Report on Trial of Urea Deep Placement Technology for Productivity and Profitability Enhancement under Rain-fed Rice Systems in Odisha, India

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1. EXECUTIVE SUMMARY

The MSSRF conducted field trials to evaluate the efficacy of the Urea Deep Placement (UDP) methodology in rice under rainfed system in Koraput District of Odisha state in India. The IFDC provided the initial orientation on their rapid fertilizer deep placement (FDP) technology diffusion programme in Bangladesh and supplied required amount of Urea Super Granules (USG) for evaluation with kharif rice. This UDP procedure not only enhances the incremental income but also provides solution to the nitrogen accumulation in farm environment. The trial was conducted in farmer's field during the kharif season of 2013 in *Banuaguda* village of *Baipariguda* block in Koraput district of Odisha. Basic data on plant height, number of tillers/plants, and number of panicles/plant etc. were recorded at different stages of crop development. Deep placement of USG recorded maximum number of tillers and grain yield plausibly due to minimal loss of nitrogen from the soil due to the slow release of nitrogen by the USG. The impact of USG was evident at all stages of crop growth and development as it increased the plant height, number of tillers and panicle /hill, the grain yield (28% increase) and straw yield (29% increase). Incomeof the farmers who used USG for the rice variety *Jyotirmayee* was more by 27% in comparison to those who did not go for this procedure. Similarly farmers who grew variety *Hiranmayee* as direct seeded rice or as transplanted rice harvested 16% and 17% more paddy than those who did not adopt the procedure. In effect, the UDP technology gave a net profit increase of 78% in the case of *Jyotirmayee* and *Hiranmayee* direct seeded rice and transplanted rice the profit level was more by 49% and 53%, respectively.

Key words: Fertilizer Deep placement Technology, Urea Super Granules, Farmer field trial.

2. BACKGROUND

The International Fertilizer Development Center (IFDC), USA and M.S. Swaminathan Research Foundation (MSSRF), India entered into a collaborative research in facilitating the rapid diffusion of fertilizer deep placement (FDP) technology in Koraput district of Odisha in India. In this connection, exchange visits of scientists from MSSRF and IFDC, Bangladesh took place during 2013. MSSRF undertook field experimentation to understand the efficacy of the Urea Deep Placement (UDP) technology in rice under rain fed system in Koraput District of Odisha state in India. IFDC provided initial orientation on their rapid FDP technology diffusion programmein Bangladesh and supplied required amount of Urea Super Granules (USG). The objective of this mutual cooperation and experience sharing were aimed at leveraging the scientific understanding to help the small holder farmers to optimize the available resources for maximizing the returns[1].

3. INTRODUCTION

Nitrogen fertilizers[2] enable farmers to achieve higher yields that drive modern Indian agriculture. It is evident from the current level of use of nitrogenous fertilizer[3]in the country that it will

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[1] Increase in incremental income by reducing cost of cultivation by judicious use of fertilizers and improve the fertilizer use efficiency.

[2] The major source of nitrogenous fertilizer in India is Urea (more than 66%) as per Agriculture census, 2013, DAC, Govt. of India

[3] A study by Fertilizer Association of India (2010) shown that 89% of the soil in the country is deficient in nitrogen.

continue to increase substantially and positively correlated with the increase in demand for food production.While fertilizers are effective in driving crop yield improvements; they also frequently have a negative impact on the environment. Since most plants are able to utilize less than one-half of the nitrogen fertilizer applied by growers, much of the remaining nitrogenous fertilizer leaches into the air, soil and water and pollutes lakes, rivers, aquifers and oceans.Evidences from the scientific publications it is well known that a significant portion of the unabsorbed nitrogenous fertilizer volatizes in the form of N_2O. In fact, agriculture is the second largest industrial contributor to global greenhouse gases (GHGs) -- ahead of the transportation sector and behind only electrical and heat generation. It is estimated that nitrogen fertilizer accounts for one-third of the GHGs produced by agriculture[4]. In addition to environmental pressures, nitrogen costs can represent a significant portion of a farmer's input costs and can significantly impact farmer profitability. The Fertilizer Deep Placement (FDP) program of IFDC in Bangladesh[5] and many other countries in Africa have generated evidence that growers will have a powerful incentive to use this technology because it makes economic sense for them to do so. The impact of the technology is more significant in rice growing areas which mean the beneficiaries are the small holder farmers. In effect, FDP technology will help growers protect the environment while helping them run a more profitable farming business.

4. RICE &NITROGEN NEXUS

Rice covers just over 22% of the total gross cropped area in India followed by wheat (15%)[6]. Nitrogenous fertilizer is the most common fertilizers used by the Indian farmers (Table-1).

Table-1. Nitrogenous Fertilizer consumption in India

Year	Total Consumption of Nitrogen (in MT)	Consumption of Nitrogen per hectare (in Kg)	Total Consumption of Fertilizers (in MT)
2009-10	15.6	79.1	25.9
2010-11	16.7	81.2	26.3
2011-12	17.3	81.8	27.8
2012-13	16.8	80.4	25.6

(Source: Annual Report (2012-13), Department of Agriculture & Cooperation, govt. of India)

It is evident that the nitrogenous fertilizer is 60% of the total fertilizers utilized in India of which Urea is the most common and economical nitrogenous fertilizer. Per hectare consumption of nitrogen is comparable higher than the phosphate and potassium. India imports almost 30% of the total nitrogen consumed for food production. Rice is a voracious consumer of nitrogenous fertilizers and it has been accepted that the yield enhancement could be made by use of nitrogen which is the most essential nutrient and help vegetative growth of the crop. Nitrogen contributes about 20% of the rice yields out of total application of Nitrogen, Phosphorous and Potassium fertilizers. Most of the nitrogen applied through fertilizer is lost from soil in many ways.

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[4]The Stern Review on the Economics of Climate Change, Govt. of UK, 2006

[5] IFDC is working with the farmers in Bangladesh for last 35 years and developed FDP as more effective alternative to the traditional methods. It is an innovative proven fertilizer application technology that achieves average yield increase of 18% while reducing fertilizer use by about one third. The rice farmers of Bangladesh have increased incremental incomes by more than US$200 (as per 2012 price) per hectare by using Urea Deep Placement (UDP) as compared to broadcasting method (IFDC Report, Vol38, no2 p 1)

[6]Annual Report (2012-13), Department of Agriculture & Cooperation (DAC), Govt. of India.

Knowledge on processes of nitrogen loss from rice field can generate the means of preventing its loss and thus boosting the rice yield. The different means of nitrogen loss from rice fields are: a) Leaching, b) Volatilization, c) Surface runoff, d) De-nitrification and d) Crop removal.

5. RICE PRODUCTION VIS-À-VIS NITROGEN CONSUMPTION IN ODISHA

Riceis the principal crop of Odisha and the area covered is slightly more than 9% of all India area under rice cultivation. It is cultivated in about 4 million hectares under *kharif* and 30 thousand hectares in *rabi* season of 2012-13. The productivity of rice in Odisha ranges from 17-19 Quintals per hectare (Table-2).

Table-2. Rice production in Odisha

Year	Area (million hectare)*	% to All India	Production (million tonnes)	Yield (Kg per hectare)
2011-12	4.00	9.09	6.83	1890
2012-13	4.03	9.50	7.64	1708

* Area includes both *kharif* &*rabi* season
(Source: Annual Report (2012-13), Department of Agriculture & Cooperation, govt. of India)

Odisha state is situated in the eastern part of India and here use of nitrogenous fertilizers is less (65.7 Kg per hectare) in comparison to say, Punjab or Haryana. Nevertheless, nitrogen is a vital nutrient for rice production in the state. It has been estimatedthat for a quintal of rice grain and straw production 2kg and 0.5 kg of nitrogen is removed from soil respectively. One hectare of land producing 40quintals of grain and 45quintals of straw will remove 80kg and 22.5kg N per hectare. Thus a total of 102.5kg N/ha is removed from one hectare rice field which causes regular N deficiency in the soil [7].Looking to the various types of losses of nitrogen, the nitrogen use efficiency of rice soil can be increased through right choice of source, right dose, right time and right method of application of N fertilizers along with proper water management practices and recycling of crop residues.

6. THE DEMONSTARTION

6.1 Context of Koraput district

Koraput is a high land plateau district of Odisha state in India with hills and hillocks forming part of the Eastern Ghats. The altitude ranges between 150 to 1500 meters above mean sea level. Mean average annual rainfall is 1520 mm, providing a potentially productive agro climate along with different types of land categories for cultivation of different crops. The topographic diversity of the Koraput region has resulted in a wide diversity in ecosystems under which rice is cultivated viz. upland, medium land (irrigated and rain fed) or low land condition. The region is characterized by small farmers with low and unpredictable agricultural productivity, lack of adequate market and infrastructure leading to poverty and large-scale migration.

6.2 Rice production in Koraput

[7]Sahu, S.K and Samanta, P.K (2006): Nitrogen Loss from Rice Soils in Odisha; Orissa Review, December, 2006

Rice is the predominant crop in this district – both in terms of acreage as well as in terms of production. More than 40% of the land is under paddy cultivation. The other important crops grown are maize (*Zea mays*), finger millet (*Eleusinecoracana*), green gram (*Vignaradiata*), black gram (*Vignamungo*), mustard (*Brassica juncea*), sesame (*Sesamumorientale*) and groundnut (*Arachis hypogea*). The tribal people in the hills grow minor millets, little millet (*Panicummiliaceum*), foxtail millet (*Sateriaitalica*), niger (*Guizotiaabyssinica*), pigeon pea (*Cajanuscajan*) and horse gram (*Dolichosbiflorus*).The methods of cultivation practiced by tribal population were those based on traditional knowledge. The climatic aberration interspersed with drought and flooding rain was un-favorable for realizing stable yields under traditional practices of cultivation.

6.3. The Trials

Demonstrations to improve the fertilizer use efficiency by using Urea Super Granules (USG) were been under taken in farmer's field of *Banuaguda* village of *Boipariguda* block under Koraput district of Odisha. Three acres of land in each land categories medium land and lowland selected through participatory methods for the demonstration. Orissa University of Agriculture and Technology (OUAT) released high yielding variety *Jyotirmayee* (103 days) was selected only for medium land and *Hiranmayee* (135 days) was selected both for medium and low land demonstration (Table-3).

Table-3. Characteristics of the varieties used in the trials:

Characteristics	**Var: *Jyotirmayee***	**Var: *Hiranmayee***
Days to maturity	103	135
Grain type	Medium slender	Medium slender
Average yield/ha	4.4 ton/ha	5.5 ton/ha
Potential yield/ha	8.1 ton/ha	12.5 ton/ha

(Source: Odisha University of Agriculture & Technology, Bhubaneswar and Central rice Research Institute, Cuttack)

The demonstration was under taken in *Kharif*season of 2013 and modified method of cultivation practices recommended by Orissa University for Agriculture & Technology (OUAT) has been followed. For each category 0.5 acres of land was selected purposively for the experiment (USG application) as well as control (traditional urea application method).

- ***Trial 1: Control – Traditional methods***

  The application of in-organic fertilizer (FYM) as per recommended 60:30:30 (N: P: K) kg/ha in split doses basal, tillering and booting stages in both medium land and low land. In basal dose in medium and low land 50% nitrogen, 100% phosphorus and 50% potash applied. 25% nitrogen only applied during tillering stage and rest 25% nitrogen along with 50% potash applied in booting stage.

- ***Trial – 2 : Experimental USG***

  In this trial Urea Super Granules (USG) was applied after 30 days of sowing @60% of the recommended dose in case of direct seeded rice (DSR) and 10 days after transplanting (DAT) in case of transplanted rice (TSR). All other practice like application of 100%

Single Super Phosphate (SSP) and 50% Muriate of Potash (MoP) in basal and rest 50% MoP at booting were applied. The USG were applied by using the applicator[8].

6.4 Results and discussion

6.4.1 Agronomic characteristics

Basic agronomic data on plant height, no. of tillers/plants, and no. of panicles/plants were collected in different stages (Table-4). The yield comparison were also studied in all two land categories and two varieties.

Table-4. Agronomic data

Land type:		Medium Land		Medium Land		Low land	
Varieties		Jyotirmayee		Hiranmayee		Hiranmayee	
Details of the Experiments		DSR	DSR	TSR	TSR	TSR	TSR
Plot type		Exp	Control	Exp	Control	Exp	Control
Sl.	**Particulars**						
1	Plant height (cm)	99.4	91.3	131	118	132	107
2	Number of tillers (n)	20	14	13	7	10	6
3	Number of panicles (n)	18	13	12	7	9	6
4	Length of panicle (cm)	23.1	19.5	25.6	25.5	25.2	23.6
5	Grains per panicle (n)	144	102	238	197	201	166
6	Chaffs per panicle (n)	26	25	33	37	24	40
7	Grain weight /plant (gm)	37.5	20.5	40.4	20	25.7	11
8	Straw weight /plant (gm)	50.6	42.3	80.6	42	68	23
9	Grain length(mm)	0.52	0.52	0.6	0.6	0.6	0.6
10	Grain width (mm)	0.27	0.25	0.3	0.3	0.3	0.3
11	Grain weight (2m x 2m)kg	2.8	2.2	3.04	2.7	3.1	2.7
12	Straw weight (2m x 2m) kg	3.1	2.4	4.1	2.9	4.5	3.5
13	Estimated Grain yield/ha (qtl)	70	55	76	67.5	77.5	67.5
14	Estimated Straw yield / ha (qtl)	77.5	60	102.5	72.5	112.5	87.5
15	1000 grain weight (gm)	29.5	26.5	18.9	18.4	22.6	21.4

Exp: Experimental plots

(Source: Field experiments, kharif, 2013)

From the experiment it was found that growth of rice plant was greatly influenced by different methods of application of urea fertilizer. In this experiment plant height was significantly affected by USG application. Tiller number per plant was significantly influencedby different urea treatments. Deep placement of USG showed highest number of tillers might be due to lesser loss of nitrogen from the soil and slow releasing process. Application of USG significantly influenced the yield components. The impact of USG is clearly visible in all stages as it increases

[8] USG applicator is a simple equipment through which urea is deep placed (5-7 cm) in the soil.

the plant height, no. of tillers and panicle /hill as well as grain yield and straw yield. In case of *Jyotirmayee* the grain yield in USG application has been increased by 28% and straw yield is also increased by 29%. There is not much difference in direct seeded and transplanted *Hiranmayee*. In case of *Hiranmayee* direct seeded experiment (application of USG), both the grain yield and straw yield has been increased by 14%. The grain yield and straw yield has been increased by 16% and 28% respectively by application of USG in *Hiranmayee* transplanted rice. It showed that application of USG produced more yield components compared to normal urea

6.4.2 Benefit-Cost analysis

To understand the efficiency of USG as compared to the normal method of application, benefit-cost analyses were also undertaken by recording the cost incurred at various stages of cultivation (Table-5).

Table-5. Benefit-Cost analysis

Sl. #	Variety	Type of land	Method of cultivation	Expenditure (INR / ha)	Income (INR / ha)	Net profit (INR / ha)
1	*Jyotirmayee*	Medium land	DSR : Control plot	35590	55960	20370
2	*Jyotirmayee*	Medium land	DSR: Experimental plot	34580	71020	36440
3	*Hiranmayee*	Medium land	TSR: Control plot	43344	68200	24856
4	*Hiranmayee*	Medium land	TSR: Experimental plot	41802	78777	36975
5	*Hiranmayee*	Low land	TSR: Control plot	42680	68750	26070
6	*Hiranmayee*	Low land	TSR: Experimental plot	40174	80180	40006

Note: 1. DSR: Direct Seeded Rice; TSR: Transplanted Rice
2. The opportunity cost of the land and the imputed cost of labour were considered
(Source: Field experiment, *kharif*, 2013)

From the table above it can be observed that the cost of cultivation has been reduced by 3% in case of *Jyotirmayee*; 4% and 6% in case of *Hiranmayee* (DSR) and *Hiranmayee* (TSR) respectively by applying USG. On the other hand, income has been increased by 27% in case of *Jyotirmayee* and 16% and 17% respectively in *Hiranmayee* (DSR) and *Hiranmaye*e (TSR) by using USG. In effect, the UDP technology is showing a net profit enhancement by 78% in case of *Jyotirmayee*. In case of *Hiranmayee* (DSR) and TSR it is 49% and 53% respectively.

7. OBSERVATION OF FIELD DAY

The entire experiment was done by using Farmers Field School (FFS) methods and the local farmers were exposed to various stages of the plant growth. A grand field day was also observed during the tillering stage of the crop which was attended by the farmers from the local and far flung villages. The grain and tillering density of the crop with USG were appreciated by the farming community keeping in view the demand in the local markets. The general views of the farming communities were highly encouraging on the UDP technology and the demands for USG for the next *kharif* season were visible. The following suggestions were emerged during the discussion:

- Although farmers of the area showed their interest to use USG in their crop field but availability of USG in the local market is a constraint. Therefore it has been suggested by the farmers group to install an USG making unit in one of the intervention village for easily available of the same.
- The demonstration is restricted in one village. Therefore it should be expand in more villages for the awareness of the farmers.
- Some farmers were curious to know whether USG could be applying in vegetable crop or not? If it can be applied which is the appropriate period for applying this?
- How IFDC can help to the farmers to establish an USG processing unit?
- Improving nutrition through household kitchen garden is one of the major components of the project. Details package of practices on vegetable cultivation by using USG for which technical guidance from IFDC is strongly required.

8. LESSONS LEARNT

- Good agronomic practices are helpful in enhancing productivity of rice which includes appropriate land preparation for direct sowing through drum seeder, line transplanting of seedlings, nitrogen application method.
- Generation of demandof USG for large scale cultivation in next *Kharif*
- Though the rice variety *Hiranyamayee* shown higher yield potential but the seed blast disease in late stage may pose challenge for quality seed production.

9. WAY FORWARD

After successful application of USG in the farmers field in the Koraput district of Odisha, MSSRF is now organized 2 more experimental plots in Tamil Nadu and Pondicherry 9differnt agro-climatic zone). The results of these experiments may lead to a better understanding on the efficacy of the UDP trials.

Keeping in view the demand of the USG for the next *kharif* season (2014), MSSRF may request the IFDC Bangladesh to supply 2 USG manufacturing machines to be installed in Koraput and Chennai.

Reflections from the field is documented in ANNEXURE