Fertilizer Sector Improvement (FSI+)

2016 Wet Season Trials

Trials with the Urea Deep Placement Technique on Transplanted Rice, Broadcast Rice, and Rice-Gram System in Myanmar

September 2017

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Acronyms and Abbreviations

AE	Agronomic Efficiency
ANOVA	Analysis of Variance
BR	Broadcast Rice
Ca	Calcium
cm	centimeter
FP	Farmer's Practice
FSI	Fertilizer Sector Improvement
ft	foot
g	gram
ha	hectare
HYV	High-Yielding Variety
IFDC	International Fertilizer Development Center
in	inch
K	Potassium
kg	kilogram
lb	pound
LSD	Least Significant Difference
m	meter
MOP	Muriate of Potash
N	Nitrogen
P	Phosphorus
PU	Prilled Urea
RCB	Randomized Complete Block
S	Sulfur
t	ton
TSP	Triple Superphosphate
TPR	Transplanted Rice
UB	Urea Broadcast
UDP	Urea Deep Placement
USAID	United States Agency for International Development

Conversions

To Convert	To	Multiply by
acre	hectare	0.4047
hectare	acre	2.471
U.S. ton/acre	t/ha	2.24
lb/acre	kg/ha	1.12
kg/ha	lb/acre	0.89
K_2O	K	0.83
K	K_2O	1.2047
P_2O_5	P	0.4364
P	P_2O_5	2.2915

Trials with the Urea Deep Placement Technique on Transplanted Rice, Broadcast Rice, and Rice-Gram System in 2016 Wet Season, Myanmar

Introduction

Urea deep placement (UDP) is a proven technology that can increase the yield of transplanted lowland rice by 15-20% with less use of urea (up to 40%) compared to broadcast application of urea. This has been proven in Bangladesh and in sub-Saharan African countries.

A number of UDP trials, with transplanted rice (TPR), have been conducted at selected locations in Yangon, Bago, and Ayeyarwady regions in Myanmar, from the 2014 wet season to the 2016 dry season by the International Fertilizer Development Center (IFDC) through the Fertilizer Sector Improvement (FSI) project, funded by the United States Agency for International Development (USAID).

In the **2014 wet season**, UDP technology, using the same or a lesser rate of nitrogen (N), showed superiority over urea broadcasting (UB) at rates recommended by the Department of Agriculture and at rates used by local farmers (farmer's practice, FP). Average yield increased by 11.57%, ranging from 3.06% to 24.92%.

In the **2015 dry season**, UDP adaptation trials were run again, and it was found that the UDP treatment out-yielded the FP treatment and the UB treatment by up to 29.55% and 36.73%, respectively. The average yield superiority of the UDP treatment across all locations over the second highest yield of FP was 11.10%, which was nearly the same as the average increase during the 2014 wet season. Nitrogen rate trials carried out at two locations showed significant response to N rates and the type of application (UDP and broadcast). Broadcast prilled urea (PU) produced a significantly higher yield of up to 104 kilograms (kg) N per hectare (ha). For UDP, the yield differences were significant at up to 78 kg N/ha.

In the **2015 wet season**, UDP adaptation trials continued in new locations. The yield increments from UDP varied from 3.36% to 18.95%. On average over all locations, UDP resulted in a yield increase of 7.37% over UB and 14.70% over FP. UDP technology was also evaluated on broadcast rice (BR) since farmers practiced the broadcast seeding method more than the transplanting method for rice cultivation in this season. Other trials relating to N rate, potassium (K) rate, time of application, plant spacing, and fertilizer management on the rice-gram system were also conducted. The results showed the possibilities for applying UDP technology on BR. With a very early variety (75 days to maturity), UDP applied just before seed broadcasting gave a higher yield than FP urea application and UDP application 26 days after seed broadcasting. The trial has to be repeated using a popular early maturing high-yielding variety (HYV) rather than using a very early variety, which is not popular. Significant yield results between treatments were observed in an N x K trial and a plant spacing x UDP rate trial. Confirmation of those results is still needed with additional trials. No significant result was observed with fertilizer management trials on the rice-gram cropping system. This is designed as a long-term trial and is still in its infancy.

In the **2016 dry season**, all trials of the 2015 wet season were repeated. UDP adaptation trials at four locations consistently showed the highest yield with UDP. UDP yield was significantly higher than other treatments at three locations. UDP produced 24.7% and 25.3% over UB and FP treatment, and agronomic efficiency was double. The N rate trial showed no differences but the highest yield was not produced by the highest N rate. An N rate of 155 kg/ha gave the highest yield. The trial needs repeating to confirm results. The UDP application method trial showed different results at two locations. UDP application just before seed broadcasting was better than UDP application 24 days after sowing at one location, which was not significant. At another location, UDP after sowing gave significantly higher yield than UDP before sowing. The trial was tested with an early maturing summer variety and needs to be tested in the wet season using a popular wet season variety with medium growth duration. Other trials such as UDP spacing, N x K rates, plant spacing x N rate, and different seed rate trials were inclusive and showed the need for further tests. Within the long-term fertilizer trial on the rice-gram system, this was the first test on the second crop, gram, and the results showed no differences. The long-term trial will be continued with higher fertilizer rates (P and K) on the same fields at the same locations in coming seasons.

In this 2016 wet season, two UDP adaptation trials were conducted at new locations. Other trials of the 2016 dry season were repeated. The long-term trials on the rice-gram system as a second season of the rice crop were continued. Another long-term trial on the rice-gram system with starter nitrogen on the gram crop was initiated. UDP evaluation under submerged condition trials were also initiated at selected sites in submerge-prone areas. All trials are conducted in the three project regions, i.e., Yangon, Bago, and Ayeyarwady. The trials established are listed below.

Trials Tested in 2016 Wet Season

There were ten types of trials in the 2016 wet season with eight trials from previous seasons being repeated for confirmation and two new trials starting from this year/season. With the site replications of some trials, 21 trials were planned overall.

Trial No.	Trial Names	Number of Trials
1.	UDP adaptation trials on TPR	2
2.	Different N-rate trial using UDP on TPR	1
3.	UDP before seed broadcasting trial on BR	2
4.	UDP spacing trial on BR	2
5.	Different seed rate trial on BR using UDP	2
6.	Nitrogen x potassium trial on TPR	2
7.	Plant spacing x nitrogen trial on TPR	2
8.	Fertilizer management trial on rice-gram system	3
9.	Fertilizer management trial on rice-gram system with starter N	1
10.	UDP evaluation on submergence rice trial	4
	TOTAL	**21**

Materials and Methods

Site Selection

During the 2016 wet season, most of the trial sites and farmers were newly selected, with the following exceptions: the Research Farm in Myaungmya where the N-rate trial with higher rates was repeated; the long-term fertilizer management trials on the rice-gram system, which continued at their same locations; and the UDP spacing trial and UDP before sowing trial in Taikkyi, where trials were conducted with the same farmer. Another rice-gram system location was selected to test the long-term trial with starter N applied on a gram crop. UDP evaluation under submergence conditions will be tested at selected submergence-prone areas. The coordinates of the selected sites with the number of trials are given in Table 1. Soil samples taken from each location were dried and stored for later testing to identify initial soil conditions.

Table 1. Locations and Coordinates of Field Trials, Wet Season 2016

Region	Township	Village	Latitude	Longitude	Elevation	Trial No.
Yangon	Kawhmu	Magyi Kan	16° 34.263' N	96° 03.417' E	23 ft	1
		Magyi Kan	16° 34.350' N	96° 03.342' E	32 ft	4
		Tar Lan Thit	16° 33.040' N	96° 04.521' E	25 ft	10
	Hlegu	Sar Bu Daung	17° 13.071' N	96° 13.030' E	79 ft	5
	Thanlyin	Nyaungthonebin*	16° 45.627' N	96° 17.157' E	8 ft	3
	Thonegwa	Anauk Ywa	16° 45.617' N	96° 30.534' E	27 ft	9
	Hmawbi	Ahtayon*	17° 04.425' N	96° 08.917' E	37 ft	10
	Taikkyi	Yindaikkwin	17° 20.359' N	95° 55.240' E	46 ft	3
		Yindaikkwin	17° 20.359' N	95° 55.240' E	46 ft	4
	Kyauktan	Ashae Bine	16° 38.765' N	96° 20.645' E	44 ft	8
Bago	Letpadan	The Wat Chaung	17° 50.084' N	96° 45.408' E	77 ft	7
		Gway Dauk Kwin	17° 49.369' N	95° 45.558' E	78 ft	6
	Kyauktaga	Than Payar Kon	18° 12.344' N	95° 26.759' E	204 ft	1
			18° 11.931' N	95° 26.791' E	185 ft	5
Ayeyarwady	Einme	Thar Kwin	16° 44.336' N	95° 05.527' E	36 ft	8
		Parami Daunt	16° 26.958' N	95° 41.917' E	23 ft	8
	Maubin	Wayon Gayet	16° 43.268' N	95° 29.073' E	33 ft	6
	Pantanaw	Bawine	17° 01.335' N	95° 30.498' E	8 ft	7
	Myaungmya	Research Farm	16° 36.756' N	94° 54.943' E	24 ft	2
		Kyar Phoo Ngon	16° 38.198' N	94° 57.258' E	26 ft	10
	Kangyidaunt	Anauk Sugyi*	16° 49.372' N	94° 51.472' E	19 ft	10

* Trials failed due to poor germination.

Trial Failures

Three trials failed in the 2016 wet season. The UDP before seed broadcasting trial at Nyaung Thone Bin, Thanlyin, was sown twice due to poor and uneven germination of the first sowing. However, even the second sowing did not give good germination. Poor and uneven germination was mainly due to heavy rain just after seed broadcasting due to poor land leveling. The trials evaluating UDP under submerged condition at Ahtayon, Hmawbi, and Anauk Sugyi, Kangyidaunt. At Ahtayon, both failed. At Ahtayon, seedlings were flooded in the nursery and died. At Anauk Sugyi, seedlings were also flooded, and the trial failed just after transplanting due to prolonged flooding. All three trials were abandoned.

Varieties and Farmers

Varieties and farmers for all locations are given in Table 2.

Table 2. Varieties, Trial Types, and Collaborating Farmers for the 2016 Wet Season Trials

Township	Village	Farmer	Variety		Trial No.
Kawhmu	Magyi Kan	U Zaw Htay	Sin Thu Kha	HYV	1
	Magyi Kan	U Zaw Htay	Sin Thu Kha	HYV	4
	Tar Lan Thit	U Ngwe Thein	2 varieties	HYV + Swarna	10
Hlegu	Sar Bu Daung	U Kyaw	Sin Thu Kha	HYV	5
Thanlyin	Nyaungthonebin*	Daw Zin Mar Kyaw	2 varieties	HYVs	3
Thonegwa	Anauk Ywa	U Zaw Wate	Yar Kyaw	HYV	10
Hmawbi	Ahtayon*	U Mya Han	2 varieties	HYV + Swarna	10
Taikkyi	Yindaikkwin	U Zaw Min Htwe	2 varieties	HYVs	3
	Yindaikkwin	U Zaw Min Htwe	Sin Thu Kha	HYV	4
Kyauktan	Ashae Bine	U Aung Myo	Sin Thu Kha	HYV	8
Letpadan	The Wat Chaung	U Thein Hlaing	Sin Thu Kha	HYV	7
	Gway Dauk Kwin	U Tin Win	Sin Thu Kha	HYV	6
Kyauktaga	Than Payar Kon	Daw Khin Aye	Sin Thu Kha	HYV	1
		U Sein Win	Sin Thu Kha	HYV	5
Einme	Thar Kwin	U Aung Htay Win	Sin Thu Kha	HYV	8
	Parami Daunt	U Thet Naing Soe	Sin Thu Kha	HYV	8
Maubin	Wayon Gayet	U Tin Maung	Thee Dat Yin	HYV	6
Pantanaw	Bawine	U Sein Win	Sin Thu Kha	HYV	7
Myaungmya	Research Farm	U Htain Lin Tun	Sin Thu Kha	HYV	2
	Kyar Phoo Ngon	U Kyi Win	2 varieties	HYV + Swarna	10
Kangyidaunt	Anauk Sugyi*	U Nay Soe	2 varieties	HYV + Swarna	10

*Trials failed.

Experimental Design

A Randomized Complete Block (RCB) design with four to six treatments and three replications was used in most of the trials. A split plot and split block design were used for the nitrogen x potassium trial and the UDP before seed broadcasting trial (Table 3). A detailed plan for each trial is available in a separate document on protocols.

Basal Fertilizers

In all the trials, a basal fertilizer of triple superphosphate (TSP), muriate of potash (MOP), and gypsum was used as the source of phosphorus (P), potassium (K), and sulfur (S). However, other sources, such as compound fertilizer, were used on the farmer's practice treatment. In calculating the rates, it was assumed:

TSP = 45% P_2O_5 or 20% P

MOP = 60% K_2O or 50% K

Gypsum = 18% S and 23% Ca

Table 3. Experimental Designs Used for 2016 Wet Season Trials

No.	Trial Name	Treats x Reps	Design
1	UDP adaptation trial on TPR	4 x 3	RCB
2	Different N-rate trial using UDP on TPR	6 x 3	RCB
3	UDP before seed broadcasting trial on BR	2 x 3 x 3	Split plot
4	UDP spacing trial on BR	5 x 3	RCB
5	Different seed rate trial on BR using UDP	6 x 3	RCB
6	Nitrogen x potassium trial on TPR	6 x 3	RCB
7	Plant spacing x nitrogen trial on TPR	2 x 3 x 3	Split plot
8	Fertilizer management trial on rice-gram cropping system	4 x 3	RCB
9	Fertilizer management trial on rice-gram with starter N		RCB
10	UDP evaluation on submergence rice trial	4 x 3	RCB

Treatments

UDP Adaptation Trials on Transplanted Rice

There were four treatments, as in previous seasons. Rice was transplanted with a 20 x 20 cm spacing.

Treatment 1 = Zero N.

Treatment 2 = Farmer's Practice (FP) – urea broadcast with two or three splits.

Treatment 3 = Urea Broadcast (UB) (51.8 kg N/ha) – urea with three splits.

Treatment 4 = Urea deep placement[1] (UDP) (51.8 kg N/ha).

After discussion with farmers at each location, there were two different doses of urea application in FP, depending on location. At Thanpayar Kon, Kyauktaga, the dose was 25 kg urea per acre (28.4 kg N/ha) with two split applications. The first application was seven days after transplanting, and the second application was 43 days after transplanting. At Magyi Kan, Kawhmu, the dose was 50 kg urea per acre (56.8 kg N/ha) with three splits. The first application was seven days after transplanting, the second application was 35-40 days after transplanting, and the third application was just before flowering.

[1] 1.8-gram briquette size.

As basal fertilizer application on a FP treatment, a compound fertilizer with a nutrient ratio of (15:15:15 – $N:P_2O_5:K_2O$) was applied at 25 kg/acre at Thanpayar Kon, Kyauktaga. No basal fertilizer was applied on the FP treatment at Magyi Kan, Kawhmu.

UDP was applied only one time seven days after transplanting. The first broadcast urea application of UB treatment and FP treatment was also applied seven days after transplanting. The second application of broadcast urea was applied 40 days after transplanting, and the third application of urea was applied at flowering time for both UB and FP treatment (at Magyi Kan). Sowing dates, transplanting dates, UDP dates, and harvesting dates are given in Table 5.

N-Rate Trials on Transplanted Rice

This trial was repeated with the same six treatments (control and five different nitrogen rates), with three replications, as in the 2015 wet season and the 2016 dry season. Treatments are as follows:

1. Zero N (control)
2. UDP with 2.7 grams (g) x 1 briquette (Urea 66 kg/acre)
3. UDP with 1.8 g x 2 briquettes (Urea 88 kg/acre)
4. UDP with (1.8 + 2.7) g x 1 briquette (Urea 110 kg/acre)
5. UDP with 1.8 g x 3 briquettes (Urea 132 kg/acre)
6. UDP with (1.8 g x 2) + (2.7 g x 1) (Urea 154 kg/acre)

TSP at 50 kg/acre (56 kg P_2O_5/ha or 25 kg P/ha), MOP at 25 kg/acre (37 kg K_2O/ha or 30 kg K/ha), and gypsum at 10 kg/acre (4.5 kg S/ha) were applied as basal fertilizer at plot layout time, just before transplanting.

UDP Before Broadcasting Seed

In this season, two popular varieties were tested with three fertilizer treatments. The two varieties have different growth durations. They are:

1. Thee Day Yin – short duration.
2. Sin Thu Kha – medium duration.

The three fertilizer treatments included:

1. UDP just before sowing (44 kg urea/acre = 51.8 kg N/ha).
2. UDP at 20-25 days after sowing (44 kg urea/acre = 51.8 kg N/ha).
3. Control (Zero N).

TSP at 50 kg/acre (56 kg P_2O_5/ha or 25 kg P/ha), MOP at 25 kg/acre (37 kg K_2O/ha or 30 kg K/ha), and gypsum at 10 kg/acre (4.5 kg S/ha) were applied as basal fertilizer for all treatments just before seed broadcasting.

A briquette size of 1.8 g was applied one time at a spacing of 16 x 16 inches on UDP plots. UDP was applied just before seed broadcasting for Treatment 1 (UDP before sowing) and 20-25 days after sowing for Treatment 2 (UDP after sowing).

UDP Spacing Trial on BR

UDP application at 16 x 16 inch spacing seemed wider on broadcast rice since yellow lines are left between UDP rows. Therefore, this trial was tested with closer UDP spacing than 16 x 16 inches. There were five treatments in this trial. Four spacings of UDP application were compared with the control treatment (0 N).

1. Control (0 N).
2. UDP with 16 x 14 inch spacing (75.6 kg urea/acre or 85.9 kg N/ha).
3. UDP with 16 x 12 inch spacing (88.2 kg urea/acre or 100.3 kg N/ha).
4. UDP with 14 x 14 inch spacing (86.4 kg urea/acre or 98.2 kg N/ha).
5. UDP with 14 x 12 inch spacing (100.8 kg urea/acre or 114.6 kg N/ha).

TSP at 50 kg/acre (56 kg P_2O_5/ha or 25 kg P/ha), MOP at 25 kg/acre (37 kg K_2O/ha or 30 kg K/ha), and gypsum at 10 kg/acre (4.5 kg S/ha) were applied as basal fertilizer for all treatments just before seed broadcasting. UDP was applied one time only 20-25 days after sowing by placing one 1.8-g urea briquette 3-4 inches deep in the soil.

Different Seed Rates on BR Using UDP

This is the second time to repeat the seed rate trial on broadcast rice. This time there was one additional treatment with 0 N applied. A medium seed rate was used with 0 N. The treatments are:

1. 30 kg dry seed per acre (nearly 1.5 baskets) + 0 N.
2. 20 kg dry seed per acre (nearly 1 basket) + UDP.
3. 25 kg dry seed per acre (nearly 1.25 baskets) + UDP.
4. 30 kg dry seed per acre (nearly 1.5 baskets) + UDP.
5. 35 kg dry seed per acre (nearly 1.75 baskets) + UDP.
6. 40 kg dry seed per acre (nearly 2 baskets) + UDP.

TSP at 50 kg/acre (56 kg P_2O_5/ha or 25 kg P/ha), MOP at 25 kg/acre (37 kg K_2O/ha or 30 kg K/ha), and gypsum at 10 kg/acre (4.5 kg S/ha) were applied as basal fertilizer at plot layout time, just before transplanting.

The nitrogen was applied as UDP one time only, 20-25 days after seed broadcasting by placing 1.8-g briquettes at a depth of 3-4 in and 14 in x 12 in spacing. The nitrogen rate was therefore 76.4 kg/ha.

Nitrogen x Potassium on TPR

This trial was an RCB experiment in rice transplanted with 20 x 20 cm spacing. Unlike last year's trial, there were six treatments, including 0 N with higher K and 0 K with higher N. Treatments are as follows:

1. N0 K2 (0 N + 74 kg K_2O/ha).
2. N1 K1 (51.8 kg N/ha + 37 kg K_2O/ha).
3. N1 K2 (51.8 kg N/ha + 74 kg K_2O/ha).
4. N2 K0 (75.2 kg N/ha + 0 kg).
5. N2 K1 (75.2 kg N/ha + 37 kg K_2O/ha).
6. N2 K2 (75.2 kg N/ha + 74 kg K_2O/ha).

TSP at 50 kg/acre (56 kg P_2O_5/ha or 25 kg P/ha) and gypsum at 10 kg/acre (4.5 kg S/ha) were applied on all plots as basal fertilizer at plot layout time, just before transplanting.

Plant Spacing x Nitrogen Trials on TPR

This trial was a split block design with two factors. The main factor was plant spacing and the sub-factor was fertilizer rates, including 0 N treatment.

Main Plot – Spacing (S)

1. 20 cm x 20 cm spacing
2. 20 cm x 15 cm spacing

Sub-Plot – UDP (3 doses)

1. Zero N (Control)
2. Using 1.8-g briquette
3. Using 2.7-g briquette

The urea rates were 44.1 kg/acre (51.8 kg N/ha) with 20 x 20 cm spacing and 58.8 kg/acre (69 kg N/ha) with 20 x 15 cm spacing using a 1.8-g urea briquette. By using a 2.7-g urea briquette, the rates were 66.2 kg/acre (77.6 kg N/ha) with 20 x 20 cm spacing and 88.2 kg/acre (103.5 kg N/ha) with 20 x 15 cm spacing.

TSP at 50 kg/acre (56 kg P_2O_5/ha or 25 kg P/ha), MOP at 25 kg/acre (37 kg K_2O/ha or 30 kg K/ha), and gypsum at 10 kg/acre (4.5 kg S/ha) were applied as basal fertilizer at plot layout time, just before transplanting.

Fertilizer Management in the Rice-Gram System

This trial is a long-term trial that extends across the rice crop and the gram crop at the same location. It is a 4 x 3 RCB design with four treatments. According to results from the previous year, which showed no carryover effect of fertilizer applied to the first crop on the subsequent crop, the trial was tested with fertilizer rates 1.5 times higher than before. Treatments were as follows:

	Treatments on Rice	Treatments on Gram
1.	P_2O_5 60 kg/ha + K_2O 60 kg/ha	P_2O_5 0 kg/ha + K_2O 0 kg/ha
2.	P_2O_5 30 kg/ha + K_2O 30 kg/ha	P_2O_5 30 kg/ha + K_2O 30 kg/ha
3.	P_2O_5 0 kg/ha + K_2O 0 kg/ha	P_2O_5 60 kg/ha + K_2O 60 kg/ha (no residue)
4.	P_2O_5 0 kg/ha + K_2O 0 kg/ha	P_2O_5 60 kg/ha + K_2O 60 kg/ha (+ crop residue)

In this season, the trials were tested with rice crops. Nitrogen was applied to all plots as UDP. The briquette size used in the trial was 1.8 g, and the N rate was therefore 51.8 kg/ha.

Fertilizer Management in the Rice-Gram System With Starter N

This trial is a new long-term trial for the rice-gram system, starting with rice in this season. This trial is different from the trial above. Both UDP and prilled urea were applied as N fertilizer with the full amount of P and K, and 0 P and 0 K. There were two additional treatments. Starter N as prilled urea for the gram crop was applied in addition to UDP and prilled urea in the rice crop with full P and K rates. So there were a total of six treatments. An RCBD was used with three replications. Treatments were as follows:

	Treatments on Rice (per hectare)	Treatments on Gram (per hectare)
1.	UDP 51.8 kg N + 60 kg P_2O_5 + 60 kg K_2O	0 kg N + 0 kg P_2O_5 + 0 kg K_2O
2.	UDP 51.8 kg N + 0 kg P_2O_5 + 0 kg K_2O	0 kg N + 60 kg P_2O_5 + 60 kg K_2O
3.	PU 51.8 kg N + 60 kg P_2O_5 + 60 kg K_2O	0 kg N + 0 kg P_2O_5 + 0 kg K_2O
4.	PU 51.8 kg N + 0 kg P_2O_5 + 0 kg K_2O	0 kg N + 60 kg P_2O_5 + 60 kg K_2O
5.	UDP 51.8 kg N + 60 kg P_2O_5 + 60 kg K_2O	**PU 14 kg N** + 0 kg P_2O_5 + 0 kg K_2O
6.	PU 51.8 kg N + 60 kg P_2O_5 + 60 kg K_2O	**PU 14 kg N** + 0 kg P_2O_5 + 0 kg K_2O

UDP Evaluation Under Submerged Condition Trial

This trial was implemented as part of the "Soil Fertility Technology (SFT) Adoption, Policy Reform and Knowledge Management Project." Two fertilizer practices, namely farmer's practice (F1) and UDP (F2), were applied on two varieties, namely local popular variety (V1) and submergence-tolerant variety (V2). Varieties were sown in blocks and fertilizer treatments were put randomly on each variety block. The experimental design was split block design with two factors. Treatments were therefore:

1. F1 V1 (Farmer's practice on popular variety).
2. F1 V2 (Farmer's practice on submergence-tolerant variety).
3. F2 V1 (UDP on popular variety).
4. F2 V2 (UDP on submergence-tolerant variety).

Sin Thu Kha was used as the popular variety and Swarna sub1 was the submergence-tolerant variety.

Plot Size and Spacing

There are variations in plot size between trials according to the type of trial and the kind of treatments. Many trials were conducted with a plot size of 16 ft x 16 ft. Plot sizes used in each trial are given Table 4. A detailed plan can be seen in separate documents on protocols.

Table 4. Plot Size and Spacing Used for Specific Trials, 2016 Wet Season

No.	Trial Name	Plot Size	TPR Spacing
1	UDP adaptation trial on TPR	28 x 24 ft	8 x 8 in
2	Different N-rate trial using UDP on TPR	16 x 16 ft	8 x 8 in
3	UDP before seed broadcasting trial on BR	16 x 16 ft	Broadcast
4	UDP spacing trial on BR	28 x 28 ft	Broadcast
5	Different seed rate trial on BR using UDP	21 x 18 ft	Broadcast
6	Nitrogen x potassium trial on TPR	16 x 16 ft	8 x 8 in
7	Plant spacing x nitrogen trial on TPR	20 x 16 ft	2 spacings tested
8	Fertilizer management trial on rice-gram cropping system	16 x 16 ft	8 x 8 in
9	Fertilizer management trial on rice-gram with starter N	16 x 16 ft	Broadcast
10	UDP evaluation on submergence rice trial	20 x 13.2 ft	8 x 8 in

Trial descriptions about varieties used, sowing dates, UDP dates, topdressing dates, and harvest dates can be seen in Table 5.

Table 5. Locations, Varieties, and Dates of All Trials, 2016 Wet Season

No.	Region/ Township	Village	Variety	Date of:						
				Sowing	Layout	Transplant	UDP	Topdress 1	Topdress 2	Harvest
	Yangon									
1	Kawhmu	Magyi Kan	Sin Thu Kha	17-Jun	2-Aug	2-Aug	9-Aug	12-Sep	2-Oct	17-Nov
2		Magyi Kan	Sin Thu Kha	29-Jul	29-Jul	-	23-Aug	-	-	1-Dec
3		Tar Lan Thit	Swarna sub1	5-Aug	14-Sep	14-Sep	26-Sep			2-Jan
4	Hlegu	Sar Bu Daung	Sin Thu Kha	24-Jun	24-Jun	-	15-Jul	-	-	26-Oct
5	Thonegwa	Anauk Ywa	Yar Kyaw	25-Jun	5-Jul	-	21-Jul	16-Sep	14-Oct	16-Nov
6	Taikkyi	Yin Daik Kwin	Sin Thu Kha	14-Jun	13-Jun	-	8-Jul	-	-	18-Oct
7		Yin Daik Kwin	STK & TDY	14-Jun	13-Jun	-	8-Jul	-	-	18-Oct
8	Kyauktan	Ah Shae Pine	Sin Thu Kha	12-Jun	7-Jul	7-Jul	14-Jul	-	-	31-Oct
	Bago									
9	Letpadan	The Wat Chaung	Sin Thu Kha	13-Jun	10-Jul	11-Jul	19-Jul	-	-	8-Nov
10		Gway Dauk Kwin	Sin Thu Kha	15-Jun	12-Jul	12-Jul	19-Jul	-	-	9-Nov
11	Kyauktaga	Thanpayar Kon	Sin Thu Kha	19-Jun	13-Jul	13-Jul	20-Jul	25-Aug	-	1-Nov
12		Thanpayar Kon	Sin Thu Kha	21-Jun	21-Jun	-	17-Jul	-	-	6-Nov
	Ayeyarwady									
13	Einme	Thar Kwin	Sin Thu Kha	25-Jun	21-Jul	22-Jul	27-Jul	-	-	19-Nov
14		Parami Daunt	Sin Thu Kha	25-Jun	21-Jul	22-Jul	27-Jul	-	-	18-Nov
15	Maubin	Wayon Gayet	Thee Dat Yin	3-Jul	24-Jul	27-Jul	3-Aug	-	-	20-Nov
16	Pantanaw	Bawine	Yadanartoe	26-Jun	24-Jul	24-Jul	1-Aug	-	-	3-Nov
17	Myaungmya	Research Farm	Sin Thu Kha	22-Jun	19-Jul	20-Jul	26-Jul	-	-	12-Nov
18		Kyar Phoo Ngon	Swarna sub1	29-Jun	28-Jul	28-Jul	4-Aug	-	-	10-Nov

Weeds and Water Problems

Weed problems were encountered with three trials. One trial was with direct-seeded rice testing different seed rates at Kyauktaga, and another was the plant spacing and UDP rate trial at The Wat Chaung. The other was the N x K trial at Gway Dauk Kwin, Letpadan. Weed problems were often observed in the two Letpadan trials.

Water, especially in low-lying and flooded areas, is the main problem in the wet season. For testing UDP in submerged conditions, locations with a history of flooding were selected. However, the flooding was excessive, and two trials had to be abandoned due to flooding at the nursery stage and just after transplanting at Hmawbi and Kangyidaunt, which caused seedling death. At harvest time, another submerged trial at Kawhmu could only harvest two replications. The other replication did not have enough plants to harvest.

Results and Discussion

UDP Adaptation Trials

Yield (t/ha)

The results (Table 6 and Figure 1) showed that the UDP treatment gave the highest yield at both locations, but only one trial (Kawhmu) showed a significant yield (tons per hectare, t/ha) difference at $P_{(0.05)}$. At Kawhmu, Table 6 shows UDP produced the highest yield with 4.03 t/ha, which was not statistically different from UB, which gave 3.54 t/ha but was statistically superior to FP and control. The UB treatment was not different from the FP treatment, which was third with 3.16 t/ha but statistically superior to the control. There was statistical differences at Kyauktaga, although UDP yield was the highest with 4.03 t/ha. Also at Kyauktaga, FP yielded higher than UB, although the difference was not significant. Zero-N plots gave the lowest yield at all locations.

The Kyauktaga trial gave better yields than at Kawhmu in all treatments. The FP treatment, which used less N fertilizer (28.4 kg N/ha) than the UB treatment, which used 51.8 kg N/ha, gave better yield, which seems to indicate that the Kyauktaga soil is supplying enough nitrogen. At Kawhmu, the FP treatment, with a N rate of 56.8 kg/ha, gave lower yield than UB with a N rate of 51.8 kg/ha. However, this treatment had no basal P, K, or S, and its use is likely limiting the yield.

Other Yield Component Traits

Yield component traits, such as the number of panicles per hill, number of grains per panicle, 1,000-grain weight, and all biomass weight showed no significant differences among treatments at both locations. However, UDP gave the highest values in most traits. The number of panicles per hill with UDP was the highest with 15.5 at Kawhmu and 14.2 at Kyauktaga. UDP gave the highest number of grains per panicle with 113 and 179 at Kawhmu and Kyauktaga, respectively. Biomass weights of both fresh straw and grain were the highest with UDP, but dry straw weight at Kawhmu was lower but not statistically lower (see Table 6 and refer to the Magyi Kan, Kawhmu and Thanpayar Kon, Kyauktaga data sheet in Appendix 1). Significance was observed on plant height at Kyauktaga. The plant height was tallest (115 cm) with UDP treatment, and it was significantly taller than other treatments. (Refer to the Thanpayar Kon, Kyauktaga data sheet in Appendix 1.)

Table 6. Records of Yield and Component Characteristics With Different Treatments at Test Locations

Location Treatment	Plant Height (cm)	No. of Panicles per Hill	No. of Grains per Panicle	1,000-Grain Weight (g)	Fresh Straw Weight (g)	Fresh Grain Weight (g)	Dry Straw Weight (g)	Dry Grain Weight (g)	Yield (t/ha)	LSD Comparison*
Magyi Kan, Kawhmu										
Control (0 N)	91	13.9	100	18.5	1,012	425	352	409	3.02	c
FP treatment	89	14.7	105	19.1	1,052	403	348	391	3.16	bc
UB treatment	92	15.3	111	19.4	912	459	407	452	3.54	ab
UDP treatment	94	15.5	113	18.9	1,305	477	327	463	4.03	a
Thanpayar Kon, Kyauktaga										
Control (0 N)	107	12.5	176	20.6	1,784	610	576	595	5.41	ns
FP treatment	105	12.4	178	19.8	1,816	604	530	589	5.85	ns
UB treatment	108	12.8	177	20.1	1,914	683	558	663	5.82	ns
UDP treatment	115	14.2	179	20.0	2,071	717	635	687	6.03	ns

* Treatments with the same letter are not statistically difference at $P_{(0.05)}$.

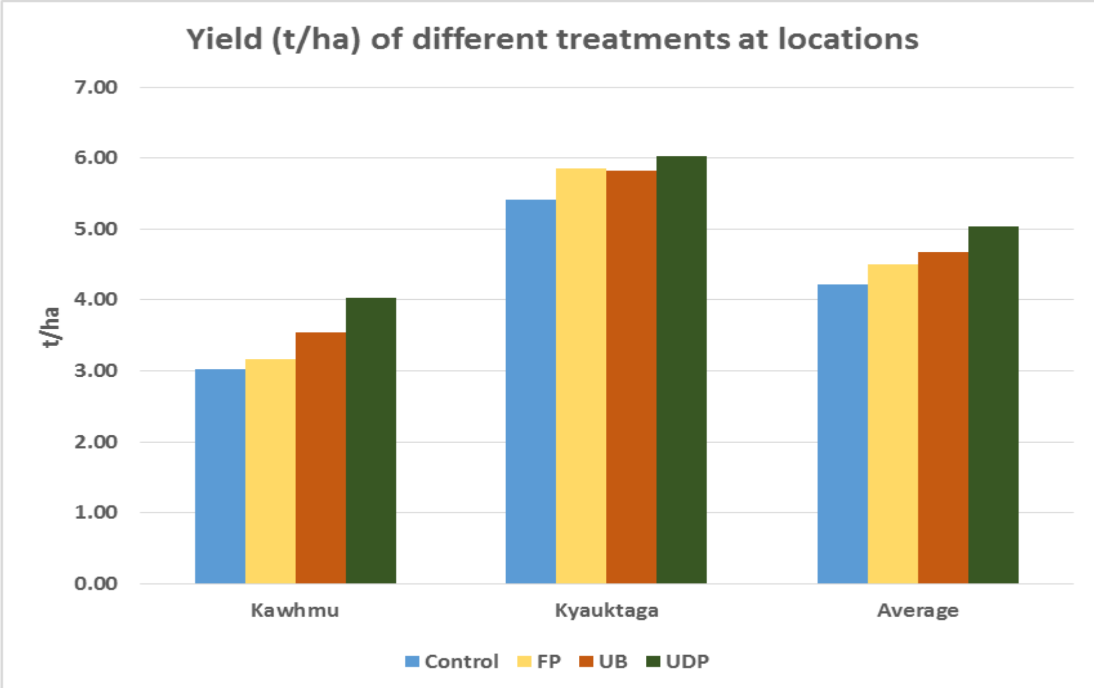

Figure 1. Paddy Yield Comparison of Different Treatments by Location

Agronomic Efficiency (AE) – Yield Grain per Kilogram N Applied

In the 2016 wet season, the AE value[2] was the highest with UDP at both locations, with 19.4 kg/kg N at Kawmhu and 11.9 kg/kg N at Kyauktaga. At Kawhmu, UB, which used the same N rate and basal fertilizer as UDP, had the second highest AE value with 10.0 kg/kg N. FP, with a little higher N rate than UB, and UDP, with no P or K, produced 2.4 kg of grain with each kilogram of N applied. It was concluded that P and K are limiting nutrients at Kawhmu (Table 7). At Kyauktaga, UDP and FP had nearly the same AE values with 11.9 and 11.6 kg/kg N, respectively. At Kyauktaga, all treatments yielded higher than Kawhmu, including the FP treatment, which had only two-thirds of the UDP rate. With the FP treatment, P and K were also applied as basal.

Yield Superiority[3] of UDP Over Other Treatments – % Over

UDP out-yielded other treatments at both locations. The percentage increase in yield of UDP over other treatments was higher at Kawhmu, where the yields of treatments were lower and different than at Kyauktaga. At Kawhmu, the UDP treatment gave a 13.8% yield increase over

[2] (Yield of fertilizer crop – Yield of control)/Amount of fertilizer applied
[3] (Yield of UDP – Yield of other treatment)/Yield of other treatment*%

the UB treatment, which applied the same N rate and basal P, K, and S. With the FP treatment, which used more N than UDP but no basal P, K, and S, the yield was 27.6% less than with UDP. Again, this indicates that P, K, or S (or all three) are the limiting nutrients in the soil at Kawhmu. At Kyauktaga, UDP did not give as much yield increment over other treatments since the yields of all treatments were high and not statistically different from each other. UDP could produce only 3.1% and 3.6% higher yields than FP and UB (Table 7).

Table 7. AE Values and Yield Superiority of UDP Over Other N Treatments at Test Locations

Treatment	Kawhmu			Kyauktaga		
	Yield (t/ha)	AE Value kg/kg N	UDP Yield % Over	Yield (t/ha)	AE Value kg/kg N	UDP Yield % Over
Control (0 N)	3.02	-	33.3	5.41	-	11.4
FP treatment	3.16	2.4	27.6	5.85	11.6	3.1
UB treatment	3.54	10.0	13.8	5.82	7.9	3.6
UDP treatment	4.03	19.4	-	6.03	11.9	-

N-Rate Trial at Myaungmya

In the 2016 wet season, the N-rate trial at Myaungmya showed no significant differences in yield or other characteristics. The variability among treatments was different in each rep. (Refer to the Research Farm, Myaungmya data sheet in Appendix 1.) Many parameters show inconsistent response to treatments with different N rates. The highest yield (3.89 t/ha) was observed with a N rate of 129.4 kg/ha. However, it was only slightly different from other treatments and not significant. The same response was observed with the number of panicles per hill and number of grains per panicle. Both showed the highest value with 129.4 kg N/ha. There were 12 panicles per hill and 170 grains of 209 spikelets per panicle. The highest N rate (181.1 kg/ha) did not give the highest yield. The N rate of 129.4 kg/ha was the third highest, or medium rate, among treatments.

Other characteristics had no consistent response to different N rates. Biomass straw weights were the highest with the second highest N rate (155.3 kg/ha), and biomass grain weights and 1,000-grain weights were the highest with the control. Crop lodging was observed on almost all N-applied plots at harvest. It was also noted at harvest time that grains of 0 N plots were heavier and cleaner than other treatments. Grain discoloration was observed more with high N rates. Lodging might be the main reason for inconsistent results among treatments.

The trial was conducted four times (two dry seasons and two wet seasons) on different plots at the same location, Myaungmya Research Station. During the first time, the trial applied low N rates, and the yield was still increasing with the highest N rate tested. Starting from the second time, the trial was tested with higher N rates. The results of the previous two trials showed that the highest yield occurred with the second highest N rate (155.3 kg/ha). The yield result of this season was different than the previous two seasons. The highest yield was produced by the third highest N rate (129.4 kg/ha). Lower yield with higher N rates may be due to disease (bacterial leaf streak) and/or the difficulty of water management and/or crop lodging. One of these factors (or a combination of them) may cause insignificant results in this season. However, it can be concluded that with balanced basal fertilizer, nitrogen fertilizer at a rate of 130-150 kg N/ha with UDP technology is required for maximum rice yield at Myaungmya.

UDP Before Seed Broadcasting Trials

The trial was conducted to determine possible alternatives for applying UDP technology on broadcast rice. The trial was planned to be conducted at two locations, Yindaikkwin, Taikkyi township and Nyaung Thone Bin, Thanlyin township in Yangon region. The Nyaung Thone Bin trial failed due to uneven and poor germination after two attempts.

It is a factorial experiment with two factors. Two popular varieties namely Sin Thu Kha with medium growth duration and Thee Dat Yin with early growth duration were tested. Three fertilizer treatments included in the trial were UDP application before seed broadcasting (Treatment 1), UDP application at 20-25 days after sowing (Treatment 2), and control with 0 N (Treatment 3). UDP was applied 24 days after sowing for Treatment 2.

According to the analysis of variance for factorial experiment, it was found that both factors were highly significant at $P_{(0.01)}$. But there was no significant interaction of variety by fertilizer application time. The Sin Thu Kha variety gave significantly higher yield than the Thee Dat Yin variety. The average yield of Sin Thu Kha was 3.77 t/ha while Thee Dat Yin gave 1.55 t/ha (Figure 2 and Table 8). Thee Dat Yin is a short growth duration high-yielding variety and normally known as dry season rice. It was harvested in the rain before Sin Thu Kha was mature.

Thee Dat Yin is therefore suited best for the dry season. Sin Thu Kha is also a high-yielding variety with medium growth duration and can be grown in both the wet season and dry season.

Significant differences in fertilizer application were seen between fertilized plots (UDP) and non-fertilized plots (control) only. There was no difference between UDP application before seed broadcasting and UDP application at 24 days after sowing. As an average across varieties, UDP application after sowing gave a little higher yield (3.02 t/ha) than UDP application before sowing, which gave 2.99 t/ha. The control plot produced significantly lower yield with 1.98 t/ha (Table 8). Although there were no significant interactions of varieties by UDP application, the responses of varieties to UDP application were different. Sin Thu Kha variety produced higher yield (4.35 t/ha) with UDP application at 24 days after sowing. It gave 3.83 t/ha with UDP application before sowing. However, Thee Dat Yin had higher yield (2.15 t/ha) with UDP before sowing than with UDP after sowing (1.69 t/ha) (Table 8). The result indicated that the short duration Thee Dat Yin utilized the N applied earlier than the longer duration variety. With application of UDP at 24 days after sowing, all the applied N might not be utilized by the earlier maturing variety. Some of the applied N might be left in the soil. The Thee Dat Yin variety may start utilizing the N applied much earlier, right after depleting the N in the seed. For the short duration variety, having N available early, especially when deep-placed, offsets any risks of N loss and the yield losses when applied late in the vegetative stage. Another reason might be seasonal adaptation of Thee Dat Yin, which performs well and gives high yield in the dry season. With the Sin Thu Kha variety, which is a medium growth duration variety, some of the N applied before sowing seemed to be lost before being utilized by the plants, and the N applied after sowing could be better utilized. However, there was no statistical difference between UDP application before seed broadcasting and UDP application at 24 days after sowing.

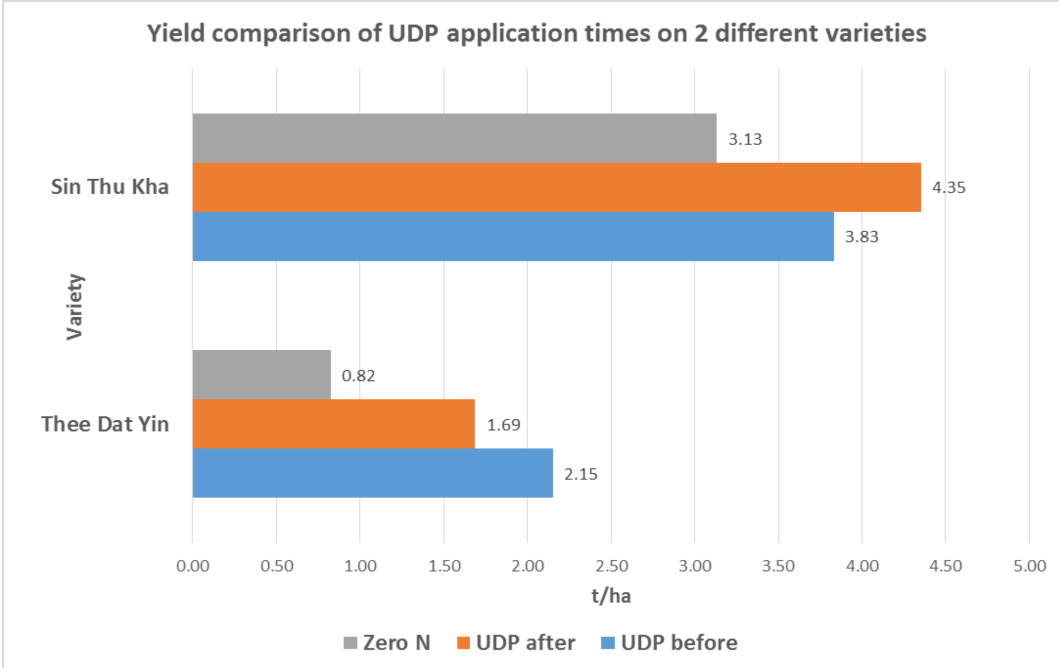

Figure 2. Yield Comparison of UDP Application Time on Two Varieties at Yindaikkwin

Table 8. Average Yield (t/ha) of Test Varieties with Different Time of UDP Application

Treatment	Yield (t/ha)		
	Thee Dat Yin	Sin Thu Kha	Average
UDP (before seed broadcasting)	2.15	3.83	2.99 a*
UDP (24 days after sowing)	1.69	4.35	3.02 a
Control (0 N)	0.82	3.13	1.98 b
Average (variety)	1.55	3.77	

* The yields with the same letter are not significantly different.

UDP Spacing Trials on BR

These trials were designed to determine the best spacing for UDP application on broadcast rice, since the UDP spacing (16 x 16 inches) on broadcast rice seemed wide, leaving thin yellow lines between points of placement of urea briquettes. This was interpreted as a sign that the plants were not getting enough N. This was the third season this trial had been conducted. Trials were conducted at two locations, Taikkyi township and Kawhmu township, Yangon region, using a popular medium growth duration variety, Sin Thu Kha. UDP spacing treatments were 16 x 14, 16 x 12, 14 x 14, and 14 x 12 inches. Nitrogen rates were therefore 57.3 kg/ha with 16 x 14 inch, 66.8 kg/ha with 16 x 12 inch, 65.5 kg/ha with 14 x 14 inch, and 76.4 kg/ha with 14 x 12 inch spacing. UDP treatments were tested against the control (0 N).

Yindaikkwin, Taikkyi – In this trial, significant differences were observed on yield, plant height, and fresh straw weight. Other characteristics were not significantly different. The control treatment with 0 N gave the lowest yield with 3.87 t/ha. The second lowest yield (4.13 t/ha) was observed with UDP spacing of 14 x 12 inches, which was the closest spacing (and highest N rate), and it was not significantly different from the control treatment. The highest yield (4.87 t/ha) was found with 14 x 14 inch UDP spacing (second highest N rate), but it was not significantly different from the second and third highest yield. So there were no differences in yield among UDP spacing treatments except the closest spacing, which was 14 x 12 inches. The other component characteristics, such as the number of panicles per square meter (m^2), number of spikelets, and number of grains per panicle were also the highest with 14 x 14 inch UDP spacing. However, they were not significantly different from other treatments. Significance was found on fresh straw weight. The highest fresh straw weight of 3,895 g was given by the closest spacing of UDP, which had the highest N rate of 76.4 kg/ha. (Refer to Yindaikkwin, Taikkyi data sheet in Appendix 1.)

Magyi Kan, Kawhmu – In this trial, the analysis of variance showed no significant difference between treatments for yield and all characteristics. The highest yield (3.58 t/ha), the highest number of panicles per m^2 (334), and the highest biomass weight aboveground were found with UDP spacing of 16 x 12 inches. But the result was different with panicle characteristics. Panicle length was the longest, and the number of spikelets and grains per panicle were the highest with 14 x 14 inch UDP spacing. However, there were no statistical differences among treatments for any of the parameters. Even the control plot with 0 N was not different from N-applied treatments with different UDP spacing. (Refer to Magyi Kan, Kawhmu data sheet in Appendix 1.)

According to results from the above two locations, closer spacing of UDP, which means a higher N rate, did not produce significantly higher yield than wider spacing (with low N rate) for broadcast seeded rice in this wet season. Significant results at Yindaikkwin showed no difference between UDP treatments, and the closest spacing of UDP (with the highest N rate) was not different from the control plot with 0 N. Other UDP spacings were not different from each other. However, more straw could be expected with the high N rate with closer UDP spacing for animal feed. The number of panicles per m^2, a major component characteristic, depends on uniform seed broadcasting, uniform germination, and the water and weed condition in the field. Yindaikkwin, Taikkyi trial had more panicles per m^2 than Magyi Kan, Kawhmu, and so it produced more yield. The Yindaikkwin trial had more than 550 panicles per m^2 and produced 4.4 t/ha, while the Magyi Kan trial had 300 panicles/m^2 and produced 3.3 t/ha. Another yield component characteristic, panicle size, was not significantly different among treatments. The high N rates, with closer spacing of UDP, did not produce larger panicles with more grains than the low rates of N, with wider UDP spacing (Table 9).

Table 9. Yield and Component Characteristics With Different UDP Spacing at Two Test Locations

Location / Treatment	N Rate (kg/ha)	No. of Panicles per m^2	Panicle Length (cm)	No. of Spikelets per Panicle	No. of Grains per Panicle	Yield (t/ha)	LSD Comparison*
Yindaikkwin, Taikkyi							
Control (0 N)	0	592	23.0	173	136	3.87	c
16 x 14 spacing	85.9	575	22.2	169	146	4.85	a
16 x 12 spacing	100.3	568	22.4	185	155	4.31	ab
14 x 14 spacing	98.2	597	23.2	194	163	4.87	a
14 x 12 spacing	114.6	542	22.9	182	153	4.13	bc
Magyi Kan, Kawhmu							
Control (0 N)	0	333	22.6	155	132	2.97	ns
16 x 14 spacing	85.9	296	23.0	163	138	3.43	ns
16 x 12 spacing	100.3	334	22.8	174	151	3.58	ns
14 x 14 spacing	98.2	290	23.6	187	158	3.22	ns
14 x 12 spacing	114.6	272	23.6	174	144	3.31	ns

* Treatments with the same letter are not statistically difference at $P_{(0.05)}$.

Different Seed Rates Trial

Five different seed rates (20, 25, 30, 35, and 40 kg/acre) were tested at two locations (Hlegu and Kyauktaga) on broadcast rice. N was applied as UDP, and the 0 N treatment was also included on the medium seed rate of 30 kg/ha as a control. The experimental design was therefore RCB design with six treatments with three replications.

Sar Bu Daung, Hlegu – Significant difference was observed only on plant height. The difference was between N-applied plots and the control plot. There were no differences in yield and other traits for all seed rates. The yields of N-applied plots ranged from 3.18 to 3.81 t/ha. The highest yield was observed with a 35 kg/acre seed rate. The control plot (30 kg seed with 0 N) produced the lowest yield with 2.86 t/ha. The number of panicles per m^2, panicle length, and number of spikelets per panicle also showed their highest values with a 35 kg/acre seed rate. Other traits, such as biomass weight and 1,000-grain weight, showed inconsistent results. (Refer to Sar Bu Daung, Hlegu data sheet in Appendix 1.)

Than Payar Kon, Kyauktaga – Variability in response to treatments was observed. Significant results were found with panicle length and the number of spikelets per panicle only. The yield and other traits were showing no significant differences among treatments. The longest panicle length and maximum number of grains per panicle were found with 30 kg seed/acre, which is the medium seed rate. They were significantly higher than other treatments at $P_{(0.05)}$. The number of spikelets per panicle, which supports the number of grains per panicle, and 1,000-grain weight were also the highest, with a seed rate of 30 kg/acre. However, the yield was not the highest with 30 kg seed/acre. It was the highest with 25 kg seed/acre, giving 5.91 t/ha yield. The second highest yield was with 0 N, which was 5.55 t/ha, although it was not much different from the third highest yield of 5.48 t/ha. (Refer to Than Payar Kon, Kyauktaga data sheet in Appendix 1.) Such inconsistent results have no cause other than non-uniform plant density of the harvested crop cut area, which is often found in the field due to uneven germination on uneven land, uneven water level, and delays in weeding.

Although there were no significant differences among treatments, broadcasting at a high seed rate of 40 kg/acre seemed too much and did not produce a high yield. Some farmers are still using 60 kg/acre seed on their broadcast fields. In general, 30 kg seed is acceptable to broadcast. With this seed rate, along with proper land preparation and leveling and balanced fertilizer application, acceptable yields can be produced while saving rice for consumption.

Nitrogen x Potassium on TPR

Two different rates of nitrogen (51.8 kg N/ha and 77.6 kg N/ha) using two different sizes of urea briquettes and two different rates of potassium (37 kg K_2O/ha and 74 kg K_2O/ha) were tested with three replications at two locations, Maubin and Letpadan. A control treatment for N and K was included as N0 K2 and N2 K0, respectively. The trial was tested using an RCB design with six treatments. ANOVA was run using RCB design with six treatments and three replications.

Wayon Gayet, Maubin – Variations in response to yield and other characteristics were observed among treatments. Significant differences were found in plant height at $P_{(0.01)}$ and the number of panicles per hill and 1,000-grain weight at $P_{(0.05)}$ only. The number of panicles per hill showed differences between the highest and the lowest rates only. Yield and other characteristics were not significantly different among treatments. The highest yield (4.48 t/ha), the highest plant height (95 cm), and the highest number of panicles (14.7) were found with the highest N (77.6 kg/ha) and K (74 kg/ha) rate. Other characteristics had variable responses to treatments. (Refer to Sar Bu Daung, Hlegu data sheet in Appendix 1.)

The results showed that the yield is increasing with increasing N rate at the same K rate and with increasing K rate at the same N rate. Both N and K seemed deficient in Wayon Gayet soil. The highest yield of 4.48 t/ha with the high N and K rate confirmed this result. But the yield increase due to increasing N rate was higher than the increase due to increasing K rate (Table 10). N might therefore be a more limiting factor than K in Maubin. However, it is noted that these increases were not significantly different from one another.

Gway Dauk Kwin, Letpadan – In Letpadan, significant differences among treatments were observed on plant height and dry straw weight only. The significant characteristics showed the highest value with the low N rate and high K rate. The tallest plant was 101 cm. The highest dry straw weight was 643 g with the low N rate (51.8 kg N/ha) and the high K rate (74 kg K_2O/ha). There were no significant differences in yield or other characteristics, although the highest yield (4.52 t/ha) was found with the high N and low K rate. An increasing yield was observed with increasing N rate. It was not observed with increasing K rate. The yield even decreased when K application was increased from 37 to 74 kg K_2O/ha. Therefore, K is not as deficient as N in the Letpadan soil (Table 10). (Refer to Gway Dauk Kwin, Letpadan data sheet in Appendix 1.)

In these trials, the interaction of N with K was not analyzed. The study was done separately at two locations. The effect of location was not studied. However, it can be said that N is deficient at both locations, and K is critical in Maubin but not in Letpadan.

Table 10. The Effect of Different N and K Rates on Yield at Test Locations

Treatment	Maubin		Letpadan	
	Yield (t/ha)	Increment	Yield (t/ha)	Increment
N0 K2 (0 kg N + 74 kg K_2O)	3.94	-	4.02	-
N1 K2 (52 kg N + 74 kg K_2O)	4.11	0.17	4.26	0.23
N2 K2 (78 kg N + 74 kg K_2O)	4.48	0.37	4.32	0.06
N2 K0 (78 kg N + 0 kg K_2O)	4.27	-	4.40	-
N2 K1 (78 kg N + 37 kg K_2O)	4.39	0.12	4.52	0.11
N2 K2 (78 kg N + 74 kg K_2O)	4.48	0.09	4.32	-0.20

Plant Spacing x Nitrogen Rate Trial on TPR

Two different plant spacings (S1 = 20 x 20 cm and S2 = 20 x 15 cm) were tested as the main factor, and three different N rates, including the control (0 N), were tested as the second factor in a split plot design with three replications. Nitrogen rates were therefore 51.8 kg N/ha (20 x 20 cm spacing) and 69.0 kg N/ha (20 x 15 cm spacing) for a 1.8-g briquette, 77.6 kg N/ha (20 x 20 cm spacing) and 103.5 kg N/ha (20 x 15 cm spacing) for a 2.7-g briquette, and 0 N as the control. The trial was tested at two locations, The Wat Chaung, Letpadan, and Bawine, Pantanaw.

The Wat Chaung, Letpadan – Similar results as the previous year were observed in Letpadan. According to the statistical analysis, both factors (plant spacing and N rates) showed no significant difference. The interaction of plant spacing by N rate was also not significant. Table 11 shows that the highest yield was achieved with the 1.8-g briquette, regardless of plant spacing, and closer spacing resulted in slightly higher yield than the wider spacing. Increasing the nitrogen by using a 2.7-g briquette did not increase yield with either spacing. With lower N rates, closer spacing (20 x 15 cm) gave a higher yield (4.04 t/ha) than wider spacing (20 x 20 cm) (3.77 t/ha). With higher N rates, wider spacing (20 x 20 cm) gave higher yield (3.28 t/ha) than closer spacing (20 x 15 cm) (3.12 t/ha). Generally, plants sown using wider spacing produced more productive tillers (10.5 panicles/hill) than plants with closer spacing, which produced

9.5 panicles/hill. On average, closer spacing, which has a higher plant population in a given area than wider spacing, gave higher yield (3.43 t/ha) than wider spacing (3.33 t/ha). This result is influenced by the yield with 0 N and 20 x 20 cm spacing (2.96 t/ha), the lowest yield among all treatment combinations (Table 11). However, it is noted that all parameters were not statistically different. (Refer to The Wat Chaung, Letpadan data sheet in Appendix 1.)

Bawine, Pantanaw – According to statistical analysis, yield was not statistically different for both factors (plant spacing and N rates). With 20 x 20 cm spacing, the lower N rate (1.8-g briquette) produced a higher yield of 4.63 t/ha than the higher N rate (2.7-g briquette), which gave 4.05 t/ha. But with closer spacing (20 x 15 cm), the yields with high and low N rates were very similar. The interaction of spacing with the N rate was not significant. It is difficult to state the determinant factor as other traits showed variabilities in response to treatments. But it was noted that the effects of both spacing and N rate were not significant according to analysis of variance. As an average across all N rates, closer spacing give higher yield (4.40 t/ha) than wider spacing (4.31 t/ha), and the lower N rate produced higher yield (4.25 t/ha) than the higher N rate (4.25 t/ha) (Table 11). (Refer to Bawine, Pantanaw data sheet in Appendix 1.)

According to the results of both locations, it seemed the higher N rate did not give higher yield for either spacing. The lower N rate seemed enough to produce the highest yield for both spacings. This trial used UDP technology for N application. With the farmer's practice of surface broadcasting prilled urea, the results may be different. However, without N application, closer spacing is the farmer's practice to obtain higher yield. It is noted that fertilizer management in a specific area/location depends on many factors, such as initial soil fertility, application methods, type of fertilizer used, etc.

Table 11. Treatment Yield and Factor Yield of Spacing by N Rate Trials at Test Locations

Treatment	The Wat Chaung Yield (t/ha)	The Wat Chaung Nitrogen Average	The Wat Chaung Spacing Average	Bawine Yield (t/ha)	Bawine Nitrogen Average	Bawine Spacing Average
S1 N1 (0 N)	2.96	3.04	3.33	4.26	4.29	4.31
S1 N2 (51.8 kg N/ha)	3.77	3.90		4.63	4.53	
S1 N3 (77.6 kg N/ha)	3.28	3.20		4.05	4.25	
S2 N1 (0 N)	3.13		3.43	4.32		4.40
S2 N2 (69.0 kg N/ha)	4.04			4.43		
S2 N3 (103.5 kg N/ha)	3.12			4.45		

Fertilizer Management Trials on Rice-Gram Cropping System

Different amounts of P and K on rice or gram were tested in the rice-gram cropping system. This is a long-term experiment to study the carryover effect of P and K on the subsequent crop (gram or rice). According to insignificant results with fertilizer treatments on both rice and gram crops from previous years, higher fertilizer rates of P and K were tested this year starting with the rice crop. Fertilizer rates were therefore 60 kg P_2O_5/ha and 60 kg K_2O/ha. UDP was applied on all plots using 1.8-g briquettes as nitrogenous fertilizer. The N rate was therefore 51.8 kg/ha.

In the 2016 wet season, the same four treatments were tested. With Treatment 1, 60 kg P_2O_5/ha and 60 kg K_2O/ha were applied. With Treatment 2, half the amount of P (30 kg P_2O_5/ha) and half the amount of K (30 kg K_2O/ha) were applied. Zero P and 0 K were applied on Treatments 3 and 4. But all crop residue obtained from the gram crop was added on Treatment 4. The trials were conducted on the same plots as previous years at all locations. All treatments were located on the same plots as before.

Thar Kwin, Einme – No significant differences were observed on yield or other characteristics, but the treatment with the full amount of P and K produced the highest yield with 6.96 t/ha. It was slightly higher than other treatments. The yield of the treatment that received half the amount of P and K was lower than the treatments with no P or K. It was only 6.59 t/ha while 0 P and 0 K plots produced 6.81 and 6.66 t/ha. Treatment 4, which had additional application of gram crop residue, did not result in higher yield. The yield was even a little lower than

Treatment 3 with no crop residue. Inconsistent results were observed among other characteristics. (Refer to Thar Kwin, Einme data sheet in Appendix 1.)

Parami Daunt, Einme – According to the ANOVA, there were no differences between treatments on all plant characteristics and yield. Although not significant, the treatment with the full amount of P and K gave the highest yield of 4.09 t/ha. It was slightly higher than other treatments. Half the amount of the P and K treatments gave the same yield as 0 P and 0 K with crop residue treatment. Each treatment produced 4.02 t/ha. The 0 P and 0 K treatment with no crop residue gave the lowest yield of 3.87 t/ha. However, it was noted that they were not statistically different from one another. The number of spikelets and grains per panicle and most of the biomass weight were also the highest with the full P and K rate. An important trait, the number of panicles per hill, showed variability in response to treatments. But it is noted that there were no significant differences in yield or other traits. (Refer to Parami Daunt, Einme data sheet in Appendix 1.)

Ashae Pine, Kyauktan – This trial also showed no significant difference among treatments. The full P and K rate produced the highest yield of 4.13 t/ha. The half P and K rate did not give the second highest yield, which was even a little lower than the zero P and K rate. Half and 0 P and K rate treatments had similar yields, ranging from 4.05 to 4.09 t/ha. Other traits did not result in their highest values with the full P and K rate. Most of the biomass weights were the highest with 0 P and 0 K with no crop residue. It was therefore difficult to draw conclusions due to inconsistent responses of the traits to treatments. (Refer to Ashae Pine, Kyauktan data sheet in Appendix 1.)

This is the second rice season of the long-term trial, and no significant differences were found with higher P and K rates. However, all trials showed the highest yields with the full rate of P and K (60 kg/ha each). The half rate of P and K did not give the same results at all locations. It was equal or lower than the 0 P and 0 K treatments. The effect of crop residue was not visible. This may be due to insufficient gram biomass. The trial will continue.

Fertilizer Management Trial on Rice-Gram System With Starter N on Gram

This is the beginning of a long-term trial on the rice-gram system in which starter N will be applied on the gram crop in the coming dry season. The trial was conducted on broadcast rice at Anauk Ywa in Thonegwa township.

The ANOVA showed significant results at $P_{(0.05)}$ on yield and fresh straw weight and highly significant results at $P_{(0.01)}$ on plant height. Other traits were not significantly different among treatments. Treatments 1 and 2, which used UDP with P and K and without P and K, produced higher yields (3.17 and 3.33 t/ha) among treatments. The yields were not significantly different from each other and also not different from the third highest yield (2.81 t/ha) produced with prilled urea with P and K treatment (Treatment 6). Prilled urea application without P and K gave the lowest yield (2.28 t/ha). However, some variations in response to treatments were observed. Treatments 1 and 5, which received the same treatment (UDP with P and K), did not give similar yield, and they were significantly different. Treatments 3 and 6 with the same fertilizer application (PU with P and K) gave similar yields (2.65 and 2.81 t/ha), and they were not significantly different. (Refer to Anauk Ywa, Thonegwa data sheet in Appendix 1.) Other significant characteristics, plant height and fresh straw weight, resulted in high values with UDP-applied plots with different P and K rates. The average yield of UDP across all P and K treatments was 3.04 t/ha, and the average PU yield was 2.58 t/ha. This indicates that UDP is the most efficient method of N application and promotes vegetative growth and yield. Variations in response to treatments with the same fertilizer application may be due to different plant density within the crop cut area of broadcast rice rather than due to the effect of the fertilizer. The carryover effect of P and K on gram and the effect of starter N will be studied during the next dry season on the gram crop.

UDP Evaluation Under Submerged Condition Trial

This trial was planned and conducted at four locations. Only two trials could be continued through to harvest. One trial was abandoned at the nursery stage, and another trial ended just after transplanting due to flooding. The whole trial at Kyar Phoo Ngon, Myaungmya, was harvested, and only two replications out of three could be harvested at Tar Lan Thit, Kawhmu. This trial was conducted in flood-prone areas and more or less affected by the submerged condition of floodwater. A popular variety (Sin Thu Kha) and submergence-tolerant variety (Swarna sub1) were tested with two fertilizer practices.

Kyar Phoo Ngon, Myaungmya – A significant result was found with fertilizer treatment according to ANOVA using split plot design. Variety and interaction of variety by fertilizer were not significant. The farmer's fertilizer practice gave 3.80 t/ha yield with Sin Thu Kha and 4.27 t/ha with Swarna sub1. UDP gave 4.76 and 4.47 t/ha with Sin Thu Kha and Swarna sub1 variety. As an average across two varieties, UDP produced 4.61 t/ha and farmer's practice produced 4.03 t/ha; the yields were significantly different at $P_{(0.05)}$. The N rate with UDP was 51.8 kg/ha with P, K, and S basal, and the FP N rate was 28.4 kg/ha with no basal. Both varieties performed better with UDP than with FP. Sin Thu Kha, a HYV, did better with UDP than Swarna sub1, a submergence-tolerant variety. On average, Swarna sub1 gave higher yield than Sin Thu Kha, meaning that a submergence-tolerant variety is better-suited with submerged conditions than normal HYVs (Table 12). This trial received deep flooding two times in the season. Flooded water reached up to the tips of the rice plants, but the rice plants never went completely under the flooded water. (Refer to Kyar Phoo Ngon, Myaungmya data sheet in Appendix 1.)

Tar Lan Thit, Kawhmu – The trial was sown twice in the season. The nursery of the first sowing in July was destroyed by flood and was re-sown in August. According to ANOVA, no significant results on yield were found. Both fertilizer and variety treatments showed no differences. Insignificant results may be due to less replicates and few treatments of both factors in the trial where the degrees of freedom of those have only one each. However, the UDP treatment produced higher yield with 3.30 t/ha than the FP treatment, which produced 3.14 t/ha. This difference was not significant. As an average yield across two fertilizer treatments, Swarna sub1 performed better with 3.35 t/ha yield than Sin Thu Kha, which had 3.10 t/ha yield. The Sin Thu Kha variety performed better with FP than with UDP while the Swarna sub1 variety produced higher yield with UDP (3.78 t/ha) than with FP (2.92 t/ha). However, there was no significant interaction of variety with fertilizer practice. This trial was flooded, and rice plants were under water for some days at the vegetative stage. One replication was seriously damaged and some small damaged hill(s) were observed in the other two replicates, although rice plants survived. (Refer to Tar Lan Thit, Kawhmu data sheet in Appendix 1 and Table 12).

As an average across varieties, UDP yield was always better than FP yield at both locations. However, it is still early to state that UDP could be applied in submerged areas and perform better than FP because Sin Thu Kha was not showing better yield with UDP than with FP in Tar Lan Thit, Kawhmu. Both varieties produced better yield with UDP than with FP at Kyar Phoo Ngon, Myaungmya. According to results, the Swarna sub1 variety showed better suitability than the Sin Thu Kha variety under submerged conditions, but this needs more testing for confirmation. The reality in flood-prone areas is that the fields are already flooded at or just before transplanting. Farmers use transplanting sticks (forks) to transplant rice plants in the field with water at knee-high depth. Instead of applying UDP in deep water after transplanting, it should be applied before transplanting when the water depth is somewhat shallow.

Table 12. Yields of Treatments Under Submerged Conditions at Two Test Locations

Treatment	Kyar Phoo Ngon			Tar Lan Thit		
	Yield (t/ha)	Fertilizer Average	Variety Average	Yield (t/ha)	Fertilizer Average	Variety Average
FP with Sin Thu Kha	3.80	4.03	4.28	3.36	3.14	3.10
FP with Swarna sub1	4.27		4.37	2.92		3.35
UDP with Sin Thu Kha	4.76	4.61		2.83	3.30	
UDP with Swarna sub1	4.47			3.78		

Conclusion

UDP Adaptation Trials

The UDP treatment gave the highest yield at test locations. It was significantly higher than all other treatments at Kawhmu but not at Kyauktaga. The yields with UDP were 4.03 t/ha at Kawhmu and 6.03 t/ha at Kyauktaga. They were the highest among all treatments. The highest yield with UDP was determined by the highest number of panicles per hill (Table 6). The trial at Kyauktaga produced higher yield than at Kawhmu. The control plot also could produce 5.41 t/ha at Kyauktaga. The FP treatment that used a lower N rate than UDP and UB also produced high yield with 5.85 t/ha, and this was slightly higher than the UB treatment. However, the yields at Kyauktaga were not significantly different (Table 6).

The AE of UDP was clearly higher than other N-applied plots at Kawhmu. Rice grains of 19.4 kg can be produced by 1 kg of N applied by UDP technology. With the same N rate and same basal fertilizer, 10 kg of rice grain was produced by surface broadcasting urea. With higher N rates but no basal fertilizer, 1 kg of N can produce only 2.4 kg of grains, meaning that P, K, and S are also limiting in Kawhmu soil. At Kyauktaga, UDP had a higher AE value (11.9 kg/kg of N) than UB, which had 7.9 kg/kg N. Both treatments had the same N rate and basal fertilizer, meaning that UDP is a more effective method to apply nitrogen. However, N is not the major limiting element, because the FP treatment, which applied a lower N rate than UDP with basal, had an AE value of 11.6 kg/kg N, which was only a little lower than that with UDP (Table 7). Kyauktaga soil is more fertile than Kawhmu soil. Even control treatments gave 5.41 t/ha at Kyauktaga.

N-Rate Trial

This trial was tested three times at the same location on different plots. The results of this year were different from the previous two seasons. The highest yield was produced by the 129.4 kg N rate. The number of panicles per hill and number of spikelets and grains per panicle were also highest with 129.4 kg N/ha. Biomass weights showed variable results with different treatments. However, according to the statistical analysis, yield and all other characteristics were not different. (Refer to Research Farm, Myaungmya data sheet in Appendix 1.) Previous seasons showed the highest yield with the higher N rate (155.3 kg/ha) than this year. Based on the results of three seasons, although without significant differences, it is suggested that the N rate of 130-150 kg/ha with balanced fertilization gives higher yields in Myaungmya, and these rates could be recommended to farmers.

UDP Before Broadcasting Trial on BR

Unlike previous seasons, the trial was tested with two popular varieties (Sin Thu Kha and Thee Dat Yin). Sin Thu Kha is a medium growth duration variety and widely grown in both wet and dry seasons. Thee Dat Yin is an early variety and mostly grown in the dry season in the Delta region. ANOVA showed significant results on both variety and fertilizer treatments. No significant result was observed on the interaction of variety by fertilizer practice. The Sin Thu Kha variety gave higher yield (3.77 t/ha) than Thee Dat Yin, which gave 1.55 t/ha. As an average, UDP application after sowing gave a little higher yield with 3.02 t/ha than UDP application just before seed broadcasting, which gave 2.99 t/ha. They were not significantly different. Significant differences only occurred between the control plot with 0 N and the UDP-applied plots. Although there was no significant interaction effect, Thee Dat Yin gave higher yield (2.15 t/ha) with UDP before sowing than with UDP after sowing (1.69 t/ha), and Sin Thu Kha gave higher yield with UDP after sowing (4.35 t/ha). It seems Thee Dat Yin did not have enough growing period to utilize all the N when it was applied after sowing and gave a lower yield. However, Sin Thu Kha, which has medium growth duration, could utilize all the N that was applied after sowing (Figure 2 and Table 8).

Based on the results, it can be said that Thee Dat Yin does not perform well in the wet season. This may be due to its flowering during the raining period. UDP can be applied both before seed broadcasting and after seed broadcasting. There is no significant difference between the two application times. With a short duration variety like Thee Dat Yin, UDP before sowing may supply more nutrients than when applied after sowing. Proper deep placement application should be considered to reduce nutrient loss before plants uptake. With a medium duration variety like Sin Thu Kha, UDP application after seed broadcasting may avoid nutrient loss, which might happen if it was applied before sowing. However, the time of application should be considered, and it may be earlier than 24 days after sowing. Plant density may be another consideration since farmers are broadcasting with high seed rates (150 kg/ha), which make it inconvenient to apply UDP in a dense field.

UDP Spacing Trials on BR

One test location, Taikkyi, showed significant yield differences between treatments. The Kawhmu trial showed no differences in yield and all characteristics. The Taikkyi trial gave the highest yield with UDP spacing of 14 x 14 inches, while the Kawhmu trial gave its highest yield (3.58 t/ha) with 16 x 12 inches. The highest yield at Taikkyi was not different from that with 16 x 14 and 16 x 12 inch spacing. The closest UDP spacing (14 x 12 inch), which had the highest N rate, did not produce the highest yield, and it was not significantly different from the control. At Kawhmu, different UDP spacing treatments produced nearly the same yields, which ranged from 3.22 to 3.58 t/ha. Nitrogen rates were not much different between 16 x 12 inch and 14 x 14 inch UDP spacing, which gave the highest yield at Taikkyi and Kawhmu (100.3 kg/ha and 98.2 kg/ha, respectively) (Table 9).

Based on the results, which showed no differences between UDP-applied plots, a UDP spacing of 16 x 12 inches or 14 x 14 inches could be applied along with a seed rate of not more than 75 kg/ha. The recommended spacing on transplanting rice, which is 16 x 16 inches, could also be practiced on broadcast rice.

Different Seed Rates Trial

No statistical differences on yield with different seed rates were observed at both locations. The second highest seed rate (35 kg/ha) gave the highest yield at Sar Bu Daung, Hlegu, and the second lowest seed rate (25 kg/ha) gave the highest yield at Than Payar Kon, Kyauktaga. The Kyauktaga trial produced much higher yields than the Hlegu trial. The control plot (0 N) with medium seed rate (30 kg/acre) also produced good yield (5.55 t/ha) in Kyauktaga.

The Hlegu trial showed significant difference at $P_{(0.01)}$ on only plant height. Other characteristics were not different among seed rate treatments. The Kyauktaga trial showed significant difference at $P_{(0.05)}$ on two characteristics (panicle length and number of grains per panicle) only. The longest panicle and the highest number of grains per panicle were with the medium seed rate of 30 kg/acre. (Refer to the Sar Bu Daung, Hlegu and Than Payar Kon, Kyauktaga data sheets in Appendix 1.)

Although the results on yield and most characteristics at both locations are not significant, they indicate that using a high seed rate up to 40 kg/acre wastes a lot of seeds with no return. Farmers are now broadcasting seed on a wider scale than transplanting mainly due to labor scarcity and cost. They are broadcasting at very high rates, possibly to control weeds and compensating for less inputs with a denser population. Seed quality and germination rates are also low. Areas under broadcast rice is expanding in the major rice-growing region. These results show farmers can use less seed with balanced fertilizer management, proper land preparation, and proper weed control to get high yield with quality seed.

Nitrogen x Potassium Trial on TPR

Increasing yield was observed with increasing rates of P and K at Wayon Gayet, Maubin. Zero N and 0 K plots gave the lowest yields. The N rate of 52 kg/ha produced 4.11 t/ha, and when the N rate increased to 72 kg/ha, the yield was 4.48 t/ha with the same high K rate (74 kg K_2O/ha). Yield response to K was also the same as N. However, increasing yield with increasing nutrient rate was found with N but not found with K at Gway Dauk Kwin, Letpadan (Table 10). It seems N is more critical than K at Gway Dauk Kwin, and both N and K are deficient in Wayon Gayet. Results indicate that nutrient management should be site-specific.

Plant Spacing and N Rate Trial on TPR

The results of two test locations showed no significant differences among both factors and interaction. Generally, the higher N rate did not give higher yield. With wider spacing (20 x 20 cm), the lower N rate, which used a 1.8-g briquette, gave 3.77 t/ha yield, and the higher N rate, which used a 2.7-g briquette, gave 3.28 t/ha at The Wat Chaung, Letpadan. With closer spacing (20 x 15 cm), the same result was observed; the lower N rate had higher yield than the higher N rate. The yield with the lower N rate was 4.04 t/ha, and the yield with the higher N rate was only 3.12 t/ha. At Bawine, Pantanaw, the same result was observed on wider spacing; the low N rate gave higher yield (4.63 t/ha) than the higher N rate (4.05 t/ha). But with closer spacing, both N rates gave similar yields. As an average across N rates, the closer spacing gave higher yield than wider spacing, which was the same result as in Letpadan.

The trials were conducted in the wet season and confirm that the 1.8-g briquette (low N rate) can be applied on wet season rice cultivation with balanced nutrients on other major elements. Closer spacing should be practiced when applying less or no inputs to get reasonable yield, not high.

Fertilizer Management Trials on Rice-Gram Cropping System

This was the first rice crop of a long-term trial on the rice-gram system, testing with a higher P and K rate than last year. The trial was continued on the same plots at all sites. The highest yield was produced by application of the higher amount of P and K at all locations, which indicated that P and K are limiting in these soils. A similar yield resulting from application of half P and K and no P and K indicates that 30 kg/ha each of P and K was not enough to increase yield in test locations. A comparison of Treatments 3 and 4, which used different amounts of gram crop residue, showed no differences. The amount of crop residue seems insufficient to enrich organic matter of the soil. According to the results, all P and K with half the amount might all be used by rice plants, leaving nothing for the next crop.

Fertilizer Management Trials on Rice-Gram System With Starter N

This is the first season and the first crop for a long-term trial that will study the carryover effect of P and K on both crops and the effect of starter N on the gram crop. The results showed significant effect of P and K on yield. It was clear on PU-applied plots and not as clear on UDP-applied plots. PU with P and K plots had higher yields (2.65 and 2.81 t/ha of Treatments 3 and 6) than PU without P and K (Treatment 4), which gave 2.28 t/ha. UDP with 0 P and 0 K plot (Treatment 2) gave the highest yield with 3.33 t/ha. Treatments 1 and 5, which had the same treatments (UDP with P and K), did not have the same yield. However, the UDP method was found to be a more effective use of fertilizer than the PU surface broadcasting method. (Refer to Anauk Ywa, Thonegwa data sheet in Appendix 1.) This was the first season and any carryover effect of P and K will be studied on the gram crop next dry season.

UDP Evaluation Under Submerged Condition Trial

One of two locations, Kyar Phoo Ngon, gave significant results with fertilizer practice. Variety and interaction of variety by fertilizer practice were not significant. The UDP treatment gave better yields with 4.61 t/ha than FP (4.03 t/ha). Both varieties were better with UDP than FP. However, the Sin Thu Kha variety was much better than Swarna sub1 with UDP, giving much higher yield over FP. But Swarna sub1 gave 4.37 t/ha, on average, which was better than Sin Thu Kha (4.28 t/ha). At Tar Lan Thit, no effects were significant, and varieties had different responses to fertilizer treatments. The Sin Thu Kha variety was better with FP, and Swarna sub1 was better with UDP. However, as an average, UDP gave higher yield (3.30 t/ha) than FP, which gave (3.14 t/ha); Swarna sub1 produced 3.35 t/ha, and Sin Thu Kha produced 3.10 t/ha. This result was the same as in Kyar Phoo Ngon (Table 12).

The results indicate that the Swarna sub1 variety, which is submergence-tolerant, is more suitable than Sin Thu Kha, the normal variety, in a submerged-prone area. Both varieties are high-yielding varieties. UDP also seems effective under submerged conditions. However, UDP is supposed to be applied after transplanting and, at that time, the water level is at 50 cm or higher in those areas. Application of UDP in deep-water fields will be an issue.