

## Drain of nutrients imposed when *Aphis sambuci* and *A. fabae* feed on the inflorescence of *Yucca flaccida*, and the amounts retained by the aphids

P. M. L. TAMMES<sup>1</sup> and J. VAN DIE<sup>2</sup>

<sup>1</sup> Centre for Plant Physiological Research, Wageningen

<sup>2</sup> Department of Botany, University of Utrecht

Accepted 22 July 1975

### Abstract

For the production of 1 g dry weight of aphids about 10 g dry weight (55 ml) of sieve tube sap of *Yucca flaccida* is required, provided all N taken up by the aphids is retained by them. The production capacity of an average *Yucca* leaf was calculated at 4 mg dry weight of aphids per day or 30 µg per cm<sup>2</sup> leaf area per day. Compared with N only about 30% of the P, K, Na, Mg, and Ca ingested by the aphids is retained by them, apparently in the same mutual ratios as these elements occur in the sieve tube fluid.

### Introduction

*Aphis sambuci* L. and *A. fabae* Scop. have regularly been found on the inflorescences of *Yucca flaccida* Haw. Populations of the former were found on the base of the young inflorescence stalk, and those of the latter species developed near the tips of the inflorescence branches. As the composition of the sieve tube exudate of the inflorescence stalk is known in many details (Tammes and Van Die, 1964, 1966; Van Die, 1968; Van Die and Tammes, 1975), we could compare the composition of an aphid with that of its diet. Such a comparison could give some value for estimating the drain of nutrients from a plant caused by an aphid population feeding on it, and it also may show which nutrients are retained, and how much of them, by the aphids.

### Material and methods

Sieve tube exudate was tapped as described by Van Die and Tammes (1975). Samples of the aphid colonies were scraped off the stalks, freeze dried, stored in a desiccator above sulphuric acid, weighed, and the number of specimen in a sample determined by counting and weighing a subsample of 300 aphids at random. A sample of *A. fabae* on *Dahlia* was added for comparison. The aphid samples contained wingless specimen at all stages of development. The methods of analysis were the same for exudate and aphids (Van Die, 1974). All analytical results are expressed on a dry weight or on a total-ash basis, the latter having the advantage of being independent of losses of carbon due to respiration.

## Results and discussion

The results of the analyses presented in Table 1 show a good agreement in order of magnitude of the mineral composition of the aphids and that of their diet, i.e. the sieve tube exudate, if expressed on a total-ash basis. Apparently an appreciable selective uptake by the aphids of one or more of the mineral elements does not take place. 1 g dry weight of aphids contained the nitrogen of about 10 g of dry sieve tube sap, but the ash constituents of only about 3 g of it. Therefore at least 70% of the ingested mineral elements, together with the bulk of the sieve tube sucrose, is supposed to be excreted as honeydew by the aphids. This is in accord with the high K content of honeydew reported in literature (e.g. Peel, 1963). It should be stressed that the 70% value is a minimum value based on a 100% utilization of the ingested nitrogen by the aphid. If only 60% of the ingested N were utilized, it becomes a factor 1.7 higher, and thereby is in good agreement with the findings of Banks and Macaulay (1965) that 20% of the ingested solids and 50–70% of the ingested N are utilized for growth by *A. fabae* on *Vicia faba*.

The efficiency of the N utilization by the aphid found by Banks and Macaulay (1965) is lower than in other reports. Ziegler (1956) found that only 0.7% of the N of sieve tube sap of *Hedera* could be recovered in the honeydew of a coccid feeding on it. Mittler (1958 a and b) showed that 55–70% of stylet (sieve tube) exudate of the willow is taken up by the nymphs and 70–100% by mature specimens of *Tuberolachnus salignus*.

From the rather small differences in composition of *A. fabae* feeding on either *Dahlia* or *Yucca* (Table 1) may be inferred that the sieve tube fluids of both plant species are also rather similar in composition. Although that of *Dahlia* has not been reported in literature, it is known (Van Die and Tammes, 1975) that sieve tube exudates in general have a rather uniform composition, regardless the plant species from which they are obtained.

In a previous study (Van Die et al., 1973), a *Yucca* plant produced an average of 5.7 ml of exudate per day during 8 days, which probably contained all products of photosynthesis of its 25 leaves. Consequently about 100 mg of aphid dry matter may be produced daily per plant, or 4 mg per leaf, or 30 µg per cm<sup>2</sup> of leaf area, provided

Table 1. Composition of aphids on *Dahlia* and on *Yucca*, and of *Yucca* sieve tube exudate.

	Number of aphids per g dry weight	mg/g dry weight			mg/g ash				
		ash	N	P	P	K	Na	Ca	Mg
<i>Aphis fabae</i> on:									
<i>Dahlia</i>	7200	66	69.3	1.52	23	280	2	3	27
<i>Yucca flaccida</i>	9400	74	79.2	1.78	24	227	3	7	26
<i>Aphis sambuci</i> on:									
<i>Yucca flaccida</i>	7900	57	59.8	1.69	30	287	2	4	24
Sieve tube exudate from									
<i>Yucca flaccida</i>		24	6.8	1.0	42	350	1	3	23

Tabel 1. Samenstelling van luizen op *Dahlia* en op *Yucca*, en van *Yucca* zeefvatensap.

a 100% retainment of the ingested nitrogen. If only 75% of the ingested N were retained by the aphids, then the calculated capacity of the plant to produce aphids, as given in the figures above, should be multiplied by 0.75.

### Acknowledgments

The authors are indebted to Dr D. Hille Ris Lambers for identifying the aphid species and for advice, to Mr P. Harrewijn for literature, to Miss Netty Willemse for careful analysis, and to Mr J. C. Rigg for checking the English.

### Samenvatting

*Drainage van voedingsstoffen uit Yucca flaccida door Aphis sambuci en Aphis fabae op de bloeiwijze, en de hoeveelheden die door de luizen worden opgenomen*

Bij een aangenomen 100% benutting van de door luizen uit zeefvaten opgenomen N, is voor de ontwikkeling van 1 g drooggewicht van *A. fabae* en *A. sambuci* ca. 10 g droog zeefvatensap nodig (55 ml). De productiecapaciteit van een *Yucca* blad van gemiddelde grootte werd berekend op 4 mg droge luis per dag, overeenkomend met ca. 30 µg per cm<sup>2</sup> bladoppervlak.

Vergeleken met die van de N is de benutting van de door de luizen opgenomen hoeveelheden P, K, Na, Mg, en Ca slechts ongeveer 30%; dit gebeurt in ongeveer dezelfde onderlinge verhoudingen als waarin deze elementen in het zeefvatensap aanwezig zijn (Tabel 1).

### References

- Banks, C. J. & Macaulay, E. D. M., 1965. The ingestion of nitrogen and solid matter from *Vicia faba* by *Aphis fabae* Scop. Ann. appl. Biol. 55: 207–218.
- Die, J. van, 1968. The use of phloem exudate from *Yucca flaccida* Haw. in the study of translocation of assimilates. Vertr. GesGeb. Bot., n. F. 2: 27–30. Fischer Stuttgart.
- Die, J. van, 1974. The developments of the fruits of *Cocos nucifera* and *Phoenix dactylifera* as physiological sinks importing and assimilating the mobile aqueous phase of the sieve tube system. Acta bot. neerl. 23: 521–540.
- Die, J. van & Tammes, P. M. L., 1975. Phloem exudation from monocotyledonous axes. In: Zimmerman, M. H. & Milburn, J. E. (Eds), Encyclopedia of plant physiology; New series. Springer, Berlin, Heidelberg, New York. Vol. 1.
- Die, J. van, Vonk, C. R. & Tammes, P. M. L., 1973. Studies on phloem exudation from *Yucca flaccida* Haw. XII. Rate of flow of <sup>14</sup>C-sucrose from a leaf to the wounded inflorescence tip. Evidence for a primary origin of the major part of the exudate sucrose. Acta bot. neerl. 22: 446–451.
- Mittler, T. E., 1958a. Studies on the feeding and nutrition of *Tuberolachnus salignus* (Gmelin) II. The nitrogen and sugar composition of ingested phloem sap and excreted honey dew. J. exp. Biol. 35: 74–84.
- Mittler, T. E., 1958b. Studies on the feeding and nutrition of *Tuberolachnus salignus* (Gmelin) III. The nitrogen economy. J. exp. Biol. 35: 626–638.
- Peel, A. J., 1963. The movement of ions from the xylem solution into the sieve tubes of willow. J. exp. Bot. 14: 438–447.
- Tammes, P. M. L. & Die, J. van, 1964. Studies on phloem exudation from *Yucca flaccida* Haw. I. Some observations on the phenomenon of bleeding and the composition of the exudate. Acta bot. neerl. 13: 76–83.
- Tammes, P. M. L. & Die, J. van, 1966. Studies on phloem exudation from *Yucca flaccida* Haw. IV. *Neth. J. Pl. Path.* 82 (1976)

Translocation of macro and micro nutrients by the phloem sap stream. Proc. ned. Akad. Wet. Sect. C69.5: 655–659.  
Ziegler, H., 1956. Untersuchungen über die Leitung und Sekretion der Assimilate. Planta 47: 447–500.

### **Addresses**

Dr P. M. L. Tammes, Centrum voor Plantenfysiologisch Onderzoek, P.O. Box 14, Wageningen, the Netherlands.  
Prof. Dr J. van Die, Botanisch Laboratorium van de Rijksuniversiteit, Lange Nieuwstraat 106, Utrecht, the Netherlands.