Effects of fertilization on flower size in species-rich grasslands

Korevaar H.
Plant Research International, P.O. Box 616, 6700 AP Wageningen, the Netherlands
E-mail: hein.korevaar@wur.nl

Abstract

Reduction of soil fertility is a key factor for restoration of species-rich grasslands. However, when soil fertility is already low, a further reduction may reduce flower size and weight. Low fertilization rates could then enhance grass production and enlarge the size of the flowers of grassland herbs and legumes. To test this hypothesis we collected inflorescences of *Leucanthemum vulgare* and *Trifolium pratense* on two species-rich grasslands with three different treatments: a) control: no fertilization; b) application of cattle slurry; c) application of P and K fertilizer. The length of the flowering stem and the diameter and weight of the flowers of 50 inflorescences were measured per treatment. As expected, with fertilization, grassland productivity increased as well as the length of the flowering stem for both species. A limited application of cattle slurry or P and K did not affect species-richness of the grasslands. For *L. vulgare* the diameter and weight of the flowers were significantly larger with slurry application, but not with P and K fertilization. For *T. pratense,* only the diameter of the flowers was increased by slurry application. We conclude that at nutrient-poor conditions the flower size of the *L. vulgare* and *T. pratense* could be increased by limited application rates of slurry or P and K fertilizer, without affecting the overall species-richness of the swards.

Keywords: flower size, re-introduction, restoration management, species-rich grasslands

Introduction

Most grassland on farms is nowadays heavily fertilized, intensively managed and frequently reseeded. It generally contains only about ten plant species (Korevaar and Geerts, 2007); some sown grass species and common weeds. Reduction in soil fertility is a key factor for restoring these intensively used grasslands into species-rich grasslands. At high soil fertility, tall grass species dominate the sward and suppress herbs. Therefore, a reduction in soil fertility generally is a first step in restoration management (Isselstein *et al*., 2005; Pierik *et al*., 2011; Pywell *et al.*, 2012). Agri-environmental schemes stimulate farmers to adapt their farm management to more environmentally friendly production systems. Reduction of the fertilization level is one of the options; it favours the development of species-rich grasslands. However, when soil fertility is already low, a further reduction of soil fertility may also decrease sward productivity and decrease flower size and weight. To test the hypothesis that under nutrient-poor conditions flower size is smaller than under more fertile conditions, we collected inflorescences of *Leucanthemum vulgare* (oxeye daisy) and *Trifolium pratense* (red clover) on two fields with different fertilization treatments and measured their sizes.

Materials and methods

On two farms on sandy soils in the eastern part of the Netherlands, near the municipality of Winterswijk, two fields of 1.3 and 2.0 ha, respectively, were ploughed and sown with a species-rich seed mixture from an *Arrhenatheretum elatioris* community in the first week of October 2002. Seeds were sown at a quantity of 20 kg ha^{-1}. Of the total seed weight, 75% originated from nine grass species: *Cynosurus cristatus, Lolium perenne, Festuca rubra, F. pratensis, Dactylis glomerata, Phleum pratense, Poa pratensis, Arrhenatherum elatius* and

Anthoxanthum odoratum. The other 25% was harvested on a species-rich grassland in the neighbourhood with, among others, seeds from *Achillea millefolium, Bellis perennis, Centaurea jacea, Crepis biennis, Holcus lanatus, Hypochaeris radicata, Leucanthemum vulgare, Lotus corniculatus, Plantago lanceolata, Prunella vulgaris, Ranunculus acris, R. bulbosus, R. repens, Rumex acetosa, Stellaria graminea, Trifolium dubium, T. pratense* and *T. repens.* In 2003 the new swards received no fertilization. In 2004 the fields were divided into three equal parts. Each part received one of the following three treatments: a) control: no fertilization, b) application of cattle slurry (15 tonnes ha^{-1}), and c) fertilization with 11 kg ha^{-1} phosphorus (P) and 83 kg ha^{-1} potassium (K). These treatments were introduced to study the impact of low fertilizer application rates on species-rich grasslands. The background is the on-going discussion in the Netherlands between farmers and nature conservationists on 'maintenance' fertilization. Farmers argue that without any fertilization the nutrient status could become too low, with even a decline in species diversity. In practice 'maintenance' fertilization generally is performed through the application of cattle slurry. For herbs, notably legumes, P and K are essential. N stimulates the growth of tall grass species, resulting in the shading of herbs and legumes. In treatment (c) we therefore applied only P and K. Fertilization was applied annually after the first cut at the end of June. Total number of plant species, dry matter (DM) production and feeding value of the grass for ruminants were measured during 2005-2008. After 2008 the fertilization treatments were continued, but production was no longer recorded.
In June 2010, fifty inflorescences of *Leucanthemum vulgare* and *Trifolium pratense* were collected randomly from each treatment at the two sites. The length of the flowering stem, diameter of the flower and weight of the flower without stem were measured for each inflorescence collected.

Results and discussion

The effects of the fertilization treatments on species numbers, DM production and feeding value of the grass are presented in Table 1.
The data demonstrate that a limited application of cattle slurry or P and K did not affect species-richness of the grasslands. As expected, grassland productivity increased with fertilization. Feeding value, presented as the net energy content in the DM, was not affected by the treatments. Similar results were observed in another field experiment in which two different species-rich grasslands were compared with a *Lolium perenne* sward (Korevaar and Geerts, 2012).

Table 1. Number of plant species, DM production and feeding value of grass on two farms. The figures are average values of two sites and four years (2005-2008).

Treatment	Fertilization (kg ha^{-1} yr^{-1}) N P K	Total number of species (per 100 m^2)	DM production (kg ha^{-1} yr^{-1})	Net energy (MJ kg^{-1} DM)
Control	0 0 0	27.4 a	5653 a	5.02 a
P and K	0 11 83	27.9 a	7260 b	4.97 a
Cattle slurry	35 9 85	26.6 a	7896 b	4.99 a
LSD ($P \leq 0.05$)		1.9	1337	0.14

Different letters: parameters are different $P \leq 0.05$

The flowering stems of both species were longer on treatments with fertilization (Table 2). For oxeye daisy, flower diameter and weight were significantly greater on the treatment with slurry application than on the control, P and K fertilization had no significant effect. For red clover, the diameter of the flowers was larger with slurry application, but the weight did not

differ from the control. The impact of P and K on diameter and weight of the flowers was limited and not significantly different from the control.

Table 2. Length of flower stem, flower diameter and flower weight of *Leucanthemum vulgare* and *Trifolium pratense*.

Treatment	*Leucanthemum vulgare*			*Trifolium pratense*		
	Length stem (cm)	Flower diameter (cm)	Flower weight (g)	Length stem (cm)	Flower diameter (cm)	Flower weight (g)
Control	38.4 a	4.0 a	0.52 a	18.3 a	2.4 a	0.28 a
P and K	48.1 b	4.2 ab	0.59 a	25.1 b	2.6 ab	0.36 a
Cattle slurry	53.8 c	4.4 b	0.69 b	30.6 c	2.7 b	0.40 a
LSD ($P \leq 0.05$)	3.2	0.3	0.09	3.7	0.3	0.18

Different letters: parameters are different $P \leq 0.05$

In a three-year experiment growing different combinations of cereals (barley or rye), peas and associated plants (arable weeds), Stilma (2008) concluded that in a mixture with cereals and associated plants, peas did not affect the number of associated plants, but stimulated individual plant biomass resulting in larger associated plants. The positive effect of pea was due to the accumulated nitrogen stocked in the soil by the pea in previous years.
Galen (1999) hypothesized that smaller flowers require less investment of essential resources from the plant than large, showy flowers. Reduced flower size will be advantageous under resource-poor conditions, but it could be a disadvantage for pollinators like bumblebees, because they prefer large flowers (Galen, 1999).

Conclusion

We conclude that there is evidence that under nutrient-poor conditions the flower size of *Leucanthemum vulgare* and *Trifolium pratense* can be increased by limited application rates of slurry or P and K fertilizer, without affecting the overall species-richness of the swards.

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