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**Ashvin Kumar Meena**
Department of Agronomy, G. B. Pant University of Agriculture and Technology Pantnagar, Uttarakhand, India

**DK Singh**
Department of Agronomy, G. B. Pant University of Agriculture and Technology Pantnagar, Uttarakhand, India

**PC Pandey**
Department of Agronomy, G. B. Pant University of Agriculture and Technology Pantnagar, Uttarakhand, India

**Gangadhar Nanda**
Department of Agronomy, G. B. Pant University of Agriculture and Technology Pantnagar, Uttarakhand, India

**Correspondence**
**Ashvin Kumar Meena**
Department of Agronomy, G. B. Pant University of Agriculture and Technology Pantnagar, Uttarakhand, India

# Effects of neem coated urea on yield, P and K uptake in transplanted rice (*Oryza sativa* L.) and soil chemical properties

**Ashvin Kumar Meena, DK Singh, PC Pandey and Gangadhar Nanda**

**Abstract**
A field experiment conducted to assess the influence of nitrogen (N) management practices through neem coated urea (NCU) on phosphorus (P), potassium (K) uptake and distribution in different plant parts (leaf, stem and panicle), grain yield and soil chemical properties of transplanted rice. The results indicated that application of NCU at 125% recommended dose of N (RDN) with 50:25:25 split schedule at basal (B), active tillering (AT) and panicle initiation (PI) stages resulted in higher P, K uptake and distribution to leaf, stem and panicle at harvest than the application of prilled urea at 100% RDN with the same split schedule (existing practice). Further, the increment in grain yield was 10.95% higher than the existing practice. The significantly higher available soil nitrogen (226 kg $ha^{-1}$) was recorded with of NCU at 125% recommended dose of N (RDN) with 33.3:33.3:33.3 split schedule at B, AT and PI stages.

**Keywords:** Neem coated urea, phosphorus accumulation, potassium accumulation, rice, yield

## Introduction
Rice (*Oryza sativa* L.) is one of the major staple food crops that is mostly grown in lowland rainfed conditions (Singh *et al.* 2017) [18]. The slogan “Rice is life” is most appropriate where it plays a pivotal role in food security and is a means of livelihood for millions of rural households. In India, national food security system largely depends on the productivity of rice ecosystem. The effect of nitrogen (N) on crops is profound; however, most understanding on crop growth responses to this element is empirical. An appropriate amount of nitrogen fertilizer encourages photosynthesis in rice (Hussain *et al.*, 2016) [4], it enhances resistance to biotic stress (Guo *et al.*, 2016) [2], improves dry matter accumulation and nutrient uptake (Barlog and Grzebisz, 2004) [1]; However, over fertilization has become a major concern for sustainable agriculture (Meng *et al.*, 2013) [10]. The yield of rice faces significant decline or stagnation as their sustainability is threatened by lower nitrogen use efficiency (Tian *et al.*, 2013) [19]. In the soil, nitrogen is lost through nitrate-nitrogen ($NO_3^-$ N) leaching, ammonia ($NH_4^+$) volatilization, surface runoff, and denitrification that is why the efficiency of applied nitrogen fertilizer is only 20-50% (Shivay *et al.*, 2005) [12]. So, the fast transformation is the principal cause of lower use efficiency of both applied and soil nitrogen. These losses can be minimized if it is preserved in ammonium form for a fairly long period of time. Addition of nitrification inhibitors with N fertilizers is one of the important methods of maintaining nitrogen in $NH_4^+$ form (Kumar *et al.*, 2015) [7]. Though a number of NIs (nitrapyrin, dicyandiamide, ammonium thiosulphate etc.) has been developed, they are still unpopular among resource-poor Asian farmers due to their high cost and limited availability (Kumar *et al.*, 2010). On the other hand, neem coated urea (NCU) which is an indigenous nitrification inhibitor and have been reported to increase the growth, yield, uptake, and use efficiency of applied nitrogen fertilizer in rice (Shivay *et al.*, 2001; Singh and Shivay, 2003; Kumar and Shivay, 2009; Thind *et al.*, 2010; Meena *et al.*, 2018) [15, 14, 13, 18, 9]. Recently with the decision of the government of India in 2015 to produce the entire amount of urea produced in the country as NCU, there is a need to quantify its rate of application in transplanted rice. In addition, altering the split doses according to the crop growth stages may synchronize the supply of nitrogen with that of the plant demand, and help augment yield, P and K uptake. But there is lack of information regarding the dose and split schedule of neem coated urea in transplanted rice. Hence, the present study was undertaken with the objective to study the different N management strategies on yield, phosphorus and potassium uptake in transplanted rice (*Oryza sativa* L.) and soil chemical properties.

## Material and Methods

### Experimental site

A field experiment was conducted during the *Kharif* (rainy) season of 2016 in the $A_2$ block at N. E. Borlaug Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand, India. Geographically, it is located at 29˚N latitude, 79˚29' E longitude and at an altitude of 243.84 m above mean sea level. This region enjoys sub-humid, sub-tropical climate with dry summer and cool winter. The maximum temperature exceeds 42.5ºC during hot summer in the month of May and June, and minimum temperature occasionally falls below 1ºC during winter in the month of December and January. The mean annual rainfall is about 1410 mm, of which 90% is received from June to September.

The soil of experimental field was silt loam in texture, of alluvial origin and classified as Aquic hapludoll. The chemical analysis of upper 20 cm soil showed that it had 224 kg $ha^{-1}$ alkaline $KMnO_4$ oxidizable nitrogen (Subbiah and Asija 1956) [16], 20.6 kg $ha^{-1}$ available phosphorus (Olsen *et al.*, 1954) [11], 211 kg $ha^{-1}$ 1 N neutral ammonium acetate exchangeable potassium (Hanway and Heidel, 1952) and 0.88% organic carbon (Walkley and Black, 1934) [20]. The pH of the soil was 7.6 (1:2.5 soil: water ratio) (Jackson, 1973) [5].

### Experimental design and treatments

The treatments were $T_1$= 100% RDN as PU (50% basal (B) + 25% active tillering (AT) + 25% panicle initiation (PI) (existing practice), $T_2$= 100% RDN as NCU (100% B), $T_3$= 100% RDN as NCU ( 75% B + 25% AT ), $T_4$= 100% RDN as NCU (50% B + 50% AT), $T_5$= 75% RDN as NCU (50% B + 25% AT + 25% PI), $T_6$= 100% RDN as NCU (50% B + 25% AT + 25% PI), $T_7$= 125% RDN as NCU (50% B + 25% AT + 25% PI), $T_8$= 100% RDN as NCU (33.3% B + 33.3% AT + 33.3% PI), $T_9$= 125% RDN as NCU (33.3% B + 33.3% AT + 33.3% PI) and $T_{10}$= no nitrogen application (control). These were tested in a randomized complete block design with three replications. The net plot size was 10.08 $m^{-2}$.

### Application of treatments and fertilizers

The experimental field was ploughed once by disc plough followed by two cross disc harrowing and levelling. The individual plot was first prepared with power tiller and then manually by spade. Two days before transplanting, the layout was shaped and bunds were prepared. The individual plot was flooded with water and then puddling followed by levelling was done manually. Phosphorus @ 60 kg $ha^{-1}$ $P_2O_5$ was applied through single super phosphate (SSP) and potassium @ 40 kg $ha^{-1}$ $K_2O$ was applied through muriate of potash. The full dose of phosphorus and potassium fertilizer and nitrogen as per the treatment were applied just before transplanting on drained puddle surface and incorporated into the top 20 cm soil manually with the help of spade. The remaining quantity of nitrogen was top dressed as per the treatment at active tillering (24 days after transplanting (DAT)) and panicle initiation (46 DAT) stages.

### Crop management

Four-week-old seedlings of rice variety "HKR-47" was transplanted in rows with the help of nylon rope at a spacing of 20 cm × 20 cm keeping two seedlings per hill on 25th June 2016. It is a medium duration (135 days), semi-dwarf high yielding indica rice variety with long slender grains of golden yellow colour. The yield potential of this variety is 45-50 q $ha^{-1}$. After 10 and 20 DAT, the missing hills in the plots were replanted (gap filled) with the seedling of the same age so as to maintain required plant population. A thin film (2-3 cm) of water was maintained during the initial stage up to the seedling establishment, thereafter the water level was gradually raised to 5 cm and irrigation was applied 2 days after the disappearance of ponded water. For correction of zinc (Zn) deficiency, a foliar spray of Zn at 0.5% $ZnSO_4.7H_2O$ + 0.25% slaked lime in 500 litres of water $ha^{-1}$ was given on 6th July 2016. All other crop management was done with recommended package of practices.

### Grain yield

When ninety per cent of grains in the panicles were fully ripe (free from greenish tint), harvesting was done manually from the net plots with the help of sickles. After that sun drying was done for 3-4 days and then threshing was done with a Pullman thresher. Grains were collected in a cloth bags as per treatment and recorded as kg $plot^{-1}$ and were later 120 expressed as kg $ha^{-1}$ at 14% moisture content. On the basis of grain to straw ratio, obtained from the plant sample of 16 hills, straw yield was calculated from the grain yield of the individual plot and was expressed as kg $ha^{-1}$. The total biological yield was obtained by adding grain and straw yield of individual plot and expressed as kg $ha^{-1}$.

### Phosphorus and Potassium accumulation and its distribution in different plant parts

The phosphorus and potassium content in different parts (leaf, stem and panicle) of rice plant at harvest were determined with Vandomolybdo phosphoric acid yellow color method (Jackson,1973) [5] and Flame photometer method (Jackson, 1973) respectively, P and K accumulations in leaf, stem and panicle were obtained by multiplying the respective concentrations (%) with their dry weights (kg $ha^{-1}$) at harvest. Total P and K accumulation (kg $ha^{-1}$) in a particular treatment was the sum of respective leaf, stem and panicle P and K accumulations.

## Results and discussion

### Phosphorus content

Phosphorus content in leaf, stem, and panicle was affected by different treatments (Figure 1A). All the nitrogen containing treatments were statistically *at par* with regard to leaf, stem and panicle P contents. The maximum phosphorus content in leaf (0.126%) was recorded in treatment $T_7$, $T_8$ and $T_9$ whereas the minimum was found under control (0.099%). The maximum phosphorus content in stem and panicle (0.260% and 0.299%) was recorded in treatment $T_9$ but the minimum was found under control (0.188% and 0.249%). NCU acts as nitrification retarder and therefore more concentration of $NH_4^+$-N might have resulted in higher conecentration of P in the soil leading to more uptake by plants. These results in confirmety with the study of Hagin *et al.* (1990) [3] and Shaviv (1993) [3].

### Phosphorus uptake

The maximum leaf, stem, panicle as well as total P uptakes by rice crop was found with $T_7$ which were statistically at par with $T_9$, $T_8$ and $T_6$ with regard to leaf and with $T_9$ and $T_8$ with regard to stem and with $T_9$ with regard to panicle as well as total P uptake (Figure 1C). The increase in uptake of P was mostly because of increase in dry matter production due to nitrogen application. Application of NCU @ 120 kg N $ha^{-1}$ as 50:25:25 split schedule ($T_6$) recorded significantly higher total P uptake (28.9 kg $ha^{-1}$) than PU ($T_1$) (26.6 kg $ha^{-1}$) with the same dose and splitting. However, among N-containing treatment the lowest total P uptake was observed in treatment $T_2$ ($NCU_{120}$ 100% as basal).

### Potassium content

Potassium content in leaf, stem, and panicle was affected by different treatments. It is apparent from the data that significantly higher K content leaf (1.16%) was recorded with $T_9$ ($NCU_{150}$ 33.3:33.3:33.3 split schedule at basal, AT and PI stages) which was statistically at par with all other treatments except $T_5$ ($NCU_{90}$ 50:25:25 split schedule) (1.02%) and control (0.89%). The maximum potassium content in stem (1.78%) was recorded with $T_7$ ($NCU_{150}$ 50:25:25 split schedule) and maximum K content in panicle (0.399%) was recorded with $T_9$ ($NCU_{150}$ 33.3:33.3:33.3 split schedule at basal, AT and PI stages) which were statistically *at par* with all other treatments except control. A relatively higher potassium content in leaf, stem, and panicle was observed with the application of NCU @ 120 kg N ha$^{-1}$ as 50:25:25 split schedule ($T_6$) than PU ($T_1$) with the same dose and splitting. However, among the N-containing treatments the lowest K content in leaf, stem, and panicle was found in $T_5$ ($NCU_{90}$ 50:25:25 split schedule).

### Potassium uptake

The significantly higher K uptake by leaf (31.9 kg ha$^{-1}$) was recorded with $T_9$ ($NCU_{150}$ 33.3:33.3:33.3 split schedule) which was statistically at par with $T_7$ ($NCU_{150}$ 50:25:25 split schedule), $T_8$ ($NCU_{120}$ 33.3:33.3:33.3 split schedule), $T_6$ (50:25:25 split schedule) and $T_4$ ($NCU_{120}$ ½ B + ½ AT). Significantly higher K uptake by stem (65.9 kg ha$^{-1}$) was recorded with $T_7$ which was statistically at par with $T_9$, $T_8$, $T_6$ and $T_4$. Significantly higher panicle and total K uptakes were found with $T_7$ which was statistically at par with $T_9$ and $T_8$. Application of NCU @ 120 kg N ha$^{-1}$ as 50:25:25 split schedule ($T_6$) recorded significantly higher total K uptake (113.5 kg ha$^{-1}$) over PU ($T_1$) (103.6 kg ha$^{-1}$) with the same dose and splitting. However, among N-containing treatments the lowest total K uptake (98.6 kg ha$^{-1}$) was recorded with $T_2$ ($NCU_{120}$ 100% as basal) and $T_5$ ($NCU_{90}$ 50:25:25 split schedule). The higher K uptake with higher nitrogen doses might be due to the synergistic effect of nitrogen and potassium due to increased availability of nitrogen which in turn increased the K concentration in grain and straw and finally led to increased K uptake. The similar results were also reported by Olsen (1986) [11].

### Soil chemical properties

The data pertaining to soil chemical properties (pH, EC, organic carbon, available N, P and K) as influenced by different nitrogen management treatments are presented in Table 1. It is apparent from the data that except available N, none of the studied soil chemical parameters was influenced by different nitrogen management treatments. The significantly higher available soil nitrogen (226 kg ha$^{-1}$) was recorded with $NCU_{150}$ 33.3:33.3:33.3 split schedule at basal, ($T_9$) this was statistically at par with all other treatments except control (209 kg ha$^{-1}$). The higher available soil nitrogen in treatment $T_9$ might be due to the application of neem coated urea could be attributed to the inhibition of nitrification this caused the more nitrogen fixation, slow and steady release of nitrogen into the soil system and reduces the losses of the applied nitrogen. The similar findings were also reported by Suresh and Swarna (2008) [15]. Among the N-containing treatments the lowest available soil nitrogen (214 kg ha$^{-1}$) was observed with $NCU_{120}$ 100% B ($T_2$) and this was followed by $PU_{120}$ ½ B + ¼ AT + ¼ PI ($T_1$).

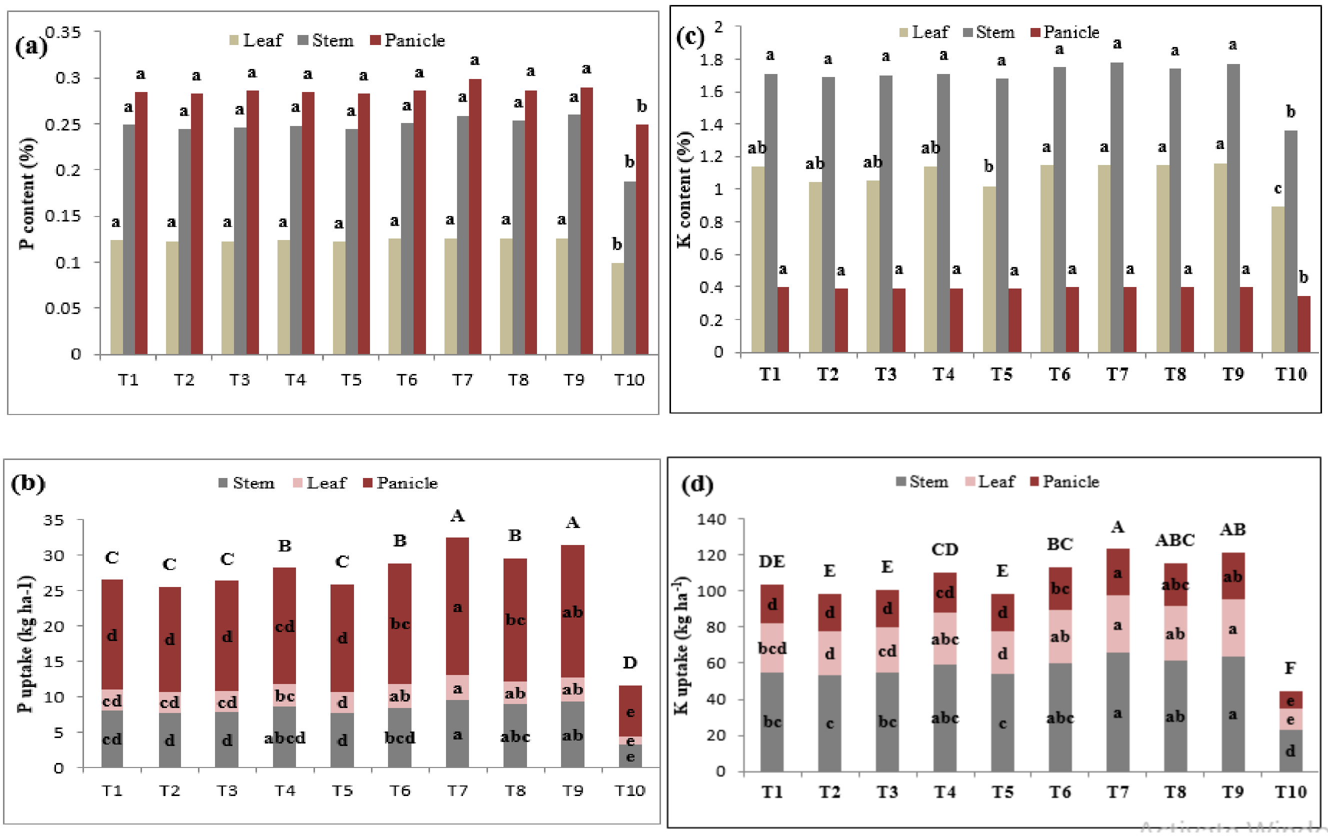


**Fig 1:** Effect of nitrogen management through neem coated urea on contents and uptakes of P (a and b) and K (c and d). Means marked by at least a lower case ( for P and K contents and uptakes by different plant parts) or upper case (for total P and K uptake) common letter do not differ significantly according to LSD test (P=0.05).

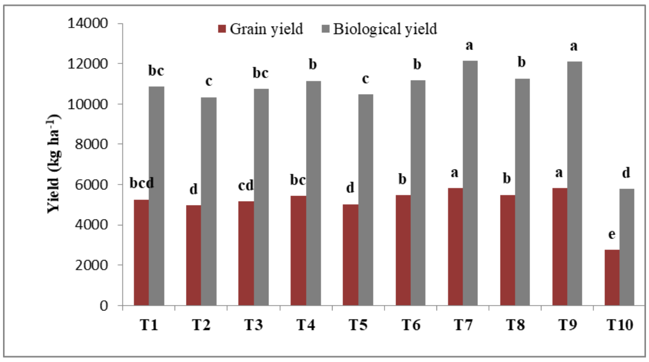


**Fig 2:** Effect of nitrogen management through neem coated urea on yield of rice. Means marked by at least a common letter do not differ significantly according to LSD test (P=0.05).

**Table 1:** Effect of nitrogen management through neem coated urea on soil chemical properties.

| Treatment | Soil pH | EC (dS $m^{-1}$) | Organic carbon (%) | Available N (kg $ha^{-1}$) | Available P (kg $ha^{-1}$) | Available K (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|
| T1 | 7.72 | 0.179 | 0.86 | 214 | 21.0 | 205 |
| T2 | 7.71 | 0.180 | 0.86 | 214 | 20.5 | 209 |
| T3 | 7.71 | 0.170 | 0.87 | 220 | 21.3 | 206 |
| T4 | 7.70 | 0.170 | 0.87 | 221 | 21.6 | 206 |
| T5 | 7.71 | 0.180 | 0.86 | 214 | 20.4 | 209 |
| T6 | 7.70 | 0.170 | 0.87 | 223 | 21.8 | 206 |
| T7 | 7.68 | 0.170 | 0.88 | 225 | 22.0 | 202 |
| T8 | 7.69 | 0.170 | 0.87 | 224 | 21.8 | 205 |
| T9 | 7.68 | 0.170 | 0.88 | 226 | 22.0 | 203 |
| T10 | 7.72 | 0.180 | 0.86 | 209 | 19.2 | 196 |
| SEm ± | 0.13 | 0.004 | 0.01 | 3.7 | 0.7 | 3.3 |
| CD(*P*=0.05) | NS | NS | NS | 10.9 | NS | NS |

## Conclusion

From the present study, it can be concluded that nitrogen management through neem coated urea can play an important role in augmenting yield, P and K uptke in transplanted rice. Application of 100% RDN through neem coated urea with 50:25:25 or 33.3:33.3:33.3 split schedule at basal, AT and PI stages can improve the performance of transplanted rice in terms of yield, P and K uptake over existing practice *i.e.* application of 100% RDN through prilled urea with 50:25:25 split schedule. Further, application of neem coated urea @ 125% RDN with 50:25:25 split schedule can maximize the yield and P, K uptake of transplanted rice over the existing practice in *Tarai* region of Uttarakhand, India.

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