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STUDY OF NITROGEN RELEASE PATTERN IN RED SANDY, MEDIUM BLACK AND DEEP BLACK SOILS OF NORTHERN TELANGANA ZONE: A LABORATORY INCUBATION STUDY

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ABSTRACT

An incubation study was carried out on surface soil samples (0-15 cm) to study the release pattern of available nitrogen release pattern under the influence of different levels of urea, DAP and MOP in red sandy, medium black and deep black soils of the Northern Telangana zone. The release of available N was the highest with T_{18} (N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1}) and low available N was released with T_1 (N-P_2O_5-K_2O @ 60-20-20 kg ha^{-1}) in all types of soils. Release of available nitrogen was highest at 15 DAI, there after availability of nitrogen slowly decreased, sharply decreased at 45 and 60 DAI respectively, in all type of soils. N release was high in deep black soils, moderate in medium black and low in red sandy soils.

***Key words*:** Nitrogen release pattern, red sandy, medium black and deep black soils, Northern Telangana zone and incubation study.

Introduction

Nitrogen (N) is a vital element found in all living things. Crops require nitrogen in relatively large amounts making it the nutrient most often deficient in crop production. Despite nitrogen being one of the most abundant elements on in the universe, nitrogen deficiency is probably the most common nutritional problem affecting plants worldwide. Healthy plants contain 3-4 percent nitrogen in their above ground tissues. It is a major component of chlorophyll, amino acids and building blocks of proteins. Nitrogen is a component of energy-transfer compounds, such as ATP (adenosine triphosphate) which allows cells to conserve and use the energy released in metabolism. Soil nitrogen can be divided into three categories *viz.*, (i) small inorganic components consisting of ammonical, nitrate and nitrite nitrogen (ii) large organic components consisting of the residues of plants and other organics and (iii) elemental nitrogen component in the soil atmosphere. Plants absorb nitrogen in the form of nitrate and ammonium ions. (Shilpa *et al.*, 2017). Urea is the most widely used fertilizer globally because of its high nitrogen content (46%), low cost, easy availability, rapid action and ease of application (Zheng *et al*., 2009). Plant roots and leaves can take up urea. Once entered inside the plant, it is converted to ammonium and assimilated as amino acids and amides. The form of N uptake is mainly determined by its abundance and accessibility, which make N-NO^{3-} and NH_4^+ the most important N forms for plant nutrition under agricultural conditions (Vyas *et al*., 1991). The gaseous losses of ammonium are related to soil moisture, soil pH, granular size and shape, the salinity of the soil environment and fertilizer placement. N-NO^{3-} is highly susceptible to nitrate leaching as it moves through the soil with diffusion and mass flow of water. The increase in soil pH to the value of 7-8 has an impact on nitrogen transformation, stimulating the formation of nitrates, which form nitrous oxide; this process is strongly inhibited at pH 8.5. The conversion rate of organic compounds into mineral compounds underlies processes responding to Nitrogen efficiency and losses. With minor importance, the form of N uptake is also subject to plant preferences, by which

plants maintain their cation/anion balance during uptake. However, some species seem to have an obligatory preference that prevents their growth on certain other N sources (Niedziñsk *et al.*, 2021).

The toxic effect of ammonium ions on the root system when the fertilizer is placed deeply is mitigated by the minimal contact between the source of N in the deposit and the surface of the root system. Furthermore, new local conditions created within the nitrogen source zone slow down nitrobacteria activity, and less N- NO^{3-} loss occurs. If the release rate is more compatible with the metabolic needs of plants, high productivity of fertilization can be achieved. Plant nutrient availability is controlled by soil properties and microbe interactions. High soil pH accelerates nitrification, with an optimum pH of 8.3 to 9.3 for Nitrobacter and 8.5 to 8.8 for Nitrosomonas. Beyond that, the availability of nutrients differs substantially in the root zone and as a medium of plant growth in bulk soil. Inorganic nitrogen forms N-NH_4^+ and N-NO^{3-} can trigger pH changes in soil of up to 1 to 2 pH units under field conditions. A surface application of urea increases the pH until the nitrification process accelerates. This improvement can be accomplished faster with higher soil temperature and soil humidity. (Niedziñsk *et al.*, 2021). The individual physical and chemical properties of granules influence the soil characteristics, changing the soil parameters until a new balance is reached. Analyzing release rate patterns enables a better understanding of how each N fertilizer works in different soils. Optimal nutrient management can then be achieved by supplying crops according to the nutrient uptake requirements of each stage. To achieve the objective of this study, a laboratory experiment was carried out using a soil incubation method, which is common practice for release pattern measurement. The 60-day incubation of fertilizers in red sandy, medium black and deep black soil allows the nitrogen release pattern to be analyzed throughout the incubation period.

Material and Methods

Soil sampling

Three samples were selected from the 30 samples collected from sesamum growing soils of Adilabad, Nizamabad and Karimnagar districts of Northern Telangana zone. Surface soil samples were collected in bulk, from these three fields for an incubation study based on available N, P and K contents in the soil samples. The soil samples were air dried, sieved through 2 mm sieve and used for incubation.

Incubation study

An incubation study was carried out in the selected three soils over a while to study the nitrogen release pattern under the influence of different levels of applied nutrients (NPK). Treatments consist of different levels of N, P and K. For each treatment, 300 g of soil sample was weighed into separate plastic containers (in two replications). Moisture contents were maintained at field capacity. Soil samples were taken from the container at 0, 15, 30, and 45 and 60 days of initiation. Collected samples were shade dried and processed and used for analysis of available nutrient N content. 18 treatments were taken in two replications each. Nitrogen (through urea and DAP), phosphorous (through DAP) and potassium (through MOP) were applied at the start of incubation as per the treatments. Treatments are given in Table 1.

Table 1: Different fertilizer doses as treatments in an incubation study.

Treatment	Treatment symbol	Nutrient dose (kg N-P_2O_5-K_2O ha^{-1})
T_1	$N_{60}P_{20}K_{20}$	60-20-20
T_2	$N_{80}P_{20}K_{20}$	80-20-20
T_3	$N_{100}P_{20}K_{20}$	100-20-20
T_4	$N_{60}P_{40}K_{20}$	60-40-20
T_5	$N_{80}P_{40}K_{20}$	80-40-20
T_6	$N_{100}P_{40}K_{20}$	100-40-20
T_7	$N_{60}P_{60}K_{20}$	60-60-20
T_8	$N_{80}P_{60}K_{20}$	80-60-20
T_9	$N_{100}P_{60}K_{20}$	100-60-20
T_{10}	$N_{60}P_{20}K_{40}$	60-20-40
T_{11}	$N_{80}P_{20}K_{40}$	80-20-40
T_{12}	$N_{100}P_{20}K_{40}$	100-20-40
T_{13}	$N_{60}P_{40}K_{40}$	60-40-40
T_{14}	$N_{80}P_{40}K_{40}$	80-40-40
T_{15}	$N_{100}P_{40}K_{40}$	100-40-40
T_{16}	$N_{60}P_{60}K_{40}$	60-60-40
T_{17}	$N_{80}P_{60}K_{40}$	80-60-40
T_{18}	$N_{100}P_{60}K_{40}$	100-60-40

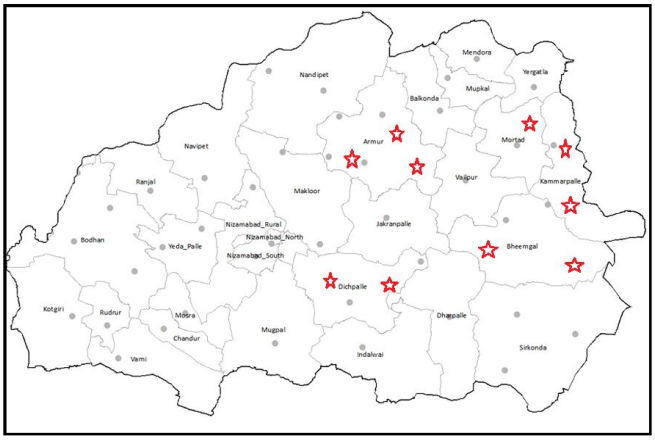

Fig. 1: Location of soil samples collected in Nizamabad district.

Table 2: Soil fertility status of Adilabad district.

SN	pH	EC	OC	AN	AP	AK
1	7.24	0.49	4.8	158.4	45.25	375.3
2	7.92	0.56	3.6	239.5	35.24	402.2
3	7.61	0.53	4.0	182.8	30.27	392.3
4	6.94	0.42	2.5	220.6	35.01	408.3
5	7.52	0.61	6.4	233.1	40.18	394.8
6	**8.19**	**0.59**	**4.4**	**145.7**	**33.28**	**441.3**
7	7.62	0.22	3.3	192.5	28.25	396.2
8	8.26	0.49	3.2	142.5	39.57	452.8
9	7.35	0.59	1.5	185.8	34.04	402.0
10	8.18	0.62	3.5	182.8	32.08	363.5

Sample no. 6 is taken as deep black soil for incubation study
SN: Sample Number; **EC:** EC (ds m^{-1}); **OC:** OC (g kg^{-1});
AN: Available N (kg ha^{-1}); **AP:** Available P (kg ha^{-1});
AK: Available K (kg ha^{-1})

Table 3: Soil fertility status of Nizamabad district.

SN	pH	EC	OC	AN	AP	AK
11	8.18	0.26	2.0	239.6	35.68	410.7
12	7.16	0.69	3.2	212.4	61.24	399.3
13	**7.95**	**0.42**	**7.5**	**182.7**	**75.63**	**313.5**
14	7.85	0.55	4.5	220.6	51.28	392.1
15	6.85	0.20	4.4	233.1	49.62	452.6
16	8.12	0.56	1.5	145.8	55.61	403.9
17	7.19	0.45	4.9	220.5	48.51	373.6
18	7.71	0.92	6.4	120.6	39.45	390.3
19	6.92	0.56	7.0	195.3	66.17	410.6
20	7.31	0.57	2.0	182.6	48.22	384.8

Sample no. 13 is taken as medium black soil for incubation study
SN: Sample Number; **EC:** EC (ds m^{-1}); **OC:** OC (g kg^{-1});
AN: Available N (kg ha^{-1}); **AP:** Available P (kg ha^{-1});
AK: Available K (kg ha^{-1})

Experimental site

The field experiment was taken up at the Regional Agricultural Research Station (RARS), Polasa, Jagtial. The experimental farm is geographically situated at an altitude of 243.4 m above mean sea level on 180° 49' 40" N latitude and 78° 56'45" E longitude. It is in the Northern zone of Telangana.

Soil characteristics of the experiment site

Surface soil (0-15 cm) was analyzed for physical and chemical properties by adopting standard procedures. Soil sample 1 was red sandy in texture, alkaline in reaction (pH) (7.97), low in electrical conductivity (EC) (0.41), low in organic carbon (OC) (2.2 g kg^{-1}), low in nitrogen (N) content (220.5 kg ha^{-1}), high in phosphorous (P) (58.96 kg ha^{-1}) and potassium (K) content (371.8 kg ha^{-1}) (Red sandy soil). (Table 4).

Soil sample 2 was medium black in texture, alkaline in reaction (pH) (7.95), low in electrical conductivity (EC) (0.42), low in organic carbon (OC) (2.2 g kg^{-1}), low in nitrogen (N) content (182.7 kg ha^{-1}), high in phosphorous (P) (75.63 kg ha^{-1}**)** and potassium (K) content (313.5 kg ha^{-1}**) (**Medium black soil). (Table 3).

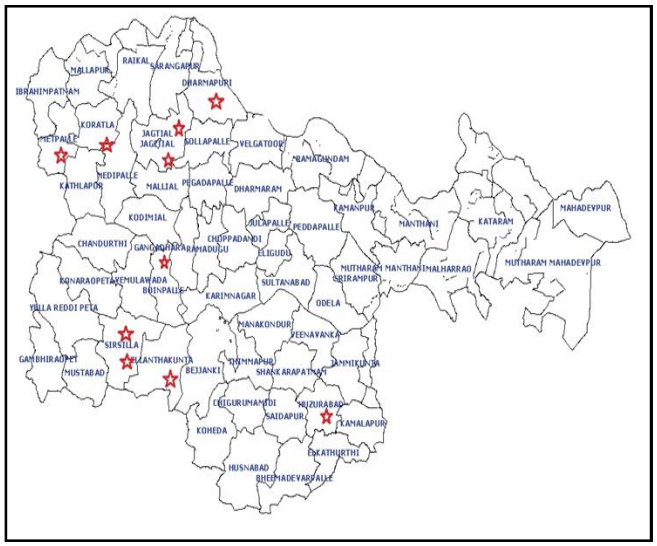

Fig. 2: Location of soil samples collected in Karimnagar district.

Soil sample 3 was deep black in texture, alkaline in reaction (pH) (8.19), low in electrical conductivity (EC) (0.59), low in organic carbon (OC) (4.4 g kg^{-1}), low in nitrogen (N) content (145.7 kg ha^{-1}), medium in phosphorous (P) (32.28 kg ha^{-1}**)** and high potassium (K) content (441.3 kg ha^{-1}**)** (Deep black soil). (Table 2).

Treatment details

Design: 3 × 3 × 2 - Factorial CBD, No. of factors: 3 (Application of varying levels of nitrogen, phosphorous and potassium through fertilizers).

Fertilizer levels

Nitrogen: 3 levels (60, 80 and 100 kg N ha^{-1} as urea and DAP), Phosphorous: 3 levels (20, 40 and 60 kg P_2O_5

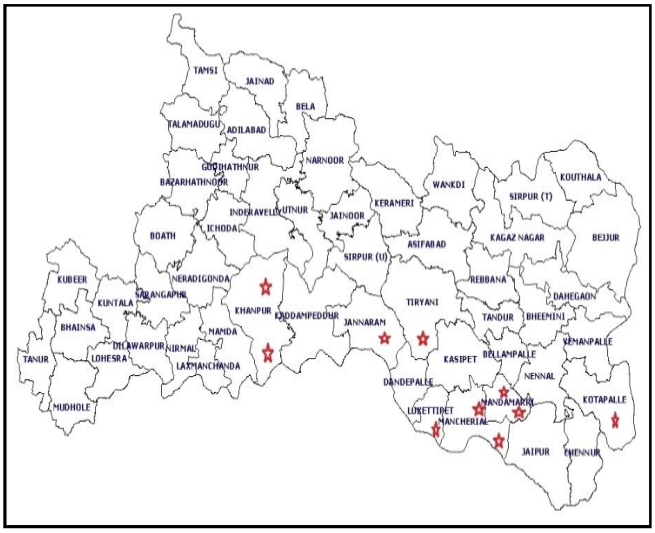

Fig. 3: Location of soil samples collected in Adilabad district.

Table 4: Soil fertility status of Karimnagar district.

SN	pH	EC	OC	AN	AP	AK
21	7.53	0.16	4.5	133.3	60.25	393.8
22	7.67	0.37	4.3	162.5	51.24	292.2
23	6.96	0.46	4.2	175.8	33.48	397.2
24	8.21	0.41	4.1	170.2	36.25	414.0
25	**7.97**	**0.41**	**2.2**	**220.5**	**58.96**	**371.8**
26	8.15	0.39	3.6	201.7	70.22	384.7
27	8.41	0.42	4.5	176.4	45.63	437.6
28	7.31	0.56	6.2	195.4	40.25	399.2
29	5.35	0.67	3.7	182.8	38.77	358.9
30	8.24	0.36	2.9	115.3	45.66	400.6

Sample no. 25 is taken as Red Sandy soil for incubation study
SN: Sample Number; **EC:** EC (ds m^{-1}); **OC:** OC (g kg^{-1});
AN: Available N (kg ha^{-1}); **AP:** Available P (kg ha^{-1});
AK: Available K (kg ha^{-1})

ha^{-1} as DAP), Potassium: 2 levels (20 and 40 kg K_2O ha^{-1} as MOP).

Soil chemical analysis

Soil reaction (pH) (1:2.5)

Soil pH was determined in 1:2.5 soil-water suspension by the potentiometric method using a glass electrode in association with a reference electrode (Jackson, 1973).

Electrical conductivity (EC) (dS m^{-1} at 25 °C)

The electrical conductivity of soil was determined in 1:2 soil-water suspension using a conductivity bridge and the values recorded were expressed in dS m^{-1} at 25°C (Jackson, 1973).

Soil organic carbon (SOC) (%)

Determination of potassium dichromate oxidizable carbon in soil was carried out by the wet oxidation method described by Walkley and Black (1934). About 0.5 g of 0.2 mm sieved soil sample was taken into a 500 ml capacity Erlenmeyer flask. 10 ml of 1N $K_2Cr_2O_7$ solution and 20 ml of concentrated H_2SO_4 were gently mixed and the contents were kept for half an hour. After half an hour 200 ml of distilled water, 10 ml of H_3PO_4, about 0.2 g of NaF and 8 to 10 drops of diphenylamine indicator were added. Contents were titrated against standard ferrous ammonium sulphate until it became bright green. Blank titration was run by following all the above steps without soil. After recording the burette readings of both blank and sample titrations, potassium dichromate oxidizable carbon in the soil was calculated using the following formula and converted to g kg^{-1}.

$$SOC\ (\%) = \frac{10\ (\text{Blank titre value} - \text{Sample titre value}) \times 0.003}{\text{Blank value} \times \text{Weight of soil (g)}} \times 100$$

Available nitrogen content

The available nitrogen in the soil was determined by alkaline permanganate method as described by Subbaiah and Asija (1956) and expressed as kg N ha^{-1}.

Soil available P_2O_5 (kg ha^{-1})

Available phosphorus in the soil samples was extracted by Olsen's method for alkaline soils (0.5 *M* $NaHCO_3$) and Brays and Kurtz's method for acid soils (0.03 *N* NH_4F + 0.025 *N* HCl) as described by Jackson (1973). Phosphorus in the extractant was complexed by molybdenum and reduced by ascorbic acid in the presence of H_2SO_4 and estimated by using spectrophotometer at 660 nm.

Soil available K_2O (kg ha^{-1})

Available potassium in the soil was extracted with neutral normal ammonium acetate solution (pH 7.0). Where, ammonium ions exchange with potassium ions of the soil. The amount of potassium in the extract was determined by using flame photometer as described by Jackson (1973).

Statistical analysis

The field experiment data recorded on various

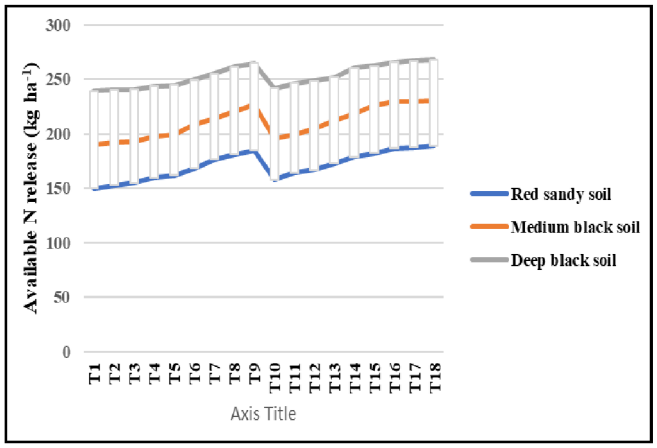

Fig. 4: Effect of different treatments on available nitrogen release pattern in different soils at 15 DAI.

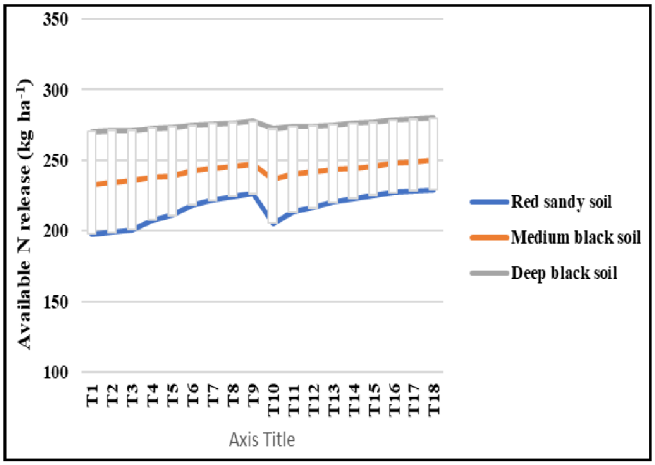

Fig. 5: Effect of different treatments on available nitrogen release pattern in different soils at 30 DAI.

Table 2: Available nitrogen content of red sandy soil under incubation as affected by different fertilizer treatments.

	Available N in soil (kg N ha^{-1}) at 15 DAI							Available N in soil (kg N ha^{-1}) at 30 DAI						
P levels »	**P_1**		**P_2**		**P_3**		**Mean**	**P_1**		**P_2**		**P_3**		**Mean**
K levels »	**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**		**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**	
N levels ˅														
N_1	219.8	228.2	231.1	245.2	247.3	260.0	238.6	206.4	216.2	221.0	231.1	231.7	239.1	224.2
N_2	223.6	236.6	234.0	251.5	256.1	262.2	244.0	210.4	227.0	223.8	233.9	235.3	241.0	228.5
N_3	224.9	239.6	243.8	257.1	257.6	263.1	247.7	212.5	228.3	230.0	236.9	237.8	242.5	231.3
Mean	222.8	234.8	236.3	251.2	253.7	261.8		209.8	223.8	224.9	233.9	234.9	240.9	
Mean for P levels	228.7		243.7		257.7			216.7		229.4		237.9		
Mean for K levels	**K_1** = 237.5				**K_2** = 249.2			**K_1** =223.2				**K_2** =232.8		
Factor	**N**	**P**	**K**	**N×P**	**N×K**	**P×K**	**N×P×K**	**N**	**P**	**K**	**N×P**	**N×K**	**P×K**	**N×P×K**
S. Em (+/-)	2.48	2.48	2.02	4.29	3.51	3.51	6.07	3.21	3.21	3.05	3.96	3.85	3.85	4.02
C.D (5%)	7.44	NS	NS	NS	NS	NS	NS	9.63	NS	NS	NS	NS	NS	NS
C.V (%)	3.53							3.65						

parameters during the course of investigation were statistically analysed duly following the analysis of variance technique for Factorial controlled block design as suggested by Panse and Sukhame (1978).

Results and Discussion

Available nitrogen content of red sandy soil

At 15 DAI

The highest available nitrogen (263.1 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18}) and lowest available nitrogen (219.8 kg ha^{-1}) in soil was recorded at N-P_2O_5-K_2O @ 60-20-20 kg ha^{-1} (T_1). Application of 100 kg N ha^{-1} (N_3) had shown highest available nitrogen content (247.6 kg ha^{-1}) and it was on par with application of 80 kg N ha^{-1} (243.9 kg ha^{-1}) (N_2). Lowest available nitrogen content (238.6 kg ha^{-1}) was recorded with the 60 kg N ha^{-1} (N_1) (Table 2) (Fig. 4).

At 30 DAI

The highest available nitrogen (242.4 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18}) and lowest available nitrogen (206.4 kg ha^{-1}) in soil was recorded at N-P_2O_5-K_2O @ 60-20-20 kg ha^{-1}(T_1). (N_3) had shown highest available nitrogen content (231.3 kg ha^{-1}) and it was on par with (N_2) (228.56 kg ha^{-1}) and (N_1) (224.2 kg ha^{-1}). Lowest available nitrogen content (224.2kg ha^{-1}) was recorded with the (N_1) (Table 2) (Fig. 5).

At 45 DAI

The results pertaining to available nitrogen content in soil as influenced by different treatments at 45 DAI, 60 DAI were given in the Table 3.

The highest available nitrogen (226.3 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18})

Table 3: Available nitrogen content of red sandy soil under incubation as affected by different fertilizer treatments.

	Available N in soil (kg N ha^{-1}) at 45 DAI							Available N in soil (kg N ha^{-1}) at 60 DAI						
P levels »	**P_1**		**P_2**		**P_3**		**Mean**	**P_1**		**P_2**		**P_3**		**Mean**
K levels »	**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**		**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**	
N levels ˅														
N_1	172.9	183.6	187.3	202.7	204.1	220.6	195.2	137.9	151.7	155.6	177.7	181.1	207.5	168.5
N_2	177.2	194.9	191.1	205.1	208.0	223.6	200.0	143.7	162.3	159.4	184.9	188.4	213.1	175.5
N_3	180.5	197.8	200.2	210.0	214.3	226.3	204.9	148.8	169.4	173.9	193.2	198.4	222.4	184.4
Mean	176.9	191.8	192.9	206.0	209.0	223.5		143.5	161.3	162.9	185.1	189.5	214.3	
Mean for P levels	184.4		199.5		216.2			152.4		174.0		202.0		
Mean for K levels	**K_1** = 192.9				**K_2** = 207.1			**K_1** =165.3				**K_2** =186.9		
Factor	**N**	**P**	**K**	**N×P**	**N×K**	**P×K**	**N×P×K**	**N**	**P**	**K**	**N×P**	**N×K**	**P×K**	**N×P×K**
S. Em (+/-)	2.48	2.48	2.02	4.29	3.51	3.51	6.07	2.50	2.50	2.03	4.28	3.38	3.38	7.25
C.D (5%)	7.44	NS	NS	NS	NS	NS	NS	7.50	NS	NS	NS	NS	NS	NS
C.V (%)	3.53							3.79						

Table 4: Available nitrogen content of medium black soil under incubation as affected by different fertilizer treatments.

	Available N in soil (kg N ha^{-1}) at 15 DAI							Available N in soil (kg N ha^{-1}) at 30 DAI						
P levels »	**P_1**		**P_2**		**P_3**		**Mean**	**P_1**		**P_2**		**P_3**		**Mean**
K levels »	**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**		**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**	
N levels ˅														
N_1	229.3	239.5	242.5	260.2	263.8	277.4	252.0	189.6	197.1	198.3	213.6	217.3	231.3	207.8
N_2	233.1	247.5	244.4	266.4	270.2	279.6	256.8	192.1	203.9	201.8	220.4	223.0	232.7	212.3
N_3	235.2	250.5	254.6	274.3	275.3	281.1	261.8	194.8	207.8	210.2	226.8	228.4	233.9	216.9
Mean	232.5	245.8	247.2	266.9	269.8	279.3		192.2	202.9	203.4	220.2	222.9	232.6	
Mean for P levels	239.1		257.0		274.5			197.5		211.8		227.7		
Mean for K levels	**K_1** = 249.8				**K_2** = 264.3			**K_1** =206.1				**K_2** =218.5		
Factor	**N**	**P**	**K**	**N×P**	**N×K**	**P×K**	**N×P×K**	**N**	**P**	**K**	**N×P**	**N×K**	**P×K**	**N×P×K**
S. Em (+/-)	2.25	2.25	1.84	3.90	3.19	3.19	5.52	1.63	1.63	1.33	2.82	2.30	2.30	3.99
C.D (5%)	6.75	NS	NS	NS	NS	NS	NS	4.89	NS	NS	NS	NS	NS	NS
C.V (%)	3.04							2.95						

and lowest available nitrogen (172.9 kg ha^{-1}) in soil was recorded at N-P_2O_5-K_2O @ 60-20-20 kg ha^{-1}(T_1). (N_3) had shown highest available nitrogen content (204.9 kg ha^{-1}) and it was on par with (N_2) (200.0 kg ha^{-1}). Lowest available nitrogen content (195.2 kg ha^{-1}) was recorded with the (N_1) (Fig. 6).

At 60 DAI

The highest available nitrogen (222.4 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18}) and lowest available nitrogen (137.9 kg ha^{-1}) in soil was recorded at N-P_2O_5-K_2O @ 60-20-20 kg ha^{-1}(T_1). (N_3) had shown highest available nitrogen content (184.4 kg ha^{-1}) and it was significantly higher than (N_2) (175.5 kg ha^{-1}), (N_1) (168.5 kg ha^{-1}). Lowest available nitrogen content (168.50 kg ha $^{-1}$) was recorded with (N_1) (Table 3) (Fig. 7).

The effect of P, K levels, and the interaction effect of nitrogen release pattern influenced by different treatments, were found to be non-significant in all intervals.

There is an increasing available nitrogen content from 0 DAI to 15 DAI due to rapid nitrification with added nitrogen fertilizer. Thereafter after significantly lower levels of available nitrogen content were observed from 30 DAI to 60 DAI. It might be due to more losses from volatilization and the less water holding capacity of sandy soil. Similar results are attached with Anudeep *et al.*, (2013).

Available nitrogen content of medium black soil

At 15 DAI

The highest available nitrogen (281.1 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18}) and the lowest available nitrogen (229.3 kg ha^{-1}) in soil was recorded at N-P_2O_5-K_2O @ 60-20-20 kg ha^{-1}(T_1). Application of 100 kg N ha^{-1} (N_3) had shown the highest available nitrogen content (261.8 kg ha^{-1}) and it was on

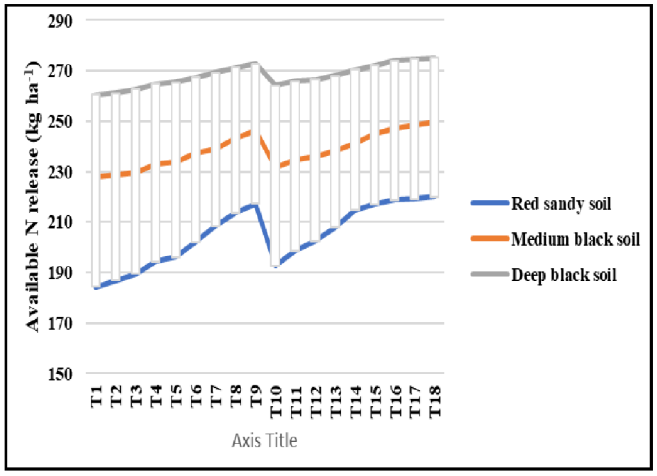

Fig. 6: Effect of different treatments on available nitrogen release pattern in different soils soil at 45 DAI.

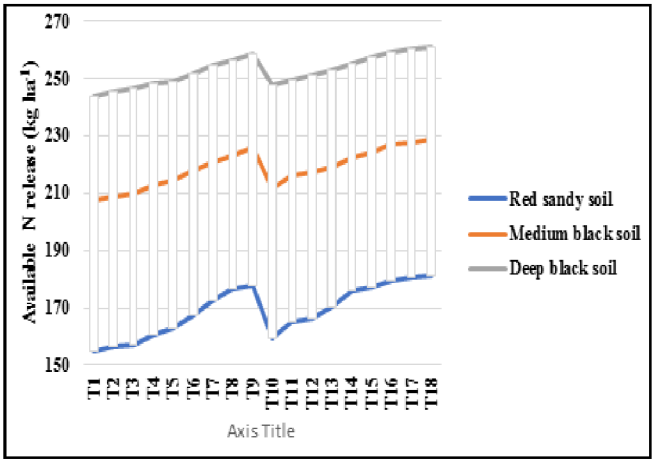

Fig. 7: Effect of different treatments on available nitrogen release pattern in different soils at 60 DAI.

Table 5: Available nitrogen content of medium black soil under incubation as affected by different fertilizer treatments.

	Available N in soil (kg N ha^{-1}) at 45 DAI							Available N in soil (kg N ha^{-1}) at 60 DAI						
P levels »	**P_1**		**P_2**		**P_3**		**Mean**	**P_1**		**P_2**		**P_3**		**Mean**
K levels »	**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**		**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**	
N levels ˅														
N_1	180.5	187.71	189.39	200.83	203.05	215.42	196.1	159.4	168.7	172.2	193.7	197.1	213.3	184.9
N_2	184.53	194.48	191.37	206.43	209.81	217.08	200.6	162.7	183.4	175.5	200.9	203.0	215.0	190.5
N_3	185.07	195.73	199.06	211.3	213.35	217.91	203.7	165.4	186.3	189.6	204.8	209.8	219.5	195.9
Mean	183.37	192.64	193.27	206.19	208.74	216.8		162.5	179.5	179.1	199.8	203.3	215.9	
Mean for P levels	188.0		199.7		212.7			170.9		189.4		209.6		
Mean for K levels	**K_1** = 195.1				**K_2** = 205.2			**K_1** =181.6				**K_2** =198.3		

par with application of 80 kg N ha^{-1} (N_2) (256.8 kg ha^{-1}). The lowest available nitrogen content (252.0 kg ha^{-1}) was recorded with the 60 kg N ha^{-1} (N_1) (Table 4) (Fig. 4).

At 30 DAI

The highest available nitrogen (232.6 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18}) and the lowest available nitrogen (189.5 kg ha^{-1}) in soil was recorded at N-P_2O_5-K_2O @ 60-20-20 kg ha^{-1}(T_1). (N_3) had shown the highest available nitrogen content (216.9 kg ha^{-1}) and it was on par with (N_2) (212.30 kg ha^{-1}). The lowest available nitrogen content (207.8 kg ha^{-1}) was recorded with the (N_1) (Table 4) (Fig. 5).

At 45 DAI

The results about available nitrogen content in soil as influenced by different treatments at 45 DAI, 60 DAI are given in Table 5.

The highest available nitrogen (217.9 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1}(T_{18}) and lowest available nitrogen (180.5 kg ha^{-1}) in soil was recorded at N -P_2O_5-K_2O @ 60-20-20 kg ha^{-1}(T_1). (N_3) had shown the highest available nitrogen content (203.7 kg ha^{-1}) and it was on par with (N_2) (200.61 kg ha^{-1}). The lowest available nitrogen content (196.1 kg ha^{-1}) was recorded with the (N_1) (Fig. 6).

At 60 DAI

The highest available nitrogen (219.4 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18}) and lowest available nitrogen (159.3 kg ha^{-1}) in soil was recorded at N -P_2O_5-K_2O @ 60-20-20 kg ha^{-1} (T_1). (N_3) had shown the highest available nitrogen content (195.9 kg ha^{-1}) and it was on par with (N_2) (190.09 kg ha^{-1}). The lowest available nitrogen content (184.0 kg ha^{-1}) was recorded with (N_1). (Table 5) (Fig. 7).

The effect of P, K levels and the interaction effect of nitrogen release pattern influenced by different treatments were found to be nonsignificant in all intervals.

The release of available nitrogen from 0 DAI to 15 DAI gradually increased. From 15 DAI to 60 DAI

Table 6: Available nitrogen content of deep black soil under incubation as affected by different fertilizer treatments.

	Available N in soil (kg N ha^{-1}) at 15 DAI							Available N in soil (kg N ha^{-1}) at 30 DAI						
P levels »	**P_1**		**P_2**		**P_3**		**Mean**	**P_1**		**P_2**		**P_3**		**Mean**
K levels »	**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**		**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**	
N levels ˅														
N_1	240.4	251.1	254.1	269.5	270.3	283.9	261.5	229.5	238.7	242.0	253.7	256.4	267.7	248.0
N_2	244.0	261.8	259.5	273.3	276.1	285.0	266.6	232.1	245.8	247.0	258.7	262.5	271.0	252.8
N_3	246.8	263.9	266.4	278.0	280.4	288.8	270.7	235.9	248.3	251.9	263.1	264.9	272.4	256.0
Mean	243.7	258.9	260.0	273.6	275.6	285.9		232.5	244.3	247.0	258.5	261.3	270.4	
Mean for P levels	251.3		266.8		280.7			238.3		252.7		265.8		
Mean for K levels	**K_1** = 259.7				**K_2** = 272.8			**K_1** =246.9				**K_2** =257.7		
Factor	**N**	**P**	**K**	**N×P**	**N×K**	**P×K**	**N×P×K**	**N**	**P**	**K**	**N×P**	**N×K**	**P×K**	**N×P×K**
S. Em (+/-)	2.09	2.09	1.61	3.55	2.88	2.88	4.90	2.71	2.71	2.21	4.69	3.83	3.83	6.63
C.D (5%)	6.27	NS	NS	NS	NS	NS	NS	8.13	NS	NS	NS	NS	NS	NS
C.V (%)	3.68							3.72						

Table 7: Available nitrogen content of deep black soil under incubation as affected by different fertilizer treatments.

	Available N in soil (kg N ha^{-1}) at 45 DAI							Available N in soil (kg N ha^{-1}) at 60 DAI						
P levels »	**P_1**		**P_2**		**P_3**		**Mean**	**P_1**		**P_2**		**P_3**		**Mean**
K levels »	**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**		**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**	
N levels ˅														
N_1	220.9	228.8	231.3	247.8	251.1	266.0	240.9	203.2	211.7	214.0	225.2	227.0	234.6	219.2
N_2	222.9	237.7	233.8	253.4	257.7	267.6	245.4	206.0	218.9	217.1	228.7	231.1	236.0	222.9
N_3	226.0	241.8	244.5	261.3	263.8	269.3	251.1	209.3	221.4	223.9	232.2	233.1	237.0	226.1
Mean	223.2	236.1	236.5	254.2	257.5	267.6		206.2	217.3	218.3	228.7	230.4	235.8	
Mean for P levels	229.6		245.3		262.5			211.7		223.4		233.1		
Mean for K levels	**K_1** =239.0				**K_2** = 252.6			**K_1** = 218.2				**K_2** = 227.2		
Factor	**N**	**P**	**K**	**N×P**	**N×K**	**P×K**	**N×P×K**	**N**	**P**	**K**	**N×P**	**N×K**	**P×K**	**N×P×K**
S. Em (+/-)	2.79	2.79	2.25	4.65	3.82	3.82	6.70	3.12	3.12	3.05	5.25	3.59	3.59	6.35
C.D (5%)	8.37	NS	NS	NS	NS	NS	NS	9.36	NS	NS	NS	NS	NS	NS
C.V (%)	3.82							4.52						

significantly decreased, but less losses than red sandy soil. It might be due to less losses from volatization and better water holding capacity compared with sandy soil. Anudeep *et al*., (2013)

Available nitrogen content of deep black soil

At 15 DAI

The highest available nitrogen (288.8 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18}) and the lowest available nitrogen (240.3 kg ha^{-1}) in soil was recorded at N -PO_5-K_2O @ 60-20-20 kg ha^{-1}(T_1). Application of 100 kg N ha^{-1} (N_3) had shown the highest available nitrogen content (270.7 kg ha^{-1}) and it was on par with application of 80 kg N ha^{-1} (N_2) (266.6 kg ha^{-1}). The lowest available nitrogen content (261.5 kg ha^{-1}) was recorded with the 60 kg N ha^{-1} (N_1). (Table 6) (Fig. 4).

At 30 DAI

The highest available nitrogen (272.3 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18}) and the lowest available nitrogen (229.5 kg ha^{-1}) in soil was recorded at N -P_2O_5-K_2O @ 60-20-20 kg ha^{-1}(T_1). (N_3) had shown the highest available nitrogen content (256.6 kg ha^{-1}) and it was on par with (N_2) (252.85 kg ha^{-1}). The lowest available nitrogen content (248.0 kg ha^{-1}) was recorded with the (N_1). (Table 6) (Fig. 5).

At 45 DAI

The results of available nitrogen content in soil as influenced by different treatments at 45 DAI, 60 DAI are given in the Table 7 (Fig. 6).

The highest available nitrogen (269.3 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18}) and the lowest available nitrogen (220.8 kg ha^{-1}) in soil was recorded at N -P_2O_5-K_2O @ 60:20:20 kg ha^{-1}(T_1). (N_3) had shown the highest available nitrogen content (251.1 kg ha^{-1}) and it was on par with (N_2) (245.4 kg ha^{-1}). The lowest available nitrogen content (240.9 kg ha^{-1}) was recorded with the (N_1).

At 60 DAI

The highest available nitrogen (237.0 kg ha^{-1}) in soil was observed at N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1} (T_{18}) and the lowest available nitrogen (203.2 kg ha^{-1}) in soil was recorded at N -P_2O_5-K_2O @ 60-20-20 kg ha^{-1}(T_1). (N_3) had shown highest available nitrogen content (226.1 kg ha^{-1}) and it was significantly higher (N_2) (222.9 kg ha^{-1}), N_1 (219.26 kg ha^{-1}). The lowest available nitrogen content (219.26 kg ha^{-1}) was recorded with (N_1) (Table 7) (Fig. 7).

The effect of P, K levels and the interaction effect of nitrogen release pattern influenced by different treatments were found to be non significant in all intervals.

Due to more water holding capacity and vigorous microbial growth and high CEC, gradual release of nitrogen after fertilized with nitrogen. It might be due to rapid mineralization within 20-25 days. Fixation of nitrogen can be minimized by application of nitrogen with potassic fertilizers or after the application of K fertilizers. After 30 DAI due to decreased nitrification rate and higher fixation rate significantly lowered rates available nitrogen contents. Anudeep *et al*., (2013).

Conclusion

Among all treatments, T_{18} (N-P_2O_5-K_2O @ 100-60-40 kg ha^{-1}) recorded high values at 15 DAI, 30 DAI, 45 DAI and 60 DAI. Low values are observed with N-P_2O_5-K_2O @ 60-20-20 kg ha^{-1} (T_1) at 15 DAI, 30 DAI,

45 DAI and 60 DAI. Similarly, with increasing levels N, P_2O_5, and K_2O there was increase in available N content in red sandy, medium black, and deep black soils. Available nitrogen showed higher values up to 15 DAI and decreased after 15 DAI up to 60 DAI in all three soils. Sharp decrease was noticed up to 30 DAI and gradual decrease was noticed thereafter.

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