NITROGEN AND POST-HARVEST YELLOWING OF BRUSSELS SPROUTS

A.P. Everaarts
Applied Research for Arable Farming and Field Production of Vegetables
P.O. Box 430, 8200 AK Lelystad
The Netherlands

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Abstract

A study was made of the effect of a late nitrogen application on post-harvest yellowing of Brussels sprouts. Application of nitrogen, whether as granular fertilizer or as a lower amount sprayed over the crop in a watery solution, increased the nitrogen concentration in the outer leaves of the sprouts, but this did not result in less post-harvest yellowing. Size of the sprouts and moment of harvest, however, strongly influenced post-harvest yellowing.

1. Introduction

Yellowing of the outer leaves of sprouts towards harvest and especially post-harvest, is an important quality defect. Yellowing of the outer leaves before harvest necessitates extra work in sorting out the yellow sprouts. Post-harvest yellowing determines shelf-life. Farmers aim to prevent yellowing by applying a small amount of nitrogen shortly before harvest, as nitrogen may intensify the green color. The effect of this practice, especially on post-harvest yellowing, is under investigation. This paper reports on the results of a first field experiment in which the effect of near harvest application of nitrogen was evaluated for effects on yellowing of sprouts at harvest and post-harvest. To investigate whether the efficiency of nitrogen application could be increased, a comparison was made between the conventional fertilizer application as granules and spraying the nitrogen in a watery solution over the crop.

2. Materials and methods

2.1. General

The experiment was carried out in 1996 at the research station in Lelystad on a marine loam soil with the Brussels sprouts (*Brassica oleracea* var. *gemmifera*) cultivar Maximus. Soil preparation for planting was carried out shortly before planting. Modular raised transplants were used and the crop was planted by hand. At planting 162 kg/ha nitrogen as calcium ammonium nitrate (CAN) was given. Soil available nitrogen (0-60 cm) at planting was 49 kg/ha. At 112 days after planting (DAP) the crop was stopped (the apex removed) and two days later 43 kg/ha nitrogen as CAN was given. Plots contained 12 plants at a planting distance of 0.75 x 0.40 m.

2.2. Experimental procedures

The experiment was laid out in a randomized complete block design with eight treatments in four replicates. The treatments were carried out at 127 DAP. The nitrogen treatments were: (i) no nitrogen application, (ii) application of 31 kg/ha nitrogen as granular calcium nitrate (standard), and (iii-vii) application of 0, 3, 6, 12 and 24 kg/ha nitrogen as urea in 1000 l water/ha sprayed over the crop. Another treatment consisted of application of magnesium sulphate. This treatment had no effect and is not further considered here. There were two harvests at 140 and 155 DAP. After harvest marketable sprouts were graded in the sizes 14-18, 18-30, 30-41 and >41 mm diameter. Marketable yield was the total of these four size classes.

At harvest fifty sprouts of both size classes 18-30 and 30-41 mm were evaluated for yellowing and placed in a split plot design with four replicates in the dark at 90 % relative humidity and 12 °C. The field treatments were the plot factor in this design and the size class was the split factor. During 17 days the sprouts were scored for yellowing every two or three days. A sprout was scored 'yellow' when 50 % or more of the surface of at least one of the outer leaves was yellow. The percentage of yellow sprouts was calculated and used to evaluate the treatment effects. In another sample of both size classes the sprouts were split in outer leaves and residual. In both parts the nitrogen concentration was determined. Leaves completely or partly exposed were regarded as outer leaves.

Statistical analysis was done through analysis of variance with the Genstat 5 programme (Genstat 5 Committee, 1993).

3. Results

3.1. Marketable yield and grading

Average marketable yield for the whole experiment was 19.1 t/ha at the first harvest and 27.8 t/ha at the second harvest. Marketable yield in the experiment was not consistently influenced by the treatments (Table 1). At both harvests the sprouts in the size classes 18-30 mm and 30-41 mm together constituted 98 to 99 % of the total yield for each treatment. Size grading was not or not consistently influenced by treatments.

3.2. Nitrogen concentration

The nitrogen concentration in the outer leaves of the large sprouts was significantly lower as compared to that of the small sprouts (Table 2). For both grades the application of 12 and 24 kg of nitrogen per hectare as urea resulted in a significant increase in the nitrogen concentration of the outer leaves of the sprouts. This also was the case for the small sprouts, when 31 kg nitrogen per hectare as calcium nitrate was applied. There was no difference in effect between the 12 and 24 kg of nitrogen applied as urea and

Table 1. The effect of nitrogen on marketable yield and grading.

	Harvest	No nitrogen	Nitrogen applied (kg/ha N) in the form of:						LSD (α=0.05)
			$Ca(NO_3)_2$	Urea in 1000 l water/ha					
			31	0	3	6	12	24	
Marketable	1	17.8	19.5	19.8	19.0	18.3	20.2	18.7	2.7
yield (t/ha)	2	30.5	29.7	27.8	25.5	28.2	25.6	28.3	
Size 18-30 mm	1	56	53	53	50	54	50	50	7
(%)	2	17	18	25	30	19	26	21	
Size 30-41 mm	1	42	46	45	48	45	49	48	7
(%)	2	81	80	73	69	80	72	78	

Significance	Marketable yield	Size 18-30 mm	Size 30-41 mm
nitrogen	ns	ns	ns
harvest	p<0.001	p<0.001	p<0.001
nitrogen x harvest	p=0.009	p=0.023	ns

Table 2. The effect of nitrogen on the nitrogen concentration (g/kg) of the outer leaves of the sprouts at the first harvest.

	No nitro-gen	Nitrogen applied (kg/ha N) in the form of:						LSD (α=0.05)
		$Ca(NO_3)_2$	Urea in 1000 l water/ha					
		31	0	3	6	12	24	
Size 18-30 mm	23.7	26.6	25.6	25.7	24.6	26.5	27.1	2.0
Size 30-41 mm	21.8	23.4	23.0	22.4	20.8	24.4	24.1	

Significance	
nitrogen	p=0.024
size	p<0.001
nitrogen x size	ns

the 31 kg nitrogen applied as granular calcium nitrate. Apparently a lower amount of nitrogen sprayed over the crop can have the same result as a higher amount of granular fertilizer.

3.3. Yellowing

At both harvests no effects of nitrogen treatments on yellowing were observed (data not shown). Ten days after the first harvest there was no effect of nitrogen on yellowing of the small sprouts (Table 3). In the large sprouts an application of 31 kg/ha nitrogen as calcium nitrate, significantly increased yellowing. The urea treatments in this case had no effect. At the second harvest there were no significant effects of nitrogen treatment on yellowing for both sprout grades. Independent of nitrogen treatment the large sprouts showed more yellowing as compared to the small sprouts. On average of all treatments sprouts of the second harvest showed more yellowing than sprouts from the first harvest. The effect of harvest date on yellowing was larger for the small sprouts than for the large ones.

Table 3. The effect of nitrogen on the percentage yellow sprouts at ten days after the first and second harvest.

Harvest		No nitro-gen	Nitrogen applied (kg/ha N) in the form of:						LSD (α=0.05)
			$Ca(NO_3)_2$	Urea in 1000 l water/ha					
			31	0	3	6	12	24	
1	Size 18-30 mm	10	12	10	10	10	14	10	11
	Size 30-41 mm	35	53	28	42	45	38	38	
2	Size 18-30 mm	29	31	22	21	26	19	26	11
	Size 30-41 mm	46	57	43	47	39	43	36	

Significance	
nitrogen	p=0.018
harvest	p<0.001
nitrogen x harvest	ns
size	p<0.001
size x nitrogen	ns
size x harvest	p<0.001
size x nitrogen x harvest	ns

4. Discussion

The results show that a late nitrogen application can indeed lead to an increased nitrogen concentration in the outer leaves of the sprouts and the efficiency of application can be increased by spraying nitrogen in a watery solution over the crop. The increased nitrogen in the outer leaves of the sprouts, however, did not result in a lower percentage of yellow sprouts at ten days after harvest. In one instance the application of nitrogen even resulted in increased yellowing (Table 3). Booij *et al.* (1997) observed under field conditions that a late nitrogen application resulted in greener sprouts. No evaluation was made of post-harvest quality performance of the sprouts. In our experiment differences between treatments in the intensity of the green color of the sprouts in the field or at harvest were not obvious. Booij *et al.* (1997) related the greener color to a higher nitrogen concentration in the sprouts. Present results show that a higher nitrogen concentration does not necessarily prevents or delays yellowing at harvest or post-harvest.

The fact that yellowing was more severe after the second harvest and the fact that the large, probably older, sprouts showed more yellowing than the small ones, suggests that it is not as much simply the nitrogen concentration of the outer leaves of the sprouts that determines yellowing, but that more complex aging processes, likely related to levels of plant hormones (Thomas, 1977), are involved.

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