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Evaluation of controlled release compound fertilizer on T. Aus rice

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ABSTRACT

A field experiment was conducted at Central Research Farm, Maona, Shreepur, Gazipur of Advanced Chemical Industries (ACI) Limited, Bangladesh during Aus season 2016 to evaluate the efficacy of controlled release compound fertilizer as a slow released Nitrogen fertilizer for crop production. Two types of NPK compound fertilizer viz. 28-6-7 and 22-8-12 were compared with the straight and ACI mixed fertilizer in this study. The experiment was laid out in a randomized complete block (RCB) design with three replications. The individual plot-size was 5m x 4m. Six treatments were included in this study. Results revealed that the tested slow release controlled compound fertilizer NPK (22-8-12), which was used once as basal, produced the similar level of grain yield with our traditional use of fertilizers. The Benefit Cost Ratio (BCR) of 20.36 was obtained with T_6= N-P-K-S@ 63-10-29-10 kg/ha (tested material), which was superior to T_4= N-P-K-S@ 60-10-30-10 kg/ha (traditional practice) (17.30).

Introduction

Crop yield reductions are strongly related with soil productivity degradation, particularly nutrient depletions (Roy *et al*., 2003), which can be attributed to either insufficiency or imbalanced use of fertilizers (Tan *et al*., 2005). The rate and types of fertilizers used depend on a farmer's financial ability and choice often made without considering indigenous supply capacities of soils under variables agro ecological zone (AEZ) of Bangladesh. Besides, being cheaper and prompt visible response of Nitrogen fertilizer than Phosphate and Potash fertilizers, farmers apply more Nitrogenous fertilizer for rice production (Biswas *et al*., 2004) and thus create nutrients imbalance in many cases. The imbalanced fertilizer use in Bangladesh agriculture is speeding up nutrients depletion (Panaullah *et al*. 2006; Rijpma and Islam, 2015), which becomes a major problem in rice production.

Applying proper doses of major fertilizers and adopting improved management practices can increase yield of crops. Nitrogen is the most limiting nutrient for crop production in Bangladesh and in many parts of the world (Fageria and Baligar, 2005). Besides, use efficiency of nitrogen is only about 30-40% and the rest is lost as leaching, volatilization, surface runoff, and denitrification (Fageria and Baligar, 2001) and thus responsible for environmental pollution. So, scientists are trying to improve use efficiency of Nitrogen by adopting different means like neem coating, deep placement, use of growth promoters etc. Selection of a fertilizer depends on supplying capability of nutrients to rice plants at right time and optimal amount based on crop demand, capability to increase yield and to reduce nutrient losses to the environment.

It is necessary to determine an appropriate type of fertilizer for rice cultivation that can help in minimizing environmental pollution. In many countries, like China, Japan, Korea and many developing countries use the controlled release compound fertilizer as a slow released Nitrogenous fertilizer for crop production. Controlled release compound fertilizers are Polymer Coated Fertilizer (PCF) with advanced granule-coating techniques; the granules of compound fertilizers are coated with a biodegradable polymer material to achieve predictable release of the nutrients. In Bangladesh context, it is a newly approach. ACI limited, a renowned company imported this fertilizer in Bangladesh as a test material for research purpose. We have taken a study to evaluate the performance of compound fertilizer viz. 28-6-7 and 22-8-12 on transplanted Aus rice cultivation.

Materials and Methods

The field experiment was conducted during transplanted Aus season 2016 under the supervision of ACI fertilizer team at Central Research Farm,

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Maona, Shreepur, Gazipur, of Advanced Chemical Industries (ACI) Limitted, Bangladesh. The initial soil properties of the research field were presented in Table 1.

The soil texture is silty-loam. The soil has the strongly acidic reaction having deficient (low) N, P and S level. The chemical composition of applied fertilizer NPK (22-8-12) is given in Table 2. The experiment was laid out in a randomized complete block (RCB) design with three replications. The individual plot-size was 5m x 4m. Six treatments were included in this study. These were as follows: T_1= Absolute control (No fertilizer); T_2*= N-P-K-S@ 42-4-9-10 kg/ha from the compound fertilizer (28-6-7) as basal only (Recommended by producer); T_3*= N-P-K-S@ 56-5-12-10 kg/ha from the compound fertilizer (28-6-7) as basal only; T_4= N-P-K-S@ 60-10-30-10 kg/ha from the straight fertilizer as usual (Recommended by BRRI); T_5= N-P-K-S@ 60-10-30-10 kg/ha from the ACI mixed fertilizer (8-20-14-5) as usual and T_6= N-P-K-S@ 63-10-29-10 kg/ha from the compound fertilizer (22-8-12) as basal only.

Nitrogen (N) from compound fertilizer in T_2, T_3 and T_6 was applied once as basal only. In T_4 and T_5 nitrogen was applied in three equal splits from urea: one third as basal, one third at active tillering stage and the rest one third at 7 days before panicle initiation (PI) stage. All treatments had received a blanket dose of S @ 10 kg /ha from gypsum. All fertilizers except urea were applied as basal at final land preparation.

Table 1: Initial soil properties of the experimental field (AEZ-28)

Parameters	Value	Interpretations
Texture	Silty-loam (sand-23%, silt-54%, clay-23%)	-
pH	5.2	Strongly acidic
Organic matter (%)	1.82	Medium
Total N (%)	0.09	Low
Available P (ppm)	11.77	Low
Exchangeable K (meq/100 g soil)	0.41	High
Available S (ppm)	14.82	Low
Available B (ppm)	0.38	Medium
Available Zn (ppm)	2.76	Very high

N.B. Soil analysis was done in Central Lab of Soil Resource Development Institute (SRDI), Bangladesh

Table 2: Physical and chemical properties of the slow controlled release compound fertilizer (NPK 22-8-12)

Appearance	Granular in blue, red, gray color
Solubility	Soluble in water. 111g/L (20°C)
Total N	22(%)
Nitrogen in 3 months	4(%)
Nitrogen in 2 months	5(%)
Nitrogen in 10 days	13 (%)
Phosphorus (P_2O_5)	8 (%)
Potassium (K_2O)	12(%)

Twenty four days old seedlings of BRRI dhan48 were transplanted on 2nd week of May, 2016. Irrigation, weeding and other cultural management practices were done equally as per needed. At panicle initiation stage, randomly four hills from the corner of each plot were collected for growth parameter study. At maturity the crop was harvested manually from an area of 5 m^2 at the centre of the plot for grain yield, however, 16 hills from each plot were harvested at the ground level for straw yield data. The grain yield was recorded at 14% moisture content and straw yield as oven dry basis. Number of tiller per plant, shoot and root length, shoot and root dry matter yield at panicle initiation stage and at maturity stage, plant height, number of panicle per square meter, panicle length, % sterility, % filled grain, grain per panicle and 1000 grain weight were also recorded. All the obtained data were analyzed statistically with the software Crop Stat 7.2 version.

Result and Discussion

Root and shoot length, shoot dry matter yield at panicle initiation stage were significantly influenced by the application of different types of fertilizer; whereas number of tiller/meter square and root dry matter yield didn’t vary significantly (Table 3).

Table 3: Effect of fertilizers on the growth parameters of transplanted Aus rice (BRRI dhan 48) at panicle initiation stage at ACI Central Research Farm, Maona, Shreepur, Gazipur (AEZ-28)

Treatments	**Number of tiller/m^2**	**Root length (cm)**	**Shoot length (cm)**	**Root dry matter yield (g/ m^2)**	**Shoot dry matter yield (g/ m^2)**
T_1= Absolute control (No fertilizer)	444	18.5 ab	88.1 b	51.2	381.1 c
T_2*= N-P-K-S@ 42-4-9-10 kg/ha from the compound fertilizer[a] (28-6-7) as basal only	485	19.6 ab	94.8 ab	68.9	409.7 bc
T_3*= N-P-K-S@ 56-5-12-10 kg/ha from the compound fertilizer[a] (28-6-7) as basal only	421	18.5 ab	91.8 ab	80.2	394.9 c
T_4= N-P-K-S@ 60-10-30-10 kg/ha from the straight fertilizer as usual (Recommended by BRRI)	475	20.4 a	95.8 a	72.3	456.6 ab
T_5= N-P-K-S@ 60-10-30-10 kg/ha from the ACI mixed fertilizer (8-20-14-5) as usual	465	17.1 b	97.0 a	69.8	449.2 b
T_6**= N-P-K-S@ 63-10-29-10 kg/ha from the compound fertilizer[a] (22-8-12) as basal only	481	19.9 a	97.9 a	78.2	503.6 a
LSD $_{0.05}$	-	2.8	7.2	-	56.2
Significant level	NS	*	*	NS	*
CV (%)	9.6	8.1	4.2	19.3	7.1

[a] Polymer Coated Fertilizer (PCF)- the granules of compound fertilizers are coated with a biodegradable polymer material to achieve predictable release of the nutrients

In T_2 and T_3 treatments N P K has been applied from the compound fertilizer (28-6-7) at the rate of 150 and 200 kg/ha, respectively at one time as basal only. Sulphur (S) has been applied from gypsum

[**]In T_6 treatment N P K has been applied from the compound fertilizer (22-8-12) at the rate of 286 kg/ha at one time as basal only. Sulphur (S) has been applied from gypsum

In a column, the figures having the same letter (s) do not differ significantly at 5% level.

*NS= Not Significant, *= Significant at 5 % level*

The shortest root length (17.1 cm) was observed in the treatment of ACI mixed fertilizer (T5), which was statistically identical to the treatments T1, T2 and T3. The longest root length (20.4 cm) was observed in the treatment T_4 i.e N-P-K-S@ 60-10-30-10 kg/ha from the straight fertilizer as usual (Recommended by BRRI) which was followed by T_6 (19.9 cm.). The longest shoot length (97.9 cm) was obtained from the application of N-P-K-S@ 63-10-29-10 kg/ha from the compound fertilizer (22-8-12) as basal only, which was statistically at par to other treatments (T_2- T_5). The shortest shoot length (88.1 cm.) was obtained from the absolute control where no fertilizer was applied (Table 3). The highest shoot dry matter yield (503.6 g/m^2) was observed in the treatment T_6, which was statistically at par to the treatment T_4. The lowest shoot dry matter yield (381.1 g/m^2) was observed in the treatment T_1 (Table 3). A general view of the experimental field at maturity stage is shown in figure 1. The effect of different fertilizers on the vegetative growth of BRRI dhan 48 at panicle stage is shown in figure 2.

Figure 1: A general view of theexperimental field at maturity stage

Figure 2: Effect of different fertilizers on the vegetative growth of BRRI dhan-48 at panicle

Table 4: Effect of fertilizers on the growth parameters, grain and straw yield of transplanted Aus rice (BRRI dhan 48) at maturity stage, ACI Central Research Farm, Maona, Shreepur, Gazipur (AEZ-28)

Treatments	Plant height (cm)	No. of tiller/m^2	No. of panicle /m^2	Panicle length (cm)	No. of Spikelet/panicle	% un-filled grain	1000 grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
T_1=Absolute control (No fertilizer)	109.2 c	232	207	25.9	188	20.8	21.0 abc	4.21 b	4.35 b
T_2*=N-P-K-S@ 42- 4-9-10 kg/ha from the compound fertilizer[a] (28-6-7) as basal only	121.2 a	269	254	25.8	181	21.3	20.7 bc	4.89 a	5.26 a
T_3*= N-P-K-S@ 56-5-12-10 kg/ha from the compound fertilizer[a] (28-6-7) as basal only	115.6 b	250	227	26.6	193	20.1	20.6 c	4.85 a	4.27 b
T_4= N-P-K-S@ 60-10-30-10 kg/ha from the straight fertilizer as usual (Recommended by BRRI)	121.4 a	287	262	25.3	171	19.5	21.7 a	5.17 a	5.49 a
T_5= N-P-K-S@ 60-10-30-10 kg/ha from the ACI mixed fertilizer (8-20-14-5) as usual	120.7 a	272	245	25.7	180	21.1	21.6 a	5.06 a	5.49 a
T_6**= N-P-K-S@ 63-10-29-10 kg/ha from the compound fertilizer[a] (22-8-12) as basal only	121.3a	282	267	26.1	179	21.5	21.4 ab	5.01 a	5.28 a
$LSD_{0.05}$	4.2	-	-	-	-	-	0.70	0.36	0.61
Significant level	**	NS	NS	NS	NS	NS	*	**	**
CV (%)	2.0	9.7	10.8	2.1	5.8	15.8	1.8	4.0	6.7

[a]Polymer Coated Fertilizer (PCF)- the granules of compound fertilizers are coated with a biodegradable polymer material to achieve predictable release of the nutrients

***In T_2 and T_3 treatments N P K has been applied from the compound fertilizer (28-6-7) at the rate of 150 and 200 kg/ha, respectively at one time as basal only. Sulphur (S) has been applied from gypsum*

[**]In T_6 treatment N P K has been applied from the compound fertilizer (22-8-12) at the rate of 286 kg/ha at one time as basal only. Sulphur (S) has been applied from gypsum

In a column, the figures having the same letter (s) do not differ significantly at 5% level.

*NS= Not Significant, *= Significant at 5 % level, **= Significant at 1 % level of significance*

Plant height, 1000 grain weight, grain and straw yield at maturity stage were significantly influenced by the application of different types of fertilizer; whereas tiller and number of panicle/m^2, panicle length, number of spikelet/panicle and percent unfilled grain did not vary significantly (Table 4). The shortest plant (109.2 cm.) was observed in the control plot (T_1), where no fertilize was applied. The longest plant was observed in the treatment T_4, which was statistically identical to the treatments T_2, T_5 and T_6. The highest 1000 grain weight (21.7 g) was observed in the treatment T_4, which was statistically identical to the treatments T_5 and T_6. The lowest 1000 grain weight (20.6 g) was observed in the treatment T_3.

The highest grain yield (5.17 t/ha) was observed in the treatment T_4, which was statistically identical to the treatments T_2, T_3, T_5 and T_6. The tested material treatment T_6 i.e. NPK (22-8-12) produced 5.01 t/ha grain yield. The lowest grain yield (4.21 t/ha) was observed in the treatment T_1, where no fertilizer was applied. Similar trend was also observed in case of straw yield (Table 4).

Economic analysis

Economic analysis was done considering fertilizer cost, fertilizer application cost and labor cost, additional product and by-products due to fertilizer application. The estimated total variable cost (TVC), gross return, net additional income and benefit cost ratio (BCR) are presented in Table 5. Application of all kinds of fertilizer increased gross return and net additional income (Table 5). Gross return from the control plot was only about Tk. 1,14,370 ha^{-1}. Application of nutrients increased gross return ranging from Tk. 1,28,050 ha^{-1} in T_3 to Tk. 1,41,190 ha^{-1} in T_4. The highest net additional income of Tk. 1,33,476 ha^{-1} was obtained with T_4 followed by T_5 (Tk. 1,31,188 ha^{-1}) and T_6 (1,30,223 ha^{-1}). An economic indicator for the farmer to determine the profitability of using fertilizer products is the benefit cost ratio (BCR). The minimum profitability is fixed normally at a BCR of 2. However, under more risky conditions, e.g. under tropical and sub-tropical farming conditions, the BCR should be at least of 3 (Trenkel, 1993). The BCR of 20.36 was obtained with T_6 (tested material), which was superior to T_4 (traditional practice) (17.30).

Table 5: Yield and economy of different NPKS compound*/mixed fertilizers for transplanted Aus rice production at ACI Central Research Farm, Maona, Shreepur, Gazipur

Treatment	Yield (t ha^{-1}) (BRRI dhan29)		Gross return** (Tk ha^{-1})	TVC* (Tk ha^{-1})	Net additional Income (Tk ha^{-1})	BCR
	Grain	Straw				
T_1= Absolute control (No fertilizer)	4.21	4.35	114370	0	114370	-
T_2= N-P-K-S@ 42-4-9-10 kg/ha from the compound fertilizer[a] (28-6-7) as basal only	4.89	5.26	133880	4173	129707	31.08
T_3= N-P-K-S@ 56-5-12-10 kg/ha from the compound fertilizer[a] (28-6-7) as basal only	4.85	4.27	128050	4827	123223	25.53
T_4= N-P-K-S@ 60-10-30-10 kg/ha from the straight fertilizer as usual (Recommended by BRRI)	5.17	5.49	141190	7714	133476	17.30
T_5= N-P-K-S@ 60-10-30-10 kg/ha from the ACI mixed fertilizer (8-20-14-5) as usual	5.06	5.49	138770	7582	131188	17.30
T_6= N-P-K-S@ 63-10-29-10 kg/ha from the compound fertilizer[a] (22-8-12) as basal only	5.01	5.28	136620	6397	130223	20.36

** Total variable cost (TVC) included fertilizer cost (chemical fertilizer), fertilizer application cost and labor cost for additional product*
*Price (Taka/kg): Urea = 16.00; TSP=25.00; MP = 15.00; Gypsum = 9.00; Labor wage rate = Tk.300 day^{-1} **Price (Taka kg^{-1}): Paddy = 22.00; straw = 5.00.*
Two additional man-days/ha are required for applying fertilizer and four man-days ha^{-1} for per ton additional products including byproducts.

Conclusion

The tested slow release controlled compound fertilizer NPK (22-8-12), which was used once as basal, produced the similar level of grain yield with our traditional use of fertilizers. The BCR of this treatment T_6 (tested material) was superior to T_4 (traditional practice).

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