Seed production of subalpine and alpine leguminosae

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ABSTRACT

Species-rich seed mixtures in a mountain environment at middle and high altitude, primarily aiming at site-specific vegetation for nature protection rather than to the production of forage, have gained significance in recent years. In a time of the relegation and destruction of extensively used grassland, the areas suitable for restoration must also be seen as areas of potential ecological balance. A prerequisite for the successful realisation of these aims is the production and availability of seed of suitable site-specific species.

Four different leguminosae (*Anthyllis vulneraria* ssp. *alpestris*, *Trifolium alpinum*, *Trifolium badium* and *Trifolium pratense* ssp. *nivale*), all naturally occurring in the middle and higher zones of the Alps, were investigated during the last decade. The possibilities and conditions of their successful seed production as well as their applicability for agricultural utilisation were assessed. All four species proved to be suitable for restoration and agricultural utilisation of areas in the middle and higher zones of the Austrian Alps. The seed production of *Trifolium alpinum* and *Trifolium badium* is considered too expensive because of a very slow juvenile growth, low competitiveness and seed yields clearly below 100 kg ha^{-1}. The seed production of *Anthyllis vulneraria* ssp. *alpestris* and *Trifolium pratense* ssp. *nivale* is more realistic and can be recommended for site-specific seed mixtures in the sub-alpine and alpine vegetation belt.

Keywords - leguminosae, seed production, site-specific, mountain environment

INTRODUCTION

Due to the climatic and edaphic constraints at high altitudes of the Alpine area, the use of site-specific seed mixtures has gained more and more significance in recent years. Above all in restoration activities connected with large building projects (separation of wood and pasture, revitalisation and improvement of sub-alpine and alpine grassland, ski lifts, ski runs, snow-making facilities, reservoir power stations, roads and tourist infrastructure), this type of restoration has become prominent (Krautzer *et al.* 2006). However, together with the standard demands of rapid surface protection, restoration stability and forage quality, the function of protecting biotopes is to be increasingly considered. In a time of the relegation and destruction of extensively used grassland, the areas suitable for restoration must also be seen as areas of potential ecological balance. If these aims are to be met the production, the availability and the use of seed of suitable site-specific species must be taken care of.

During the last fifteen years, research work was carried out in order to test the possibilities and conditions of the successful use of site-specific species, occurring naturally in the middle and higher zones, in landscape construction. Detailed instructions for the economic seed production and use of four different sub-alpine and alpine leguminosae were assessed in Austria, Italy and Germany.

MATERIAL AND METHODS

Seeds of *Anthyllis vulneraria* ssp. *alpestris* (Alpine Kidney-vetch), *Trifolium alpinum* (Alpine clover), *Trifolium badium* (Brown clover) and *Trifolium pratense* ssp. *nivale* (Snow clover), all occurring naturally in the middle and higher zones of the Alps (Hegi 1975), were collected from natural plant stands in the Alps and important characteristics for their general suitability for agricultural use were assessed (Krautzer 1995). In order to develop and optimise the seed propagation in lowland regions, different trials on small (trial range 3-15 m^2) and large scale (trial range 350-8 000 m^2, see *Table 1*) were established at differing altitude in Austria and Germany (Krautzer *et al.* 2003). Several observations and assessments were carried out in order to get basic knowledge about seed properties, field preparation, maintenance, fertilization, weed and disease control as well as harvesting methods, yield and product quality (Peratoner 2003, Krautzer *et al.* 2004).

Table 1: Description of sites

Site	Country	Altitude	pH $CaCl_2$	Soil type	Soil texture
Hochwurzen	Styria, A	1.830	6.6	leptosol	gravelly loamy sand
Gumpenstein	Styria, A	710	5.2-6.4	cambisol	loamy sand to silty sand
Hebenshausen	Hessen, D	220	6.5-7.1	luvisol	silt loam

RESULTS AND DISCUSSION

Suitability for agricultural use

Investigations on natural plant stands of all four assessed species showed different distribution as well as different demands on soil properties and different tolerance against agricultural utilisation (*Table 2*). In general, all four species can be considered suitable for the use in site-specific seed mixtures at middle and high altitude in mountain environment.

Table 2: Important characteristics and suitability for agricultural use

species	vegetation belt montane	vegetation belt subalpine	vegetation belt alpine	parent rock silicious	parent rock calcareous	moisture dry	moisture wet
Anthyllis vulneraria ssp. *alpestris*	+	(+)	-	(-)	+	+	-
Trifolium alpinum	-	(+)	+	+	-	(+)	(+)
Trifolium badium	(+)	+	+	+	+	+	+
Trifolium pratense ssp. *nivale*	-	+	+	+	(+)	(+)	+

species	tolerance against fertilisation	tolerance against cutting	tolerance against trampling	nutritional value	sward density
Anthyllis vulneraria ssp. *alpestris*	(+)	(-)	(+)	(-)	-
Trifolium alpinum	+	+	+	+	-
Trifolium badium	(+)	+	+	+	(-)
Trifolium pratense ssp. *nivale*	(+)	+	+	+	(-)

+ = very good, (+) = good, (-) = poor, - = very poor

Cultivation and fertilisation

Alpine leguminosae are generally susceptible to pests and diseases. Soils are preferred that are intermediate to medium heavy, deep, rich in humus, not too acid, and easily warmed. With the exception of *Anthyllis vulneraria* ssp. *alpestris*, arable land that tends to drought should be avoided for seed production.

The optimal seed rate for the species assessed mainly depends on the dimension and „Thousand Seed Weight" (TSW) of the seeds. *Table 3* gives an overall view on seed rate and recommended row spacing.

Effects of different cover crops on Alpine kidney-vetch, brown clover and snow clover were assessed in several trials. The effect on the different species (positive or negative) mainly depended on the type of cover crop. In general, winter cereals were not suitable as cover crop. Spring cereals, especially durum wheat and spring barley, were most promising. However, there is a wide range of suitable alternatives for the use of cover crops. In practice, the choice must depend on the effect on agricultural production and farm management. Seeding in pure stand would also be a successful method, especially for *Trifolium pratense* ssp. *nivale*, that can be seeded up to the end of August, after crop harvest. Such an approach always requires more efforts for successful weed control.

Table 3: Characteristics for cultivation and fertilization

specie	seed rate kg ha^{-1}	row spacing cm	fertilisation N kg ha^{-1}	P_2O_5	K_2O	notes
Anthyllis vulneraria ssp. *alpestris*	7 - 10	20 - 45	30*	70	120	no potassium cloride
Trifolium alpinum	10 - 14	12 - 24 or 45	30*	40	70	nematode-free soils, pH < 5,5 recommended
Trifolium badium	8 - 10	15 - 20	30*	40	70	low growth rate no potassium cloride
Trifolium pratense ssp. *nivale*	6 - 8	20 - 25	30*	70	120	cut in spring recommended no potassium cloride

* at sowing in pure stands

Three assessed leguminosae showed best results on soils with a pH around 6, medium to high contents of nutrients and semi-intensive fertilization. For *Trifolium alpinum*, soils with limestone should be avoided. Inoculation with soil from the site stimulates the growth rate, as experimentally shown (Peratoner 2003).

Leguminosae need adequate amounts of phosphorous and potassium (*Table 3*). If sown in pure stands, 30 kg ha^{-1} nitrogen after sowing speeds up the development of the seedlings.

Compared to cultivated species and varieties, all assessed species showed the common characteristic of an early slow development and less resistance to competition. Measures for plant protection must be undertaken as early as possible to avoid large deficiencies in yield. Thus, populations with low weed infestation are only possible if there is a mechanical weed control (weeding combined with brushing and hoeing between the rows) optimally combined with a chemical control. *Trifolium pratense* ssp. *nivale* showed relatively high competitiveness and can be treated like normal red clover. The risk of crossbreeding with the lowland *Trifolium pratense* ssp. *pratense* can though cause problems. However, it can be used successfully for restoration at high altitudes for three to four generations.

Harvest, yield and seed quality

Under normal conditions, the first harvest takes place during the second growing season. Only *Trifolium pratense* ssp. *nivale* was able to produce ripe seeds during the first growing season, having been sown in pure stand in early April. Seed ripened from the end of July to August, with the exception of *Trifolium badium*, showing a harvesting period from the end of June to the beginning of July (*Table 4*). For *Anthyllis vulneraria* ssp. *alpestris*, the genetic characteristics of the propagated ecotype were decisive for the possibility of a second harvesting year. The plants of some ecotypes wilted after harvest like *Trifolium badium*, but most of the assessed provenances had enough surviving plants for a second harvest. For *Trifolium badium* and *Trifolium alpinum*, low competitiveness and slow plant development were reflected in poor yields. For these species, successful seed production is not yet possible.

According to the rules of the „International Seed Testing Association“ (ISTA 2004), the average seed quality, characterised by thousand seed weight (TSW in g), purity (% of weight) and germination capacity (GC in %) was assessed (*Table 4*). With the exception of *Trifolium alpinum*, results of our trials showed that seed germination is positively correlated with the seed weight. Higher germination rates were found for seed propagated at low altitudes compared to seeds from natural plant stands (Krautzer 1995). In general, the assessed species achieved a seed quality comparable to commercially produced varieties of forage leguminosae.

External quality such as purity and germinating capacity are mostly within the producers sphere of influence. Time and technique of harvesting as well as the quality of the drying equipment can decisively influence the quality of the product.

Table 4: Harvest, yield and seed quality of the investigated species

specie	period of harvest	number of harvesting years	average yield 1st harvest kg ha^{-1}	average yield 2nd harvest kg ha^{-1}	yield kg ha^{-1}	TSW* g	GC** %	purity %
Anthyllis vulneraria ssp. *alpestris*	01.08. - 10.08.	1 - 2	300	260	100 - 250	3,28	94	97
Trifolium alpinum	01.07. - 12.07.	1 - 2	10	20	0 - 40	5	98,5***	98
Trifolium badium	23.06. - 04 07.	1	70	0	21 - 80	0,98	78	98
Trifolium pratense ssp. *nivale*	25.07. - 30.08.	2 - 3	100	120	120 - 380	1,1	86	97

* thousand seed weight ** germination capacity *** with scarification

CONCLUSIONS

Seed production of site-specific leguminosae is difficult and risky. In view of low competitiveness and yields, the seed production of *Trifolium alpinum* and *Trifolium badium* is not reasonable. On the other hand, *Anthyllis vulneraria* ssp. *alpestris* and *Trifolium pratense* ssp. *nivale* can be recommended for seed production.

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