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GROWTH AND YIELD PERFORMANCE OF TIDAL LOCAL AMAN RICE AS INFLUENCED BY USG APPLICATION AT NON TIDAL CONDITION

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Abstract

An experiment was carried out at research field of Bangladesh Rice Research Institute, Gazipur to evaluate the performance of tidal local *aman* rice as influenced by urea super granule (USG) at non-tidal condition. Four tidal local *aman* varieties such as Sadamota, Razashail, Kutiagoni and Kalagura were used as planting materials. Nitrogen was applied as USG (1.8g) at 10 days after transplanting (DAT), 25 DAT, before panicle initiation (BPI) stage (date of PI stage of these 4 varieties were identified from previous experience) and no nitrogen (control). The experiment was laid out in a split-plot design where varieties in main plot and USG in sub-plot with three replications. Varietals response was significant on plant height, effective tillers hill^{-1}, grains panicle^{-1} and grain yield. All the yield and yield components were influenced significantly by the time of USG application. Higher dry matter was produced by all the varieties when USG was applied at early growth stage (10 to 25 DAT) but crop lodges at milking stage due to more vegetative growth resulting increases sterility, decreases grain fertility and yield. On the other hand, when USG was applied at BPI stage grain fertility and yield were increased. The highest grain yield (3.51 t ha^{-1}) was recorded from Kalagura when USG applied before panicle initiation stage. So, application of USG at BPI stage in local *aman* rice in non-tidal condition increased yield resulting higher gross and net return in all varieties.

Introduction

Sustainable rice production is a great challenge for the rice grower under climate change condition. Low productive tidal submergence ecosystem is one of the major unfavorable agro-ecological situations in Bangladesh (Hossain *et al.,* 2002). More than 1.0 million ha of greater Barisal and Patuakhali districts are inundated up to the range of 6-90 cm for about 4-5 months from June to October (BRRI, 2004). *Aman* season (June to November) is one of the major crops growing seasons and farmers cultivate local varieties. High yielding varieties cannot survive under tidal ecosystem. Locally popular traditional varieties like Lothor, Lalpyka, Kutiagoni, Mutha, Razashail, Sada pajam, Lal chikon, Sada chikon Sada muta, Lal muta and Moulata etc. are resistant and perform better in tidal areas. Due to tidal water movement, farmers do not apply fertilizer in *aman* season. It is often impossible to follow recommended practices of nutrient management like nitrogen (N) fertilizer because there is a high risk of surface N losses to tidal water. So, the yield of cultivated local rice varieties is low and it is because of low N concentration in the leaf canopy during grain filling period, early senescence of leaves and low rates of photosynthesis (Cassman *et al.,* 1995). The increase in amount of N at the booting stage may provide sufficient N to rice plants during the late filling stage. High plant N content delays leaf senescence and therefore increases photosynthetic duration (Makino, 2011). The application of N fertilizer has been reported to have a great effect on filling of grain (Juan *et al.,* 2006). It has been reported that the amount and time of nitrogen application had tremendous effects on filling and dry matter accumulation in rice (Mnzava, 2002). Moreover, nitrogen application at PI stage through deep placement of USG (UDP) may escape vegetative growth and this may increase the number of grains panicle^{-1} and better grain filling. Increased application of N fertilizer at flowering stage found to increase the yield of rice (Cassman *et al.,* 1994). Usually, urea super granule (USG) is placed to the rice field at 8-10 days after transplanting that helps to vigorous vegetative growth (Ranjith *et al.,* 2008). Little research has been done on USG deep placement in local rice varieties in tidal areas of Bangladesh. Under the above circumstances, the study was undertaken to evaluate the performance of local *aman* rice varieties in respect of yield and nitrogen use efficiency and to find out suitable time of nitrogen application in local *aman* rice in agro-climate condition of Gazipur.

Materials and methods

The experiment was carried out at Agronomy field of Bangladesh Rice Research Institute, Gazipur during the *Aman* season, 2014. The soil of BRRI farm was clay loam of shallow brown terrace under Madhupur tract (AEZ 28), with pH 6.2 and low in organic matter (1.2%).The experimental field was ploughed with the help of power tiller followed by laddering to get a well puddled condition. A blanket dose of 16, 35, 10 and 1.8 kg ha^{-1} of P, K, S and Zn were applied as triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively at final land preparation. The treatments were, Factor A: Local *aman* varieties, i. Sadamota, ii. Razashail, iii. Kutiagoni and iv. Kalagura; Factor B: Time of USG (1.8g) application at i. 10 DAT, ii. 25DAT, iii. Before Panicle Initiation (BPI) stage and iv. No nitrogen (control).The experiment was laid out in split-plot design assisning varieties in main plot and USG in sub-plot with three replications.Thirty-days-old seedlings were transplanted maintaining 30 cm × 30 cm spacing on 7th August, 2014. Intercultural operation like gap filling was done on 15th August, 2014. Two hand weeding was done on 22nd August and 10th September, 2014. Irrigation water was applied as and when necessary. Data on tillering dynamics, SPAD value, dry matter production, yield and yield components were recorded following standard procedure. Grain yield was adjusted to 14% moisture content. Agronomic efficiency, partial factor productivity and grain yield efficiency index were calculated using following formulae.

i. Agronomic efficiency (AE)

$AE_N = (GY_{+N} - GY_{0N}) / FN$

Where, AE_N = Agronomic efficiency of N; GY_{+N} = Grain yield due to addition of FN; GY_{0N} = Grain yield without addition of N; FN = Amount of N applied (kg ha^{-1}).

ii. Partial factor productivity (PFP)

$PFP_N = GY_{+N} / FN$

Where, PFP_N = Partial factor productivity of N; GY_{+N} = Grain yield due to addition of FN; FN = Amount of N applied (kg ha^{-1}).

iii. Grain yield efficiency index (GYEI)

$$GYEI = \frac{\text{Grain yield in N applied plot}}{\text{Average grain yield for all varieties in N applied plot}} \times \frac{\text{Grain yield in control plot}}{\text{Average grain yield for all varieties in control plot}}$$

Data gathered on different parameters were statistically analyzed and the mean different among the treatments were compared by least significance difference (LSD) test at 5% level of significance.

Results and Discussion

Tiller production (no. hill^{-1})

Tiller production varied in cultivated varieties due to USG application at different times (Table 1). In general, the number of tillers per hill increases with the advance of time upto certain period.

Maximum number of tillers was recorded at 40 to 60 DAT from almost all the studying varieties irrespective of time of USG application. The lowest number of tillers was recorded with var. Kalagura from control plot and the highest from var. Razashail when USG was applied at BPI at 20 DAT of crop. At 40 DAT, there was no significant difference among the varieties in case of tiller production. At 60 DAT, the highest number of tillers per hill was recorded when USG applied at BPI in var. Kalagura. At 80 DAT, highest number of tillers was found from var. Sada mota and Kutiagoni when USG applied at BPI. At 80 DAT, the lowest number of tillers was recorded from the var. Razashail when USG applied at early crop growth stage (10 DAT). Number of tillers per hill is most important component of yield. The decrease in tiller number was attributed to the death of some tillers as a result of their failure in competition for light and nutrients (Fageria *et al.*, 1997). More number of tillers might be due to the more availability of nitrogen that played a vital role in cell division.

Table 1. Variation of tiller/hill production due to interaction of variety and time of USG application at different days after transplanting (DAT) of rice

Time of USG Application	Variety			
	Sada mota	Razashail	Kutiagoni	Kalagura
		20 DAT		
10 DAT	6	7	7	6
25 DAT	6	6	7	6
BPI	7	8	6	7
Control	6	7	7	5
LSD $_{(0.05)}$		NS		
CV (%)		16.3		
		40 DAT		
10 DAT	20	20	19	19
25 DAT	19	20	20	19
BPI	21	21	21	21
Control	18	19	19	18
LSD $_{(0.05)}$		NS		
CV (%)		13.2		
		60 DAT		
10 DAT	18	20	17	21
25 DAT	20	21	19	22
BPI	21	22	20	23
Control	19	19	16	18
LSD $_{(0.05)}$		NS		
CV (%)		12.6		
		80 DAT		
10 DAT	16	15	17	17
25 DAT	20	17	20	19
BPI	21	19	21	20
Cont	14	16	16	15
LSD $_{(0.05)}$		NS		
CV (%)		15.7		

BPI = Before panicle initiation stage

SPAD values

The interaction effect of variety and time of USG application on SPAD value was not significant at 20 DAT (Table 2). The highest SPAD value was recorded with var. Razashail during application of USG at BPI stage and lowest from Kalagura when USG applied during 10 DAT and 20 DAT of rice. At 40 DAT, the highest SPAD value (43.23) was demonstrated from Kalagura from USG application at 10 DAT. The interaction between the variety and the time of USG application was not significant at 40 and 80 DAT. At 60 DAT, the highest SPAD value (43.33) was recorded from Kalagura with USG application at 25 DAT and the lowest (32.93) from the control plot with Sada mota when USG applied at 10 DAT. The var. Sada mota gave the lowest SPAD value and the highest SPAD value from Kalagura when USG applied at 25 DAT and 80 DAT. Hassan *et al.* (2009) reported that SPAD value and nitrogen content showed significant differences under variable nutrient levels and time of urea application.

Table 2. Variation of SPAD values due to interaction of variety and time of USG application at different days after transplanting (DAT) of rice

Time of USG Application	Variety			
	Sada mota	Razashail	Kutiagoni	Kalagura
	20 DAT			
10 DAT	36.40	36.19	35.56	32.53
25 DAT	34.95	34.21	35.26	34.13
BPI	35.94	36.76	36.86	34.20
Control	35.08	35.14	36.16	33.60
LSD $_{(0.05)}$	NS			
CV (%)	4.8			
	40 DAT			
10 DAT	39.30	40.87	39.73	43.23
25 DAT	40.33	42.17	39.67	42.27
BPI	38.67	40.20	43.20	40.33
Control	39.93	40.90	41.83	39.67
$LSD_{0.05}$	NS			
CV (%)	7.0			
	60 DAT			
10 DAT	36.73	37.23	35.67	35.63
25 DAT	34.43	36.73	36.70	37.33
BPI	36.83	34.80	35.03	35.67
Control	32.93	35.10	34.23	34.80
LSD $_{(0.05)}$	2.74			
CV (%)	4.6			
	80 DAT			
10 DAT	33.23	33.40	33.67	36.50
25 DAT	31.13	31.97	33.53	39.30
BPI	33.90	32.13	36.77	36.93
Control	34.20	31.33	35.23	36.40
LSD $_{(0.05)}$	NS			
CV (%)	7.1			

BPI = Before panicle initiation stage

Dry matter production at flowering stage (g m^{-2})

The interaction between variety and time of USG application was not significant statistically for dry matter production DAT (Table 3). Application of USG at 25 DAT produced higher leaf blade dry matter in Kalagure (230.96 g m^{-2}) followed by Sada mota (228.85 g m^{-2}). The lowest dry matter was obtained from Razsahil when USG applied at 10 DAT. On the other hand, Sada mota gave maximum leaf sheath dry matter (256. 52 g m^{-2}) when USG applied at 25 DAT. Stem dry matter was maximum in Kalagura in USG application at 25 DAT and BPI stage. The var. Kutiagoni produced maximum panicle dry matter when USG applied at 25 DAT. The total dry matter was maximum when USG applied at 25 DAT in Kalagura (833.61 g m^{-1}) followed by Sada mota (826.90 g m^{-1}) (Table 3). The lowest dry matter was obtained from Razashail in control plot. Crop attributes such as leaf area index and shoot dry matter were dependent on the applied nitrogen level applied and time of application. The higher growth resulting from increased nitrogen application could be attributed to the effects of nitrogen on cell division and elongation, synthesis of amino acids as well as its impact on some physiological processes favoring growth. Dry matter production exhibited a greater response to late-season application of N (Fageria and Baligar, 2001).

Table 3. Interaction of variety and time of USG application on dry matter production (g m^{-2}) at flowering stage

Time of USG application	Variety			
	Dry matter (g m^{-2})			
	Sada mota	Razashail	Kutiagoni	Kalagura
	Leaf blade			
10 DAT	186.77	86.11	181.15	205.10
25 DAT	228.85	113.80	108.85	230.96
BPI	162.73	92.57	126.23	221.23
Control	159.82	99.50	104.68	180.59
LSD $_{(0.05)}$	NS			
CV (%)	21.2			
	Leaf sheath			
10 DAT	205.70	77.82	140.48	236.03
25 DAT	256.52	72.64	158.38	223.31
BPI	203.12	91.15	133.03	224.36
Control	171.01	82.65	112.36	199.88
LSD $_{(0.05)}$	NS			
CV (%)	25.2			
	Stem			
10 DAT	178.92	135.88	187.86	219.47
25 DAT	221.60	199.14	177.46	271.68
BPI	218.24	150.52	143.14	271.86
Control	151.51	129.75	136.48	220.63
LSD $_{(0.05)}$	NS			
CV (%)	20.5			
	Panicles			
10 DAT	102.65	95.85	141.62	116.75
25 DAT	146.93	117.79	180.23	107.64
BPI	136.23	118.96	197.58	113.50
Control	129.23	83.324	155.10	115.11
LSD $_{(0.05)}$	NS			
CV (%)	18.7			
	Total			
10 DAT	674.06	395.66	669.38	777.37
25 DAT	826.90	503.38	677.32	833.61
BPI	754.96	453.21	606.50	790.96
Control	611.28	395.13	509.55	716.23
LSD $_{(0.05)}$	NS			
CV (%)	15.4			

BPI = Before panicle initiation stage

Crop lodging at milking stage

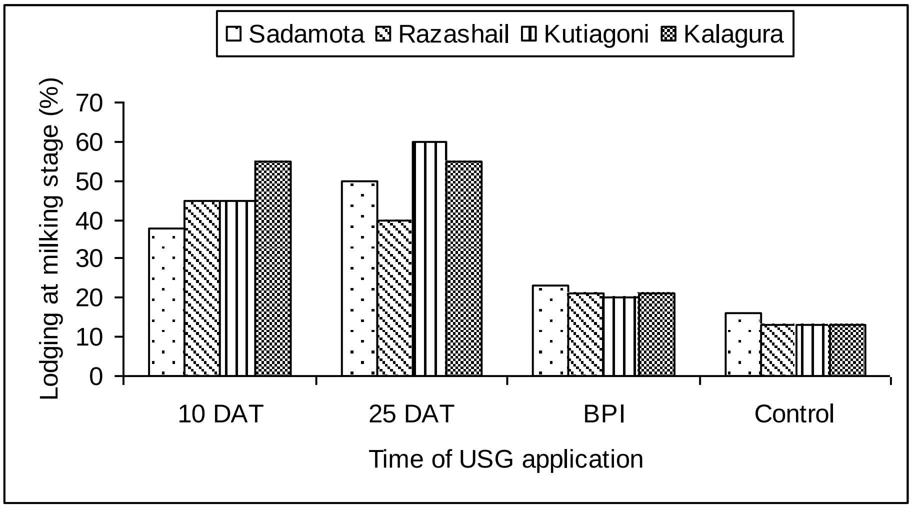

Fig. 1. Variation of crop lodging at milking stage due to interaction of variety and time of USG application

All varieties were lodged at milking stage. The lodging was the maximum when USG applied at 10 and 25 DAT but more than 40 % plant lodged at 10 and 25 DAT but less than 20% plant lodged when USG applied at BPI stage (Fig. 1).

Yield and yield contributing characters

Variation of 1000 - grain weight, grains panicle^{-1}, panicle m^{-2}, grain yield was not statistically significant (Table 4) due to interaction of variety and time of USG application. Numerically, 25 DAT of Sada mota gave the highest 1000-grain weight (33.20g) followed by the BPI of Sada mota (32.29) whereas lowest from the control plot of var. Kutiagoni. The number of grains per panicle varied from 83 to 135 where maximum number of grains per panicle (135) was found from Kutiagoni at 10 DAT followed by Kutiagoni at BPI but var. Kalagura and 10 DAT combinations showed the least number of grains per panicle (83). The maximum number of panicle per m^{-2} (201) was recorded from Kalagura at 10 DAT followed by Kalagura 25 DAT (193) whereas lowest from control plot of var. Kutiagoni (112). The number of panicles per unit area depends on environmental conditions during tiller bud initiation and subsequent development stages. Grain yield varied from 2.23 to 4.02 t ha^{-1} where BPI of var. Kalagura gave the maximum yield (4.02 t ha^{-1}) followed by BPI of Sada mota (3.90 t ha^{-1}). Control plot of Razashail yielded the lowest grain yield (2.23 t ha^{-1}). The variation in grain yield with nitrogen fertilization varied from 66 to 93% depending on genotypes (Fageria *et al.*, 2004). It was found that application of nitrogen improves various crop parameters like 1000- grain weight, more productive tillers and grain yield thus resulting in higher yields (Chaturvedi, 2005).

Agronomic efficiency

Agronomic efficiency was significantly varied due to interaction of variety and time of USG application (Table 5). Agronomic efficiency varied from 20.88 to 49.75.The maximum agronomic efficiency (49.75) was recorded from Kalagura during BPI stage followed by agronomic efficiency (44.03) Kutiagoni at BPI while the lowest agronomic efficiency (20.88) from Sada mota during 10 DAT (Table 5). Agronomic efficiency in low land rice in the tropics to be in the range of 15 to 25 kg grain produced per kg of applied N (Yoshida, 1981).

Table 4. Interaction of variety and time of USG application on yield and yield components of rice

Time of USG Application	Variety			
	1000-grain weight (g)			
	Sada mota	Razashail	Kutiagoni	Kalagura
10 DAT	29.58	25.83	26.71	30.35
25 DAT	33.20	24.17	29.28	27.23
BPI	32.29	26.36	27.51	27.27
Control	30.40	25.04	23.75	26.20
LSD $(_{0.05})$	NS			
CV (%)	9.2			
	No of grains panicle^{-1}			
10 DAT	105	97	135	83
25 DAT	96	86	102	97
BPI	113	91	126	117
Control	95	85	106	94
LSD $(_{0.05})$	NS			
CV (%)	15.3			
	No of panicle m^{-2}			
10 DAT	129	182	148	201
25 DAT	142	175	163	193
BPI	152	150	154	190
Control	125	125	112	140
LSD $(_{0.05})$	Ns			
CV (%)	12.7			
	Grain yield (t ha^{-1})			
10DAT	3.39	3.36	3.18	3.75
25 DAT	3.67	3.32	3.60	3.69
BPI	3.90	2.97	3.79	4.02
Control	2.78	2.23	2.51	2.57
LSD $(_{0.05})$	NS			
CV (%)	7.5			

DAT = Days after transplanting, BPI = before panicle initiation stage,

Table 5. Variation of agronomic efficiency due to interaction of variety and time of USG application

Time of USG Application	Variety				
	Agronomic efficiency				
	Sada mota	Razashail	Kutiagoni	Kalagura	Average
10 DAT	20.88	38.81	23.00	40.46	30.78
25 DAT	30.57	37.34	37.48	38.34	35.93
BPI	38.44	25.36	44.03	49.75	39.39
Average	29.96	33.84	34.84	42.85	
LSD $(_{0.05})$					
Variety (V)	8.86				
Treatments (T)	NS				
`V × T	15.36				
CV (%)	25.1				

DAT = Days after transplanting, BPI = Before panicle initiation stage,

Partial factor productivity

The partial factor productivity was the highest with Kalagura variety when USG applied BPI and the lowest from Razashail when USG applied at 10 DAT (Table 6). Matsuo *et al.* (1995) reported that the partial factor productivity for rice straw is high in the early growth stages and reaches the peak more quickly if more N is provided. Matsuo *et al.* (1995) also reported that the extent of nitrogen's contribution to rice yield correspond to the development of the growth pattern of the rice plant.

Table 6. Effect of time of urea super granule application on partial factor productivity of rice.

Time of USG Application	Variety				
	Partial factor productivity				
	Sada mota	Razashail	Kutiagoni	Kalagura	Average
10 DAT	116.67	115.71	109.46	129.07	117.74
25 DAT	126.38	114.29	123.95	126.95	122.89
BPI	134.20	102.30	130.42	138.35	126.35
Average	125.77	110.78	121.30	131.46	
LSD $_{(0.05)}$					
Variety (V)		8.86			
Treatments (T)		NS			
V × T		15.35			
CV (%)		7.3			

DAT = Days after transplanting, BPI = Before panicle initiation stage,

Cost and return from the application of USG at different time

Cost for applying USG was varied from Tk. 4075.0 to Tk. 4425.0 ha^{-1} (Table 7). At the time of USG application during 10DAT, it required 7 labors @ Tk. 350.0 day^{-1}and 65.0 Kg USG @ Tk.25 kg^{-1} and the total cost was Tk. 4075.0 ha^{-1}. At 25DAT and BPI one additional labor was needed. So, the cost was Tk. 4425.0 ha^{-1} during 25DAT and BPI. But there was no cost in control plot for USG application. The highest gross return was obtained from BPI by Tk.73110.0 ha^{-1}followed by 25 DAT and 10 DAT. The lowest gross return Tk. 52660.0 ha^{-1} was found from control plot.Net return of 10DAT, 25DAT and BPI was Tk. 64505.0, Tk. 66965.0 and Tk. 68685.0 ha^{-1}, respectively. The highest profit over control was Tk. 16025.0 ha^{-1} from BPI followed by 25 DAT and 10 DAT.

Table 7. Cost and return from the application of USG at different time

Items	Time of USG application			
	10 DAT	25 DAT	BPI	Control
Amount of urea (kg. ha^{-1})	65	65	65	0
Cost of urea (Tk. ha^{-1})	1625.00	1625.00	1625.00	0.00
Labor needed for fertilizer application (man-day)	7	8	8	0.00
Labor cost (Tk. ha^{-1})	2450.00	2800.00	2800.00	0.00
Total cost (Tk. ha^{-1})	4075.00	4425.00	4425.00	0.00
Grain yield (tha^{-1})	3.42	3.57	3.67	2.52
Return from yield (Tk. ha^{-1})	58140.00	60690.00	62390.00	42840.00
Straw yield (tha^{-1})	5.22	5.35	5.36	4.91
Return from straw (Tk. ha^{-1})	10440.00	10700.00	10720.00	9820.00
Gross return (Tk. ha^{-1})	68580.00	71390.00	73110.00	52660.00
Net return (Tk. ha^{-1})	64505.00	66965.00	68685.00	52660.00
Profit over control (Tk. ha^{-1})	11845.00	14305.00	16025.00	

Cost of urea = Tk. 25.00 Kg^{-1}, Labor cost = Tk. 350.00 Man-day^{-1}, Paddy price = Tk.17.00 Kg^{-1}, Straw price = Tk. 2.00 kg^{-1}.

Cost and return from different local *aman* varieties

Total cost was the same for four varieties that was Tk. 4075.0 ha^{-1}. The highest gross return was obtained from Kalagura by Tk. 72870.0 ha^{-1}followed by Sada mota and Kutiagoni (Table 8). The lowest gross return by Tk. 58050.0 ha^{-1} was found from Razashail. Net return of different varieties varied from Tk. 53975.0 ha^{-1} to Tk. 68795.0 ha^{-1}. The highest net return was obtained from Kalagura by Tk. 68795.0 ha^{-1} followed by Sada mota and Kutiagoni. The lowest net return by Tk. 53975.0 ha^{-1} was found from Razashail (Table 8). Inspite of the same cost the net return was highest in case of Kalagura because of its higher yield.

Table 8. Cost and return from different local *aman* vareties

Items	Variety			
	Sada mota	Razashail	Kutiagoni	Kalagura
Amount of urea (kg. ha^{-1})	65	65	65	65
Cost of urea (Tk. ha^{-1})	1625.00	1625.00	1625.00	1625.00
Labor needed for fertilizer application (man-day)	7	7	7	7
Labor cost (Tk. ha^{-1})	2450.00	2450.00	2450.00	2450.00
Total cost (Tk. ha^{-1})	4075.00	4075.00	4075.00	4075.00
Grain yield (tha^{-1})	3.43	2.97	3.27	3.51
Return from yield (Tk. ha^{-1})	58310.00	50490.00	55590.00	59670.00
Straw yield (tha^{-1})	5.59	3.78	4.87	6.60
Return from straw (Tk. ha^{-1})	11180.00	7560.00	9740.00	13200.00
Gross return (Tk. ha^{-1})	69490.00	58050.00	65330.00	72870.00
Net return (Tk. ha^{-1})	65415.00	53975.00	61255.00	68795.00

Cost of urea = Tk. 25.00 kg^{-1}, Labor cost = Tk. 350.00 $Man\text{-}day^{-1}$, Paddy price = Tk.17.00 kg^{-1}, Straw price = Tk. 2.00 kg^{-1}.

Selection of N efficient varieties

The highest grain yield efficiency index (GYEI) was obtained from the variety Kalagura (Table 9). The GYEI value of Kalagura is 1.10 followed by Sada mota (1.01). The grain yield efficiency index of cultivated varieties Razashail and Kutiagono were 0.80 and 0.99, respectively.

Table 9. Grain yield efficiency index local *aman* varieties

Varieties	Yield in N treated plot	Average	Yield in control plot	Average	GYEI
Sada mota	3.65	3.55	2.50	2.52	1.01
Razashail	3.22		2.23		0.80
Kutiagoni	3.52		2.51		0.99
Kalagura	3.82		2.57		1.10

GYEI: Grain yield efficiency index

Conclusion

From the findings of this experiment it may be concluded that the var. Kalagura was found most efficient varieties in respect of yield and nitrogen use efficiency. Application of N through USG before panicle initial stage increased grain fertility and yield. So, application of USG before panicle initiation stage might be recommended for increased yield and higher net return in cultivating local *aman* rice varieties.

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