Ammonia and Nitrate Concentrations in Three Varieties of Field-Grown Turnips, Brassica rapa

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INTRODUCTION

There are legal limits of nitrate (NO_3-) and nitrite (NO_2-) in food. They are hazardous chemical that can accumulate in vegetables and fruits from application of fertilizers. Large-scale animal operating production systems yields huge amounts of manure rich in NO_3- which seeps into groundwater and accumulate in edible plants grown in animal manures amended soils. Therefore, keeping NO_3- concentrations below legal limits is a challenge for farmers and health authorities. We investigated the impact of animal manures used as organic fertilizers on the concentrations of NH_3 and NO_3- in three varieties of turnips, *Brassica rapa*.

Vegetables receive relatively high rates of N fertilizers which adds to the problem of NO_3-poisoning due to vegetables ability to accumulate NO_3- at high levels (Lorenz 1978). Quantification of NO_3- on a fresh-weight basis enables a better comparison of the NO_3- content of vegetables since most vegetables are consumed fresh. Bacteria in the mouth and gut convert NO_3- to NO_2- by salivary or gastrointestinal reduction, then NO_2-reacts with hemoglobin to produce methemoglobin, which becomes no longer able to carry oxygen (Katan, 2009). Salehzadeh et al. (2020) also reported that during various processes in the body, NO_3- are converted to NO_2- which causes various diseases, such as blue baby syndrome and cancer.

Accordingly, the intend of this investigation was to identify turnips varieties and/or animal manures that have the potential for accumulating high levels of NO_3- in turnip roots. The objectives were to: 1)-assess the overall impact of six soil amendments (SA): sewage sludge SS, horse manure HM, chicken manure CM, vermicompost Vermi, commercial organic fertilizer Nature Safe 10N-2P-8K) (Org), inorganic fertilizer (19N-19P-19K) (Inorg), and no-amendment (NM native soil) on NH3 and NO3- concentrations in turnip roots. 2)-screen three varieties of turnips, Brassica rapa (Purple Top White Globe, Scarlet Queen Red and Tokyo Cross) for their accumulation of NH_3 and NO_3-.

MATERIALS AND METHODS

The field study included a randomized complete block design (RCBD) of 63 plots (3 turnip varieties × 7 treatments × 3 replicates) of 4 ft. (1.22 m) length and 3 ft. (0.91 m) width. The soil treatments included six soil amendments (Figure 1) and NM used as control treatment. The native soil in the experimental plots was a Bluegrass-Maury Silty Loam (2.2% organic matter, pH 6.2) of 56% silt, 38% clay, and 6% sand. Three varieties of turnips, *Brassica rapa* were var. Purple Top White Globe (PTWG), var. Scarlet Queen Red (SQR), and var. Tokyo Cross (TC) (Figure 2). NH_4 + and NO_3 – in fresh turnip roots were extracted using 80% ethanol and determined using a Fisher brand XL500 Benchtop Meter equipped with Orion High-Performance ammonia and nitrate electrodes.

Fig. 1 Natural appearance of (A) sewage sludge, (B) chicken manure, (C) organic fertilizer, Nature Safe NPK (10:2:8), (D) inorganic fertilizer (NPK 19:19:19), (E) horse manure, and (F) vermicompost amendments used for growing turnip under field conditions at Fayette County, Kentucky, USA.

Fig. 2 Three varieties of turnip, Brassica rapa grown at Fayette County, Kentucky, USA.

RESULTS AND DISCUSSION

There were significant differences in NH_3 and NO_3 – content among the three turnip varieties tested. Figure 3 shows that the concentrations of NH_3 averaged 20.2, 12.8, and 8.9 µg g-1 fresh turnip roots, whereas NO3 – values averaged 107.6, 64.1, and 62.9 µg g^{-1} fresh turnip roots in varieties SQR, PTWG, and TC, respectively. Results also showed that Vermi, Inorg, CM, HM, and Org amended soil significantly increased NO_3 – concentrations in turnip roots compared to the roots of plants grown in the control treatment (Fig. 4).

Human lethal doses of 67-833 mg NO_3- ion kg^{-1} body weight (bw) have been reported. Toxic doses with methaemoglobin formation as a criterion for toxicity - ranged from 33-350 mg NO_3- ion kg^{-1} bw (Speijers, 1996a). The oral lethal dose to humans was estimated to vary from 33 to 250 mg NO_2– ion kg^{-1} bw. Doses of 1 to 8.3 mg NO_2- ion kg^{-1} bw gave rise to induction of methaemoglobinaemia in which the hemoglobin iron (Fe) is oxidized and cannot reversibly bind oxygen (Speijers, 1996b).

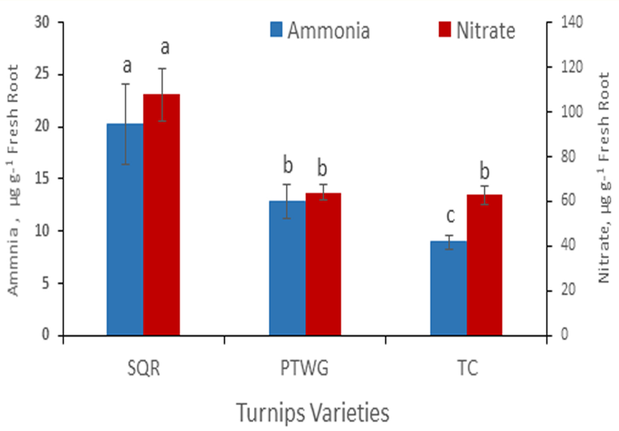

Fig. 3 Variability in the concentrations of ammonia and nitrates of three varieties of turnips: Scarlet Queen Red (SQR), Purple Top White Globe (PTWG), and Tokyo Cross (TC) in root, regardless of soil treatments. Statistical comparisons were carried out among varieties. Bars accompanied by different letter indicate significant differences (P< 0.05) using Duncan's multiple range test (SAS Institute, 2016).

Accordingly, variety TC has the lowest level of NH_3 and NO_3 – content compared to SQR variety. A person with an average weight of 70 kg should not consume more than 255.5 mg of NO_3- daily (Salehzadeh et al. 2020). The acceptable daily intake (ADI) for NO_3 – was assigned as 0-3.7 mg kg^{-1} body weight (bw) expressed as NO_3 – ion (Boink and Speijers, 2001) or 277 mg NO_3 per person of 75 kg average weight. Considering that the concentration of NO_3- in variety TC is 62.9 µg g^{-1} fresh root weight, therefore a person with an average weight of 75 kg consuming 100 g of TC would have 0.08 mg kg^{-1} bw. These values would be 0.14 and 0.09 mg kg^{-1} bw four varieties SQR and PTWG, respectively.

Accordingly, the ADI is acceptable and none of the three varieties tested could cause any NO_3 –adverse effects on average human consumption. Similarly, consuming turnip roots grown in any of the animal manures tested do not represent any hazardous issues (Figure 4).

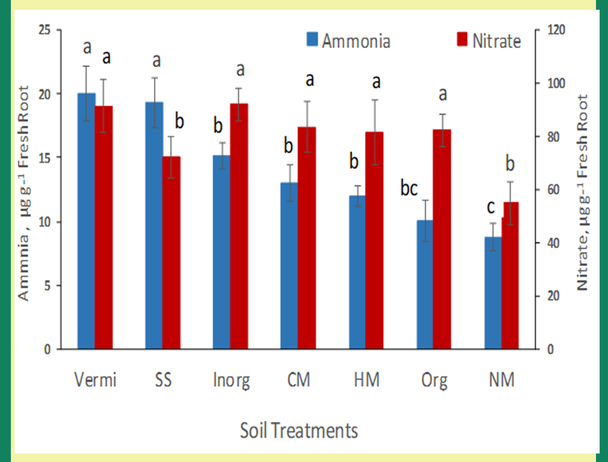

Fig. 4 Concentrations of ammonia and nitrates in turnips roots of plants grown under seven soil treatments, regardless of turnips variety. Statistical comparisons were carried out among soil treatments. Bars accompanied by different letter indicate significant differences (P< 0.05) using Duncan's multiple range test (SAS Institute, 2016).

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