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Response of applied neem coated urea (NCU) on yield and yield attributing parameters of rice (*Oryza sativa* L.)

Shriman Kumar Patel, Yogesh Kumar, Mahemdra Singh, Prem Singh, B P Dhyani and Adesh Singh

Shriman Kumar Patel
Department of Soil Science and Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Yogesh Kumar
Department of Soil Science and Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Mahemdra Singh
Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Prem Singh
Department of Soil Science and Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

B P Dhyani
Department of Soil Science and Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Adesh Singh
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Correspondence
Shriman Kumar Patel
Department of Soil Science and Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Abstract
A field experiment was conducted during *kharif* season of 2016 at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) to evaluate the Response of applied neem coated urea (NCU) on yield and yield attributing parameters of rice (*Oryza sativa* L.). The study was carried out with eleven treatments comprising T_1-control (No N), T_2-50:25:25 N, T_3-33:33:33 N, T_4-25:25:50 N, T_5-25:50:25 N, T_6-00:50:50 N, T_7-00:75:25 N, T_8-00:25:75 N, T_9-50:50:00 N, T_{10}-50:00:50 N through neem coated urea as basal, at maximum tillering and panicle initiation stage and T_{11}-LCC based (≤ 4 critical value) replicated thrice estimated in a randomized block design. The data on growth, yield and its contributing traits were calculated on plot area basis (15 m^2), whereas content and uptake of nutrients at various stages along with available N, P and K as well as availability at surface, sub surface was recorded as per the standard procedure. The experimental results revealed that growth attributes (plant height, number of tillers and dry matter accumulation), yield attributing traits (grains $panicle^{-1}$and test weight), yields *viz.*, grain, straw and biological and uptake of nitrogen, phosphorus and potassium in rice differ significantly among different treatments and were maximum with the application of 25% N as basal, 50% at maximum tillering and 25% at panicle initiation stage. Application of 50% N as basal and rest through LCC (≤ 4) critical value improved the organic carbon of soil. Therefore, application of 25% N as basal, 50% at maximum tillering and 25% panicle initiation stage, proved to be better for achieving higher yield and maintaining the nutrient status of soil. The rice also accumulated significantly higher nitrogen in grains, straw as well as total (69.65, 59.04 kg ha^{-1} and 128.69 kg ha^{-1}, respectively) in this treatment.

Keywords: Rice, Nitrogen, Neem coated urea, yield

1. Introduction

Rice is the most important food crop of the developing world and the staple food for more than 60% of the Indian population. Among the cereals, rice (*Oryza sativa* L.) is the major source of calories for 40 per cent of the world population. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. China and India are the largest rice producing and consuming countries in the world. India produced about 106.4 m tonnes of rice and made 40% contribution to the total food grain production of the country (Anonymous, 2016) [4]. About 63 per cent of total rice area is situated in Uttar Pradesh, Bihar, West Bengal, Assam, Orissa and Madhya Pradesh. Uttar Pradesh is the 2nd largest rice growing state only after West Bengal in the country, in which rice is grown over an area of 5.86 million hectares with the production of 14.41 million tonnes and the productivity is 2.46 tones ha^{-1}**.** Basmati rice is known as queen of rice and area under scented rice varieties is also increasing day by day with the opening of world market as well as domestic consumption (Singh *et al*., 2008) [19]. In India, aromatic (Indian Basmati) rice is being produced in Punjab, Haryana, Western U.P, Uttaranchal, Jammu & Kashmir covering an area of 21.03 ha with production of 80.29 tonnes and an average productivity of 38.20 q ha^{-1} (Sharma, 2015) [17]. Out of 17 essential nutrients require by crop plants for their normal growth and reproduction, nitrogen (N) is generally required by them in the largest amounts. Urea is one of the most widely used sources of fertilizer N in the world. It also has high nitrogen content (46%), in comparison to many other popular nitrogen sources. When it is applied to the soil, urea is first transformed into ammoniacal (NH_4^+) form after its hydrolysis and then to nitrite (NO_2^-), followed by to nitrate (NO_3^-) forms by the process of nitrification.

Most of the crop plants uses nitrate as a source of nitrogen except rice plants which prefers ammoniacal form. The use efficiency of fertilizer N by a crop, especially through chemical fertilizer such as urea, in India ranges from 30 to 50% for rice. One scientific study has estimated nitrogen use efficiency (NUE) below 33% for cereal production at the global scale.

Many research studies in India have conclusively established that neem oil acts as an effective nitrification inhibitor if coated on the urea neem coated urea aims to achieving efficient nitrogen release pattern and use of chemical N by crop plants beside improve in the efficiency of nitrogen. Supplying N in a slowly available form reduces volatilization, leaching or denitrification losses and the evidence suggests that sulphur and agrotain coated urea are effective for crops in irrigated coarse textured soil (Ahmad *et al*., 2008) [8]. Various approaches have been adopted inhibit the urease activity and to delay the hydrolysis process of urea. "On an average, 20 per cent less neem-coated urea is required as compared to ordinary urea. It is also helpful in preventing insect attacks (Kumar *et al*., 2015) [11]. Government policy on neem coated urea In January 2015, the government allowed the urea producers to produce up to 100% of production as neem coated urea. Further, the government made it mandatory to produce at least 75% of domestic urea as neem coated.

2. Methods and Materials

A field experiment was conducted during the *Kharif* season of 2016 at the crop research center Chirauri of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.), India to study the Response of applied neem coated urea (NCU) on yield and yield attributing parameters of rice (*Oryza sativa* L.). The experimental site is located at latitude of 29^0 40′ North and longitude of 77^0 42′ East and at an altitude of 237 metre above mean sea level (MSL). Meerut lies in the heart of Western Uttar Pradesh and has semi-arid to sub-tropical climate. The mean maximum temperature was noticed in June, which is the hottest month of the year, ranges from 40^o to 45^oC while very low temperature (4°C) accompanied by frost may be experienced in December to January. The winters are cool; frost generally occurs towards the end of December and may continue till the end of January. The mean annual rainfall of the Meerut is about 840 mm, of which nearly 80 per cent is received in the monsoon period from June to September. The soil of experimental plot was loam in texture. Soil samples from a depth of 0-15 cm were collected from each plot of the experimental field prior to transplanting and a composite sample was drawn for determining its physical and chemical properties. The characteristics of top soil (0–15 cm layer) at the start of experiment was neutral in reaction (pH 8.03), electrical conductivity 0.21 dSm^{-1}, soil organic carbon 0.44%, available N 205.37 kg/ha (Subbiah and Asija 1956) [21], available P 10.87 kg/ha (Olsen *et al*. 1954) [15] and available K 231.43 kg/ha (1 N NH4OAc-extractable K). Eleven treatments comprising T_1 control (No N), T_2 (50:25:25 N) T_3 (33:33:33 N), T_4 (25:25:50 N), T_5 (25:50:25 N), T_6 (00:50:50 N), T_7 (00:75:25 N), T_8 (00:25:75 N), T_9 (50:50:00 N), T_{10} (50:00:50N) through neem coated urea as basal, at maximum tillering and panicle initiation stage and LCC based (≤ 4 critical value) replicated thrice estimated in a randomized block design. The treatment means were compared using least significant differences at 5% level of significance (Gomez and Gomez 1984) [10].

3. Results and discussion

3.1 Effect of neem coated urea on growth parameter of rice

Plant height (cm)

The data related to plant height as affected by different treatments at various days interval are presented in Table 1. It is clearly depicted from the presented data that plant height which is measured in cm at different day's interval was varied significantly with the application of different treatments when compared with control treatment. Plant height of rice increased with the advancement of crop growth and reached to maximum at harvest stage, irrespective of the treatments. At 30 DAT, the maximum plant height (44.7 cm), statistically *at par* to T_3 and significantly taller than the remaining treatments was found in T_5 where the 25:50:25 N through neem coated urea as basal, at maximum tillering and panicle initiation respectively was adopted. The shortest plant height (34.2 cm) statistically *at par* with T_6 to T_9 but significantly lower than all the remaining treatments was found in T_1 control. Plant height was found similar in the plots receiving 25:50:25 as well as 33:33:33 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively. At 60 DAT, the maximum plant height of 78.4 cm which was significantly higher than the remaining treatments was recorded in T_5. The shortest plants of 55.1 cm were found under control At 90 DAT, the maximum plant height of 104.2 cm, statistically *at par* with T_3 but significantly higher than the remaining treatments was recorded in treatment T_5 where N was applied as 25:50:25 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively while the shortest plants were observed under control. At harvest stage, maximum plant height of 113.3 cm being statistically *at par* with T_5 but significantly higher than the remaining treatments was noticed in T_3 (33:33:33) N. However, the minimum plant height was observed under control. The use of 50% N as basal and rest through LCC (≤4) also recorded significantly taller plants as compared to the existing recommendation (T_2). The supply of sufficient N at early growth stage maximizes the plant growth. The finding is in contradiction to recommended N application schedule of 50:25:25. This is possible because at the time of transplanting applied 50% N may not be utilized perfectly and a major portion may be subjected to various losses. The reduction in N application at the time of transplanting and higher application at the mid-season of crop growth may taroun the plant growth. Moreover, shortest plant was measured under control plot which might be due to restricted supply of primary nutrients in unfertilized plot and deficient of NPK in experimental soil (Mirza *et al*., 2009) [14].

3.2 Number of tillers per meter row length

The data related to effect of different treatments on the number of tillers per meter row length at different stages i.e. 30, 60, 90 DAT and harvesting stage of rice are presented in Table 1. It is legible from the Table 1 that number of tillers per metre row length increased with the advancement in crop growth up to 60 DAT, thereafter decline slightly up to harvest. The data revealed that at 30 DAT, the highest number of tillers per metre row length (66), statistically *at par* to T_3 and T_{11} and significantly higher than the remaining treatments were found in T_5 (25:50:25 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively). The lowest number of tillers per metre row length (49) found in T_1 which was *at par* to T_8 but significantly lower than all the remaining treatments.

Although, the statistically same number of tillers per metre row length were found in the plots receiving 50:25:25 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively and 50:50:00 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively. At 60 DAT, the maximum number of tillers per metre row length (77), statistically *at par* to T_3 and significantly higher than the remaining treatments were found in T_5 where N application schedule 25% N as basal, 50% at maximum tillering and 25% N at panicle initiation stage was adopted. The minimum number of tillers per metre row length (51) found in T_1 were statistically *at par* to T_6 and T_8 and significantly lower than all the remaining treatments. Treatments receiving 50% N as basal, 25% at maximum tillering and 25% N at panicle initiation and 50% N as basal and 50% N at panicle initiation, also brought significant variation this regard. At 90 DAT, the highest number of tillers per metre row length (74), statistically *at par* to T_3 and significantly higher than the remaining treatments were found in T_5 with the application of N as 25:50:25 through neem coated urea at basal, maximum tillering and panicle initiation, stage respectively. Significantly minimum number of tillers per meter row length (48) were found under control. At harvesting of rice, the maximum number of tillers per metre row length, statistically *at par* to T_3 and T_{11} but significantly higher than the remaining treatments were found in T_5 (71). The use of 50% N as basal and rest through LCC (≤4) remained on par to the existing recommendation (T_2) in this regard. Plant nourished with higher proportion of N application at maximum tillering and panicle initiation resulted in higher absorption and translocation of nitrogen to effective plant parts, and thereby possibly high number of tillers (Ladha *et al*., 1998). Moreover, less number of tillers were recorded under unfertilized plot. Nitrogen increase the proportion of protoplasm to cell wall material and lead to several consequences, one of them being an increase in size of cell which expressed increased morphologically growth attributes (Arnon, 1953) [5]. Similar by with a late nitrogen application during the booting stage the increased number of tillers were also reported by Ellen and Spiertz (1980) [20]. Further, in the US applying N in 2-3 applications gives more number of tillers than just 4-5 splits (Alcoz *et al*., 1993) [2].

3.3 Dry matter accumulation (q ha^{-1})

Data pertaining to the effect of different treatments on the dry matter accumulation of rice are presented in Table 1. It is evident from the data shown in Table 1 that dry matter accumulation in rice increased with advancement of crop growth. Different treatments influenced the dry matter accumulation significantly at different growth stages of rice. At 30 DAT of rice the highest dry matter accumulation of 14.9 q ha^{-1}, statistically *at par* to T_3, T_{10} and T_9 but significantly higher than the remaining treatments, was found in T_2 (50:25:25 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively). The minimum dry matter accumulation of 8.9 q ha^{-1} was found in T_1 followed by 00:75:25 N with 9.6 q ha^{-1}. At 60 DAT of rice, maximum dry matter accumulation (43.4 q ha^{-1}) found with the application of 25% N as basal, 50% at maximum tillering and 25% N at panicle initiation stage (T_5) was statistically *at par* to dry matter accumulation in treatment consisting application of 33% N as basal, 33% at maximum tellering and 33% N at panicle initiation stage (T_3) and significantly higher than the rest of the treatments. The minimum dry matter accumulation of 30.5 q ha^{-1} was under from control (T_1). The dry matter accumulation with the application of 25% N at maximum tillering and 75% at panicle initiation, stage through neem coated urea (T_8) 33.6 q ha^{-1} was statistically *at par* to T_7 and T_6 but significantly lower than all the remaining treatments, except control (T_1). At 90 DAT of rice, the maximum dry matter accumulation (85.5 q ha^{-1}), statistically *at par* to T_3 and significantly higher than the remaining treatments was found in T_5 where 25% N as basal, 50% at maximum tillering and 25% N at panicle initiation stage was applied. The minimum dry matter accumulation of 67.8 q ha^{-1} was recorded in control. Addition of 25:75 N through neem coated urea at maximum tillering and panicle initiation, stage respectively and 50% N as basal and 50% N at panicle initiation stage by neem coated urea did not show any significant variation in dry matter accumulation. At harvesting stage, dry matter accumulation with the application of 25% N as basal, 50% at maximum tellering and 25% N at panicle initiation stage through neem coated urea was 120.4 q ha^{-1} and 3.3% more than control (T_1) and 33% N as basal, 33% at maximum tillering and 33% N at panicle initiation stage, respectively. Dry matter accumulation in T_5 was superior to T_1 and T_8, and statistically *at par* with rest of the counterparts. Unfertilized plot recorded significantly lowest dry matter accumulation. The increase in dry matter accumulation under the application of 25% N as basal, 50% at maximum tillering and 25% at panicle initiation through NCU (T_5) was mainly due to better growth attributes viz; and plant height and tiller with increased cell division, enlargement, photosynthesis and protein synthesis. The similar opinions were also forwarded by Alam *et al.* (2010), and Coventry *et al.* (2011) [6]. The application of 120 kg N ha^{-1}in three splits (25% basal + 50% tillering stage + 25% panicle initiation stage) in rice also recorded the maximum dry matter **(**Rao *et al.,* 1996) [16].

3.4 Yield attributes and yields of rice

Data pertaining to yield attributes *viz*., Panicle length (cm), number of panicle per metre row length, number of grains per panicle, test weight (g), grain, straw, biological yield (q ha^{-1}) and harvest index of rice crop are shown in Table 2. The application of nitrogen as 25:50:25 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively (T_5) produced the longest panicle (29.1 cm) whereas the shortest panicle (21.0 cm) was noticed under control (T_1). The maximum panicles per metre row length (68), statistically *at par* to T_2, T_3 and T_{11} and significantly greater than the remaining treatments were found in T_5 (25:50:25 N as basal, at maximum tillering and panicle initiation, respectively).

The maximum number of grains per panicle (135), statistically *at par* to T_2, T_3 and T_{11} and significantly superior than the remaining treatments were observed in T_5, where 25% N as basal, 50% at maximum tillering and 25% at panicle initiation, was applied.

The significantly maximum 1000 grains weight (20.5 g) was recorded when nitrogen 25% N applied as basal, 50% at maximum tillering and 25% at panicle initiation (T_5). The next best treatments in regards to test weight were T_3, T_2 and T_{11}. All the fertilized treatments brought significant variation over control.

The highest grain yield (36.28 q ha^{-1}), statistically *at par* to T_2, T_3 and T_{11} and significantly higher than the remaining treatments was found in T_5. Where, 25% N was applied as basal, 50% at maximum tillering and 25% at panicle initiation stage. The minimum grain yield of 20.58 q ha^{-1} was found in T_1. Application of 50% N at maximum tillering and 50% N panicle initiation, or 75% N at maximum tillering and 25% N panicle initiation did not exhibited any significant variation in grain yield.

The maximum straw yield (77.68 q ha^{-1}), statistically *at par* to T_3 and T_{11} and significantly higher than the remaining treatments was found in T_5 (25:50:25 N through neem coated urea as basal, at maximum tellering and panicle initiation, respectively). The application of 50% N at maximum tillering and 50% at panicle initiation, or 25% N at maximum tillering and 75% at panicle initiation, did not exhibited any significant variation in straw yield. Biological yield (grain + straw) in rice under various treatments ranged from 73.12 to 113.96 q ha^{-1}.

The maximum biomass (113.96 q ha^{-1}), statistically *at par* to T_3 but significantly higher than the remaining treatments was found in T_5 (25:50:25 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively). The minimum biological yield of 73.12 q ha^{-1} was found under the control plot. Biological yield (96.98 q ha^{-1}) statistically *at par* to T_6 but significantly lower than all the remaining treatments except T_1 was found with the application of 25% N at maximum tillering and 75% at panicle initiation.

The minimum and maximum harvest index of 28.13 and 32.11 per cent, respectively was noticed in T_7 (75% N at maximum tillering and 25% at panicle initiation,) and T_3 (33% N as basal, 33% at maximum tillering and 33% at panicle initiation). The increment of yield under this treatment may be attributed to scheduling of N where 50% N was applied at maximum tillering stage that lead the production of new meristemic tissue by better growth performance and favourable source sink relationship. The results are in close conformity with those of Coventry *et al.* (2011) [6] and Ganga D. *et al*. (2012) [9]. Higher straw yield was produced under with the application of 37.5% N as basal through NCU, 47.0 and 15.5% N, at maximum tillering and panicle initiation respectively over rest of the counterparts. Applying higher quantity of N at tillering stage accumulate more dry matter and increase the vegetative growth compared to other splits. The result gets conformity from the work of Maskina *et al*. (1992) [12]. Higher biological yield was mainly due to combined effect of grains and straw. Similar results were also reported by Kumar *et al*. (2015) [11]. Ganga D. *et al*. (2012) [9] observed that higher grain yield of scented rice at par to 150 kg ha^{-1} was obtained with highest level of nitrogen i.e. 175 kg/ha application in four equal splits of nitrogen at ¼ basal + ¼ at active tillering + ¼ at panicle initiation and ¼ at heading due to increase yield attributes and growth parameters. Harvest index, which is a ratio of grain yield to biological yield was maximum in T_2 (50% N as basal, 25% at maximum tillering and 25% at panicle initiation, stage) treatment while minimum in case of T_9. Higher harvest index indicate more translocation of photosynthates from grain leaves towards sink. Grain by improving the yield attributes and yields, in which nitrogen plays a vital role. Similar opinions were also made by Youseftabar *et al*. (2012) [22].

3.5 Effect of neem coated urea on soil chemical properties

Soil pH, electrical conductivity and organic carbon as affected by different fertility treatments at harvesting stage stages are presented in Table 3.

3.6 pH on soil

Soil pH of in different treatments are shown in table 3. pH of soil (0-15 cm) was varied from 7.18 to 7.84. Highest soil pH was recorded in soil sample with the application of 25:50:25 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively (T_5). Minimum soil pH 7.18 was found in control. These results are in line with the findings of Doberman *et al*. (2002) [7] and Naresh *et al.* (2014).

3.7 Electrical conductivity

Soil electrical conductivity of different treatments are shown table 3. Electrical conductivity (dSm^{-2}) varied from 0.21 to 0.27. Highest soil EC was recorded in soil sample with the application of 25:50:25 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively (T_5). Minimum soil pH 0.21 was found in control, also similarly reported by Kumar *et al* (2015) [11].

3.8 Organic carbon in soil (g kg^{-1})

At harvesting stage of rice crop, organic carbon in soil under different treatments varied from 3.84 to 4.41 g kg^{-1}. The maximum organic carbon of 4.41 g kg^{-1}, statistically *at par* to T_4, and T_{11} and significantly higher than the remaining treatments was found in T_5 where the 25:50:25 N through neem coated urea as basal, at maximum tellering and panicle initiation was applied. The minimum organic carbon (3.84 g kg^{-1}) found under control was statistically *at par* to T_{10}, T_7 and significantly lower than all the remaining treatments. The organic carbon content in soil with the recommended N application schedule (T_2) and 50% N as basal and rest through LCC (≤ 4) also differed significantly. Organic carbon in soil was also comparatively higher in T_3 and T_4. Similar trend of finding were reported by Mauray *et al.* (2015).

3.9 Effect of neem coated urea on available nutrients in soil

Available nitrogen in soil

Available nitrogen (kg ha^{-1}) in soil as affected by different fertility treatments at different stages is presented in Table 4. It is showed from the Table 4 that the available nitrogen in soil decline gradually with the advancement of the crop growth in all the treatments.

At tillering stage, available nitrogen in soil under different treatments `ranged from 131.34 to 147.00 kg ha^{-1}. The maximum available nitrogen (147.00 kg ha^{-1}) statistically *at par* to T_2, T_3, T_4, T_9, T_{10}, T_{11} and significantly higher than the remaining treatments was found in T_5 (25% N as basal through NCU, 50% at maximum tillering and 25% panicle initiation, respectively). The minimum available nitrogen (131.34 kg ha^{-1}) statistically similar to T_6, T_7 and T_8 and significantly lower than the reaming treatments found under control. At Panicle initiation stage, the minimum available nitrogen (116.80 kg ha^{-1}) found under control was significantly lower than the remaining treatments while maximum available nitrogen (146.67 kg ha^{-1}) recorded in T_7 (00:75:25 N through NCU at maximum tillering and panicle initiation, respectively) was statistically *at par* to T_9 and T_5 and significantly higher than all remaining treatments. Available nitrogen was comparatively higher in there treatments which received higher N application at tillering stage. At harvesting stage, the maximum available nitrogen (141.40 kg ha^{-1}) statistically *at par* to T_3, T_5 and T_9 and significantly higher than the remaining treatments was found in T_{10} where 50% N through neem coated urea as basal and 50% at panicle initiation was applied. The minimum and significantly lower available nitrogen than the other treatments (111.20 kg ha^{-1}) was found under control followed by 25% N at maximum tillering and 75% panicle initiation

(T_8) with 131.78 kg ha^{-1} available nitrogen. The use of 50% N as basal and rest through LCC (≤ 4) also recorded significantly maximum available nitrogen as compared to the existing recommendation (T_2).

3.10 Available phosphorus in soil

Available phosphorus (kg ha^{-1}) in soil as affected by different treatments at different stages of rice is presented in Table 4. It is evident from the Table 4 that the available phosphorus in soil decline gradually with the advancement of crop growth in all the treatments. At tillering stage, available phosphorus in soil under different treatments varied from 10.21 to 13.96 kg ha^{-1}. The maximum available phosphorus 13.96 kg ha^{-1} statistically *at par* to T_2, T_4, T_{11} and significantly higher than the remaining treatments was found in T_5 (25:50:25 N through neem coated urea as basal, at maximum tellering and panicle initiation. respectively). The minimum available phosphorous (10.21 kg ha^{-1}) significantly lower than the reaming treatments was found in control. At Panicle initiation stage, the maximum available phosphorus (15.24 kg ha^{-1}) found in T_5 (25:50:25 N through neem coated urea as basal, at maximum tellering and panicle initiation, respectively) was statistically *at par* to T_3, T_4, T_9, T_{10} T_{11} and significantly higher than the remaining treatments. The minimum available phosphorus (10.00 kg ha^{-1}) found in T_1 significantly lower than all the remaining treatments. Phosphorus availability improve significantly over (T_2) due to application of 50% N as basal through neem coated urea and rest through LCC (≤ 4). At harvesting stage, available phosphorus in soil under different treatments varied from 9.85 to 12.21 kg ha^{-1}. The maximum available phosphorus (12.21 kg ha^{-1}) found with 25:50:25 N through neem coated urea as basal, at maximum tillering and panicle initiation. respectively (T_5) was followed by T_3 (33:33:33 N through neem coated urea as basal, at maximum tellering and panicle initiation stage). Minimum available phosphorus (9.58 kg ha^{-1}) was found under control was significantly lower than all the remaining treatments. The use of 50% N as basal and rest through LCC (≤ 4) also recorded significantly maximum available phosphorus as compared to T_2.

3.11 Available potassium in soil

Available potassium (kg ha^{-1}) in soil as affected by different treatments at various stages of rice are presented in Table 4. It is legible from the Table 4. that the available potassium in soil decline gradually with the advancement of crop growth in all the treatments. At tillering stage, available potassium in soil under different treatments varied from 175.08 to 230.95 kg ha^{-1}. The maximum available potassium (230.95 kg ha^{-1}), statistically *at par* to T_3, T_4, T_{11} and significantly higher than the remaining treatments was found in T_5 (25:50:25 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively). The minimum available potassium (175.08 kg ha^{-1}) found under control was significantly lower than all the remaining treatments. At panicles initiation and harvesting stage the application of 25% N through neem coated urea as basal, 50% at maximum tillering and 25% panicle initiation stage (T_5) resulted into maximum available nitrogen in soil. It might be due to delayed N application through NCU. Higher nitrogen availability can also be described due to slightly higher organic carbon content which is an index of nitrogen availability. Available phosphorus in soil increased initially and reached to maximum at PI stage, thereafter reduced to lowest value at harvesting in all the treatments. Higher availability of phosphorus at panicle initiation stage may be supposed due to reduction process owing to submergence. The highest available phosphorus at maximum tillering and PI stage, respectively was noticed with the application of 25% N through NCU as basal, 50% at maximum tillering and 25% panicle initiation, stage (T_5). Availability of phosphorus in soil was minimum in control plot. Highest available phosphorus at maximum tillering and PI stage could be ascribed to higher organic matter content in this treatment, which may reduce the fixation of phosphate by providing protective cover on sesquioxides and chelating cations responsible for fixation (Singh *et al.*, 2008) [19]. Treatment T_5 recorded maximum available phosphorus at harvesting, it may be attributed to the effect of organic acids released due to mineralization of crop residues. Kumar *et al.* (2015) [11] and Tomar *et al*. (2016) also reported similar results. Further, the available potassium in soil decline gradually with the advancement of crop growth in all the treatments. Available potassium in soil at all the stages of crop growth varied significantly with the application of nitrogen. Application of 25% N through NCU as basal, 50% at maximum tillering and 25% panicle initiation, respectively being on par with (T_3), resulted into significantly higher available potassium in soil as compared to control at all the stages of crop growth. The improvement in K was might be due to slow and steady supply of K due to solubilization effect of organic acid produced during decomposition processes (Singh *et al*., (2008) [19].

Table 1: Effect of neem coated urea on growth parameter of rice

Treatment	Plant height (cm)				Number of tillers per metre row length				Dry matter accumulation (q ha-1)			
	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest
T_1 Control (No N)	34.2	55.1	71.5	92.5	49	51	48	46	8.9	30.5	67.8	80.5
T_2 50:25:25 N	40.9	73.2	103.7	109.6	62	71	68	68	14.9	40.2	81.2	117.6
T_3 33:33:33 N	44.5	74.5	103.3	113.3	64	75	72	70	13.6	41.5	83.5	118.4
T_4 25:25:50 N	40.7	72.3	100.6	109.3	60	69	71	63	10.9	39.9	72.8	117.9
T_5 25:50:25 N	44.7	78.4	104.2	112.6	66	77	74	71	12.1	43.4	85.5	120.4
T_6 00:50:50 N	35.8	69.4	92.8	101.4	51	67	57	63	9.7	35.3	72.9	100.2
T_7 00:75:25 N	35.4	71.5	93.3	102.1	52	72	59	54	9.6	34.9	73.3	99.7
T_8 00:25:75 N	35.8	70.2	92.4	99.5	50	65	56	52	9.9	33.6	71.5	96.9
T_9 50:50:00 N	35.7	72.6	97.9	109.4	61	72	64	56	13.3	38.9	72.4	101.9
T_{10} 50:00:50 N	38.0	71.1	99.3	108.5	60	66	65	61	13.7	39.2	69.6	100.4
T_{11} LCC Based (4 ≤ Critical value)	41.5	73.7	101.7	111.2	63	74	71	69	12.6	40.3	81.5	114.2
SEm±	1.3	1.0	0.5	0.7	1	1	1	1	0.6	0.7	0.9	0.9
CD at 5%	3.0	2.7	1.5	2.0	3	3	3	3	1.6	2.0	2.8	3.0

N = Nitrogen through neem coated urea at basal, at maximum tillering and panicle initiation, respectively

Table 2: Effect of neem coated urea on yield attributes and yield of rice

Treatment	Panicle length (cm)	No. of panicles per metre row length	No of grains per panicle	Test weight (g)	Yields (q ha^{-1})			
					Grains	Straw	Biological	H I (%)
T_1 Control (No N)	21.0	43	122	18.3	20.58	49.54	70.12	29.34
T_2 50:25:25 N	27.3	66	133	20.2	34.29	75.23	109.52	31.30
T_3 33:33:33 N	28.5	67	134	20.3	35.94	75.98	111.92	32.11
T_4 25:25:50 N	25.5	64	131	19.7	33.75	74.73	101.38	30.33
T_5 25:50:25 N	29.1	68	135	20.5	36.28	77.68	113.96	31.83
T_6 00:50:50 N	23.4	57	129	19.7	27.90	69.68	97.58	28.59
T_7 00:75:25 N	23.2	56	128	19.3	27.68	70.72	98.40	28.13
T_8 00:25:75 N	22.5	55	127	18.7	27.33	69.65	96.98	28.18
T_9 50:50:00 N	25.6	60	131	18.8	29.60	71.61	101.21	29.24
T_{10} 50:00:50 N	25.4	62	130	19.4	30.55	73.12	103.67	29.46
T_{11} LCC Based (4 ≤ Critical value)	28.9	66	134	20.4	34.35	75.60	109.95	31.24
SEm±	0.9	1	1	0.2	0.71	0.90	0.77	0.63
CD at 5%	2.7	3	3	0.4	2.04	2.60	2.22	1.83

N = Nitrogen through neem coated urea at basal, at maximum tillering and panicle initiation, respectively

Table 3: Effect of neem coated urea (NCU) on the soil pH, Electrical conductivity and organic carbon at harvesting stage in surface soil

Treatment	pH (1:2.5 Soil Water)	Electrical conductivity (dSm^{-2})	Organic carbon at harvest stage (g kg^{-1})
T_1 Control (No N)	7.18	0.21	3.84
T_2 50:25:25 N	7.75	0.26	3.99
T_3 33:33:33 N	7.70	0.24	4.10
T_4 25:25:50 N	7.66	0.25	4.32
T_5 25:50:25 N	7.84	0.27	4.41
T_6 00:50:50 N	7.60	0.24	3.96
T_7 00:75:25 N	7.64	0.24	3.94
T_8 00:25:75 N	7.61	0.23	3.98
T_9 50:50:00 N	7.67	0.24	3.95
T_{10} 50:00:50 N	7.62	0.22	3.92
T_{11} LCC Based (4 ≤ Critical value)	7.79	0.25	4.34
SEm±	0.02	NS	0.04
CD at 5%	0.07	NS	0.10

Table 4: Effect of neem coated urea (NCU) on available nutrient (kg ha-1) at various stages of rice

Treatment	Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
	Tillering Stage	P.I. Stage	Harvesting Stage	Tillering Stage	P.I. Stage	Harvesting Stage	Tillering Stage	P.I. Stage	Harvesting Stage
T_1 Control (No N)	131.34	116.80	111.20	10.21	10.00	9.58	175.08	169.32	155.51
T_2 50:25:25 N	144.38	138.72	133.67	12.74	13.94	11.41	222.25	213.77	193.70
T_3 33:33:33 N	146.43	140.27	136.42	12.03	15.20	12.19	228.87	215.63	193.07
T_4 25:25:50 N	144.22	138.49	133.67	12.52	14.56	11.35	227.30	214.20	194.57
T_5 25:50:25 N	147.00	142.32	139.41	13.96	15.24	12.21	230.95	216.63	195.97
T_6 00:50:50 N	133.95	140.49	133.21	12.64	12.66	10.12	215.30	201.43	190.50
T_7 00:75:25 N	133.47	146.67	132.61	12.66	13.34	10.73	217.50	197.67	189.33
T_8 00:25:75 N	132.25	140.90	131.78	12.57	13.79	11.60	212.27	196.30	183.40
T_9 50:50:00 N	143.80	145.67	140.48	12.79	14.04	11.84	225.63	207.00	185.50
T_{10} 50:00:50 N	143.60	135.24	141.40	12.68	14.58	11.88	222.80	205.40	186.87
T_{11} LCC Based (4 ≤ Critical value)	145.42	137.42	132.24	12.61	15.04	11.53	231.40	214.47	192.27
SEm±	1.13	1.46	1.39	0.54	0.46	0.45	1.59	2.15	1.09
CD at 5%	3.37	4.71	5.57	1.56	1.33	1.32	4.73	6.20	3.12

4. Conclusion

The growth parameter and yield attributes of rice was observed highest under the treatment (T_5) 25:50:25 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively. Grain and straw yield of rice was found significantly higher under treatment T_5 (25:50:25 N through neem coated urea) Followed by (T_3) 33:33:33 N through neem coated urea as basal, at maximum tillering and panicle initiation, respectively and minimum was recorded under (T_1) in control plot. Nitrogen efficiency and agronomic efficiency was found higher under T_{11} LCC based (4 ≤ critical value), respectively. The soil nutrient status was improved by application of neem coated urea. The results indicated that the available nitrogen, Phosphorus and Potassium status was observed higher under (T_5) 25:50:25 N through neem coated urea.

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