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Municipal solid waste compost increased yield and decreased nitrate amount of broccoli

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Abstract

A study of the nitrate uptake of Broccoli (*Brassica oleraceae* var. *italica*), grown with different amount of municipal solid waste compost (MSWC) was conducted in 2006 on open field at the University of Guilan, Rasht, Iran. The experiment was arranged in complete randomized block design with four treatments (0, 25, 50 and 100 Mg. ha^{-1} MSWC) and four replications. The results revealed that under prevailing local conditions, total yield of the broccoli was higher when fertilized with MSWC and low when compost was not applied to the planted area. The plants with the highest compost application (100 Mg ha^{-1}) gave significantly highest yield at 37.03 Mg ha^{-1} which was statistically different from other treatments. The significant differences were found also on marketable yield with an exception at lowest compost treatment. The lowest amount of nitrate (0.197 % in DM) in broccoli edible part was with application of 50 Mg. ha^{-1} compost.

Key words: Broccoli, municipal solid waste compost, nitrate, yield, quality.

Introduction

Nitrate occurs in many foods and drinking water, but vegetables are by far the main sources. Excessive use of nitrogen (N) fertilizers contributes to the accumulation of nitrate (NO_3^-) in soil and vegetable crops. The toxicity of NO_3^- in humans is a result of the reduction of NO_3^- to nitrite. By reacting with hemoglobin, NO_3^- forms methemoglobin, a substance that does not bind and transport oxygen to tissues. In many developing countries, the major increases in N use by agriculture during the last decades have inevitably been associated with large rises in N losses as NO_3^- in drainage water and higher NO_3^- content in arable and horticultural plants (Hudak, 2000; Nolan, 2001). Fertilizer consumption in developing countries is expected to continue to increase at a rate of about 2.6% per annum (Singh *et al.*, 1995).

Land application of wastes is becoming increasingly more popular as a means of disposal, treatment, nutrient cycling, irrigation, and groundwater recharge in many areas of the world (Cameron *et al.*, 1996). The nutrient contents in most effluents and wastes can be employed as fertilizers for agricultural production, if properly used. The use of composts in agricultural soils is a widespread practice and the positive effects on soil and vegetables are known from numerous studies (Stopes *et al.*, 1989; Thy and Buntha, 2005; Peyvast and Abbassi, 2006). Vegetable production would thus seem to be the logical target for studies to demonstrate the advantages of the different kinds of organic fertilizers (Peyvast *et al.*, 2007, 2008a, 2008b). Their recycling into soils with low amount of organic matter, which is widespread in these regions, could benefit soil structure and long term fertility, and is also an alternative to inorganic fertilizers in the growing organic vegetable production business (Peyvast *et al.*, 2007). If appropriate fertilizers are not applied, physiological disorders are apt to occur (Takahashi, 1981). The overall result has been a decline of fertility, imbalance in soil nutrients and low crop yields. For these reasons, most farmers like to use chemical fertilizers because they are easy to transport, are used efficiently for growth of the plants and give high yields, but it has been observed that with succeeding crops, the quantity of chemical fertilizer has to be increased apparently because of declining soil fertility. In contrast, organic fertilizer have beneficial effects on soil structure and nutrient availability, help to maintain yield and quality of the product and are less costly than chemical fertilizers (Thy and Buntha, 2005). Intensive production for crops such as spinach, parsley, lettuce, green and broad been occurs in North of Iran, which is a major supplier of these vegetables nationwide (Peyvast, 2006). The mild climate and the high input of fertilizers allow the production of two or three crops per year. Traditional practice in Iran is to use cattle manure although the quantity is not usually enough for the available crop areas. Alternative ways to improve the availability of organic manure seems to use compost from waste which is now available from a new compost manufactory in Guilan Province located in North of Iran. However, there have been few attempts to study the effect of composts on nitrate accumulation by vegetables.

The concentration of nitrates in the edible parts of vegetables are regulated by the European Commission Regulation No 563/2002 which has set upper limits in order to protect consumers from potential toxicological risks following the consumption of nitrate-rich foods (Maynard *et al.*, 1976; Walker, 1990; Bruning Fann and Kaneene, 1993).

The main objective of this research is to study the effect of municipal solid waste compost (MSWC) on the yield and nitrates accumulation in broccoli to estimate beneficial effect from this type of organic fertilizer.

Materials and methods

The study was conducted to assess the yield and nitrate content of broccoli (*Brassica oleracea* var. *Italica*) grown in the field during 2006 at the University of Guilan in Rasht, Iran. Four

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different levels (0, 25, 50, and 100 Mg ha^{-1}) of municipal solid waste compost purchased from Bazyaft Zobaleh Co., Rasht, Iran and were supplied to the soil before planting. The physical and chemical characteristics of MSWC were measured (Table 1). Soil analyses prior starting the experiment also is shown in Table 1. The sandy loam soil used in these experiments was well drained with a total Kjeldhal N content of 1.80 g kg^{-1} (Table 2). Seeds of cv. `Embassy` (Asgrow Seed Company) were sown in plastic trays, tinned in plastic bags, when the seedlings became the first true leaf, and transplanted, when they had 2 to 4 true leaves. Plants were spaced at 50 × 50 cm^2. Water was supplied whenever necessary. All samples were collected at the stage when they were being harvested for market. Samples were transferred to the laboratory as soon as possible. Only edible portions were prepared for analysis, and roots of broccoli were discarded. The data gathered were on nitrate amount of leaves, peduncles and flowers. Samples were washed successively with tap water and distilled water. Plant materials were oven dried for 24 h at 65°C and ground to pass through a 1 mm sieve. Nitrate content in plants was measured at 410 nm by a Hitachi U-2001 spectrophotometer following the nitration by salicylic acid method described by Cataldo *et al.* (1975). Yield was calculated from all harvests. All data were subjected to a one-way analysis of variance to test for Duncan's multiple range tests. All analyses were performed using SAS statistical package (Ver. 6.04, SAS, Inc., Cary, N.C.).

Result and discussion

Plants treated with 100 Mg ha^{-1} of compost had the highest yield (37.03 Mg ha^{-1}) (Table 2). Similar results were reported previously for other crops (Bazzoffi *et al.*, 1998; Mkhabela and Warman, 2005; Peyvast and Abbassi, 2006; Peyvast *et al.*, 2007). For broccoli, this amount of organic matter was needed to provide a suitable balance in soil nutrition and increase broccoli yield. Significant differences were also found on broccoli nitrate between treatments. The highest nitrate amount (0.479 %in DM) in edible part of broccoli was obtained from treatment without compost (Table 2).

Accumulation of nitrates in vegetables has been shown to be affected by the soil texture and the source of fertilizer-N (Scaife *et al.*, 1986; Gianquinto *et al.*, 1992; Gunes *et al.*, 1995), the NH_4-N-to-NO_3-N fertilizer-N ratio (McCall and Willumsen, 1998), the timing of fertilizer-N release (Tesi and Lenzi, 1998), the light intensity and duration (Behr and Wiebe, 1992; Chadjaa *et al.*, 1999; Drews *et al.*, 1995; Gaudreau *et al.*, 1995), crop season (Gianquinto *et al.*, 1992), and vegetables type and cultivar (Blom Zandstra and Eenink, 1986; Siomos, 2000., Escobar-Gutierrez *et al.*, 2002)

In view of health reasons, absorption of nitrate from vegetables to the human nutrition should be decreased. Nitrate is for all plants an important nitrogen sources and it is very mobile in plants. Phloem and xylem have the highest nitrate amounts (Krug, 1986). Reduced nitrate accumulation results have been reported for farm yard manure fertilized lettuce for one crop season only (Gianquinto *et al.*, 1992; Stopes *et al.*, 1989) and for three crops seasons (Pavlou *et al.*, 2007). Our results also showed that MSWC applications were particularly safe in terms of nitrate accumulation in broccoli (Tables 2).

Table 2. Effect of MSWC on nitrate accumulation and yield (fresh weight) in broccoli

MSWC (Mg ha^{-1})	Peduncle (% DM)	Leaves (% DM)	Flower (% DM)	Yield (Mg ha^{-1})
0	0.296^{a}	0.613^{az}	0.479^{b}	11.39^{c}
25	0.267^{a}	0.630^{a}	0.382^{b}	15.01^{bc}
50	0.235^{a}	0.640^{a}	0.197^{a}	28.29^{ab}
100	0.275^{a}	0.679^{a}	0.323^{ab}	37.03^{a}

^{z} values in a column followed by the same letter are not significantly different, $P \leq 0.01$, Duncan multiple range test.

The respective organic fertilization treatments (MSWC) did differ significantly from the control by broccoli whereas the control resulted in the highest nitrate accumulation (Table 2) so that the 25, 50 and 100 t ha^{-1} MSWC brought 9.8, 20.6 and 7.1% lower nitrate accumulation compared to control, respectively. Accumulation of nitrates results from an imbalance between the uptake and translocation of nitrates by the xylem and the reduction of these nitrates to ammonia which is subsequently rapidly incorporated into amino acids (Maynard *et al.*, 1976). However, the internal nitrate concentration in the plant seems to be controlled by a self-regulatory mechanism exerted either by negative feedback control on the net nitrate uptake rate or by passive control on nitrate efflux (Cardenas Navarro *et al.*, 1998). The viewpoint that non-structural carbohydrates and nitrates have a complementary role in maintaining cell tugor (Blom Zandstra and Lampe, 1985; Behr and Wiebe, 1988) offers a credible model for the plant nitrate regulation mechanism suggesting the accumulation of nitrates in the vacuole as an alternative osmoticum under low radiation conditions (Blom-Zandstra, 1989; Buwalda and Warmenhoven, 1999).

No significant differences were found by leaves and peduncles between the treatments. Our results showed that an accumulation of nitrates in broccoli can be affected by source of municipal solid waste compost and probably its effect on soil structure as mentioned by Scaife *et al.* (1986), Gianquinto *et al.* (1992) and Gunes *et al.* (1995). However, there was no significant tendency by tested treatments. This finding is similar to the results by Blom-Zandstra and Eenink (1986), Siomos (2000) and Escobar-Gutierrez *et al.* (2002).

From these results, it can be concluded that, in general, municipal solid waste compost didn't affect nitrate accumulation on the broccoli. Therefore, in Iran, that ranks first in soil erosion in the Middle East (Shahvali and Abedi, 2006), an application of this compost can be recommended for broccoli in every 2-3 years to reduce this important problem. On the other hand, by reducing

Table 1. Physical and chemical characteristics of MSWC and soil used in the experiment

	pH	EC (dS m^{-1})	Total Porosity (% by vol.)	Total N (%)	Total C (%)	C/N (%)	P (mg kg^{-1})	K (mg kg^{-1})	Ca (mg kg^{-1})	Mg (mg kg^{-1})
MSWC	7.1	5.2	55.5	2.10	33.8	13.0	10.2	6.8	53.2	3.3
Soil	6.8	0.08	_	2.70	1.3	0.48	68	110	12	_

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application of chemical fertilizer in farm lands, the saline and sodium problems which are sometimes the result of excessive chemical fertilization and irrigation can be solved.

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