SUITABILITY OF ENTEC 26 AS A SOURCE OF NITROGEN FOR RED BEET AND CELERIAC

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Summary

Entec 26 a new concept nitrogen fertilizer containing DMPP nitrification inhibitor was evaluated as a source of N for red beet and celeriac in field studies conducted in 2003-2006. In experiments with red beet there were determined the effects of the use of ammonium nitrate, ammonium sulphate, calcium nitrate and Entec 26 applied in the amounts of 50, 100, 150, 100 + 50 kg N ha⁻¹ in cultivation for bunches, and additionally 200 kg N ha⁻¹ for storage purpose. In the study with celeriac ammonium nitrate was supplied in split doses of 75, 150, 225 and 300 kg N ha⁻¹, while Entec 26 at the same rates as preplant or split application.

Results of the study showed that Entec 26 was equally valuable source of N for red beet as ammonium nitrate and calcium nitrate and more efficient than ammonium sulphate. In experiment with celeriac, plants supplied with this fertilizer in split doses overyielded those receiving ammonium nitrate in the same amounts. The important advantageous effect of Entec 26 use was a considerable reduction of nitrates accumulation in red beet grown for bunches and in celeriac roots.

key words: nitrogen fertilizers, red beet, celeriac, yield, plant composition

INTRODUCTION

A large part of success in vegetable culture has been due to proper mineral nutrition of vegetables. However, the surplus of supplied nutrients, especially nitrogen, may have an adverse effects on the environment as well as quality of the crops, and in consequence the health of human beings. In a temperate climatic zone usually not more than 50% of N applied is effectively used by plants, while considerable part is lost by leaching causing the contamination of ground and surface waters. On the other hand its intensive uptake by plants may result in high nitrates accumulation in the crop (Rahn 2002).

These disadvantageous effects can be partly reduced by split application of N fertilizers as preplant and top dressing doses or the use of controlled release sources of the nutrient.

Considerable field research has been conducted with sulphur coated urea (Kołota 1982, Wiedenfeld 1986, Hochmuth 2003) and polymer coated urea (Drost *et al.* 2002) as nitrogen fertilizers for vegetables. High costs of production and similar or sometimes lower efficiency in comparison to soluble N sources were the reasons that till now such fertilizers are still not widely used in the field vegetable growing.

Another approach to reducing N losses in crop production is the use of nitrification inhibitors, which reduce the conversion of ammonium N to nitrate N. First studies with nitrification inhibitors were conducted with nitrapyrin (2-chloro 6 trichloromethyl pyridine) and DCD (dicyandiamide), which have not received widespread commercial use in vegetable crops production (Hendrickson *et al.* 1978, Kołota & Dobromilska 1985, Frye *et al.* 1989, Hochmuth 2003). Recently there was developed a new formula N fertilizer containing DMPP nitrification inhibitor. In a field studies there was proved its higher efficiency than soluble N sources expressed by either increased yield level or lower requirement for N rate application (Hähndel & Strohm 2001, Hähndel & Zerulla 2000, 2001, Pasda *et al.* 2001).

The aim of the experiment was to evaluate the effects of Entec 26 on yield and chemical composition of red beet and celeriac.

MATERIAL AND METHODS

Two field experiments with red beet and one with celeriac were conducted in 2003-2006 at Piastów Horticultural Experimental Station on a sandy clay soil with pH 7.1-7.4 and organic matter content 1.8%. Available forms of phosphorus and potassium expressed in 1 dm³ of the soil were raised up to the standard level for red beet (50 mg P, 150 mg K) and celeriac (80 mg P, 200 mg K) by early spring fertilization with triple superphosphate and potassium chloride.

In experiments I and II there were evaluated the effects of the use of ammonium nitrate, calcium nitrate, ammonium sulphate and Entec 26 – fertilizer containing the mixture of ammonium sulphate and ammonium nitrate with total amount of 26% N and addition of DMPP nitrification inhibitor (3,4-dimethylpyrazole phosphate). All rested fertilizers were applied in the amounts of 50, 100, 150 and 100 + 50 kg N ha⁻¹ in red beet grown for bunches and 50, 100, 150, 100 + 50 or 200 kg N ha⁻¹ in growing for storage purpose. Preplant doses of nitrogen were supplied shortly before seed sowing, while top dressing fertilization 4 weeks after sowing at the stage of 4-6 leaves. Seeds of Czerwona Kula cv. grown for bunches were sown into the field on 23 April in the rows 30 cm apart. Harvest was arranged in the half of July, when most of the plants formed roots ≥ 3.0 cm in diameter. For storage purpose seeds of the same cultivar were sown in the middle of June in the rows 45 cm apart, and harvest was done in early October. Marketable yield included roots with 4-10 cm in diameter.

In experiment III with celeriac, ammonium nitrate was supplied in split doses of 75 ($\frac{1}{2} + \frac{1}{2}$), 150 ($\frac{1}{2} + \frac{1}{2}$), 225 ($\frac{1}{3} + \frac{1}{3} + \frac{1}{3}$) and 300 ($\frac{1}{2} + \frac{1}{4} + \frac{1}{4}$) kg N ha⁻¹ in preplant and one or two top dressings, conducted on 8-9 June and 15-16 July. Entec 26 was used in the same amounts of N and terms of fertilization as ammonium nitrate or in a single preplant dose incorporated into the soil by harrowing.

Celeriac cv. Monarch was grown from transplants produced in multicell trays, with cell volume 55.8 cm³, filled with peat substrate. Well developed and hardened seedlings were planted into the field on 6-9 May in spacing 40 x 20 cm. During harvest there was evaluated the marketable yield of roots including those with 5-13 cm in diameter.

At harvest of red beet and celeriac, samples of edible parts were collected for nitrates determination by using the reflectometric method.

The experiments were arranged in two factorial design with four replications and plot area 8.1 m² (2.7 x 3 m) for red beet and 7.2 m² (2.4 x 3 m) for celeriac. Data of the study were analysed by standard statistical procedure and the least significant differences calculated by Tukey test at P=0.05.

RESULTS AND DISCUSSION

Data of the study shown in Table 1 indicate that the marketable yield of red beet grown both for bunches and storage purpose was significantly influenced by the kind of nitrogen fertilizer as well as rate of this nutrient supplied to plants. Application of ammonium nitrate, calcium nitrate and Entec 26 gave similar to each other and considerable better results than ammonium sulphate. Irrespective of the N rate, the yield of plants supplied with ammonium sulphate was equal to 42.78 t ha⁻¹ while on plots with the other sources of this nutrient varied between 48.00 and 50.69 t ha⁻¹. Very similar response of this vegetable species was observed in its growing for roots used for storage purpose (Table 2).

The most efficient method of N plant nutrition, taking into account the growth rate of plants and yield of beet for bunches was split application of the total dose 150 kg N ha⁻¹ and the use of 100 kg N ha⁻¹ before planting, supplemented by 50 kg N ha⁻¹ in a top dressing dose. In growing this species for a longer period of time to obtain the roots suitable for storage the best yielding was the treatment receiving 200 kg N ha⁻¹ in one preplant fertilization rate. However, not significant differences were found between yield assured by this dose and 150 kg N ha⁻¹. Split application of the nitrogen fertilization applied in the total amount of 150 kg N ha⁻¹ was more preferable for the table beet growth and yield only in the cultivation for bunches.

Nitrates accumulation, both in roots and leaves, increased along with the level of nitrogen supplied within 50 and 150 kg N ha⁻¹ from 121 to 487 mg kg⁻¹ f.w. and from 798 to 1352 mg kg⁻¹ f.w., respectively. In any treatment the accumulation of NO₃-N did not reach the level of 1500 mg per 1 kg of fresh weight, which is the acceptable limit for this vegetable species supplied to the market in Poland.

Table 2. The effect of nitrogen fertilization on yielding and nitrates content in red beet grown for storage (mean for 2003-2006)

Kind of fertilizer	Marketable yield (t·ha ⁻¹)					N-NO ₃ (mg·kg ⁻¹ f.m.)				
	rate of nitrogen (kg N·ha ⁻¹)					rate of nitrogen (kg N·ha ⁻¹)				
	100	150	100+ 50	200	mean	100	150	100+ 50	200	mean
Ammonium nitrate	40.06	40.87	38.44	43.31	40.67	1480	1555	1008	963	1251
Calcium nitrate	34.91	40.71	40.13	44.27	40.00	1295	1710	950	1210	1291
Ammonium sulphate	32.67	34.09	35.75	40.34	35.71	945	1367	1686	1354	1338
Entec-26	39.76	41.38	41.32	41.00	40.86	1195	1235	1345	1195	1243
Mean	36.85	39.26	38.91	42.23	39.31	1229	1467	1247	1180	1281
LSD _{0.05} for:										
kind of fertilizer (I)					2.88					
rate of nitrogen (II)					3.95					
Interaction (I×II)					7.42					

In reverse to the statement of Peck *et al.* (1974), split application of nitrogen fertilizers caused some reduction of NO₃-N content in plants in comparison to the preplant dose. More efficient way for its limitation occurred in the case of Entec 26 use – a new concept nitrogen fertilizer containing DMPP as a nitrification inhibitor, which retards the conversion of ammonium N to nitrate N form. The positive effect of Entec 26 application was especially pronounced in roots of beets grown for bunches.

Data of the three year's study with celeriac showed that Entec 26 applied in a split dose (Table 3) was found to be a better source of nitrogen for this species than ammonium nitrate. The average marketable yield of roots for all tested N rates reached the level 47.04 t·ha⁻¹ in treatment with Entec 26, while 41.72 t·ha⁻¹ with ammonium nitrate. This advantageous effect was particularly noticeable at the doses of 75 and 150 kg N·ha⁻¹, which caused the yield increment by 16.2% and 26.7%, respectively. Slight and not significant differences in efficiency of both fertilizers were observed in treatments supplied with 225 or 300 kg N·ha⁻¹ as well as in the case of application the whole amounts of N in one preplant dose.

Irrespective of the source of nitrogen and time of its application, the maximum yield of marketable celeriac roots was assured by using the dose of 225 kg N·ha⁻¹. This finding is generally in agreement with the recommendations elaborated by Krug (1991) and Sady (2000) for celeriac grown in not irrigated fields.

Table 3. The effect of the kind of fertilizer and nitrogen rate on marketable yield and nitrates content in celeriac (mean for 2003-2005)

Kind of fertilizer	Marketable yield (t·ha ⁻¹)					N-NO ₃ (mg·kg ⁻¹ f.m.)				
	rate of nitrogen (kg N·ha ⁻¹)					rate of nitrogen (kg N·ha ⁻¹)				
	75	150	225	300	mean	75	150	225	300	mean
Ammonium nitrate	34.47	38.08	49.43	44.91	41.72	260	291	328	433	328
split application										
Entec-26	40.05	48.23	53.84	46.03	47.04	258	278	321	358	304
split application										
Entec-26										
preplant application	36.47	40.47	53.09	38.55	42.15	239	265	272	306	271
Mean	37.00	42.26	52.12	43.16	43.64	252	278	307	366	277
LSD _{0.05} for:										
kind of fertilizer (I)					4.14					
rate of nitrogen (II)					5.24					
interaction (I×II)					n.s.					

Chemical plant analysis indicated that the source of nitrogen considerably influenced nitrates accumulation in celeriac roots at harvest. Plants fertilized with Entec 26 contained lower amounts of NO₃-N in comparison to those supplied with ammonium nitrate. Nitrates content in plants grown on plots fertilized with ammonium nitrate varied from 260 mg·kg⁻¹ f.w. at the dose of 75 kg N·ha⁻¹ up to 433 mg·kg⁻¹ f.w. at 300 N·ha⁻¹, exceeding the value admitted for this vegetable crop in Poland (400 mg NO₃-N·kg⁻¹). Split application of Entec 26 caused the decrease of NO₃-N content to 258-358 mg·kg⁻¹ f.w. and its use in one preplant dose to 239-306 mg·kg⁻¹ f.w. depending on N dose. Beneficial effects of Entec 26 use as a source of nitrogen, expressed by the decrease of nitrates accumulation was observed in the other studies with celeriac and also another vegetable species such as lettuce, spinach, cauliflower, leek and carrot (Hähndel & Zerulla 2001, Pasda *et al.* 2001).

Heavy N application at the rates of 225 and 300 kg N·ha⁻¹ caused the increment of nitrogen uptake and nitrates accumulation in celeriac roots, irrespective of N source and method of its application.

CONCLUSIONS

1. Entec 26 was equally valuable source of nitrogen for red beet grown for bunches and storage purpose as ammonium nitrate and calcium nitrate, and provided higher yields of this vegetable species than ammonium sulphate.
2. Split application of Entec 26 produced higher, while preplant supply the whole fertilizer dose similar yield of celeriac roots as ammonium nitrate used at the same rates.
3. Plant nutrition with Entec 26 was associated with the reduction of nitrates accumulation in red beet grown for bunches and in celeriac roots.

4. Maximum yield of red beet was assured by application 100 kg N·ha⁻¹ as a preplant dose and 50 kg N·ha⁻¹ as a top dressing, while celeriac by the use of 225 kg N·ha⁻¹ divided into there equal preplant and top dressing rates.

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PRZYDATNOŚĆ NAWOZU ENTEC 26 W UPRAWIE BURAKA ĆWIKŁOWEGO I SELERA KORZENIOWEGO

Streszczenie

W 3 doświadczeniach polowych przeprowadzonych w latach 2003-2006 oceniono przydatność nawozu Entec 26 zawierającego DMPP (2-chloro-6-trójklorometylo-pirydyna) jako inhibitor nitryfikacji do nawożenia buraka ćwikłowego i selera korzeniowego. W doświadczeniach z burakiem przedmiotem oceny były saletra amonowa, saletra wapniowa, siarczan amonu i Entec 26 stosowane w dawkach 50, 100, 150 i 100

+ 50 kg N ha⁻¹ w uprawie na zbiór pęczkowy oraz dodatkowo 200 kg N ha⁻¹ na potrzeby przechowywania. Seler nawożono podzielonymi dawkami saletry amonowej wynoszącymi 75, 150, 225 i 300 kg N ha⁻¹ oraz tej samej wielkości dawkami nawozu Entec 26 stosowanymi w całości przedwegetacyjnie bądź w nawożeniu dzielonym.

Wyniki przeprowadzonych badań dowiodły, że Entec 26 stanowił równorzędne źródło azotu dla buraka ćwikłowego jak saletra amonowa i saletra wapniowa, przewyższał natomiast pod względem skuteczności siarczan amonu. W uprawie selera użycie dawki podzielonej tego nawozu zapewniło uzyskanie wyższego plonu handlowego korzeni aniżeli równorzędne dawki saletry amonowej. Istotną korzyścią wynikającą ze stosowania nawozu Entec 26 było obniżenie zawartości azotanów w buraku ćwikłowym zbieranym na pęczki oraz w korzeniach spichrzowych selera.