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NITROGEN TRANSFORMATION AS AFFECTED BY APPLICATION OF NITROGEN, VERMICOMPOST AND HERBICIDE (*CLODINAFOP PROPARGYL*) IN SANDY SOIL

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ABSTRACT

Application of Nitrogen (N) @ 100 and 200 mg kg^{-1} soil significantly increased the NH_4^+-N and NO_3^--N contents in soil, respectively over control. NH_4^+-N increased from 9.10 to 39.25 and 59.70 mg kg^{-1} soil respectively (14th day) and was the peak observed whereas NO_3^--N contents increased from 11.74 to 86.79 and 104.66 mg kg^{-1} soil respectively (peak value) on the 56th day of incubation. Addition of vermincompost at 1% significantly increased the NH_4^+-N and peak was found on 14th day and the increase was from 15.76 to 58.48 mg kg^{-1} soil. Moreover in case of NO_3^--N contents increase was from9.79 to 65.87 mg kg^{-1} soil (peak value) on the 56th day of incubation. Effect of nitrogen at both the levels (100 and 200 mg kg^{-1}) was not spectacular on NO_2^--N contents in soil except from 3rd to 7th day of incubation where increase was from 0.16 to 2.56 and to 3.23 mg kg^{-1} on 3rd and from 0.17 to 2.05 to 2.74 mg kg^{-1} soil on 7rd day of incubation respectively . However, addition of herbicide in soil significantly decreased the NH_4^+-N, NO_3^--N and NO_2^--N contents at all incubation periods.

INTRODUCTION

Nitrogen is a macronutrient and plays an important role in increasing the agricultural production. Available N includes NH_4^+-N, NO_3^--N and NO_2^--N forms. Mostly total N in soil is bound in organic compounds (95 %), the rest is in inorganic forms, mainly as nitrate and ammonium (NO_3^--N, NH_4^+-N) and content of mineral nitrogen (N_{min}) in the soil is one of the most important factors with a decisive role in high crop yields and a potential risk of environmental pollution. Thus, an accurate prediction of N that is mineralized from soil organic matter and other sources of nitrogen during a growing season would result in a more efficient use of N fertilizer and decrease the potential surface and groundwater contamination (Haney *et al*. 2001).Organic manures could also add substantial amount of N to soil. Among the different wastes utilized, it is evident that the vermicompost from tea waste had high level of nutrients and was able to promote growth and advance the onset of flowering and fruiting in the plant used (Indirabai and Suja Pratha, 2009). Application of vermicompost showed an increased growth of *Abelmoschus esculentus* in terms of height of the plant. It also increased the carbohydrate and protein content. The vermin composting of poultry waste is the best method of disposal and it could be a better alternative to inorganic fertilizers (Tamilselvi and Devi, 2009). Transformation of nitrogen is a complex process brought about by succession of different micro-organisms in the soil which affect the soil fertility, whereas herbicide application may inhibit various processes such as nitrification, denitrification and N fixation (Jolankai *et al.,* 2006). Although we are able to appreciate the significance of microorganisms in the soil, we have little information on the importance of microbial diversity in the functioning of soil systems, and most research suggests that the relationships are neither consistent nor direct (Nannipieri *et al*., 2003, Brussaard *et al*., 2004). Microbial diversity in soils is influenced by different factors including anthropogenic activities, and microbial communities are known to respond to organic matter amendments with increased activity and growth, which affects soil processes, including nitrogen (N) mineralization (Fauci and Dick, 1994). With advancement of agricultural technology use of herbicides is now-a-days a common practice to manage weeds to get higher production and profit. Clodinafop propargyl is such a commonly used soil applied herbicide which is used to manage weeds. However, this chemical may alter the balanced soil ecology and result into altered mineralization pattern. The studies on alterations in microbial activities and numbers brought about by pesticides have been undertaken by several authors (Pampulha and Oliveira, 2006, Sebiomo, *et al*., 2011, Cycon and Piotrowska-Seget, 2009, Lo, 2009, Valiolahpor *et al*., 2011). While most of the reports suggest that the application of these chemicals decrease the microbial population (Latha and Gopal, 2010, Newton, *et al.,* 2010), some are also in favour of increase in population when these products are applied to soil (Niewiadomska, 2004). However, the information regarding the effect of herbicide on nitrogen transformation in the soil is very scanty. Keeping this in view, the present study was planned to assess the effect of nitrogen and vermin compost and clodinafop propargyl on nitrogen transformation in soil.

MATERIALS AND METHODS

Study area and soil sampling

An incubation study was conducted under controlled laboratory condition in the Department of Soil Science CCSHAU, Hisar (29º05′ N, 75º38′ E, 222 m elevation) to study the effect of nitrogen and vermin compost and herbicide (clodinafop propargyl) on nitrogen transformation. Bulk surface soil sample (0-15 cm) was collected from village Balsamand, District Hisar. The soil sample was air dried ground and passed through 2 mm sieve. After mixing thoroughly, the soil was used for laboratory studies. The physico-chemical properties of soil are presented in Table 1.

Collection and processing of vermicompost

Vermi compost was collected from Department of Agronomy, CCS HAU, Hisar. It was first air dried at room temperature then ground and passed through 2 mm sieve before use. The nitrogen, phosphorus, potassium and organic carbon content of vermin compost are given in Table 1.

Incubation study

The incubation study was conducted in well controlled laboratory conditions. The treatments comprised of three levels of nitrogen (0, 100 and 200 mg kg^{-1}), two levels of vermin compost (0 and 1 % on dry wt. basis) and two levels of herbicide (0 and 60 g a.i. ha^{-1}). Total 360 wide mouth plastic bottles were used. They were properly washed and dried well before starting the experiment. Thirty gram of air dry soil per bottle was filled. Then vermicompost was added to half the number of bottles and thoroughly mixed with soil. Then solutions of 100 mg kg^{-1} N, 200 mg kg^{-1} N and herbicide were prepared. The soil samples in each bottle were treated with these solutions, making required combination of nitrogen, vermicompost and herbicide and the moisture was maintained at field capacity. After this total weight of each bottle was recorded and mouth of the bottles were closed with cotton. Then these bottles were put into the incubator at 25 ^{0}C. Moisture level was maintained daily by taking the weight of bottles on top pan balance. One set of 36 bottles at each sampling period was analyzed for different nitrogen fractions. After treatment the soil was incubated for 56 days in wide mouth plastic bottles maintaining the soil moisture at field capacity. The soil was analyzed for NH_4^+-N, NO_3^--N and NO_2^--N contents on 0, 3rd, 7th, 14th, 21st, 28th, 35th, 42nd, 49th and 56th days of incubation. Completely randomized design was followed by keeping three replications. For different fractions of nitrogen, soil was extracted with 2 M KCl solution and determined by steam-distillation method (Keeney and Nelson, 1982).

RESULTS AND DISCUSSION

Effect of nitrogen levels at different incubation periods on:

NH_4^+-N

Data (Table 2) indicated that with the application of nitrogen significantly recorded the higher NH_4^+-N contents in soil over control and vermin compost throughout the incubation study. Application of nitrogen @ 100 and 200 mg kg^{-1} significantly increased NH_4^+-N contents upto third day of incubation in the soil and the increase was from 39.25 to 63.52 mg kg^{-1} and from 59.70 to 87.59 mg kg^{-1}, respectively over the zero day of incubation. Thereafter, it starts declining and this trend was observed till the end of incubation. However, at the end of incubation NH_4^+-N contents in soil were 31.22 and 39.62 mg kg^{-1}respectively with the application of nitrogen @ 100 and 200 mg kg^{-1}. So, peak values (63.52 and 87.59 mg kg^{-1}) were observed on the 3rd day of incubation. Hence, from the above results it can be concluded that hydrolysis of added urea might be highest in first 2-3 days and then part of NH_4^+-N started converting into NO_3^--N. N fertilizer application stimulated release of NH_4^+-N from fertilizer nitrogen and favoured the mineralization of vermicompost (Sharma and Mahapatra, 1990). Long-term organic matter applications shifted mineralization towards the labile organic N pool, while mineral N applications stimulated mineralization from the recalcitrant organic N pool. Gross mineralization rates in the vermicompost treatment soil are significantly higher than in control soil (Duhan *et al.,* 2001). Data presented above can be graphically represented as shown in Fig. 1.

NO_3^--N

The data presented in Table 3 revealed that application of nitrogen increased the NO_3^--N content in soil over

Table 1: Physico-chemical properties of soil and vermicompost

Property	Values	Method used
Soil		
Organic carbon (%)	0.15	Walkley and Black Wet oxidation method (Jackson, 1973)
Soil pH	8.10	Glass electrode pH meter (Jackson, 1973)
EC (dS/m at 25 ^{0}C)	0.15	Conductivity bridge meter (Richards, 1954)
Available nitrogen (mg kg^{-1})	54.50	Alkaline per magnate method (Subbiah and Asija, 1956)
NH_4^+-N (mg kg^{-1})	9.10	Steam-distillation method (Keeney and Nelson, 1982).
NO_3^--N (mg kg^{-1})	11.74	Steam-distillation method (Keeney and Nelson, 1982).
NO_2^--N (mg kg^{-1})	0.16	Steam-distillation method (Keeney and Nelson, 1982).
Vermicompost		
Total N (%)	1.30	Colorimetric (Nessler's reagent) method (Lindner, 1944)
Total P (%)	0.52	Vanadomolybdophosphoric yellow color method (Koenig and Johnson, 1942)
Total K (%)	1.22	Using flame photometer (directly)
Organic carbon (%)	15.23	Rapid titration method (Walkley and Black, 1934)

Table 2: Effect of different treatments on the NH_4^+-N contents (mg kg^{-1}) in soil

Treatments	Incubation Days										Mean
	0	3	7	14	21	28	35	42	49	56	
Control	9.10	20.80	33.84	41.24	39.07	36.08	32.26	29.18	21.80	21.72	28.61
N (100 mg kg^{-1})	39.25	63.52	59.41	57.17	43.48	42.98	40.37	36.64	33.28	31.22	44.73
N (200 mg kg^{-1})	59.70	87.59	78.64	75.28	72.48	54.56	47.65	45.23	41.86	39.62	60.26
Vermicompost (1%)	15.76	41.87	49.24	58.48	42.43	40.50	38.51	36.22	31.52	24.70	37.92
Herbicide (60 g a.i. ha^{-1})	8.74	18.55	30.67	38.51	37.09	34.40	30.48	28.61	19.79	17.41	26.43
Mean	26.71	46.47	50.36	54.14	46.91	41.70	37.85	35.18	29.65	26.93	
CD (at 5%)	1.81	4.22	3.96	4.50	3.56	2.95	2.63	2.47	3.44	4.04	

Table 3: Effect of different treatments on the No_3^--N contents (mg kg^{-1}) in soil

Treatments	Incubation Days										Mean
	0	3	7	14	21	28	35	42	49	56	
Control	11.74	14.49	19.51	26.75	32.90	35.57	38.17	39.39	39.62	39.85	29.20
N (100 mg kg^{-1})	14.32	27.40	33.34	62.69	79.47	81.55	83.67	85.48	86.38	86.79	64.11
N (200 mg kg^{-1})	19.56	31.33	46.18	77.73	97.33	99.42	101.54	103.35	104.25	104.66	78.54
Vermicompost (1%)	9.79	25.35	34.69	47.09	58.55	60.63	62.75	64.56	65.46	65.87	49.47
Herbicide (60 g a.i. ha^{-1})	5.41	13.08	16.90	22.93	28.97	29.97	35.33	37.50	37.98	38.23	26.63
Mean	10.96	22.33	30.12	47.44	59.44	61.43	64.29	66.06	66.74	67.08	
CD (at 5%)	1.83	2.11	1.28	1.01	1.24	1.168	1.33	1.23	1.33	1.19	

Table 4: Effect of different treatments on the NO_2^--N contents (mg kg^{-1}) in soil

Treatments	Incubation Days										Mean
	0	3	7	14	21	28	35	42	49	56	
Control	0.16	0.16	0.17	0.17	0.18	0.17	0.17	0.16	0.16	0.16	0.17
N (100 mg kg^{-1})	0.16	2.56	2.05	1.80	1.27	0.85	0.35	0.24	0.18	0.17	0.96
N (200 mg kg^{-1})	0.16	3.23	2.74	2.14	1.51	0.92	0.45	0.25	0.20	0.18	1.18
Vermicompost (1%)	0.16	0.16	0.19	0.46	0.56	0.89	0.38	0.24	0.18	0.17	0.34
Herbicide (60 g a.i. ha^{-1})	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.16	0.15	0.16	0.16
Mean	0.16	1.25	1.06	0.95	0.74	0.60	0.30	0.21	0.17	0.17	
CD (at 5%)	N.S.	0.19	0.16	0.07	0.04	0.04	0.03	N.S.	N.S.	N.S.	

vermicompost alone and control. With the application of nitrogen @ 100 and 200 mg kg^{-1}, NO_3^--N content in soil increased significantly throughout the incubation study and the extent of increase was from 14.32 to 86.79 mg kg^{-1} and from 19.56 to 104.66 mg kg^{-1}, respectively over initial values. However, increase in NO_3^--N contents in the soil were prominent upto 42nd day of incubation and later on contents were almost stable. The increase in NO_3^--N contents in soil might be due to the reason that NH_4^+-N started converting into NO_3^--N and upto the 42nd day of incubation most of the NH_4^+-N converted into NO_3^--N and then NO_3^--N content in soil become almost stable. So, peak values (86.79 and 104.66 mg kg^{-1}) were observed on the 56th day of incubation. Data presented above can be graphically represented as shown in figure 2. The stimulation of gross nitrification after mineral or organic N supply shows that this N transformation is very sensitive to any changes in N supply (Schimel and Bennett, 2004). NO_3^--N concentration start increasing on the 2nd day of incubation with the nitrogen application and this increase in NO_3^--N was continued till last of incubation (Duhan *et al.* 2005).In arable soils, most ammonia oxidation is carried out by autotrophic nitrification (Barraclough and Puri, 1995).

NO_2^--N: Data presented in Table 4 indicated that accumulation of NO_2^--N contents in soil was very low except on third day of incubation. Application of nitrogen @ 100 and 200 mg kg^{-1} were not spectacular with respect to NO_2^--N contents in soil except from third to seventh day of incubation. Application of nitrogen (@ 100 and 200 mg kg^{-1}) increased the NO_2^--N content in soil from 0.16 mg kg^{-1}to 2.56 and to 3.23 mg kg^{-1}, 0.17 mg kg^{-1}to 2.05 and to 2.74 mg kg^{-1}and 0.17 mg kg^{-1}to 1.80 and to 2.14 mg kg^{-1}soil on third, seventh and 14th day of incubation, respectively. The peak of NO_2^--N contents in soil (2.56 and 3.23mg kg^{-1}) was observed on third day of incubation. These higher NO_2^--N contents in soil on third day might be intermediate product of NH_4^+-N and NO_3^--N which is completed within in one week. N application increased the potential NO_2^--N contents in the system, regardless of whether it was supplied in mineral or organic form (Table 4). The results of our investigation agreed with previous observations demonstrating that fertilizer addition increased N_2O emissions (Ding *et al.*, 2010). Results were also in agreement with those reported by Prasad and Singhania (1989), Sahrawat (1992) and Duhan *et al*. (2001).Data presented above can be graphically represented as shown in Fig. 3.

Effect of vermicompost at different incubation periods on NH_4^+-N

Data presented in the Table 2 indicated that application of vermicompost recorded higher contents of NH_4^+-N contents in soil over control. Application of vermicompost significantly increased NH_4^+-N contents in soil upto 14th day of incubation in the soil and the extent of increase was from 15.76 mg kg^{-1}

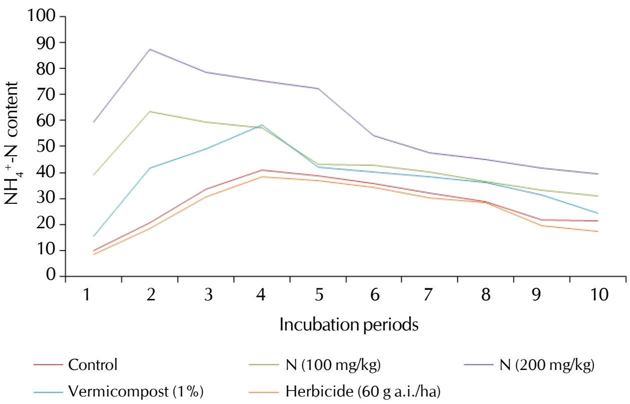

Figure 1: Effect of nitrogen, vermicompost and herbicide on NH_4^+-N content (mg kg^{-1}) of soil

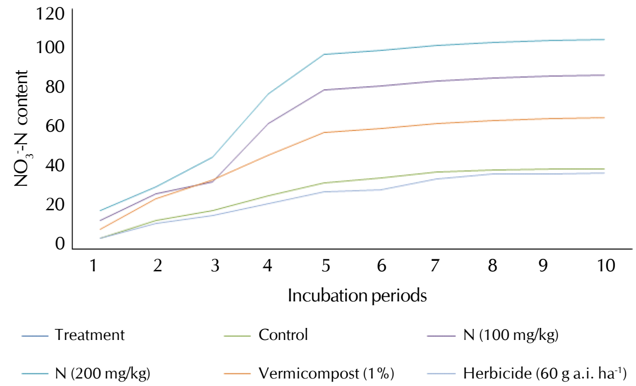

Figure 2: Effect of nitrogen, vermicompost and herbicide on NO_3^--N content (mg kg^{-1}) of soil

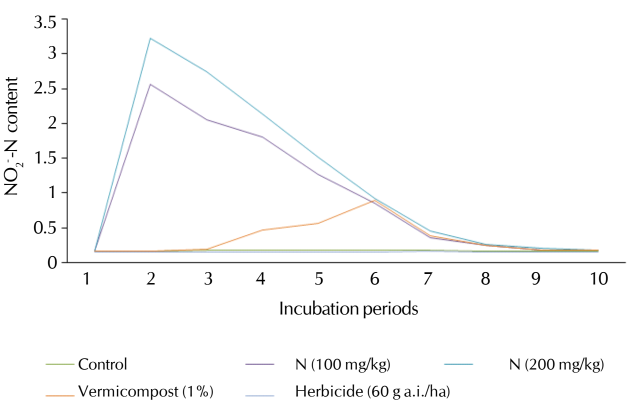

Figure 3: Effect of nitrogen, vermicompost and herbicide on NO_2^--N content (mg kg^{-1}) of soil

to 58.48 mg kg^{-1} over the zero day of incubation. Thereafter, it starts declining and this trend was observed till the end of incubation. However, at the end of incubation contents of NH_4^+-N was 24.70 mg kg^{-1}. So, peak value (58.48 mg kg^{-1}) was observed on the14th day of incubation. Data presented above can be graphically represented as shown in figure 1. This may be due to reason that vermicompost application increased the microbial activity and its mineralization was at peak on the 14th day which increased the NH_4^+-N content in soil. However, amount of release of nitrogen from applied vermicompost varied among the different time periods. This was in agreement with the similar reports of Sharma and Verma (2001). Khankhane and Yadav (2000) also reported similar results. Prasad and Singhania (1989) also reported that organic manure application increased the NH_4^+-N contents in the soil.

NO_3^--N

The data presented in Table 3 revealed that with the application of vermicompost NO_3^--N content in soil increased significantly throughout the incubation study and the extent of increase was from 9.79 to 65.87 mg kg^{-1} over initial value. However, increase in NO_3^--N contents in the soil were prominent upto 42nd day of incubation and later on contents were almost stable. So, peak value (65.87 mg kg^{-1}) was observed on the 56th day of incubation. Data presented above can be graphically represented as shown in Fig. 2. The data suggested that despite the higher input of N by fertilizer nitrogen the accumulation of NO_3^--N content in soil was more with application of vermicompost. This could be because of the much slower release of N from vermicompost resulting in smaller losses of N and building of a higher concentration of NO_3^--N content in soil. Khankhane and Yadav (2000) also reported that vermicompost application increased the NO_3^--Ncontent in soil may be because of presence of more NH_4^+-N content in soil due to mineralization of vermicompost and its oxidation leads to a higher concentration of NO_3^--N content in soil. Prasad and Singhania (1989) and Mukherjee (1998) also reported that the application of vermicompost increased the NO_3^--Nin the soil during incubation.

NO_2^--N

Data presented in Table 4 revealed that the effect of vermicompost on NO_2^--N contents in soil were not spectacular. Although, there was slight increase in NO_2^--N contents in soil on the 14th day of incubation from 0.17 mg kg^{-1}to 0.46 mg kg^{-1} and from 0.18 mg kg^{-1}to 0.56 mg kg^{-1}on 21st day while on 28th day increase was from 0.17 mg kg^{-1}to 0.89 mg kg^{-1} and then decreased till the end of incubation periods and NO_2^--N contents in soil on 56th day of incubation were 0.17 mg kg^{-1}. Data presented above can be graphically represented as shown in figure 3. Vermicompost application increased the NO_2^--N content in soil may be because of presence of more NH_4^+-N content in soil due to mineralization of vermicompost and its oxidation leads to a higher concentration of NO_2^--N content. These results are in contrast to those of Senapati *et al.* (1992) and Duhan *et al.* (2001).

Effect of herbicide (clodinafop propargyl) at different incubation periods on

NH_4^+-N

Data (Table 2) indicated that application of herbicide decreased the NH_4^+-N contents in soil throughout the incubation period over the control (without clodinafop propargyl). NH_4^+-N content was decreased from 10.10 to 8.74mg kg^{-1} at zero day with herbicide application. On the 14th day of incubation, decrease in NH_4^+-N contents of soil with application of herbicide was from 41.24 to 38.51 mg kg^{-1}. Data further revealed that this trend of decrease in NH_4^+-N was observed till the 56th day of incubation study and decrease was from

21.72 to 17.41 mg kg^{-1}. Data presented above can be graphically represented as shown in Fig. 1.The decrease in NH_4^+-N contents in the soil with herbicide application may be due to its adverse effect on micro-organisms responsible for ammonification process which was suppressed and hence NH_4^+-N contents were decreased. These findings were in agreement with results of Kucharski *et al.* (2009) and Parlda *et al.* (2010) who reported that NH_4^+-N decreased with time. Urea treatments contained higher amount of NH_4^+-N as compared to other treatments. Application of pendimethallin caused reduction in NH_4^+-N contents during the initial periods. NO_3^--N content however, increased with time and urea treatments. Pendi methallin application increased the NO_3^--N contents.

NO_3^--N

Data presented in table 3 revealed that application of herbicide also decreased the NO_3^--N content in the soil from 5.74 to 5.41 mg kg^{-1} on zero day of incubation. This trend of decrease in NO_3^--N content in the soil with herbicide application was observed throughout the incubation study. The decrease in NO_3^--N contents in soil with herbicide application may be due to its adverse effect on nitrifying bacteria responsible for nitrification process and hence NO_3^--N contents were decreased. Data presented above can be graphically represented as shown in Fig. 2. These results were in agreement with those reported by Singh and Prasad (1991) reported that application of different pesticides inhibited the nitrification rate in soil. Duhan *et al.* (2005) also reported similar results.

NO_2^--N

Data presented in Table 4 revealed that the effect of herbicide on NO_2^--N contents in soil were not spectacular. Although, there was slight decrease in NO_2^--N contents in soil on the 7^{th} day to 28^{th} of incubation and thereafter, effect of herbicide was found non-significant with respect to NO_2^--N contents in soil. The decrease in NO_2^--N contents in soil with herbicide application may be due to its adverse effect on nitrification process. Similar results were reported by Lucian *et al.* (1998). Data presented above can be graphically represented as shown in Fig. 3.

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