Response of Rice Yield and Nutrient Use Efficiency to Different Sources of Nitrogen and Phosphorus Fertilizers in Hmawbi

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Abstract

Field experiments were conducted in Myanmar Rice Research Center, Hmawbi township in Yangon region during dry and wet seasons to compare the effect of two sources of nitrogen and phosphorus fertilizers on growth and yield of rice and to study the effect of the combination of nitrogen and phosphorus fertilizers on rice and to examine nutrient use efficeiency of each fertilizer. The experimental design was 3x3 factorial arrangements in randomized complete block design with four replications. Treatments for nitrogen sources were N_0 - nitrogen omission, N_1 - prilled urea (PU) (80 kg N ha^{-1}) and N_2 - urea super granule (USG) (80 kg N ha^{-1}) and phosphorus sources; P_0- P omission, P_1- triple super phosphate (TSP) (22 kg P ha^{-1}) and P_2 - diammonium phosphate (DAP) (22 kg P ha^{-1}). In both seasons, USG significantly increased plant height, total dry matter, number of panicles hill^{-1}, number of spikelets panicle^{-1} leading to more grain yield as compared with PU. The application of USG increased grain yield by 26% and 25% over PU in dry and wet seasons, respectively. In the tested P sources, DAP fertilizer gave increase yield by 7% in dry season and 6% in wet season than TSP fertilizer. Combination of PU and DAP resulted not only in higher grain yield by 16% in dry season but also in reducing the dosage of 25% PU fertilizer than the combination of TSP. The greater grain yield were obtained from USG combining with DAP by 8% and 5% than combining with TSP in dry and wet seasons, respectively. Application of DAP alone gave the best nitrogen use efficiency (NUE) among treatments. USG, USG + TSP and USG + DAP gave more NUE than PU, PU + TSP and PU + DAP. DAP, DAP + PU, DAP + USG resulted superior phosphorus use efficiency (PUE) than TSP, TSP + PU and TSP + USG. Nutrient use efficiency were increased in combined application of any tested N and P fertilizers when compared with using N or P fertilizer alone. The use of USG and DAP fertilizers resulted the best growth parameters, yield components, yield, NUE and PUE.

Key words: Prilled Urea, Urea Super Granule, Triple Super Phosphate, Diammonium Phosphate, Rice Yield, Nitrogen Use Efficiency, Phosphorus Use Efficiency

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereals in the world and staple food for more than half of the world population. Rice is one of the leading food crops in the world (Manzoor et al, 2006). In Myanmar, the average rice yield was 3.84 ton ha^{-1} in 2012-13 and 3.93 ton ha^{-1} in 2015. Thus, the yield of rice in Myanmar is quite low in comparison with other leading rice producing countries such as China (6.8 ton ha^{-1}), Japan (6.7 ton ha^{-1}) and Vietnam (5.7 ton ha^{-1}) (Fao stat, 2016). Improvement of its production has not been possible due to low soil fertility and inadequate nutrient management among other factors (Heluf Gebrekidan and Mulugeta Seyoum, 2006).

Fertilizers are one of the main inputs in rice production and proper fertilization is an important management practice that can increase the yield of rice. The appropriate fertilizer input is not only for obtaining high grain yield but also for getting maximum profitability (Khuang et al,2008). Nitrogen (N) and phosphorus (P) fertilizers are major essential plant nutrients and key input for increasing crop yield (Dastan et al, 2012). There are many different types of nitrogen and phosphorus fertilizers in the

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market of Myanmar. Among the nitrogen fertilizers, prilled urea is the most popular and the nitrogen efficiency was only 25-30 percent and the rest 70-75 percent is lost by many reasons after application (BRRI, 2008). These losses can be reduced by using improved fertilizer products such as slow released or controlled release fertilizers. Urea Super Granule is one of the improved nitrogen fertilizer products and it reduces denitrification process, reduces urea concentration in irrigation water, thus reduces nitrogen loss and improves N use efficiency (Craswell and De Datta, 1980).

In case of phosphorus fertilizers, triple super phosphate has several agronomic advantages that made it such a popular P source for many years. It has the highest P content (46%) among solid phosphorus fertilizers that do not contain N. Diammonium phosphate is also an excellent source of ammonium-nitrogen and phosphate and it contains NH_4^+-N (18%) and P_2O_5 (46%) (www.ipni.net). Increased growth of rice plant requires more both N and P, the inference being mutually synergistic effects which result in growth stimulation and enhanced uptake of both elements (Sumner and Farina, 1986). Nitrogen and phosphorus fertilizers have great impact in increasing rice yields and there has been limited research work done in Myanmar on the study combination of the improved nitrogen and phosphorus fertilizer. So the experiments were conducted (1) to compare the effect of two sources of nitrogen and phosphorus fertilizers on growth and yield of rice, (2) to study the effect of the combination of the nitrogen and phosphorus fertilizers and (3) to examine the nutrient use efficiency of each fertilizer.

Materials and Methods

Two field experiments were conducted at Myanmar Rice Research Center, Hmawbi Township, in Yangon Region during dry and wet seasons, 2017. In both seasons, the same treatments and the same size of plots were used. Double bounds were constructed 1 m apart between each plot and 1.5 m apart between the blocks to prevent flowing water from one plot to another. Total numbers of the experimental plots were 36 plots and each plot size was 5m x 4m. All experimental plots were fertilized with 42 kg K ha^{-1} of potassium fertilizer as muirate of potash (MOP) by three split applications at 7 day after transplanting (DAT), panicle initiation and heading stages of rice.

The experimental design was 3x3 factorial arrangements in randomizes block design (RCB) with four replications. Treatments were factor A: Nitrogen sources i.e., N_0 - N omission, N_1 - Prilled Urea (PU) and N_2 - Urea Super Granule (USG) and factor B: Phosphorus sources i.e., P_0 - P omission, P_1 - Triple Super Phosphate (TSP) and P_2 - Diammonium phosphate (DAP). Application rates of tested nitrogen and phosphorus fertilizers were shown in Table 1. All required amounts of phosphorus fertilizers (triple superphosphate and diammonium phosphate) were applied at basal according to the treatments. Twenty days old seedlings were immediately transplanted with two plants per hill with a spacing of 20 cm x 20 cm. For N fertilizer application, PU fertilizer was applied with three split applications at 7 DAT, panicle initiation and heading stages according to the treatments. In the case of USG, whole amount of USG having each granule of 2.7 g was applied to a depth at of 7-10 cm into the

Table1. Application of the rates of different types of nitrogen and phosphorus fertilizers

Treatments		kg N ha^{-1}	kg P ha^{-1}	Fertilizer (kg ha^{-1})			
				Urea	USG	TSP	DAP
N_0P_0	0	0	0	-	-	-	-
N_0P_1	(TSP)	0	22	-	-	-109	-
N_0P_2	(DAP)	20	22	-		-	-109
N_1P_0	(PU)	80	0	174	-	-	-
N_1P_1	(PU+ TSP)	80	22	174	-	109	-
N_1P_2	(PU + DAP)	60 + 20	22	130	-	-	-109
N_2P_0	(USG)	80	0	-	174	-	-
N_2P_1	(USG + TSP)	80	22	-	174	109	-
N_2P_2	(USG + DAP)	80+20	22	-	174	-	109

soil between four hills at 7 DAT. Before the experiment, the physiochemical properties of the experimental soil were analyzed and the results were mentioned in Table 2.

Cultural Practices

The experimental plots were irrigated whenever necessary. Weed control and other managements were done regularly, especially at the early stages of rice growth stages. Growth parameters such as plant height, number of tillers hill^{-1} and SPAD value were recorded from randomly selected 8 hills from each plot at two weeks interval starting from 14 DAT until heading stages. For dry matter production, three plant samples were taken at 20 DAT, 50 DAT, 80 DAT and 110 DAT and dried in the shade and then put in an oven at 65℃ ± 5℃ for 48 hours. After cooling to room temperature, dry weight was recorded and computed. Grain yield was determined from a central 5 m^2 harvested area from each plot and was adjusted to 14% moisture content. Five hills were selected as samples to assess the yield component parameters.

Calculation

$$\text{Grain Harvest} = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield (grain+straw)}}$$

$$\text{Fertilizer Use Efficiency} = \frac{\text{Grain yield (kg ha}^{-1}\text{) in fertilized plot- Control yield (kg ha}^{-1}\text{)}}{\text{Amount of fertilizer applied (kg ha}^{-1}\text{)}}$$

Harvest index, nitrogen and phosphorus use efficiency were calculated with the following formula.

(Fageria, 2009)
(Dobermannand Fairhurst, 2000)
Nitrogen use efficiency = amount of nitrogen fertilizer applied
Phosphorus use efficiency = amount of phosphorus fertilizer applied

Statistical analysis

All the collected data were analyzed using ANOVA with Statistix 8 software. The treatment means were separated by Least Significant Difference (LSD) at 5 percent probability level.

Result and Discussion

Plant height (cm)

Plant height in all treatments continuously increased from 14 DAT to 84 DAT. In both seasons, plant height significantly increased with the application of nitrogen fertilizers at 42, 56, 70 and 84 DAT in dry season and at all growth stages in wet season (Figure 1). Nitrogen application treatments gave the taller plant height than that of N omission. This result was in agreement with the findings of Irshad et al, 2000, they stated that the plant height was significantly increased by nitrogen application. For the sources of nitrogen fertilizers, highest plant height was obtained from USG. These results were similar to Alam, 2002 who recorded a positive effect of USG on plant height.

Plant heights were progressively increased by the application of P fertilizers regardless of sources

Table2. Physicochemical properties of the experimental soil before experiment

Parameters	Results	Evaluation
Soil Texture	Silt Loam	-
Soil pH	5.08	strongly acid
Total N (%)	0.14	low
Available N (mg/kg)	78	medium
Total P (%)	0.36	-
Available P (ppm)	8.79	low
Available K (mg/kg)	12.90	medium
Cation Exchange Capacity (meq/100g)	9.34	low
Organic carbon (%)	2.64	medium
Exchangeable Fe (ppm)	238.00	medium

(Figure.1). Although the plant heights were not significantly different in the application of phosphorus fertilizers, P fertilization treatments gave the taller plant height than that of P omission. Dobermann and Fairhurst, 2000 stated that phosphorus stimulates root development in young plants, thus increased its ability to absorb other nutrients from the soil. When two types of phosphorus fertilizers were compared, DAP fertilizer produced the higher plant height in numerical than TSP fertilizer.

In the combination of different types of nitrogen and phosphorus fertilizers, tallest plant height was obtained from combined treatment of USG + DAP.

Number of tillers hill^{-1}

Number of tillers hill^{-1} counted at various growth stages from 14 DAT to 84 DAT was continually increased (Figure 2). In both seasons, maximum number of tillers hill^{-1} was resulted from N fertilization treatments and minimum was resulted from N omission treatment. When comparing PU and USG fertilizers, USG fertilizer was superior in increasing number of tillers than PU fertilizer. This results were consistent with the finding of Alam, 2002, total tillers hill^{-1} increased significantly when USG was applied.

Numbers of tillers hill^{-1} were regularly increased by application of phosphorus fertilizers (Figure 2). Phosphorus fertilization produced the higher number of tillers than P omission treatment. The results were significantly different in number of tiller with the application of P fertilizers at 28 DAT, 56 DAT, 70 DAT and 84 DAT in dry season. The maximum tiller number was recorded from DAP followed by TSP. Sharma et al, 2009 observed the number of tillers hill^{-1} increased significantly with the application of DAP. In wet season they were not significant difference. Even though, no interaction effects were observed between different sources of nitrogen and phosphorus fertilizers, the higher results were obtained from USG + DAP in both seasons.

SPAD reading

SPAD value varied significantly with the application nitrogen fertilizers in both seasons. The higher SPAD value was found in N application plots than N omission. In the two sources of N fertilizers, the maximum SPAD value was obtained from USG

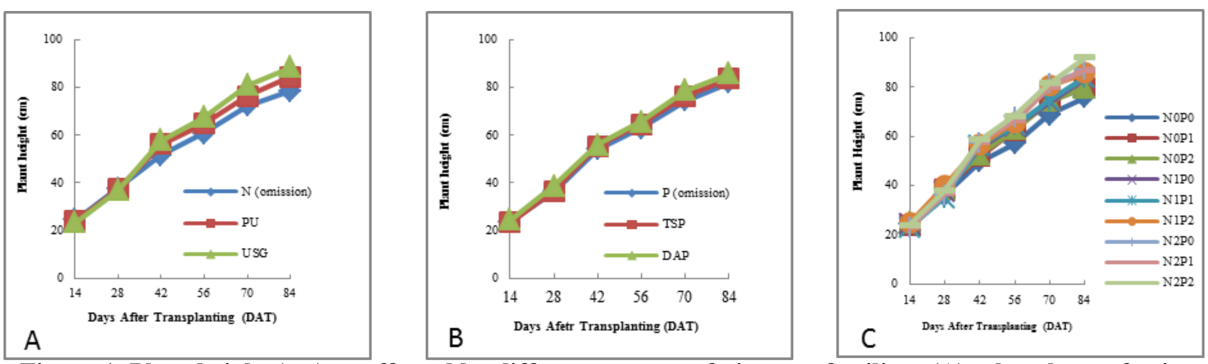

Figure 1. Plant height (cm) as affected by different sources of nitrogen fertilizer (A), phosphorus fertilizer (B) and their combination (C) during dry season, 2017.

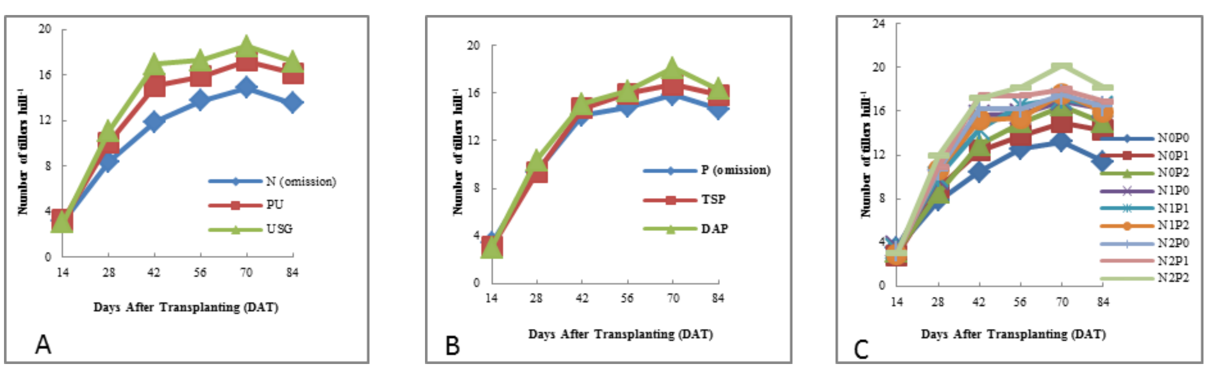

Figure 2. Number of tillers hill^{-1} as affected by different sources of nitrogen fertilizer (A), phosphorus fertilizer (B) and their combination (C) during dry season, 2017.

at early growth stages in 42, 56 and 70 DAT however PU fertilizer gave the maximum SPAD reading at 84 DAT in dry season. It may be due to the split application of PU fertilizer by the third time of this stage. Varvel et al, 1997 revealed that N fertilizer significantly increased SPAD reading. USG gave the maximum SPAD value at all growth stages in wet season. Nguyen quang co, 2015 reported that USG had highest SPAD values than other type and fertilizer methods.

The means of SPAD value of P treatment were not significantly different however P fertilization plots gave the higher SPAD value than P omission. The more SPAD value were obtained by DAP when compared TSP treatment. In the case of N and P fertilizers combination, the highest SPAD value was attained from USG + DAP in both seasons.

Total dry matter

The total dry matter continuously increased from active tillering to harvesting stages. In both seasons, nitrogen applications resulted higher total dry matter than N omission. In the tested types of nitrogen fertilizers, PU and USG fertilizers treatment were statistically similar in active tillering stage. However, in rest collecting growth stages, USG produced the highest total dry matter among N treatments. This finding was similar with the results of (Nguyen quang co, 2015) who stated that slow-release fertilizer might have the potential to get higher dry matter production in rice.

The application of P fertilizers was progressively increased on total dry matter of rice. In dry season, P application treatments were significant difference in total dry matter at active tillering stage. The significantly highest TDM was obtained from DAP which was followed by TSP fertilization. In the tested P fertilizers, maximum value was recorded from DAP. In both seasons, although the combinations of N and P sources were not significance different, USG + DAP treatment produced the best total dry matter of numerical value.

Yield and yield component parameters

Higher yield and yield component parameters were produced with the treatments containing N fertilizers than that without N fertilizer. Number of panicles $hill^{-1}$, number of spikelets $panicle^{1}$ and grain yield were highly significantly different at 1% level and panicle length and filled grain% showed

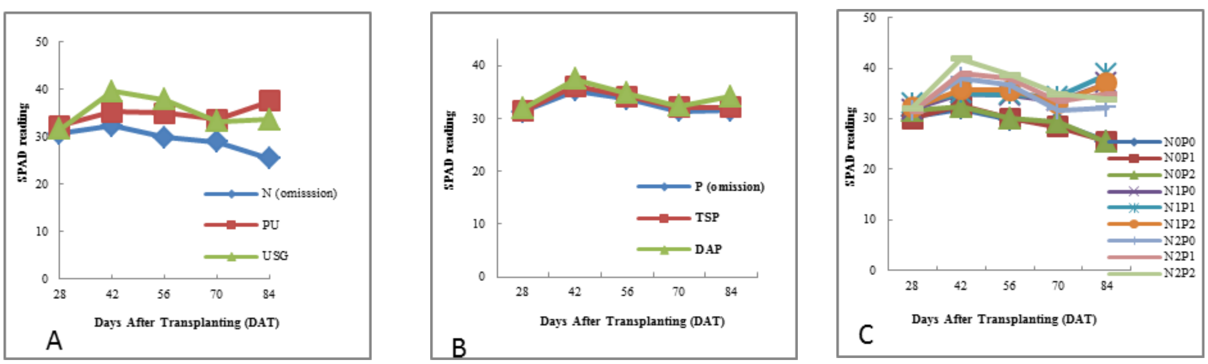

Figure 3. SPAD value as affected by different sources of nitrogen fertilizer (A), phosphorus fertilizer (B) and their combination (C) during dry season, 2017.

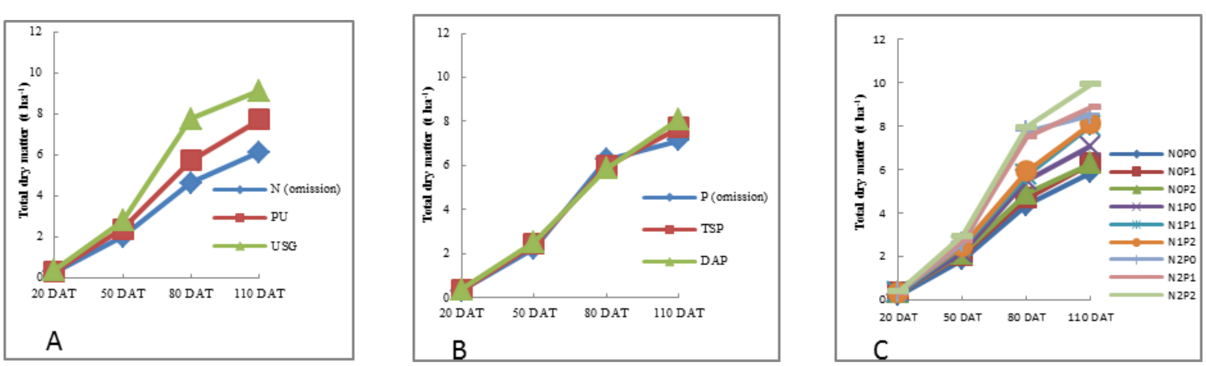

Figure 4. Total dry matter as affected by different sources of nitrogen fertilizer (A), phosphorus fertilizer (B) and their combination (C) during dry season, 2017.

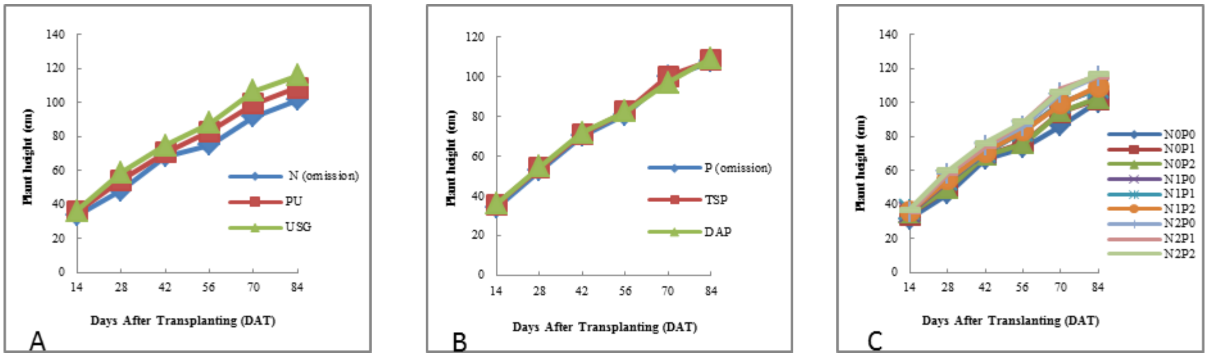

Figure 5. Plant height (cm) as affected by different sources of nitrogen fertilizer (A), phosphorus fertilizer (B) and their combination (C) during wet season, 2017.

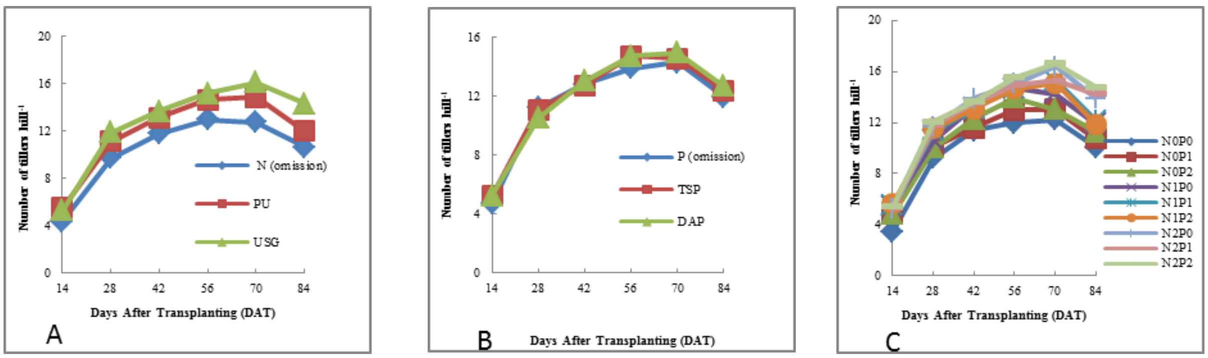

Figure 6. Number of tillers hill^{-1} as affected by different sources of nitrogen fertilizer (A), phosphorus fertilizer (B) and their combination (C) during wet season, 2017.

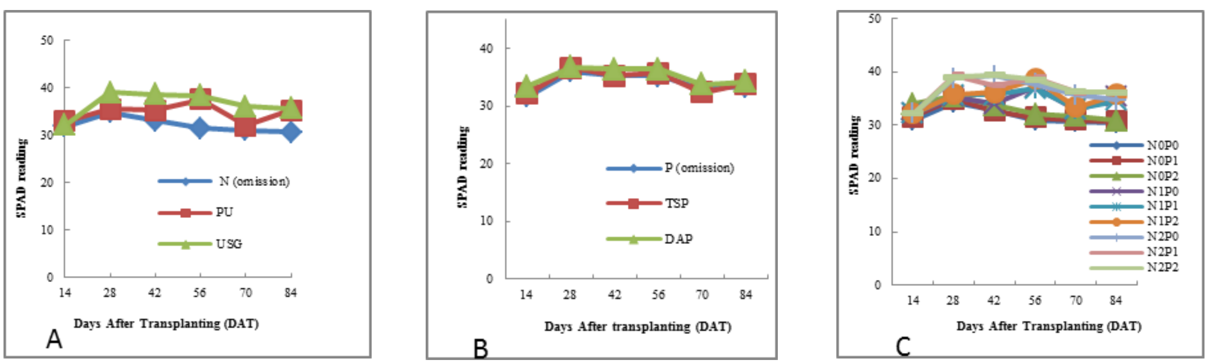

Figure 7. SPAD value as affected by different sources of nitrogen fertilizer (A), phosphorus fertilizer (B) and their combination (C) during wet season, 2017.

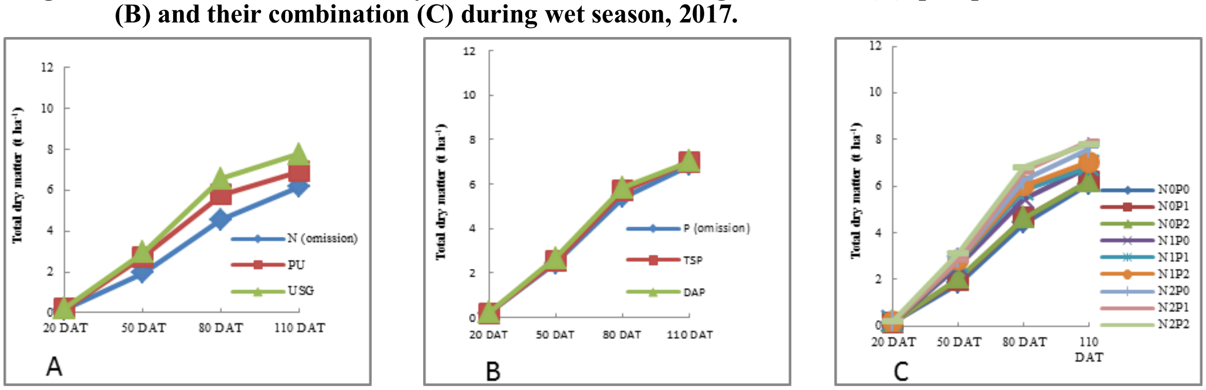

Figure 8. Total dry matter as affected by different sources of nitrogen fertilizer (A), phosphorus fertilizer (B) and their combination (C) during wet season, 2017.

Table 3. Mean values of the different sources of nitrogen and phosphorus fertilizers on yield and yield component parameters in dry and wet seasons, 2017

Treatments		Number of panicles hill^{-1}	Panicle length (cm)	Number of spikelets panicle^{-1}	Filled grain %	1000 grain weight (g)	Grain yield (t ha^{-1})
Experiment I (Dry season)							
Nitrogen (N)							
N_0	N (omission)	12.96 c	20.65 b	127.25 c	74.16 b	20.21	4.68 c
N_1	PU	14.40 b	21.69 a	153.17 b	77.73 a	20.66	5.87 b
N_2	USG	15.53 a	21.63 a	167.92 a	80.31 a	20.69	6.77 a
Pr> F		**	*	**	**	ns	**
LSD $_{0.05}$		0.89	0.84	11.17	2.94	0.53	0.67
Phosphorus (P)							
P_0	P (omission)	13.39 b	20.76 b	146.42	76.32	20.28	5.17 b
P_1	TSP	14.83 a	21.92 a	150.58	77.67	20.57	5.86 a
P_2	DAP	14.67 a	21.29 ab	151.33	78.23	20.71	6.27 a
Pr> F		*	*	ns	ns	ns	**
LSD $_{0.05}$		0.89	0.84	11.17	2.94	0.53	0.67
CV%		7.36	4.66	8.87	4.50	3.08	11.54
Experiment II (Wet Season)							
Nitrogen (N)							
N_0	N (omission)	9.27 c	20.51 b	121.50 c	72.70 b	20.54	3.33 c
N_1	PU	10.37 b	21.13 a	139.93 b	75.96 a	20.65	4.16 b
N_2	USG	12.97 a	21.55 a	152.18 a	78.24 a	21.00	4.84 a
Pr> F		**	*	**	**	ns	**
LSD $_{0.05}$		1.00	0.59	10.45	2.49	0.59	0.55
Phosphorus (P)							
P_0	P (omission)	10.58	20.93	132.79	74.99	20.52	3.86
P_1	TSP	10.87	21.12	139.42	75.77	20.84	4.18
P_2	DAP	11.15	21.19	141.39	76.13	20.84	4.29
Pr> F		ns	ns	ns	ns	ns	ns
LSD $_{0.05}$		1.00	0.59	10.45	2.49	0.59	0.55
CV%		10.95	3.36	8.99	3.90	3.41	15.75

Means followed by the same letter in each column are not significantly different by LSD at 5% level.

ns = no significant, * = significant at 5% level, ** = significant at 1% level significant difference at 5% level in dry and wet seasons (Table 3). In the tested N sources, the highest grain yield (6.92 ton ha^{-1}) and (4.84 ton ha^{-1}) were recorded from USG in dry and wet seasons, respectively. These results were in line with the findings of Hasanuzzaman et al, 2012, they reported that USG produced the highest number of effective tillers $hill^{-1}$, filled grains $panicle^{-1}$ which gave higher grain yield.

In phosphorus fertilizer applications, panicle length and number of panicles $hill^{-1}$ were significant difference in 5% level and grain yield was highly significantly different at 1% level in dry season. Yield and yield component parameters were not different significantly within treatments in wet season (Table 3). Phosphorus applications produced significantly greater yield than P omission treatment in both seasons. Higher grain yield (6.27 t ha^{-1}) was obtained from the application of DAP which was statistically similar to TSP (4.29 t ha^{-1}) in dry season. Although yield and yield components were not significantly different in wet season, higher grain yield was obtained from DAP than TSP fertilizer. These findings were similar to the results of Venugopalan and Prasad, 1989, who stated that different P sources did not affect grain yield in cereals. Although there were no interaction between N and P sources, the best combination was USG + DAP in both seasons.

The application of USG produced higher yield than PU fertilizer by 26% in dry season and 25% in wet season. DAP fertilizer gave greater more yield than TSP fertilizer by 7% and 6% in dry and wet seasons, respectively. Any combined use of N and P fertilizers produced the higher yield than using N or P fertilizer alone in dry season (Table 4).

When PU combined with TSP and DAP, PU with DAP produced 16% higher yield than PU with TSP in dry season but the yield was not different in wet season. When compared PU and USG combination with any tested P sources, the higher yield was obtained by combination with USG than that of PU. When TSP and DAP were combined with any tested nitrogen sources, the combination with DAP gave the higher yield increase than TSP combination. In all treatments, the highest yield increase 82% in dry season and 69% in wet season over control were resulted by the combination of USG and DAP (Table 5).

Nutrient Use Efficiency

In dry season, the results were significantly different in nitrogen use efficiency (NUE) and highly significant in phosphorus use efficiency (PUE) of the treatments. Although they were not significantly different between the NUE of PU and USG, USG gave higher NUE value than PU fertilizer in both seasons. In the case of PUE, DAP fertilizer showed higher in PUE value than TSP fertilizer in both seasons. The combination of tested nitrogen fertilizers with DAP also gave the better NUE in dry season and PUE in both seasons than combination of TSP. Combination of USG with any tested P sources gave the greater NUE and PUE value than that of PU in dry season. Nutrient use efficiencies were superior in combined application of any tested N and P fertilizers when compared with using N or P fertilizer alone. The lowest NUE and PUE were obtained from the application of N and P fertilizers alone (Table 6). It showed that application of N fertilizer without P fertilizer or application of P fertilizer without N fertilizer cannot get the better nutrient use efficiency. Sumner and Farina, 1986 reported that increased plant growth required for more of both N and P that are mutually synergistic effects resulted in growth stimulation and enhanced uptake of both elements.

Conclusion

In both seasons, nitrogen and phosphorus fertilizers produced higher yield components and yield than control treatment. The results indicated that USG significantly increased plant height, total dry matter, number of panicles $hill^{-1}$, number of spikelets $panicle^{-1}$ leading to more yield as compared with PU. The application of USG produced higher grain yield than PU by 26% and 25% in dry and wet seasons, respectively. Higher yield components and grain yield of rice by USG than PU could be due to placement of fertilizer into the root zone of rice which would minimize N losses by denitrification and ammonia volatilization. In the tested source of phosphorus fertilizers, DAP fertilizer produced increased yield by 7% in dry season and 6% in wet season than TSP fertilizer.

. When PU combined with any tested P sources, the combination of DAP resulted not only in higher grain yield than the combination of TSP by 16% in dry season but also in reducing the dosage 25% PU fertilizer. In case of USG combining with any P sources, USG + DAP gave the greater yield by 8% and 5% than USG + TSP in dry and wet seasons respectively. Judging the present observations, it can be concluded that DAP is superior to TSP for

Table 4. Combined effects of different sources of nitrogen and phosphorus fertilizers on yield and yield component parameters in dry and wet seasons, 2017

Treatments	Number of panicles hill^{-1}	Panicle length (cm)	Number of spikelets panicle^{-1}	Filled grain %	1000 grain weight (g)	Grain yield (t ha^{-1})
			Experiment I (Dry season)			
N_0P_0	11.09 d	19.57 b	123.75 d	73.49 c	19.64 b	3.92 e
N_0P_1	13.87 c	21.53 a	128.00 d	74.49 c	20.41 ab	4.92 de
N_0P_2	13.92 c	20.84 ab	130.00 cd	74.49 c	20.57 a	5.20 cd
N_1P_0	14.29 bc	21.25 a	149.25 bc	75.17 bc	20.51 ab	5.28 cd
N_1P_1	14.59 abc	22.24 a	155.50 ab	78.33 abc	20.62 a	5.84 bcd
N_1P_2	14.32 bc	21.57 a	154.75 ab	79.69 ab	20.83 a	6.48 ab
N_2P_0	14.79 abc	21.46 a	166.25 ab	80.29 a	20.69 a	6.33 abc
N_2P_1	16.03 a	21.99 a	168.25 ab	80.17 ab	20.67 a	6.83 ab
N_2P_2	15.78 ab	21.43 a	169.25 a	80.47 a	20.72 a	7.14 a
Pr> F	ns	ns	ns	ns	ns	ns
LSD $_{0.05}$	1.54	1.45	19.34	5.08	0.92	1.15
CV %	7.36	4.66	8.87	4.50	3.08	11.54
			Experiment II (Wet Season)			
N_0P_0	8.55 c	20.45 b	118.60 c	72.67 c	19.89 b	2.96 d
N_0P_1	9.70 bc	20.46 b	120.84 c	72.69 c	20.81 ab	3.44 cd
N_0P_2	9.55 bc	20.62 ab	125.04 bc	72.75 c	20.92 a	3.60 cd
N_1P_0	10.65 b	20.88 ab	130.43 bc	74.34 bc	20.79 ab	3.92 bc
N_1P_1	10.35 b	21.34 ab	140.33 ab	76.79 abc	20.63 ab	4.27 abc
N_1P_2	10.10 bc	21.19 ab	149.03 a	76.75 abc	20.52 ab	4.30 abc
N_2P_0	12.55 a	21.47 ab	149.34 a	77.98 ab	20.87 ab	4.68 ab
N_2P_1	12.55 a	21.58 a	150.10 a	77.83 ab	21.06 a	4.85 a
N_2P_2	13.80 a	21.61	157.10 a	78.91 a	21.07 a	4.99 a
Pr> F	ns	ns	ns	ns	ns	ns
LSD $_{0.05}$	1.74	1.03	18.09	4.31	1.03	0.95
CV %	10.95	3.36	8.99	3.90	3.41	15.75

Means followed by the same letter in each column are not significantly different by LSD at 5% level.

ns= no significant, *= significant at 5% level, **= significant at 1% level

Table 5. Comparison of grain yield percent increase over control during dry and wet season, 2017

Treatments	Yield increase (%)	
	Dry season	Wet season
PU	35	33
USG	61	58
TSP	26	16
DAP	33	22
PU + TSP	49	44
PU + DAP	65	45
USG + TSP	74	64
USG + DAP	82	69

Table 6. Effect of the different sources of nitrogen and phosphorus fertilization on nitrogen use efficiency (NUE) and phosphorus use efficiency (PUE) of rice during dry and wet season, 2017

Treatments	NUE		PUE	
	Dry season	Wet season	Dry season	Wet season
PU	17.07 c	20.34 b		
USG	30.10 c	20.87 b		
TSP			45.47 d	21.63 b
DAP	63.96 a	50.12 a	58.15 cd	45.56 ab
PU + TSP	23.98 c	21.86 b	87.19 bc	79.48 a
PU + DAP	32.04 bc	23.87 b	116.50 ab	75.50 a
USG + TSP	36.40 bc	24.01 b	132.37 a	87.31 a
USG + DAP	52.75 ab	23.79 b	146.20 a	93.25 a
Pr> F	0.0054	0.0549	0.0004	0.0633
$LSD_{0.05}$	21.28	19.10	35.24	50.13
CV%	32.67	40.66	19.84	41.05

PU and USG fertilizers.

In both seasons, the best NUE was obtained by using DAP among treatments and the higher NUE value was obtained from USG than PU fertilizer. Moreover, application of USG with both P sources gave the higher NUE than that of PU in dry season. Even though there was no significant difference, the higher PUE was obtained by using DAP alone or by combining with both nitrogen fertilizers than using TSP. Using the combination of both tested N and P fertilizers gave the greater NUE and PUE that leading to produce the better rice yield than using N or P fertilizer sources alone. The use of USG and DAP fertilizers resulted the best growth parameters, yield components, grain yield, NUE and PUE. It can be concluded that using combination of USG and DAP fertilizers would be a better practice for fertilizer management for Sinthukha rice production.

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