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# Nitrogen management, crop yield and quality and nitrate leaching risk in intensive vegetable production in Morogoro Tanzania

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In Tanzania, commercial vegetable production is practiced in urban areas and is of great importance for vegetable supply to the urban population. Cultivation is generally intensive, paying special attention to improved seeds, watering and fertilization for maximizing yield. On the other hand, leafy vegetables are fast growing annual crops requiring intensive application of fertilizers. This practice often leads to over fertilization, in particular N being the most often the limiting nutrient in crop production. Subsequently, high N supply makes the leafy vegetables susceptible to nitrate accumulation. Although the nitrate in itself is generally considered to be of low toxicity to the human body, its reduction to nitrite and conversion to nitrosamines by reacting with amines and amides make it toxic. In addition, agricultural activities are linked to environment pollution, making fertilization practices an important environmental issue.

This study aimed at using Morogoro municipality as a model to assess the vegetable farming practices utilizing animal manures as nutrient sources on soil fertility status, vegetable yield, nitrate accumulation in leafy vegetable crops, mineral N in soil profile and nitrate delivery to the water catchments in Tanzania. Soil fertility management practices investigation was attained through an interview of forty seven households. To investigate soil fertility status, soil samples were collected from 55 vegetable fields that are fertilized with manure and analysed for selected fertility indicators. Also N mineralization potential of chicken manure (CHM)/cattle manure (CAM) applied to soil surface or incorporated into soil as practiced by farmers in the study area was studied during a 56 days laboratory incubation experiment under controlled conditions. The influence of N source, N levels and harvesting dates on chinese cabbage and amaranthus yields, agronomic N use efficiency, nitrate concentrations and the patterns of mineral N in soils under field conditions were determined. This was done based on vegetable management practices by farmers. Two N levels from chicken manure (CHM) and cattle manure (CAM) per vegetable were

used i.e. 200 and 300 kg N $ha^{-1}$ for chinese cabbage and 170 and 250 kg N $ha^{-1}$ for amaranthus. To determine nitrate N leaching risk by residual mineral N, soil samples for $NH_4^+$-N and $NO_3^-$- N analysis were collected over 0-20, 20-40, 40-60 and 60-80 cm depth from fallow experimental plots where chinese cabbage was a preceding crop. In addition, water samples for $NO_3^-$- N analysis were collected from an irrigation well, Mindu dam and three rivers which run through Morogoro municipality to determine the contribution of farmers' current vegetable management practices on nitrate concentrations in water.

Both chinese cabbage and amaranthus were identified as the most popular leaf vegetables cultivated and consumed. The main sources of manure N were identified as chicken manure (CHM) and cattle manure (CAM). Hundred percent and 98% of the surveyed fields had medium to high soil organic carbon and total nitrogen, respectively. This implies that the soils are suitable for vegetable production. The amount of manure N applied by farmers ranged from 172 – 517 and 50 – 289 kg $ha^{-1}$ for chinese cabbage and amaranthus, respectively. The general observation was that higher fresh matter and dry matter was observed in plants fertilized by incorporating manure into soil than that broadcasted to the soil surface. However, there was no proportional relationship between N levels applied by farmers and the yields. The average measured nitrate concentrations in vegetables were higher in chinese cabbage and lower in amaranthus compared to the safety standard of nitrate for vegetables. The dependence of nitrate concentrations in vegetables on N levels was confirmed by the positive relationship between the two.

Laboratory incubation results showed that the N mineralization rate by chicken manure was higher than CAM. Soil surface applied manure caused higher total $NO_3^-$-N concentration in soil than manure incorporated into soil. The high initial net mineralization rates of surface applied or incorporated CHM, and surface applied CAM suggests that manure application one week before sowing as some of the farmers do might lead to losses of mineralized N. Thus, for maximum N utilization by short cropping cycle crops, CHM manure incorporated into soil at sowing time is recommended.

By field experiment, an increase in N rate from 200 to 300 kg N $ha^{-1}$ and 170 to 250 kg N $ha^{-1}$ caused a slight but not significant increase of commercial yield of chinese cabbage and amaranthus, respectively. The nitrate concentrations in chinese cabbage and amaranthus were markedly and significantly increased by manure N compared to unfertilized vegetables. Moreover, high N levels resulted into low agronomical nitrogen use efficiency (ANE) and higher nitrate concentrations in vegetables than low nitrogen levels. Thus, N levels can be reduced to 200 and 170 kg N $ha^{-1}$ for chinese cabbage and amaranthus, respectively, without significantly affecting the yields, while increasing ANE and improving crop quality. A positive correlation between nitrate concentration in the vegetables and nitrate-N in the soil was observed. Results showed that, both soil $NH_4^-$-N and $NO_3^-$-N in chinese cabbage and amaranthus plots were increased with increasing N application rates. Due to nutritional factors, harvesting time influenced nitrate accumulation. This is evidenced by much lower nitrate concentration in the vegetables following decreased nitrate N in the soil at second harvest.

Mineral nitrogen in the soil profile of fallow plots increased with increasing manure N levels. Nitrate-N concentration increased with increasing soil depth during high net precipitation, indicating its susceptibility to leaching. The nitrate concentrations in surface water were lower than the WHO limits for drinking water while it was higher in irrigation well. The presence of high nitrate concentrations in surface water at vegetable fields sampling locations indicates that the vegetable farms along the rivers have a negative impact on the water quality with regard to nitrate concentrations. An increased nitrate-N concentration in water with increasing precipitation could be attributed largely to soil $NO_3^-$-N that flushed into the dam and rivers by run-off and into groundwater by leaching. The excess N in the soil profile, after harvesting, was the immediate cause of the observed $NO_3^-$-N concentrations in water. Thus, the surest way of avoiding such nitrate losses is to ensure that there is as little N as possible in the soil at any time.

This study demonstrated that N levels applied by farmers are in excess of vegetable requirements, consequently, causing contamination which leads to increased risks to the environment and human health. Therefore, vegetable farmers should be guided to optimize yield and profit with minimal environmental pollution and low $NO_3^-$ concentration levels in vegetables.