Nitrate accumulation in Chinese mustard (*Brassica campestris* cv. Marubakomatsuna) grown under different light conditions

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The influence on nitrate accumulation in vegetables such as spinach and chard, by concn of applied nitrogen, light intensity and temperature during the growth period, has been reported[1-4]. The primary factors of influence on nitrate accumulation and the nitrate metabolism are both looked upon with interest from horticultural and plant nutritional stand points. Furthermore, a suspicion that nitrosamines produced from amine and nitrate reduced from nitrate by coliform bacteria in human body, can be cancerous, has made the accumulation of nitrate in vegetables a serious problem[5)6)].

Brassica campestris cv. Marubakomatsuna is a common green in Japan, young foliage of which is boiled or pickled before eaten. 'Marubakomatsuna' is one of the vegetables, in which content of nitrate is often high. The aim of the present experiment using this plant has been to study the influence of light on nitrate accumulation in plant tissues.

Effect of light intensity and concn cf applied NO_3-N on the content of NO_3-N in the plant: Sub-soil with very little nitrogen and vermiculite mixed at a ratio of 5:1 was filled in a 12 cm polyethylene pot. Seeds of *Brassica campestris* cv. Marubakomatsuna were planted in a glasshouse (25% shading rate) at the end of March. Following emergence, culture solution shown in table 1, was applied every other day until it seeped out from the bottom of the pot. At the developmental stage of the 5 th true leaf, the following 3 shading treatments were practiced in the glasshouse; no shading (shading rate 0%), 50% shading (shaded by one layer of cheesecloth) and 75% shading (two layers of cheesecloth). Each plot was then, divided into 3 sub-plots of different rate of applied NO_3-N (8, 16 and 32 mM NO_3-N), thus making a total of 9 treatments. Nutrient solution was applied every day after the 5 th true leaf stage. In case NO_3-N concn the nutrient solution was over 16 mM, $NaNO_3$ was added to attain the level. Nitrate analysis was done at the 10-12 th true leaf stage, harvesting plants for analysis between 12 a. m. and 2 p. m. plants were dissected into blades and perioles of outer and inner leaves and roots. The outer leaves, in this case, consisted of the two outer leaves (the two outermost leaves removed); the inner leaves the inner two leaves (the currently opening leaf removed). Petioles included midribs. Five grams of each plant part was homogenized with 100 ml of 11.2 mM Ag_2SO_4 solution and analyzed for NO_3-N concn with Orion Model 901 ion meter according

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Table 1. Composition in mg per ℓ of the nutrient solution.

Macro elements	mg/ℓ	Micro elements	mg/ℓ
$Ca(NO_3)_2 \cdot 4H_2O$	475	NaFeEDTA	25.0
KNO_3	405	H_3BO_3	3.0
$MgSO_4 \cdot 7H_2O$	250	$MnSO_4 \cdot 4H_2O$	2.0
$NH_4H_2PO_4$	78	$ZnSO_4 \cdot 7H_2O$	0.22
		$CuSO_4 \cdot 5H_2O$	0.05
		Na_2MoO_4	0.02

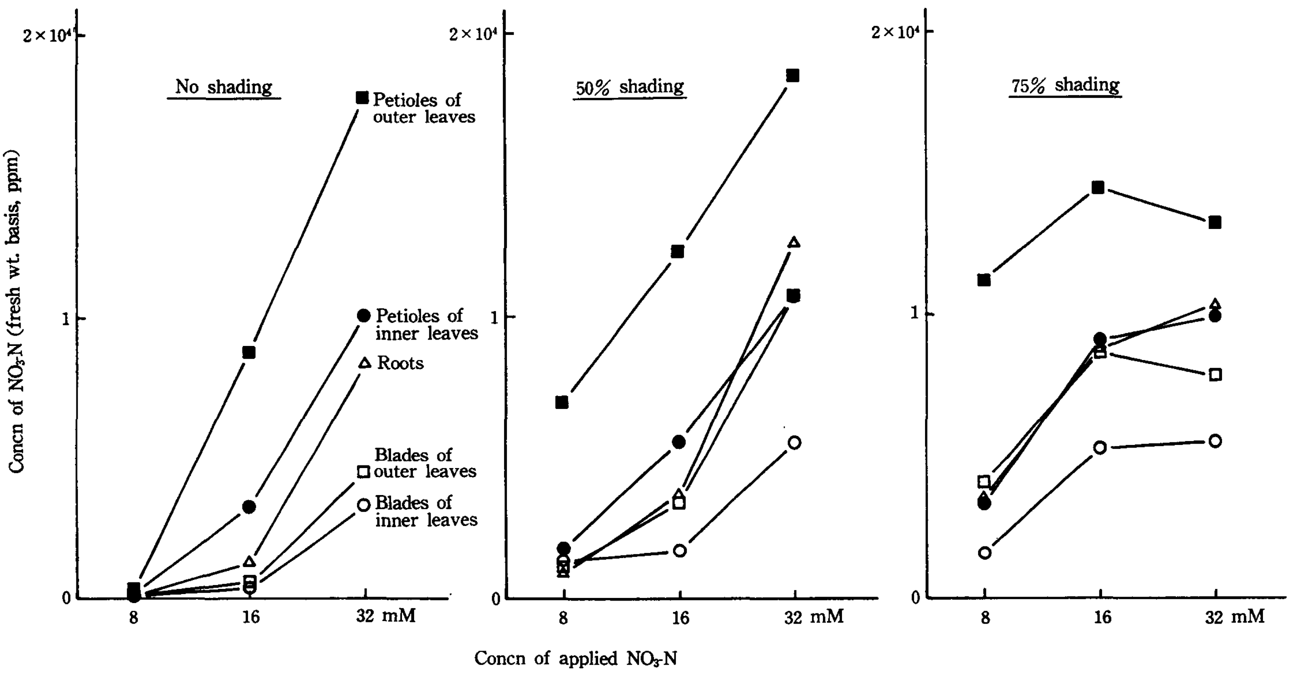

Fig. 1. Effects of light intensity and concn of applied NO_3-N on the concn of NO_3-N in plant parts.

to the method employed by McCaslin and Franklin[1].

Each analysis reflected the average of 3 plants. By no shading or 50% shading, NO_3-N concn in each plant part increased as concn of the applied nitrate increased. By 75% shading, however, it showed no difference between the 16 mM and 32 mM NO_3-N treatment. When fed 8 mM or 16 mM NO_3-N, NO_3-N concn in each part increased remarkably by 50% or 75% shading as compared to no shading. When applied 32 mM NO_3-N, neither 50% nor 75% shading showed significant difference in the NO_3-N concn. The greatest influence on NO_3-N accumulation was observed in petioles of outer leaves. That is, NO_3-N concn was the lowest in petioles of outer leaves, and increased in the order of petioles of inner leaves, roots, blades of outer leaves and blades of inner leaves, by no shading treatment. By 50% or 75% shading, NO_3-N concn was highest in petioles of outer leaves, though NO_3-N concn in other parts are not so different from each other (Fig. 1).

From these results it was concluded that NO_3-N concn in each plant part increased as light intensity decreased. When concn of the applied NO_3-N exceeded 16 mM, however, NO_3-N concn in the plant did not respond to the increased shading rate.

Effect of litght intensity on NO_3-N absorption and NO_3-N content in the plant: Seeds were sown in vermiculite on the middle of Sept. and was supplied with nutrient solution following emergence. Five seedlings at the 2 nd true leaf stage were transplanted into each of the plastic containers holding 25 ℓ of the culture solution in a glasshouse. Culture solution was aerated with a small air pump, and was renewed every 3 days. Plants were grown under the no shading condition until the 5 th true leaf stage, after which they were divided into 3 plots of no shading, 50% shading and 75% shading. At the 10 to 11th true leaf stage, 3 plants from each plot were harvested for nitrate determination. Amount of NO_3-N absorbed by plants from the culture solution in each treatment was that absorbed by the plant during the 3 days prior to NO_3-N analysis.

NO_3-N concn in plants increased as the light intensity decreased. Little difference was observed in the amount of nitrate absorption per fresh weight of the plant from the culture solution, between the no shading and the 50% shading treatments. NO_3-N absorptrion per plant, however, decreased slightly in the 50% shading as compared to the no shading. By 75% shading, the amount of NO_3-N absorption per gram or per plant was smaller than that by the no shading or 50% shading (Fig. 2).

Increased NO_3-N concn in the plant with reduced light intensity may be attributed to the decrease in photosynthesis under limited exposure to light. Photosynthate and NO_3-N are used for amino acid synthesis in plants. Decreased activity of nitrate reductase could be another reason for the increased nitrate content under the limited exposure to light[2)7)].

Change in NO_3-N concn in the plant after the change in light intenstiy: Seeds were sown in a 12 cm polyethylene pot filled with soil in the glasshouse on early Sept. Fol-

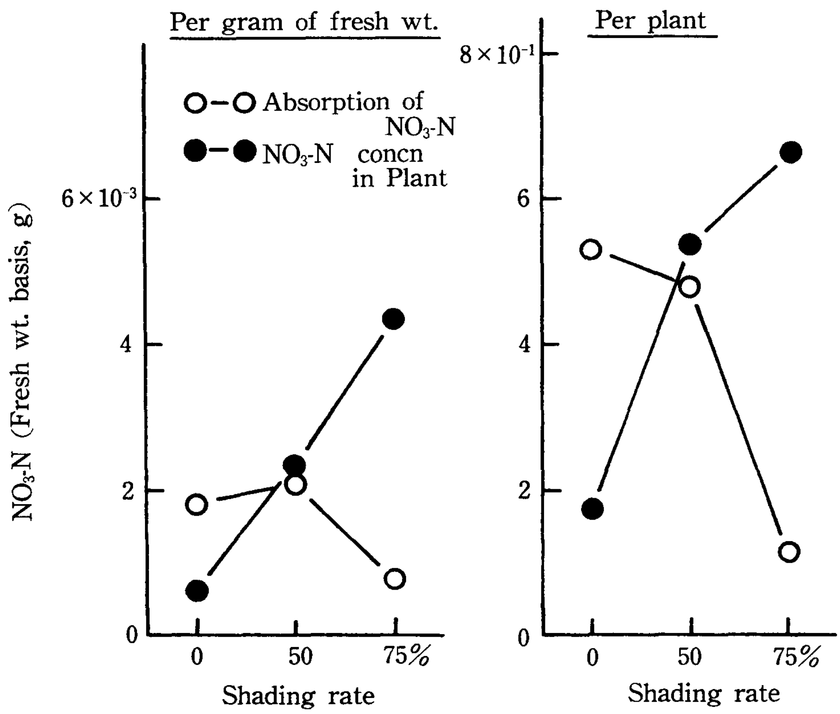

Fig. 2. Effects of light intensity on NO_3-N absorption from the culture solution in 3 days prior to harvesting and NO_3-N concn in the plant.

lowing emergence half strength of the culture solution (Table 1) was applied every other day. Application was increased to once a day after the 4 th true leaf stage. At this developmental stage plants were divided into 2 plots to be treated no shading or 75% shading. Following the 6 th true leaf stage, each of these plots was divided again into no shading and 75% shading sub-plots, making a total of 4 treatments (no shading, 75% shading, no shading to 75% shading, 75% shading to no shading). NO_3-N concn was analyzed, for each plant part, 0, 1, 2, 4, 8 and 15 days after starting the treatment.

In blades of outer leaves of plants that had received the no shading to 75% shading treatment, NO_3-N concn began to approach that of plants with the 75% shading treatment after 4 days. It remained below the concn by the 75% shading treatment even after 15 days. When plants were moved from 75% shading to no shading, NO_3-N concn began to approach that of the no shading treatment in 2 days, achieving the same value after 8 to 15 days.

NO_3-N concn of leaf blades of inner leaves of plants that received the no shading to 75% shading treatment, started to approach that of plants with the 75% shading treatment in one day and was close to the latter in 15 days. When plants were moved from 75% shading to no shading, however, NO_3-N concn in the plants started to approach that of the no shading treatment in one day, and was almost equal in 4 days. In petioles of inner leaves, when the change was made from no shading to 75% shading, NO_3-N concn started to approach that by the 75% shading treatment after 8 days, becoming very close in 15

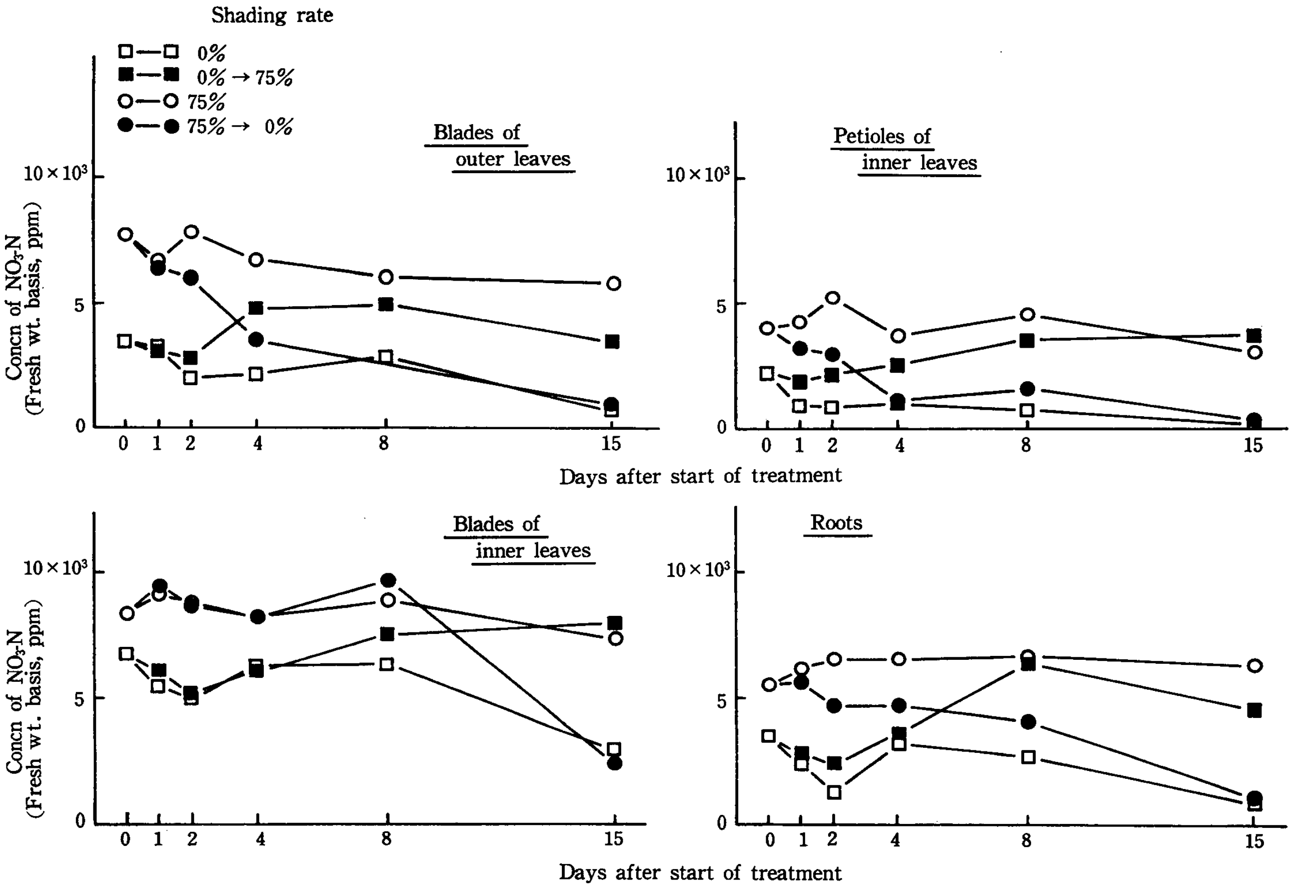

Fig. 3. Changes in NO_3-N concn of the plant parts following the change in light intensity.

days. When plants were moved from 75% shading to no shading, NO_3-N concn remained unchanged for 8 days, but did become almost the same as that by the no shading treatment in 15 days. When the change was made from the no shading to the 75% shading treatment, NO_3-N concn in roots was almost same as the 75% shading treatment in 8 days, but showed a lower value than that of the 75% shading treatment after 15 days. No clear explanation to this decrease in NO_3-N concn can be given. When moved from the 75% shading to the no shading treatments, NO_3-N concn of roots began to approach that of the no shading treatment in 2 days, becoming almost same as that in 15 days (Fig. 3).

There were no substancial difference in the NO_3-N concn at the 6 to 7 th true leaf stage between the no shadng and 75% shading treatments in the petioles of the outer leaves, and therefore, the result is not shown here.

Changes in the NO_3-N concn in the plants under changing light intensity were more rapid in younger leaves than in the older, and in blades than in petioles. Change in NO_3-N concn appears at first in young leaves regardless of the treatment of light intensity or in the concn of applied NO_3-N. Such a similarity of change in NO_3-N concn in the plant of each part under the varied conditions of light intensity and the concn of applied NO_3-N, is an interesting point to be noted.

Summary

Effects of light intensity and concn of applied NO_3-N on concn of NO_3-N in Chinese mustard (*Brassica campestris* cv. Marubakomatsuna) were investigated.

NO_3-N concn in petioles, leaf blades and roots increased as light intensity decreased. When concn of the applied NO_3-N exceeded 16 mM, however, the concn in the plant did not change with decreasing light intensity.

By 75% shading the amout of NO_3-N absorption from culture solution was smaller than that by the no shading or 50% shading.

Influences of changing light intensity on the NO_3-N concn in plant were detected within one to two days following the treatment. Changes in NO_3-N concn in the plant were more rapid in younger leaves than in the older, and in leaf blades than in petioles.

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光の強さと'丸葉コマツナ'の生体内硝酸態窒素の蓄積

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要旨

1．NO_3-N の施肥濃度が 4，8 mM では，葉柄，葉身および根の NO_3-N 濃度は，しゃ光の程度が強くなるにつれ増加した。NO_3-N の施肥濃度が 16 mM では，しゃ光処理による生体内 NO_3-N の増加は認められなかった。

2．培養液からの NO_3-N の吸収量は，しゃ光率50％区では，無しゃ光区とほとんど同じであったが，しゃ光率75％区では減少した。

3．光の強さを変化させた後の生体内 NO_3-N 濃度の経時変化は，古い葉よりも若い葉において，また葉柄よりも葉身において早く認められた。