Research article

Evaluation of Rates and Forms of Urea Fertilizer for Improved Nitrogen Use Efficiency in Hybrid Maize Cultivation

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Abstract By using different rates and forms of urea fertilizer, the field experiments were carried out at Department of Agricultural Research, Head Quarters, Yezin and Tatkon Agricultural Research Farm, during the monsoon season of 2017. For improving nitrogen use efficiency of Yezin Hybrid Maize-10 variety, four nitrogen fertilizer rates (0, 71.27, 118.78 and 166.29 kg N ha^{-1}) were applied with two forms of nitrogen fertilizer (Briquette urea and Prilled urea). The 4 x 2 factorial arrangements were assigned in the Randomized Complete Block Design with 3 replications in both experimental sites. Mean effects of applied nitrogen rates on seed yield of maize were highly significant in this study. The highest mean values of seed yield resulted with the rate of 166.29 kg N ha^{-1} in Yezin (8.14 t ha^{-1}) and Tatkon (11.69 t ha^{-1}). Although, there was no significant effect from forms of urea fertilizer on seed yield, mean seed yields of Briquette urea were generally higher than those of Prilled urea at the same level of applied N rate in both sites. Non-significant interaction was observed between rate and form of urea fertilizer factors in the variation of hybrid maize seed yield. The similar trend was also observed in comparison of agronomic nitrogen use efficiency (AE) of hybrid maize. The AE mean values of 166.29 kg N ha^{-1} (8.14 and 11.69 t increased seed kg^{-1} N applied) were significantly higher than those of other two rates of applied nitrogen in Yezin and Tatkon, respectively. The significant effect was observed from forms of urea fertilizer on nitrogen recovery efficiency (RE) in both trials. The RE means of Briquette gave 208.58 in Yezin and 631.43 in Tatkon.

Keywords hybrid maize, AE, RE, briquette, prilled, urea fertilizer

INTRODUCTION

Maize is the second most important cereal crop after rice and it is the main feed crop grown in Myanmar. One of the major nutrients limiting maize production is nitrogen. In tropical soil, the potential for loss of fertilizer N is substantial. Poss and Saragoni (1992) found that 36-153 kg N ha^{-1} had leached below the root zone (150 cm) during the growing season. Myers (1988) reported that maize takes up only 20 to 40% of available N during the main 3 to 5 months of the growing season. Nitrogen (N) management studies have been conducted for many years, mainly with the aim of reducing N losses and increasing nitrogen use efficiency (NUE). Improving efficient use of applied nutrients in crop production is a desirable agronomic, economic, and environmental goal. Improving the NUE and increasing agricultural productivity have been the major focus of research

for the last one to two decades. Some of the N management practices are the use of slow- and controlled release fertilizers and improved placement methods, which reduce the emissions of GHG gases from agricultural fields.

Urea deep placement (UDP) is a proven technology in Bangladesh, sub-Saharan African countries, and more recently in Myanmar that can increase the yield of transplanted lowland rice by 15-20 percent with less use of urea (up to 40 percent) compared to broadcast application of urea (IFDC, 2016). In Bangladesh, 15-20 percent increases in maize yields have been achieved with fertilizer deep placement (FDP), while farmers use 15-20 percent less N (IFDC, 2013). Fertilizer deep placement with briquette form is a technology that is now being promoted in Myanmar by Fertilizer Sector Improvement (FSI) Project of International Fertilizer Development Center (IFDC).

OBJECTIVES

The present study aims to investigate the efficient nitrogen fertilizer rate for maize production and to determine the appropriate fertilizer placement method to get high yield.

MATERIALS AND METHODS

The experiments were conducted during monsoon season 2017 at the Department of Agricultural Research, Head Quarters, Yezin (19˚57'N, 96˚16'E, elevation 130.85 m), Tatkon Agricultural Research Station (20˚ 07'N, 96˚ 12'E, elevation 155.25 m). The 4 x 2 factorial arrangements were assigned in the Randomized Complete Block Design with 3 replications in both experimental sites. Used cultivar in the experiment was single-crossed Yezin Hybrid Maize-10. Selected soil chemical and physical characteristics for the two research stations soil are presented in Table 1. The experimental materials were included four nitrogen fertilizer rates (0, 71.27, 118.78 and 166.29 kg N ha^{-1}) were applied with two forms of nitrogen fertilizer (Briquette urea and Prilled urea). The Prilled Urea (PU) is the most common form of urea available in the market and contains 46% nitrogen (N). The Briquette Urea (BU) is manufactured from a physical modification of ordinary urea fertilizer. The International Fertilizer Development Center (IFDC) has developed it. Its nature and properties are similar to that of PU, but its granule size is bigger and condensed in shape containing 46%N. The weight of Briquette used in this study was 1.8 g and 2.7 g. The ordinary triple super phosphate (TSP) 123.5 kg ha^{-1} and Muriate of Potash (MOP) 123.5 kg ha^{-1} were used for source of nutrient at basal for BU treatments (T2, T3 & T4) and N control treatments (T1 & T5). TSP 123.5 kg $ha^{-1}$was applied at basal and three equal split amounts of MOP (123.5 kg ha^{-1}) was used at basal, 21 days and 35 days after sowing for PU treatments (T6, T7 & T8). BU was applied at sowing time inserted into 7-10 cm deep.

Table 1 Physico-chemical properties of experimental soils

Properties	Analytical method	Tatkon	Yezin
Soil texture	Pipette method	Loamy sand	Loamy sand
Sand %		87.85	85.40
Silt %		2.10	6.33
Clay %		10.05	8.26
Soil pH	4A1-1:5 soil: water suspension	6.60	5.90
Available N (mg/kg)	Alkaline permanganate method	73.00	63.00
Available P (mg/kg)	9C-Olsen's P-Malachite green	6.40	15.00
Available K (mg/kg)	1N Ammonium acetate extraction	210.00	183.00
Organic matter (%)	Tyurin's method	2.50	2.20

Each plot comprised of 8 rows with 5 m long and spacing was 0.76 m between row and 0.23 m within plants. The standard procedure for maize was carried out during the crop stand.

Agronomic characteristics and grain yield were recorded. As N fertilizer were applied in different plots at different forms and doses, the use efficiency N was calculated by the formula NUE = (G_{y+N}-Gy_{0N})/FN, where G_{y+N}= grain yield in treatment with N application; Gy_{0N}= grain yield in treatment without N application; FN= amount of fertilizer N applied in kg ha^{-1} (Afroz, 2013). The N uptake by grain and stover was determined from N content and yield data. The recovery efficiency of applied N was calculated by the formula RE= ‰N uptake at N_x - N uptake at N_0/ applied N at N_x. Data analysis was done by using SAS program version 9.1 (SAS Institute 2001) for analysis of variance and mean comparisons.

RESULTS AND DISCUSSION

Nitrogen rates significantly affected yield in Yezin and Tatkon (Table 2). Yield increased with increasing N rates. The highest rate N4 (166.29 kg N ha^{-1}) provided maximum yield (8.14 t ha^{-1} in Yezin and 11.69 t ha^{-1}in Tatkon) which was statistically significant from lower N rates. The lowest value of yield 2.96 t ha^{-1} in Yezin and 9.37 t ha^{-1} in Tatkon was found in the no nitrogen N1 (0 kg N ha^{-1}). It was cleared that nitrogen fertilizer is needed to get better yield in hybrid maize.

Table 2 Mean effect of rate and form of urea fertilizer on seed yield and agronomic efficiency (AE) and recovery efficiency (RE) of hybrid maize during monsoon season of 2017

	Seed yield (t ha^{-1})		AE (N) (t increased seed kg^{-1} N applied)		Recovery efficiency(N)	
N rate (kg ha^{-1})	Yezin	Tatkon	Yezin	Tatkon	Yezin	Tatkon
0	2.96 ^{c}	9.37 ^{c}	-	-	-	-
71.27	6.09 ^{b}	10.68 ^{b}	6.05 ^{b}	10.55 ^{b}	154.73^{c}	579.85^{b}
118.78	6.36 ^{b}	10.46 ^{b}	6.33 ^{b}	10.39 ^{b}	194.87^{b}	627.32^{a}
166.29	8.14 ^{a}	11.69 ^{a}	8.12 ^{a}	11.63 ^{a}	234.29^{a}	540.95^{c}
$LSD_{0.05}$	0.61	0.7 9	0.53	0.81	7.23	36.58
Form of Urea (F)						
Briquette	5.99 ^{a}	10.75 ^{a}	6.98 ^{a}	11.14 ^{a}	208.58^{a}	631.43^{a}
Prilled	5.78 ^{a}	10.35 ^{a}	6.69 ^{a}	10.57 ^{a}	180.68^{b}	533.98^{b}
$LSD_{0.05}$	0.43	0.79	0.44	0.66	5.90	29.87
Pr>F						
N	< 0.0001	0.0002	< 0.0001	0.0133	< 0.0001	0.0013
F	0.3230	0.1481	0.1766	0.0832	< 0.0001	< 0.0001
N x F	0.7025	0.4264	0.5194	0.4700	0.0014	0.0240
CV (%)	8.39	6.02	6.07	5.81	2.89	4.87

Means having similar letter(s) do not differ significantly whereas means having dissimilar letter(s) differ significantly as per DMRT at 5% level, LSD: Least Significant Different, CV: Coefficient of variation

Form of nitrogen fertilizer application (Briquette urea and Prilled urea) on yield was not statistically significant in both trials (Table 2). The briquette urea treated plots were gained more value in yield than Prilled urea treated plots in both locations. Nair and Singh, 1974 and Misra et al., 1994 pointed that split N of Prilled urea provided yield and its components especially when the last split was scheduled near the phase with high N demand could have more likelihood of being deposited in sink than in other vegetative organs helping development of sink and ultimately the yield parameters. The results pointed that briquette form of urea application at once in basal could also behave as split prilled N application.

The effect of interaction between nitrogen fertilizer rate and form of nitrogen fertilizer application was not significantly on yield in both trials. The interaction of N4 (166.29 kg N ha^{-1}) with briquette form of urea gave the highest yield (8.28 t/ha) in Yezin (Fig. 1) and 12.03 t ha^{-1} in Tatkon (Fig. 2). At the same fertilizer rates, briquette form of application intended to increase yield in both locations.

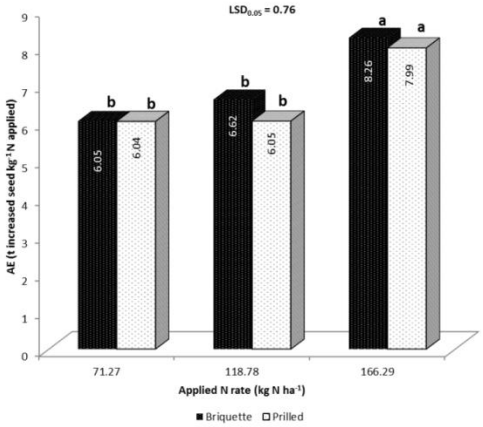

Fig. 1 Mean seed yields as affected by the different rates and forms of nitrogen fertilizer at Yezin Agricultural Research Farm during monsoon season 2017

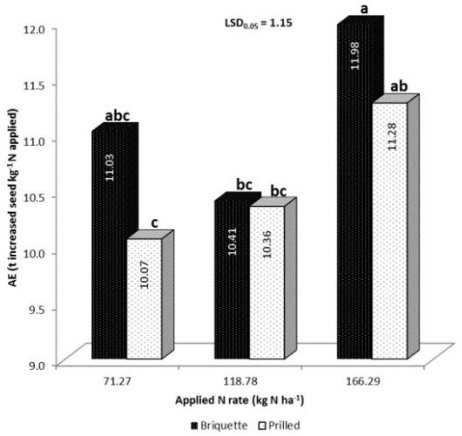

Fig. 2 Mean seed yields as affected by the different rates and forms of nitrogen fertilizer at Tatkon Agricultural Research Farm during monsoon season 2017

The nitrogen fertilizer rate significantly affected agronomic nitrogen use efficiency (AE), and nitrogen recovery efficiency (RE) in both trials. With increasing N rates AE and RE also increased in Yezin Trial (Table 2). The AE consistently increased with increase in nitrogen rates. The highest N rates (N4, 166.29 kg N ha^{-1}) provided the maximum amount of AE (8.12 t increased seed kg^{-1} N) and RE (234.29) in Yezin. Increase in nitrogen rates from N1 to N3 significantly enhanced RE in Tatkon (627.32). Further increase in nitrogen rates could not bring increase rather curved the recovery efficiency of N (Table 2).

No significant effect was given by the form of nitrogen application in AE for both trials. The mean value of AE with briquette urea treated plots gave higher values than using Prilled urea in both locations. The RE was statistically increased by using briquette urea in both trials. More RE was obtained from the briquette urea treated plots (Table 2). The nitrogen recovery efficiency is an index which determines the quantity of plant N uptake per unit of N fertilization. Dobermann (2005) and Aita and Giacomini (2008) argued that nitrogen recovery efficiency depends on the timing of the plant demand with nutrient availability. This synchronism is affected by several factors, the method of N fertilizer application, fertilizer source, fertilizer rate, quantity of residue, type of residue, and weather conditions (Wendling et al., 2007; Amado et al., 2009). The present investigation highlighted that Briquette urea with deep placement method could be effective method to maximize the recovery efficiency of N in maize production.

The effect of interaction between different rates of nitrogen fertilizer and form of nitrogen fertilizer application was not highly significant in AE of both trials (Table 2). The highest result on AE (8.26 t seed kg^{-1} N and 11.98 t seed kg^{-1} N) was found in N4 (166.29 kg N ha^{-1}) treated with briquette form of urea as well in Yezin (Fig. 3) and Tatkon (Fig. 4). The lowest AE (6.05 t seed kg^{-1} N, 10.07 t seed kg^{-1} N) was resulted from Prilled urea application with the rate of 71.27 kgN/ha (N2) in Yezin and Tatkon, respectively. The results pointed that, at the same N rate, the efficiency of briquette urea could be attributed to increase the AE in both locations (Figs. 3 and 4). Higher AE of rice due to deep placement of N fertilizer was reported by Wang (2004), Jena *et al.* (2003) and Niznin *et al.* (2013).

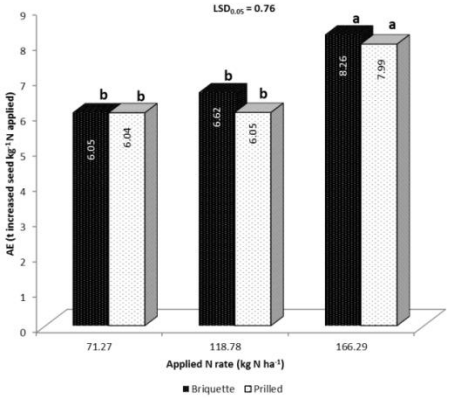

Fig. 3 Mean values of agronomic efficiency as affected by the different rates and forms of nitrogen fertilizer at Yezin Agricultural Research Farm during monsoon season 2017

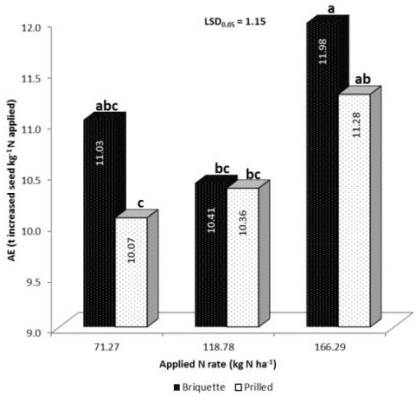

Fig. 4 Mean values of agronomic efficiency as affected by the different rates and forms of nitrogen fertilizer at Tatkon Agricultural Research Farm during monsoon season 2017

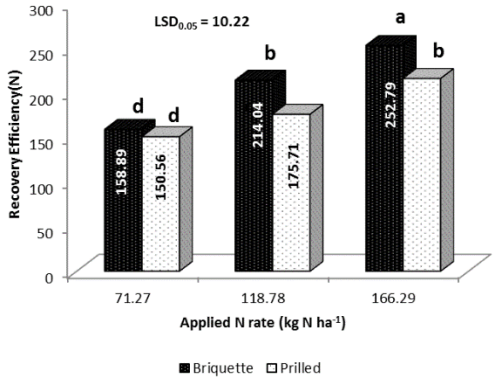

Fig. 5 Mean values of recovery efficiency as affected by the different rates and forms of nitrogen fertilizer at Yezin Agricultural Research Farm during monsoon season 2017

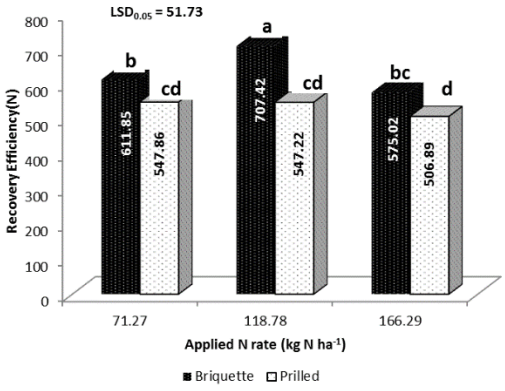

Fig. 6 Mean values of recovery efficiency as affected by the different rates and forms of nitrogen fertilizer at Tatkon Agricultural Research Farm during monsoon season 2017

The significant response in RE to the interaction of N rates and forms of urea was detected in both trials (Table 2). Improvement of RE with increasing N rate was found and it was ranged from 150.56 to 252.79 in Yezin (Fig. 5). The least RE was found at the rate of 71.27 kg N ha^{-1} using Prilled form of urea. The highest RE was obtained from briquette urea with N rate of 166.29 kg N ha^{-1}, N4 (Fig. 5). For the Tatkon trial, the RE was differed significantly and it was varied from 506.89 to 707.42 (Fig. 6). The maximum value of RE was obtained from the N rate (118.78 kg N ha^{-1}, N3) with briquette form of urea. The lowest RE was accompanied with the highest N rate 166.29 kg N ha^{-1}, N4 with Prilled urea treated plots. At the same level of applied N rates, Briquette urea using plots gave more RE values than Prilled urea using plots (Fig. 6).

CONCLUSION

Finally, results could be summed up that hybrid maize production could be favored by higher nitrogen rates. Application of the entire N in the form of briquette at basal with the rate of 166.29 kg N ha^{-1} showed better performance with respect to yield, AE of Yezin Hybrid Maize-10 compared to band placement of split N Prilled urea. Some interaction is existed in the nitrogen recovery efficiency and RE point out that even recommended fertilizer rate 118.78 kg N ha^{-1} could gain the

high yield. The results of this experiment provided valuable information about urea deep placement method which is environmental friendly and will not decrease the normal fertility of land. This study suggests that briquette urea with deep placement method can be used by farmers to improve nitrogen use efficiency and increase grain yields in hybrid maize production.

REFERENCES

Afroz, H. 2013. Effects of prilled urea, urea super granule and NPK briquettes on field water properties, N use efficiency and yield of Boro rice. M.S. Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Aita, C. and Giacomini, S.J. 2008. Nitrato no solo com a aplicação de dejetos líquidos de suínos no milho em plantio direto. R. Bras. Ci. Solo, 32, 2101-2111.

Amado, T.J.C., Pes, L.Z., Lemainski, C.L. and Schenato, R.B. 2009. Atributos químicos e físicos de Latossolos e sua relação com os rendimentos de milho e feijão irrigados. R. Bras. Ci. Solo, 33, 831-843.

Dobermann, A. 2005. Nitrogen use efficiency, State of the art. In IFA International Workshop on Enhanced-Efficiency Fertilizer, Frankfurt. Proceedings Frankfurt, 2005, 28-30.

IFDC. 2016. Annual report 2013, International Fertilizer Development Center, Alabama, USA.

IFDC. 2013. Annual report 2013, International Fertilizer Development Center, Alabama, USA.

Jena, D., Misra, C. and Bandyopadhyay, K.K. 2003. Effect of prilled urea and urea super granules on dynamics of ammonia volatilization and N use efficiency of rice. Indian J. Soil Sci. 51 (3), 257-261.

Misra, B.N., Yadav, R.S., Rajput, A.L. and Pandey, S.M. 1994. Effect of plant geometry and nitrogen application on yield and quality of winter maize (*Zea mays* L.). Indian J. Agron. 39, 468-469.

Myers, R.J. K. 1988. Nitrogen management of upland crops, From cereals to food legumes to sugarcane, 257-273. In J.R Wilson (ed.) Advances in Nitrogen Cycling in Agricultural Agroecosystems, CAB International, Wallingford, UK.

Nair, K.P.K. and Singh, R.P. 1974. Studies in fractional application of nitrogen to hybrid maize in India. Exp. Agric. 10, 257-261.

Niznin, A., Afroz, H., Hoque, T.S. and Mian, M.H. 2013. Effects of PU, USG and NPK briquette on nitrogen use efficiency and yield of BR22 rice under reduced water condition. J. Bangladesh Agril. Univ., 11 (2), 215-220.

Poss, R. and Saragoni, H. 1992. Leaching of nitrate, calcium and magnesium under maize cultivation and oxisol in Togo. Fert. Res., 33, 123-133.

SAS Institute. 2002. SAS/SAT 9 user's guide. SAS Inst.,Cary, NC.

Wang, C.H. 2004. Response of rice yield to deep placement of fertilizer and nitrogen top-dressing in panicle initiation stage and its diagnosis of fertilizer application. Taiwanese J. Agril. Chem. Food Sci., 42 (5), 383-395.

Wendling, A., Eltz, F.L.F., Cubilla, M.M., Amado,T.J.C., Mielniczuk, J. and Lovato, T. 2007. Recomendação de adubação nitrogenada para trigo em sucessão ao milhoe soja sob sistema plantio direto no Paraguai. R. Bras. Ci. Solo, 31, 985-994.