Periodic mineralisation of nitrogen under FYM amended soil

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Abstract

Sustainability of productivity is a major thrust to feed ever-increasing population of the world. The result of the various studies conducted indicates that integrated nutrient management is the only way for sustaining yields of various cropping systems. The results of a long-term experiment conducted at this station indicate that the response of nitrogen is linear up to 120 Kg N ha^{-1}. At all the doses of FYM ranging from 0 to 90 t ha^{-1} y^{-1}. It becomes all the more important to know the fate of applied nitrogen through organic and inorganic sources. Thus the present investigation was undertaken to know the mineral the mineral content of the soil at various periods of wheat growth.

Afield experiment is under progress since winter 1967 in the research area of Department of soil science, CCS HAU, Hisar. The treatment includes three doses of FYM (15, 30 and 45 t ha^{-1}) applied in three modes i.e. to every summer season, every winter season, and both the seasons. There was one FYM control. These ten treatments were assigned in main plots and each main plot is divided into three subplots receiving N at 0, 60 and 120 kg ha^{-1}. Nitrogen at 0 and 120 kg ha^{-1} were selected for the present study. Surface soil samples (0 to 15 cm) were collected at an interval of 24 days after whet sowing. The soil samples were subjected to moisture estimation by gravimetric method and wet samples were extracted with 2 M KCl. NH_4^+ and NO_3^--N were estimated in the KCl extract by steam distillation method.

The addition of nitrogenous fertilizer has increased the availability of nitrogen in the FYM amended plots and thus its suitable combination is required for proper management of nitrogen 30 t ha^{-1} FYM applied during summer season has been found to be the most suitable dose when combined with urea at 120 kg N ha^{-1} in releasing the available N with higher nitrification. If the chemical fertilizer is avoided then 30 t ha^{-1} FYM will have to be applied during both seasons for higher release of nitrogen.

Keywords: sustainability, mineralization, farmyard manure

Introduction

Nitrogen supply to cereal crops depends upon the release of nitrogen from soil organic matter after mineralisation and its supplementation from fertilizer. Understanding the rates of transformation and fate of nitrogen in farm yard manure (FYM) amended soil is important to insure that the amount of FYM applied provide sufficient available nitrogen for plant growth, but do not liberate amounts of NO_3^- in excess of plant needs. The nitrogen unutilized by a crop is lost by leaching, denitrification or NH_3 volatilization and some is incorporated by stable humus (Stevenson and Cole, 1999). Nitrate is the most important mobile nitrogen form in soils

and is susceptible to leaching and movement with water. Thus, mineral form seldom carries over from one season to the next. Hence, the changes in nitrogen in soil will have to be manipulated to minimize nitrogen losses, thereby protecting the environment. Proper management of organic matter is the heart of sustainable agriculture (Magdoff, 1992; Weil, 1992). When organic manures are supplemented with Nitrogen fertilizer under different management practices, it is difficult to predict nitrogen availability during the growing period of a crop. The knowledge of such availability is essential to ensure the release of adequate amount nitrogen as well as to minimize the losses. Also, if possible there can be utilization of the residual amount by the subsequent crop for sustaining fertility status. However, most of the available data concerning nitrogen mineralization of organic matter are from laboratory studies, which may not reflect the field conditions (He *et al*., 2000). Most soils of tropics have low buffer capacity because, of low organic matter content and predominance of low activity clays. Data of long-term experiments can be utilized to evaluate the impact of land use and soil management on soil degradative processes (Lal and Stewart, 1995). Hence a long term field experiment has been selected to evaluate the effect of inorganic nitrogenous fertilizer on the availability of mineral nitrogen in soil during the various growth periods of wheat crop up to 120 days as amended by FYM.

Materials and Methods

A long-term experiment has been running at the research farm of Haryana Agricultural University, Hisar since winter 1967. The experiment consists of 3 levels of FYM at 15, 30 and 45 t ha^{-1} applied in three modes, i.e. in summer to pearl millet, in winter to wheat or in both summer and winter. One FYM control has been maintained. These ten treatments were assigned in main plots and each main plot was divided into three subplots receiving N at 0, 60 and 120 kg N ha^{-1}. Nitrogen at 0 and 120 kg were selected for the present study. Surface soil samples (0 to 15 cm) were collected at an interval of 24 days after wheat sowing. The samples were subjected to moisture estimation by gravimetric method and the wet samples were extracted by 2 M KCl. NO_3^- and exchangeable NH_4^+-N were estimated in the extract by steam distillation method (Keeney and Nelson, 1982).

Results and Discussion

The available nitrogen status of soil over a period of 120 days of the growth of wheat was found in a continuous state of flux. In soil there is a regular turnover of nitrogen through mineralization - immobilization, with incorporation of nitrogen into microbial cells. Where much of the newly immobilized nitrogen is recycled through mineralization, some is converted into stable humus form (Stevenson and Cole, 1999).

Net mineralization with application of nitrogenous fertilizer

The application of nitrogenous fertilizer released highest amount of total mineral nitrogen when it was combined with 30 t ha^{-1} FYM than the other two doses in all the three modes of application (Figure 1a). Among all the three modes, application of FYM to both the seasons at 30 t ha^{-1} released maximum amount of mineral nitrogen.

This is evident that the application of inorganic nitrogenous fertilizer has certainly increased the availability in the FYM amended plots, which make the possibility of its suitable combination with FYM to fulfill nitrogen requirement of the crop. Interestingly, if the availability is compared with the plots which did not receive the inorganic

nitrogen (Figure 2) the highest amount of nitrogen mineralized among different doses and modes of FYM application, obtained from the residual effect of 30 t ha^{-1} FYM applied during summer season. It was followed by the combined application of 30 t ha^{-1} FYM applied during both the seasons. The stimulation of microbial activity by the addition of inorganic nitrogenous fertilizer is thought to increase decomposition of organic material with an accompanying mineralization of soil organic N (Wasterman and Kurtz, 1973). The C:N ratio of 36:1 of the applied FYM might have led to more immobilization in the freshly added FYM resulting in less availability of mineral N. The summer application produced more NO_3^--N than the other two modes of application with this dose indicating higher rate of nitrification. (Figure 1a). The residual effect of 15 and 45 t ha^{-1} FYM applied during summer season have released lower total as well as NH_4^+ –N than the other two modes. But the NO_3^--N levels were nearly the same in al these treatments. It is also an indication of higher nitrification in the residual amount of summer applied FYM. Maximum initial concentration was observed in the residual effect of FYM at 30 t ha^{-1} followed by the cumulative application with the same level.

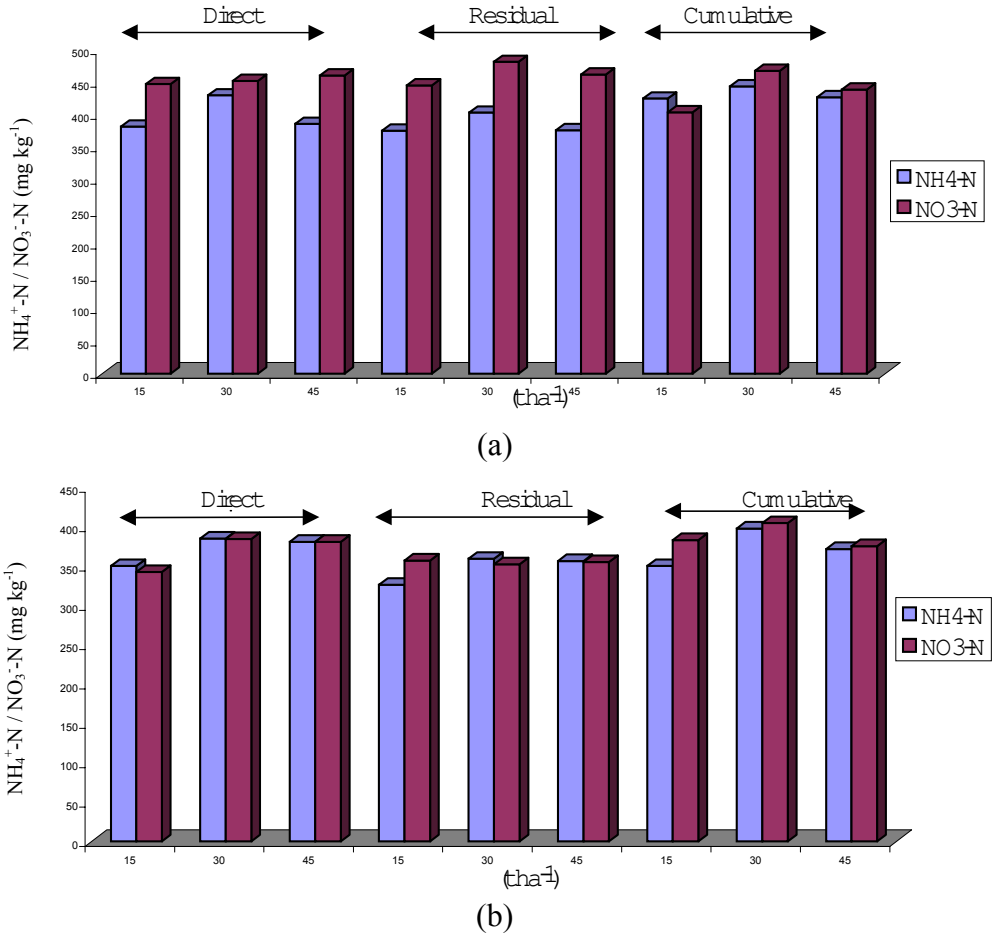


Figure 1 (a) Ammononical and nitrate-N in FYM amended soil during wheat growth period, (b) Ammonical and Nitrate N in FYM amended soil during wheat growth period without urea application.

Mineralization without application of nitrogenous fertilizer

The total mineral N released during the observation period up to 120 days was highest with 30 t ha^{-1} (Figure 1b) The lower availability and higher residual amount with higher dose foretells about the beginning of increasing nitrogen release, which can be utilized by the subsequent crop. The cumulative effect of FYM applied during both the seasons had higher release of available N as well as the amount of available N left after 120 days than either winter or summer applied FYM.

In all the treatments the concentration of NH_4^+-N was nearly at par with NO_3^--N the dominant form indicating lower rate of nitrification. This may result in lower leaching loss. The lower net mineralization and higher NH_4^+-N can be utilized in sustaining fertility status for the next crop as well as for the organic farming where the use of chemical fertilizer is avoided.

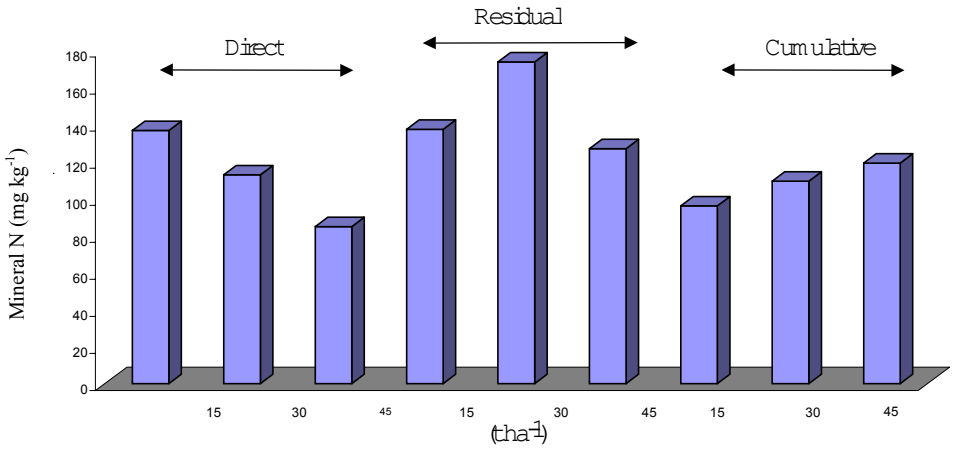
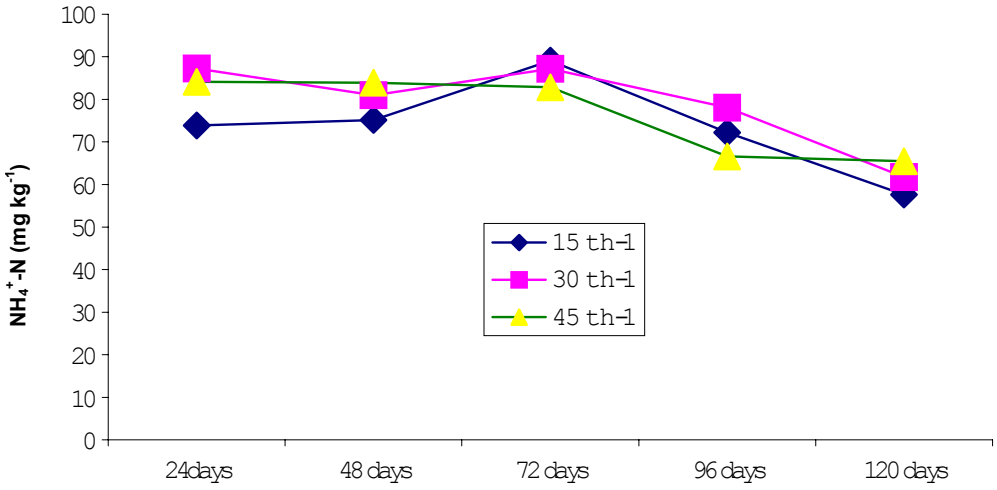


Figure 2 Effect of N on net FYM mineralization.

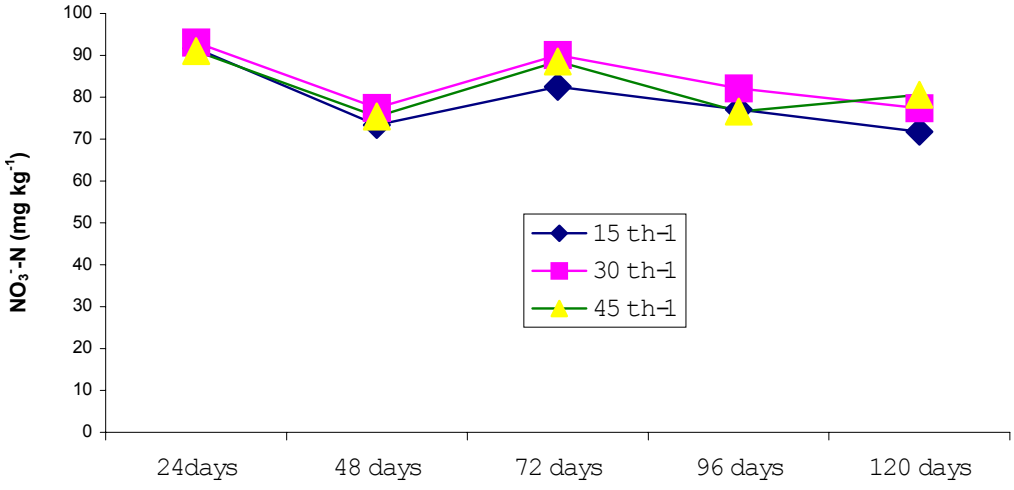
Kinetics of the release of mineral N

NH_4^+-N and NO_3^--N levels as per modes

Among the different modes (Figure 3a) direct FYM application had a rise in NH_4^+-N up to 72 days, where as the residual as well as cumulative applications had a little change in its concentration up to this period as compared to the initial level. The rise in the level even with simultaneous initial immobilisation indicates higher rate of mineralisation in the direct application. Thereafter, it continued to decline in all the three cases. The decline was faster in the direct application than the other two modes. NO_3^--N level (Figure 3b) declined at 48 days in all the three modes, may be due to the higher uptake of nitrogen during the critical growth period of wheat. After the addition of second and third split doses of urea and with the increased net mineralization there was a rise in mineral N level after 48 days. But in the direct application plots the level remained nearly constant throughout the rest of the period. After 72 days there was a steep decline in the concentration of NO_3^--N in the summer applied FYM plots due to higher plant uptake and its lower replenishment.



(a)



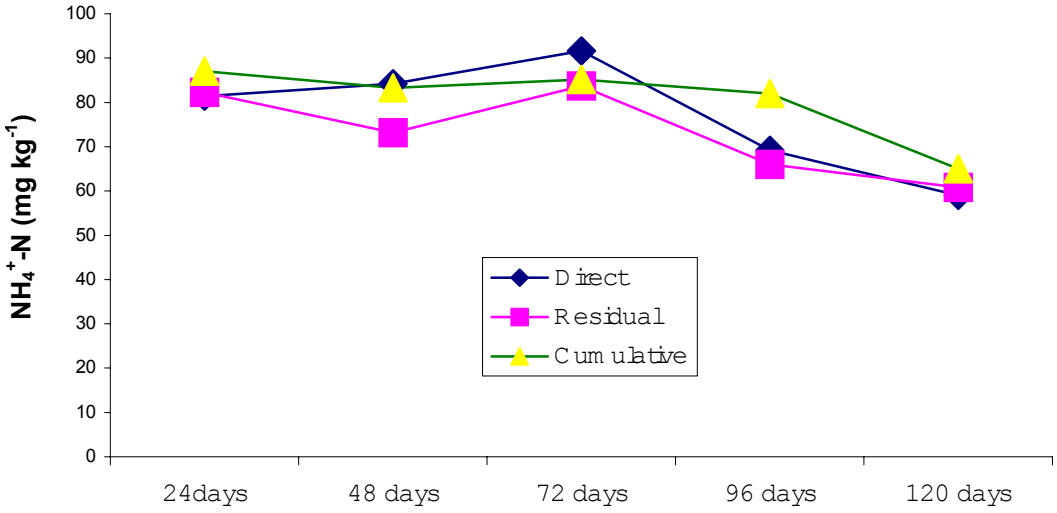
(b)

Figure 3 (a) Periodical changes in NH_4^+-N as per doses, (b) Periodical changes in NO_3^--N as per doses.

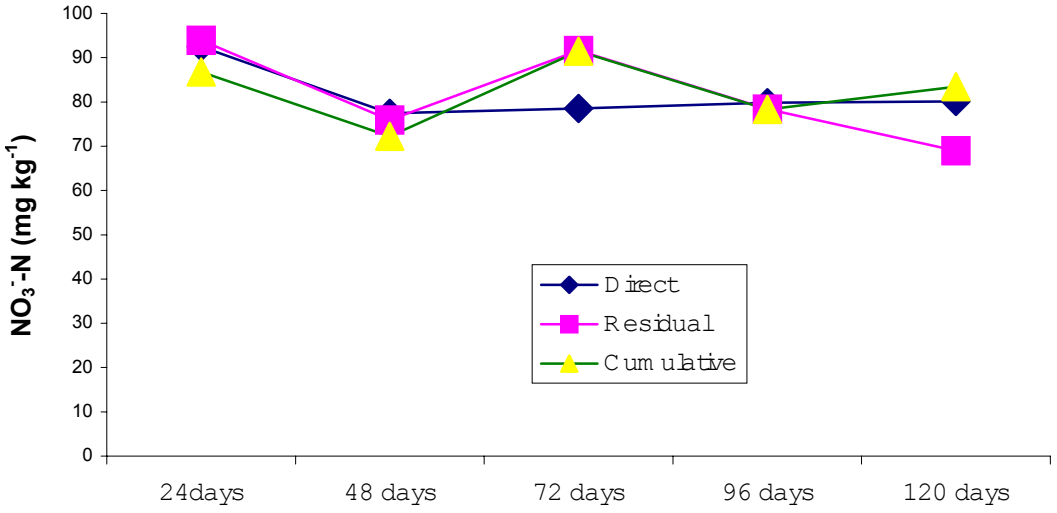
NH_4^+-N and NO_3^--N levels as per doses

Initially higher NH_4^+-N was observed with 30 t ha^{-1} followed closely by 45 t ha^{-1} (Figure 4a). Up to 72 days there was not much variation in its level with these two doses. The initial lower NH_4^+-N remained almost same up to 48 days. But, then there was a sudden increase up to 72 days and then started declining during the rest of the period. The period up to which there was utilization of ammonical form of nitrogen, the microorganisms with the simultaneous mineralization of FYM there was not much change its level. As soon as the demand of microorganisms diminishes and due to the increased mineralisation of FYM with application of chemical fertilizer the level of

ammonical nitrogen increases. Ammonium uptake by microorganism is concentrative and gradients of up to 100 fold across the cell membrane has been observed (Kleiner *et al.,* 1981). With increase in nitrification and increase in the plant uptake and also some losses the NO_3^--N starts decreasing (Figure 4b). There was not much variation in the NO_3^--N level in the soil during all the different growth periods. After a decline in its concentration at 48 days due to the increased plant demand and the initial build up of microorganism, it increased at 72 days and then declined during the rest of the period.



(a)

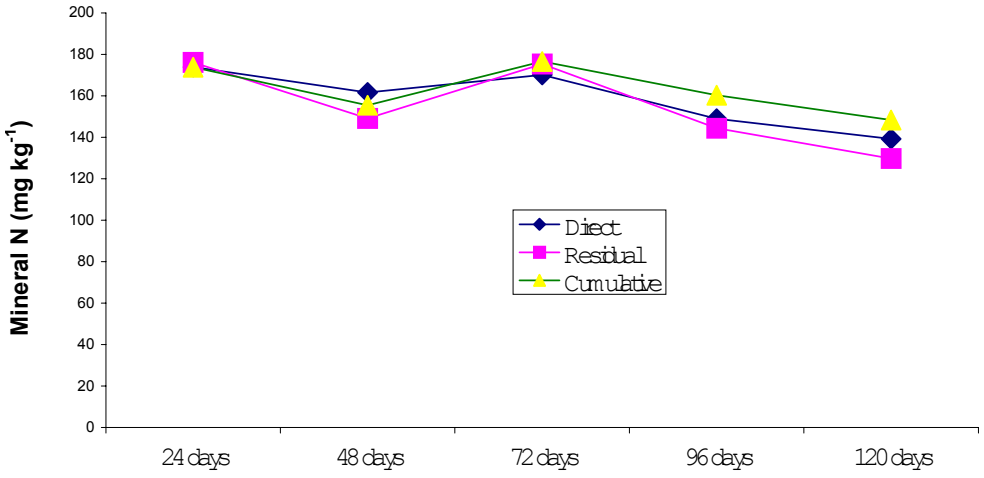


(b)

Figure 4 (a) Periodical changes in NH_4^+-N as per modes, (b) Periodal changes in NO_3^--N as per modes.

Mineral N as per doses and modes

In all the three modes, the pattern of changes in the availability of N was almost similar. (Figure 5a). With the same level of mineral N at 24 days there was a decline up to 48 days, again increased up to 72 days and then decreased. The changes in the concentration of mineral N with the different doses (Figure 5b) followed the same pattern. The mineral N content was significantly higher with application of FYM at 30 t ha^{-1} as compared to the other doses. Since or study of mineral nitrogen as at the cost of plant uptake, this may reflect better utilization of available nitrogen at this dose.



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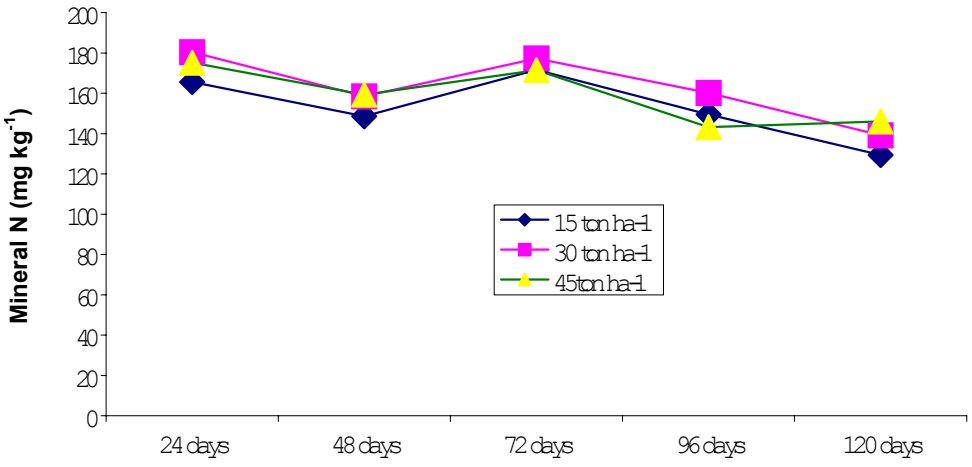

(b)

Figure 5 (a) Periodical changes in mineral N as per modes, (b) Periodical changes in mineral N as per doses.

Conclusion

In such a dynamic condition of soil where mineralisation is accompanied by immobilization as well as several other processes of nitrogen loss, the proper management of FYM becomes imperative. FYM can be supplemented by urea for the better utilization of N by wheat. In our highly weathered tropical soil the effect of 30 t ha^{-1} FYM when combined with urea at 120 kg N ha^{-1} released the maximum amount of available N with higher nitrification.

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