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Release Pattern of Nitrogen Fractions from Nitrogenous Fertilizers in *Entisol* and *Vertisol*

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A B S T R A C T

An incubation experiment was conducted to study the release pattern of nitrogen fractions in *Entisol* and *Vertisol* as influenced by the various sources of nitrogenous fertilizers viz. neem coated urea (NCU), DAP, NPK briquette, NP briquette, urea briquette and crotonylidene diurea (CDU). The total N content was ranged from 16.10% N in DAP to 43.05% N in NCU among the various fertilizers. The NH_4^+-N was highest at zero day of incubation (DOI) and then showed continuous decreasing trend up to 90 DOI. The NCU and CDU showed higher amount of NH_4^+-N in *Entisol* while DAP, NPK briquette, NP briquette, and UB showed higher amount of NH_4^+-N in *Vertisol*. The release pattern of NO_3^--N showed steady increasing trend from zero to 75 DOI. The NCU and CDU showed relatively better performance in *Entisol* whereas the DAP and briquette fertilizers showed relatively better performance in *Vertisol*. Similarly the mineral N showed steady increase from zero to 75 DOI except at 45 DOI. The *Vertisol* released the higher amount of mineral N than *Entisol.* The briquette fertilizers and NCU maintained higher release rate of mineral N in both of the soils for longer period of time. Among the different nitrogenous fertilizers, NPK briquette and NP briquette are identified as the best slow nitrogen releasing fertilizers.

Introduction

The improved understanding of N mineralization and N immobilization, along with their continuous changing dynamics may improve our ability to manage N cycling and increase nitrogen use efficiency (NUE) by minimizing N losses whatever the form and increase the sustainability of agricultural system that utilize typically applied different N sources (Cabrera *et al*., 2005). Suganya *et al.* (2009) observed that the lowest nitrate nitrogen content was under NCU products. Thus, use of neem coated urea products prolonged the nitrogen availability for the crop growth. To minimize nutrient losses and increase the use efficiency of N fertilizer, the placement of fertilizer or spot application of fertilizer, use of slow release fertilizer and nitrification inhibitors are recommended. The use of urea super granules, urea briquette and urea DAP briquette are another development in this direction and used for transplanted rice crop under anaerobic condition and found to be beneficial (Daftardar and Savant, 1995). Placement of NPK briquette at 10 cm deep

maintained higher level of NH_4^+-N and NO_3^--N in soil (More, 1999). However, the information regarding a comparative performance of neem coated urea, DAP, NPK briquette, NP briquette, urea briquette and crotonylidene diurea as a source of N and the release pattern and availability of NH_4^+-N , NO_3^-N and mineral N (NH_4^+-N + NO_3^--N) from these sources is limited. Therefore, the present study was undertaken to study the release pattern of nitrogen fractions in *Entisol* and *Vertisol* as affected by these sources of nitrogenous fertilizers.

Materials and Methods

The present laboratory experiment was carried out at Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune, Maharashtra during year 2017-18 to study the release pattern of nitrogen in *Entisol* and *Vertisol* due to effect of various inorganic nitrogenous fertilizers at field capacity moisture regime (0.33 bar). The various physico-chemical peoperties of soils ae analyzed by using various standard methods, the soil properties are given in given in table 1.

There were fourteen treatments in experiment viz. combination of six nitrogenous fertilizers viz. F_1-neem coated urea (NCU), F_2-DAP, F_3-NPK briquette, F_4-NP briquette, F_5-urea briquette and F_6-Crotonylidene diurea (CDU) and F_0-control with two soils viz. *Entisol* (S_1) and *Vertisol* (S_2). For maintaining moisture at field capacity level, double distilled water was used throughout the experiment. The amount of N fertilizers to be added are calculated on the basis of recommended dose of rice crop i.e. 100 kg N per hectare. As 1 ha of soil weight is 2.24×10^6 kg so further calculations were made to determine the quantity of N fertilizers for 1 kg of soil and 200 mg of N was added per kg of soil (Table 2). Incubation study for 0, 15, 30, 45, 60, 75 and 90 days after addition of nitrogenous fertilizers into soils was carried out at ambient condition. The NH_4^+-N and NO_3^--N in *Entisol* and *Vertisol* are evaluated by method described by Kenney and Nelson (1982).

The NH_4^+-N and NO_3^--N is determined immediately after sampling at each interval day by taking 5 gm of soil from each incubated bowl. At the same time same weight of soil sample was kept for determining the moisture content for further calculations. The data obtained in replicated experiments conducted were analysed statistically by the methods described by Panse and Sukhatme (2000). All statistical analysis was performed with the help of programme prepared in Excel software.

Results and Discussion

Release pattern of NH_4^+-N

The NH_4^+-N release from fertilizers treated soils recorded higher values than the control. It recorded highest at zero DOI and thereafter continuous decreasing trend was observed, the similar results were obtained by Mohiuddin *et al.* (2006). The DAP (76.72 mg kg^{-1}) and CDU (38.83 mg kg^{-1}) undergone rapid hydrolysis and showed immediate release of NH_4^+-N **(**at zero DOI) (Table 3). The NH_4^+-N content of. fertilizer treated soils was relatively higher until 30^{th} DOI The three briquette fertilizers maintained relatively higher amount of NH_4^+-N from 45^{th} day onwards. Similar observations were recorded by More and Shinde (2001) where briquette proved superior to non-briquette form of fertilizer.

The application of NCU and CDU showed higher amount of NH_4^+-N in *Entisol* while application of DAP, NPK briquette, NP briquette, and UB showed higher amount of NH_4^+-N in *Vertisol* during incubation study.

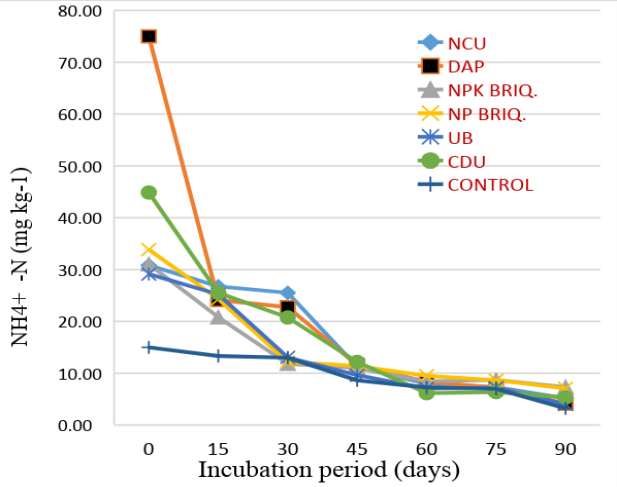

Fig.1 release pattern of NH4+-N in Entisol

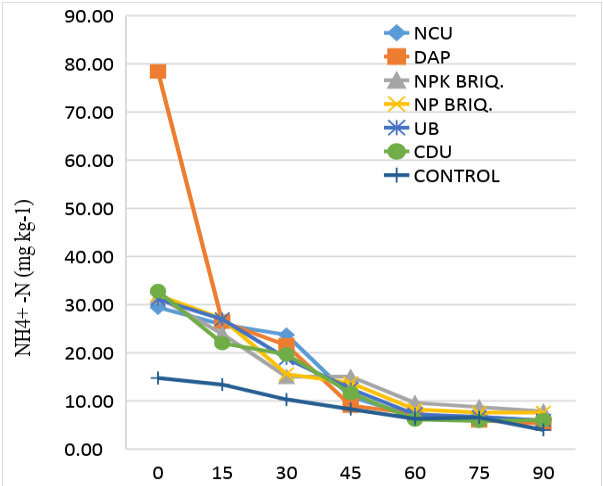

Fig.2 Release pattern of NH4+-N in Vertisol

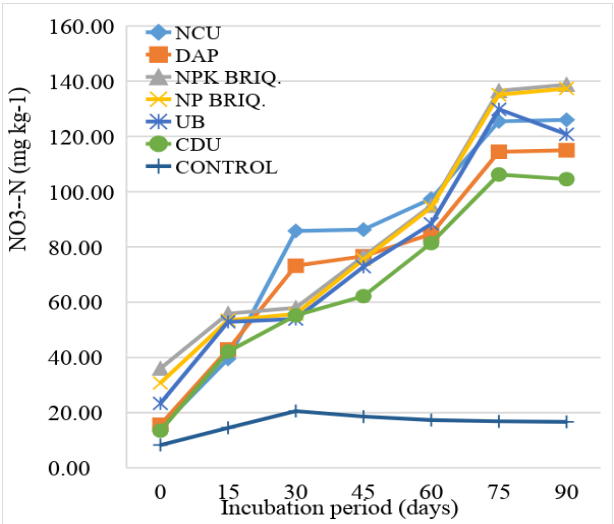

Fig. 3 Release pattern of NO3--N in Entisol

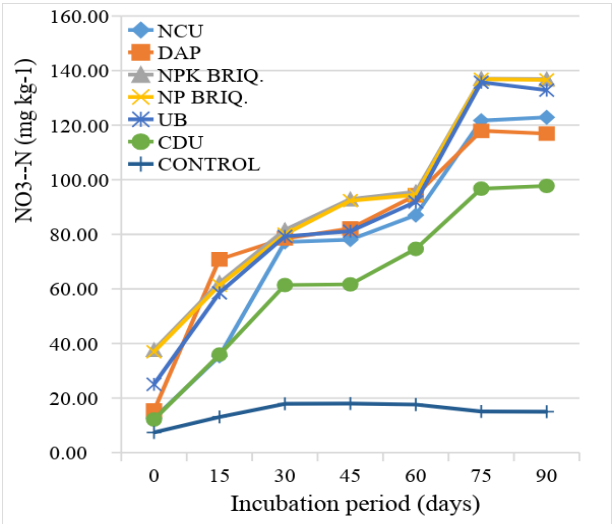

Fig. 4 Release pattern of NO3--N in Vertisol

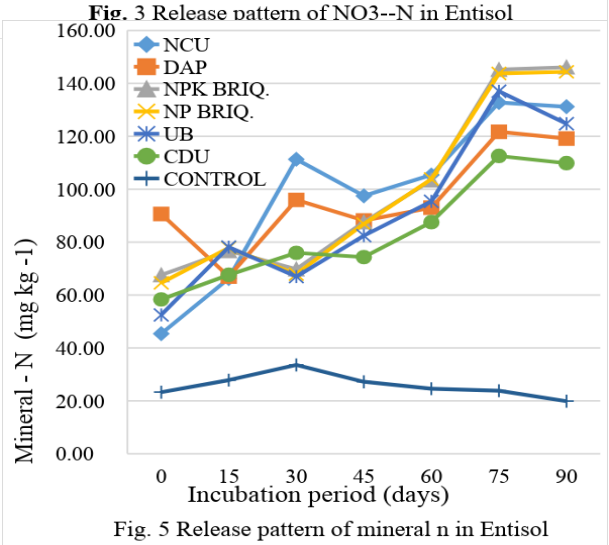

Fig. 5 Release pattern of mineral n in Entisol

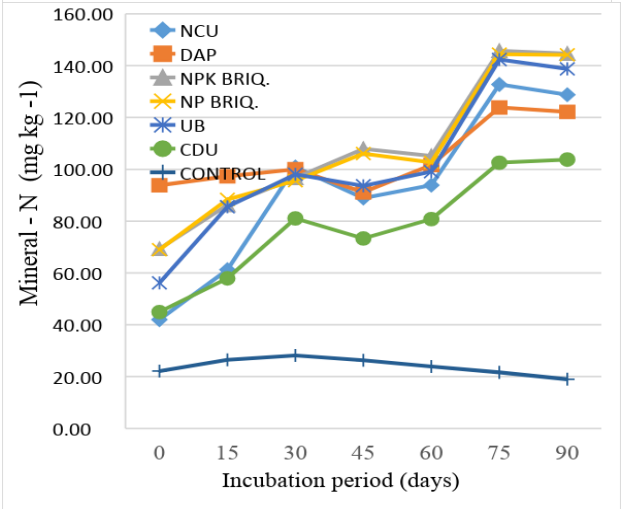

Fig. 6 Release pattern of mineral n in Vertisol

Table.1 Physico-chemical properties of *Entisol* and *Vertisol*

Sr. No.	Soil properties	*Entisol*	*Vertisol*
A.	**Physical properties**		
1.	Sand (%)	52.50	20.35
2.	Silt (%)	31.75	28.05
3.	Clay (%)	15.75	51.60
4.	Textural class	Sandy loam	Clay
5.	Bulk density (g cm^{-3})	1.45	1.27
6.	Field capacity (%)	29.02	37.60
7.	Permanent wilting point (%)	15.54	20.60
B.	**Chemical properties**		
8.	pH (1:2.5 **;** soil:water)	7.31	8.14
9.	EC (dSm^{-1})	0.12	0.23
10.	Organic carbon (%)	0.28	0.54
11.	$CaCO_3$ equivalent (%)	1.75	8.01
12.	Available nitrogen (kg ha^{-1})	213.24	288.51
13.	Available phosphorous (kg ha^{-1})	34.50	24.38
14.	Available potassium (kg ha^{-1})	329.28	499.52
15.	Ammonical nitrogen (mg kg^{-1})	13.05	19.60
16.	Nitrate nitrogen (mg kg^{-1})	22.60	31.20
17.	Exchangeable cations (meq./100 g) Ca^{2+} Mg^{2+} Na^{+} k^{+}	 26.29 13.80 21.35 23.40	 61.30 26.10 29.84 21.09

Table.2 Treatment details and Quantity of nitrogenous fertilizers used for incubation studies

Sources of N fertilizers	Estimated Total N content (%)	Amount of N fertilizers (mg) added to maintain 200 mg N kg^{-1} soil
Neem coated urea	43.05	193.80
DAP	16.10	496.00
NPK briquette	25.66	327.60
NP briquette	32.66	256.00
Urea briquette	42.00	193.80
Crotonylidene diurea (CDU)	32.50	226.00 (micro ml)

Table.3 Effect of different nitrogenous fertilizers on periodical release pattern of NH_4^+-N through *Entisol* and *Vertisol* (mg kg^{-1})

Nitrogenous fertilizers	Incubation period (Days)											
	0 Days			15 Days			30 Days			45 Days		
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
NCU	30.80	29.43	30.12	26.73	25.88	26.31	25.50	23.72	24.61	11.19	10.85	11.02
DAP	75.00	78.43	76.72	24.10	26.47	25.28	22.73	21.55	22.14	11.55	9.05	10.30
NPK briquette	31.56	31.64	31.60	20.80	23.93	22.37	11.80	15.03	13.42	10.97	15.03	13.00
NP briquette	33.83	32.00	32.92	24.30	27.08	25.69	12.15	15.58	13.87	11.35	13.74	12.55
UB	29.13	31.13	30.13	25.20	26.99	26.10	13.03	18.82	15.93	9.59	12.50	11.05
CDU	44.87	32.80	38.83	25.50	22.00	23.75	20.74	19.65	20.20	12.16	11.66	11.91
Control	14.97	14.77	14.87	13.30	13.39	13.35	12.98	10.31	11.64	8.59	8.29	8.44
MEAN	37.16	35.74		22.85	23.68		16.99	17.81		10.77	11.59	
	S.Ed±	CD		S.Ed±	CD		S.Ed±	CD		S.Ed±	CD	
F	0.435	1.259		0.417	1.209		0.302	0.874		0.168	0.487	
S	0.232	0.673		0.223	0.646		0.161	0.467		0.090	0.260	
F×S	0.615	1.781		0.590	1.709		0.427	1.237		0.238	0.689	

Nitrogenous fertilizers	Incubation period (Days)								
	60 Days			75 Days			90 Days		
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
NCU	7.94	6.84	7.39	7.30	6.69	7.00	5.15	5.88	5.51
DAP	8.31	7.37	7.84	7.22	5.96	6.59	4.12	5.27	4.70
NPK briquette	8.40	9.60	9.00	8.67	8.72	8.69	7.30	7.83	7.57
NP briquette	9.48	8.23	8.86	8.62	7.60	8.11	7.03	7.60	7.32
UB	7.04	7.23	7.13	7.18	6.64	6.91	3.99	5.94	4.97
CDU	6.14	6.13	6.14	6.33	5.83	6.08	5.29	6.02	5.66
Control	7.23	6.30	6.77	6.95	6.55	6.75	3.20	3.98	3.59
Mean	7.79	7.39		7.47	6.86		5.15	6.08	
	S.Ed±	CD		S.Ed±	CD		S.Ed±	CD	
F	0.832	1.122		0.201	0.581		0.177	0.512	
S	0.445	NS		0.107	NS		0.094	0.273	
F×S	1.177	NS		0.284	NS		0.250	NS	

Table.4 Effect of different nitrogenous fertilizers on periodical release pattern of NO_3^-N through *Entisol* and *Vertisol* (mg kg^{-1})

Nitrogenous fertilizers	Incubation period (Days)											
	0 DAYS			15 DAYS			30 DAYS			45 DAYS		
	S1	S2	MEAN	S1	S2	MEAN	S1	S2	MEAN	S1	S2	MEAN
NCU	14.57	12.55	13.56	39.51	35.38	37.45	85.80	77.16	81.48	86.26	78.04	82.15
DAP	15.63	15.40	15.52	42.86	70.83	56.85	73.21	78.48	75.84	76.62	82.10	79.36
NPK briquette	36.00	37.67	36.83	55.87	62.25	59.06	57.93	81.63	69.78	76.55	92.89	84.72
NP briquette	30.76	36.96	33.86	53.50	61.30	57.40	55.73	80.03	67.88	75.50	92.33	83.92
UB	23.33	25.03	24.18	52.89	58.56	55.72	53.92	79.25	66.59	72.83	81.14	76.99
CDU	13.47	12.13	12.80	42.12	35.92	39.02	61.41	55.19	58.30	62.17	61.67	61.92
Control	8.30	7.39	7.84	14.52	13.07	13.80	20.59	17.88	19.24	18.60	18.00	18.30
Mean	20.29	21.02		43.04	48.19		58.37	67.09		66.93	72.31	
	S.Ed±	CD		S.Ed±	CD		S.Ed±	CD		S.Ed±	CD	
F	0.342	0.993		0.643	1.863		0.571	1.654		0.3398	0.984	
S	0.183	0.531		0.343	0.996		0.305	0.884		0.1816	0.526	
F×S	0.484	1.404		0.909	2.635		0.807	2.339		0.4805	1.392	

Nitrogenous fertilizers	Incubation period (Days)								
	60 DAYS			75 DAYS			90 DAYS		
	S1	S2	MEAN	S1	S2	MEAN	S1	S2	MEAN
NCU	97.42	87.04	92.23	125.45	121.68	123.57	126.00	122.88	124.44
DAP	84.67	94.31	89.49	114.44	117.92	116.18	115.00	116.90	115.95
NPK briquette	94.97	95.55	95.26	136.50	137.01	136.76	138.77	136.83	137.80
NP briquette	94.33	94.47	94.40	135.10	136.83	135.97	137.33	136.57	136.95
UB	88.33	91.88	90.11	129.83	135.73	132.78	120.77	132.83	126.80
CDU	81.40	74.64	78.02	106.22	96.73	101.48	104.53	97.73	101.13
Control	17.34	17.62	17.48	16.87	15.10	15.99	16.67	15.01	15.84
Mean	79.78	79.36		109.20	108.71		108.44	108.39	
	S.Ed±	CD		S.Ed±	CD		S.Ed±	CD	
F	0.373	1.080		0.639	1.850		0.294	0.851	
S	0.199	NS		0.341	NS		0.157	NS	
F×S	0.527	1.527		0.903	2.617		0.416	1.204	

Nitrogenous fertilizers	Soils (S)											
	0 Days			15 DAYS			30 DAYS			45 DAYS		
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
NCU	45.37	41.98	43.68	66.24	61.26	63.75	111.30	100.88	106.09	97.45	88.89	93.17
DAP	90.63	93.83	92.23	66.95	97.30	82.13	95.94	100.03	97.99	88.17	91.15	89.66
NPK briquette	67.56	69.31	68.44	76.67	86.18	81.43	69.74	96.66	83.20	87.52	107.92	97.72
NP briquette	64.59	68.96	66.78	77.80	88.38	83.09	67.88	95.61	81.75	86.85	106.08	96.46
UB	52.46	56.16	54.31	78.09	85.55	81.82	66.95	98.07	82.51	82.42	93.64	88.03
CDU	58.33	44.93	51.63	67.62	57.92	62.77	81.06	75.93	78.50	74.33	73.33	73.83
Control	23.27	22.15	22.71	27.82	26.46	27.14	33.57	28.19	30.88	27.19	26.29	26.74
Mean	57.46	56.76		65.89	71.86		74.47	85.79		77.70	83.90	
	S.Ed±	CD		S.Ed±	CD		S.Ed±	CD		S.Ed±	CD	
F	0.489	1.417		0.719	2.082		0.650	1.883		0.336	0.972	
S	0.261	NS		0.384	1.113		0.347	1.006		0.179	0.520	
F×S	0.692	2.003		1.016	2.944		0.919	2.663		0.475	1.375	

Table.5 Effect of different nitrogenous fertilizers on periodical release pattern of mineral N through *Entisol* and *Vertisol* (mg kg^{-1})

Nitrogenous fertilizers (F)	60 DAYS			75 DAYS			90 DAYS		
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
NCU	105.36	93.88	99.62	132.75	132.75	132.75	131.15	128.76	129.96
DAP	92.98	101.68	97.33	121.66	123.89	122.77	119.12	122.17	120.65
NPK briquette	103.37	105.15	104.26	145.17	145.73	145.45	146.07	144.67	145.37
NP briquette	103.81	102.70	103.26	143.72	144.43	144.08	144.37	144.17	144.27
UB	95.37	99.11	97.24	137.01	142.37	139.69	124.75	138.78	131.77
CDU	87.54	80.77	84.16	112.55	102.57	107.56	109.83	103.75	106.79
Control	24.57	23.92	24.25	23.82	21.65	22.74	19.87	18.99	19.43
Mean	87.57	86.74		116.67	116.20		113.59	114.47	
	S.Ed±	CD		S.Ed±	CD		S.Ed±	CD	
F	0.499	1.446		0.723	2.095		0.363	1.051	
S	0.267	0.773		0.386	NS		0.194	0.562	
F×S	0.706	2.045		1.023	2.962		0.513	1.486	

The reason behind this might be that *Entisol* have lesser clay (1:1 type of clay) content and lesser surface area for binding of NH_4^+ ions than that of *Vertisol* (2:1 type of clay). Also the briquette fertilizers have lesser surface area that is responsible for slow dissolution and slow release of NH_4^+-N.

Release pattern of NO_3^-N

The soils treated with nitrogenous fertilizers recorded significantly higher values of NO_3^--N than control. The NO_3^--N release pattern showed steady increasing trend from zero to 75th DOI and afterwards it remained nearly constant. The similar results were observed by Naidu (2013) on studying the N release pattern from coated urea fertilizers and prilled urea. The NCU released significantly higher level of NO_3^--N up to 60th DOI and afterwards briquette fertilizers released significantly higher level of NO_3^-N (Table 4).

The *Vertisol* (21.02 mg kg^{-1} to 72.31 mg kg^{-1}) released significantly higher values of NO_3^--N than *Entisol* (20.29 mg kg^{-1} to 66.93 mg kg^{-1}) from zero to 45th DOI. Whereas from 60 to 90 DOI both soils recorded non-significant difference between them. The application of NCU and CDU in *Entisol* whereas the application of DAP and all briquette fertilizers in *Vertisol* released highest amount of NO_3^--N during the incubation study.

The briquette fertilizers showed the superiority by releasing nitrate nitrogen more slowly than other sources of fertilizer treatments which was in conformity with results of More and Shinde (2002).

Release pattern of mineral nitrogen (NH_4^+-N+ NO_3^--N)

The release pattern of mineral N showed steady increase from zero (92.23 mg kg^{-1} in DAP to 22.71 mg kg^{-1} in control) to 75th DOI (145.45 mg kg^{-1} in NPK briquette to 22.74 mg kg^{-1} in control) except at 45th DOI.

The highest level of release of mineral N observed at 75th DOI and afterwards it remained nearly constant. The fertilizers applied soil released significantly higher amount of mineral than control (Table 5).

The DAP showed rapid hydrolysis and released significantly higher amount of mineral N (92.23 mg kg^{-1}) at zero DOI while at 30th DOI the NCU released significantly higher values of mineral N (106.09 mg kg^{-1}). From 45 DOI onwards up to 90 DOI, the NPK briquette (97.72 mg kg^{-1} to 145.45 mg kg^{-1}) and NP briquette (96.46 mg kg^{-1} to 144.27 mg kg^{-1}) briquette released highest amount of mineral N which is in conformity with results of Durgude *et al.* (2008) where highest N recovery was reported in DAP briquettes than urea fertilizer. Also Singh (2012) have confirmed the higher NUE of briquette fertilizers for wheat crop.

In general, the N released from *Vertisol* (71.86 mg kg^{-1} to 114.47 mg kg^{-1}) was higher amount of N released than from *Entisol* (65.89 mg kg^{-1} to 113.59 mg kg^{-1}) throughout the incubation study. The application of NCU and CDU released more amount of mineral N in *Entisol* while application of DAP and briquette fertilizers released highest amount mineral N in *Vertisol* which shows the suitability of these fertilizers to the respective soils for N recovery.

The *Vertisol* released relatively higher values of NH_4^+-N**,** NO_3^--N and mineral N throughout the experiment. In *Entisol* N-mineralization of fertilizers followed the order; NCU >NPK briquette >NP briquette >UB >DAP >CDU >Control whereas in *Vertisol* NPK briquette >NP briquette >UB >NCU >DAP >CDU >Control. Among the different nitrogenous fertilizers, NPK briquette and NP briquette are identified as the best slow nitrogen releasing fertilizers followed by neem coated urea and urea briquette.

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