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Role of nitrification inhibitor DMPP (3, 4-dimethylpyrazole phosphate) in NO_3^--N accumulation in greengrocery (*Brassica campestris* L. ssp. *chinensis*) and vegetable soil

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Abstract: The influence of nitrification inhibitor (NI) 3, 4-dimethylpyrazole phosphate (DMPP) on nitrate accumulation in greengrocery (*Brassica campestris* L. ssp. *chinensis*) and vegetable soil at surface layer were investigated in field experiments in 2002 and 2003. Results showed that NI DMPP took no significant effect on yields of edible parts of greengrocery, but it could significantly decrease NO_3^--N concentration in greengrocery and in vegetable soil at surface layer. In addition, NI DMPP could reduce the NO_3^--N concentration during the prophase stage of storage.

Keywords: 3,4-dimethylpyrazole phosphate (DMPP); NO_3^--N; vegetable soil; greengrocery (*Brassica campestris* L. ssp. *chinensis*)

Introduction

Greengrocery (*Brassica campestris* L. ssp. *chinensis*) is an important horticultural crop which can accumulate a large mount of nitrate. When nitrate-rich vegetables are consumed by human beings, nitrite (NO_2^-) may be formed from NO_3^- after ingestion, causing metheamoglebinemia. The presence of NO_3^- in the blood might result in the formations of nitrosamines which are believed to be carcinogenic. Therefore, decreasing nitrate accumulation in vegetable is important to reduce the threat of nitrosamine to human health. Developing practical approaches to control nitrate accumulation in vegetable is one of the greatest problems in Chinese vegetable production, and has great significance to develop green foodstuff production to improve human health.

Previous studies have demonstrated that the new nitrification inhibitor (NI) 3, 4-dimethylpyrazole phosphate (DMPP), which has been developed by BASF (BASF Agricultural Center, Limburgerhof, Germany) could decrease NO_3^- leaching, volatilization N losses and also could improve yield (Zerutlla, 2001; Serna, 2000; Fettweis, 2001; Pasda, 2001; Xu, 2003a). However there were not many reports about NI DMPP on vegetables. The objective of this research was to investigate whether NI DMPP would depress NO_3^--N accumulation in greengrocery and in vegetable soil.

1 Materials and methods

The field experiments on greengrocery were conducted at Haining City, Zhejiang Province of China in 2002 and 2003. Properties of soil (0—20 cm, passed 1 mm mesh) are listed in Table 1. Information of the tested vegetable in the experiment is listed in Table 2.

Table 1 Soil properties at surface layer (0—20 cm) in the experiment

Year	O. M., g/kg	Total-N, g/kg	Alkali-hydrolyzable-N, mg/kg	Olsen-P, mg/kg	NH_4OAc-K, mg/kg	NO_3^--N, mg/kg	NH_4^+-N, mg/kg	pH
2002	30.5	1.90	150.6	75.5	241.0	54.2	34.1	5.45
2003	24.4	1.92	129.1	88.6	128.1	44.0	16.9	5.85

Table 2 Information of the tested vegetable in the experiment

Year	Variety	Plant density	Planting date	Harvest date
2002	Suzhou greengrocery	20 cm × 33.4 cm	Sept.24	Oct.26
2003	Chinese greengrocery	20 cm × 33.4 cm	Aug.14	Sept.9

Before planting, 500 kg/hm^2 superphosphate and 150 kg/hm^2 potassium chloride were applied and incorporated into the soil. The following N-fertilization treatments were compared: ammonium sulphate nitrate (ASN) and ammonium sulphate nitrate with NI DMPP (ASN + DMPP) at the level of 150 kg/hm^2 nitrogen. Fertilizers were side-dressed on planting date, and manually incorporated into the first 20 cm of soil. Treatments were replicated 3 times in a randomized complete block design, each plot consisting of 6 m^2 area. All of the trials were laid out in farmer's fields.

At the end of the experiment, the edible parts of greengrocery were collected and greengrocery yields and NO_3^--N concentration were evaluated. Edible parts of greengrocery were washed with distilled water, separated into leaves and stems for the analysis of NO_3^--N accumulation in different parts of greengrocery in 2002. Vegetable samples were taken at 15, 19, 23, 27 d after fertilization to monitor NO_3^--N accumulation in different stages of greengrocery in 2003. The vegetable samples in ASN, ASN + DMPP treatments were stored in refrigerator, and samples were taken at 2, 4, and 6 d after storage to investigate the effect of DMPP on the changes of NO_3^--N concentration under lower temperature condition. Soil samples for NO_3^--N analysis were

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collected from each replicate at a depth of 20 cm. Sampling was performed at 10, 20, and 30 d after fertilization in 2003.

The NO_3^--N concentration in plants was determined by ultraviolet spectrophotometry (Lu, 1997). The soil samples were extracted with 2 mol/L KCl at a soil to extracant ratio of 1:5, and NO_3^--N concentration was determined by ultraviolet spectrophotometry (ASCSSSC, 1983).

Experimental data were processed using DPS software and submitted to Duncan's test with a probability level of $\mu = 5\%$.

2 Results and discussion

2.1 Effect of NI DMPP on yield of greengrocery

The application of ammonium sulphate nitrate (ASN) with DMPP, compared to ASN without DMPP, brought a slight yield increase of + 1.8 t/hm^2 (2002) and + 0.74 t/hm^2 (2003), but it did not reach statistical significant level (Fig.1).

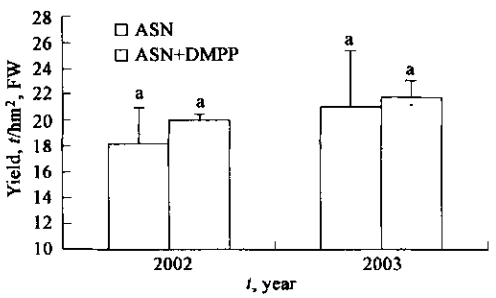

Fig.1 The yield of greengrocery

2.2 Effect of DMPP on nitrate accumulation in greengrocery

ASN + DMPP could significantly decrease NO_3^--N concentration in edible parts of greengrocery as compared with ASN. Compared to ASN, ASN + DMPP could decrease NO_3^--N concentration in edible parts of greengrocery by 13.8% (2002) and 19.1% (2003) at the harvest (Fig.2, Fig.3). By analyzing the NO_3^--N concentration in leaves and stems, we could see that the NO_3^--N content in leaves and stems decreased with the application of NI DMPP, and there was a significant difference in NO_3^--N concentration in stems between ASN and ASN + DMPP treatments (Fig.2). The application of DMPP partly resulted in a reduction in NO_3^--N concentration in leaves and in stems compared to fertilization without DMPP, particularly reduced NO_3^--N concentration in stems. This might be explained by a slow NO_3^- supply to the roots of vegetable plants under the effect of DMPP. As NH_4^+-N is supplied to the crop at a higher rate and for a longer period of time when it is fertilized together with NI DMPP, a substantial amount of NH_4^+-N rather than NO_3^--N will be taken up by the plants (Xu, 2003b). This partial NH_4^+ nutrition offers several advantages: firstly, plants may spend less energy on NH_4^+ uptake than on NO_3^- uptake, especially at a high rate of NH_4^+ supply; secondly, NH_4^+ can be used directly for protein metabolism (Klein, 1979; Gerendás, 1995). Nevertheless the mechanism is still not clear and further study is warranted.

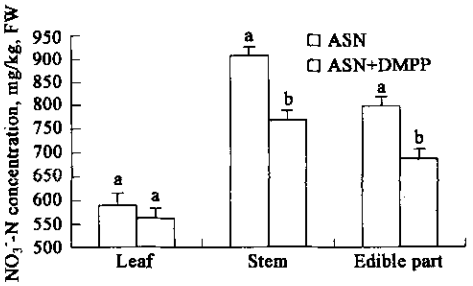

Fig.2 NO_3^--N concentration in greengrocery in 2002

NO_3^--N concentration in greengrocery treated with ASN + DMPP was remarkably lower than ASN treatment at 19, 23, 27 d after fertilization; but there was no significant difference at 15 d after fertilization (Fig.3). From these, we could conclude that NI DMPP need some time to reveal the effect on nitrate accumulation. NI DMPP could effectively decrease the NO_3^--N concentration during the whole growth stage of vegetable. NO_3^--N concentration in greengrocery treated with ASN + DMPP was 1153.8 mg/kg at 23 d after fertilization, lower than the criterion of green foodstuff production (1200 mg/kg), but in ASN treatments NO_3^--N concentration lower 1200 mg/kg was observed at 27 d after fertilization (Fig.3). Thus the time of vegetable coming into market could be advanced about 4 d fertilized nitrogen fertilizer with NI DMPP as compared without NI DMPP, and would get a better price.

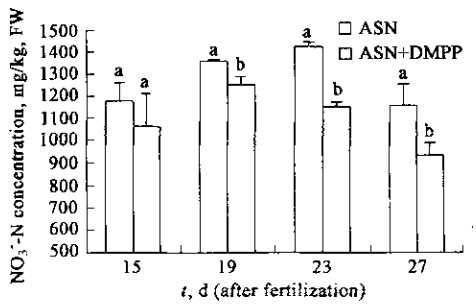

Fig.3 NO_3^--N concentration in greengrocery in 2003

There was a tendency that NO_3^--N concentration decreased in the course of storage. After 2 d storage in refrigerator, NO_3^--N concentration in greengrocery treated with ASN decreased 54.4 mg/kg, NO_3^--N concentration treated with ASN + DMPP decreased 74.4 mg/kg, and there was a significant difference in NO_3^--N concentration between ASN and ASN + DMPP. From 2 to 4 d storage, NO_3^--N concentration decreased 144.7 mg/kg for ASN and 20.1 mg/kg for ASN + DMPP (Fig.4). The reason why NO_3^--N concentration in greengrocery treated without NI DMPP

decreased so faster than with NI DMPP may be that the vitamin C in greengrocery treated without DMPP decreased faster than treated with DMPP(Table 3). Another reason may be that traces of DMPP could be detected in plants such as winter wheat, potatoes, lettuce and red cabbage. This means trace of DMPP could be uptake by plants(Recves, 1986). Thus we could conclude that NI DMPP could reduce the NO_3^--N content in the prophase course of storage.

Table 3 Vitamin C concentration in greengrocery in the storage (mg/kg)

Treatments	Time(days after storage)			
	0	2	4	6
ASN	977	927	843	820
ASN + DMPP	972	963	872	755

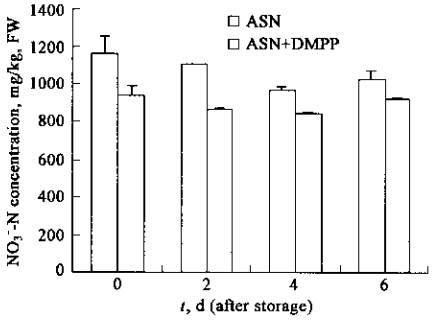

Fig.4 NO_3^--N concentration in the greengrocery in the storage

2.3 Effect of DMPP on NO_3^--N concentration in soil at surface layer

The results showed that the NO_3^--N concentration in vegetable soil treated with ASN + DMPP at surface layer maintained a lower level as compared with ASN during the greengrocery growth stage. Soil NO_3^--N concentration for ASN + DMPP treatment was significantly lower than ASN (Fig.5, Fig.6). NI DMPP could retard the process of NH_4^+ transformation NO_3^- for a long time(Xu, 2003b). A lower NO_3^--N concentration in the soil, means that the NO_3^- leaching loss would decrease, and the N_2O losses would also decrease (Linzmeier, 2001; Weiske, 2001; Fetrweis, 2001). The eco-efficiency of nitrogen fertilizer in agro-ecosystem may be increased by decreasing NO_3^--N concentration with the use of DMPP. It was beneficial for the protection of the environment.

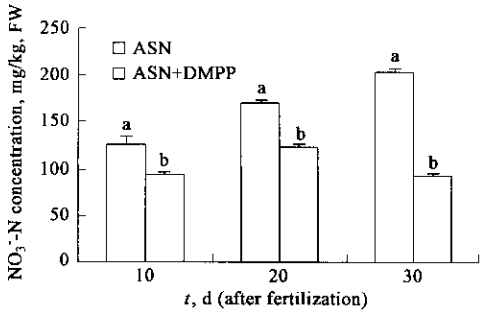

Fig.5 NO_3^--N concentration in soil in 2002

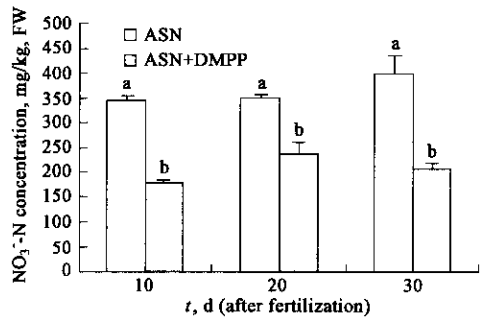

Fig.6 NO_3^--N concentration in soil in 2003

3 Conclusions

From the experiments, we could conclude that NI DMPP could evidently decrease NO_3^--N accumulation in greengrocery and soils at surface layer. NI DMPP decreasing NO_3^--N accumulation in stems was the key of DMPP decreasing NO_3^--N accumulation in vegetable. It was beneficial for the protection the environment and good for human health.

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