season.
- During peak season, fewer problems occur with fertilizer procurement and purchase.
- The cost of transportation and storage is minimized due to reduced requirement of urea.
- Foreign exchange is saved for import of a large quantity of urea.

Impact on environment:

- There is a positive impact on the environment. UDP results in reduced losses of applied nitrogen due to a decrease in N volatilization, leaching and runoff.

Exhibit 5-6 includes content that the Collaborating Partner/Implementing Agency can use in a brochure, or other information-sharing publication, for farmers.

Urea Deep Placement: Less Expense, More Rice Information for Farmers



Prilled Urea



Urea Briquettes



Broadcasting Prilled Urea



Urea Deep Placement

Prilled Urea

- The agronomic efficiency of prilled urea is only 30%.
- The nitrogen in prilled urea evaporates as a gas.
- Nitrogen is lost through leaching in the soil.
- Nitrogen also is lost through floodwater runoff.
- Compared to UDP, 30%-40% more prilled urea is required for rice.
- Prilled urea must be broadcast two, three, possibly four times.
- Due to nitrogen losses, crop production is less than with UDP.
- Nitrogen losses pollute air and water.
- There are more weeds in the field.
- Scarcity of prilled urea in the peak season causes farmers' concern.

Urea Briquettes

- The agronomic efficiency of urea briquettes is 60%-70%.
- The nitrogen is not lost through gaseous emissions.
- Nitrogen lost through soil leaching is reduced.
- Nitrogen lost through floodwater runoff is reduced.
- With the recommended dose, 30%-40% less urea is needed.
- UDP reduces expenditure of urea by 20%-25%.
- UDP increases paddy yield by 15%-20%.
- UDP encourages better water management.
- Line sowing makes weeding and pest control easier.
- A single application of urea briquettes is enough.
- Farmers earn more profit.



How to Transplant Seedlings While Using Urea Briquettes

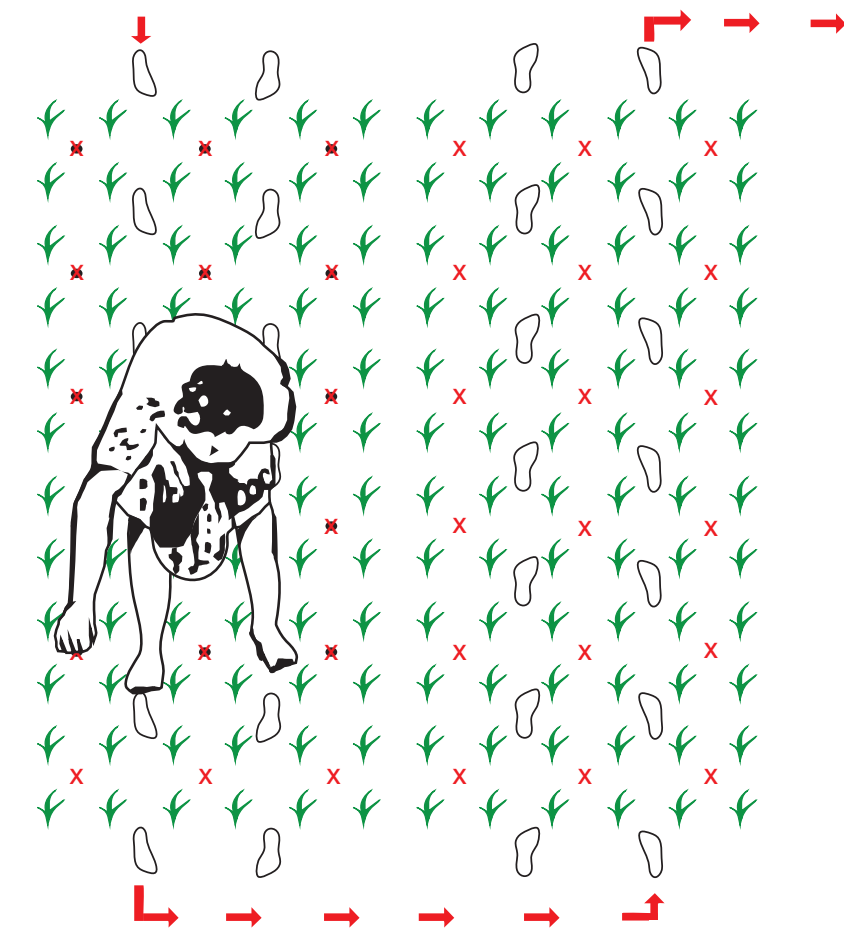
Transplant paddy seedlings five to seven days before urea briquette application, keeping line-to-line distance of 20 x 20 centimeters (8 x 8 inches) and plant-to-plant distance of 20 x 20 centimeters (8 x 8 inches).

When to Use Urea Briquettes

- Apply urea briquettes within five to seven days of transplanting, before the soil becomes hard.
- It is advisable to use briquettes when there is 2-3 centimeters (1 inch) of standing water in the field.

How to Deep-Place Urea Briquettes

- Put the required quantity of briquettes in the bag so that briquettes can be applied to the end of the line.
- Start deep placement from the right side of the field.
- Deep-place briquettes in the middle point of every four seedlings of line one and two.
- Deep placement should be made up to 7-10 centimeters (3-4 inches) into the soil.
- If the puddle soil is not soft, then cover the deep placement point with mud.



The path shown in the diagram (left) requires the farmer to walk in the rows that do not receive briquettes. Hand placement is in the process of being replaced with simple mechanized applicators. Mechanized application will reduce human labor.

☐ = One (1) hill of planted rice seedlings. ● = Briquettes. ✕ = Placement of briquettes. ☐ = Placement of feet between rows of rice.

Exhibit 5-7 Guidelines for Farmer Training

This guide is to be used in the planning and conduct of farmer training programs.

The farmer training should be a one-day event. The morning is allocated to presentations and group discussion. The afternoon is for practice. The trainer is a facilitator of the agenda, using the group to discuss the topics and ask and answer questions.

Each training session will be composed of a maximum of 40 farmers. Presentations and discussions are for awareness building/technology dissemination. Subjects to be covered include: good seed, soil health, balanced fertilization, seed quality, line sowing, perching (integrated pest management [IPM]) practices, applicator, health tips, nutrition, UDP technology benefits, method of application of urea briquettes and a simple farm budget plus an analysis showing financial returns to the farmer. A flip chart may be used for training with pictorial materials.

For farmer training, the following principles are considered to be important:

- The training is intended to motivate farmers to adopt UDP technology and spread the messages to friends and neighbors.
- Farmers need to have a reason for coming to the training. They are there because they want to know about UDP technology.
- The training needs to address real constraints and offer practical solutions in the context of existing farming systems.
- Farmers need to feel the training is directed at their needs. They need to feel they are in control.
- The training needs to be based on experience. Use the experience of the group to answer the questions. Encourage questions and answers.
- The training needs to give time to practice and evaluation.

1. **Purpose/Objectives**

The purpose of farmer training is to increase farmer awareness, knowledge and use of UDP technology. The objectives of farmer training are to:

- Generate knowledge of UDP technology and other best farm management practices among farmers so they understand the practice and its benefits.
- Develop the skills required of farmers to apply the technology.
- Motivate the farmers to adopt the new practices.
- Motivate the farmers to spread their knowledge and skills in the community.
- Create linkages between the farmers and briquette producers.

2. **Venue/Resource Requirements**

The venue should be a location convenient to farmers. It should include a designated area for the classroom-type session (may be in a building or any area that provides a suitable “learning environment”).

The resource requirements for all farmer training events include:

- Flip chart and different color writing pens.
- Facility for video.
- Access to a small plot which is prepared in advance for UDP application.

3. **Format**

Both technical classroom and hands-on field training will be done. All will be in an interactive format.

- a. ***Understanding the Expectation of Farmers*** – An interactive discussion will determine what each farmer/participant expects to achieve from the training. It will help the trainer to identify the strengths and weaknesses of the group. For example, some may be new to the technology and want to know what UDP and urea briquettes are. Others may know what it is and want to know how to use it. Some may know how to use it but want to know where to obtain briquettes, how much they cost and how much they need.

The trainer will list all of the expectations and explain how the training will meet expectations – or not. For example, some topics expected may not be covered.

The following is a sample of topics that the Training Specialist should cover:

- Cropping systems
 - ✓ Interactive discussion about the existing cropping system and its production and constraints.
 - ✓ Examination (what are the technologies), evaluation (what are their benefits), relevance (how do they fit into the farming system), constraints (what are the problems to address) and solutions (how to solve the problems) of the UDP technology:
 - UDP.
 - Balanced use of fertilizer.
 - Good seed.
 - IPM.
- Soil
 - ✓ Soil health and characteristics of good soil.
 - ✓ Balanced fertilization.
- Seed
 - ✓ Importance of good high-yielding variety and quality seed for increased production.
 - ✓ Seedling age and line transplanting.
 - ✓ Spacing and number of seedlings per hill.
- Water and fertilizer relationship
 - ✓ Uptake of plant nutrients and irrigation.
- UDP technology
 - ✓ What is UDP technology for rice?
 - ✓ Benefits of UDP technology (agronomic and economic).
 - ✓ Methodology/application technique.
 - ✓ Use of applicator.
 - ✓ Results of UDP technology in other countries.
 - ✓ Measures for achieving best results of UDP technology.
 - ✓ Experienced farmers' views.
 - ✓ Use of UDP in vegetables and other crops.
- Crop management
 - ✓ Crop protection through integrated pest management.
 - ✓ Proper/timely weeding.
 - ✓ Control of misuse of water.
 - ✓ Timely harvesting.

b. **Lunch**

- c. **Practical Demonstration** – One of the most important parts of farmers' training is field practice for urea briquette deep placement. A minimum of two hours should be dedicated to the practical field demonstration of UDP application practice. Use a demonstration method that farmers can practice and replicate. A suitable plot near the training venue will be prepared before starting the training program. *Rice seedlings and urea briquettes must be kept as training materials for the practical session.*²³ Plot size should be adequate to allow for practice by all the trainees on the following:

- Line sowing.
- Point placement technique.
- Use of applicator.

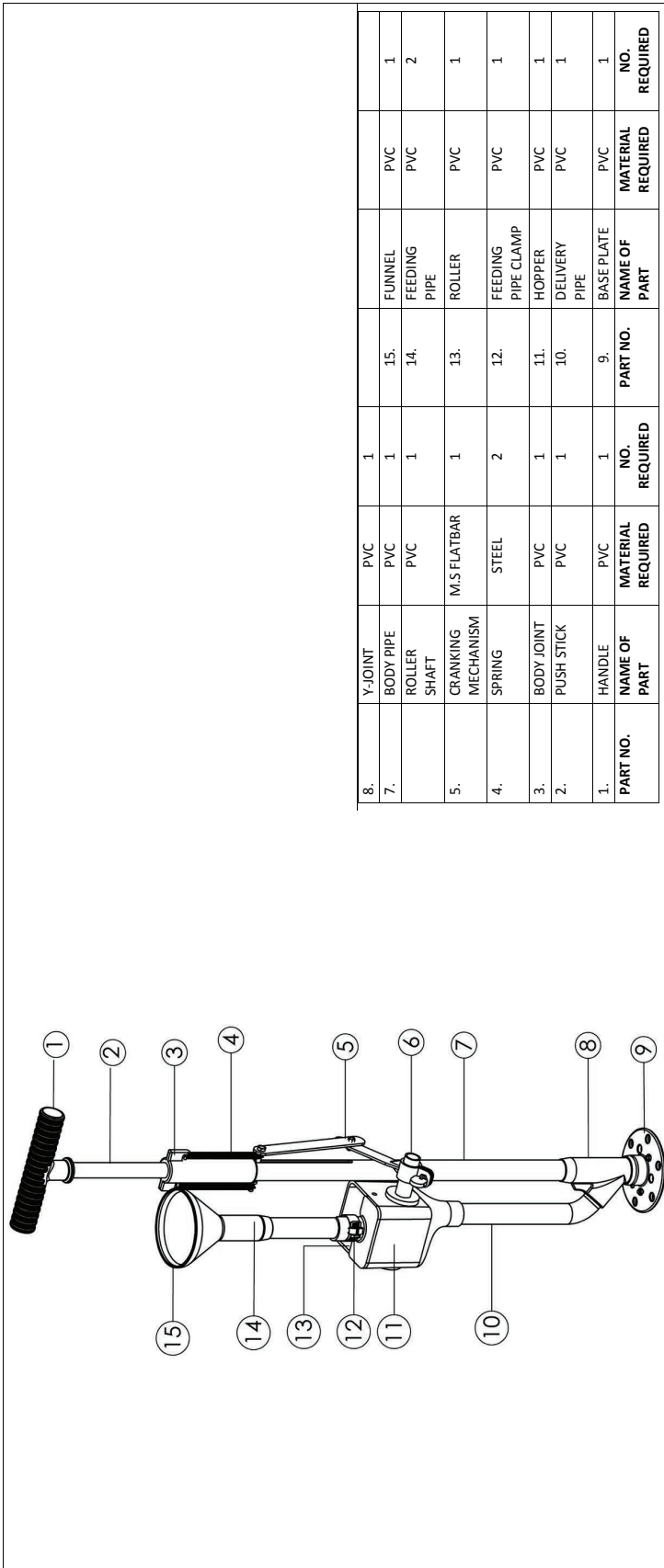
Farmer training may be conducted by trainers from the Ministry of Agriculture/Department of Agricultural Extension, non-governmental organizations, private sector agro-input dealers and the staff of the IA. Urea briquette shop owners should be encouraged to conduct farmer training. In this case, the IA staff will conduct the training but farmer selection and costs will be the responsibility of the briquette shop owners. Joint farmer training programs can be organized by the IA and private agro-dealers and/or NGOs on a cost-sharing basis.

- d. **Guidelines for Conducting Training** – The following guidelines are mandatory for all farmer training:
- Farmer training is designed for new farmers. There must not be any repeat farmers who have received training before in any season.

²³Note: For UDP practical demonstration on a vegetable crop, the plot at the training site should be planted in advance of the training event so that the crop is at the appropriate growth stage for UDP application.

- Select only farmers who are engaged in high-yielding variety or hybrid cultivation.
 - ✓ Priority must be given to ensure participation of irrigation groups with a scheme manager, farmer groups and other farmer organizations in training.
 - ✓ In vegetable-intensive areas, some farmer training programs should be organized exclusively for farmers of vegetables and other crops in consultation with field staff.
 - ✓ A suitable training program schedule must be convenient for farmers (especially women).
 - ✓ A suitable venue/classroom for farmer technical training (preferably in a primary school or other venue with electricity) must be selected.
 - ✓ Training is to be conducted by a trainer who has received “training of trainers.”
 - ✓ Briquette owners must visit the training class and be given time to promote their product and inform participants of their name, address and cell phone number.
 - ✓ Local representatives should be invited to attend training programs occasionally on a voluntary basis.


Exhibit 5-8
Injector
Applicator



PART NO.	NAME OF PART	MATERIAL REQUIRED	NO. REQUIRED	PART NO.	NAME OF PART	MATERIAL REQUIRED	NO. REQUIRED
8.	Y-JOINT	PVC	1	15.	FUNNEL	PVC	1
7.	BODY PIPE	PVC	1	14.	FEEDING PIPE	PVC	2
	ROLLER SHAFT	PVC	1				
5.	CRANKING MECHANISM	M.S FLATBAR	1	13.	ROLLER	PVC	1
4.	SPRING	STEEL	2	12.	FEEDING PIPE CLAMP	PVC	1
3.	BODY JOINT	PVC	1	11.	HOPPER	PVC	1
2.	PUSH STICK	PVC	1	10.	DELIVERY PIPE	PVC	1
1.	HANDLE	PVC	1	9.	BASE PLATE	PVC	1
PART NO.	NAME OF PART	MATERIAL REQUIRED	NO. REQUIRED	PART NO.	NAME OF PART	MATERIAL REQUIRED	NO. REQUIRED

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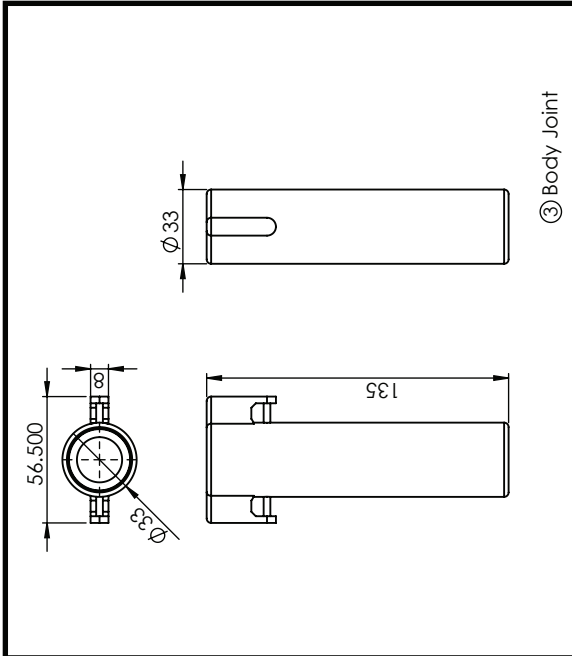
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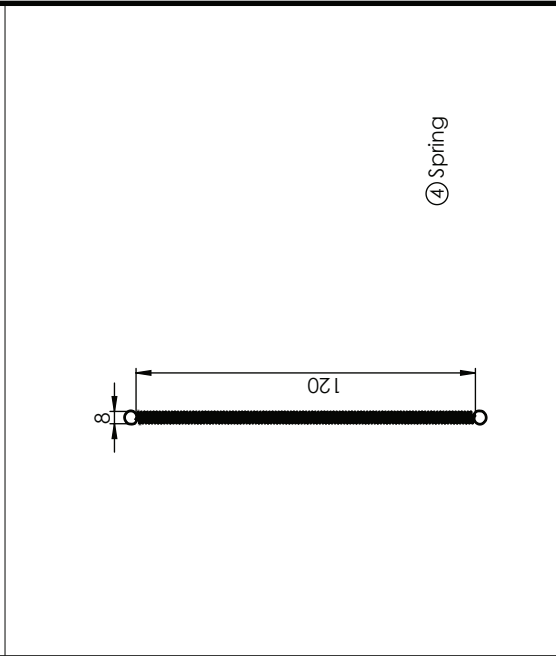
RANGPUR FOUNDRY LIMITED (RFL)

IFDC-RFL GUTTI UREA APPLICATOR

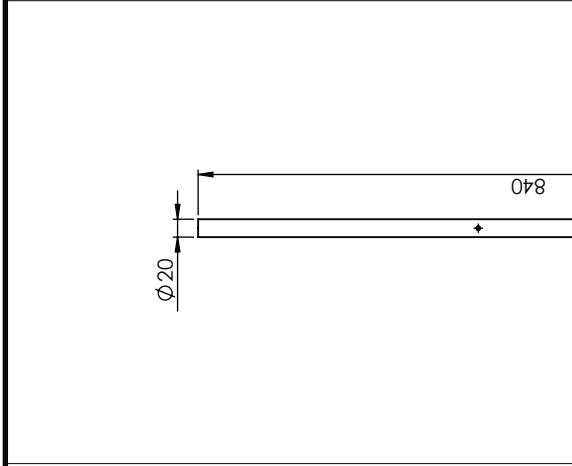
Designed By : Dr. Md. Abdul Wahab
Agriculture Engineer, AAPI-IFDC



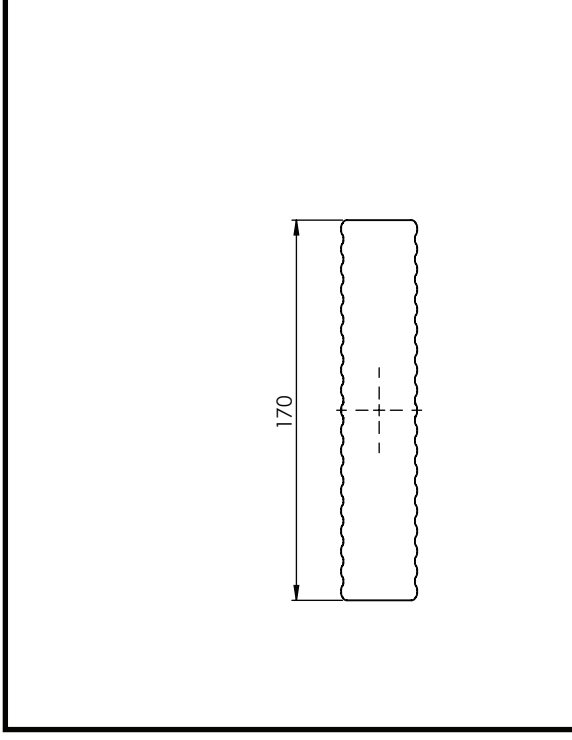
③ Body Joint



④ Spring



② Push Stick

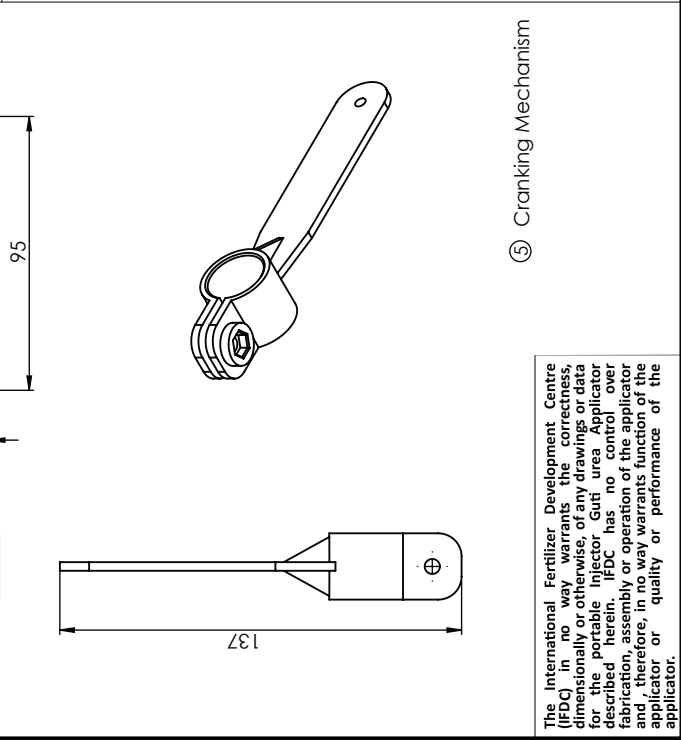
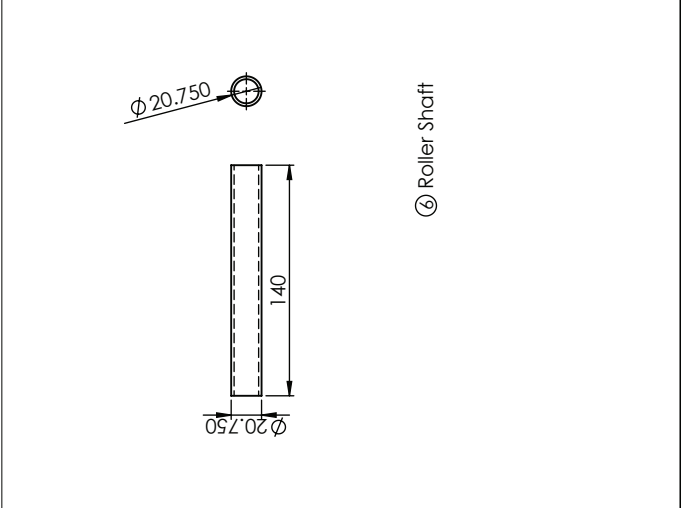
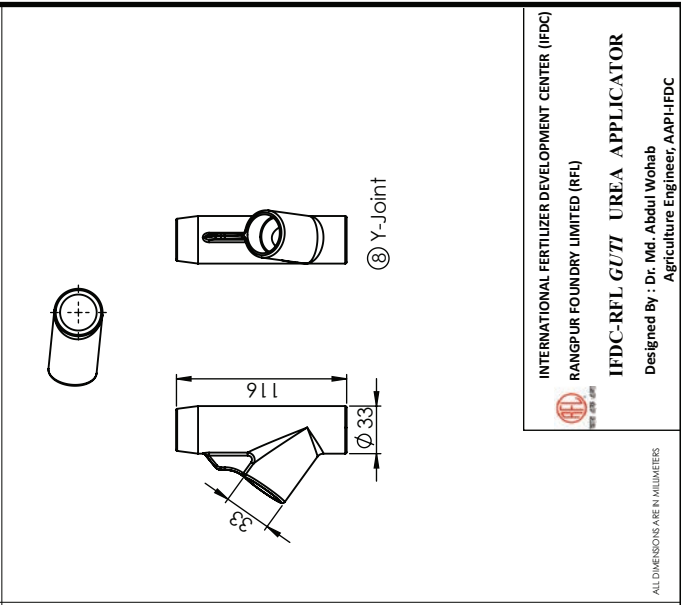
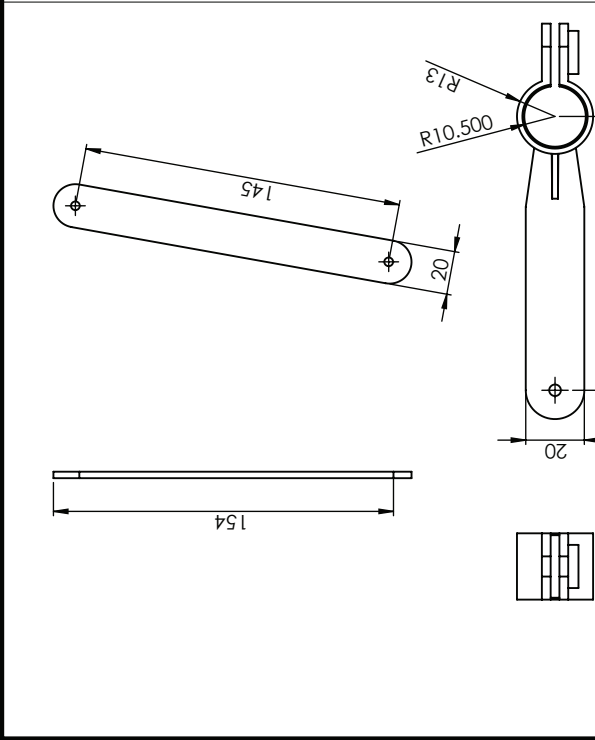
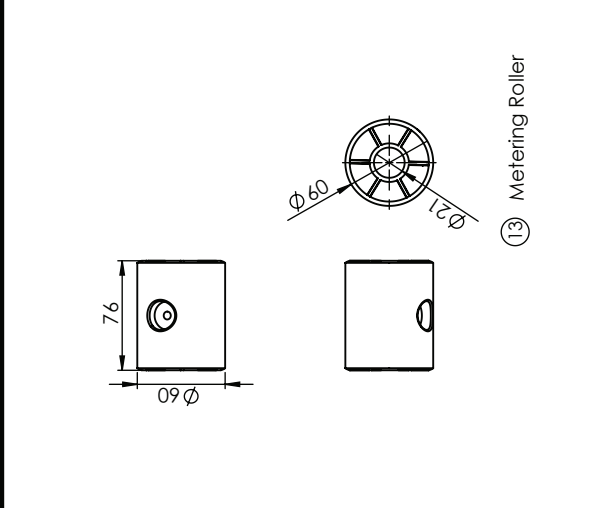
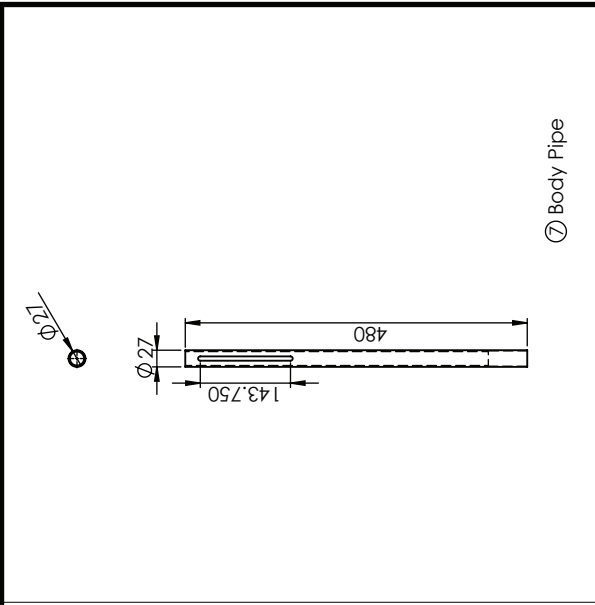


① Handle

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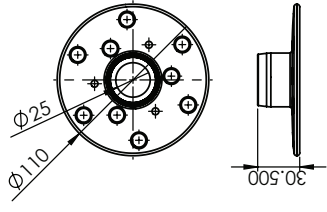


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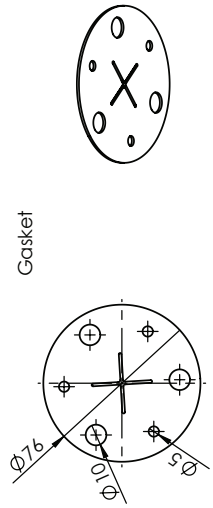
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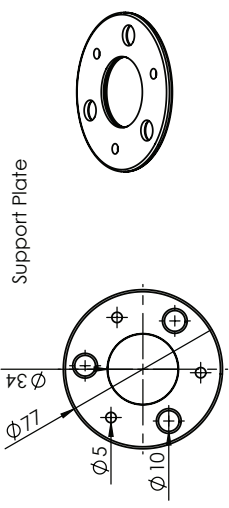
Base Plate



Gasket

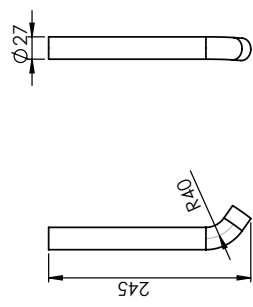


Support Plate

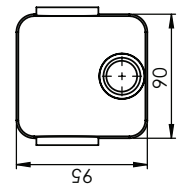


⑨ Base Plate Assembly

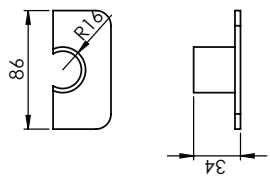
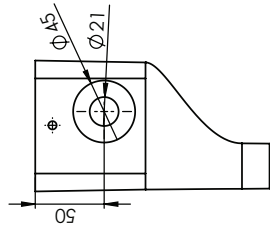
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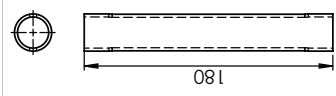
⑩ Delivery Pipe



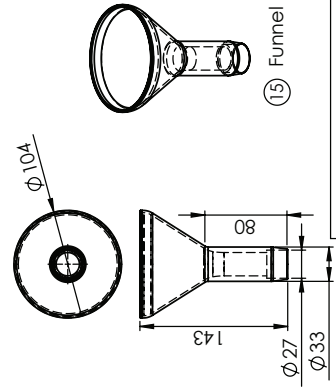
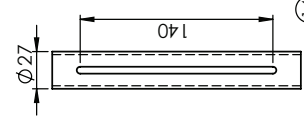
⑪ Hopper



⑫ Feeding pipe Clamp



⑬ Feeding Pipe



⑮ Funnel

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Exhibit 5-9

Field Day Checklist

Each training environment will differ in terms of facilities and basic infrastructure to support electronic equipment. This checklist should serve as a guide with tailoring to the specifics that apply to the market environment.

I. Before the Field Day

A. Responsible Person: _____

Date	Check	Tasks
_____	()	1. Determine the approximate week of the month that the demonstration will be ready for a field day.
_____	()	2. Notify field personnel involved immediately.
_____	()	3. Prepare equipment and other supplies needed during the field day.
_____	()	a. Equipment:
_____	()	(1) Sound system.
_____	()	(2) Portable loudspeaker or bullhorn.
_____	()	(3) Portable product display.
_____	()	(4) Camera.
_____	()	(5) Weighing scale.
_____	()	(6) Containers for sample harvests.
_____	()	b. Supplies:
_____	()	(1) Streamers.
_____	()	(2) Stringed pennants.
_____	()	(3) Printed certificate of cooperation.
_____	()	(4) Handout materials (fertilizer samples, educational leaflets, etc.).
_____	()	(5) Invitation and program.
_____	()	(6) Field day evaluation questionnaires.
_____	()	c. Miscellaneous:
_____	()	(1) Refreshments – cost and at whose expense.
_____	()	(2) Plot markers for demonstration plots.
_____	()	(3) Directional signs – secure permit or help with local police.
_____	()	4. Select the date of the field day:
_____	()	a. Not in conflict with community activities (market day, holidays, etc.).
_____	()	b. Agreeable to:
_____	()	(1) Dealer/retailer/extension agents.
_____	()	(2) Farmer-cooperator.
_____	()	(3) Participating agency representative and other people solicited to participate.
_____	()	5. Obtain clearance from Mayor, Chief of Police, or Village Head:
_____	()	a. Enlist assistance for possible traffic problem.
_____	()	b. Peace and order.
_____	()	6. Prepare a list of selected guests and farmers to be invited:
_____	()	a. Private and government officials, particularly those in the field of agriculture.
_____	()	b. Selected farmers:
_____	()	(1) Similar crop.
_____	()	(2) Similar needs/interests.
_____	()	(3) User/potential user of fertilizer and/or pesticides.
_____	()	7. Check field day materials and supplies two weeks before field day.
_____	()	8. Check all coordination two weeks before field day to ensure that preparations are in order:
_____	()	a. Invitations and program.
_____	()	b. Refreshments and other materials.
_____	()	c. Farmer-cooperator participation.
_____	()	9. Prepare the field day invitation two weeks before the date of the field day and distribute these three to four days before the field day. The invitation should be attractively designed indicating the date, time and place (attach a location map if necessary). Use door prizes as incentives.
_____	()	10. Dress up the site with promotional materials to bring about a festive atmosphere one day before the field day.
_____	()	11. Brief the farmer-cooperator on the points he or she will talk about during the field day.
_____	()	12. Review the program of the field day; get the consent and cooperation of the participants. An illustrative format of the field-day program (only a guide) follows:

- a. 3 minutes – national anthem – actual singing or recorded.
- b. 5 minutes – opening/welcome remarks – fertilizer supplier, dealer or extension agent.
- c. 60 minutes – brief discussion of demonstration and tour of the demonstration plots – farmer-cooperator.
- d. 30 minutes – questions and answers – extension agent and farmer-cooperator.
- e. 3 minutes – music.
- f. 3 minutes – awarding of certificate of cooperation to farmer-cooperator.
- g. 30 minutes – awarding of door prizes by private or government agricultural agency representative.
- h. 3 minutes – music.
- i. 30 minutes – filling out evaluation questionnaire.
- j. 5 minutes – closing remarks – fertilizer dealer.
- k. Refreshments

Note: Program timing – In Bangladesh, the best time to conduct the program is between 2:00 p.m. and 5:00 p.m. on a weekday.

B. Responsible Person: _____

Date	Check	Tasks
_____	()	1. Make plans to provide refreshments needed and determine how these should be given to the group attending.
_____	()	2. Make plans to provide sound system and materials to decorate platform.
_____	()	3. Distribute invitation circulars to selected group.
_____	()	4. Plan to follow up on interested prospective customers.

II. During the Field Day

Responsible Person:

- _____ for the overall conduct of field day.
- _____ for documenting important testimonies of farmer-cooperators and ensuring completion of the evaluation questionnaire.
- _____ for receiving invited guests and serving refreshments at the end of the program.
- _____ for photography.

III. After the Field Day

Responsible Person:

- _____ for preparing the evaluation report of the field day, primarily based on the answers to the evaluation questionnaire.
- _____ for removing and keeping materials used and for follow-up of potential customers.

Exhibit 5-10
Field Day
Evaluation
Questionnaire

This simple tool is used to assess the farmer opinion of the training and to make improvements that should improve future training.

Reference Data

Farm Demonstration on: _____

Location of Farm: _____ Farmer-Cooperator: _____

Date of Field Day: _____ Time: From _____ to _____

1. What did you like about the field day?

- Program.
- Door prizes.
- Results of the demonstration.
- Other:

2. What did you like about the field day?

- Improved farming practices.
- Agricultural information.
- Features of farm input products.
- Other:

3. Indicate below your first, second and third choices which you find most interesting in this field day. First choice (1), Second choice (2), Third choice (3).

- Visual results of demonstration.
- Discussions of the practice or practices demonstrated.
- Information material distributed.
- Informative product display.

4. Do you find the results of this demonstration convincing? Please check:

- Yes No
- If "No," please indicate why:

5. Can the practice or practices demonstrated here be adopted on your farm?

- Yes No
- If "No," please indicate why:

If "Yes," would you adopt the practices on your farm?

- Yes No

6. Do you have any suggestions on how the field day could be improved?

If "Yes," what are these suggestions?

Chapter 6. Criteria and Guidelines for Establishing UDP Research and Field Demonstration Plots

IFDC has validated UDP technology under various research and field environments, including in the laboratory, greenhouse and research plot conditions, and under farmer field conditions. Numerous factors impact yield results with use of UDP (e.g., soil characteristics, UDP product quality, UDP dosage and placement in the soil, seed variety, cropping system and general crop management).

It is critical that the Implementing Agency (IA) evaluate the UDP technology and develop UDP application recommendations in the target zones during the first year. For example, UDP technology yields optimal results on clay soils with a high water and nutrient capacity. Heavy, dark brown soils (Vertisols) are the most appropriate to ensure good performance of UDP and reduce losses in the sub-soil, which are frequent in light, textured soils. Soils with higher water content also allow for easier briquette insertion, reducing the intensity of labor required.

The IA should conduct further research on UDP under both research and farmer conditions. The protocol guidance provided in Exhibit 6-1 will be useful to determine the initial UDP application rates for the research sites and trials and determine recommendations and factors that pertain to seed variety, water management and other crop management variables. Remember, UDP represents both a new fertilizer product in a generic sense (see page 2) and an improved farming practice. As such, UDP should be treated as a new fertilizer product in its introduction to farmers. This means that well-managed research trials, along with farm demonstrations, will be important components to the UDP promotion strategy and the farmer education program.

The main objective of the protocols for field evaluation of UDP is to establish a set of basic treatments and experimental conditions that make all the lowland rice experiments comparable to some extent and to allow for objective evaluation of UDP performance across various agroecological, management and socioeconomic conditions. The main objective of the individual experiments evaluating UDP in lowland rice is to quantify and compare the expected higher efficiency of nitrogen (N) fertilization attributed to the one-time deep placement of N, relative to conventional N fertilization in which broadcast urea is applied in two or more equal splits into the floodwater (typical farmer practice) at various stages of crop growth. Ratios of response of the UDP treatments with respect to the response of the “conventional” broadcast urea treatments will be used for treatment comparisons.

To achieve these objectives, this protocol will provide guidelines for the following:

- Selection of a basic set of treatments for research trials (see Exhibit 6-1 for recommendations related to treatments for demonstration plots and on-farm trials).
- Establishment and maintenance of the experiment.
- Experimental technique for obtaining high-quality data.
- Data collection from demonstration plots and on-farm trials.
- Format for data collection.
- Methods of data analysis.

1. Basic Treatment Set and Experimental Design for Research Trials on Experiment Stations

Each research trial will have seven common treatments (as described in Table 6.1) laid out in a randomized complete block design with four replications. This basic set of treatments will be common to all lowland rice research experiments comparing deep placement to broadcast application of fertilizers. The N rates for these basic treatments are relative to the local N recommendation, allowing for comparison of the efficiency of the deep placement across all locations where the set of treatments is applied. Local researchers may be interested in testing additional fertilization treatments (e.g., a widely adopted farmer practice that differs from the local recommendation) or the effect of management factors. However, if other fertilization treatments are added, the total number of treatments should not exceed 10.

If a factor related to rice crop management (such as irrigated vs. rainfed or different genotypes) is included, the experimental design needs to be changed to a split-plot design. The crop management factor will be set up in the main plot with the fertilization treatments (treatments listed in Table 6.1, plus up to three additional fertilization

treatments) providing the sub-plots. This design will keep the effects of fertilization treatments separated from other factors and allow for valid comparisons between locations.

Table 6.1
Description of
Basic Treatments
for Research Trial
Protocol

TREATMENT#	SOURCE OF N	TREATMENT DESCRIPTION
1		Absolute Check: 0 N, 0 P ₂ O ₅ , 0 K ₂ O
2	Conventional urea	Local NPK recommendation
3	Conventional urea	75% of N recommendation, 100% of P & K locally recommended ^a
4	NPK briquette	75% of N recommendation, 100% of P & K locally recommended
5	NPK briquette	50% of N recommendation, 100% of P & K locally recommended
6	Urea briquettes + basal P and K ^b	75% of N recommendation, 100% of P & K locally recommended
7	Urea briquettes + basal P and K ^b	50% of N recommendation, 100% of P & K locally recommended

^a Local recommendations based on previous research.

^b Applied as triple superphosphate (TSP) or single superphosphate (SSP) and muriate of potash (MOP) (KCl). Other nutrients: Include secondary and micronutrients as recommended.

2. Establishment of the Research Trial

a. *Initial Conditions*

Prior to land preparation, collect random soil samples from the field at a 0-15 cm depth. Analyze the samples promptly for NH₄-N, NO₃-N, pH, organic carbon and available P (e.g., Olsen procedure). If the soils have not been previously characterized, analyses for texture, cation exchange capacity (CEC), exchangeable bases (magnesium, calcium, potassium, sodium) and bulk density are needed.

Establishment of the experiment requires the following practices associated with management of the experimental units (plots) and treatments:

- Seedlings should be line transplanted into pre-prepared plots (up to an optimum size of 5 x 5 meters). Seedling age may vary considerably by season and variety. The plots should be individually bunded to a height of at least 25 cm and puddled before receiving basal applications of P and K fertilizers. This should be done 15-16 days after initial submergence. Basal application of fertilizers is done at the last ploughing.
- Basal application of fertilizers (P, K, recommended secondary and micronutrients; including first split of urea-N where applicable) should be incorporated to a depth of 10-15 cm.
- Seedlings should be transplanted in hills with row and plant spacing of 20 x 20 cm.
- Typically, each hill is planted with two seedlings; two to three seedlings may be used for local improved varieties and one seedling for hybrids.
- Briquettes are placed to a depth of 7-10 cm at the center of every four hills of rice (see Figure 6.1) within seven days of transplanting.

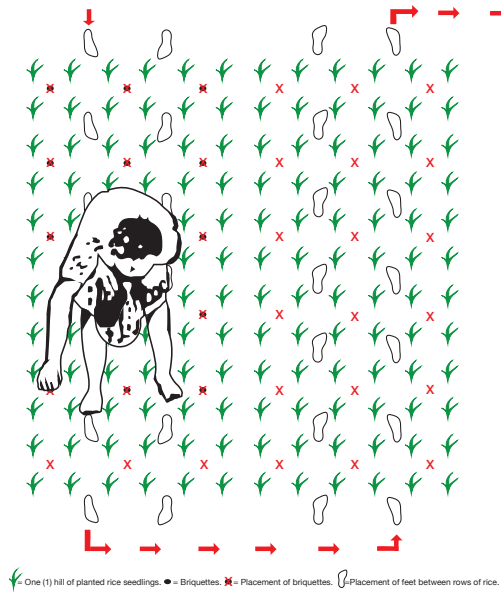
b. *Management Practices*

The trials should be conducted using the most common quality variety preferred by and accessible to farmers. Future trials will be needed to access the performance of deep placement vs. broadcast N with the new rice varieties that exhibit temperature, drought and salt tolerance. Early IFDC research indicated that short and medium duration dwarf to semi-dwarf and panicle-size rice varieties respond most positively to deep placement of N. This research also suggested that deep placement of N might not be as effective for long-duration varieties and that a supplemental topdressing of N at panicle initiation might be required. However, IFDC's activities in some countries have shown that long-duration varieties (up to 160 days) have not required supplemental N. The IA should evaluate the need for supplemental N for long-duration varieties that are under UDP technology. The best management practices in terms of water, weeds, pest and disease should be followed.

Figure 6.1a
Deep Placement
of Fertilizer
Briquettes
in Rice



Figure 6.1b
Detailed Drawing
of Briquette
Placement
in an
Experimental
Plot



Note: The path shown in Figure 6.1b requires the farmer to walk in the rows that do not receive briquettes. Hand placement is appropriate in the absence of simple mechanized applicators. Mechanized application of the briquettes is replacing hand placement and reducing human labor.

UDP requires trained farmers and extension agents who can correctly apply the fertilizer briquettes. Best results are achieved with line transplanting and good water management during the time of deep placement. The amount of N fertilizer applied with UDP depends on the size of the briquette (i.e., 0.9 g, 1.8 g or 2.7 g) and the spacing of briquette placement. Placement of briquettes should be at the *center of alternate* four rice hills (see Figure 4). After deep placement of the briquettes, avoid walking on the plots during all sampling and weeding procedures (see Figure 6.1b).

c. **Monitoring and Sampling**

Record dates of all field activities and inputs (quantities and costs) such as:

- Seeding date and type (breeders' seed/foundation seed/certified seed).
- Transplanting date.
- Dates of fertilization.
- Age of seedlings in days.
- Rice variety.
- Irrigation data by plot:
 - ✓ Periods of drying - no standing water (dates).
 - ✓ Dates of irrigation and time of irrigation.
 - ✓ Amount of water (if quantification is possible).
- Weeding schedule, etc.
- Dates of heading, flowering, maturity and harvest.
- Color chart reading at maximum tillering stage and at heading (Scale 1-6).
- Color floodwater N data (urea and NH₄-N) after each N application – install floodwater depth markers to determine the total floodwater N taking into consideration the concentration of the floodwater.

The following data will be collected at harvest from each plot in Reps 1-4 (assistance can be provided in designing the layout of the trial and in identifying plots to be harvested).

- Tiller and panicle numbers at harvest.
- Grain yield at 14% moisture.
- Straw weight.
- Grain N.
- Straw N.
- Grain P.
- Straw P.
- Grain K.
- Straw K.

An example of the layout of the plot and hills to be harvested is shown in Figure 6.2.

Figure 6.2
An Example
Layout of Hills
for Harvest Area

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
3	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
4	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
5	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
6	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
7	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
8	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
9	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
10	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
11	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
12	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
13	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
14	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
15	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
16	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Notes:

1. Harvest at maximum tillering – panicle initiation stage – green shading comprising of 5 hills x 2 hills x 2 locations in harvest area.
2. Harvest at booting/heading – peach shading comprising of 5 hills x 2 hills x 2 locations in harvest area.
3. Harvest at maturity – gray shading comprising of 12 hills x 12 hills.

For the two intermediate harvests (maximum tillering, booting heading), the following will be collected:

- Tiller number.
- Total biomass.
- Total N content.
- Total P and K content.

d. Irrigation and Maintenance

- Maintain the same level of water height to the extent possible while irrigating the plots. Monitor water depth each day at the same time.
- Monitor the number of irrigation events in a continuously flooded field.
- Maintain 2-5 cm water level from panicle initiation through grain formation.
- Irrigation will be finally closed (final drainage) two weeks before crop harvest.
- Record the date and amount of rainfall using a rain gauge installed in the field (or from the nearest weather station).
- If a weather station is located nearby, collect minimum and maximum temperatures, relative humidity and wind speed.

Objectives of Field Research Protocol

The main objective of an individual experiment for the evaluation of UDP is to compare the expected higher efficiency of some nutrients deep-placed relative to fertilization practices that are considered conventional. Conventional fertilization practices may include fertilization methods and products used by farmers in a specific location, or plant nutrition management associated with nutrient sources and rates that could be used in many areas of the world.

The main objective of a research protocol for field evaluation of UDP in various locations is to establish a set of experimental conditions and methodologies that make all the experiments comparable, allowing for an objective evaluation of UDP performance across diverse agroecological, management and socioeconomic conditions.

Ratios of response to the UDP treatments with respect to response to “conventional” treatments (equations below) will be used for the inter-location treatment comparisons.

$$R_y = \frac{y_{UDP}}{y_{Conv.}} \quad \text{or} \quad R_y = \frac{Y_{FDP}}{Y_{Conv.}}$$

Where R_y is a ratio of a response variable from a UDP treatment with respect to a conventional fertilizer treatment. For example, y_{UDP} is the response variable from a UDP treatment and $y_{Conv.}$ is the same response variable from a conventional N fertilization treatment. The R_y ratios will be calculated for every response variable and every plot in the experiment.

The data collected and the conclusions derived are expected to meet the scientific rigor required to make useful recommendations to farmers and to be published in refereed scientific journals. To achieve these general objectives, this protocol will provide guidelines in the following aspects:

- Selection of a minimum set of treatments for a particular crop.
- Experimental design.
- Experimental technique for obtaining high-quality data.
- Format for data collection related to location, conduct of experiments and results from experiments.
- Methods of data analysis.

Selection of Treatments

Treatments included in Table 6.1 are the basic set of treatments that will be common to all research experiments in sub-Saharan Africa and South Asia. Researchers can add treatments associated with variations of N, P₂O₅ and/or K₂O rates to test hypotheses associated with fertilization under local conditions. The above set of treatments, plus the ones that could be added, can be combined with other factors such as crop varieties, locations, or factors associated with management like lowland or upland rice, irrigated or rainfed conditions, etc.

Soil analysis is required for establishment of plant nutrient rates that will be used as part of the treatments. The minimum analyses required are: Soil N (total N, NH₄-N, NO₃-N), available P (Olsen, Bray1 and Pi-P procedures) and pH.

Experimental Design

The basic experimental design for situations in which the only factor involved is the set of fertilization treatments will be the randomized complete block design (RCBD). The number of blocks (replications) must be decided such that the degrees of freedom for the error (error df) are at least between nine and 12. In a RCBD, error df = total df – treatment df – block df. An experiment with five treatments and three blocks will produce only eight error degrees of freedom, meaning that four blocks which produce 12 degrees of freedom for the error would be more appropriate in terms of the experiment having higher power to detect differences between treatments.

If the field where the experiment will be conducted shows soil variability in a particular direction, due to slope, proximity to a water source, etc., the blocks should be arranged in that direction, seeking to comply with the assumption of far higher variability between blocks than

within blocks. To obtain blocks that are as homogeneous as possible, they need to be kept small with the smallest possible plots and ten treatments at most. Running experiments with large blocks due to many treatments, unusually large plots, or a combination of both will likely result in obtaining biased treatment responses.

Randomization should be applied independently in each block during experiment establishment in a field during the first year or season. Treatments will be applied to the same plots (without additional randomization) during subsequent executions of the experiment in the following seasons or years in the same field.

If other factors besides the basic fertilizer treatments are included, the experiment should be conducted following a split-plot design within a RCBD where the fertilizer treatments will be assigned to the sub-plots and the additional factor (e.g., genotype) will be assigned to the main plots. Using this design will keep fertilization treatment effects separated from other factors to allow for comparison of the basic fertilization treatments across experiments from different regions or countries.

Experimental Technique

Experimental technique refers to the practices that are applied for conducting the experiment and collecting data. An appropriate experimental technique results in variability that can be attributed only to treatment effects and the random variability originated in the intrinsic variability of the experimental material (soil, plants, fertilizers) plus the random variability associated with sampling and measuring. Deficient experimental technique adds variability that could have random components and non-random components. The random variability can increase the experimental error and can be estimated. The non-random component also increases the experimental error in magnitude but cannot be estimated. The deficient experimental technique also can result in bias of the treatment responses. The following are concepts that are applied for improvement of the experimental technique:

Field Selection

The main criteria for the selection of the field where a research experiment is going to be conducted are accessibility, availability for about three growing seasons or years and uniformity. The field must be close to a road to facilitate transportation of materials used in the experiment, sample products, harvest and personnel involved in the experiment management. The experiment is expected to be developed for about three growing seasons or years in the same field. Moving to a different field will complicate assessing the actual treatment responses and testing hypotheses about differences between them. Uniformity of the field is very important for conducting an experiment. Fields where fertilization experiments have been conducted previously should be avoided, because they produce high variability that will be difficult to control. Variability of soil characteristics is the main contributor to the experimental error. Other contributors to the experimental error can be variability of the plant material, variability due to sampling and evaluation of response variables. Control of the experimental error can be accomplished through:

- Use of the appropriate experimental design.
- Choice of size, shape and orientation of the experimental units (plots).
- Use of techniques such as sub-sampling and collection of concomitant observations (covariables).

In most situations, the resources do not allow the intense soil sampling required to establish the spatial variability of soil properties in the experimental field. The judgment about uniformity of the field must be done by visual inspection, observation of uniformity of crops grown on it, observation of weed growth and proximity to water sources (creeks, rivers, lakes) that usually create texture gradients and slope

Arrangement of Plots and Orientation of Blocks Based on Presence/Absence of a Gradient in the Field



Plot Size, Shape and Orientation

A number of studies indicate that the optimum plot size for rice research is between 8 and 25 m². After excluding borders, the final plot for estimating yield and any other treatment effects should never be smaller than 5 m². This same guideline is useful for plot size of other crops if there is not particular information from experimental data.

When a fertility gradient in the field is not apparent, plot shape and orientation are not critical, but blocks should be kept square to the extent possible. The largest variability between blocks is achieved with square blocks. When a fertility gradient is evident, the experimental error is reduced with rectangular plots oriented with their larger length in the same direction of the gradient to keep the within-block variability low (see figure on page 94). In flooded rice experiments, water depth can become a very important source of variability and may require particular management to minimize variability within plots and within blocks. Usually a plot that is square or near square will have more uniform water depth. One resource for reducing experimental error in experiments with plots that have variable water depth is sub-sampling.

Treatment Application

Fertilization treatments should be carefully and uniformly applied to the whole plot area or to specific sections of the plot, depending on the application method. It should be done by trained operators. Ideally, all the treatments are applied to the full experiment in the same day. If that is not possible, the application should be done per blocks. Application of treatments can be done on different days, ensuring that full blocks are treated in a particular day. If treatments to a set of plots in a block are applied in one day, do not wait until a later date to continue treatment application to the remaining plots. If treatment application is to be done by more than one operator, assign a full block or a set of full blocks to individual operators. Applications of treatments within a block should not be done by more than one operator.

Before the beginning of treatment application, the research leader must develop an experiment diagram that displays the location of blocks and plots and identifies the treatment assigned to each plot. One way to make sure treatments are applied to the correct plots is to set a bag or bags that contain a treatment in front of the respective plots. Uniform application of a fertilizer treatment to the entire plot is not always straightforward, especially when the quantity of fertilizers is small. A strategy to ensure uniform application of fertilization treatments must be developed. One of these strategies is to separate the quantity to be applied in a number of fractions, separate the plot in the same number of sections (area sections or length sections) and apply a fraction of fertilizer treatment to each of the plot sections. Similar strategies should be devised for applying the UDP briquettes. Plot sections should be clearly marked to avoid overlapped applications of treatment portions. The research leader must carefully supervise and oversee the treatment applications to ensure that the correct treatments are applied to the correct plots and that the method of fertilizer application is uniform.

Experiment Development

After the experiment is established, all the crop protection practices should be applied, and observations should be done plot by plot to detect possible lack of homogeneity within individual plots, as well as throughout the entire experiment. Researchers should identify sources that may introduce variability apart from the components of the experimental error (assessed from the variability between blocks) and treatment effects. This type of variability is usually called "noise." Common causes of noise are variations of plant population, insect, rodent or disease attacks, weed infestation and flooding. Factors causing the noise variability have to be identified, and the spatial variability patterns must be diagrammed for planning of sampling strategies that will contribute to improved estimation of the experimental error variance under the presence of noise variability. If the research leader judges that the noise variability completely impairs the performance of the treatments, particular areas within plots or complete plots should be eliminated for sampling to avoid treatment biases.

Areas of the experiment that are affected by factors that do not occur randomly, such as those that originated from mistakes in the management of treatments, should also be discarded for sampling because the contribution of this type of non-random variability to the experimental error cannot be estimated. Two sampling strategies designed to improve estimation of the experimental error under the occurrence of noise in the experiments are sub-sampling and quantification of covariables.

Sub-Sampling

Sub-sampling is used when the area inside plots presents heterogeneity because of a variability source other than the treatments or the soil variability (following the block's pattern). This variability inside plots can often be predicted before the plants start growing because of obvious evidence of a factor that makes plots non-homogeneous (e.g., uneven distribution of previous crop residues and presence of soil clods in some areas of the plots), or can become evident after plants start growing (e.g., uneven plant population, weed infestation, localized pest or disease attack). Every plot in the experiment is divided in a fixed number of sections of the same area. The number of plot sections used to perform sub-sampling can be any number, but three is usually sufficient to make a good estimate of the within-plot variability. From each of the plot sections, a sub-sample is collected. Using data from sub-samples, a sampling error is estimated and then subtracted from the experimental error. This results in the lack of homogeneity inside the plots not affecting the precision of the hypothesis test regarding treatment differences.

A typical experimental situation in which sub-sampling is used to improve precision in treatment comparison occurs when the plant population inside the plots is not uniform due to germination problems that can be attributed to seed quality, uneven distribution of crop residue, deficient soil tillage, etc. All the plots in the experiments should be divided in three sections of the same area. Every sampling (biomass, tillage count, yield, etc.) should be performed separately within each plot section, and the data should be recorded, identifying the plot section where the sub-sample originated. Sub-sampling can be employed in any situation where there is variability inside the plots, due to pest or disease attacks, weed infestation, flooding, etc.

Quantification of Covariables

Quantification of covariables is practiced when sources of variability that do not follow the pattern of the blocks are identified across the experiment. These sources of variability may have the potential to affect the performance of treatments.

The factor(s) responsible for this variability are quantified and become random concomitant variables or covariables. The effect of the covariables on treatment responses is tested for significance and the treatment means are adjusted if the covariable effect is significant using the methodology named Analysis of Covariance. Some common covariables used to adjust treatment responses are: number of plants per area unit, incidence/severity of an insect or microorganism attack, weed population or any factor that may affect the normal growth of the plants in the plots. A value of the covariable will be collected from every plot in the experiment. More than one covariable can be used to adjust treatment responses. Each covariable has to be evaluated at each plot and the data used in the analysis of covariance with several covariables.

The attack of a fungal disease is a typical example of a random variability that does not follow the pattern of the blocks. Since the disease has the potential to affect treatment performance, causing distortion of the actual crop response to the fertilization treatments, we should evaluate the disease attack at each plot and use it as a covariable. The severity of the disease damage measured as a percentage of foliage that is unable to photosynthesize in each plot is a covariable to be used in the analysis of covariance.

Recordkeeping

Keep notes from observations made at every visit to the experiment. Keep dates and records of every activity performed in the experiment, starting with planting date, treatment applications, samplings, etc.

Sampling

Sampling for the quantification of the following response variables should be performed in rice experiments.

- Color chart reading at maximum tillering stage (Scale 1 to 6).
- Color charts reading at heading (Scale 1 to 6).
- Heading date (date or days from planting).
- Maturity date (date or days from planting).
- Harvest date (date or days from planting).

- Tiller and panicle numbers at harvest.
- Grain yield (kg/ha).
- Straw yield (kg/ha).
- Grain N, P and K concentration (%).
- Straw N, P and K concentration (%).

Sampling for the ten response variables enumerated is carried out on the plot area that remains after excluding two border rows from the lateral sides and two plants from the two ends of every remaining row in each plot. Quantification of response variables 1 to 6 should come from averaging three sub-samples from evaluations of the response variable at three plot sites. If so, b-sampling is carried out in the experiment due to variability within plots, the evaluations from three plot sites should be recorded separately. For use of the color charts, follow directions on the back of the chart. Grain and straw yields should be collected from the full plot area or from each sub-plot if sub-sampling is performed because of variability within the plot. Sampling for determinations of grain and straw nutrient concentrations should be taken by randomly collecting three sub-samples of harvested material and combining them to obtain a composite sample. If sub-sampling is applied, a composite sample must be obtained from harvested material from each harvest sub-sample.

All sampling activities have to be carried out by trained personnel. As in treatment application, sampling initiated for an entire block or blocks should be completed in one day. In other words, after initiating the sampling of a block(s), avoid continuing/completing the sampling of the same block(s) on a separate day.

If evaluation of response variables that involve counting have to be done by several people, a full block or set of blocks should be done by the same person. More than one person making counts of the same variable in a block should be avoided. People making evaluations that involve the use of scales or judging of percentages for the response variables or the covariables must become well familiarized with the scale and conduct practice tests before doing the actual assessments. These practices and cross calibration between different judges are necessary to achieve consistency in the use of scales and estimation of percentages.

Data Collection from Demonstration Plots or Trials on Farmers' Fields

During the second season, demonstration plots can be implemented. The demonstration plots usually do not have research purposes and do not follow an experimental design that would allow for statistical analysis to make an appropriate estimate of treatment means and to test hypotheses about differences between treatments. Establishing and taking good care of the demonstration plots, using practices from experimental techniques for the elimination or reduction of uncontrolled variability, and taking an *appropriate* number of random yield samples within each plot will result in the production of good quality data valuable for the evaluation of UDP technology. The samples collected from each plot are not actual replications, but they can be used to estimate the variance of a random component that is used in a particular type of analysis of variance (ANOVA) to test hypotheses about differences between treatments. This type of analysis requires some coding using Statistical Analysis Software (SAS).

The number of treatments (t) for demonstration plots has very little flexibility. It is usually two or three, and rarely four or more. To obtain an *appropriate* number of samples (s), compensation for the reduced number of treatments with a number of samples is needed to obtain a minimum of six degrees of freedom for the error term in the ANOVA. Having less than six error degrees of freedom results in insufficient sensitivity of the ANOVA to detect differences between treatment means. The number of samples to be collected from each plot depends on the number of treatments and can be obtained using the following equation for the error degrees of freedom (DF_{error}):

$$\text{DF}_{\text{error}} [(t*s)-1] - (t - 1) - (s - 1)$$

Example: t = 3, s = 4

$$\text{DF}_{\text{error}} = [3*4 - 1] - (3 - 1) - (4 - 1) = 11 - 2 - 3 = 6$$

Collecting four samples from each of the three treatment plots will produce six degrees of freedom for the error, which is the minimum required for the ANOVA. More than four samples will increase the power of the ANOVA to detect differences between treatment means. If the number of samples entered in the above equation produces less than six degrees of freedom for the error, the number of samples should be increased until obtaining at least six for the DFerror.

The trials in farmers' fields very often follow an experimental design, but the restriction of resources (monetary, land, personnel) impose limitations in the data quality generated by these type of trials or experiments. Running experiments in farmers' fields demands a higher level of care in the use of appropriate experimental technique due to the numerous sources of uncontrolled variability that usually occur under farmers' field conditions relative to the more controlled environment of experimental stations. Regrettably, the experimental technique of trials on farmers' land often is neglected due to limited resources and to the misconception that badly conducted trials are justified by the "non-research" character of the projects. Even if the project does not have direct research objectives, poor quality data may result in seriously misleading recommendations for farmers.

Good quality data from trials performed on farmers' fields will be critical for evaluation of UDP technology and, in general, for determining good recommendations to farmers. Obtaining good quality data from this type of research demands application of the principles of appropriate experimental techniques described in this document. Among the concepts associated with good experimental techniques for on-farm trials, the experiment size ($t \cdot r$: t : number of treatments, r : number of replications) is particularly important because the limited funds may result in a small experiment with very low sensitivity for detecting differences between treatments. The minimum number of treatments and replications can be estimated using the equation for the error degrees of freedom shown above. A combination of a number of treatments with a number of replications that produce six error degrees of freedom is the minimum experiment size to detect differences between treatments by the ANOVA. Having more than six degrees of freedom for the error is always recommended to increase the difference detection power of the ANOVA. As previously mentioned, the number of treatments for field experiments should not exceed 10 to avoid blocks of large size that may introduce bias to the treatment mean estimates.

Land restrictions may not allow the establishment of more than one replication of a set of treatments on a farmer's land. In cases like this, the replications of the set of treatments can be located in separate farms having the same type of soil and management.

Format for Data Collection

An Excel spreadsheet should be adapted with formats to be used for the capture of local information about the conditions in which the experiments are performed: soil identification and characterization, plant genotype, weather, chronology of experiment activities, and a format for recording data produced by the experiment.

Data Analysis

Data can be analyzed with different degrees of sophistication. For the researchers in the field to gain information and understanding about the performance of treatments and the differences between treatments, they can analyze the data using a two-way ANOVA methodology available in many statistical software, assuming the data follows a normal distribution; otherwise, a data transformation should be used. For mean comparison, use one of the methodologies available in the software. Least Significant Difference (LSD) is one of the best despite its simplicity and age.

If the experiment planned and developed for a particular location involves additional factors other than the treatments and the blocks, ANOVA models for split-plot designs or similar designs can be used. Researchers from IFDC will be available to advise in the design and analysis of more complicated experiments and in the cases in which sub-sampling and/or covariables need to be identified and quantified to improve precision of the experiment.

IFDC will provide support with data analysis using mixed models and other methods that will allow for comparisons across years, locations and interactions of treatments with time and local conditions, if desired.

Chapter 7. Developing a Monitoring and Evaluation (M&E) Plan

Proper monitoring of progress and results achieved is essential to success in UDP technology introduction and market development.

The Implementing Agency (IA) will develop its own management system to satisfy its internal management requirements and to ensure that proper attention is given to: (a) planning activities and events; (b) establishing targets for activities and results; (c) ensuring that resources are timely and adequately available to support program implementation; (d) ensuring that systems are in place for quantifying results, measuring results achieved against pre-determined targets (performance and results) and reporting results; and (e) identification of data problems and opportunities that impact market development.

An M&E plan is a useful tool employed by international development agencies and, to some extent, the private sector. A basic assumption in this manual is that the Collaborating Partner (CP) will be either an international development organization, such as the U.S. Agency for International Development (USAID), Netherlands' Directorate-General for International Cooperation (DGIS) or International Fund for Agricultural Development (IFAD), or a host country government seeking to raise farmer incomes and improve food security. This chapter provides information and guidance in establishing an M&E plan in the context of UDP technology introduction as a key strategic component of a more robust development assistance program.²⁴

What is an M&E Plan?

An M&E plan comprises establishment of targets of performance, results and impact indicators and key assumptions. The M&E plan is a continuous process to collect information on actual implementation of program activities compared to those scheduled in the plans, including the delivery of quality outputs in a timely manner. The M&E plan is useful to identify problems and constraints (technical, human resource and financial), make clear recommendations for corrective actions and identify lessons learned and best practices for UDP technology introduction.

Why is the M&E Plan Important in Management?

The M&E plan is useful to ensure that proper attention is given to planning, establishing targets and results, ensuring that resources are available to support program implementation, and ensuring that systems are in place to quantify results and measure them against pre-determined targets.

The M&E plan should be designed to accurately measure and report “progress against targets” in UDP technology supply system development and farmer demand. **The M&E plan should be designed early in the planning stage** and be consistent with the schedule for the UDP technology rollout program. The plan will indicate the major activities that will be performed, results and deliverables that will be achieved and resource requirements for staff, logistic support and program activities.

M&E Components

As indicated previously, the Rollout Phase will build on the planning results and information developed during the Initiation Phase. The Rollout Phase will have program components that address specific objectives. For illustrative purposes, Table 7.1 provides indicative program components and associated objectives. In addition, UDP technology diffusion will have cross-cutting targets, including participation of women in all relevant activities.

²⁴ Note: If a commercial enterprise seeks to expand its product mix to include UDP briquettes, its already established management system would be modified to include UDP briquettes as an additional product. Only some of the M&E plan elements described herein may be appropriate for the entrepreneur management system. For example, emphasis would likely be on UDP briquette sales patterns, costs, product profitability, growth potential and impact on sales of other fertilizer products (e.g., urea).

Table 7.1
UDP
Technology
Rollout Phase
Components
and Objectives

PROGRAM COMPONENT		OBJECTIVE
1	Improved agricultural productivity (technology demonstration and diffusion - demand)	<ul style="list-style-type: none"> • Rapidly diffuse UDP in rice production to attain 50-80% adoption rate (adoption rate will vary by location). • Develop UDP use for other crops. • Emphasize improved soil nutrient management.
2	Strengthened private sector capacity to improve farmers' access to appropriate technology (supply)	<ul style="list-style-type: none"> • Expand network of metal shops to fabricate the requisite number of urea briquetting machines. • Expand private sector network of micro-enterprises to service farmers' demand.
3	Improved pro-market policy environment	<ul style="list-style-type: none"> • Improve enterprise access to raw materials. • Improve market transparency. • Identify restrictive policies and provide analyses and policy papers.
4	Strengthened support systems to facilitate sustainability (capacity building and awareness creation - cross-cutting issues)	<ul style="list-style-type: none"> • Strengthen the capacity of government to monitor soil nutrient conditions. • Upgrade crop-specific soil nutrient management information. • Improve the capacity of extension and NGO field staff, fertilizer association members and private dealers in UDP technology.

M&E Strategy

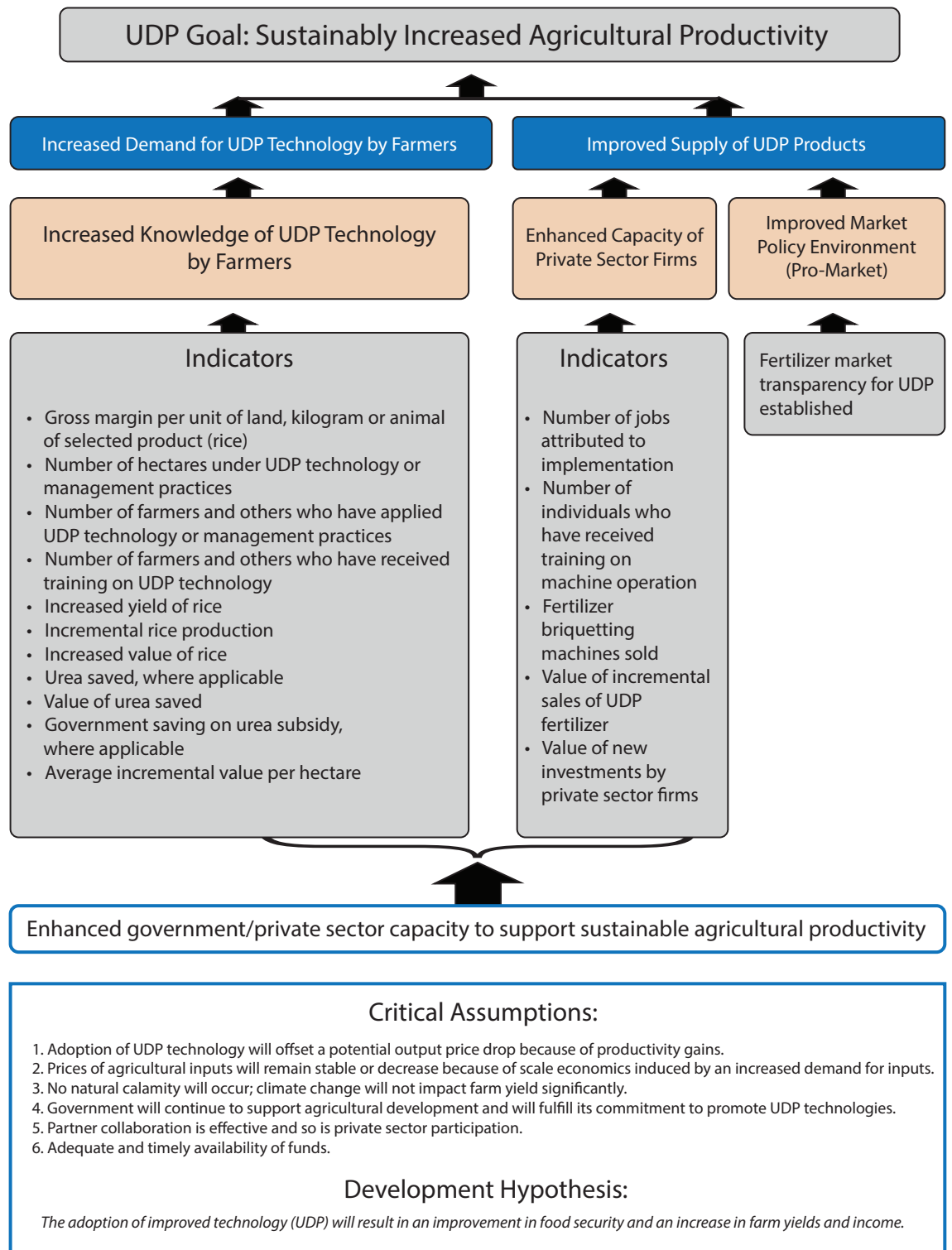
The M&E strategy should flow from the (a) performance and impact indicators; (b) available information sources that allow for accurate and timely measurement of indicators; and (c) financial resources available for M&E. The M&E focal areas will need to adjust to the requirements of the CA. For illustrative purposes, the following is a brief overview of the main M&E focal areas and means of assessment which may be considered:

- a. **Impact on agricultural productivity and production and on-farm household income** (assessed by measuring the change in area using UDP technology, and then multiplying this change in area by differential yields and inputs *with vs. without* UDP).
- b. **Impact of UDP on household welfare** (assessed by measuring yield and income differentials *with vs. without* UDP). This impact also will be assessed by collecting information (in a final impact survey) on household investments over the last several years and other measures of welfare for households that did and did not use UDP technologies.
- c. **Impact on UDP producers/manufacturers/distributors and production** (assessed through: continuous monitoring and reporting by M&E field staff, detailing production by each urea briquetting machine owner; periodic reports from briquetting machine owners during technical and business training [these may cover issues such as profitability and sales strategies]; and a final survey of owners when the rollout target is achieved).
- d. **Impact on soil fertility management practices** (assessed through: crop cuts in farmers' fields [information will be collected on inputs, including organic and inorganic fertilizers applied]; discussions with government extension agencies; routine monitoring of briquette producers' production and farmers' adoption of urea briquettes; and final impact surveys of farmers and briquetting machine owners).
- e. **Impact on the policy environment for fertilizer marketing** (assessed through: routine monitoring of briquetting machine owners; ongoing dialogue with the Ministry of Agriculture [MOA] and fertilizer association members; discussions with other stakeholders; and final impact surveys of farmers and briquetting machine owners).
- f. **National impacts** (derived from measures of impact on agricultural production, productivity and farm household income). These impacts are calculated from changes in area, yield and input use multiplied by prices, subsidies, etc.

The M&E Results Framework

Achieving the objectives of the Rollout Phase will involve intensive activities that address both demand and supply issues related to UDP technology diffusion. Key project components are to increase farmer knowledge and adoption

Figure 7.1
Illustrative
UDP
Results
Framework



of the technology and to support development of a supply system providing farmers access to the technology. Many of the activities will be linked to more than one output. For example, training fertilizer briquette producers contributes to increased farmer demand for UDP technology and also enhanced capacity of private sector firms to ensure improved supply of UDP products so that UDP is sustainable. An illustrative results framework is presented in Figure 7.1. The indicators may be adjusted according to the needs of the CP.

a. Development Hypothesis

The development hypothesis may be defined as follows: **The adoption of improved technology will result in an improvement in food security and an increase in farm yields and income.**

b. Critical Assumptions

The critical assumptions that underpin the UDP results framework may include the following:

- Adoption of cost-reducing UDP technology will offset potential output price drops because of productivity gains.
- Prices of agricultural inputs will remain stable or decrease because of scale of economies induced by an increased demand for inputs.
- No natural calamity will occur; climate change will not impact farm yield significantly.
- Government will continue to support agricultural development and will fulfill its commitment to promote UDP technologies.
- Partner collaboration is effective and so is private sector participation.
- Adequate and timely availability of funds.

c. Results Framework Narrative

A brief narrative will be needed for the results framework. The following may be appropriate:

• **Overview**

UDP promotes food security improvement and poverty alleviation through increased on-farm productivity. UDP technology improves efficiency in crop nutrient management, which contributes to improvement in crop yields with less use of fertilizers. Farmers' access to high-quality UDP products at a reasonable price is a prerequisite to roll out this technology. In order to facilitate sustainable agriculture, the IA will work closely with the government and other relevant stakeholders to strengthen the capacity to monitor soil nutrient conditions, upgrade crop-specific soil nutrient management information, improve the capacity of agriculture extension field staff in UDP technology and provide a monitoring and regulatory function.

• **Impact**

Sustainably Increased Agricultural Productivity – Improved agricultural productivity has a causal relationship to improved food security. UDP promotes efficient use of agricultural inputs through an integrated approach, emphasizing the use of good quality seed, judicious application of balanced fertilizer and better water management practices. The emphasis is on technology diffusion and development of agriculture support systems to achieve sustainability. UDP technology is extremely well-suited for rice production, and use in other crops is promising. During the *Rollout Phase*, support should be provided to facilitate institutional development, policy reform and public-private partnerships to improve performance in the fertilizer sub-sector.

• **UDP Demand-Side Issues**

The lack of awareness among farmers of UDP technology and associated benefits constrains widespread diffusion and farmer adoption. Improving farmer awareness and knowledge are key to rolling out UDP technologies nationwide. A rapid penetration strategy will be launched for UDP technology that involves training of farmers and awareness building through promotional activities such as motivational field visits, field days, advertisements and displays of promotional materials. The following “demand-side” issue will be addressed through the M&E plan:

Increased Knowledge of UDP Technology by Farmers

Outputs:

Targeted Number of Farmers Trained and Targeted Area of Rice Covered with UDP Products

Activities:

- ✓ Farmer trainings on UDP.
- ✓ Motivational meetings with early adopters.
- ✓ Demonstrations and trials.

- ✓ Field days.
- ✓ Motivational workshops, meetings and field trips.
- ✓ Promotions.
- ✓ Consultation with MOA/Department of Agricultural Extension (DAE) headquarters officials.
- ✓ Training of fertilizer association members/dealers and MOA officials.

- **UDP Supply-Side Issues**

There are no established national networks of UDP product suppliers. The potential for rapidly rolling out the UDP product supply system will depend on the knowledge gained through activities during the Initiation Phase, stimulating entrepreneurs to invest in UDP briquetting machines (e.g., via information flows, creating access to financial sources, stimulating farmer demand for UDP) and increasing capacity of UDP briquetting machine fabricating shops. Moreover, rapid development of the supply system is crucial to service and further build demand.

Enhanced Capacity of Private Sector Firms

The Rollout Phase will work toward rapid expansion of a supply network of UDP products by working closely with agro-input associations, briquetting machine fabricators, light engineering workshops and relevant agriculture projects. Awareness of the micro-enterprise opportunities involved in fertilizer briquette manufacture and repair at the local level will be created. A grants program may need to be incorporated to allow for cost-sharing to procure machines. Dealers will invest their own funds to cover a share of the cost of the machines. This effort will expand the capacity to disseminate information and knowledge and collect, analyze, plan, monitor and evaluate the impact of agriculture sector performance. This will strengthen key public sector institutions at the national and district level.

Output:

Micro-Enterprises Producing UDP Products

Activities:

- ✓ Sales of briquetting machines.
- ✓ Training of briquette producers/local mechanics/fertilizer dealers.
- ✓ Linking briquette producers to rice farmers and to funding sources.
- ✓ Increased employment opportunities in briquetting machine shops.

Cross-Cutting Issues: Improved Market Policy Environment (Pro-Market)

To promote market-led agriculture growth, policy-related activities should be undertaken to develop the private sector value chain for UDP technology.

Output:

Fertilizer Market Transparency Established – The Rollout Phase will work to establish public-private partnerships to better perform the function of market information management.

Activities:

- ✓ Policy assessments.
- ✓ Policy dialogue.
- ✓ News bulletins.
- ✓ Study tours.
- ✓ UDP technology in agriculture extension system curriculum.
- ✓ Training of government agriculture-related department and MOA officials.
- ✓ Gender.

The M&E System

The M&E system will facilitate more effective results-based management and strengthen accountability and transparency. It will adopt a participatory approach that takes advantage of staff and agriculture extension officials' familiarity with local farmers and their constraints. Constant engagement with field staff and frequent monitoring and supervision of the program's field coordinators, senior agriculture specialists and soil scientists will help to ensure that the Rollout Phase activities achieve their desired objectives and goals.

Field-level data will be collected at regular intervals in order to monitor pre-established input and output indicators of the project. The data are duly processed, cleaned and stored in a data management unit; outcome- and impact-level data will be analyzed by a senior data management specialist and M&E specialist and evaluated to validate results.

In collecting data from the field, all staff will strictly adhere to the following five criteria of data quality assessment (DQA):

- Validity.
- Integrity.
- Precision.
- Reliability.
- Timeliness.

Data Collection Tools and Techniques

The data collection tools and techniques will depend on the needs of the CP. For illustrative purposes, possible techniques include the following:

- **Weekly Reports** – Data on all project activities may be reported on a weekly basis by field staff who verify and record the data on prescribed data sheets.
- **Crop Cut Reports** – Crop cut results should be collected from farmers' plots, demonstration plots and trial plots as described below:
 - **Farmers' Plots** – The crop cuts in farmers' fields should be conducted every crop season at the time of harvesting. Each crop cut should be randomly selected from the most intensive areas of UDP use. The number of crop cuts will be decided based on a sample methodology with a 95% confidence level and statistically significant. Each crop cut is actually two samples – one within a UDP field and one (nearby) within a broadcast urea field with the same variety and soil type and same quantity of other agricultural inputs used. The samples will be threshed and weighed with grain moisture measured to calculate yield adjusted to a moisture content of 14%.
 - **Demonstration Plots** – A register must be maintained for each demonstration with recording of: dates and data for every action taken in the demonstration, labor, costs and results. Constant supervision in the demonstration plots ensures that any problem is addressed.
 - **Trial Plots** – The trials are used to investigate the effect of a certain treatment under closely managed field conditions. Site selection is similar to that for demonstrations, but more care goes into selecting the farmer, monitoring the performance, designing layout and setting up the plots. Respective farmers are trained before trial plots are set. Most trials assess the effect of UDP in other crops.
- **Gross Margin Surveys** – After the crop harvest in each season, a sample survey of gross margin should be conducted on a randomly selected sample of farmers in all farm categories – small, medium and large – who are growing a particular variety. This survey will measure the cost and return during each season and report on indicators such as gross margin, productivity, employment at the farm level, cost:benefit ratio and incremental sales of rice.
- **Studies Using Surveys** – Performance evaluation surveys/studies will include a survey of beneficiaries – a farmer impact assessment and a study of briquetting machine owners.

The farmer impact assessment will collect and present information to support a clear and accurate appraisal of the impact of the UDP technology on factors such as crop yields, farmer income and adoption of UDP technology.

The briquetting machine owners' assessment will identify progress achieved in UDP product supply, geographic service area coverage of briquetting machine owners, profitability of shops, policy constraints that inhibit growth, product line, investment in promotional activities, employment generation and the level of female participation in briquetting machine ownership.

- **Baseline Information** – A baseline survey should be conducted to collect information on the result indicators before rolling out UDP technology.
- **Routine Internal Project Reporting and Monitoring** – Routine internal reporting will provide information on all performance indicators, as well as on most impact indicators as shown in the results framework in Figure 7.1. Internal reporting may include the following:
 - Oral weekly reports from field staff (through field coordinators) on all relevant activities and achievements.
 - Information collected by senior staff during supervision of activities.
 - *Ad hoc* reporting as directed by the project manager.
- **Special Studies** – Special studies may be arranged – one during the middle of the Rollout Phase and then another at end of the phase. A survey of beneficiaries (including a farmer impact assessment and a study of briquetting

machine owners) would be useful to include in both special studies. For illustrative purposes, details of special studies that may be appropriate are provided in Table 7.2. See Exhibit 7-1 for more details.

Table 7.2
UDP M&E
Surveys

DATE AND TYPE OF SURVEY	PURPOSE STATEMENT, TARGETED SURVEY PARTICIPANTS AND INFORMATION COLLECTED
Baseline Survey	<p><u>Purpose:</u> To obtain representative data and information about pre-intervention characteristics of rice production and the socioeconomic circumstances of farmers with attention to marginal, small and medium-large farm households and the rural population.</p> <p><u>Who is surveyed:</u> Random sample of farmers selected from all locations where UDP will be promoted.</p> <p><u>Information to be collected:</u></p> <ul style="list-style-type: none"> • Household characteristics. • Agricultural activities and incomes during the last project year. • Fertilizer use on rice and on other crops. • Organic fertilizers used on rice and other crops. • UDP knowledge, source of knowledge. • Opinions about UDP advantages and disadvantages. • Other incomes. • New investments for the coming year: land, household, agricultural equipment, livestock. • Level of all result indicators prior to UDP introduction.
Farmers' Impact Survey	<p><u>Purpose:</u> To assess changes in knowledge of UDP, UDP use, differential incomes and household investments for UDP users and non-users, with attention to marginal, small and medium-large farm households.</p> <p><u>Who is surveyed:</u> Random sample of farmers selected from all locations where UDP will be promoted.</p> <p><u>Information to be collected:</u></p> <ul style="list-style-type: none"> • Household characteristics. • Agricultural activities and incomes after intervention. • Fertilizer use on rice and on other crops. • Organic fertilizers used on rice and other crops. • UDP knowledge, source of knowledge. • Opinions about UDP advantages and disadvantages. • Other incomes. • New investments for next year: land, household, agricultural equipment, livestock. • What did UDP users do with income from UDP use?
Briquetting Machine Owners' Survey	<p><u>Purpose:</u> To collect information on briquette production for one year, on whether or not machines were operated and why, and on owners' access to urea (as an input into fertilizer market analyses and policy dialogue).</p> <p><u>Who is surveyed:</u> Urea briquette producers randomly selected from a list of all owners that acquired machines.</p> <p><u>Information to be collected:</u></p> <ul style="list-style-type: none"> • Year machine was bought, price of machine, source. • Types of UDP products produced in the last few years. • UDP product production and production costs. • UDP product sales and sales prices. • If not operated, why not? • Owners' status as dealer, sub-dealer or other. • Reliability and flexibility of owners' access to urea; price of urea to briquetting machine owner. • Owners' household and business investments during the last few years.

Data Quality Control

The IA should take appropriate measures (including, among others, the use of data verification tools, impromptu field visits and periodic M&E system audits) to ensure good quality data for the various raw data elements. For a village-level survey, the MOA/DAE field official may be in a good position to collect quality data on UDP coverage and on the number of farmers using UDP. Spot checks should be done by senior staff as additional quality control of the data.

To measure and attribute results accurately, the IA team will ensure that data meet certain criteria through internal DQA:

- **Validity** – Before collection of data in each season, all enumerators and data-entry operators should be trained on data collection and data entry. Appropriate guidelines should be provided by the senior data management/M&E specialists for data acquisition and data entry. Data should also be verified by setting queries into computer software.
- **Integrity** – The procedure of quality control described above is aimed to ensure that data is real and accurate. The data collection system should have mechanisms such as pre-testing of questionnaires, surprise visits by senior staff, cross checking with agriculture extension staff and also spot-checking on a sample basis to reduce the possibility of intentional manipulation.
- **Precision** – The data to be gathered from beneficiaries and national-level sources should be sufficiently precise to reflect program performance and enable management review and decision-making.
- **Reliability** – Implementation staff should ensure that data collection and analysis procedures are stable and consistent over time. A well-rehearsed procedure for data collection will be established with data collected at the end of each season. Spot checks of data and investigations of anomalies will be useful to improve data quality.
- **Timeliness** – Data must be timely in order to be useful. Data should be collected, collated, analyzed and reported in a timely manner.

The M&E plan is designed to demonstrate the extent to which UDP project implementation is achieving its objectives and to ultimately improve its adoption and impact. It defines the indicators that measure progress toward the project objectives and the donors' desired indicators (for example, Feed the Future indicators would be used in the case of USAID). The M&E plan determines what data must be collected, at what time, the methods of data collection and how findings will be analyzed and reported.

UDP M&E System

The M&E system aims to facilitate more effective results-based management and strengthen project and stakeholders' accountability and transparency. A participatory approach is employed, one that takes advantage of project staff and Ministry of Agriculture (MOA) and/or Department of Agriculture (DAE)/extension staff's familiarity with local farmers and their constraints. The system includes constant engagement of project field staff and frequent monitoring and supervision of field coordinators by experienced senior agriculture specialists and soil scientists to ensure that project activities achieve their desired objectives and goals.

Field-level data are collected on regular intervals in order to monitor pre-established input and output indicators of the UDP project. The data are duly processed, cleaned and stored in the project data management unit; outcome- and impact-level data are analyzed by a senior data management specialist and M&E specialist and evaluated to validate project results under the supervision of the project coordinator. An independent evaluator conducts periodic data quality assessments (DQAs) using five established criteria of validity, precision, reliability, integrity and timeliness.

1. Data Collection Tools and Techniques

- ***Weekly Reports***

Data on all activities are reported on a weekly basis by field staff to field coordinators who verify the data, report on prescribed Excel sheets and forward to the senior data management specialist, who collates data from all regions and prepares a cumulative report. In addition, the senior staff also provide information on all activities related to their work on a weekly basis in a prescribed form. These data are then forwarded to the senior data management specialist, who collates all the data and forwards them to the chief of party/project coordinator on a weekly basis.

- ***Area Survey***

An area survey in a prescribed format²⁵ is carried out at the beginning of a season after the crop is transplanted, urea briquettes are applied or topdressing of urea fertilizer is completed. In this instance, a block is the lowest tier of agriculture-related administrative unit; the project will collect data for the area under UDP technology (new and continuing) and the number of farmers using the technology disaggregated by gender. Field staff will also report the number of producers of UDP products and production volumes during the season in prescribed forms.²⁶

Field staff collect data for the area survey jointly with the DAE/extension staff on the areas of crops fertilized with UDP products and the amounts of UDP products used in each area in prescribed forms. The data are then checked by respective field coordinators and forwarded to the data management unit for data check and entry. The data analysts are each assigned specific target zones for area survey data checking and entry.

- ***Crop Cut Reports***

✓ ***Farmers' Plots*** – The project will implement crop cuts in farmers' fields every rice season at the time of harvesting. Each crop cut is randomly selected from the most rice intensive blocks, and the number of crop cuts can vary between 500 and 800, depending on the season. Each crop cut is actually two samples – one within a UDP field and one (nearby) within a broadcast urea field with the same variety, soil type and quantity of other agricultural inputs used. The samples are threshed and weighed, and grain moisture is measured to calculate yield adjusted to a moisture content of 14%.

²⁵ Exhibit 7-1-A: Seasonal Farmer Survey form.

²⁶ Exhibit 7-1-B: Seasonal Report form.

Each crop cut is supervised by project field staff, and then data are collected in prescribed forms.²⁷ The data are then checked by field coordinators and forwarded to the data management unit for data check and entry. The data analysts in the data management unit are each assigned specific target zones for the crop cut survey.

- ✓ **Demonstration Plots** – Demonstration plots are established to improve farmers’ knowledge of UDP and other accompanying management practices (e.g., alternate wetting/drying [AWD] technology), benefits and briquette applicator demonstrations. The site is selected carefully, and cooperating farmers are selected and trained to set up demonstration plots under the supervision of the project’s senior agriculture specialists and soil scientists. Demonstration plots exhibit the physical difference between UDP treatments with balanced doses of fertilizers and broadcast application fertilizers, keeping all other input use the same. Similar plots can be used to demonstrate other management practices. Regarding the applicator demonstration, the deep placement process is compared using different applicators and manual application.

Field staff keep a register for each demonstration that itemizes dates and data for every action taken in the demonstration, labor, costs and results; all the data are stored in the prescribed forms.²⁸ Constant supervision in the demonstration plots ensures that any problem is addressed in consultation with project specialists to confirm actions. The progress of development at different stages of crop growth is monitored regularly. The same methodology is applied for crop cuts, as indicated above.

- ✓ **Trial Plots** – Trial plots are used to investigate the effect of a certain treatment under closely managed field conditions. Site selection is similar to that for demonstrations, but more care goes into selecting the farmer, monitoring the performance, designing the layout and setting up the plots. Respective farmers are trained before trial plots are set. Trials assess the effect of UDP briquette deep placement and UDP in other crops. The same methodology is applied for crop cuts, as indicated above. Records are kept in separate prescribed forms.²⁹

- **Database Development**

Master rolls (registration list and summary of expenditures of training program) of farmer trainings are forwarded by field staff to field coordinators for verification after completion of trainings in each month. The hard copy of master rolls, disaggregated by gender, of each training program is then forwarded to the data management unit, where data of training participants by gender are recorded by the data analyst. Data for training are then reported to the donor on a quarterly basis.

- **Gross Margin Surveys**

After the crop harvest in each season, a sample survey of gross margin is conducted on a randomly selected sample of farmers in all farm categories – small, medium and large – who are growing a particular variety.³⁰ This survey measures the cost and return during each season and reports on indicators such as gross margin, productivity, employment at the farm level, cost:benefit ratio and incremental sales of rice.

- **Studies with Surveys**

The UDP project will arrange two studies – one in the middle of the project and another in the final phase of the project. Each will include a survey of beneficiaries – a farmer impact assessment and a study of briquetting machine owners.

The farmer impact assessment will collect and present information to support a clear and accurate appraisal of the impact of the project on factors such as crop yields, farmer income and adoption of UDP technology.

²⁷ Exhibit 7-1-C: Crop Cut Report form for field staff.

²⁸ Exhibit 7-1-D: Data Sheet for Demonstration Plots of Rice.

²⁹ Exhibits 7-1-E and 7-1-F: Data Sheet for Trial Plots of Rice and Data for Trialing UDP Applicator (respectively).

³⁰ Exhibit 7-1-G: Gross Margin Survey Questionnaire.

A performance assessment of briquetting machine owners will be conducted to identify progress achieved in UDP product supply, geographic service-area coverage, profitability of shops, policy constraints that inhibit growth, product line, investment in promotional activities, employment generation and the level of female participation in briquetting machine ownership.

2. UDP Project Goal, Components, Objectives, Outputs and Activities

The overall goal of a UDP program is *to improve food security and accelerate income growth in rural areas by increasing agricultural productivity on a sustainable basis.*

Successful promotion and adoption of the UDP technology will increase crop productivity and farmer income, improve food security and provide benefits to the environment by reducing nitrogen losses to air and water.

UDP promotes food security through increased on-farm productivity. To deliver the outputs and to achieve objectives, UDP projects will implement a range of activities. Many of the activities are linked to more than one output. For example, training national extension staff contributes to technology transfer and also strengthens the MOA/DAE to extend UDP in coming years so that UDP is sustainable.

2.1 UDP Technology Indicators

The UDP technology rollout is designed to strengthen and reorient agricultural production systems. It promotes efficient use of agricultural inputs through an integrated approach, emphasizing the use of good quality seed, judicious application of balanced fertilizer and better water management practices. The emphasis is on technology diffusion and development of agriculture support systems to achieve sustainability.

The impact and outcome of the UDP project can be measured by a number of indicators related to sustainable intensified production, capacity building and market development.

2.1.1 Sustainable Increased Agricultural Productivity

UDP Technology Transfer

The lack of awareness among farmers of UDP technology and associated benefits constrains widespread diffusion and farmer adoption. Improving farmer awareness is key to rolling out UDP technologies nationwide. The Implementing Agency (IA) will launch a rapid penetration strategy for UDP technology that entails training of farmers and awareness building through promotional activities such as motivational field visits, field days, advertisements and displays of promotional materials. Primary indicators include:

- Increased crop yield.
- Increased crop value.
- Incremental crop production.
- Urea saving.
- Value of urea saved.
- National government's savings if urea subsidy is in place.
- National government's savings from reduced rice imports due to incremental crop production.
- Average incremental value per hectare.
- Farmers trained.
- Gross margin per unit of land, kilogram, or animal of selected product (rice, horticulture, fisheries production).
- Number of hectares under improved technologies or management practices as a result of assistance.
- Number of rural households benefiting directly from interventions.
- Value of incremental sales (collected at farm level) attributed to implementation.
- Number of farmers and others who have applied new technologies or management practices as a result of assistance.
- Number of individuals who have received/supported short-term agriculture sector productivity or food security training.

Outputs

Number of Farmers Trained and Crop Area Covered with UDP Products – Farmer training programs will be held to rapidly diffuse UDP technology and this, in turn, will lead to an increased number of farmers adopting UDP technology on an increased area of land.

Activities

Farmer Trainings on UDP – The IA will provide training to farmers to develop their skills in understanding and adopting UDP technology and in better management of fertilizer use to increase productivity. In previous UDP projects, a large number of the participants have indicated the benefits of the training.

Demonstrations and Trials – Based on the concept of “seeing is believing,” the IA will develop field demonstration plots. Demonstration plots are established to improve farmers’ knowledge on UDP technology. The sites are selected carefully, and cooperating farmers are selected to be trained to set up demonstration plots under the supervision of the IA. Demonstration plots exhibit the physical difference between UDP treatments and broadcast application fertilizers. During the life of the project, the number of technology demonstration sites will be established based upon the project work-plan.

The trials are used to investigate the effect of a certain treatment under closely managed field conditions. Site selection is similar to that for demonstrations, but more care goes into selecting the farmer and monitoring the performance. Respective farmers are trained before trial plots are set.

Field Days – Field days will be organized for farmers to observe the method and results of the demonstrations and trials. Local leaders and MOA/DAE personnel will be invited to attend the field days.

At the tillering stage of the field days, the farmers will mainly observe physical differences: the color of the plants, number of tillers per hill, plant height and pest and weed infestations between the treatments. At the harvesting field day, farmers will observe the number of panicles per hill, the number of grains per panicle (including color, size, weight and grain) and the yield difference compared with the UDP treatment and broadcast application of fertilizers.

These effective tools for technology dissemination will help the participants to benefit from the technologies.

Motivational Workshops and Field Trips – Motivational workshops are part of the campaign to mobilize the private sector, media and local government officials to increase their awareness of the benefits of UDP and to solicit their support to promote the technology. The activity is managed within the target zone as a stakeholder workshop with participation from community and religious leaders, non-governmental organizations (NGOs), leaders of local organizations and Integrated Pest Management/Integrated Crop Management (IPM/ICM) clubs, government departments, banks, fertilizer dealers, briquette shop owners and educational institutions.

Motivational field trips are visits for farmers in a new area, accompanied by their local extension agent and project field staff, to exchange views with those in an area that demonstrates the benefits of the technology. Normally, about 40 farmers (both men and women), along with the extension agent and other interested local agricultural officers, are taken from a less developed area to an area where UDP technology is widely established. Therefore, the visits can occur only when there is something to show.

Promotions – To support technology transfer and create farmer awareness and interest, the IA will engage in an aggressive advertising and promotion campaign. It includes the use of billboards and tree sign boards in rural areas and market centers to promote balanced fertilizer use and UDP technology, technical leaflets disseminated through MOA/DAE field staff and private dealers, wall hangings and posters showing UDP application provided to input dealer shops and demonstration plots to exhibit the effect of UDP on crop production. The IA will also use the media campaign for large-scale awareness building. The project will develop open sky videos, radio and television segments and newspaper articles. Videos promoting UDP and

balanced fertilizer use may be developed and used in public gatherings to create awareness and build knowledge. Dissemination of promotional materials, such as T-shirts and caps, in project areas is often useful. All these activities are complemented by participation in MOA/DAE agricultural fairs.

Grants for Applicator Development – The application of UDP products is labor intensive. Efforts will continue to modify current designs and to increase small-scale mechanization via collaboration and engagement with national agricultural research organizations (NAROs) and universities through a small grants program to develop, test and provide blueprint designs for an effective mechanized applicator tool to local fabrication shops. The applicator will be introduced through the MOA/DAE, private sector organizations, briquette manufacturers and rural “light engineering” workshops to achieve awareness and accelerate market development.

2.1.2 Building Institutional Capacity

Curriculum Development in MOA/DAE Institutions – MOA/DAE will be strengthened through supporting the development of the curriculum of DAE training institutes to include UDP technology for field staff and training officers.

2.1.3 Improved Access through Market Systems

There will be no established national network of UDP product suppliers in the target country. Based upon the Bangladesh experience gained in pilot-level activities and the increasing capacity of UDP briquetting machine fabricating shops, the potential for rapidly scaling up the UDP product supply system is great. Moreover, rapid development of the supply system is crucial to service and further build demand. Indicators will include:

- Number of jobs attributed to UDP implementation.
- Number of rural households benefiting directly from UDP interventions.

Private Sector Capacity to Improve Farmers’ Access to Technology

The IA will work toward rapid expansion of a supply network of UDP products by working closely with relevant agriculture projects to link rural light engineering workshops to briquetting machine fabrication expertise. The IA will create awareness of the micro-enterprise opportunities involved in fertilizer briquette manufacture and repair at the local level. A grants program will be incorporated to allow for cost-sharing to procure machines. Dealers will invest their own funds to cover a share of the cost of the machine. Indicators will include:

- Number of briquetting machine fabricators.
- Number of briquetting machines sold.
- Number of training programs on machine maintenance and briquette production conducted.

Output

The number of briquetting machines required to service farmer demand will depend on the number of farmers and number of hectares of lowland rice production in the target zone.

Activities

Sales of Briquetting Machines – The IA will be engaged in linking UDP briquetting machine fabricators with potential UDP dealers and facilitating sales of briquetting machines; a cost share element may be involved with the IA covering a substantial share of the machine cost until demand for UDP products is robust.

Training Micro-Enterprises – Training programs and workshops (indicate specific number for each) will be conducted to improve briquetting machine owners’ knowledge on machine operation safety, product quality and machine repair (through light engineering workshops), marketing technical aspects of UDP use in farmers’ fields and record-keeping.

Increased Employment Opportunities in Briquetting Machine Shops – These new briquetting machine shops will create new jobs in their locality.

Policy Analysis and Reform

To promote market-led agriculture growth, the IA will engage in activities to develop the private sector value chain for UDP technology. Indicators will include:

- Number of policy assessments conducted.
- Number of policy workshops conducted.
- Number of reforms related to agricultural policies.

Output

Public-Private Partnership Market Fertilizer Transparency – The IA will work to establish public-private partnerships to better perform the function of market information management.

Activities

Policy Assessments – Assessments will be conducted to identify the policies related to the national fertilizer market, appraise the constraints and suggest appropriate reform measures. These policy assessments will be disseminated through a series of workshops with various stakeholders.

Policy Dialogue – The IA will work directly with the MOA and in collaboration with private sector agribusinesses to achieve policy reform. One-on-one policy dialogues, stakeholder meetings, workshops and policy analysis will be conducted by the IA.

Market Information Reports – The IA will emphasize providing all stakeholders with information on fertilizer supply (production and imports), in-country stock levels, demand and prices for all fertilizer products. This will be done through the development and widespread dissemination of market information via a news bulletin targeting public and private sector stakeholders. Joint supply and demand forecasts will be developed. Sustainability will be emphasized by engaging the MOA to manage the data collection, analysis and dissemination functions.

Exhibit 7-1-A
 Seasonal
 Farmer Survey
 Report Form

Season: _____
 Village/Location: _____

1. Total number of farmers in the target zone/administrative unit (i.e., village): _____
 Number of men: _____; Number of women: _____

2. Farmers by tenure status in this season and by number of farmers and total land area:

LAND TENURE STATUS	NUMBER OF MALE FARMERS	NUMBER OF FEMALE FARMERS	TOTAL LAND AREA (ha)
Household farming own land only			
Household farming own and rented land			
Household farming own and sharecropped land			
Household farming rented land only			
Household farming only sharecropped land			

3. Number of farmers using fertilizer applicator: _____

4. Total area planted to rice this season: _____ ha
 Hybrid seed: _____ ha; HYV seed: _____ ha; Local seed: _____ ha
 of which:
 Area fertilized with UDP urea: _____ ha
 Area fertilized with broadcast urea: _____ ha

5. Number of farmers using UDP urea on rice this season: _____
 a) Male Farmers
 Number of repeat users, who used UDP urea in any previous same season: _____
 New users: _____
 b) Female Farmers
 Number of repeat users, who used UDP urea in any previous same season: _____
 New users: _____

6. Number of farmers using urea broadcast on rice this season: _____
 a) Male Farmers
 Number of repeat users, who used broadcast urea in any previous same season: _____
 New users: _____
 b) Female Farmers
 Number of repeat users, who used broadcast urea in any previous same season: _____
 New users: _____

7. Total number of farmers using UDP or urea broadcast on any crop
 (including rice): _____
 Number of men: _____; Number of women: _____

8. Total prilled urea used this season:
In Hybrid/HYV land: _____ kg
In local variety land: _____ kg

9. Total UDP urea used this season: _____ kg

Signature: _____
Name: _____
Designation: _____
Date: _____

Signature: _____
Name: _____
Extension Agent _____
Date: _____

Exhibit 7-1-B
Seasonal
Dealer Survey
Report Form

Season: _____

Target Zone (e.g., Village, Community): _____ District: _____

1. Number of briquetting machine owners in the target zone/administrative unit who produced
UDP products this season: _____
Of which, number of men: _____; Number of women _____

2. UDP products produced/sold:
1.8 g UDP: _____ mt
2.7 g UDP: _____ mt

3. Sale of other fertilizers:
DAP: _____ mt TSP: _____ mt
SSP: _____ mt MOP: _____ mt
Gypsum: _____ mt Zinc: _____ mt
Urea: _____ mt Other: _____ mt

Signature: _____
Name: _____
Designation: _____
Date: _____

Signature: _____
Name: _____
MOA/Extension Agent
Date: _____

Date: _____
Farmer's name: _____ Father's name: _____
Administrative units
Village/Location: _____

1. SEASON, VARIETY, SEED SOURCE

Season: _____
Variety name: _____ [check one]: Hybrid ____ HYV ____
Seed source [check one]: Own saved seed ____ Bought seeds ____ Bought seedlings ____
If he/she purchased seeds, where did he/she buy them? _____ Price: _____
Buy seedlings: Yes ____ No ____
If yes, from where: _____ Price: _____

2. PLOT (a plot is the area surrounded by a bund and planted to a single variety)

Plot size (in ha): _____ Plot dimensions: _____ meters x _____ meters

3. YIELD

Size of cut: _____ square meters
Weight of grain: _____ kg Moisture content of grain: _____ %
Calculated yield at 14% moisture: _____ kg/ha Price of paddy: _____ \$/kg

4. USE OF INORGANIC FERTILIZERS (kg/plot):

UDP: _____ kg Price of UDP: _____ \$/kg
Broadcast urea: _____ kg Price of broadcast urea: _____ \$/kg
Did you apply any topdressing of urea? Yes ____ No ____
If yes, how much applied: 1st topdressing _____ kg 2nd _____ kg 3rd _____ kg

TSP: _____ kg DAP: _____ kg
MOP: _____ kg NPK: _____ kg
Other (specify): _____ kg
Price of fertilizers (\$/kg): TSP: _____ DAP: _____
MOP: _____ NPK: _____

5. USE OF ORGANIC FERTILIZERS (kg/plot)

Animal manure: _____ kg Green manure: _____ kg Compost: _____ kg
Price of organic fertilizer (\$/kg): Animal manure: _____ Green manure: _____
Compost: _____

6. PESTS, DISEASES, PESTICIDES

Was your crop badly or very badly affected by pests or disease? Yes ____ No ____
If yes, name of pest or disease: _____
Did you use any pesticides or weedicides? Yes ____ No ____
If yes, name(s) of pesticide(s) or weedicide(s): _____ Total cost: \$ _____

7. IRRIGATION

Did you irrigate the crop? Yes ____ No ____ If yes, number of times irrigated: _____
Did you irrigate from your own machine? Yes ____ No ____
If yes, cost of irrigation from own machine (\$/season): _____
Did you buy irrigation services from another's machine? Yes ____ No ____
If yes, cost of irrigation from another's machine (\$/season): _____

8. LABOR DAYS AND LABOR COSTS (only tasks that might differ between fields with UDP vs. prilled urea)

TASKS, LABOR DAYS AND COST (\$)	FAMILY LABOR		HIRED LABOR	
	MEN	WOMEN	MEN	WOMEN
What is the usual wage for agricultural labor (\$/day)?				
How many days of household and hired labor did you use for the following tasks on this plot?				
Transportation of inputs				
Transplanting				
UDP or urea broadcast application				
Broadcast urea application				
Other fertilizer application				
Weeding				

9. ADDITIONAL COMMENTS

Does the farmer consider this yield to be [check one]:

Normal _____ High _____ Low _____

Did the crop suffer any unusual conditions? Yes _____ No _____ If yes, explain: _____

Additional comments: _____

CROP CUT SUPERVISED AND REPORT SUBMITTED BY:

Signature: _____

Signature: _____

Name: _____

Name: _____

Designation: _____

Extension Agent, MOA/DAE

Date: _____

Date: _____

Data Sheet for Demonstration Plots

Farmer's Name: _____

Administrative Units

Village: _____ Date of Transplantation: _____

Seedling Age: _____ Variety: _____ Date of Harvest: _____ Tel: _____

Plot with UDP Application

DETERMINATION	HARVEST AREA NO. 1 (10 SQ. METERS)				HARVEST AREA NO. 2 (10 SQ. METERS)			
UDP Urea Plot								
No. of panicles from 4 hills (3 replications)				av.				av.
No. of hills per harvest area								
Weight of clean paddy, kg								
Moisture content of paddy, % (3 replications)				av.				av.
Paddy yield at 14% moisture, kg/ha								
Plot with Farmer's Practice (Urea Broadcast)								
No. of panicles with grain from 4 hills (3 replications)				av.				av.
No. of hills per harvest area								
Weight of clean paddy, kg								
Moisture content of paddy, % (3 replications)				av.				av.
Paddy yield at 14% moisture, kg/ha								

Number of panicles from adjacent hills should be taken from three different places outside the harvest area, but adjacent to each harvest area.

Other Information:

UDP Urea Plot: Area: _____ ha

Fertilizer use:

UDP: _____ kg Urea: _____ kg DAP: _____ kg TSP: _____ kg NPK: _____ kg MOP: _____ kg

Farmer's Practice Plot (Urea Broadcast): Area: _____ ha

Fertilizer use:

Urea: _____ kg DAP: _____ kg TSP: _____ kg SSP: _____ kg MOP: _____ kg

Cost (\$/kg):

UDP urea: _____ Urea: _____ DAP: _____ TSP: _____ MOP: _____ Zinc sulfate: _____

Labor rate/day: \$ _____ Paddy price: \$/kg _____ Straw Price: \$/kg _____

Signature: _____

Designation: _____

Date: _____

Harvest Records of Trial Plots

Farmer's Name: _____
 Village: _____
 Date of Seedling: _____ Date of Transplantation: _____
 Seedling Age: _____ Variety: _____ Date of Harvest: _____ Tel: _____

A. Growth parameter

1. Plant height in cm

TREATMENT	SPOT - 1	SPOT - 2	SPOT - 3	SPOT - 4	AVERAGE
T ₁					
T ₂					
T ₃					
T ₄					

2. Number of tillers and panicles

TREATMENT	PARAMETER	PER 16 HILLS (4 x 4 HILLS)	PER SQ. METER
T ₁	Tillers		
	Panicles		
T ₂	Tillers		
	Panicles		
T ₃	Tillers		
	Panicles		
T ₄	Tillers		
	Panicles		

B. Grain yield of paddy

TREATMENT	WEIGHT OF CLEAN PADDY in kg/ 5 SQ. METERS			MOISTURE CONTENT OF PADDY (%)				GRAIN YIELD IN KG/HA AT 14% MOISTURE CONTENT
	Harvest Area-1	Harvest Area-2	Average	Sample 1	Sample 2	Sample 3	Average	
T ₁								
T ₂								
T ₃								
T ₄								

Treatment*

T₁ _____

T₂ _____

T₃ _____

T₄ _____

Signature: _____

Designation: _____

Date: _____

Data Collection Sheet on Research Trial/Demonstration of Urea Briquette Applicator

Farmer's Name: _____
Village: _____ Mobile No: _____

Table 1. Field Performance Test Results of Urea Briquette Applicator Trial

Sl. No.	PARTICULARS	SINGLE ROW APPLICATORS	DOUBLE ROW APPLICATORS	INJECTOR APPLICATORS	HAND PLACEMENT
1.	Date of test conducted				
2.	Date of transplanting				
3.	Length of plot, m				
4.	Width of plot, m				
5.	Plot area, sq. m				
6.	Land area, sq. m				
7.	Number of rows/plot				
8.	Number of plants in row				
9.	Row spacing, cm				
10.	Plant spacing, cm				
11.	Size of urea briquette, gram				
12.	Effective width of operation, cm				
13.	Speed of operation, km/hr				
14.	Depth of water in the field, cm				
15.	Depth of placement, cm				
16.	Time req./plot, min				
17.	Urea briquettes required/plot, kg				
18.	Urea briquettes applied/plot, kg				
19.	Urea briquette application rate, kg/ha				
20.	Urea briquette application efficiency, % (less or over dose)				
21.	Effective field capacity, ha/hr				
22.	Field efficiency, %				
23.	Labor cost/day				
24.	Urea briquette application cost, \$/ha				

Applicator trouble, if any: _____
Farmer's/operator's comments/advice: _____
Data collected by: _____

Table 2. Data to be Collected During Growth Stages of Paddy

Sl. No.	PARAMETERS	TREATMENTS	DAYS AFTER UREA BRIQUETTE PLACEMENT				
			14	24	34	44	54
1.	Number of hills relatively less green/pale green/ yellowish per plot.	T ₁					
		T ₂					
		T ₃					
2.	Number of poor/uneven growth of hills per plot.	T ₁					
		T ₂					
		T ₃					

Treatments:

T₁-Injector applicator, T₂-Hand placement, T₃-Prilled urea broadcast

Other Information:

UREA BRIQUETTE APPLICATION METHODS	PLOT AREA (HA)	FERTILIZER USED (kg)						
		UREA BRIQUETTE/ PRILLED	DAP	TSP	SSP	MOP	GYPSUM	ZINC SULFATE
Mechanized Applicator								
Injector Applicator								
Hand Placement								
Prilled Urea Broadcast								
Cost (\$/kg)								

Labor rate (\$/day) _____; Paddy price (\$/kg) _____; Straw price (\$/kg) _____

Table 3. Data to be Collected During Harvesting of Paddy

A. Growth parameters

Plant height in cm

TREATMENT	SPOT - 1	SPOT - 2	SPOT - 3	SPOT - 4	AVERAGE
T ₁					
T ₂					
T ₃					
T ₄					

Number of tillers and panicles

TREATMENT	PARAMETER	PER 16 HILLS (4 x 4 HILLS)	PER SQ. METER
T ₁	Tillers		
	Panicles		
T ₂	Tillers		
	Panicles		
T ₃	Tillers		
	Panicles		
T ₄	Tillers		
	Panicles		

B. Grain yield of paddy

TREATMENT	WEIGHT OF CLEAN PADDY IN KG/ 5 SQ. METERS			MOISTURE CONTENT OF PADDY (%)				GRAIN YIELD IN KG/HA AT 14% MOISTURE CONTENT
	Harvest Area-1	Harvest Area-2	Average	Sample 1	Sample 2	Sample 3	Average	
T ₁								
T ₂								
T ₃								
T ₄								

Signature: _____ Date: _____

Questionnaire for Survey on Gross Margin for Sample Farmers

Interviewer's Name: _____ Date: _____ Questionnaire No. _____

A. Name of the Farmer and Farm Location

Name: _____ Gender: Male ___ Female ___

Village: _____ Mobile No: _____

B. Farm Size and Land Rent

1. What is the total land cultivated this season? _____ ha
2. Please provide the following information on variety of HYV paddy used, land cultivated and tenure status of land under UDP this season?

HYV VARIETY	TOTAL LAND (ha)	LAND UNDER UDP (ha)	TENURE STATUS OF LAND UNDER UDP (ha)		
			OWNED	RENTED	SHARECROPPED

3. If land was rented, what was the rent paid during this season? \$ _____ per ha
4. If land was sharecropped, what was the arrangement of payment?

Cash: \$ _____ per ha Kind: _____ kg of paddy per ha

C. Use of Fertilizer, Seed, Labor, Irrigation and Pesticides

1. Please provide the following information for _____ (crop name/year)

ITEM	UNIT	UREA BRIQUETTE PLOT _____ ha		PRILLED UREA PLOT _____ ha	
		QUANTITY	TOTAL COST (\$)	QUANTITY	TOTAL COST (\$)
Animal labor	Rent				
Power tiller	Rent				
Seed	kg				
FERTILIZER					
Urea	kg				
Prilled urea	kg				
DAP	kg				
SSP	kg				
TSP	kg				
MOP	kg				
NPK	kg				
Any other, please specify	kg				
Cow dung/compost/ organic fertilizer	kg				
Pesticides cost	\$				
Irrigation cost	\$				

What was the number of labor days used for production in _____ (crop name/year) under above variety/varieties?

TASKS	UDP PLOT				PRILLED UREA PLOT			
	FAMILY		HIRED		FAMILY		HIRED	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
Seedbed preparation								
Transportation of inputs								
Land preparation								
Transplanting								
Broadcast urea application								
Urea briquette application								
Other fertilizer application								
Weeding								
Irrigation								
Pesticide application								
Harvesting and carrying								
Post-harvest tasks*								

*Post-harvest tasks include threshing, cleaning, drying, parboiling, husking, transporting and storage work.

What is the cost of labor per day? \$ _____

D. Use of Agricultural Credit

1. Was any credit received for production of paddy in UDP plot during this season under above variety/varieties? ____ Yes ____ No

2. a. Was any credit received for production of _____ (crop name/year) under above HYV variety/varieties? ____ Yes ____ No
If yes, please provide the following information:

b. What was the amount of loan received for production of _____ (crop name/year) under above HYV variety/varieties? \$ _____
What was the amount of interest paid on the loan? \$ _____

c. What was the source of loan? ____ NGO ____ Money lender ____ Bank
____ Friend ____ Relative

E. Paddy Production and Sale

1. What was the production of paddy in _____ (crop name/year) under above HYV variety/varieties?

UREA BRIQUETTE PLOT (kg)	PRILLED UREA PLOT (kg)

2. From the above-mentioned produced paddy (in E-1), what was the quantity of paddy sold in _____ (crop name/year) under above HYV variety/varieties?
Paddy: _____ kg Rice: _____ kg

3. What was the price per kilogram of the following products sold?
Paddy: _____ \$/kg Straw: _____ \$/kg Rice: _____ \$/kg

F. Cropping Intensity

1. Have you used UDP in the previous two seasons? (Please check boxes √)

Last season: Yes No

Season prior to last season: Yes No

Chapter 8. Resource Requirements and Management for Success in UDP Market Development

Introduction

The resource requirements needed for a UDP project are substantial. **Adequate and timely availability of funds are critical** to the success of UDP technology introduction and market development. **It is the responsibility of the Collaborating Partner (CP) to provide the Implementing Agency (IA) timely access to the required level of funds to implement the UDP project.**

The annual financial resource requirements for UDP market development will vary depending upon a number of factors, including (among others) the number of farmers targeted for adoption, stage of fertilizer market development in the target area, agroecological conditions and cropping systems in place and farmer profile. It is expected that the annual financial requirements may be in the range of U.S. \$1 to \$8 million (2016 dollars) depending upon the aforementioned factors. In order to suitably address demand- and supply-side issues that impact UDP technology introduction and achieve sustainable farmer demand and supply system development, it is estimated that an intensive program of four to seven years in duration is needed. Hence, an overall commitment of financial resources between \$4 million (limited geographic area/pilot-scale program) and \$56 million (national program) will be needed to achieve success in changing farmer behavior to adopt UDP technology and to establish a vibrant supply system that affords farmers timely access to high-quality UDP products.

While the range of resource requirements is quite broad, the actual level of need will be dependent upon numerous factors as described herein. For example, the staff size needed for the UDP project may range from 25 (pilot scale) to 250 for a country-wide program.

A detailed budget, with activity-specific costs and quarterly cash flow requirements, will be developed based upon planned technical activities (e.g., UDP product testing/field validation, demand-creation activities, supply system development, policy-related activities, monitoring and evaluation [M&E], logistics, financial and administration support activities). **Underestimating the financial requirements and the timeliness of the need for the flow of funds may seriously impact success.**

Once the Strategic Plan is developed, proper and ongoing attention to resource management is essential. This will include record-keeping (accounting records, human resource records, contracts management, etc.) and regular, routine analyses and reporting to assess progress against targets and early detection of any adverse variances. This chapter provides information that will guide the IA in determining and scheduling resource requirements and management of resources.

Resource Requirements

As indicated above, the financial resource requirements for the UDP technology introduction and market development initiative may range from \$1 to \$8 million per year over a period of five to seven years. Three main factors impact the financial resource requirements for the UDP market development program.

1. Size and Scope of the Target Market

The size and scope of the market influence all aspects of the resource requirements – level of field staff, logistics requirements, training materials, promotional activities, sourcing of briquetting machines and applicators for deep placement, capacity-building activities at the farmer and fertilizer dealer level, etc. For example, one field staff (equipped with a motorcycle) can provide technical support to up to 1,000 farmers in a densely populated geographic area, assuming a contiguous cropping area of 500 ha. Therefore, with a target of 40,000 farmers bringing 20,000 ha under UDP technology, 40 field staff (with necessary supporting items, such as 40 motorcycles, cell phones, calculators, etc.) will be required. Achievement of the target will be a work in progress; however, early and ongoing training of farmers will be needed. As a rule, training programs for farmers are designed for a maximum of 40 farmers per program. Hence, with the aforementioned target level of farmer participation, 1,000 farmer training programs will be conducted per year. Each program will be conducted by a project agronomist and training specialist, with the field officer being present. Field demonstrations, billboards

and other technology promotion activities will be needed and influenced by the size and scope of the target market. Staffing and logistics requirements will also be directly influenced by the size and scope of the market.

2. Duration of the Program

UDP technology is a complex technology with numerous variables that impact both farmer adoption and supply system development. One should not underestimate the complexities and the time required to change farmer behavior and to develop the various elements of the supply system.

Several factors will impact the duration of the UDP technology market introduction program. Most significant are:

- *Size and scope of the target market:* As mentioned above, the program may range from (i) a pilot-scale program targeting a limited geographic area and UDP use in a single crop (e.g., rice) to (ii) a more robust program targeting UDP market development on a country-wide scale, involving multiple crops across varied agro-climatic conditions.
- *Stage of market development in the target market:* Factors that will influence the strategic approach and duration of the UDP technology market development program include: (i) the current level of yield-enhancing agriculture technology use, (ii) farmer education levels and risk profile, (iii) number of cropping seasons, (iv) structure and effectiveness of the fertilizer supply system, (v) fertilizer policy framework, (vi) access to agriculture credit at the farmer and dealer level (in cases of markets wherein private sector participation is active), (vii) post-harvest systems and markets in place for incremental production and (viii) role and effectiveness of the agriculture extension department.
- *Effectiveness of linkages with collaborators:* The level and effectiveness of collaboration with organizations and institutions that seek to advance agriculture productivity and markets will impact the program duration. Among others, opportunities to collaborate with non-governmental organizations (NGOs), national agricultural research organizations (NAROs), international agriculture research centers, farmer/industry associations, Ministry of Agriculture extension services, financial services providers and multi-national corporations both leverage resources and may accelerate progress in UDP technology.

Having too short of a timeframe for UDP market development will jeopardize the success of the program. On the other hand, once farm-level UDP demand is well-established (based upon predetermined targets) and the fertilizer supply system includes UDP products as a part of the product mix, resources should be reduced to avoid unnecessary costs.

3. Written Plan

The IA must have a written plan that includes an estimate of the resource requirements prior to launching the UDP technology market development program. IFDC has established standards for the resource requirements needed in UDP technology market development, including supply- and demand-side variables and macro-environmental factors that may impact the target market for UDP technology.

Managing Resources to Achieve Success

The Implementing Agency's goal in resource management should be: (a) to ensure that program resources are adequately and timely available for use in supporting program implementation and (b) that application of resources is directed to achievement of specific program activity targets. The IA's systems and policies related to accounting, financial management, procurement and human resource management will govern the use of funds and day-to-day operations management.

The CP/IA should give priority attention to the following in management of resources to achieve development of the market for UDP technology:

- Ensure adequate resources on a timely basis to achieve planned activities. Resources include financial resources needed for staffing, logistics and activities.
 - ✓ The level of funds needed should be quantified by agriculture cropping season and by year to support activity performance plans. The resource needs should be linked by category (e.g., staff, logistics, materials) to activity areas/interventions. Proper planning of the availability of funds is essential to ensure that seasonal activities (e.g., crop demonstrations, field days) occur in a timely manner.

- Apply the resources properly in interventions/activities to achieve targeted results (e.g., number of farmers trained in UDP technology, number of demonstrations, number of workshops, number of signboards/billboards by season).
- Establish an effective M&E system to measure performance and results metrics that are realistic in terms of progress in UDP market development.
- Establish administrative and management systems to monitor and control the use of funds in accordance with plans and in full compliance with local laws.

1. **Staff**

The IA should be committed to the principle that success in UDP project implementation is due in large part to engaging highly qualified and experienced staff who have demonstrated the capacity to work effectively with multiple stakeholders and achieve success in a complex environment. The IA should seek skilled staff that possess the basic qualifications and demonstrate excellent technical knowledge, cultural sensitivity and the ability to perform at the highest level in a team setting.

The size of the “team” will be dependent upon the size and scope of the program. A team leader should be appointed with extensive fertilizer sector experience, with emphasis on market development and policy analysis. A deputy team leader with extensive expertise in agriculture production systems and technology transfer may also be appointed. An illustrative staffing structure is presented below. Table 8.1 provides an illustrative list of specialists and key activities to be prepared by each key staff.

Other mid- to senior-level professionals who (in addition to being competent in their professional fields) are experienced in dealing with public officials, scientists, business people, farmers and the general public need to be appointed. They may include the disciplines outlined in Table 8.1.

In addition to the above professional staff, support staff will be appointed, such as accountants and administrative (procurement, personnel, general support) staff. Again, the size and scope of the UDP market development program will influence the number of staff needed in each discipline.

2. **Logistics**

Travel by IA staff to targeted areas for UDP technology market development will be extensive and continuous throughout the duration of the program. The need for travel will be derived from a wide range of activities (e.g., capacity-building events targeting farmers, UDP dealers and briquetting machine fabrication shop owners, technology validation activities and monitoring project performance). The potential for use of public transport should be assessed. Based upon IFDC experience, fully dedicated vehicles (motorcycles for field-level staff) are needed to achieve effectiveness/efficiency in staff movements.

3. **Key Activities/Intervention Areas**

Resource requirements linked to each activity/intervention area should be identified and a budget estimate provided for each. For example, the resource requirements would need to be estimated for each planned farmer training event, field demonstration of UDP technology, farmer field day, UDP technology trial, national workshop and agriculture trade fair. The estimated costs of various elements of the UDP technology advertising campaign (e.g., billboards, sign boards, wall hangings) will need to be determined. Initially, due to the fact that there is no farmer demand for UDP and dealers will be reluctant to invest their funds in briquetting machines and applicators, consideration will need to be given to offering machines and applicators on a subsidized basis. Although the machine/equipment cost is about \$2,500-\$5,000 (local production – imported) per briquetting machine,³¹ getting the supply system started to facilitate farmer access to UDP may require initial financial support. It is IFDC experience that a phased cost-share program with dealers initially (Years 1 and 2) covering 25% of the briquetting machine cost may be appropriate. This must be carefully factored into the resource planning phases. Collaboration with partners through public-private partnership-type relationships should clearly identify roles and responsibilities as well as resource requirements.

4. **Other**

Financial requirements for miscellaneous administrative and support activities should be estimated (e.g., communications/cell phones for field staff/internet, office occupancy costs, software/computers, office equipment and field equipment/moisture meters/scales).

³¹ Depending upon local fabrication or import with ocean freight costs.

5. **Financial Management**

Financial management is an integral part of the management system. The IA should ensure that accounting systems are in place to properly record and report costs that are incurred in the UDP market development program. Costs should be reported monthly and on the basis of the cost categories established in the budgetary process. Monthly financial statements should include, at a minimum, the following:

- Income statement: revenues and expenditures by month during project implementation, including account receivables and payables.
- Detailed report of expenses by cost category.
- Statement of fixed assets.
- Statement of budget variance analyses.
- Cash flow statement and “rolling” projection of cash inflows and outflows for the forthcoming four quarters.

Table 8.1
Illustrative
List of IA
Project Team:
Specialists and
Key Activities

ILLUSTRATIVE LIST OF IA PROJECT TEAM: SPECIALISTS AND KEY ACTIVITIES	
Agronomist/Extension Specialists	<p>Responsible for soil/crop nutrient management activities to ensure UDP technology is properly and well integrated in the UDP market development program. Key activities include (among others):</p> <ul style="list-style-type: none"> • Determine UDP fertilizer recommendations. • Plan and implement UDP trials (including collaborative research trials with NAROs and others). • Participate in the preparation of technical brochures/wall hangings/leaflets regarding UDP use and benefits. • Plan and implement technology demonstrations and field days. • Conduct farmer training events. • Participate in training of Ministry of Agriculture/Department of Agricultural Extension (MOA/DAE), agriculture trade fairs, technical workshops, etc.
Production Economist	<p>Responsible for all economic components of UDP technology performance assessment, market and private sector development and economic training.</p>
M&E Specialists	<p>Responsible for monitoring and evaluation (M&E) component of the UDP market development initiative. Key activities include:</p> <ul style="list-style-type: none"> • Determine performance targets and results indicators in UDP market development. • Conduct baseline/mid-term/completion assessments to support assessment of progress against targets.
Mechanical Engineers	<p>Responsible for technical component of UDP supply system, including briquetting machine supply, training of dealers in machine operation and maintenance, and UDP product quality control issues. Key activities include:</p> <ul style="list-style-type: none"> • Interface with local metal works shops on fabrication of briquetting machines to achieve high-quality UDP briquetting machines. • Collaborate with plastics industry for local supply of high-quality UDP applicators. • Develop training materials/conduct training of dealers in UDP briquette supply and quality control support for UDP quality assurance.
Policy Analysts	<p>Responsible for the policy component to ensure that the policy environment is conducive to rapid development of the UDP fertilizer market. Key activities include:</p> <ul style="list-style-type: none"> • Initial and ongoing assessment of government policies that may impact the supply (e.g., manufacture, product registration/approval) and marketing (e.g., sales outlets/dealer licensing, pricing, inventory management and other logistical issues) of UDP fertilizers. • Articulate recommended policy reforms needed to allow for UDP market development. • Collaborate with government authorities to achieve needed policy reforms.
Marketing/Business Development Specialists	<p>Responsible for development/implementation of the strategy and action plan to stimulate a supply system and advertising campaign for UDP fertilizers. Key activities include:</p> <ul style="list-style-type: none"> • Develop business plan for development of the UDP marketing chain (e.g., wholesalers/dealers/others to ensure orderly development of the supply network in the target market area). • Conduct business training of various marketing chain members in UDP. • Manage the UDP advertising campaign (e.g., technical leaflet preparation, use of billboards/road signs, mass media and other advertising tools).
Media Specialists	<p>Responsible for managing media relations. Key activities include:</p> <ul style="list-style-type: none"> • Interact with news media to support UDP program technical content development for mass media. • Engage mass media representatives in UDP technology field day events/trade fairs.
Gender Specialists	<p>Responsible for ensuring women participation in all UDP market development activities. Key activities include:</p> <ul style="list-style-type: none"> • Assess opportunities for women in UDP supply and marketing. • Design training programs to encourage women participation in UDP supply and on-farm use. • Participate in M&E as needed.

Training Specialists	<p>Responsible for human capacity building function. Key activities include:</p> <ul style="list-style-type: none"> • Manage/implement the UDP technology training component for UDP suppliers/dealers and farmers. • Collaborate closely with other specialists (e.g., soil scientists, mechanical engineers) to identify capacity building needs of key stakeholders. • Develop a written schedule for UDP technology field days, farmer training, dealer training and events. • Ensure that all training materials and resources are available in a timely matter for program implementation. • Collaborate with MOA/DAE to incorporate UDP technology in DAE field staff training curricula, etc.
Data Management Specialists	<p>Responsible for data management function. Key activities include:</p> <ul style="list-style-type: none"> • Establish and implement systems to monitor and measure progress in UDP market development, including hardware/software selection/installation for data management. • Conduct farmer and dealer surveys and data analyses and report results.
Field Supervisors	<p>Responsible for management and day-to-day oversight of UDP market development in specific geographic areas to ensure timely and quality implementation. Key activities include:</p> <ul style="list-style-type: none"> • Collaborate closely with the UDP technical and business management specialists on all activities. • Direct supervision of field officers in the geographic region. • Maintain positive relationships with local government officials and MOA/DAE field staff.
Field Officers	<p>Responsible for identifying farmers for project assistance with support from MOA/DAE officials and agro-input dealers. Will work to motivate farmers to adopt UDP and other technology with support from MOA/DAE field official at the village level in accordance with work plans. Key activities include:</p> <ul style="list-style-type: none"> • Identify farmers, traders and enterprises with the assistance of MOA/DAE and other private sector stakeholders concerned with UDP technology. • Promote farmers for adoption of UDP technology. • Carry out activities as per work plans at the village level. • Assist field coordinators in organizing field days, field demonstration, field trials, training programs, workshops, etc., at the village level. • Conduct farmer training programs with assistance from DAE field officials and other relevant stakeholders.
Project Management Team	<p>Responsible for ensuring proper project implementation, particularly related to financing.</p>

Note: Not all positions will be full-time; some roles can be filled by short-term technical assistance.

IV. IFDC Support

1. Introduction

Rapid diffusion of UDP technology is dependent upon many factors. This *Reference Manual*, along with IFDC videos on UDP supply and on-farm use, support the successful planning, implementation and management of the strategic interventions needed to support the UDP market development program.

While every effort has been made to address all factors that may impact a successful UDP product launch and commercialization program, the guidelines are, by necessity, generic and based upon the current “state” of UDP technology. The guidelines will need to adjust – *to adapt to conditions specific to your target market*.

During the strategic planning and roll-out phases, it is likely that clarifications and guidance on various aspects of the program will be needed. And, with innovation at IFDC, there will be advances in the technology, particularly in terms of briquetting machine upgrades and improvements in the mechanical applicator for UDP product placement.

Consistent with the IFDC mission, UDP technology offers an excellent opportunity to improve rural income growth and food security through improved efficiency in fertilizer nutrient management. We consider ourselves a partner with each Collaborating Partner (CP) in development of the market for UDP technology and, as such, will provide ongoing support as described below. The costs associated with IFDC support will be determined on a case-by-case basis. This may range from “no-cost” for questions regarding project design and technology issues to full cost recovery by IFDC wherein IFDC serves as IA.

2. Support to be Provided

IFDC may support the IA in five key areas:

a. Strategic Planning and Program Management

- Guidance on the planning/implementation of the Target Market Assessment and review/interpretation of findings.
- Policy-related support (e.g., review of IA’s policy analyses and appraisal of policy reform measures under consideration) to achieve a market environment that is conducive to private sector investment in UDP technology and market development.
- Review/guidance on IA’s plans (including budget review) for strategic interventions on demand- and supply-side.
- Review of targets for progressing the diffusion of UDP technology.

b. Technical Backstopping

- Access to IFDC’s fertilizer production program on matters related to briquetting machine installation/operation, UDP quality control issues and machine maintenance/servicing.
- Access to information and guidance from IFDC’s fertilizer R&D programs on planning and protocols as related to UDP trials and technology demonstrations as well as UDP field results from IFDC prior experiences – issues/concerns/problem resolution.
- Access to information and guidance from IFDC fertilizer marketing specialists on any business/market development issues that may impact UDP technology diffusion, including (among others) business plan development for UDP product suppliers and design of promotion campaigns.

c. Capacity Building

- Capacity-building support may be provided by IFDC in three key areas:
- Ministry of Agriculture/Department of Agricultural Extension (MOA/DAE) Staff – Review of training program content that is planned for inclusion in curricula of agriculture universities and agriculture extension staff training programs.
- Suppliers of UDP Products – Review of training program materials that are tailored by the IA for targeted UDP product suppliers.
- IA Staff – Ongoing access to guidance from the IFDC Technical Team on matters related to the UDP market development project.

d. UDP Technology Upgrades

UDP technology in its current state is well-established; it is field-tested, with proven advantages over conventional fertilizer technology and application practices in smallholder agriculture. IFDC and development partners continue to pursue upgrades in briquetting machine and applicator technologies, as well as product enhancements, to improve product quality and extend the benefits of the technology. IFDC support will include full access to the latest information on UDP technology upgrades (e.g., briquetting machine improvements, mechanical applicator, product quality enhancements).

e. UDP Market Updates (Worldwide)

The IA will stay abreast of UDP technology market development, progress and issues through periodic IFDC web-based articles and research reports. Included will be information on yield results with UDP use on various crops under different agroecological conditions, technology advances, UDP product quality control issues and other issues that may impact UDP market development.

3. IFDC Team

The IA will have continuous access to IFDC through a team of professionals – soil scientists, marketing specialists and fertilizer production engineers. Again, the cost for IFDC services (if any) will be determined on a case-by-case basis.

4. Procedures and Contact Coordinates

Requests for support should be in writing and submitted to the IFDC Fertilizer Research Division at FertRes-staff@ifdc.org. Telephone requests may be made to 256-381-6600.

5. Financial

All headquarters support provided by IFDC will be determined on a case-by-case basis.

Chapter 9. Lessons Learned and Frequently Asked Questions

IFDC's experience in UDP research and development spans more than three decades. During that time, many lessons have been learned that may impact UDP project success.

Lessons Learned

- Farmers will change behavior from traditional practice when convinced of the benefit of change.
- Private sector investment will occur when conditions are favorable and there is sufficient financial incentive.
- Quality control is essential to product success.
- Engagement of MOA/DAE in project activities will leverage resources and build public support.
- Educating farmers and other key stakeholders on UDP use cannot be overemphasized.

Frequently Asked Questions

1. *What are urea briquettes?*

Urea briquettes are large, pillow-shaped fertilizer particles developed specifically for ease of placement (point placement) near the root zone of the crop.

2. *Is this a new fertilizer product?*

Yes. In terms of the physical properties and application requirements, urea briquettes differ substantially from commercial grade urea fertilizers. From a supply perspective, there is no international supply source for the briquettes. While the chemical properties of the urea briquettes (e.g., 46% nitrogen content) and management issues (e.g., hygroscopic) are the same as conventional urea, it is a “new” product due to particle size, application requirements and sourcing of supply.

3. *Is the urea briquette a substitute for the use of prilled/granular urea fertilizer?*

Yes, urea briquettes contain the same nitrogen form and content of conventional urea fertilizers. So, when urea briquettes are used, there is generally no need for the use of prilled/granular urea.

4. *How are urea briquettes applied in crop fields?*

The briquettes are placed below the soil surface at a depth of 7-10 cm.

5. *What is the size and nutrient content of the urea briquettes?*

Approximately “thumbnail” in size, each particle is 1.8 to 2.7 g in weight. The nutrient content of the urea briquettes is 46% nitrogen.

6. *In which crops and soil types can the urea briquettes be applied?*

The briquettes can be applied in many crops and most soil types. They are particularly well-suited for use in rice production; favorable results have also been achieved from briquette use in vegetables (cauliflower, broccoli, tomato, eggplant) and some other grain crops. Use of the briquettes in sandy soils is not recommended due to the low organic content and propensity of nitrogen leaching.

7. *What is the rate of application of urea briquettes per hectare for different crops?*

The rate of application of urea briquettes will vary by crop, management practice (seed variety, water management), and other agro-climatic conditions. As a rule, the N application rate for conventional urea fertilizers may be reduced by one-third when urea briquettes are used. The recommended application rate should be determined through collaborative research trials with the MOA/DAE for each target area.

8. *Is deep placement of urea briquettes more labor intensive than surface-applied fertilizer?*

Yes, it is somewhat more labor intensive, both in the application of the briquettes and at harvest with increased yield. However, the increased labor with the briquettes is more than offset by a single application of the briquettes as compared to multiple applications with broadcast of conventional urea. Less weeding is also a benefit of urea briquette use. Finally, the significantly enhanced economic returns to farmers that use urea briquettes allows for hiring of labor in the event that non-family labor is needed in the application.

9. ***How much yield gain can be obtained using UDP technology compared to broadcast application in different crops?***
Incremental yields with UDP should range from 4% in some vegetables to 18% in the case of rice.
10. ***Is there an applicator for placement of the briquettes?***
Yes. An applicator has been especially designed for application in rice production. Two models are in use, a handheld plunger-type applicator and a push-type applicator for rice. Efforts are underway to develop/modify small mechanized planters to deep place the briquettes.
11. ***What is the price of an applicator?***
The prices range from about U.S. \$10 (plunger type) to U.S. \$50 (push type).
12. ***Where is an applicator available?***
Bangladesh is the only supplier, but the technology is fairly simple and the devices likely can be made locally.
13. ***Is soil testing needed for UDP?***
Soil testing is always recommended in soil fertility management.
14. ***What are the main benefits of UDP over prilled/granular urea fertilizer?***
 - a. Improved yield.
 - b. Lower application of nitrogen fertilizer.
 - c. Less weeds and insects.
 - d. Environmental advantages.
15. ***Does UDP technology pose any risk for soil fertility?***
UDP is an efficient fertilizer technology that will allow for improved soil nutrient management with the end result being lower application of N fertilizers and less nutrient losses with improved nutrient recovery by the crop.
16. ***What are the biggest challenges to introducing urea briquettes in the market?***
Changing farmer behavior to adopt UDP is a key challenge and requires ongoing farmer education. Developing the supply system and encouraging agro-input dealers to include urea briquettes in their product mix is a significant challenge – mainly due to low levels of demand for the product and the investment cost needed by dealers. Quality control in briquette supply is a challenge to ensure dealers are providing farmers high-quality products.
17. ***Where can I buy urea briquettes?***
The only suppliers will be local manufacturers. There are no international suppliers of the briquettes.
18. ***Are urea briquettes available in international fertilizer markets?***
No.
19. ***How are the urea briquettes manufactured?***
They are made in a specially designed briquetting machine. Conventional urea prills/granules are compacted under high pressure to make the briquettes.
20. ***What are key quality control issues in urea briquette supply?***
The main issue is the consistent supply of briquettes of the correct weight and with good physical properties – dry and free flowing when handling.
21. ***How does the agronomic efficiency of UDP compare to urea and other nitrogen fertilizers?***
The agronomic efficiency of UDP is about 50% greater than that of surface-applied urea fertilizer in flooded rice systems.
22. ***How are the briquettes packaged?***
The briquettes require the same care in packaging as conventional urea fertilizers. Protection from moisture and contamination with other products are primary concerns.
23. ***What is the cost of a 50-kilogram bag of urea briquettes?***
About U.S. \$0.75 to \$1.00 more than a bag of urea prills/granules.

24. ***Where can I buy a urea briquetting machine?***
The machines are only available from Bangladesh suppliers. Engineering design specifications are provided to IAs and will allow for machine fabrication in local metal works shops.
25. ***What is the cost of a briquetting machine?***
The cost of a briquetting machine will vary from U.S. \$2,500 to \$5,000 depending upon various factors.
26. ***How much space is needed for the briquetting machine to be installed and operated safely?***
The machine dimensions are approximately 1 m x 2.2 m. Additional space for product processing and handling/storage are needed. A total dedicated space of approximately 5-6 m² is needed.
27. ***Are there environmental issues that would impact urea briquette manufacture?***
In the case of petrol-powered engines, good ventilation is essential. The production area should be dry and away from flood-prone areas.
28. ***How are the machines powered?***
Electricity or petrol engines.
29. ***How much training is needed to be able to manufacture high-quality urea briquettes?***
One week of training is sufficient for machine operation and daily maintenance.
30. ***Is it possible to make multi-nutrient fertilizer briquettes that contain N as well as P and K, plus secondary and micronutrients?***
Yes. This can further the benefits of the technology. Special conditions apply to manufacture multi-nutrient briquettes with corresponding increases in dealer training and quality control monitoring.
31. ***What will be key challenges to make the multi-nutrient briquettes?***
Quality control factors related to raw material selection, proper quantities of raw materials to achieve a desired nutrient grade, proper mixing of the raw materials and post-manufacture factors.
32. ***Are there any special handling and/or storage requirements for the urea briquettes?***
Yes. The briquettes must be free from moisture. The briquettes will have good physical properties, but care should be taken to avoid actions that may break/chip the briquettes.
33. ***What costs are involved in the manufacture of the urea briquettes?***
The costs comprise fixed and variable costs and the volume of throughput impacts production costs. Typically, with an average annual throughput of 100 mt of briquettes per year, the cost per 50-kg bag of briquettes is less than U.S. \$0.60.
34. ***How should the urea briquettes be priced to be competitive in the market?***
Based upon value-pricing and the agronomic efficiency factor, pricing could be as high as 50% more than conventional urea. But, due to the low level of cost involved, most dealers price briquettes at about U.S. \$0.75 to \$1 more per 50-kg bag than conventional urea fertilizers.
35. ***How important is a strong promotion program in developing farmer awareness and demand for the urea briquettes?***
It is essential and must be started at the onset of the program to coincide with the supply system development.
36. ***What are the best promotion methods to encourage farmers to use UDP?***
A complete promotion program is needed. Farmer education through classroom-type programs and farm-level demonstrations and field days are very effective in creating awareness and building farmer knowledge.
37. ***Will there be an opportunity for collaboration with other stakeholders in UDP market development and, if so, who are likely candidates for collaboration?***
Yes. Best candidates are likely to be the DAE, MOA, non-governmental organizations (NGOs), farmer groups, agro-input dealers/retailers and national agricultural research organizations (NAROs).
38. ***Are there policy issues that I should be concerned with in the manufacture and selling of urea briquettes?***
Yes. The policy environment is important from three key perspectives: (a) licensing of dealers who can buy/manufacture/sell fertilizers; (b) pricing – what is the fertilizer pricing policy and will dealers be allowed a fair

margin; (c) approved fertilizer products – is there an official list of approved fertilizer products and what (if any) is the procedure to allow for UDP briquettes.

39. *What is an example of a typical Collaborating Partner and what role does it play?*

The Collaborating Partner (CP) will typically be an international development agency, development bank, or foundation which includes in its mission food security improvement and/or smallholder farmer poverty alleviation. U.S. Agency for International Development (USAID), Netherlands' Directorate-General for International Cooperation (DGIS), Food and Agriculture Organization of the United Nations (FAO), the World Bank, AGRA and the Africa Development Bank are examples of current and potential UDP project CPs.

The CP's role is to (a) select an Implementing Agency (IA) to implement the UDP project in a target area (e.g., region, country or specific geographic area within a region/country), (b) provide timely access to funds (at an approved funding level) for the UDP project and (c) provide guidance and support to the IA during project implementation.

40. *What is an example of a typical Implementing Agency and what role does it play?*

The IA will typically be an international organization or consulting firm experienced in fertilizer and agriculture market development. IFDC, Winrock International, Development Alternatives International, ACDI-VOCA, and International Development Enterprises are examples of current and potential IAs for a large-scale UDP project.

The IA's role is to conduct an assessment of the agroecological zones and fertilizer markets in the areas targeted by the CP for UDP project implementation and implement the project. For illustrative purposes, the IA's role will include (among others): (a) design a Strategic Action Plan for the UDP project, (b) establish the project implementation team, (c) implement systems to ensure a high level of technical performance in concurrently creating farmer demand for UDP products and a supply system to meet farmer needs and further demand, (d) activate systems for project performance management (technical and financial), (e) establish mutually beneficial stakeholder relationships to leverage resources and build synergies and (f) liaise with the CP throughout implementation.

41. *What ongoing support is provided by IFDC?*

IFDC has a dedicated technical team that provides ongoing support to technical and market development inquiries related to UDP. At the time the IA initiates the program, one IFDC specialist will make a site visit to the IA's offices for one week to participate in discussions and planning of the program. Technology upgrades will be provided to the IA on an ongoing basis. After completion of the initial one-week site visit by the IFDC specialist, specific issues related to UDP market development may include site visits by the IFDC team for training, strategic planning and other matters. Such visits will be covered through a separate agreement that will provide the terms and conditions which would apply.

42. *Who should I contact if I have questions about UDP supply- or demand-related issues?*

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