

Research Article

Relative performance of neem coated urea *viz-a-viz* ordinary urea applied to rice-wheat cropping in sub-tropical soils

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Summary

On-farm trials (OFTs) at eighteen different farmer field locations varying in soil fertility were conducted (2006–08) to assess the relative performance of different nitrogen sources *viz.*, neem coated urea (NCU) and ordinary urea (OU). The treatments thus compared consisted of 96 and 120 kg N ha⁻¹ through NCU and OU, thus, constituting T₁ = 80% NCU, T₂ = 80% OU, T₃ = 100% NCU and T₄ = 100% OU. The grain yield for wheat and rice in T₃/T₄ was significant (p < 0.05) (6.9% and 13.8%, respectively) higher than T₁/T₂, however, the grain yield among equivalently applied N treatments was statistically at par. The results revealed no significant differences in agronomic efficiency of N (AE_N) applied through different sources at equal applied level. However, there was significantly higher AE_N for T₁/T₂ than T₃/T₄ in both wheat and rice. The total energy productivity for wheat in T₃/T₄ was 6.87 per cent higher, with a decrease in energy productivity by 0.11 MJ ha⁻¹ than T₁/T₂. However, in rice the total energy productivity was 14.9 per cent higher in T₃/T₄ with 0.16 MJ ha⁻¹ over T₁/T₂. Thus, it can be concluded that the two N sources are equally effective for rice-wheat cropping in sub-tropical soils.

Key words : Agronomic efficiency, Crop yield, Energy productivity, Neem coated urea, Sub-tropical soils

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Introduction

Rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) are grown sequentially in an annual rotation constituting a rice-wheat (RW) cropping system and is a dominating system being practiced an ~85 per cent of the cultivated area in Punjab. The nitrogen (N) requirement of these crops in the region is being met through urea (46% N) and through an extensive research it has been substantiated that of the total quantity of applied N through urea, ~50–70 per cent is subjected leaching, ammonia volatilization and denitrification losses. According to Singh and Singh (2003) N use/recovery efficiency in RW cropping system rarely exceeds 30-40 per cent. The improvement in the N efficiency is, therefore, of prime importance, not only for achieving and sustaining high crop grain yield but also to protect the natural resources from degradation. The use of slow release N-fertilizers such as

sulphur coated urea (SCU) in rice has been reported to be a better option than ordinary urea (OU) in almost all types of soils (Meelu *et al.*, 1983; Singh and Katyal, 1987). In India, the blended use of OU with neem cake was the traditional practice with the belief that when they are applied together nitrogen use efficiency (NUE) in rice is enhanced (Agarwal *et al.*, 1980; Singh and Singh, 1986). Devakumar and Goswami (1992) reported that oil derived from neem seeds contain melicians of which epinimbin, deacetyl, salanin and azadirachtin showed dose dependent inhibition of nitrification. According to Singh and Singh (2003) oil forms a fine coating and protects the N due to denitrification losses and thereby ensuring regulated and continuous availability of N over a long period of time, as required by crops. Although it had been established long ago that neem products, when applied along with urea, can enhance NUE in crops (Singh and Singh, 1986), the practice

did not find large-scale application because a process to coat urea with neem products on a large scale was not available. The Indian Agricultural Research Institute (IARI) refined the technique of coating urea using neem oil emulsion @ 0.5–1.0 kg neem oil tonne⁻¹ of urea (Suri *et al.*, 2004). Recently, National Fertilizer Limited (NFL) has also started the manufacturing of NCU on commercial scale. Therefore, there was need to compare the efficiency of NCU in comparison to OU in RW cropping being practiced at farmers field. The on-farm trials (OFTs) at eighteen different farmer’s field locations were conducted in Kapurthala district of Punjab to investigate the effect of N application through NCU and OU to evaluate their relative performance in sub-tropical soils in terms of yield, agronomic efficiency and total energy productivity.

Resources and Research Methods

Soil sampling and analysis :

Experiments at 18 different farmer’s field locations, characterized by sub-tropical semi-arid climatic conditions of Kapurthala district of Punjab (Fig. A) under Rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) cropping sequence were conducted during 2006-2008. The soil samples were collected after wheat harvest in the month of May. The description of surface (0-15 cm) soil physico-chemical properties of the selected locations has been compiled in the Table A. The soil samples were ground to pass through 2.0 mm stainless steel sieve and stored in polythene bottles with tight lids. Soil reaction (pH) and electrical conductivity (EC) were determined by using 1:2 soil-water solution (w/v basis) ratio (Jackson, 1967). The soil organic carbon content was determined by Walkley and Black (1934). The content of available – phosphorus and K was determined as described by Olsen *et al.* (1954) and Mervin and Peech (1950), respectively.

Experimental site characteristics :

Kapurthala (a formerly princely state) is one among smallest districts of Punjab and is located at 31°36’ N and 75°37’ E and mean sea level of 221 m. The climate of the experimental site is sub-tropical characterized by hot summers with a maximum

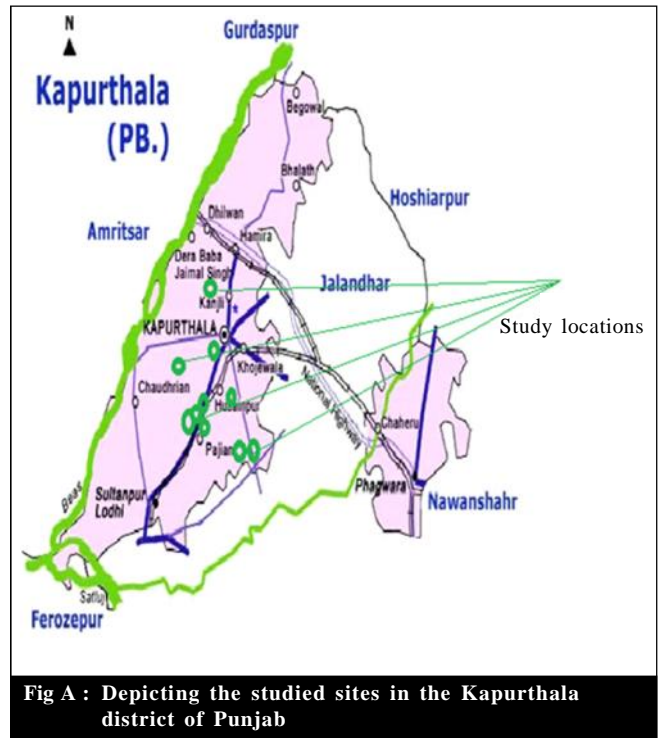


Fig A : Depicting the studied sites in the Kapurthala district of Punjab

temperature of 41 ± 4°C in May-June and with cool winters with mean minimum temperature of 5 ± 3°C in November-December. The experimental area is characterized by an annual rainfall of 733 mm, of which nearly 80 per cent is received during monsoon season extending from June to September when wetland transplanted rice is grown during summer season and rest during the winter season when the wheat crop is in the field. The agro-climatic conditions of the district Kapurthala coincide with the Central Punjab with smooth-plain topography.

Description of treatment application :

The two sources *viz.*, NCU and OU were tested at two N levels *viz.*, 80 and 100 per cent of the recommended level of 120 kg N ha⁻¹ for the region with 26 kg P, 30 kg K and 10 kg Zn ha⁻¹. Phosphorus and potassium application was made on soil

Table A : Important soil (0-15 cm) characteristics of the selected experimental sites						
Locations	pH (1:2)	E.C. (d.Sm ⁻¹)	SOC (%)	Av-P (kg ha ⁻¹)	Av-K (kg ha ⁻¹)	Soil texture
Kapurthala-KVK (L ₁)	7.23	0.423	0.355	18.06	153.0	Loamy sand
Blairkhanpur (L ₂)	8.12	0.235	0.402	18.74	162.4	Sandy loam
Barindpur (L ₃)	7.56	0.356	0.388	22.56	140.4	Loamy sand
Nawanpind (L ₄)	7.68	0.427	0.505	17.56	128.6	Sandy loam
Kadhal Nau Bad (L ₅)	8.02	0.354	0.456	18.56	138.9	Loamy sand
Blerkhanpur (L ₆)	7.52	0.321	0.398	20.23	178.4	Loamy sand
Mohablipur (L ₇)	8.24	0.221	0.405	19.87	156.8	Sandy loam
Karalnaubad (L ₈)	8.31	0.201	0.425	16.54	176.4	Loamy sand
Blairkhanpur (L ₉)	7.53	0.189	0.496	17.56	156.4	Loamy sand

test basis. In most of the cases, soil was high in available-K. For the study area, Bhatt and Sharma (2011) reported that the deficiency of K has started appearing areas of the district owing to intensive cropping and its application in K-deficient has lead to yield gain range from 2.8-6.3 per cent at farmers field. The treatments thus applied at each experimental location comprised of T₁: 80 % neem coated urea (NCU), T₂: 80 % ordinary urea (OU), T₃: 100% NCU and T₄: 100% OU.

The recommended dose of P, K and Zn were applied basal, but N was applied as split to both the crops. In rice, N was applied in three equal splits, first at transplanting and then second and third after 21 and 42 days after transplanting of rice seedlings, respectively. However, to wheat, N was applied in two equal splits; one at sowing and second at first irrigation to crop, about 25 days after sowing. Wheat (var. PBW-343) was seeded in rows 20 cm apart @ 100 kg seed ha⁻¹ in first fortnight of November. The crop was supplied with 120 kg N, 63 kg P and 30 kg K ha⁻¹ for 100 per cent recommended rate plots. The dose of N for 80 per cent recommended rate plots were, therefore, adjusted accordingly. The crop was harvested in the first fortnight of April and grain yield was recorded. However, other crop management practices adopted were as per package and practices recommended for wheat cultivation in the region (Anonymous, 2005). Rice seedlings (25-35 days old) were manually transplanted in pre-puddled field in the second to third week of June.

Statistical analysis :

The statistical analysis of the grain yield was carried out by analysis of variance in randomized block design (Cochran and Cox, 1950). Mean separation for different treatments was performed using least significance difference (LSD) test at 0.05 level of probability. The energy input and output was calculated using energy equivalent as suggested by Devasenapathy *et al.* (2009) considering input energy

associate with nutrient and FYM application only. The energy productivity related to fertilizer application through inorganic and organic (FYM) sources was calculated after dividing total production by total energy used (Nedunchezhiyan, 2010).

Research Findings and Discussion

The results of the present study as well as relevant discussions have been presented under following sub heads:

Wheat grain yield and agronomic efficiency :

The effect of N application at differential rate from two sources was studied at farmers field in rice-wheat cropping system. The application of N through 100% NCU or OU has resulted in significant increased grain yield of rice and wheat to N application @ 80 % NCU and/or OU (Table 1). However, the yield differences at equivalent N application rate applied through different sources were statistically non-significant. Wheat grain yield varied from 4.10 to 4.31 t ha⁻¹ in 80% NCU and from 4.08 to 4.30 t ha⁻¹ in 80% OU treated plots. However, the average wheat grain yield varied from 4.30 to 4.71 t ha⁻¹ in NCU and from 4.29 to 4.60 t ha⁻¹ in OU treated plots when N applied was 100 per cent. The agronomic efficiency in T₁/T₂ was higher than the T₃/T₄ because of the lesser N application as compared to T₃/T₄. During 2007/08, T₁ resulted in the grain yield of wheat being 6.68 per cent greater than T₂ while the yield increase in T₃ over T₄ was reported to be 6.70 per cent (Table 1). These results suggest that the impact of nitrification-inhibiting properties of NCU is more visible in the coarse-textured soils of Kapurthala, Punjab.

Rice grain yield and agronomic efficiency :

Rice responded better to NCU than wheat did in 2007-08. On an average of two years *viz.*, 2007-08 revealed that at

Table 1: Wheat grain yield and agronomic efficiency of nitrogen application through different sources

Locations	Grain yield (t ha ⁻¹)				Agronomic efficiency (kg kg ⁻¹ ha ⁻¹)			
	T ₁	T ₂	T ₃	T ₄	T ₁	T ₂	T ₃	T ₄
<i>Rabi 2006-07</i>								
L ₁	4.21	4.19	4.60	4.60	43.9	43.6	38.3	38.3
L ₂	4.20	4.20	4.60	4.59	43.8	43.8	38.3	38.3
L ₃	4.27	4.27	4.71	4.70	44.5	44.5	39.2	39.2
L ₄	4.10	4.08	4.50	4.49	42.7	42.5	37.5	37.4
<i>Rabi 2007-08</i>								
L ₅	4.31	4.30	4.50	4.50	44.9	44.7	37.5	37.5
L ₆	4.12	4.10	4.38	4.37	43.0	42.7	36.5	37.4
L ₇	4.28	4.27	4.30	4.29	44.5	44.4	35.8	35.8
L ₈	4.16	4.13	4.32	4.32	43.3	43.0	36.0	36.0
L ₉	4.10	4.10	4.32	4.32	42.7	42.7	36.0	35.0
Minimum	4.10	4.08	4.30	4.29	42.7	42.5	35.8	35.0
Maximum	4.31	4.30	4.71	4.60	44.9	44.7	37.5	39.2
LSD (p<0.05)	0.20							

the lower dose of N (80%), grain yield was 14.8 per cent higher in plots supplied with NCU than in those supplied with ordinary urea; at the higher dose (100%), the corresponding figure was 12.8 per cent (Table 2). These results clearly depicted that the effect of neem coated urea is more prominent in paddy as compared to that of the wheat and it may be because of the nitrification inhibition properties of Neem coated urea.

The recommended dose applied in the form of NCU led to the highest yields, the treatment being significantly better for wheat (4.6 t ha⁻¹ and 4.4 t ha⁻¹, respectively in 2007/08 and 2008/09 than 80 per cent of the recommended dose, whether given in the form of ordinary urea (4.2 t ha⁻¹ and 4.2 t ha⁻¹, respectively) or in the form of NCU (4.2 t ha⁻¹ and 4.2 t ha⁻¹, respectively) although at the higher dose the two forms were statistically at par (4.6 t ha⁻¹ and 4.4 t ha⁻¹, respectively) (Table 2). The pattern with paddy yield was identical, with 100% N applied as NCU performing significantly better (7.3 t ha⁻¹ and 6.6 t ha⁻¹ in 2007 and 2008, respectively) than 80 per cent N applied either as ordinary urea (6.1 t ha⁻¹ and 5.8 t ha⁻¹, respectively) or as NCU (6.2 t ha⁻¹ and 5.9 t ha⁻¹, respectively) but being statistically at par with the treatment involving 100 per cent N given as ordinary urea (7.2 t ha⁻¹ and 6.5 t ha⁻¹, respectively). The beneficial effects of various neem products,

when used in combination with ordinary urea, are well established and take the form of smaller N losses and higher yield. Singh and Singh (1986) observed a significant reduction in nitrogen being leached as NO₃-N when urea was blended with neem cake. Blending neem seed cake with urea reduced volatilization of ammonia by 31.4 per cent (Reddy and Mishra, 1983). The coated form produced 5.6 per cent higher grain yield than that produced by ordinary urea when applied in three equal split doses. These results suggest that the positive impact of the nitrification-inhibiting properties of NCU. Since neem inhibits nitrification, the main effect of NCU in improving NUE in rice is probably due to the reduction in the amount of nitrogen being lost by leaching in the form of NO₃-N. However, as reported by Mikkelsen and De Datta (1979) and Vlek and Craswell (1979) for coarse-textured soils, when conditions are unfavourable for nitrification, N volatilization is greater and NCU may well have been instrumental in checking the loss of N in this form. This study shows that NCU was at par with ordinary urea both at 80 and 100 per cent dose under the field conditions.

Energy relationships under different treatments :

Data pooled for two years (Table 3) revealed that in wheat total input energy (MJ ha⁻¹) was 25 per cent higher in 100 per

Table 2 : Rice grain yield and agronomic efficiency of nitrogen application through different sources

Location	Grain yield (t ha ⁻¹)				Agronomic efficiency (kg kg ⁻¹ ha ⁻¹)			
	T ₁	T ₂	T ₃	T ₄	T ₁	T ₂	T ₃	T ₄
<i>Khariif-2007</i>								
L ₁	6.60	6.50	7.54	7.45	68.8	67.7	62.8	62.1
L ₂	5.99	5.80	6.94	6.85	61.4	60.4	57.8	57.1
L ₃	6.50	6.40	7.49	7.40	67.7	66.7	62.4	61.7
L ₄	5.93	5.88	7.25	7.20	61.8	61.3	60.4	60.0
<i>Khariif-2008</i>								
L ₅	6.25	6.21	7.04	6.75	65.1	64.7	58.7	56.3
L ₆	5.82	6.78	6.56	6.55	60.6	60.2	54.7	54.6
L ₇	4.21	4.17	5.10	4.99	43.9	43.4	42.5	41.6
L ₈	6.66	6.61	7.55	7.49	69.4	68.9	62.9	62.4
L ₉	6.05	5.98	6.54	6.50	63.0	49.8	54.7	54.2
Minimum	4.21	4.17	5.10	4.99	43.9	43.4	42.5	41.6
Maximum	6.66	6.61	7.55	7.49	69.4	68.9	62.9	62.4
LSD (p<0.05)	1.62							

Table 3 : Total energy input and output and energy productivity of rice and wheat as influenced by N application at differential rate through different sources (Data pooled for 2 years)

Treatments	Wheat			Rice	
	Total input energy (MJ ha ⁻¹)	Total output energy (X 10 ⁴ MJ ha ⁻¹)	Energy productivity (kg MJ ⁻¹)	Total output energy (X 10 ⁴ MJ ha ⁻¹)	Energy productivity (kg MJ ⁻¹)
T ₁	5818	10.50	0.72	14.98	1.03
T ₂	5818	10.45	0.71	14.83	1.08
T ₃	7272	11.20	0.61	17.23	0.95
T ₄	7272	11.20	0.61	17.00	0.94

cent dose of urea while total energy output was 7.0 per cent higher with 100 per cent dose of urea as compared to the 80 per cent dose of urea. However, the energy productivity (kg MJ⁻¹) in 80 per cent dose was found to be 17.2 per cent higher than 100 per cent dose. In rice, energy relationships has almost similar trend as that of the wheat as total energy output was 15 per cent higher with 100 per cent dose of urea while energy productivity in 80 per cent dose was found to be 11.6 per cent higher than 100 per cent dose. There is no difference between NCU and OU as far as energy relationships was concerned.

Conclusion :

The results revealed that application of nitrogen through neem-coated urea was superior in rice as compared to that in wheat. However, the two N sources were statistically at par with each other for their effect on crop grain yield. The beneficial effect of NCU over OU might be because of its nitrification inhibiting action of neem coating in NCU. Thus, it can be concluded that the two N sources are equally effective for rice-wheat cropping system in sub-tropical soils.

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