

# Nitrogen uptake rate with compost application and its effect on the sugar content of sweet corn (*Zea mays* L.)

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## Abstract

A series of field experiments was conducted to test whether nitrogen (N) similarly affected crop quality when supplied in compost or in chemical fertilizer. N was supplied to sweet corn via either compost or chemical fertilizer, and soil nitrate-N, N uptake and the sugar content of sweet corn were investigated. Soil nitrate-N integrated from the date of application to harvest and the amount of N uptake by sweet corn were positively correlated irrespective of the N source. This finding may indicate that the amount of N uptake was determined primarily by the amount of nitrate-N supplied by the compost in addition to the chemical fertilizer. The growth of early stage was accelerated by the application of compost, and the date of maximum sugar content became earlier with increased compost application. The relationship between sugar content and N uptake was the same irrespective of the N source when compared at the time of maximum sugar content for each treatment. So we concluded that the sugar content was determined by the amount of N uptake regardless of the N source (compost application or chemical fertilizer application).

## Key Words

Compost, crop quality, nitrogen uptake, soil nitrate nitrogen, sugar content, sweet corn

## Introduction

The effect of organic matter application on crop quality has been discussed from various perspectives. However, if the amount of N applied to crops via compost or chemical fertilizer is equal, it remains unclear whether the effect on the crop quality is the same. We conducted a series of field experiments to test whether N supplied as compost or as chemical fertilizer similarly affected the sugar content of sweet corn. First, the nitrate-N releasing patterns from applied compost and from chemical fertilizer in the soil (0-15 cm) were compared, and it was discussed whether the amount of N uptake was explained by the amount of N released during the growing season. It was then examined whether crop quality was determined by the amount of N uptake regardless of the N source.

## Methods

### Experiment 1

Field experiments were conducted in the fields of the National Agricultural Research Center for Hokkaido region in Sapporo from 2006 to 2007 (Takebe *et al.*, 2010). The soil type in the fields is Melanaquands. Sweet corn (variety: Ohisamacorn) was supplied with N in the form of compost or chemical fertilizer. Cow compost (C/N=8.4-10.4, N=28-32 g kg<sup>-1</sup> DW) was applied at rates of 0, 2, 4 kg m<sup>-2</sup> and chemical fertilizer N was applied as ammonium sulfate at rates of 0 and 12 g N m<sup>-2</sup> at each compost level. The grain was sampled once in 2006 and 3 times in 2007 at the harvest stage, and sugar content was analysed by the enzymatic method.

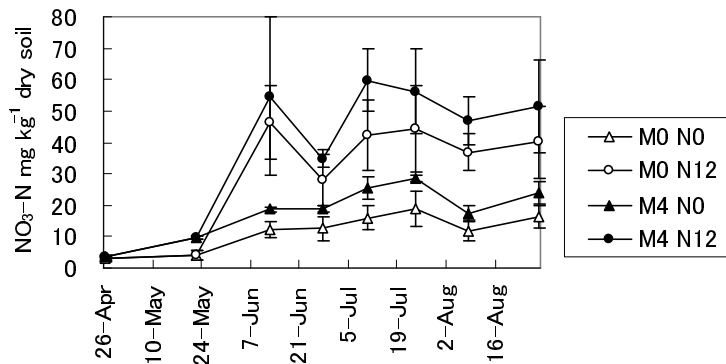
### Experiment 2

A field experiment was conducted at Yawara experimental station of the National Agricultural Research Center in Ibaraki on 2008. The soil in the field is classified as an Andisol (Hydric Hapludand) according to the USDA soil classification system. Sweet corn (variety: Petercorn) was cultivated in plots treated with swine compost (N=44 g kg<sup>-1</sup> dry matter) only, polyolefin-coated urea only for N, ammonium sulfate only for N, and no fertilizer, every plots treated identically for 15 years. The chemical fertilizers were applied at rate of 16 g N m<sup>-2</sup> and swine compost was applied at rate of 32 g N m<sup>-2</sup> according as the estimated mineralization rate (50 %) (Maeda *et al.*, 2008). After 15 years, the available P (Truog-P) became high level (524 mg kg<sup>-1</sup> dry soil) in the plot of swine compost compared with that in the chemical fertilizers (43-47 mg kg<sup>-1</sup> dry soil). The grain was sampled 4 times at the harvest stage, and sugar content was analysed by the enzymatic method.

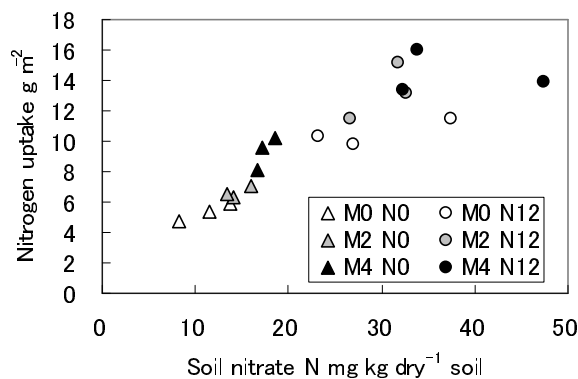
## Results

In experiment 1, soil nitrate-N increased slowly from the date of compost application in the plots that

received only compost, but increased rapidly after the application of chemical fertilizers. In a bare fallow area, the average value of soil nitrate-N (in the plow layer) throughout the plant growing season was 22 mg kg<sup>-1</sup> dry soil in the plot treated with 4 kg m<sup>-2</sup> compost, 40 mg kg<sup>-1</sup> dry soil in the plot treated with 12 g N m<sup>-2</sup> chemical fertilizer, and 51 mg kg<sup>-1</sup> dry soil in the plot treated with 4 kg m<sup>-2</sup> compost + 12 g N m<sup>-2</sup> chemical fertilizer (Figure 1). Soil nitrate-N was integrated and divided by the number of days from the date of application to harvest and compared with the amount of N uptake by sweet corn; these quantities were positively correlated irrespective of the N source (Figure 2). This may indicate that the amount of N uptake was determined primarily by the amount of nitrate-N supplied by the compost in addition to chemical fertilizer.

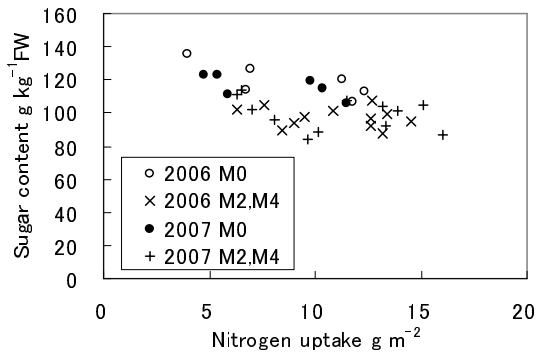


**Figure 1.** Change of nitrate-N in the soil (bare fallow area). “M0 N0” means that 0 kg m<sup>-2</sup> of compost and 0 g N m<sup>-2</sup> of chemical fertilizer was applied to the plot. Bars represent the standard deviation.

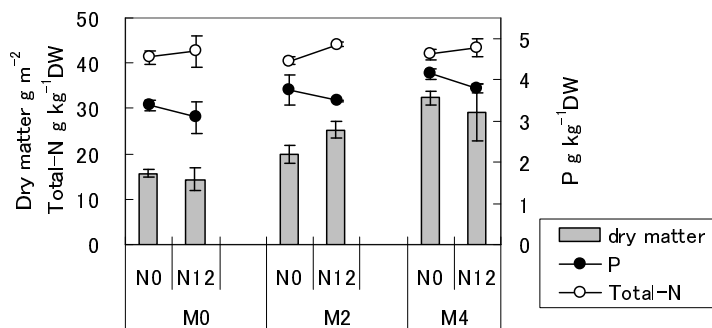


**Figure 2.** Relation between nitrate-N (integrated and divided by the number of days of compost application to harvest) in a bare fallow area and N uptake of sweet corn. “M0 N0” means that 0 kg m<sup>-2</sup> of compost and 0 g N m<sup>-2</sup> of chemical fertilizer were applied to the plot. The relationship between nitrate-N and N uptake is significant (n=18, r=0.885, p<0.01).

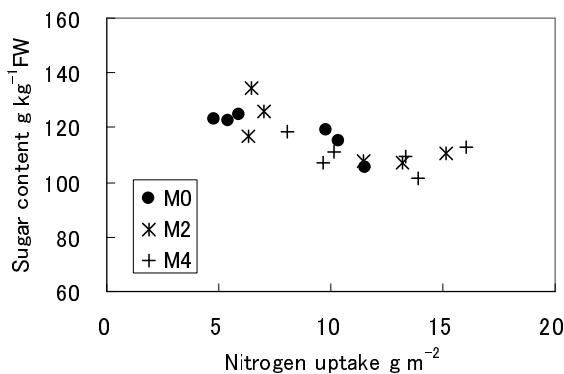
The sugar content of sweet corn decreased with increased N uptake. Plant products of all plots were harvested on the same day; those products that had received compost as the N source had lower sugar content than those that received chemical fertilizer only, even though their N uptake was the same (Figure 3). However, it would be better to compare the sugar content at the suitable harvest time, which is the time when the grain had the highest sugar content for sweet corn. The growth of early stage was accelerated by the application of compost, and the acceleration would be dependent on the phosphorus supply from the compost in early spring (Figure 4). As a result, the date of maximum sugar content became earlier with increased compost application. The relationship between sugar content and N uptake was the same irrespective of the N source when compared at the suitable harvest time for each treatment (Figure 5). We concluded that the sugar content was determined by the amount of N uptake regardless of the N source (compost application or chemical fertilizer application).



**Figure 3. Relationship between sugar content and N uptake of sweet corn (comparison at same harvest day). “M0” means that 0 kg m<sup>-2</sup> of compost was applied to the plot. The difference between compost application (M2, M4) and non-application (M0) is significant by the analysis of covariance.**



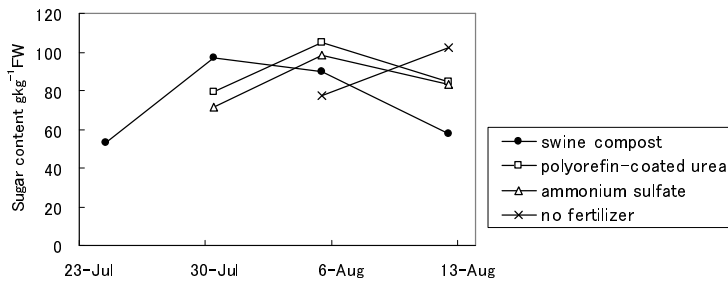
**Figure 4. Dry matter, Total-N, and P contents of sweet corn in the early growing stage (June 26, 2007). “M0” and “N0” mean that 0 kg m<sup>-2</sup> of compost and 0 g N m<sup>-2</sup> of chemical fertilizer were applied to the plot, respectively. Bars represent the standard deviation.**



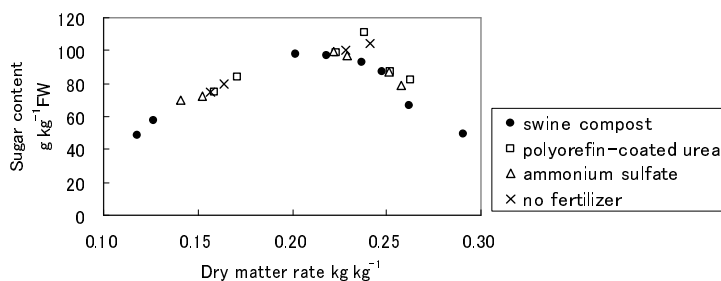
**Figure 5. Relationship between sugar content and nitrogen uptake of sweet corn (at the time of maximum sugar content for each treatment, 2007). “M0” means that 0 kg m<sup>-2</sup> of compost was applied to the plot. The difference between compost application (M2, M4) and non-application (M0) is not significant by the analysis of covariance.**

In Experiment 2, sweet corn in the plot treated with compost arrived at the silking stage earlier than the plot treated with chemical fertilizers, and the sugar content reached the maximum value on July 30 in the plot with compost and on August 5 in the plots with chemical fertilizers (Figure 6). The acceleration of growth with the compost would be dependent on the phosphorous supply, just as it was in experiment 1. The maximum values of the sugar content were almost the same among the different plots, so it is considered that the sugar content would not be influenced by whether the N source was compost or chemical fertilizer.

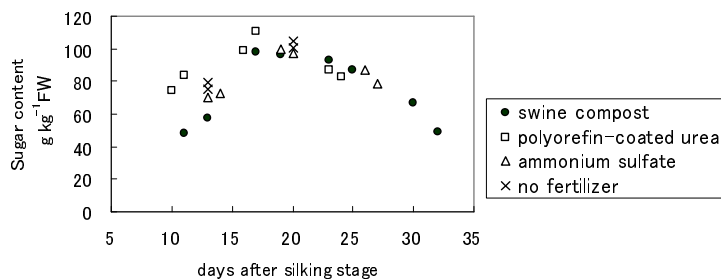
The sugar content increased with increased dry matter rate until it became about 0.24 kg kg<sup>-1</sup> (Figure 7). The sugar content also increased with the number of days after the silking stage up to 17-18 days, then decreased (Figure 8). The sugar content was related more clearly with the dry matter rate when in the increasing stage and was related more clearly with the number of days after the silking stage when in the decreasing stage. It is considered that the sugar content of sweet corn increased with the accumulation of dry matter in grain, then decreased with the change from sugar to carbohydrate.



**Figure 6. Change of sugar content of sweet corn (Yawara field).**



**Figure 7. Relation between sugar content and dry matter rate of grain.**



**Figure 8. Relation between sugar content and days after silking stage.**

## Conclusion

The amount of N uptake was determined primarily by the amount of nitrate N supplied by the compost in addition to chemical fertilizer. The sugar content was determined by the amount of nitrogen uptake regardless of the N source, and would not be influenced by whether the N source was compost or chemical fertilizer. The sugar content increased with increased dry matter rate until it became about 0.24 kg kg<sup>-1</sup>, then decreased with the number of days after the silking stage.

## References

- Takebe M, Okazaki K, Oka N, Karasawa T (2010) Nitrogen uptake rate with compost application and its effect on the quality of Japanese radish (*Raphanus sativus* L.) and sweet corn (*Zea mays* L.). *Japanese Journal of Soil Science and Plant Nutrition* **81**, 23-30.
- Maeda M, Ihara H, Ota T (2008) Deep-soil adsorption of nitrate in a Japanese andisol in response to different nitrogen sources. *Soil & Water Management & conservation* **72**, 702-710.