 Oryza Vol. 44. No.3, 2007 (234-238)

Performance of different slow release N fertilizer formulations on yield and nutrient uptake of rice in acidic soils of Kerala

Sam T. Kurumthottical* and A.I. Jose

College of Horticulture, Kerala Agricultural University, Thrissur-680 656, Kerala, India

ABSTRACT

A field experiment was conducted for three consecutive seasons comprising two wet (WS) and one dry season (DS) at the Agricultural Research Station, Mannuthy, Kerala Agricultural University (KAU), Thrissur to evaluate the efficacy of slow release fertilizer formulations in rice. The fertilizer formulations were adjusted to provide 90 kg N, 45 kg P_2O_5 and 45 kg K_2O ha^{-1}. Significant and maximum increase in crop yield parameters, yield, nutrient uptake and nutrient use efficiency were observed with a mixture comprising of Factomphos, Urea, muriate of potash (MOP) with Gypsum as physical barrier and neem cake as nitrification inhibitor and a spike formulation comprising of Factomphos, Ammonium sulphate, MOP with Gypsum and neem cake as filler and binder respectively in the first crop during wet season. However, during the dry season, the recommended package of practice (POP) of KAU, which envisages normal split applications of straight fertilizers, has taken a significant lead. The slow release fertilizer formulations were observed to be more effective than straight fertilizers in wet season. The residual effect on yield and yield attributes were small in the third crop. Though, they performed exceedingly well when compared to control.

Key words: *Slow release N fertilizers, rice, yield components, yield, nutrients uptake*

Most of the common extensively used nitrogenous fertilizers are highly water soluble. When such materials are used in rice cultivation, particularly in a state like Kerala, where rainfall is well distributed and heavy, only very low efficiency could be expected on account of several losses. In India, 85 percent of the nitrogen fertilizer demand is met from Urea, which is completely water soluble. In tropical regions where fertilizer N efficiency is too low, slow release N fertilizers have a vital role to play (Rajendraprasad, 1979). Certain materials like, coal tar, gypsum, wax and neem cake, can serve either as barriers or as nitrification inhibitors which ultimately result in regulating the release of nitrogen from urea giving higher N use efficiency. Improvement in grain yield and nitrogen use efficiency in rice has been reported by many workers (Singh *et al.*, 1984; Jena *et al.*, 1996 and Murthy *et al.*, 2002). The Fertilizers and Chemicals Travancore Ltd (FACT) undertook a pilot study to assess the comparative efficiency of urea formaldehyde. Evaluation of field efficiency of these slow release sources was undertaken as a collaborative project between KAU and FACT at different locations in Thrissur district of Kerala.

MATERIALS AND METHODS

A field experiment was conducted to evaluate the efficacy of different slow release N formulations provided by FACT for a pilot study taking rice as the test crop. Out of the three experiments which were conducted in successive seasons in the same plot, the first two received full recommended dose of fertilizers while the third one(residual crop) received only a flat application of 50% of the dose. The crops were taken during wet (WS) and dry (DS) seasons of 1999 and wet season of 2000 at Agricultural Research Station, Mannuthy, Kerala Agricultural University (KAU), Thrissur. The soil of the experimental field was sandy clay loam in texture with pH 5.0, EC 0.1 dSm^{-1} and CEC 8.2 c mol (p+) kg $soil^{-1}$. The available nutrient status was low with N, P_2O_5 and K_2O values being 162.8, 11.5 and 82.3 mg kg^{-1}, respectively. The experiment was laid out in a randomized block design

(RBD) with nine treatments, the details of which are given in Table 1. The different slow release fertilizer formulations provided by the R&D division of FACT were either in the form of spike or mixture which finally aimed to provide 90 kg N, 45 kg P_2O_5 and 45 kg K_2O ha^{-1} for both first and second crops.

All the slow release formulations, particularly in Treatments 1 to 7 were applied as a single basal dose. However, in treatment 8 (package of practice of KAU), entire P was given as basal dose and N and K in two splits (half as basal and the other half at 5-7 days before panicle initiation) in the form of straight fertilizers. Treatment 9 was offered as an absolute control.The third crop was grown in the fixed experimental site to assess the residual effect from the earlier application. This was attempted by giving uniform application of 50% of the recommended fertilizers to all treatments through straight fertilizers except control. Rice seedlings (30 days old) of variety Jaya (120-125 days duration) were transplanted at spacing of 20x15 cm with three replications. Yield parameters and yield were recorded at maturity. Grain and straw samples were analyzed for NPK content using standard procedures (Jackson, 1973) and their uptake was calculated by multiplying the nutrient content with the dry weight of the biological yield. All the data were analyzed statistically following standard procedure (Gomez and Gomez, 1984). The nutrient use efficiency indices were computed using the following formulae (Dobermann and Fairhurst, 2000):

1. Agronomic efficiency (AE) = Grain yield increase over control/ Total amount of nutrients applied.

Grain yield increase =Grain yield (kg) in treated plot – Grain yield (kg) in control plot;

Total amount of nutrients=Quantity of applied nutrients (NPK) in kg.

2. Physiological efficiency (PE) = Grain yield increase /Increase in total nutrient uptake.

Grain yield increase = Grain yield in treated plot (kg) – Grain yield in control plot (kg);

Increase in total uptake = Total NPK uptake in treated plot (kg) - Total NPK uptake in control (kg).

3. Partial factor productivity (PFP) = Grain yield / Total amount of nutrients (NPK) applied.

Grain yield =Grain yield in kg from where treatments have been applied;

Total amount of applied nutrients =Total amount of nutrients (NPK) applied in treatments (kg).

RESULTS AND DISCUSSION

All the fertilizer treatments, irrespective of the formulations recorded significantly higher grain yield than control (Table 2). In WS, T4 (3.41 t ha^{-1}) and T6 (3.40 t ha^{-1}) were significantly superior to the recommended practice (T8) and recorded maximum grain yield than other treatments (11-29 % more) due to their maximum panicle number and higher 1000 grain weight (Table 2). The presence of neem cake must have played a favorable role in extending the release mechanisms over a comfortable period in soil during the wet season. Further, the presence of Ammonium sulphate as a component in T6 might have provided

Table 1. Details of slow release fertilizers employed in the study

Treatment	Formulations	Treatment particulars
T1	Spike	Polymerization product-Urea formaldehyde , Factomphos, Urea and MOP with Gypsum as filler and wax as binder
T2	Spike	Phosphogypsum Urea adduct, SSP , MOP with Gypsum as physical barrier and neem cake as nitrification inhibitor
T3	Spike	Phosphogypsum Urea adduct, SSP, and MOP with Gypsum as physical barrier and wax as binder
T4	Mixture	Factomphos- (20: 20: 0) Urea and MOP with Gypsum as physical barrier and neem cake as nitrification inhibitor
T5	Mixture	Factomphos coated with coal-tar , Urea and MOP
T6	Spike	Factomphos, Ammonium sulphate and MOP with Gypsum as filler and neem cake as binder
T7	Mixture	Single application of straight fertilizers at the full recommended dose
T8	Mixture	Full P , half N+K at basal and remaining N+K as top dressing 5-7 days before panicle initiation (through straight fertilizers)
T9	Absolute control	No fertilizers were given

Table 2. Yield parameters and yield as influenced by different treatments

Treatments	Panicles m^{-2}		1000 grain wt.(g)		Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	WS-99	DS-2000	WS-99	DS-2000	WS-99	DS-2000	WS-99	DS-2000
T1	174	172	24.85	23.78	3.00	3.14	3.38	4.64
T2	134	161	23.88	24.52	3.06	3.03	3.33	4.28
T3	142	142	23.31	23.57	2.85	2.94	3.19	3.72
T4	205	190	26.39	24.09	3.41	3.38	3.70	3.96
T5	132	167	22.95	24.77	2.64	3.08	2.89	3.41
T6	206	196	25.88	25.96	3.40	3.42	3.69	3.68
T7	170	153	25.06	24.70	2.69	2.96	3.06	3.34
T8	181	210	24.93	26.42	3.00	3.79	3.28	4.83
T9 (control)	119	114	20.00	22.70	2.28	2.35	2.48	2.75
CD(P=0.05)	3.0	4.0	0.651	1.33	0.20	0.23	0.18	0.20

sulphate ions, which indirectly must have helped to produce more number of panicles in T6 during the wet season and reflected in high yield. High rain fall during the first crop season and subsequent dissolution of nutrients from straight fertilizers leading to low fertilizer use efficiency might have been a valid reason for relegating the POP (T8) to lower position. In the second crop (DS), T8 (3.79 t ha^{-1}) recorded significantly higher grain yield (11 -29 %more) than all the other treatments due to its maximum panicle number and 1000 grain weight possibly on account of better climatic conditions and improvement in water control during the growing period resulting in better fertilizer use efficiency. The treatments T4 and T6 were in the next category recording 8-16% higher yield than other treatments. In both the seasons, the treatments with higher yield parameters recorded higher grain yield. The higher grain yields with slow release fertilizers in rice-rice system were also reported by Soni and Kaur (1989), Devaraju *et al.* (1999) and Murthy *et al.* (2002) who attributed the yield increase to higher yield components due to prolonged availability of N from slow release fertilizers. But, the grain yields in general were not up to the expectation and remained inconsistent for a variety of reasons associated with soil with very poor CEC, low base saturation, low clay content and low pH, which were construed more as the peculiarity of the area.

With regard to straw yield, in both the crops, all fertilizer treatments recorded significantly higher straw yield over control. Treatments T4 and T6 in WS and T8 in DS recorded maximum straw yield over the rest.

N uptake followed the grain yield trend in both the crops (Table 3) where a significant increase in N uptake was observed in all the fertilizer treatments over control. During WS-99, T4 (107.2 kg ha^{-1}) followed by T6 (104.5 kg ha^{-1}) recorded highest N uptake and during the succeeding DS, T8 recorded maximum N uptake (127.5 kg ha^{-1}) followed by T1 (111.6 kg ha^{-1}), T4 (106.0 kg ha^{-1}) and T6 (105.2 kg ha^{-1}). The prolonged availability of N in soil from slow release fertilizers must have favoured higher N uptake as was also reported by Singh and Singh (1989). A similar contention had been reported by Murthy *et al.* (2002) while evaluating the uptake of N by paddy from slow release fertilizers.

Phosphorus uptake also followed the similar trend as that of nitrogen with significant increase noted from all fertilizer treatments over control. The

Table 3. Total nutrients uptake (kg ha^{-1}) as influenced by different treatments

Treatments	N uptake		P uptake		K uptake	
	WS-99	DS-2000	WS-99	DS-2000	WS-99	DS-2000
T1	92.6	111.6	13.9	17.7	83.3	120.0
T2	85.3	101.5	16.5	17.0	91.9	107.5
T3	78.9	102.5	12.9	14.6	78.7	96.2
T4	107.2	106.0	18.7	17.0	109.8	101.3
T5	73.0	96.6	11.2	14.4	77.7	88.2
T6	104.5	105.2	16.7	17.7	95.3	97.7
T7	72.8	92.2	15.0	14.7	80.1	88.4
T8	85.7	127.5	17.0	21.6	92.0	125
T9 (control)	51.0	72.2	8.1	10.8	55.1	63.8
CD(P=0.05)	10.8	7.02	1.62	0.9	6.48	6.76

treatments T4 (18.7 kg ha^{-1}) in WS and T8 (21.6 kg ha^{-1}) in DS were significantly superior to all other treatments. The treatments T6 and T8 in WS and T6, T1, T4 and T2 in DS were next in the order with higher P uptake. The higher yields accompanied by higher uptake of P from many treatments might be due to the regulated release of P from various formulations.

Though the trend in uptake of K remained similar to that of N and P, there had been significant increase in K uptake in all the fertilizer treatments when compared to control. Maximum K uptake was noted in T4 (109.8 kg ha^{-1}) in the first crop (WS) and T8 (125.0 kg ha^{-1}) in the second crop (DS). The treatments T6, T8 and T2 in WS and T1, T2, T4 and T6 in DS were next in order with respect to K uptake.

The residual effect of slow release fertilizers applied to the first and second crops was monitored in the third crop where all treatments except control were supplied with 50% of the recommended doses particularly through straight fertilizers. Though comparative treatment differences could be discerned, the grain yields were generally low in the residual crop (Table 4). When compared with control, the residual effect from almost all fertilizer treatments were significant on yield parameters, yield and even in nutrient uptake. Among the various treatments, T4, T6, appeared to be better in first (WS) crop and T8 in second (DS) crop, continued to retain their yield performance even from the residual effect. Interestingly, the treatment T1 that recorded significantly lower yield than best treatments in first and second crops recorded one of the highest yield, though not significantly different from that of T4 and T6, indicating the impact of urea formaldehyde in extending the residual effect over the other sources tried. The nutrient uptake in these treatments also presented a similar trend. The residual effect of slow release fertilizers in terms of yield and nutrient recovery by succeeding wheat in rice-wheat rotation was reported by Kolhe and Mittra (1989) and Agarwal *et al*. (1990).

Agronomic efficiency (AE), Physiological efficiency (PE) and Partial factor productivity (PFP) were maximum in T4 and T6 in the first (WS) crop and T8 in second (DS) crop as in case of yield and other parameters (Fig. 1). In case of third (residual) crop, T1 recorded better efficiency and remained on par with T4, T6 and T8. Increased fertilizer use efficiency with slow release fertilizers was also reported by Chakraborty and Bhattacharya (1987), Singh and Singh (1989), Suresh *et al*. (19990 and Carreres *et al.* (2003).

Thus, the present study indicated that slow release fertilizers were more effective in the wet season and recommended package of KAU was superior in dry season. The residual effect of most of the slow release fertilizer formulations was on par and remained superior to control. The two formulations, T4 and T6, which had included neem cake either as nitrification inhibitor or as binder in the formulations imparted superiority in performance to rest of the slow release formulations

Table 4. Residual effect of slow release fertilizers on the 3 rd crop (WS-2000)

Treatments	Panicles m^{-2}	1000 grain wt.(g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
T1	160	22.56	1.84	2.24	41.4	9.7	53.9
T2	160	21.83	1.71	1.96	37.1	8.9	43.7
T3	137	23.56	1.64	2.10	41.0	8.4	46.4
T4	174	24.86	1.83	2.03	44.7	8.1	46.6
T5	137	21.33	1.56	1.89	39.3	7.9	47.6
T6	174	22.76	1.81	2.17	39.8	8.9	50.7
T7	169	23.08	1.54	2.09	34.5	8.0	47.5
T8	177	22.10	1.79	1.99	37.5	8.1	47.0
T9 (control)	104	20.12	1.17	1.34	18.5	4.4	25.8
CD(P=0.05)	4	0.72	0.19	0.22	6.9	1.1	6.2

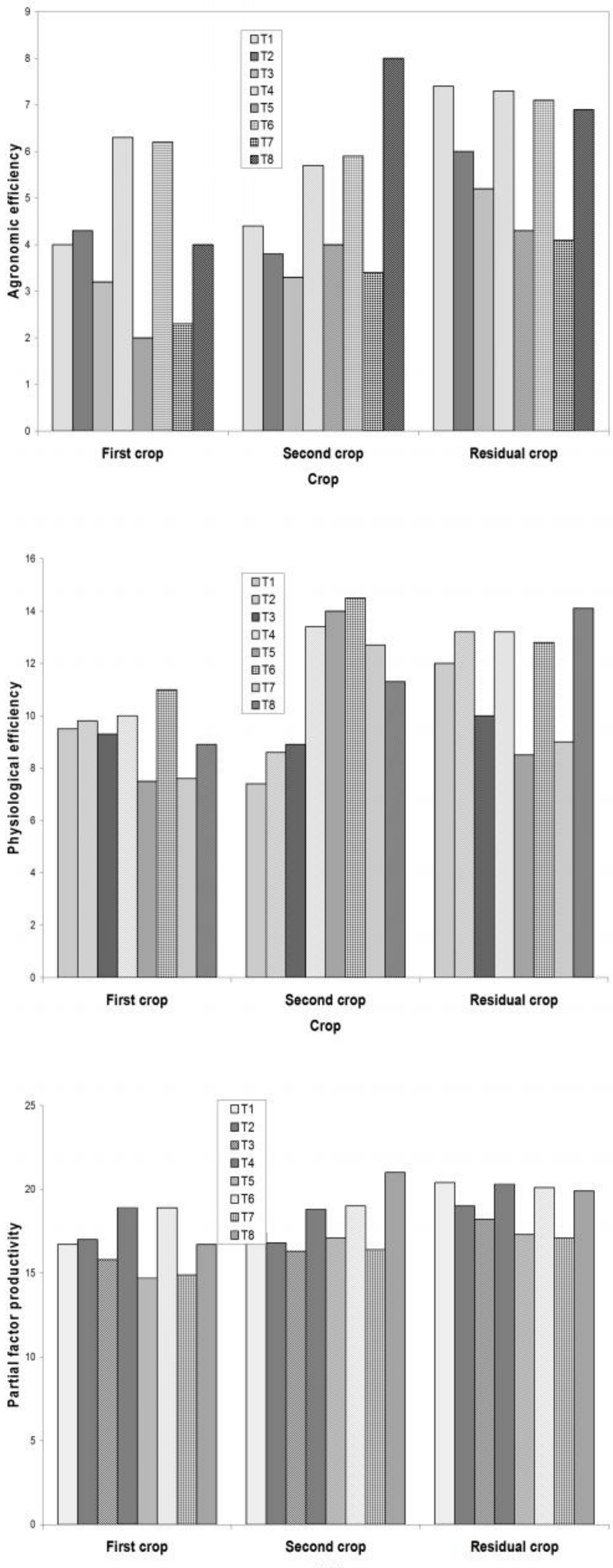

Fig. 1. Nutrient use efficiency indices as influenced by treatments

REFERENCES

Agarwal SK, Hari Shanker and Agarwal MM 1990. Effect of slow release nitrogen and Nitrification inhibitors on Rice-Wheat sequence. Indian J Agron 35(4): 337-340

Carreres R, Sendra J, Ballesters R, Valiente EF, Quesada A, Carrasco D, Leganes F and dela Cuadra JG 2003. Assessment of slow release fertilizers and nitrification inhibitors in flooded rice. Biol and Fertil of Soils 39(2): 80-87

Chakraborty AK and Bhattacharya B 1987 Effect of Slow-Release Nitrogen Fertilizers on Rice Yield Int Rice Res Newsl. 12(4): 58-59

Devaraju KM, Basavaraju HK, Siva Kumaran S and Sridhar S 1999. Influence of slow release nitrogenous fertilizers on lowland rice. Oryza 36(2): 173-174

Dobermann A and and Fairhurst TH 2000. Assessing nitrogen efficiency. In Rice: Nutrient disorders and nutrient management. IRRI Hand book series. pp. 155-160

Gomez KA and Gomez AA 1984. Statistical Procedures for Agricultural Research. Second Edition. IRRI. John Wiley and Sons Publication.

Jackson ML 1973. Soil Chemical Analysis. Prentice Hall of India, New Delhi.

Jena D, Sahu BN, Mishra C and Schepers JS 1996. Urea hydrolysis in rice root zone. Oryza 33: 119-125

Kolhe SS and Mittra BN 1989. Evaluation of slow-release Nitrogen fertilizers in Rice-Wheat cropping system. Indian J Agron 34(1): 137-138

Murthy AGK, Padmaja K, Mahender Kumar R and Subbaiah SV 2002. Efficacy of controlled release nitrogen fertilizer on grain yield of different cultivars of rice (*Oryza sativa*) in irrigated rice ecosystem. Indian J Agri Sci 72(12): 693-696

Rajendraprasad 1979. Increasing fertiliser nitrogen efficiency with slow release fertilisers and nitrification inhibitors. Fert News 24(9): 25-32

Singh S, Prasad R and Ishwaran 1984. New nitrogen carriers for rice. Madras Agric J 71: 371-74

Singh and Singh 1989. Effect of slow release nitrogen fertilizers on yield and nitrogen use ufficiency in upland rice and their residual effect on Wheat. Ann. Agric Res 10(1): 79-84.

Soni PN and and Kaur R 1989. Efficacy of slow release fertilizer in rice based cropping systems. Indian J Agron 34(2): 185-191

Suresh S, Velu V and Arunachalam G 1999. Effect of nitrogen sources on the growth and yield of rice in the Tamirabarani tract of Tamil Nadu, India. Oryza 36(4): 339-342