Annals of Plant and Soil Research 21(3): 233-238 (2019)

Response of rice (*Oryza sativa* L.) to levels and application technique of neem coated urea in irrigated ecosystem

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Received: April, 2019; Revised accepted: June, 2019

ABSTRACT

Field and laboratory studies were conducted during three consecutive Kharif season of 2015 to 2017. Fertilizer Research Farm, Uttripura, C.S. Azad University of Agriculture and technology, Kanpur to evaluate the response of rice "Pant-12" to levels and application technique of neem coated urea (NCU) in irrigated ecosystem on the yield, yield component, economics, nutrient uptake and quantity characteristics of rice. The amplitude of variation in mean values of three years, grain and straw yield of rice under impact of various treatments significantly differed with control treatment. Application of 150% N through NCU along with RDF of P, K and Zn applied as basal at the time of transplanting of seedling (T_4) responded maximum on grain (5518 kg ha^{-1}), straw (6890 kg ha^{-1}) yield, net return (Rs. 13795/-) with B:C ratio (1.74) and nitrogen (77.5 kg ha^{-1}), phosphorus (21.5 kg ha^{-1}), potassium (26.4 kg ha^{-1}), zinc (67.5 g ha^{-1}), uptake by grain and nitrogen (60.3 kg ha^{-1}), phosphorus (10.6 kg ha^{-1}), potassium (114.7 kg ha^{-1}) and zinc (101.2 g ha^{-1}) uptake by rice straw. The physical characteristics viz., hulling (74.2%), milling (58.2%), length of grain (6.85 mm) and chemical parameters i.e. crude protein (8.3%), true protein (8.0%), starch (79.2%), amylase (19.5%) and mineral matter (1.8%) were also maximum in treatment T_4. The thermal qualities viz., water uptake, volume expansion and kernel elongation of rice grain were noticed highest in control condition. It might be due to having negative correlation with enhancing levels of nitrogen. Split application of 100% N through NCU (1/2 N basal + ¼ N M.T. + ¼ N PI stage (T_6) was most suitable technique followed by 100% N through NCU (3/4 N as basal + 1/4 N M.T.) and 100% N through NCU (1/3 N as basal + 1/3 N M.T. + 1/3 N PI stage). Application of 100% N in three equal splits at various growth stages of rice through prilled urea (T_1) proved its superiority over that of 100% N – NCU (T_5) added/top dressed in three equal dose in relation to yield, yield components, nutrients uptake, quality parameters and apparent nutrients use efficiency.

Key words: Rice, yield, nutrients uptake, economics, quality, soil fertility.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the major staple food crops of India. Within the country rice occupies one quarter of total cropped area, contributing 58% total food grain production and continues to play a key role in the national food and livelihood security system. Therefore, the rice productivity needs to be enhanced from the present 2.05 q ha^{-1} to 3.3-4.05 q ha^{-1} in the next years. Earlier, rice was mostly cultivated under native soil fertility conditions without any major inputs. With the introducing of semi dwarf high yielding rice varieties during green revolution period of 1960's, rice productivity has become heavily reliant on inorganic chemical fertilization. Among the major fertility inputs, nitrogen is key nutrient element required in large quantities by rice crop. Uttar Pradesh is the largest rice growing state only after West Bengal in the country. It is grown on area of about 60 lakh ha with annual production of 131 lakh tones. The productivity, being low (21.70 q ha^{-1}) ranks 7th position in country (Tripathi *et al.* 2018). Nitrogen is a primary constituent of the nucleotides, amino acids, proteins, chlorophyll and several plant harmones and is a rate limiting crucial essential macronutrient for the growth and development of high yielding rice plants. Out of the total amount of applied nitrogen, only 30-40% reaches to rice plant (Tripathi *et al.* 2013) and remaining is lost to the environment. In irrigated rice eco-system or in low land rice cultivation, N losses are rapid because of ammonia volatilization, dentrification, surface run off and leaching in soil flood water. Thus, to minimize the loss of nitrogen and maximizing the good quality rice grain production in such type of soil it is necessary to optimize nitrogen levels and its most suitable application techniques through slow release of neem coated urea for enhancing its use efficiency.

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Indiscriminate use of high analysis chemical N fertilizer *viz.,* prilled urea resulting in the deficiency of other nutrients which decreases the yield of rice. The information regarding these facts in such condition are meager. Taking these facts in view the present investigation have been planned and conducted.

MATERIALS AND METHODS

The investigation was planned and conducted during three consecutive Kharif season 2015-2017 at Fertilizer Research Farm Station Uttripura, C.S. Azad University of Agriculture & Technology, Kanpur (U.P.) situated in sub tropical and semi arid zone. The chemical characteristics viz., pH 7.8, EC 0.52 dSm^{-1}, organic carbon 4.1 g kg^{-1}, CEC 12.18 cmol (p^{+}) kg^{-1}, available N 232 kg ha^{-1}, available P_2O_5 16.8 kg ha^{-1} and K_2O 166 kg ha^{-1} and available zinc 0.43 mg kg^{-1} of soil were determined by standard methods of Subbiah and Asiza (1956), Jackson *et al.* (1973), flame photometer and DTPA method (Lindsay and Norvell 1978), respectively. The soil was sandy loam and taxonomical class was Inceptisol. The treatments viz., T_1- 100% RDF through prilled urea (N applied 03 equal splits, T_2- 75% RDF NCU, T_3- 100% RDF NCU, T_4- 150% RDF- NCU. In treatments namely T_2, T_3 and T_4, N. P, K and Zn were applied as basal at the time of transplanting. In T_5 100% RDF NCU was applied in three equal dose as basal at transplanting, maximum tillering and panicle initiation stages of rice crop. T_6- 100% RDF-NCU applied as ½ N as basal + ¼ N MT + ¼ N PI stages of crop. T_7- 100% RDF- NCU applied as ¾ as basal + ¼ N at maximum tillering, T_8-control. Phosphorus and potassium @ 60 and 60 kg ha^{-1}, respectively were applied as basal. Zinc sulphate @ 25 kg ha^{-1}, was also added at the time of transplanting of 21 days time of transplanting old seedling of rice Pant-12 in randomized block design with three replications. Agronomical cultural practices such as irrigation, weeding and plant protection measures have been performed as per requisited. Yield and yield attributing characteristics of rice viz., grain and straw yield, tillers m^{-2}, panicles m^{-2}, filled and unfilled number of grains per panicle, test weight and plant height were recorded. Nitrogen, phosphorus, potassium and zinc content in grain and straw were determined by adopting standard procedures. Apparent recovery percentages of these nutrients were calculated. The physical, thermal and chemical characteristics of rice grains were determined by standard procedure. The crude protein content was determined by multiplying nitrogen concentration in grain with factor 5.95. The yield, nutrients uptake and quality characteristics of rice grains were recorded on the basis of 14% moisture content.

RESULTS AND DISCUSSION

Yield and yield component

It is obvious from the table-1 that grain, straw yield, tillers m^{-2}, panicles m^{-2}, filled and unfilled grain per panicle, test weight and plant height varied from 2554 to 5518 kg ha^{-1}, 3153 to 6890 kg ha^{-1}, 243 to 314, 235 to 306, 109.2 to 155.6, 2.6 to 10.4, 28.0-29.9 g and 91.2 to 110.5 cm with mean value of 4743 kg ha^{-1}, 5906 kg ha^{-1}, 283, 275, 136.7, 5.78, 28.6 g, and 102.8 cm, respectively. The maximum yield and yield components were recorded in plot which received nitrogen through neem coated urea @ 150 kg ha^{-1} as basal along with 60 kg P_2O_5 ha^{-1}, 60 kg K_2O ha^{-1} and 25 kg zinc sulphate ha^{-1} (T_4) followed by T_3, T_1 and T_2. The basal application of 100% RDF NCU (T_3) showed its superiority over 100% RDF of prilled urea applied in three equal splits (T_1) in respect of yield and yield attributes. Application of neem coated urea @ 100% RDF with phosphorus, potassium and zinc as basal recorded more grain and straw yield along with other parameters (T_3) than 100% N through prilled urea in three equal splits as basal, MT and PI stages of rice but could not differ significantly. Lower dose of nitrogen 75% RDF through NCU along with phosphorus and potassium as basal showed decreasing effect on yield as well as other attributing characters. It was noticed that application of nitrogen N through neem coated urea, ½ N with P, K and Zn as basal at the time of transplanting and remaining half dose in two equal splits (T_6) produced higher yield and yield parameters than 75% N through NCU as basal with full dose of P, K and Zn and remaining 25% N through NCU at maximum tillering stage of rice crop (T_7). It is therefore, clear that addition of 100% N or 150% N through neem coated urea as basal along with full dose P, K and Zn responded more than its split application in various ratio at different stages of rice crop under irrigated eco-system. It migh be due slow release nature of neem coated urea in irrigated rice soils. These findings have close conformity with those reported by Hardev *et al.* (2015) and Tripathi *et al.* (2016).

Table 1: Effect of neem coated urea and its application techniques on the yield and yield attributes of rice (mean value of 03 years)

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Tillers m^{-2}	Panicles m^{-2}	Filled grains $panicle^{-1}$	Unfilled grains $panicle^{-1}$	Test weight (g)	Plant height (cm)	Net return (Rs/ha)	B:C ratio
T_1	5125	6390	287	280	139.3	4.8	28.7	105.8	12812	1.48
T_2	4517	5615	268	260	130.3	7.9	28.5	95.9	11292	1.17
T_3	5262	6625	301	293	145.3	3.2	28.9	108.3	13155	1.65
T_4	5518	6890	314	306	155.6	2.6	28.0	110.5	13795	1.74
T_5	4770	5908	276	268	135.3	6.3	28.5	100.8	11925	1.28
T_6	5170	6452	291	283	142.4	3.9	28.8	106.7	12925	1.56
T_7	5032	6215	284	276	136.6	7.2	28.6	103.5	12580	1.39
T_8	2554	3153	243	235	109.2	10.4	29.0	91.2	6385	1.09
CD 5%	1.829	2.70	12.30	12.22	10.64	0.03	0.02	2.78	-	-

Nutrients uptake and recovery

Data (Table 3) revealed that the uptake of N, P, K and zinc by grain ranged from 32.1 to 77.5 kg ha^{-1}, 8.8 to 21.5 kg ha^{-1}, 11.3 to 36.4 kg ha^{-1} and 20.0 to 67.5 g kg^{-1} with mean values of 64.8, 17.7, 21.8 Kg ha^{-1} and 56.1 g ha^{-1}, respectively under the influence of different treatments. The uptake of these nutrients by straw ranged from 25.9 to 60.2 kg ha^{-1}, 4.7 to 10.6 kg ha^{-1}, 51.2 to 114.7 kg ha^{-1} and 43.5 to 101.3 g ha^{-1} with mean values of 50.9, 8.5, 97.2 kg ha^{-1} and 83.9 g ha^{-1}. The apparent N, P, K and zinc recovery varied from 42.1 to 67.9%, 18.3 to 32.1%, 81.8 to 130.8% and 121.9 to 385.8% with mean values of 55.4, 25.3. 107.4 and 256.3 per cent, respectively. Application of nitrogen, phosphorus, potassium and zinc sulphate @ 150, 60, 60 and 25 kg ha^{-1}, as basal at the time of transplanting through NCU, SSP, MOP and Zn SO_4 recorded maximum uptake of these nutrients by grain and straw of rice. The per cent recovery of these nutrients were also maximum with N_{150}, P_2O_5 60, K_2O 60 and $ZnSO_4$ 25 kg ha^{-1} as basal at the time of transplanting of rice (T_4). Lowest uptake and percentage of NPK and Zn recovery were noticed in control (Tripathi *et al.* 2013 and Mahapatara *et al.* 2015). Addition of 100% N through neem coated urea along with P, K and Zn at the time of transplanting showed its superiority for uptake and apparent recovery. The synergistic response of lower dose of NCU with PK and Zn showed beneficial effect on the uptake and recovery percentage of these nutrients than that of control.

Table 2: Effect of neem coated urea and its application techniques on the uptake of nutrients and apparent nutrient recovery by rice (mean value of 03 years)

Treatments	Grain				Straw				Apparent nutrients recovery (%)			
	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	Zn (g ha^{-1})	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	Zn (g ha^{-1})	N	P	K	Zn
T_1	70.0	19.2	23.6	60.7	54.3	9.3	105.1	91.1	55.2	26.1	110.2	317.2
T_2	61.2	16.1	20.1	52.0	47.2	7.8	91.6	78.1	42.1	18.3	81.8	121.9
T_3	73.3	20.1	24.6	63.7	56.2	10.0	110.1	95.6	67.9	28.8	120.2	346.9
T_4	77.5	21.5	36.4	67.5	60.2	10.6	114.7	101.3	66.4	32.1	130.8	385.8
T_5	64.7	17.5	21.4	55..3	49.8	8.2	96.4	82.9	47.1	21.4	92.1	262.6
T_6	70.9	19.5	24.1	61.9	55.1	7.4	106.4	92.9	56.7	26.8	113.2	328.7
T_7	68.4	18.6	23.0	59.0	52.6	8.8	101.8	85.6	52.5	24.1	103.7	288.0
T_8	32.1	8.8	11.3	29.0	25.9	4.1	51.2	43.5	-	-	-	-
CD 5%	1.43	0.36	0.54	1.45	1.32	0.18	2.14	1.63	-	-	-	-

In general, application of 100% N through neem coated urea in ½ N + P, K and Zn as basal and remaining N in two equal splits at maximum tillering and panicle initiation stage (T_6) noticed more uptake of N,P,K and Zn by both grain and straw than 100% N in three equal splits through prilled urea at basal, maximum tillering and panicle initiation stages along with P, K and Zn (T_1). Addition of ¾ N of 100% RDF through NCU along with P, K and Zn and remaining ¼ NCU at maximum tillering (T_7) significantly influenced the uptake of these nutrients than that of control. The apparent recovery percentage of these nutrients under various treatments showed similar trend of response. Singh *et al.* (2013), Hardev *et al.* (2015) and Tripathi *et al.* (2018) have showed similarity of these results.

Quality

The physical characteristics viz., hulling, milling percentage, length and length : breath ratio of rice ranged from 69.4 to 74.2%, 52.2 to 58.8%, 6.43 to 6.85 mm and 3.24 to 3.60 with mean values of 55.2%, 71.9%, 6.44 mm and 3.42, respectively (Table 3). The maximum values of hulling (74.2%), milling (58.2%) and length of grain (6.85 mm) were recorded with 150% RDF through NCU along with of P, K and Zn as basal at the time of transplanting while L:B ratio showed reverse trend which was noted maximum (3.60) in control. Addition of 75% RDF through NCU and P K and Zn as basal enhanced these physical parameters but could not differ markedly to that of control. However, 100% RDF applied ¾ N as basal with P, K and Zn at transplanting and remaining ¼ at MT (T_7) recorded lower values of these parameters than that of 100% prilled urea added in three equal splits at T.P., MT and PI stage of rice (T_1). The hulling, milling percentage and length of grain were recorded lowest in control but length: breath ratio showed highest value (4.26). it might be due to having reverse correlation with other physical characteristics. Application of 150% RDF neem coated urea along with 60 kg P_2O_5, 60 kg K_2O and zinc sulphate 25 kg ha^{-1} beneficially improved the physical quality parameters of rice Singh *et al.* (2013), Ganga Devi *et al.* (2012) and Shubha Laxmi *et al.* (2014) also reported similar results.

Table 3: Effect of neem coated urea and its application techniques on the quality characteristics of rice grains (mean value of 03 years)

Treatments	Physical parameters				Thermal parameters			Chemical parameters				
	Milling (%)	Hulling (%)	Length of grain (mm)	Length and breadth ratio	Volume expansion of its original volume	Kernal elongation (mm)	Water uptake (ml)	Crude protein (%)	True protein (%)	Starch (%)	Amylose (%)	Mineral matter (%)
T_1	55.7	72.4	6.68	3.39	4.16	1.44	368	8.08	7.78	78.85	18.85	1.72
T_2	53.1	70.3	6.48	3.55	4.23	1.50	381	7.76	7.49	78.48	18.19	1.63
T_3	57.3	73.6	6.79	3.28	4.11	1.39	359	8.26	7.92	79.08	19.32	1.79
T_4	58.2	74.2	6.85	3.24	4.09	1.36	355	8.35	8.03	79.20	19.55	1.82
T_5	54.0	71.0	6.55	3.50	4.21	1.48	376	7.85	7.57	78.60	18.38	1.65
T_6	56.5	73.0	6.74	3.33	4.13	1.41	364	8.17	7.80	78.96	19.09	1.75
T_7	54.8	71.7	6.62	3.44	4.18	1.46	372	7.96	7.69	78.72	18.62	1.68
T_8	52.2	69.4	6.43	3.60	4.26	1.53	385	7.62	7.37	78.30	17.94	1.56
CD 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

The thermal quality parameters viz., volume expansion of its original volume, water uptake and kernel elongation of rice ranged from 4.26 to 4.09, 385 to 355 ml and 1.53 to 1.36 with mean values of 4.17, 370 and 1.45, respectively (Table 3). Maximum values of expansion (4.26), water uptake (385 ml) and kernel elongation (1.55 mm) were recorded in control. The lowest value of aforesaid thermal characeteristics were noticed with 150% NCU along with P60 K60 and zinc sulphate 25 kg ha^{-1} (Table 3). Split application of 100% prilled urea (1/3 N +1/3 N +1/3 N), 100% NCU (1/2 N +1/4 N +1/4 N), 100% NCU (1/3 N +1/3 N +1/3 N) and 100% NCU (3/4 N +1/4 N) at transplanting, maximum tillering and panicle initiation stage markedly improved aforesaid thermal qualities of rice grains but effect was more pronounced with neem coated urea applied in three equal doses at transplanting, maxium tillering and panicle initiation stages of rice crop (T_5). Increasing nitrogen availability/uptake through increasing the levels and its application techniques either prilled urea or neem coated urea decreased these thermal qualities. Tripathi *et al.* (2018) and Dhruvashree *et al.* (2013) reported similar results. Perusal of the data (Table 3) revealed that maximum crude protein (8.35%), true protein (8.03%), starch (79.20%), amylose (19.55%) and mineral matter (1.82%) were recorded with 150% RDF neem coated urea along with P, K and zinc sulphate as basal at the time of transplanting (T_4).

Lowest values of crude protein (7.62%), true protein (7.37%), starch (78.30%), amylase (17.94%) and mineral matter (1.56%) were obtained in control. Enhancing the level of nitrogen through either prilled urea or neem coated urea beneficially improved these quality characteristics than that control. The impact of 150% NCU was more pronounced. Although, split application of 100% prilled urea and neem coated urea at various growth stage of rice crop in different quantity also markedly improved the concentration of crude protein, true protein, starch, amylose and mineral matter concentration in rice grains. Amongst them, split application of 100% NCU (1/2 N basal + ¼ N MT and I/4 N PI) responded more beneficially. Increased protein concentration both crude and true with increasing N levels through neem coated urea as slow releaser of N may be due to the fact that nitrogen forms the principal constituent of protein and protein concentration would be always in direct proportion with the uptake of added nitrogen (Gang Devi, *et al.* (2012). Integrated use of phosphorus, potassium and zinc sulphate along with optimum dose of nitrogen and its suitable application techniques through NCU improved of starch, amylose and mineral matter content in rice grain which might be due to having positive correlation. (Shubha Laxmi *et al.,* 2014 and Tripathi *et al.,* 2018).

Table 4: Effect of neem coated urea (NCU) on soil fertility in irrigated eco system (mean value of 03 years)

Treatments	Soil pH	EC (dSm^{-1})	Organic carbon ($g\ kg^{-1}$)	Available N ($kg\ ha^{-1}$)	Available P ($kg\ ha^{-1}$)	Available K ($kg\ ha^{-1}$)
T_1	7.78	0.77	4.3	238.2	20.2	179.3
T_2	7.79	0.75	4.2	238.2	20.4	179.3
T_3	7.76	0.80	4.4	239.8	20.4	179.5
T_4	7.77	0.85	4.5	240.9	20.6	179.7
T_5	7.80	0.83	4.3	234.5	19.7	178.4
T_6	7.75	0.76	4.3	237.1	20.1	178.6
T_7	7.77	0.73	4.2	236.0	19.8	178.5
T_8	7.82	0.68	4.1	230.8	18.3	172.4
SE±	0.051	0.019	0.07	0.951	0.149	0.558
CD 5%	0.13	0.05	0.20	2.42	0.38	1.42

Soil fertility

It is obvious from Table 4 that pH, EC, organic carbon, available N, P and K ranged from 7.75 to 7.82, 0.68 to 0.85 dSm^{-1}, 4.1 to 4.5 $g\ kg^{-1}$, 230.8 to 240.9 $kg\ ha^{-1}$, 18.3 to 20.6 $kg\ ha^{-1}$ and 172.4 to 179.7 $kg\ ha^{-1}$ with mean values of 7.78, 0.77 $d\ Sm^{-1}$, 4.3 $g\ kg^{-1}$, 236.9 $kg\ ha^{-1}$, 19.9 $kg\ ha^{-1}$ and 178.21 $kg\ ha^{-1}$, respectively under the influence of various treatments. Highest values of electrical conductivity (0.85 $d\ Sm^{-1}$), organic carbon (4.5 $g\ kg^{-1}$), available N (240.9 $kg\ ha^{-1}$), P (20.6 $kg\ ha^{-1}$) and K (179.7 $kg\ ha^{-1}$) were recorded with 150% N RDF through neem coated urea along with P, K and zinc sulphate applied as basal at the time of transplanting of rice seedling. Lowest availability of N, P, K in post harvested soil was with 100% N through NCU applied (1/2 N basal + ¼ N MT + ¼ N PI) followed by 100% N NCU (1/3 N +1/3 N +1/3 N) and 100% N NCU (3/4 N basal + ¼ N MT). The addition of 100% N through prilled urea at various growth stages of rice ((1/3 N basal + 1/3 N MT + 1/3N PI) recorded its superiority over 100% N through NCU applied in 1/3 N basal + 1/3 N MT and 1/3N PI stage of rice crop. It might be due to reduced loss of nitrogen under the influence of split application of neem coated urea. In general, pH, EC and organic carbon content with prilled urea and neem coated urea significantly improved over control but could not show definite trends. Similar results were reported by Tripathi *et al.* (2018) and Kumar *et al.* (2010).

Economics

Perusal of data (Table 1) clearly indicated that maximum net return of Rs. 13795 ha^{-1} with BC ratio of 1.74 was obtained with 150% N through NCU along with $P_{60}K_{60}$ and $ZnSO_4$ 25 kg ha^{-1} were applied as basal at the time of transplanting of rice seedling (T_4) and minimum net return of Rs. 6385 ha^{-1} with B:C ratio of 1.09 in control. Application of 100% N through NCU (1/2 N + ¼ N +1/4 N as basal, MT and PI stage) proved its superiority over 100% N through NCU added in 03 equal splits and 100% N through NCU applied in ¾ N as basal + ¼ N at MT stage. These findings are in accordance with those of Tripathi *et al.* (2018).

It can be concluded from the results that integrated use of nitrogen, phosphorus, potassium and zinc sulphate through neem coated urea SSP, MOP and $ZnSO_4$ @ 150:60:60 and 25 kg ha^{-1} as basal at the time of transplanting of rice seedling under irrigated eco-system was found optimum for production of grain yield, improved quality, nutrients uptake and net returns along with the soil fertility status. Therefore 150% N through NCU along with recommended doses of P K and Zn as basal may be suggested for maximization of good quality of rice grain production and improving the physico-chemical characteristics of rice soils.

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