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A physiological approach to reduce population densities of *Colchicum autumnale* L. in extensively managed grasslands

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Abstract

In parts of Germany, high densities of toxic *Colchicum autumnale* in extensively managed grasslands cause problems in hay marketing. As a solution to reduce population densities, early mowing is indicated in the literature. However, opinions on the best date for leaf removal differ between authors. In contrast to other studies, we use a physiological approach, suggesting mowing when nutrient contents are high in above-ground plant parts and low in the storage organ. To this end, we assessed nutrient content in above- and below-ground biomass during one vegetation period. Every ten days from April until June 2009, a sample of 15 plants was collected from each of three German *C. autumnale* populations within one biogeographical region. Plant parts were analysed for N, P, K, and starch. As the plant corm is renewed every year, old and new corm were both analysed. Nutrient content in the above-ground biomass increased until the beginning of May; in the old corm most nutrients decreased until the same time, while nutrients in the new corm increased steadily. Our results suggest an optimal mowing in late April/early May to reduce plant density.

Keywords: Meadow saffron, resource depletion, starch, mowing date, segmented regression analysis

Introduction

In parts of Germany, high densities of toxic *Colchicum autumnale* in extensively managed grasslands cause problems in hay marketing. Consequently, there is a risk of management intensification or abandonment and the loss of valuable, high-diversity habitats. Under extensive management, *C. autumnale* profits from its extraordinary life cycle. At the beginning of the vegetation period, storage reserves of the corm are mobilized for leaf growth. Shortly thereafter, new storage reserves are built up in a new corm which gradually replaces the old corm. As a solution to reduce population densities, leaf removal is recommended, but opinions on the best time for management differ between authors (Stebler and Schröter, 1981; Briemle and Elsässer, 2008). Therefore, the aim of this study was to determine the optimal point for weakening the plant through mowing. In contrast to other studies, we used a physiological approach: to determine the best mowing date, we identified the point of time when nutrient contents are high in above-ground plant parts and low in the storage organ.

Material and methods

In 2009, every ten days from April until mid-June, which is the common first mowing date of the investigated grassland sites, a sample of 15 plants (each with three leaves and one capsule) was collected from each of three German *C. autumnale* populations in the biogeographical region Vorderer Vogelsberg (altitude: 180 m). Plants were separated into three fractions: above-ground parts (leaves plus capsule) and two storage organs, i.e. old and new corm. For each fraction, plants from the same population were pooled. Corms were halved, one part of

corm halves and the leaves plus capsule were dried at 60°C, weighed, finely ground and analysed for concentrations of nitrogen, phosphorus, and potassium. The other corm halves were freeze-dried, weighed, ground, and analysed for starch concentration, as starch is the major storage compound in *C. autumnale* (Franková *et al.*, 2003). Concentration of total phosphorus was analysed by the Vanadate-Molybdate-method, that of potassium by atomic absorption spectroscopy, and nitrogen concentration by a CNS analyser. Starch concentration was determined applying a starch-UV-test kit (Boehringer Mannheim GmbH/R-Biopharm). Nutrient concentrations were converted into amounts per plant part before statistically analysis. Data were analysed by segmented regression analysis (SRA; with SegReg v. 2010 by Oosterbaan, <http://www.waterlog.info/segreg.htm> - access 21.02.2011).

Results and discussion

In above-ground plant parts, temporal changes of nutrients were best described by a segment with a positive slope, followed by a horizontal segment (Table 1).

Table 1. Results of segmented regression analysis of *C. autumnale* ($n =$ three populations) collected at 10-day intervals from April until mid-June. BP = breakpoint, n.a. = not analysed, ft = function type, hs = horizontal followed by sloping segment, l = single linear segment, sh = sloping followed by horizontal segment.

Plant fraction	Nitrogen			Phosphorus			Potassium			Starch		
	BP	<i>P</i>	ft	BP	<i>P</i>	ft	BP	<i>P</i>	ft	BP	<i>P</i>	ft
Leaves+capsule	28.IV	<0.001	sh	11.V	0.002	sh	27.IV	<0.001	sh	n.a.		
New corm	21.IV	<0.001	hs	-		L	01.V	<0.001	hs	-		l
Old corm	28.IV	<0.001	sh	10.V	<0.001	sh	28.IV	0.003	sh	-		l

Nitrogen and potassium content increased until the end of April (N given as example in Figure 1a), phosphorus content almost until mid-May. The quantities of nutrients in the new corm increased linearly to exponentially, whereas they decreased exponentially in the old corm (Figure 1b). Therefore, quantity changes of most nutrients in the old corm were characterized by a decreasing and a horizontal segment. Nitrogen and potassium reserves were mostly exhausted until the end of April, phosphorus reserves until the 10th of May. In contrast, starch content decreased steadily but was already low at the first sampling date, as the largest part of starch content is hydrolysed at the end of autumn when leaves develop underground (Franková *et al.*, 2003). In the new corm, there was a steady increase of phosphorus and starch content, while nitrogen and potassium content only increased in the second half of April and the beginning of May, respectively. The major storage compound in *C. autumnale* is starch, contributing up to 50% of corm dry weight, followed by proteins with up to 22% (Franková *et al.*, 2003; 2006). Thus, when judging storage reserves, emphasis should be given to starch and nitrogen content. From this point of view, reserves of the mother corm are mostly exhausted by the end of April, while storage reserves in the new corm start forming at the beginning or middle of April, suggesting the end of April as the point of lowest total storage reserves. Our results are in accordance with observations from other authors. Godet (1987) reported a large decrease of dry weight until the beginning of May in the old corm, and a fast increase of dry weight in the new corm from about mid-March. Franková *et al.* (2003) found that the largest part of starch content in the old corm was used up until the end of April, although starch reserves were not exhausted before mid-June.

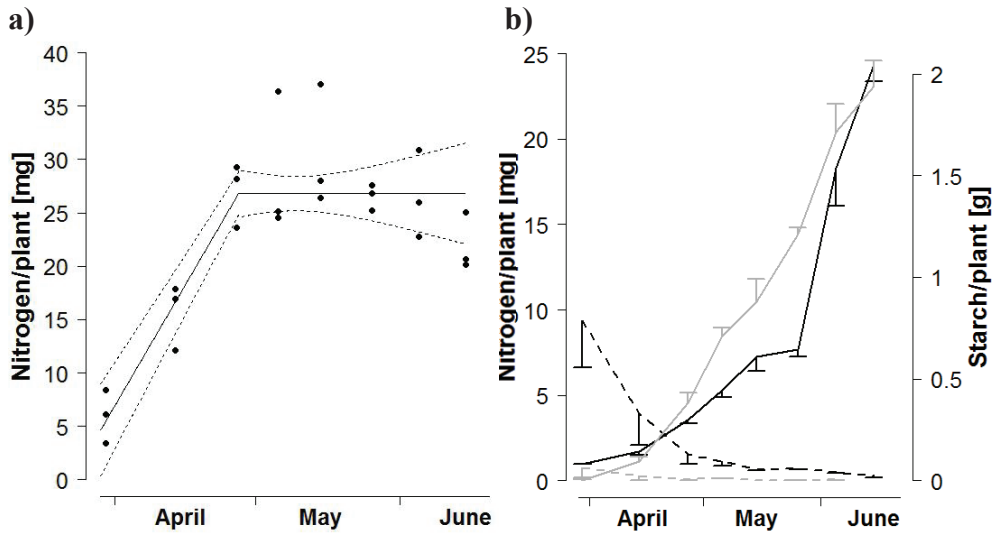


Figure 1. Temporal change of nutrient contents in *C. autumnale* ($n =$ three populations) from 30.3. 15.6.2009. a) Graphical result of segmented regression analysis for nitrogen content in above-ground parts with 95% confidence interval, and b) mean of nitrogen (black line) and starch content (grey line) \pm SE in storage organs, continuous line = new corm, broken line = old corm.

Besides being the point of lowest storage reserves, the end of April was also the point after which nitrogen and potassium content in leaves showed no marked increase. Under the given climatic conditions, we thus conclude that the removal of leaves and capsules of *C. autumnale* at the end of April or very beginning of May leads to the largest reduction of plant resources, and thus vitality. At the indicated date, average plant height was 25.7 ± 3.7 SD and capsules were visible, their top being located at 8–10 cm above ground.

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