Mineral N-content in the Substrate and N-uptake of Container Grown Shrubs[1]

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Abstract

Three woody species *Forsythia* x *intermedia* 'Lynwood', *Weigela* 'Bristol Ruby', and *Prunus laurocerasus* 'Otto Luyken' were grown in 5 liter (# 1.3) containers with white peat and peat-reduced substrates. Plants were fertilized by a controlled-release or organic fertilizer. The aim was to investigate the relation between mineral N-content in the substrate and growth and N-uptake of the plants. Plant biomass was influenced by the mineral N-content in the substrate and by the substrate, but not by the type of fertilizer. Plant biomass of plants in the white peat substrate was significantly greater than plants grown in the peat-reduced substrates. Different equations describe the relation between mineral N in the substrate and biomass. Only for the white peat substrate in June and August was the slope of these regressions significant and the determination coefficient (r^2) high. Dry matter of above ground biomass was 38% of fresh matter. The root-to-shoot ratio varied widely. There was a significant exponential relation between the biomass and the height of the plants, but not with the number of shoots. The N-content of the plant was related to its fresh matter. The findings establish a possibility to deduce N-uptake from plant biomass and thus improve fertilization.

Index words: fresh matter, dry matter, shoot-to-root ratio, plant height, peat-reduced substrate, water tension.

Species used in this study: *Forsythia* x *intermedia* 'Lynwood', *Weigela* 'Bristol Ruby', *Prunus laurocerasus* 'Otto Luyken'.

Significance to the Nursery Industry

Knowing a container crop's N-uptake enables growers to match fertilizer application with the demand of the plant and to reduce leaching of N. By measuring the above ground fresh matter of representative plants, N-uptake can be estimated. An additional charge has to be considered for the roots. Knowledge concerning the biomass of shoots (aerial tissue) and roots will improve the estimated N-uptake of the crop. However, more data are necessary to improve the prediction of N-uptake from the biomass. Since the mineral N-content in the substrate is correlated with the biomass in June and August, but not in May (approx 6 weeks after potting), high fertilizer doses in May will increase leaching, while refertilization in August can increasee the growth through September. Due to the low amount of available water in peat-reduced substrates irrigation has to be carried out more frequently in smaller volumes to avoid leaching.

Introduction

Growing plants in containers is a well-established production method. The large number of cultivars makes it difficult to compile fertilizer recommendations. N-uptake is low; in the literature it is reported that not more than 56% of the added N is taken up by plants (3). Struve et al. (20) calculated nitrogen recoveries from 2 to 19%. Correspondingly, Alt et al. (2) found 40% (*Corylus avellana*) and 80% (*Ribes sanguineum*) of N given with the fertilizer which was recovered neither in the plant nor in the substrate ('unknown residuals' in N balances).

For soil-grown trees nutrient uptake was related to above ground biomass (1, 11). Thus, knowing the above ground fresh matter it is possible to estimate the uptake of N. Roots are estimated to be 30% of the shoot's N-content (1). Although there are data concerning % N in the biomass, only rarely is total N-uptake reported for container-grown plants. Even less information is available concerning the contribution of roots. Hence the concept to estimate N-uptake from plant biomass as introduced by Alt (1) for soil-grown plants will be tested for container-grown plants. The aim of this study was to answer the following questions in a container production system:

- Does the mineral N-content of the substrate or the fertilizer type affect the biomass production of the plants?
- What is the relation between biomass and N-content of the plant?
- Is there a relation between biomass and other growth parameters such as height or number of shoots?

The experiments were carried out with two types of substrates. One type consists mainly of white peat, which is little decomposed peat. In most cases this substrate is used by growers. Due to ecological reasons because of peat extraction there is pressure to reduce the use of white peat. From this so-called peat-reduced or peat-free substrates are increasingly important. Substrates used in the experiments consisted mainly of components which fulfilled the quality regulations (13, 14, 15) for these specific constituents.

Materials and Methods

Weigela 'Bristol Ruby' and *Forsythia* x *intermedia* were chosen as examples of plants with a 'medium to high' N-demand, *Prunus laurocerasus* 'Otto Luyken' as an example for 'medium to low' N-demand. This classification is based on fertilizer recommendations provided by fertilizer producers (19). One-year-old rooted cuttings were potted into peat-free or peat-reduced substrates (Table 1). Spacing of plants was 30 × 30 cm (12 × 12 in). They were not pruned during the vegetation period. A white peat substrate served as the control. Plants were fertilized with Osmocote 6M, 16+8+12+2+micronutrients (Scotts[4]) or by two organic fer-

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Table 1. Substrates, plants and fertilizers in the experiments.

Treatments		
Substrate [v/v]	**Fertilizer**	**Plant**
Peat-free		
40% substrate compost[z]	Osmocote 800 mg N/l (O800)	*Weigela* 'Bristol Ruby'
30% bark compost[y]	Maltaflor universal 800 mg/l[w] (M800)	
30% wood fibre[x]	Maltaflor universal 1200 mg/l[w] (M1200)	
Peat-free		
40% substrate compost[z]	Osmocote 400 mg N/L (O400)	*Prunus laurocerasus* 'Otto Luyken'
30% bark compost[y]	Maltaflor universal 400 mg N/l[v] (M400)	
30% wood fibre[x]	Maltaflor universal 800 mg N/l[v] (M800)	
White peat 1 served as control for *Weigela* 'Bristol Ruby' and *Prunus l.* 'Otto Luyken', same fertilizer as in peat-free substrates		
Peat-reduced		
30% white peat	Osmocote 800 mg N/l (O800)	*Forsythia* x *intermedia* 'Lynwood'
30% substrate compost[z]	Maltaflor special 1200 mg N/l[v] (M1200)	
20% wood fibre[x]	Günther Cornufera 1200 mg N/l[v] (G1200)	
20% rice hulls		
White peat 2 served as control for *Forsythia* x *intermedia* 'Lynwood', same fertilizer as in peat-reduced substrate.		

[z,y,x]According to quality regulations for substrates (14, 13, 15).

[w]Divided into 4 doses; applied at potting and the beginning of July, August, September.

[v]Divided into 3 doses; applied at potting and the beginning of July and August.

tilizers (Maltaflor[5], Günther Cornufera[6]). Osmocote is a controlled-release fertilizer, Maltaflor and Günther Cornufera are plant derived organic fertilizers. *Weigela* 'Bristol Ruby' and *Forsythia* x *intermedia* received 800 mg N/liter, and *Prunus laurocerasus* 'Otto Luyken' 400 mg N/liter substrate (0.14 and 0.07 oz/plant, resp.). Osmocote was mixed into the substrates at potting. Plants receiving organic fertilizers received several doses (Table 1) with refertilization by topdressing. Plants were cultivated in 5 liter (# 1.3) containers and irrigated via drip irrigation. The water tension was measured with tensiometers, which were connected to an irrigation device. Irrigation started automatically when the water tension reached 100 hPa. To prevent leaching the amount of water per irrigation event was adapted to the amount of available water (AW) (Table 2) per container.

The experiments were carried out in a split-plot-design with three replications with the substrates as main blocks and the fertilizers as sub-plots. Plants were measured (height, number of shoots) and plant and substrate samples were taken five or four times during the production, respectively. Total fresh and dry matter of the plants was measured. Their N-content was determined by Dumas combustion analysis (7). Ashing of plants was carried out at 105C until a constant weight was achieved. The substrates were analysed for their mineral N-content (8). NO_3-N and NH_4-N were determined photometrically with a rapid flow analyser (RFA 300, Alpkem Corp.). Water tension was measured weekly. Air and water characteristics of the substrates were determined with the M-ISHS-method (23).

Statistical evaluation was carried out with R (12). No distinction was made between species and year of the experiment. The first step for the statistical evaluation was to check which model (linear or non-linear) describes the data best and which factors (mineral-N content, substrate, fertilizer, and all interactions) influence the data. The decision was made based on highest r^2. First, all the factors and interactions were focused for the linear model, then for the non-linear. Factors and interactions without an improvement for the statistical model (no increasing r^2) were eliminated. Later on, it turned out that only certain remaining factors were significant. Only for these models an ANOVA was carried out.

Results and Discussion

In only one case (see below) were interactions significant, hence main effects are presented.

Biomass of shoots and roots and other growth parameters. The fresh matter of the shoots (aerial tissue) varied between 87 and 580 g/plant, shoot dry matter ranged between 71 to

Table 2. Physical properties of the four substrates used in the experiment.

Substrate	Total porespace (v/v, %)	Air volume at 10 [hPa] (v/v, %)	Water volume at 10 [hPa] (v/v, %)	Available water between 10 and 100 [hPa] (v/v, %)
Peat-free	88.3 (SD ± 1.0)	36.1 (SD ± 0.5)	52.2 (SD ± 0.7)	15.6 (SD ± 2.6)
White peat 1	94.5 (SD ± 0.5)	21.0 (SD ± 5.1)	73.5 (SD ± 4.7)	34.1 (SD ± 0.8)
Peat-reduced	77.0 (SD ± 0.9)	21.2 (SD ± 3.7)	59.9 (SD ± 3.0)	21.3 (SD ± 2.6)
White peat 2	90.1 (SD ± 0.4)	7.1 (SD ± 2.7)	83.8 (SD ± 2.4)	37.1 (SD ± 4.8)

In parentheses: standard deviation

Table 3. Fresh matter, dry matter, and N-uptake of the plants at the end of the vegetation period.

Plant	Year	Substrate	Fertilizer	Fresh matter (g/plant) shoot	Dry matter (g/plant) shoot	Dry matter (g/plant) roots	Shoot:root ratio	Dry matter as a % of fresh matter	N-uptake (g/plant) shoot	N-uptake (g/plant) roots	N-uptake (g/plant) total	N-uptake roots as a % of shoots
Weigela ,B.R.	2001	peat-free	O800	343	133	68	2.0	39	1.11	0.68	1.79	61
		peat-free	M800	295	103	82	1.3	35	0.73	0.82	1.55	112
		peat-free	M1200	351	113	84	1.3	32	0.91	0.92	1.83	101
Weigela ,B.R.	2002	white peat	O800	580	247	11	22.5	43	1.68	0.12	1.80	7
		white peat	M800	410	179	15	11.9	44	1.20	0.15	1.35	13
		white peat	M1200	570	242	15	16.1	43	1.89	0.16	2.05	8
		peat-free	O800	330	122	15	8.1	37	0.98	0.16	1.14	16
		peat-free	M800	220	76	21	3.6	35	0.66	0.23	0.89	35
		peat-free	M1200	300	108	36	3.0	36	0.98	0.43	1.41	44
Prunus l.'O.L.'	2002	white peat	O400	134	105	n.d.	n.d.	78	1.03	n.d.	n.d.	n.d.
		white peat	M400	116	87	n.d.	n.d.	75	0.97	n.d.	n.d.	n.d.
		white peat	M800	154	102	n.d.	n.d.	66	1.47	n.d.	n.d.	n.d.
		peat-free	O400	116	76	n.d.	n.d.	66	1.51	n.d.	n.d.	n.d.
		peat-free	M400	87	71	n.d.	n.d.	82	1.35	n.d.	n.d.	n.d.
		peat-free	M800	93	77	n.d.	n.d.	83	1.97	n.d.	n.d.	n.d.
Forsythia x *i.*	2003	white peat	O800	513	210	242	0.9	41	1.74	1.29	3.02	74
		white peat	M1200	507	204	159	1.3	40	1.58	1.09	2.67	69
		white peat	M1200	539	220	197	1.1	41	1.77	1.17	2.94	66
		peat-reduced	O800	358	136	257	0.5	38	1.41	2.22	3.63	158
		peat-reduced	M1200	263	94	213	0.4	36	0.93	1.55	2.48	167
		peat-reduced	M1200	298	109	220	0.5	37	0.80	1.38	2.18	173

247 g/plant (Table 3). For *Magnolia soulangeana*, *Forsythia* x *intermedia* 'Flojor', *Caryopteris* x *clandonensis* 'Heavenly Blue', *Hydrangea paniculata* 'Grandiflora' dry matter of 70–115 g/plant were reported (9). Craig et al. (6) found 70–170 g/plant (*Aronia arbutifolia* and *Cotoneaster dammeri*). For *Weigela* 'Bristol Ruby' dry matter varied from 77–137 g (4). In the experiments reported in the literature rooted cuttings or young seedlings are used while plants in the experiments presented here are one year older.

Dry matter of the deciduous shrubs (without *Prunus l.*) is 38% of the fresh matter, with a variation of 32 to 44%. Dry matter of *Prunus l.* amounted to 75% of the fresh matter (Table 3). In the experiments of Andersen and Hansen (3) the dry matter was only 24% of the fresh matter. Alt (1) reported for soil-grown trees and shrubs 37% as the ratio of fresh matter to dry matter with a variation of 25 to 46%. Except for *Prunus l.* the ratio of fresh matter to dry matter of the container grown plants is in the range of those grown in the soil.

Allocation of biomass to the roots differed widely. The shoot to root ratio varied between 0.4 and 22.5, being higher than 10 only three times out of 15 (Table 3). Craig et al. (6) reported shoot to root ratios of 2 and 5 for *Aronia arbutifolia* and *Cotoneaster dammeri* respectively. An increasing shoot to root ratio from 1 to 10 with increasing nitrogen application rate was measured in experiments with *Ternstroemia gymnanthera* by Conden et al. (5). Similarly Larimer and Struve (10) stated the relative dry weight of roots from seedlings of *Quercus rubra* decreased with increasing N-fertigation from 69 to 53% and of roots from *Acer rubrum* from 50 to 33% of the total dry weight. In a review of the literature Alt (1) calculated a mean shoot to root ratio for deciduous trees and shrubs of 2.8–3.3 and for coniferous trees of 3.0–3.1, the mean of both being 3.1. Apart from the exceptions already mentioned, the shoot to root ratios in the experiments presented here are in the range given in the literature. For *Weigela* and *Forsythia* the shoot to root ratios are — though not statistically significantly ($p = 0.07$) — lower in the peat-reduced substrates compared to white peat. Plants with a high shoot to root ratio may have difficulties surviving in environments where water and nutrients are not easy available (10).

Trees and shrubs are not sold according to their biomass, but according to their height and number of shoots. For both white peat and peat-reduced substrates the relation between the height of plants and the above ground biomass was best described by an exponential equation (white peat: $y = 0.37x^{0.88}$, r^2 0.85; peat-reduced $y = 0.23x^{1.01}$, r^2 0.82). In both cases the slope is significant ($p < 0.001$). Concerning the number of shoots there was a linear relation, the slope and the intercept are significant ($p < 0.05$). However, the determination coefficient (hereinafter abbreviated as r^2) was low (0.23). From this it can be concluded that increasing aboveground biomass favours plant height, but not the number of shoots.

Above ground biomass in relation to mineral N in the substrate, kind of substrate, and type of fertilizer. All data are presented in Tables 3 and 4. The mineral N-content in the substrate from May until August significantly influenced the fresh matter produced until October ($p < 0.01$). Moreover, the kind of substrate influenced the fresh matter production from May to August ($p < 0.05$), in August there was an interaction with the substrate ($p < 0.001$). In no case the type of fertilizer had a statistically significant effect nor showed interactions.

As an example Fig. 1 shows the relation between mineral N in the substrate in June and fresh matter of the plants in October. Less than 200 g fresh matter/plant is produced by *Prunus laurocerasus* 'Otto Luyken'. Within this group slightly higher fresh matter production results from plants grown in white peat. Concerning *Forsythia* x *intermedia* and *Weigela* all plants grown in peat-reduced and peat-free substrates yield a lower fresh matter (> 200 and < 400 g/plant) than those grown in white peat (> 400 g/plant).

Table 4. Mineral N-content in the substrates.

Plant	Year	Substrate	Fertilizer	Mineral N-content (mg/l)			
				May	June	August	October
Weigela ‚B.R.'	2001	peat-free	O800	90	47	28	17
		peat-free	M800	47	25	10	6
		peat-free	M1200	13	7	22	6
Weigela 'B.R.'	2002	white peat	O800	263	230	61	50
		white peat	M800	119	69	116	18
		white peat	M1200	161	183	237	48
		peat-free	O800	137	183	59	89
		peat-free	M800	3	69	85	66
		peat-free	M1200	7	124	115	129
Prunus l.'O.L.'	2002	white peat	O400	n.d.	45	7	4
		white peat	M400	n.d.	14	11	2
		white peat	M800	n.d.	38	20	4
		peat-free	O400	n.d.	83	28	45
		peat-free	M400	n.d.	17	26	13
		peat-free	M800	n.d.	48	78	33
Forsythia x *i.*	2003	white peat	O800	73	96	82	62
		white peat	M1200	11	89	73	73
		white peat	M1200	93	60	93	64
		peat-reduced	O800	46	204	150	133
		peat-reduced	M1200	21	46	67	96
		peat-reduced	M1200	38	38	54	138

The best fit (r^2) for the relation between mineral N in the substrate and fresh matter production of the plants is given using different equations: exponential ($y = ax^b$), logarithmic ($y = a(\ln)x + b$), and linear ($y = ax + b$) (Table 5). The equations are valid only in the range of mineral N contents measured in these experiments (3–260 mg N/liter). Only for the white peat substrate is there — from June until August — a statistically significant positive effect of the mineral N-content in the substrate on the amount of fresh matter produced until October. In the peat-free and peat-reduced substrates this was the case only in August; however, r^2 was very low. From May to August the determination coefficients are not higher than 0.34 for the peat-free and peat-reduced substrates, indicating that at most 30% of the variation in fresh matter can be explained by the mineral N-content in the substrate. For the white peat substrates r^2 is almost 0 in May and increases in August (0.82). (Table 5). From Fig. 1 it can be hypothesized that the fresh matter production in plants grown

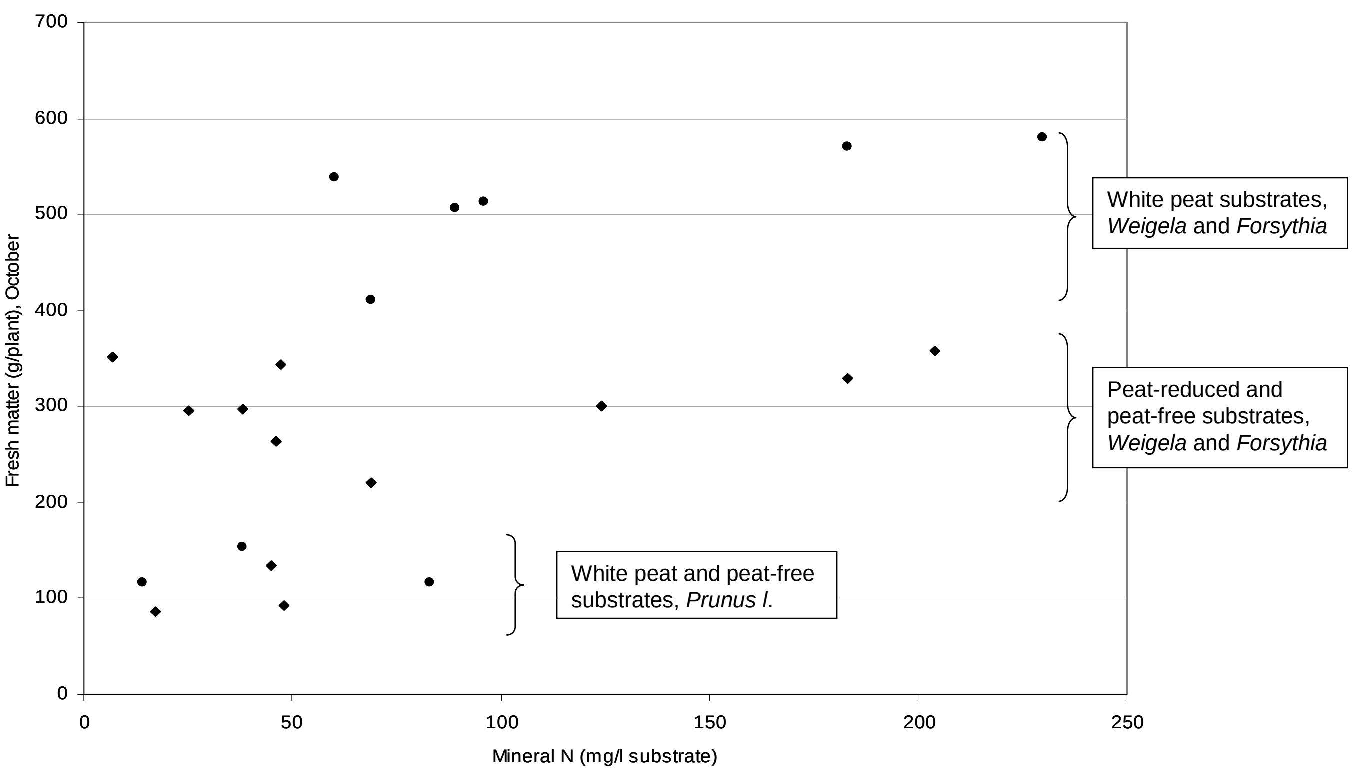

Fig. 1. Fresh matter produced until October in relation to mineral N in the substrate in June.

Table 5. **Summary of estimated parameters and determination coefficient (r^2) of the regression of the N-content in the substrate and the fresh matter production until October.**

	White peat substrates				Peat-reduced and peat-free substrates			
	Type of regression	a	b	r^2	Type of regression	a	b	r^2
May	$y = ax + b$	0.3 ns	480.9***	0.01	$y = ax^b$	230.4***	0.08 ns	0.34
June	$y = a(\ln)x + b$	201.0**	–459.8 ns	0.69	$y = ax + b$	0.53 ns	214.9***	0.02
August	$y = ax^b$	40.9***	0.54***	0.82	$y = ax + b$	225.3**	0.49 ns	0.05

in white peat substrates is greater than those grown in peat-reduced substrates. This is confirmed by the t-test ($p < 0.05$).

In May, the mineral N-content in the substrate does not influence plant fresh weight produced until October. This is not surprising since plant growth and N uptake is very small at the beginning of the vegetation period (4, 6). Release of nutrients from controlled-release fertilizers can be low in this period of time. Matching nutrient to crop demand will minimize nutrient loss and reduce fertilizer cost. Mineral N-content from May to June ranges from 7 to 263 mg/liter. According to Schütt et al. (18) optimum growth can be expected when the N concentration in the substrate is above 30 mg/liter, provided there is further N supply from either slow-release fertilizer or N mineralization from organic fertilizers or refertilization. Similar results were reported by Röber and Rohde for *Forsythia* x *intermedia* (16, I), *Lonicera xylosteum* (16, II), and *Philadelphus inodorus* (16, III). Only in five cases (out of 24) was the mineral N-content less than 30 mg/liter (Table 4). Higher substrate mineral N-content had no influence on the fresh matter production of the plant. Based on the determination coefficients 70 to 80% of the fresh weight variations can be explained by the mineral N-content of the substrate. For the peat-reduced substrate the mineral N-content is between 3 and 204 mg/liter, being less than 30 mg N/liter 12 times (out of 33) (Table 4). But the r^2 is very small. The influence of the mineral N content in the substrate on plant growth seems to be overridden by another growth factor. This is supported by grouping the data in Fig. 1 which shows that with a similar mineral N content the peat-reduced substrate yields plants with less fresh weight. From

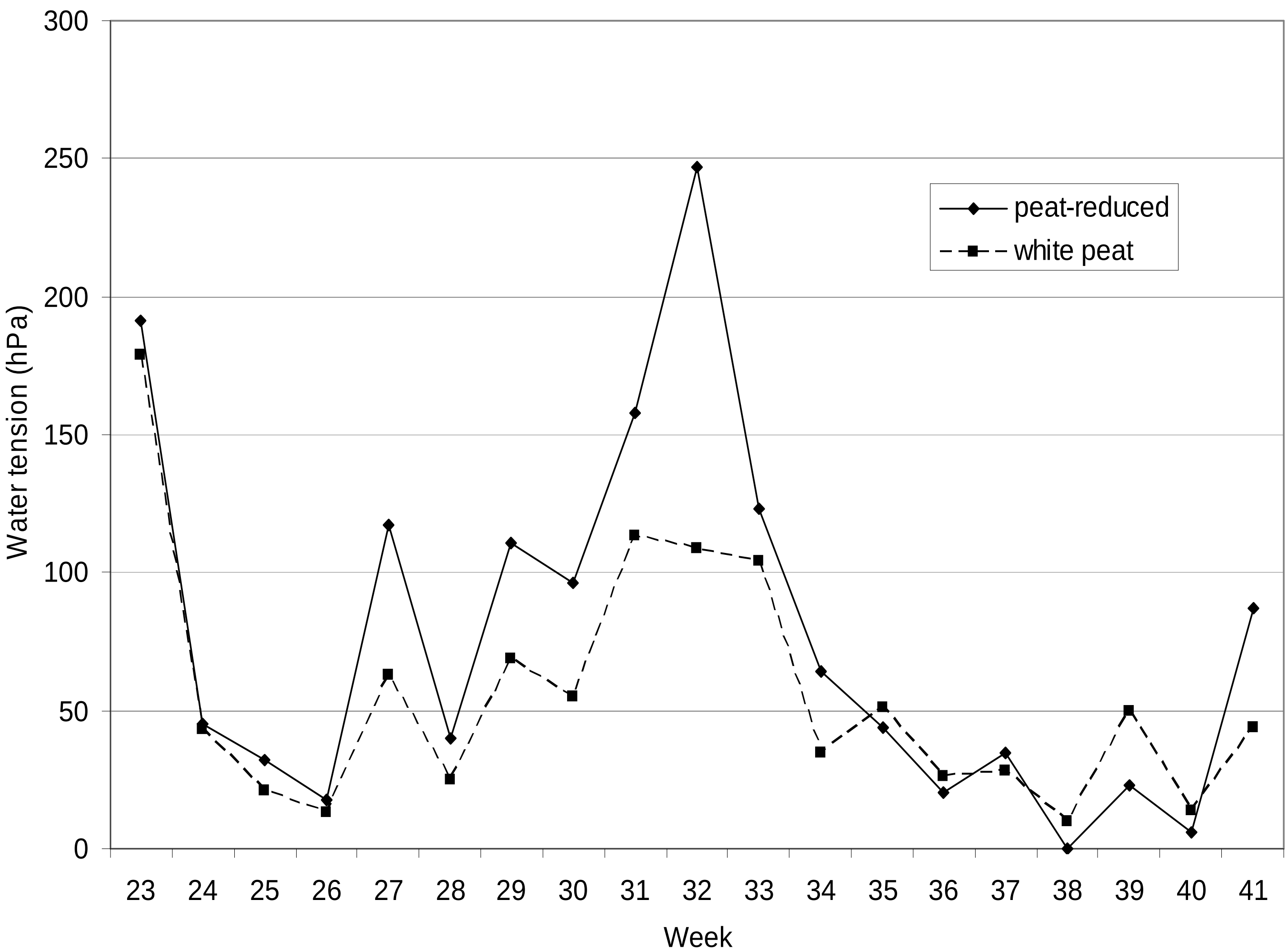

Fig. 2. Water tension during growth of *Forsythia* x *intermedia* 'Lynwood' in a peat reduced and in a white peat substrate.

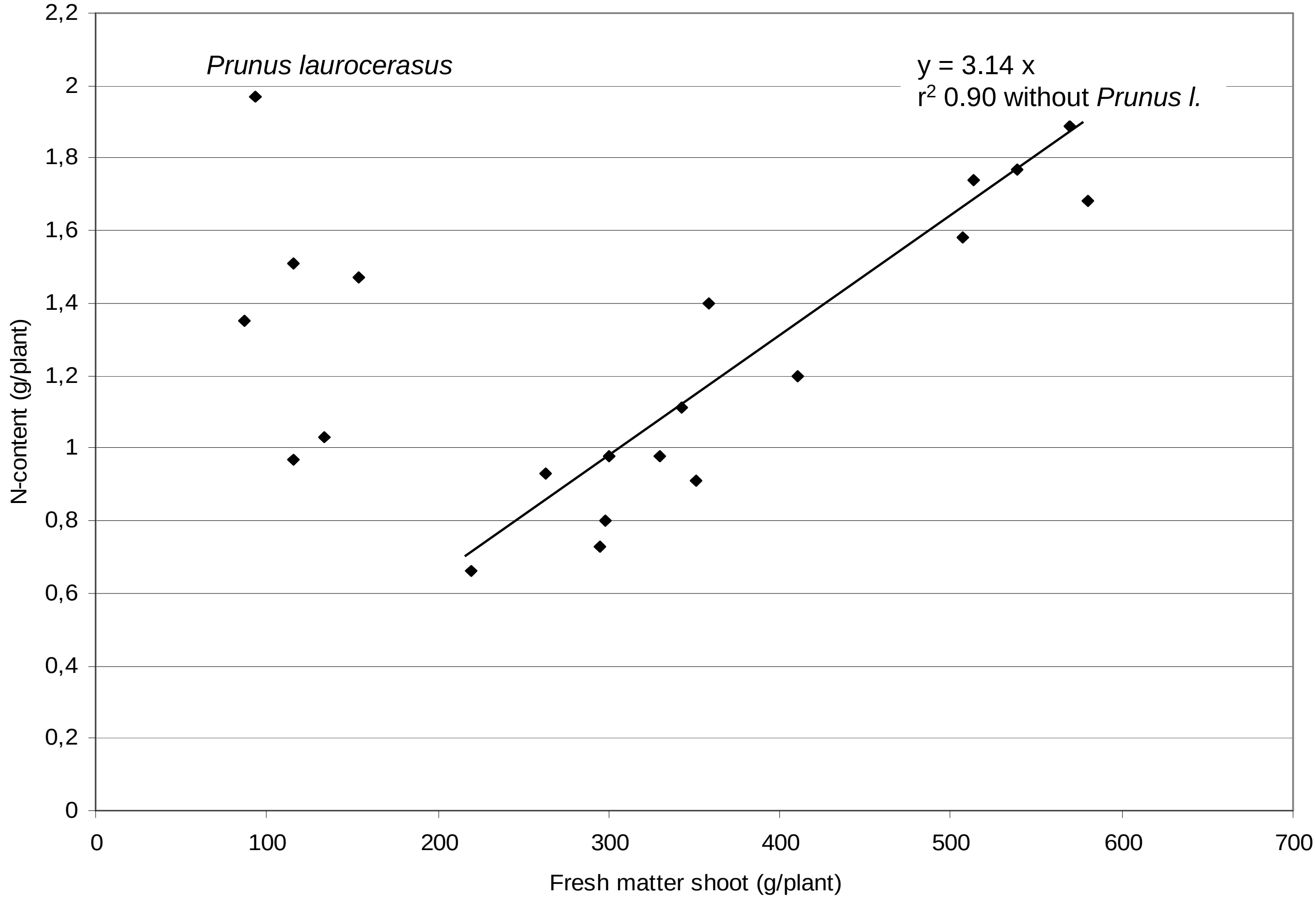

Fig. 3. N-content in the shoot in relation to shoot fresh matter (end of vegetation period).

this and from the small r^2 it is not the mineral N content but another growth factor which impaired plant growth in the peat-reduced substrate. This is supported by the %N in the one-year-old shoots, which were in the range 0.76–1.16 for *Weigela* and *Forsythia* (data not given). For *Lonicera xylosteum* 0.5–0.7% N is reported to be sufficient (16, II) and for *Philadelphus inodorus* 0.6–0.9% N (16, III). From this we hypothesized that the available water (AW) in the peat-reduced substrates was not adequate. The amount of AW is less in peat-reduced substrates (Table 2) compared to white peat and water tension during plant growth was higher during periods with high water demand (Fig. 2 as an example for *Forsythia* x *intermedia*). Thus, irrigation frequency has to be increased with peat-reduced and peat-free substrates.

N-uptake in relation to plant fresh matter. Fig. 3 shows the relation between the amount of fresh matter in the shoots and the N-content. For plants with fresh matter between 200 and 600 g per plant there is a linear relation between fresh matter and N-content of the shoots. For amounts of fresh matter < 200 g/plant there is no such relation. In these cases the wintergreen shrub *Prunus laurocerasus* 'Otto Luyken' was investigated, while plants with more than 200 g fresh matter/plant are *Weigela* 'Bristol Ruby' and F*orsythia* x *intermedia* 'Lynwood'. Since there were not enough data to test the difference between wintergreen and deciduous plants, the option of a statistical evaluation was abandoned and a linear regression excluding the data of *Prunus laurocerasus* 'Otto Luyken' was calculated. There were no difference between the slopes for the white peat and the peat-reduced substrates. Since slopes and intercepts are very similar (results not shown) data for both substrates are used to calculate the linear regression (y = 3.14x). From this approximately 0.31 g N is taken up when 100 g fresh matter (shoot and leaves) was produced. Most of the data are within a confidence interval of ± 0.1 g N/100 g fresh matter, in one case the calculated data underestimate the measured N uptake by 0.29 g. The N uptake of roots in relation to the shoots varied much (between 7 and 170%) with the mean of 81%. Hence, total N uptake of a plant with 100 g fresh matter amounts to 0.56 g. However, deviation from actual data due to the variations in root growth can be large. The N-uptake of the wintergreen shrub *Prunus laurocerasus* is much higher: 1.18 g N/100 g fresh matter (shoots).

Relating N uptake to fresh matter production is an easy-to-apply instrument for growers to assess the N uptake of their crop by measuring the aboveground amount of fresh matter of representative plants. In most cases only dry matter and N concentrations are reported in the literature which does not allow the calculation of total N uptake. Total N-content, however, is essential for fertilization. The following data were taken from the literature by estimating fresh matter from dry matter using the already mentioned proportion of 38% dry matter. Craig et al (6) showed an N-uptake of 0.8 and 3.1 g/plant (*Cotoneaster dammeri* 'Coral Beauty', *Aronia arbutifolia* 'Brilliantissima', shoot), which is approximately

0.76 and 0.87 g N/100 g shoot fresh matter. For *Cotoneaster dammeri* 'Skogholm' an N uptake of 0.30 and 0.38/100 g fresh matter was calculated (22), for *Rhododendron* 'Sunglow' 0.38, 0.57 and 0.59 g N/100 g fresh matter (21). Larimer and Struve (10) reported a calculated uptake of 0.33 g N/100 g fresh matter for *Quercus rubra* and 0.65 g N/100 g fresh matter for *Acer rubrum* seedlings. For rooted cuttings of *Acer* x *freemanii* E. Murr. 'Jeffersred' (17) a N-uptake of 0.27–0.30 g in one growing season and 0.37–0.48 g in another growing season was calculated. Our own data give 0.31 g N/100 g fresh matter which is at the lower end of this range. In these experiments one-year old rooted cuttings were used and the total plant was harvested, including older shoots which are lower in %N of the dry mass.

For field-grown trees and shrubs Alt (1) found an uptake of 0.52 g N/100 shoot when including the old shoots compared to 0.62 g N for the new shoots only (11). For soil-grown deciduous trees and shrubs the N-uptake of the roots is reported to be 30% of the uptake of the shoots (1) which is much lower than for container grown plants.

Although there is a relation between fresh matter and N-uptake as shown by Alt (1) and Obermayr and Alt (11) for soil-grown trees and shrubs, for container-grown crops this could only be determined from data from one experimental site. Not all data from the literature fit into the relation, indicating that additional growth factors influence biomass and N uptake. However, 50% of all data reported here are within the range of 0.3–0.4 g N/100 g fresh matter. Knowing the relation between fresh matter and N-content for specific growing conditions will help to obtain an estimate concerning the N-uptake of a crop.

The amount of fresh matter of shoots varied between 220 and 580 g/plant (except *Prunus l.*). The highest N uptake measured (shoot and roots) for *Forsythia* x *intermedia* was 3.63 g/plant, for *Weigela* 'Bristol Ruby' 2.05 g/plant (Table 3). In fertilizer recommendations (15) *Forsythia* is classed as high N-demand, *Weigela* as medium N-demand. This is confirmed by the data reported here. For plants with a high N-demand of 5.5–6.5 g/liter fertilizer (Plantacote Depot 8M, 14 %N) is recommended, which means an N input of 3.85–4.55 g N for a 5 liter (# 1.3) container. The corresponding amount for crops with medium N demand is 4.5–5.5 g/liter fertilizer, respectively; 3.15–3.85 g N/5 liter (# 1.3) container. This is more than the highest N uptake measured. Furthermore, peat-reduced substrates with compost can contain available N which has to be taken into account. From this leaching of N is to be expected. For *Prunus laurocerasus* 'Otto Luyken', however, the measured N uptake did not confirm that this crop has a low N-demand.

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