SITE-SPECIFIC GRASSES and HERBS

Seed production and use for restoration of mountain environments
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by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2004
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ISBN 92-5-105188-7

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ACKNOWLEDGEMENTS

Thanks are expressed to the scientists, farmers and staff of EC-project CT98-4024 who contributed to the production of this publication.

Austria – Federal Research Institute for Agriculture in Alpine Regions (BAL), Martin Greimel, Wilhelm Graiss and the staff of the Department for Restoration, with special thanks to Brunhilde Egger for layout and desktop publishing; Kärntner Saatbau, Gerald Laggner and Christian Tamegger; seed producers Franz Weber, Josef Dienst and Georg Hager-Roiser; Amt der Tiroler Landesregierung, Christian Partl; special thanks toFoto studio Laxenburg and Wolfgang Krautzer for photographs and print optimization of illustrations (unless otherwise indicated); University of Salzburg, Institute of Zoology, Astrid Obermayer; Institute of Botany and Botanical Gardens, Irina Kurtz.

Germany – University of Kassel, Faculty of Organic Agricultural Sciences, Günter Spatz and the staff of the Department of Forage Production and Grassland Ecology, with special thanks to Margit Rode and Wolfgang Funke for assistance in the field; Weissdorn Verlag Jena for permission to use the figures from Hegi, G., Illustrierte Flora von Mitteleuropa.

Italy – Province of Pordenone, Giuseppe Parente, Sonia Venerus and the staff of the Aziende Sperimentali-Dimostrative; Michele Lamesso and the staff of the Istituto Genetica e Agraria, Montecchio Precalcino; Caterina Batello, Agricultural Officer Pasture Improvement, Crop and Grassland Service, FAO-Rome, for her assistance in the preparation of this publication.

A major part of this study has been carried out with financial support from the European Commission, specific research and technological development programme “Agriculture and Fisheries”, FAIR-CT 98-4024, “Seed Propagation of Indigenous Species and their use for Restoration of Eroded Areas in the Alps”. The findings do not necessarily reflect the Commission’s views and in no way anticipate its future policy in this area.
FOREWORD

Richly varied seed mixtures at middle and high altitudes in mountain environments that provide a natural-like or site-specific vegetation cover, primarily oriented towards nature protection rather than merely the production of forage have gained significance in recent years. Particularly during large building projects (such as ski lifts, ski runs, snow-making facilities, reservoir power stations, roads and tourist infrastructure), this type of restoration has become prominent within the project areas. However, together with the standard demands of rapid surface protection and restoration stability, the function of protecting biotopes is to be increasingly considered. In a time of relegation and destruction of extensively used grasslands, areas suitable for restoration must also be seen as areas of potential ecological balance. Prerequisites for the successful realization of such aims are the production and availability of seeds of suitable site-specific species.

This book intends to give impulse to the viability of these prerequisites. The possibilities and conditions for successful use in landscape construction of 25 different grasses and herbs naturally occurring in the middle and high zones are shown, and their botany and distribution comprehensively described. A significant element of the book gives the possibility of lucrative, non-regulated production detailed instructions for the economic seed production of all the species. This is made available to innovative farmers and seed producers, which will help to ensure the income of these agricultural enterprises.

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**INTRODUCTION**

The production of most of the species summarized in this book is much more risky and significantly more costly than for conventional seed production. It is therefore essential to follow the instructions exactly in order to ensure viable production. However, several fundamental and general valid comments can be made as follows.

**Profitability**

Profits and yields are essential for profitable production. An economic evaluation of the production of site-specific species within the sphere of a research project for the optimization of seed production showed a satisfactory cover level for most of the species. Great care, preparedness for high risk and a learning process of several years are prerequisite. Nevertheless, the niche sector of the production of site-specific seed varieties has its own rules.

The market is relatively limited. A lack of legal regulations still enables commercial mixtures of ecologically unsuitable species, which are significantly cheaper, to be used. Site-specific seed mixtures can only be sold through the intensive service and expertise of seed buyers.

**Cultivation and plant protection**

Compared to cultivated species and varieties, all site-specific species have the common characteristic of an early slow development and little resistance to competition. All species need a perfectly prepared seedbed. Measures for plant protection must be undertaken as early as possible to avoid large deficiencies in yields. Biological planting is therefore out of the question for most species.

Many grasses show a high tendency to blight diseases. Only early control with suitable fungicides can prevent damage to the plant stand over a wide area. The regulations of the respective countries should be observed with regard to permission, use and precautionary measures when using pesticides.

Several of the sprays introduced have given good results in practice, but are not permitted for the relevant types of culture. Because weeds are one of the most significant problems in the production of site-specific seeds, the appropriate agents are at least named.

**Quality**

External qualities such as purity and germinating capacity are mostly within the producers' sphere of influence. A balanced species and timely supply of nutrition optimize the development and yield capacity of the species produced. Irrigation is indispensable in dry areas during the summer, and helpful at all sites in dry years.

The time and harvesting technique can decisively influence yield as well as the quality of the product. Drying facilities appropriately adapted for seed varieties are a prerequisite for the grasses, legumes and herbs described. Drying temperatures of 42°C should never be exceeded. Rapid transportation from the field to the drying facility is important for grasses above all because of the relatively high water content of the seeds and excessive independent heating of the threshed material.

Low humidity and low air temperatures are essential factors for long storage of seeds without damage.
Common yarrow, milfoil

*Achillea millefolium* s.l.

*BOTANY*

Perennial, with a rootstock and rhizomes.  
**Stems** 30-100 cm high, quite robust, erect, long hairs scattered to dense, branched towards the top.  
**Foliage leaves** scattered and pilose, becoming glabrous later; lanceolate in contour, basal ones tripinnately incised, 20-40 mm wide, intermediate and upper ones auriculate, bi- to tripinnately incised, 10-20 mm wide.  
**Leaflets** remote, segments of last order linear.  
**Inflorescence** an open, often compound umbel, 4-10 cm in diameter.  
**Calyx** 4-5 mm long. Ray flowers white, pink or red, 2-2.5 mm long.  
**Achene** 1.4-2.5 mm long.
SUITABILITY FOR RESTORATION
Euro-Siberian species with various ecotypes, very common; often found on soils that are nutrient-deficient to moderately nutrient-rich, on fields, along paths, even in semi-dry grasslands; on loam that is moist to moderately dry, medium-deep to deep, sandy, stony or pure.
Sensitive to long-lasting moisture or compactness of the topsoil as well as to deficient soil aeration.
Extremely common in the Alps.
All-purpose grass for restoration in lower altitudes up to the lower alpine region. Good tolerance of nutrients and cutting, resistance to trampling, not likely to be grazed by livestock.

SEEDS
Achene 1.4-2.5 mm long, 0.8 mm wide, 0.3 mm thick; flat, thin like paper, oblong-cuneate, cross-truncate at the apex. Hilum at the acute margin. Surface slightly vaulted, with fine longitudinal bands.
Surface silver-grey to light greenish-grey, margin brighter, glossy.
**Thousand seed weight:** 0.15-0.25 g.

REQUIREMENTS (soil and climate)
There are no special requirements for soil and climate. Common yarrow prefers an intermediate to good supply of nutrients. The pH should range between 5.5 and 7.5. Wet, waterlogged and badly aerated soils should be avoided, as well as soils that are rich in peat and very light, dry soils.

CULTIVATION
Open sowing is possible, if sowing is carried out by the beginning of June at the latest (at mild locations by the middle of June). Crop irrigation is recommended. Sowing underneath low-density cover crops is also feasible.
**Seed rate:** 2-3 kg/ha.
**Row spacing:** 20-25 cm. Depending on the construction of the seeder and the method of weed control there should either be dense populations or sufficient row spacing (for mechanical and/or chemical weed control).

FERTILIZATION
For a satisfactory crop yield an intermediate amount of nutrients is required.
**Phosphorus and potassium:** on soils with an intermediate phosphorus and potassium content, basic fertilization with manure (15-25 tonnes/ha solid or liquid manure) is sufficient in autumn. For mineral fertilization 40-60 kg/ha P₂O₅ and 60-100 kg/ha K₂O are recommended.
**Nitrogen:** a sufficient supply of nitrogen in autumn guarantees satisfactory tillering. The following amount is necessary for seed formation: 50-60 kg/ha of N-total to be added in autumn and early spring.

Seeds
MAINTENANCE AND WEED CONTROL
The species has intermediate juvenile development and produces little leaf mass. Thus, populations having low competition with weeds are only possible if mechanical weed control takes place (weeding, respectively brushing and hoeing between the rows), optimally combined with chemical weed control. As for the majority of herbs, focused chemical control of weed grasses poses no problems. To date there has been insufficient practical experience regarding the chemical control of dicotyledonous plants. But in summer and autumn of the seeding year and in spring of the harvesting year, it is possible to protect these plants by wiping wick and total herbicides (e.g. Glyphosate), thanks to the differences in growth heights between many weed grasses and common yarrow.

HARVEST AND YIELDS
Resistance to lodging: high.
Shattering tendency: low.
Ripeness: after flowering, the compound umbels change colour from dunnnish, when ripe, to dark grey and dark brown. Until ripeness the seeds adhere fairly to the umbel quite well.
In order to check ripeness the inflorescence should be rubbed off on the palm of the hand: if sufficiently ripe, the silver-grey seeds will shed easily.
Ripening period: from the second to the third decade of July.

Harvesting technique: direct threshing is possible. The seeds are very small but have a good seed flow. During threshing the crop and sieves need to be checked frequently. The settings of the threshing concave should be narrow. Cleaning the seeds poses no particular problems.
Crop yields: yield forecasts are difficult, because of lack of experience concerning the cultivation of common yarrow. Yields range between 80 and 120 kg/ha. With proper experience, yields up to 100-150 kg/ha (and more) can be expected. Optimal maintenance leads to three harvesting years.
Sweet vernal grass

*Anthoxanthum odoratum*

**BOTANY**

Annual grass growing in bunches, or perennial with short, thin rhizomes and numerous young shoots.

**Culms** are up to 50 cm high, slim, smooth and glabrous.

**Leaf blades** adaxially greenish-grey and matt, undersurface greenish-yellow, shiny; on fully developed plants rolled up to a pipe undersurface out.

**Leaf sheaths** with margins not connate as far as base, round, grooved, scabrous, glabrous or pilose, bunches of long hairs at the aperture.

**Ligules** form a 2-8 mm long, membranous fringe.

**Inflorescence** a panicle, 0.5-8 cm long, up to 2 cm wide, ovoid to oblong, dense, contracted, multiflowered, usually tawny.

**Spikelet** with two infertile, stunted florets with a fertile, laterally contracted. Above glume divided, in ripeness abscission of three florets in one unit, while glume stays adnate.
SUITABILITY FOR RESTORATION
In the Alps this European species grows in hilly, montane and subalpine zones. Because of its early flowering period and ripeness, advancing to sites desiccating in summer is possible. This species grows on soil that is free of groundwater, and on almost any meadow land. As a result of its low growth, it prefers meadows. Apart from rocks and rough debris the plant grows on almost any moist to semiarid soil with a low to intermediate nutrient supply and a pH between 3.2 and 6.5. This is an all-purpose grass in montane and subalpine sites, excellent for filling gaps thanks to the early ripeness of seeds and high seed production, its low biomass growth and low nutrient requirements. The grass is highly resistant to exhaust gases.

SEEDS
Lemma of lower awned florets often apically glabrous with broad, membranous, white margins. Lemma of upper fertile florets at least on margins (often dorsally and the entire upper half) with short, stiff, patulous bristly hairs, often long cilia. Glum oblong-elliptic, contracted, auburn, with long, shaggy, auburn hair; hairs pointing up; tips of glumes light yellow, translucent, membranous, glabrous, rounded. Awns of lower glumes 7-8 mm long, emerging from a little above the base, knee-high (same height as tip of glume), tightly contorted, black-brown, then thinner and lighter, tip of awn is whitish-yellow.
Inflorescence a panicle, 1.5-2 mm long, 0.6-0.8 mm wide and 0.3-0.5 mm thick, ovate-acuminate, can easily be squeezed out at glumes. Lemma smooth, auburn, shiny; palea finely scabrous, matt. Fruit 1.5-1.5 mm long, 0.3-0.7 mm wide, 0.3 mm thick, ovate-acuminate, tawny, matt.
Thousand seed weight: 0.5-0.6 g.

REQUIREMENTS (soil and climate)
Light soil that is permeable and free of groundwater with a pH between 5.5 and 7.0 is suitable for seed production of sweet vernal grass. Propagation is not successful on compact, flat, waterlogged soil.

CULTIVATION
Sweet vernal grass needs a well-prepared, flat, fine seedbed. Seeds have a sufficient seed flow and are therefore suitable for all common seeding systems. Cultivation is possible by open sowing as well as under a cover crop. When using cover crops (e.g. summer cereals or linseed), it is important to have a light cover crop population because sweet vernal grass is not very tolerant to shade. Open sowing can be undertaken until the end of June or the beginning of July. Sufficient water supply is important.
Seed rate: 7-9 kg/ha are sufficient for good germination and optimal conditions for seed emergence.
Row spacing: 12-15 cm. Depending on the construction of the sower, broadcast sowing (e.g. by removing the sowing tubes) is also possible.

FERTILIZATION
Phosphorus and potassium: an intermediate supply of phosphorus and potassium is usually sufficient for propagation to develop successfully. Should additional fertilization be required, 20 tonnes/ha of well-decomposed manure is recommended in autumn.

Nitrogen: main application of nitrogen should be carried out early in autumn in order to facilitate tillering and the development of spermatophors. Mineral fertilization might prove necessary on poor soil and in dry weather in spring, in the event of bad nitrogen mobilization. Sweet vernal grass develops quickly in spring. Later fertilization at a disadvantageous stage of development (blossom, ripeness) facilitates the growth of leaves only and inhibits compact ripeness.

MAINTENANCE AND WEED CONTROL
In the year of cultivation any maintenance has to be carried out with great care. Straw of the cover crop has to be removed and the stubbles cut.

Effective weed control in the first year is the basis for a population that is free of weeds and has a high crop yield.

As for most grasses the following guidelines apply. Before sowing, only contact herbicides should be used, up to three days before the beginning of sowing. Hormone-type and broad-spectrum herbicides should generally not be used until the species has reached the three leaf stage. Note that the herbicides listed in Table 3 on p. 109 are not registered for use in seed cultivation in some countries.

Especially when cultivated in lowlands or in humid weather, sweet vernal grass is very sensitive to rust and leaf diseases. Application of fungicides: (usage and dose as in grain cultivation) may, therefore, already be necessary in late summer of the first year or specifically after the first harvest. Note the instructions for the use of herbicides given in the introduction.

Cutting in autumn is only necessary for high growth. Sweet vernal grass is resistant to snow mould and low temperatures in winter. Especially with high rust infestation, cutting in late summer or in spring of the first harvest year might be useful or even necessary. Because of early ripeness, competition with weeds may be very high in the
summer of the first harvest year. Selective weed control with wick and total herbicides (e.g. Glyphosate) is possible because of different growth heights.

**HARVEST AND YIELDS**

*Resistance to lodging:* high.
*Shattering tendency:* very high.
*Ripeness:* seeds assume a typical brown colour. Panicles change colour to golden yellow, similar to straw. Seeds ripen one after the other from the apex down to the base. Defining the optimal time of ripeness is extremely difficult.
*Ripening period:* very early, in warm regions in the middle of May, in cooler regions in the last week of May to the beginning of June. There are important differences between ecotypes. A more compact ripeness can be achieved by appropriate selection.
*Harvesting technique:* because of the plant’s high shattering tendency, direct threshing is recommended. The rotational speed of the threshing drum should be low to avoid dehusking of seeds. Seeds as well as chaff in the sieve should be checked several times while threshing.

[Image: Seed propagation stand]

Settings of the threshing concave: generally close; the drier the seeds, the wider the setting in order to prevent seed damage.
*Crop yields:* crop yields can vary greatly, between 50 and 250 kg/ha. As for all site-specific species, specialized knowledge and several years of experience are necessary to obtain optimal, stable crop yields.

Only two harvesting years are possible because of the intensive maintenance required.
Common kidney vetch

*Anthyllis vulneraria*

*BOTANY*

Perennial or annual to biennial, mostly with a robust taproot and a short, single or branched, multiheaded rootstock. **Stem** 5-40 cm high, single or branched, mostly ascending or erect, hairs appressed (minimally spiky), white-tomentose to the apex.

**Foliage leaves** variously pinnate, the basal ones often without leaflets or with one to four reduced pairs of leaflets, the cauline ones (one to six) with seven pairs of leaflets, apical ones sessile, basal ones long-petiolate.

**Leaflets** oblong-ovate to elliptic or
lanceolate, lateral ones 0.25-2.5 cm long and a third to one sixth times as wide, apical leaflet up to 6 cm long and up to 2 cm wide, often almost oblong, rounded to slightly acute on both sides; all leaflets entire, no conspicuous lateral veins. Light blue to chartreuse, adaxially (upper leaf surface) glabrous or scarcely, with appressed hairs, abaxially (lower leaf surface) with densely accumbent, minimally spiky, silky hairs.  

Stipules small, largely or entirely sheathing. Flowering heads appear terminal, in fact sessile, in the axils of the topmost foliage leaves that are floral bract-like, broad, 3-7-fid; densely arranged at the apices of the stems and branches, mostly multiflowered. Flowers almost sessile, with short, centrally divided pedicels, 9-19 mm long, erect. Spherical flower heads with dense, golden to orange-yellow flowers.  

Strict cross-fertilizer, flowering between June and August.  

SUITABILITY FOR RESTORATION  
This central and south European species occurs in the foothills of the Alps, the montane and - as with subspecies alpestris - the subalpine zone. In the valleys it grows mainly on semiarid grasslands; on mountain slopes on calcareous, poor grasslands. It prefers skeletal brown soils, pararendzina, rendzina, stony brown and red loam and initial and bare soils. Found in the Alps up to approximately 1800 m.  

This species is suitable for restoration between the foothills and subalpine zones, especially on semiarid and stony sites, combined with low-growing grasses. It protects the soil against surface and depth erosion by means of its leaves, which grow close to the ground, and its extensive root system. Tends not to grow in mass and does not require many nutrients.  

SEEDS  
Seeds 2.3 mm long, 1.2 mm wide and 0.8-1.2 mm thick; broad-ovoid, sometimes with a slight lateral indentation. Radicle clinging, not sticking out. Hilum centrally ventral, round, whitish, with dark border.  

Surface colour significant: yellow up to two-third, remaining part green; glossy, smooth.  
Pod one-seeded, inflated oblique-ovoid, pilose, dark to black-grey.  
Thousands seed weight: 2.3-2.7 g,  

REQUIREMENTS  
(soil and climate)  
Common kidney vetch is extremely undemanding and adaptable, while tolerating fertilization intermediatively; even suited to poor habitats with shallow, nutrient-deficient soils. Sites that are too damp and clay and peat soils are not suitable. The pH should not be above 6, otherwise there may be a deficient root development. Kidney vetch prefers arid weather, having a low transpiration coefficient. It has high nitrogen accumulation capabilities, is self-tolerant and a good previous crop for cereals, sweetcorn and rape. As for all legumes, there should be a long crop rotation in order to prevent an accumulation of fungal pathogens.
CULTIVATION
Common kidney vetch needs a fine, crumbly and compact seedbed.
Open sowing is possible throughout the year. In order to guarantee a satisfactory crop yield the following year, seeds should be sown up to July at the latest. According to early literature on seed cultivation of forages, autumn sowing underneath rye is possible in September. Common kidney vetch is suitable as a nurse crop for summer barley or durum. It is not troublesome at sowing.
Seed rate: 8-10 kg/ha.
Row spacing: 12-25 cm, depending on the construction of the seeder.

FERTILIZATION
Phosphorus and potassium: common kidney vetch requires very few nutrients. In autumn before cultivation, basic fertilization with manure (15-20 tonnes/ha) is considered sufficient. Using mineral fertilizer, an application of 60-80 kg/ha P₂O₅ and 100-140 kg/ha K₂O is recommended, depending on soil content.
Nitrogen: kidney vetch meets its nitrogen requirements by means of nitrogen-fixing bacteria. As for all legumes, fertilization with 20-30 kg N is recommended for open sowing in order to stimulate juvenile development.

MAINTENANCE AND WEED CONTROL
In early autumn before the crop year, cutting is recommended if populations are densely grown.
Having low competition with weeds, mechanical weed control should be combined with the application of herbicides. Kidney vetch is not sensitive to the use of curry combs. As for all legumes, specific weed control with herbicides is not always possible. In this context, experiences in clover seed production should be mentioned. However, compared to most clover species, kidney vetch does not tolerate herbicides containing butyric acid (MCPB).

Pests and diseases: common kidney vetch is usually healthy, although several fungus diseases (mildew, focal spot disease, rust and stem fungal) are possible. In the north of Italy, root rot caused by fungal pathogens appears from time to time, which can lead to heavy losses.
Most kidney vetch plants die off after seed ripeness. Plant survival depends on origin, ecotype and sowing time. A second harvest the following year can be profitable if the reproductive populations together with the juvenile plants – grown through seed shedding – remain sufficiently dense. In this case, densely grown populations have to be cut in autumn in order to minimize losses over winter.

HARVEST AND YIELDS
Resistance to lodging: intermediate to low, depending on origin.
Shattering tendency: extremely high.
Ripeness: at time of ripeness florets change colour to silver-grey and pods become dark to black-brown. Seeds become firm (nail test) and change colour to a typical green-yellow. Because of the plant's unequal ripening and high shattering tendency, harvesting is only recommended when at
least 60 percent of the flowers are ripe. Often this state of ripeness is reached when the third axis of flowers at the stem is ripe for threshing.

**Ripening period:** starting in the middle of July and lasting up to the middle of August, depending on origin.

**Harvesting technique:** experiments show conspicuously higher crop yields with direct threshing. Swath threshing is not recommended because of high losses through seed shedding. Threshing has to be carried out with great care.

**Crop yields:** yield forecasts amount to between 200 and 400 kg/ha. Depending on ecotype and weed infestation a second harvest is possible. Depending on the thresher, harvested seeds can still remain covered with 60 to 90 percent of pods. As is common practice in seed production, seeds should be dried gently immediately after harvesting. Hulling the seeds should be carried out with special machines (clover rubber).
Alpine kidney vetch

*Anthyllis vulneraria ssp. alpestris*

*Anthyllis vulneraria ssp. alpestris* (Schröter, 1888)

**BOTANY**

Semi-rosette herbaceous plant, perennial or annual to triennial, with a thick rootstock.

**Stem** short, compact, ascending to erect, hairs appressed, lower part with one to three stem leaves.

All foliage leaves almost glabrous, fleshy; unlike *Anthyllis vulneraria* the basal ones are mostly non-pinnate. Petioles often reddish.

**Flowering heads** large, calyx 13 to 14 mm long, most of the races with golden corolla.
SUITABILITY FOR RESTORATION
This plant of the central and southeast European mountains occurs on similar sites to *Anthyllis vulneraria*. It is very common in the Alps, but only in the subalpine and alpine zones. The species prefers calcareous soils, but is also found on lime-deficient ground. On calcareous, poor grasslands it sometimes represents the stand structure. The species is also frequently found on talus sites; it grows in the Alps at altitudes of up to 3000 m. On calcareous ground the plant is particularly suitable for restoration of slopes and rocky, planed soils of the subalpine and alpine zones.

SEEDS
Seeds 2.4-3.2 mm long, 1.6-2 mm wide and 0.8-1.2 mm thick; broad-ovoid, sometimes with a slight lateral indentation. Radicle clinging, not sticking out. Hilum centrally ventral, round, whitish, with dark border.
Surface colour significant: yellow up to two-thirds, remaining part green; glossy, smooth.
Pod one-seeded, inflated oblique-ovoid, pilose, dark to black-grey.
Thousand seed weight: 3.2-3.5 g.

REQUIREMENTS (soil and climate)
Alpine kidney vetch is extremely undemanding and adaptable, while tolerating fertilization intermediately. Even poor habitats with shallow, nutrient-deficient soils are well suited. Sites that are too damp and clay and peat soils are not suitable. The pH should not be below 6, otherwise a deficient root development may form. Alpine kidney vetch prefers arid weather having a low transpiration coefficient. It is self-tolerant and a good previous crop for cereals, sweetcorn and rape. As for all legumes, there should be a long crop rotation in order to prevent an accumulation of fungal pathogens.

CULTIVATION
Alpine kidney vetch should be threshed close to the ground. A flat, fine, crumbly seedbed without stones is preferred. Open sowing is possible throughout the year. In order to guarantee a satisfactory crop yield the following year, seeds should be sown up to July at the latest. Alpine kidney vetch is extremely suitable as a nurse crop for summer barley or durum. It does not cause any problems during sowing.
Seed rate: 8-10 kg/ha.
Row spacing: 12-25 cm, depending on the construction of the seeder.

FERTILIZATION
Phosphorus and potassium: alpine kidney vetch requires very few nutrients. In autumn before cultivation, basic fertilization with manure (15-20 tonnes/ha) is considered sufficient. Using mineral fertilizer, an application of 60-80 kg/ha P₂O₅ and 100-140 kg/ha K₂O is recommended, depending on soil content.
Nitrogen: kidney vetch meets its nitrogen requirements by means of nitrogen-fixing bacteria. As for all legumes, fertilization with 20-30 kg/ha is recommended for open sowing in order to stimulate juvenile development.
MAINTENANCE AND WEED CONTROL

Compared to common kidney vetch, alpine kidney vetch has a slower juvenile development and produces conspicuously less leaf mass. Thus, populations with low competition with weeds are only possible with mechanical weed control, optimally combined with chemical controls. The plant is not sensitive to the use of curry combs. As for all legumes, specific weed control with herbicides is not always possible. In this context, experiences in clover seed production should be mentioned. However, compared to most clover species alpine kidney vetch does not tolerate butyric acid (MCPB).

Pests and diseases: Anthyllis vulneraria ssp. alpestris is usually healthy, although several fungal diseases (mildew, local spot disease, rust and stem fungal) are possible. In the north of Italy, root rot caused by fungal pathogens appears from time to time, which can lead to heavy losses.

Most alpine kidney vetch plants die off after seed ripeness. Plant survival depends on origin ecotype and sowing time. A second harvest the following year can be profitable if the reproductive populations together with the juvenile plants – grown through seed shedding – remain sufficiently dense. In this case, densely grown populations have to be cut after the first harvest in autumn in order to minimize losses over winter.

**HARVEST AND YIELDS**

**Resistance to lodging:** low.

**Shattering tendency:** extremely high.

**Ripeness:** at time of ripeness florets change colour to silver-grey and pods become dark to black-brown. Seeds become firm (nail test) and change colour to a typical green-yellow. Because of the plant’s unequal ripening and high shattering tendency, harvesting is only recommended when at least 60 percent of the flowers are ripe. Often this state of ripeness is reached when the third axis of flowers at the stem is ripe for threshing.

**Ripening period:** about one week earlier than common kidney vetch, mostly in the first decade of July.

**Harvesting technique:** because of limited leaf mass the stems lie close to the ground and therefore the board has to be kept very low. Swath threshing is not recommended because of high losses through seed shedding. Threshing has to be carried out with great care.

**Crop yields:** yield forecasts amount to between 100 and 300 kg/ha. Depending on ecotype and weed infestation a second harvest is possible.

Depending on the thresher, harvested seeds can still remain covered with 60 to 90 percent of the pods. As is common practice in seed production, seeds should be dried gently immediately after harvesting. Hulling the seeds should be carried out with special machines (clover rubber).
**Wavy hair grass**

*Avenella flexuosa*

**BOTANY**

Perennial, forming 30-70 cm high, dense to light thickets, rhizomes, numerous intravaginal young shoots.

*Culms* are 20-60 cm high, thin, erect or geniculate, shiny, smooth and glabrous. The plant is one to three-noded, nodes glabrous and grooved.

*Leaf sheaths* grooved, smooth and glabrous, only apically scabrous, basal ones thin and disintegrating into parallel fibres.

*Ligule* is a 1-mm long, membranous fringe, broadly rounded at the apical end.

*Leaf blades* up to 20 cm long, 0.3-0.8 mm in diameter, bristly, pointed, smooth and glabrous, only apically scabrous, hexagonal in cross-section.

*Inflorescence* a panicle, 4-15 cm long, up to 8 cm broad, open, expanding, outline broadly ovate. Lateral branches ramifying in pairs off glabrous main axis, expanding,
up to 8 cm long, not branched in lower third, squarrosely branched above, mostly meandering, filiform and scabrous as the 3-10 mm long rachis. Spikelets are two-flowered, 46 mm long, light brown, often coated purple or shining silver, seldom growing to foliage shoots.

**SUITABILITY FOR RESTORATION**

This plant occurs worldwide and in the Alps it grows in the foothills and the montane, alpine and subalpine zones. In the foothills and montane zones it needs shade and therefore grows mainly in forests. In the high montane and subalpine zones it tolerates or requires full exposure. There it occurs in glades, meadows and dwarf shrub heaths. The species is sensitive to airdeficiency in soils. Its natural habitats in Europe are generally nutrient-deficient. The type of soil is usually fustyhumus brown soil, sandy to loamy brown soil, podsol brown soil, podsols or desiccated peat. The plants grow on soils with a pH between 4 and 7, although a pH of 3.3-3.5 is sometimes tolerated. In the Alps it grows up to 2 750 m above sea level. Important grass for soil with fine-earth deficiency and humus, acidic, arid sites above the timber line as well as half-shaded forest aisles and slopes in lower altitudes. It prefers nutrient-deficient soil and is sensitive to foraging.

**SEEDS**

Fruit of the husk 25-35 mm long, 0.6-0.9 mm wide, 0.5-0.8 mm thick, ovate-lanceolate.

Awn meandering, auburn, slightly longer than lemma, growing from above the base.

Lemma membranous, silvery translucent, longer than fruit, lemma transcending margins of palea.

Palea flat, in narrow hollow, illnessy. Base with few white hairs.

Stipellus short with few but long hairs.

Surface tawny to brownish matt.

Fruit 2-3 mm long, 0.5-0.7 mm wide, 0.5-0.6 mm thick, oblong, brown, matt.

**Thousand seed weight:** 0.5-0.7 g.

**REQUIREMENTS (soil and climate)**

This species prefers arid or moist sites up to 1 000 m above sea level. Compact and air-deficient soils should be avoided. Soils should be water permeable and rich in humus. In the literature there are reports of growth disorders and chlorosis when the pH of the soil is above 6. However, in cultivation experiments on soils with pH 7 this was not the case. On arid sites irrigation is recommended in order to facilitate a regular water supply. Wavy hair grass is, however, sensitive to waterlogged soil and soil that is blocked by alluvial deposits, especially in its juvenile development.

**CULTIVATION**

Wavy hair grass should preferably be sown in spring with broadcast sowing no deeper than 0.5 cm. Cultivation below
winter barley is not recommended because the species has a slow juvenile development. Satisfactory development of single plants until autumn will therefore not be possible. Seed flow is sufficient for common seeding systems. A light cover crop population is important because of slow juvenile development. Summer barley and linseed have proved worthwhile in practice.

**Seed rate:** 10-12 kg/ha.

**Row spacing:** for this species, row spacing should be between 12 and 15 cm. Broadcast seeding is possible.

**FERTILIZATION**

**Phosphorus and potassium:** wavy hair grass prefers nutrient-deficient soils. For an intermediate supply of phosphorus and potassium additional fertilization is not necessary. In autumn small amounts of manure can be applied without risk.

**Nitrogen:** this too should only be applied in small amounts. A moderate application of nitrogen in autumn and/or in early spring (no more than 20-40 kg/N each, depending on climate) facilitates a good yield. On soils with a pH higher than 6, chlorosis may occur; the application of ferruginous fertilizers (not as sulphate) will then be necessary.

**MAINTENANCE AND WEED CONTROL**

Because of slow juvenile development, intensive maintenance is necessary and weed control has to be carried out in the weeks after harvesting the cover crop. Wavy hair grass does not grow very high in the summer of cultivation (0.5-1.5 cm) and easily risks being covered by crop residues. Therefore straw has to be removed immediately. Chaffing and spreading crop residues lead to plant losses on large areas.

As for most grasses the following guidelines apply. Before sowing, only contact herbicides should be used, up to three days before the beginning of sowing. Hormone-type and broad-spectrum herbicides should generally not be used until the species has reached the three leaf stage. It should be noted that the herbicides listed in Table 3 on p. 109 are not registered for use in seed cultivation in some countries.

The low growth height of this species requires considerable effort in maintenance and weed control. Selective grass weed control is difficult. Because of different growth heights of wavy hair grass and other grasses, selective control with wick and total herbicides (e.g. Glyphosate) is possible within certain periods of the growing season.
HARVEST AND YIELDS
Resistance to lodging: high.
Shattering tendency: low to intermediate.
Ripeness: the axes of the panicles change colour to light tawny. Seeds adhere well to the panicle after ripeness and change colour from greenish-brown to brown. To check ripeness, a bunch of panicles should be ducted firmly: the brown seeds will fall off easily if ripe.
Ripening period: last decade of June or first decade of July. Because of the low shattering tendency it is easy to fix the time of threshing.
Harvesting techniques: wavy hair grass can easily be threshed directly. The rotational speed of the threshing drum should be set low to avoid mechanical damage or dehusking of seeds. Seed flow is sufficient. Seeds as well as the chaff in the sieve should be checked several times while threshing.
Settings of the threshing concave: generally close, the drier the seeds, the wider the setting in order to prevent seed damage. Cleaning of seeds usually presents no problems.
Crop yields: crop yields can vary greatly (12-150 kg) where there is little experience in propagation. Where experience is considerable 100-150 kg can be expected. Appropriate prices for seeds are a precondition for economically profitable production.
For optimally maintained populations, three harvest years are possible.
**Violet meadow grass**

*Bellardiochloa variegata*

*Bellardiochloa variegata* (Hegi, 1997)

**BOTANY**

Perennial, blue-green, small, dense thickets, numerous intravaginal young shoots, no stolons or rhizomes.

**Culms** are 15-20 cm high, erect or geniculate, underneath panicle scabrous, one to two dark nodes.

**Leaf sheaths** with margins not connate down to the base, lower leaves scabrous, at the base of culms and young shoots clustered, persistent, straw-coloured, tough.

**Ligule** of young shoots is a 3-mm long, tongue-shaped, torn, pointed membranous fringe.

**Leaf blades** of fresh plant flat to channelled, approximately 2 mm wide, dry, bristly, 0.5 mm broad, acicular, scabrous, erect, often reaching up as far as the panicle.

**Inflorescence** a panicle, 4-12 cm long, outline lanceolate, dense, usually contracted, lateral branches ramifying in groups of five to seven, erectly patulous, meandering, scabrous. Three to five flowered spikelets, 4.5-7 mm long, laterally contracted, green, mostly coated purple, rachilla between florets 1 mm long, in upper half with 0.5 mm long stiff hairs.
SUITABILITY FOR RESTORATION
In arid grasslands on sunny, warm slopes, pioneer plant in crevices, on ledges and cornices. On dry soil that is free of fine, neutral to slightly acidic, nutrient-deficient, stony to rocky soil. Indicates aridity, poorness and light (heliophyte). Preferably in the subalpine, seldom in the alpine zone.
All-purpose grass for all silicious sites or sites deficient in lime, as far as the lower alpine zone. Tolerant of nutrient but not dependent on it, tolerant of cutting to a certain extent, not tolerant to grazing.

SEEDS
Glumes almost similar, three-veined, 3-4.5 mm long, lanceolate, acuminate, keeled, midvein scabrous.
Lemma five-veined, 3.6-4 mm long, slightly keeled, apically acuminate, at least lower ones expiring in 0.3-1 mm long awns. On lower half of keel and marginal veins short hair, florets without woolly hair on base.
Palea two-veined, almost as long as lemma, oblong-lanceolate, apically slightly notched; in-between keels short hair, keels with very short, acute, bristly hair.
Anther 1-1.8 mm long, smooth and glabrous, outline elliptic.
Thousand seed weight: 0.3-0.5 g.

REQUIREMENTS
(soil and climate)
Violet meadow grass has no special soil requirements. Moist or waterlogged soil, ground with high weed infestation, peat and light, dry soil should be avoided. Competition with weeds is low. Locations with a high presence of annual meadow grass (Poa annua) rough meadow grass (Poa trivialis) and, above all, smooth meadow grass (Poa pratensis) should be avoided at all costs. Propagation is possible with a pH between 5.0 and 7.0.

CULTIVATION
Violet meadow grass needs a fine, crumbly seedbed. Open sowing is possible but risky because of the danger of high weed infestation. For the sufficient development of single plants until autumn, open sowing must be carried out until the middle of June. For open sowing in summer, irrigation must be possible.
Seeding underneath summer barley/durum wheat is common. A thin cover crop population is important. If stands are too dense, the development of single plants is suppressed, which leads to bad tillering in autumn. Furthermore, increased weed competition and a severely decreased crop yield may occur. Good experience has been recorded with linseed as a cover crop. Because of the plant’s slow juvenile development, seeding should be done immediately after seeding the cover crop. Seeds have a good seed flow and are suitable for all common seeding systems. It is important that seeds are applied flat and evenly in a maximum depth of 0.5 cm, and rolled afterwards.
Seed rate: 8-10 kg/ha with an excellent seeding technique, otherwise higher amounts are required to obtain regular stands.
Row spacing: 15-20 cm, depending on the seeder.
FERTILIZATION
Violet meadow grass is fairly undemanding. For satisfactory seed development a good supply of nutrients is necessary.
**Phosphorus and potassium:** on soil with an intermediate supply of phosphorus and potassium early fertilization with manure in autumn is recommended. For soils with sufficient nutrient content 50-70 kg/ha P₂O₅ and 80-120 kg/ha K₂O are necessary.
**Nitrogen:** after harvesting the cover crop and cutting the stubbles, an application of 30 kg/ha N-total is recommended, to achieve optimal development until autumn. Nitrogen necessary for seed development should be applied in autumn or in early spring, for an amount of approximately 70 kg/ha N-total. Late fertilization in spring mainly stimulates the development of leaves.

MAINTENANCE AND WEED CONTROL
This species grows quite high and forms rather dense, enduring stands after having outgrown the juvenile phase. Herbicides are well tolerated. Because of low competition, weed control has to start as early as possible to obtain a satisfactory development.
A special problem is weed infestation by other meadow grasses. Selective weed control is only possible for *Poa annua* (see *Poa alpina*). Smooth meadow grass in particular can overgrow the entire population within two years and cause problems with yields and quality as a result. The only effective weed control is to use a wick for the control of single plants with total herbicides (Glyphosate).
**Sensitivity to rust:** quite low. Rust control will only be necessary for a few years. There should be no cutting between the harvest and autumn in order to minimize the development of weeds. Violet meadow grass is not used as forage.

HARVEST AND YIELDS
**Resistance to lodging:** intermediate.
**Shattering tendency:** intermediate.
**Ripeness:** branches of panicle and upper parts of culms change colour to golden yellow. Seeds shatter easily when touched. At the time of ripening the stands should be checked up to twice a day because ripeness is not very compact.
**Ripening period:** usually shortly after alpine meadow grass in the last decade of June.
Threshing is always done from the root. The cutter bar of the harvester can be set fairly high. Settings for threshing are usually unproblematic. The rotational speed of the threshing drum can vary between 800 and 1,000 rpm with close settings of the threshing concave. The fan
should be set very low—usually the wind produced by the threshing drum is sufficient.  

**Crop yields:** Crop yields are usually higher in the second harvest year. In existing seed production the average crop yield has been about 200 kg/ha. The yield potential is approximately 400 kg/ha. Maintenance and weed control are crucial for a satisfactory yield level.
Perennial quaking grass, quaking grass

*Briza media*

**BOTANY**

Perennial, 20-50 cm high, cespitose with low-density, short rhizomes, young shoots extravaginal.

*Culms* are 20-50 cm high, slender, erect, smooth and glabrous; two to three noded, nodes glabrous.

*Leaf sheaths* of the young shoots at the beginning are closed up to the apex, later but slightly torn open, glabrous, smooth or sparsely scabrous.

*Ligule* is a fringe 1-2 mm long, collar-shaped and membranous.

*Leaf blades* are 5-15 cm long, 2-4 mm wide, flat, smooth and glabrous, scabrous only at the margins.

*Inflorescence* a panicle, 5-16 cm long,
4-12 cm wide, open, spreading, pyramid-shaped. The lowest lateral branches come off in pairs from the main axis, erectly sticking out, sparsely ramified, lengths of rachises are highly unequal, thin, scabrous and 5-20 mm long. Spikelets with 3-14 florets, 4-7 mm long, broadly ovate or cordate, pellucidous.

SUITABILITY FOR RESTORATION
In the Alps this European species occurs in hilly, montane and subalpine zones. At lower locations mainly in thin populations, at higher altitudes in densely grown turfs also. In nutrient-deficient meadows and pastures, along road embankments, on rocky slopes, and in low-density stands. On clay soil, loam and sandy loam that is moderately dry or moist up to wet, alkaline, often nutrient-deficient, moderately acid soil, rich in humus or peat, with a pH of 3.8-7.2. Indicating nutrient-deficiency and light (heliophyte), shallow-root plant on humus. Good but low-productive forage. In meadows and pastures without fertilization the plant is stimulated by maintenance, but disappears with intensified fertilization and grazing.

All-purpose grass for restoration in montane to alpine regions, less qualified for highly acid and moist soils; espiteose, preferably for poor habitats, intermediate forage quality.

SEEDS
Glumes similar, three to five-veined, 2.5-3.8 mm long, broadly ovate to orbiculate as seen from dorsal view, upper margin rounded, vaulted, membranous, margins hyaline, glabrous, midvein sparsely scabrous. Lemma seven to nine-veined, 3.6-4.2 mm long, similar shape to glumes, densely arranged, membranous, green, often coated purple, margins hyaline and whitish. Palea two-veined, 3.5-4 mm long, flat, ovate, apex slightly nicked, keels prominent and narrow-winged. Anther 2.2-5 mm long.

Thousand seed weight: 0.3-0.5 g.

REQUIREMENTS
(soil and climate)
Warm, moist to moderately dry soils with a pH of 5.0-7.5 are suitable for seed gain cultivation. Compacted waterlogged soils should be avoided.

CULTIVATION
Like most grasses, perennial quaking grass needs a carefully prepared, fine, crumbly seedbed. Seeds have sufficient seed flow; however, they can be easily blown away by the wind. This species is relatively fast-growing compared to most of the species described. It can be sown underneath spring corn, blank seed is also possible. Attention should be paid to low-density cover crop populations. Open sowing should be carried out by the end of June at the latest, in order to allow sufficient tillering in autumn. In this case, it is recommended that the crop is irrigated during summer droughts.
Crop yields: Under average conditions, optimal maintenance allows for yields between 120 and 300 kg/ha.

Seed rate: 10-12 kg/ha is common. Generally speaking, a decrease in the seed rate can help to produce well-developed and well-tillered single plants. However, this is only recommended where there is expert knowledge and best population tending.

Row spacing: 15-20 cm, depending on the construction of the seeder. Broadcast sowing is also possible in combination with a curry comb.

FERTILIZATION
Phosphorus and potassium: although quaking grass requires few nutrients, moderate fertilization (40-60 kg/ha P₂O₅ and 80-100 kg/ha K₂O) works well. Fertilization with liquid or solid manure (in late summer and early autumn) stimulates the growth the single plants until their rest period. Application of liquid manure in spring should be avoided because of nitrogen mobilization during an unfavourable vegetation stage.

Nitrogen: this should be applied in early spring, only with mineral fertilizer, in amounts of 50-70 kg/ha depending on soil and climate.

MAINTENANCE AND WEED CONTROL
The straw of the cover crop should be removed immediately and then cut. As for most grasses the following rules apply. Before sowing, only contact herbicides should be used, preferably up to three days before the beginning of sowing. Hormone-type and broad-spectrum herbicides should generally not be used until the species has reached the three leaf stage. It should be noted that the herbicides mentioned in Table 3 on p. 109 are not registered for use in seed cultivation in some countries.

Having tended the species well after the cover crop harvest, densely grown populations can develop until autumn. Where heavy growth of weed grasses is evident, the specific application of Ethofumesate can control Poa annua in particular. However, an expert should be responsible for evaluation as well as composition. National guidelines on the use of herbicides should always be followed.

Rust diseases: perennial quaking grass is extremely sensitive. Especially after the first seed harvest in summer, the population may be infected within a couple of days and collapse as a result. Continuous monitoring and - weather permitting – prophylactic spraying with a suitable fungicide are advisable.

If the crop is already infected by rust, it should be cut and removed immediately, and combined with spraying about one week after the cutting in order to save the remaining population. Crop yield losses need to be reckoned with the following year.

HARVEST AND YIELDS
Resistance to lodging: intermediate.

Shattering tendency: intermediate.

Ripeness: culms and flower spikes change colour from reddish light brown to tawny or light brown. Until complete ripeness is reached, there is a low shattering tendency.
which then becomes high. As for most grasses appropriate to the habitat, it is very important to keep an eye the ripening in order to optimize crop yield and quality.

Ripening period: between the end of June and the beginning of July, depending on climate and ecotype.

Harvesting technique: direct threshing is possible and easy. Because of a high accumulation of biomass, the straw from the harvest should at least be chaffed or carried away. More than for other species, seed producers should set the threshing drum at a low rotational speed, with a comparatively wide gap between drum and threshing concave. Large sieves are needed. In order to avoid high losses at threshing, the air supply should be reduced, if necessary to zero. Seeds should be cleaned with great care. Cleaning with air and adequate sieve systems is normally sufficient.

Crop yields: Under average conditions, optimal maintenance ensures yields between 120 and 300 kg/ha.
Upright brome, erect brome

*Bromus erectus*

*Bromus erectus* (Schröter, 1888)

**BOTANY**

Perennial species, 80-100 cm high, forming dense thickets, scarcely sarmentose.

*Culms* are stiff, slender, erect, scarcely ascending, smooth and glabrous, up to 100 cm high.

*Leaf sheaths* of young shoots are crimped in the bud (not rolled like *Bromus inermis*), margins ciliated with long stiff hairs.

*Leaf blades* of the young shoots broad, open, with 7 to 11 distinct veins and six to ten indistinct ones lying in between.

*Inflorescence* a panicle, narrow, 10-15 cm long, contracted, perfectly erect, with short, scabrous branches; few spikelets with the basal ones totalling two to five.

*Spikelets* slender, lanceolate, multi-flowered (with 5 to 12 florets), 20-38 mm long.
SUITABILITY FOR RESTORATION

This European species occurs in the Alps, in the foothills and the montane zones. It requires a temperate, highly maritime climate. Upright brome grows mainly on dry, lime-rich soils. But in the Mediterranean region it prefers shady sites and moister soils. It grows also on rendzina, para-rendzina, calcareous brown soils and alkaline ranker with a pH of 6.3-7.4.

General-purpose grass for restoration of drier, alkaline, nutrient-deficient sites at intermediate altitudes. Partial tolerance of cutting, sensitive to grazing and fertilization.

SEEDS

Fruit 9-11 mm long excluding awn, 1.5 mm wide, and 1-1.2 mm thick.
Lemnaa narrowly oblong, apically and basally acuminate, dirty straw coloured, dorsally with short or long hairs, partly glabrous.

Awn 4-6 mm long, erect, originating below the apex of the lemma.
Palea irregularly sparsely ciliated at both keels, flatly grooved, a little shorter than the lemma, hyaline, colourless. In comparison to Bromus inermis the keels have longer teeth, with shorter ones lying in between.
Rachilla 1.5-3 mm long, straight, round, becoming thicker towards the apex, often with short hairs.
Fruit adhering, separable from the husks only with effort, 7-9 mm long, 1.5-2.5 mm wide and 0.5-0.7 mm thick.

Thousand seed weight: 3.2-5.5 g.

REQUIREMENTS (soil and climate)

Like Bromus inermis, upright brome is extremely undemanding. Intermediate to light soils that are rich in humus and drier sites are suitable. It is important to select sites with little weed competition because of limited possibilities for the use of specific herbicides.

CULTIVATION

This species needs a well-prepared seedbed.
Open sowing is recommended (this is possible until the end of June if irrigation is available).
Upright brome is moderately tolerant if grown underneath a cover crop. Therefore populations of spring corn should be low density; linseed oil flax is recommended.

Seed depth: 1.5-2 cm maximum.
Seed rate: 12-15 kg/ha.
Row spacing: 25-30 cm. Broadcast sowing is also appropriate.
FERTILIZATION

Upright brome requires an intermediate amount of nutrients.

**Phosphorus and potassium:** on soils with an intermediate phosphorus and potassium content, basic fertilization with manure (liquid or solid, 15-25 tonnes/ha) is sufficient in autumn. Depending on soil content, fertilization with 60-80 kg/ha P₂O₅ and 80-120 kg/ha K₂O is considered sufficient, depending on the yield.

**Nitrogen:** after harvesting the cover crop, or at sowing, fertilization with 30-50 kg/ha of N-total is recommended so as to obtain best development until autumn. For harvest growth, 70-80 kg/ha/y of N-total is necessary; to be added in autumn and early spring. If spring fertilization is carried out too late, the main result is development of the leaf mass.

MAINTENANCE AND WEED CONTROL

There are special problems connected to the control of undesirable brome species. *Bromus tectorum* or *B. sterilis* accumulate especially on drier sites and it is complicated to control them.

Dense populations grow extensively until autumn of the seeding year. The timely and consistent use of herbicides is vital. Specific control of weed grasses can only be carried out by controlling single plants, or in favourable years by the temporary use of wiping wicks.

HARVEST AND YIELDS

**Resistance to lodging:** high.
**Shattering tendency:** low.

**Ripeness:** the spike changes colour to brown and appears to dry up. The ripeness of the seeds is determined by the nail test. Culms and leaves are still green at this point.

**Ripening period:** from the middle until the end of July.

**Harvesting technique:** direct threshing is recommended. Seeds have sufficient seed flow and can be cleaned easily.

**Crop yields:** yields depend largely on the cultivator’s experience. The range is between 200 and 500 kg/ha. Optimal maintenance ensures two to three harvesting years.
Smooth brome, awnless brome

*Bromus inermis*

**BOTANY**
Perennial species, 30-140 cm high, low-density cespitose because of highly ramified rhizomes.

*Culms* are stiff, erect and inflorescence symmetrical.

*Leaf sheaths* glabrous, more or less densely ciliated.

*Ligules* 1-2 mm long, greenish-white, truncate, lacerate.

*Leaf blades* 2-10 mm wide, light green to grey-green; adaxially mostly glabrous with wax coating (greasy), abaxially keeled and scabrous especially towards the apex. Margins serrate; leaf base strong, bright, often undate.

*Inflorescence* a panicle, grand, 10-15 cm long, widely expanding, partly one-sided.

*Spikelets* large, slender, multiflowered, 15-25 mm long.
SUITABILITY FOR RESTORATION
This Eurasian species occurs in the Alps, in the foothills and sparsely in montane zones; it prefers a continental climate. In central Europe — excluding the eastern parts of its distribution area — smooth brome mainly grows on artificial sites, such as slopes along roads and waysides. It is fairly tolerant to temporary flooding and low salinity. The species grows on loam that is sparsely covered with vegetation, warm in summer, moderately moist, rich in minerals, sandy or pure, with a pH of 6.1-7.2. Because of its rapid juvenile development and its armaments, the species is suitable for restoration on slightly inclined slopes in warmer regions. It is an important forage in warmer, humid continental regions (e.g. on soils that are rich in sodium bicarbonate, as in Hungary and the United States).

SEEDS
Fruit 10-13 mm long, 1.5-3 mm wide, and 1 mm thick. Oblong, flat, with only a short awn and often without one. Lemma a little vaulted, seven-veined; midvein quite distinct. Awn 4-6 mm long, erect, originating below the apex of the lemma. Palea flat, both keels with dense short hairs, colourless.
Thousand seed weight: 2.3-2.7 g.

REQUIREMENTS
(soil and climate)
Smooth brome is extremely undemanding. Intermediate to light soils that are rich in humus and drier sites are suitable. It is important to select sites with little weed competition, because of limited possibilities for the use of specific herbicides.

CULTIVATION
This species needs a well-prepared seedbed. Open sowing is recommended. (this is possible until the end of June if irrigation is available). Smooth brome is moderately tolerant if grown underneath a cover crop. Therefore populations of spring corn should be low density; linseed oil flax is recommended.
Seed depth: 1.5-2 cm maximum.
Seed rate: 12-15 kg/ha.
Row spacing: 25-30 cm. Broadcast sowing is also a practical alternative.

FERTILIZATION
Smooth brome requires a great deal of nutrients.
Phosphorus and potassium: on soils with an intermediate phosphorus and potassium content, basic fertilization with manure (liquid or solid, 20-30 tonnes/ha) is sufficient in autumn. If the soil content is adequate, fertilization with 60-80 kg/ha P₂O₅ and 100-140 kg/ha K₂O is considered sufficient, depending on the yield.
Nitrogen: after harvesting the cover crop, or at sowing, fertilization with about 50 kg/ha of N-total is recommended in order to obtain best development until autumn. A certain amount of nitrogen is necessary for the formation of seeds: 70-100 kg/ha of N-total should be added in autumn and early spring. If fertilization in spring is carried out too late, it is principally the leaf mass that is stimulated.

MAINTENANCE AND WEED CONTROL
Smooth brome germinates quickly. There is then a short stagnation in its growth rate, followed by rapid juvenile development. Until autumn of the seeding year this species sometimes forms high-density populations. However, the timely use of herbicides should be emphasized. Particular control of weed grasses can only be carried out by the control of single plants or – in favourable years – by the temporary use of wiping wicks.
Mechanical weed control by means of curry combs is well tolerated. Leaf spot diseases: in some years a more marked decay is possible. In this case the timely use of broad-spectrum herbicides or additional cutting is recommended.

HARVEST AND YIELDS
Resistance to lodging: intermediate. Shattering tendency: low. Ripeness: the spike changes colour to grey-brown and appears to dry up. The ripeness of the seeds is determined by the nail test. Culms and leaves are still green at this point.
Ripening period: at the end of July. Harvesting technique: direct threshing is recommended. Because of leaf mass, there may be a proportionate amount of threshing to contend with (4-6 tonnes/ha). Seeds have sufficient seed flow and can be cleaned easily. Crop yields: yields depend greatly on the cultivator’s experience and range between 200 and 600 kg/ha. Optimal maintenance allows two to three harvesting years.
Crested dog's tail, dog's tail grass

*Cynosurus cristatus*

**BOTANY**

Perennial, 20-60 cm high, forming dense thickets or turf patches. Young shoots numerous, intravaginal.

*Culms* are 10-70 cm high, slender, erect. They ascend from a ground stem that is rather thick and mostly dark to black. Also unramified, smooth and glabrous, one to three noded, nodes glabrous.

*Leaf sheaths* of the young shoots are almost closed up to the apex, slightly torn open, grooved, smooth and glabrous, the lowest ones disintegrating into fibres.

*Ligule* is a fringe that is 0.5-1.5 mm long, collar-shaped and membranous.

*Leaf blades* of the young shoots are 4-15 cm long and 1-2 mm wide, flat, adaxially glabrous or with short hair, scabrous within the top third; leaf blades of the culm are up to 3 mm wide.

*Inflorescence* a panicle, 2-12 cm long.
5-10 mm wide, dense, contracted, with a main axis that is bent zigzag. The groups of spikelets are arranged on one side of the main axis. Panicle also erect, green, often coated purple, with very short and ramified branches, ciliated like the main axis and the rachis. The spikelets are always next to a stalked dense fan of empty husks, several together, arranged in short balled groups. Spikelets with two to five florets, 3-6 mm long without awns, laterally compressed.

**SUITABILITY FOR RESTORATION**

In the Alps this perennial Eurasian species occurs from the foothills to the subalpine zone. In the lower valleys of the Alps that are warm in summer, the plant decreases significantly. At these locations dog's tail grass prefers sites with good water support and less sun. In the montane zone with its more balanced climate, the plant grows more often in meadows and pastures. There it also appears in natural and artificial turf sites, in country lanes and in low-density stands.

On clay soil and loam that is moist, rich in nutrients, alkaline, moderately acid, mostly compacted, indicating light (heliophyte). It likes moist, moderately rich in nutrients and humus, loamy-clayey soils with a pH of 5-7.

It is a good forage grass that protects the soil against erosion thanks to its good resistance to intensive grazing (sheep pastures). Good nutrient tolerance (with the exception of high amounts of nitrogen), suitable for restorations up to the subalpine zone as well as in lower regions. Dog's tail grass is an intermediate forage that is also used as a component in grassland mixtures.

**SEEDS**

Glumes similar, one-veined, 3-4.5 mm long, narrowly lanceolate as seen from a lateral view, acuminate, hyaline, glabrous, with a conspicuous scabrous keel. Lemma five-veined, 3-4 mm long, lanceolate, apex narrowly rounded and mostly with a thin awn, up to 1 mm long, membranous, margins hyaline; glabrous, scabrous at upper part. Palea about as long as the lemma, lanceolate, apex nicked, scabrous on the keels.

**Thousand seed weight:** 0.5-0.7 g.

![Seeds](https://via.placeholder.com/150)

**REQUIREMENTS (soil and climate)**

Seed production is possible on all kinds of productive soils. Soils that are rich in nutrients and have good water management are preferred. However, heavily waterlogged or very light sandy soils are not suitable.

**CULTIVATION**

Dog's tail grass is fairly tolerant to shade and therefore can be sown underneath winter wheat as well as spring corn. Open sowing should be carried out by the middle of June at the latest. Effort concerning weed control is needed.

**Seed rate:** 7-9 kg/ha are sufficient if growing conditions and germination
capacity are satisfactory. If sown underneath a cover crop in autumn or blank in spring, the seed rate should be slightly increased. Row spacing: 15-20 cm. Broadcast sowing (e.g. by removing sowing tubes) is also possible in combination with a curry comb.

**FERTILIZATION**

**Phosphorus and potassium:** although dog’s tail grass requires few nutrients, a moderate fertilization (40-60 kg/ha P₂O₅ and 80-100 kg/ha K₂O) has shown good results. Timely fertilization with liquid or solid manure (late summer, early autumn) stimulates the growth of the single plants until their resting period. Application of liquid manure in spring should be avoided because of undesirable nitrogen mobilization during an unfavourable vegetation stage.

**Nitrogen:** total requirement per harvesting growth is 70-80 kg/ha N. The plant should be fertilized in spring, only with mineral fertilizer, in amounts between 40 to 60 kg/ha depending on climate and weather.

**MAINTENANCE AND WEED CONTROL**

Dog’s tail grass has a slow initial development. Even if there is more fertilization, only a little leaf mass will be produced. Thus, as a rule, additional cutting is necessary only in autumn. Particularly at lower locations, dog’s tail grass is sensitive to rust diseases. In this case it is essential to use fungicides or carry out early cutting.

Before sowing, only contact herbicides should be used, up to three days before the beginning of sowing. Hormone-type and broad-spectrum herbicides should generally not be used until the species reaches the three leaf stage. Until autumn of the year of sowing and after the seed harvest, specific weed control can be successfully carried out with wiping wick and total herbicides (Glyphosate).

**HARVEST AND YIELDS**

**Resistance to lodging:** high.

**Shattering tendency:** intermediate.

**Ripeness:** the culm changes colour to tawny and the pseudo-spike goes from light brown to a coffee colour. When unripe the seeds are stained bright greenish-yellow, becoming more and more tawny during ripening. Even at the beginning, the seeds can be rubbed off quite easily, although they are relatively firm.

**There is a risk of flailing too early:** in order to estimate the ripeness of the seeds, a nail test is advised. The seeds should at least be at the yellow ripeness stage.

**Ripening period:** does not flower too late; ripeness depends to a great extent on the weather. On average, it can be expected within the last decade of July.
Harvesting technique: direct threshing is recommended, which is very easy because of the high resistance to lodging. The seeds have an excellent seed flow and can be cleaned easily.

Crop yields: optimal maintenance allows yields between 200 and 600 kg/ha. Up to three harvesting years are possible.

Harvesting crested dog’s tail
Tufted hair grass

*Deschampsia cespitosa*

**BOTANY**
Perennial, forming dense, large thickets. Young shoots numerous, intravaginal. **Culms** are 20-150 cm high, slender to moderately thick, erect or geniculate at the base; two to three noded, nodes glabrous. **Leaf sheaths** are grooved, keeled and scabrous only on the upper part, otherwise smooth and glabrous. **Leaf blades** are 10-60 cm long, 2-5 mm wide, mostly flat (involute if there is soil drying), abaxially grooved, smooth and glabrous; extremely scabrous on the adaxially prominent ribs as well as at the margins. **Inflorescence** a panicle, 10-50 cm long, up to 20 cm wide, spreading, open, pyramid-shaped; erect or slightly nodding at the apex, green and silvery, coated purple or golden. **Spikelets** with two florets, 4-5 mm long. Sometimes produce leaf shoots.
SUITABILITY FOR RESTORATION

This species occurs worldwide in temperate humid regions. In the Alps it can be found in the foothills and the montane, subalpine and alpine zones. Because of its deep roots, the species tolerates occasional drought in the topsoil. Its pronounced ability to crowd out other species results in generous growth. Deschampsia cespitosa var. alpina prefers depressions, slopes with soakage and sites around the leakage of spring water. The species grows on soils with a pH of 4.3-8.1 and grows at altitudes of up to 2750 m in the Alps.

With regard to altitude, there is considerable ecological amplitude. This is the most important grass in the restoration of damp to alternating moist and dry locations. After restoration, spontaneous dispersal to sites appropriate to its habitat is often noted. Good stabilization of the soil and tolerance of nutrients; at higher locations it is grazed by livestock, but its forage value is low. On pastures it is controlled because it is a weed and also takes up space; different control methods are used.

SEEDS

Fruit 1.5-2.5 mm long, 0.6-0.8 mm wide, 0.5-0.6 mm thick; ovate-lanceolate.

Awn meandering, auburn, slightly longer than the lemma, arising almost basally.

Lemma hyaline, translucent, about twice as long as the fruit, dentate at the top; margins bent.

Dense white hair tuft at base.

Rachilla: with white hair.

Fruit 1.5 mm long, narrowly acuminate, brown.

**Thousand seed weight:** 0.2-0.4 g.

REQUIREMENTS (soil and climate)

Seed cultivation is possible on any soil that is well supplied with water and has a pH range from 5.0 to 7.5. Tufted hair grass also tolerates compact and waterlogged soils, where farming is still possible.

The species is hardy and even tolerates strong frost.

Provided water supply is sufficient, fertility is satisfactory.

CULTIVATION

Tufted hair grass needs a well-prepared, fine, crumbly seedbed. It is sensitive to seed depths exceeding 0.5 cm. Seeds have sufficient seed flow and can be sown with an established seeder.

It is advisable to sow underneath spring corn or blank until the beginning of June, in order to guarantee the sufficient development and tillering the single plants. When sown on bare soil, attention should be paid to irrigation.

**Seed rate:** 6-8 kg/ha is sufficient for dense populations.

**Row spacing:** 15-20 cm, depending on the construction of the seeder. Broadcast sowing is also possible.

FERTILIZATION

This species is robust and undemanding. Nevertheless, a good supply of nutrients is recommended in order to optimize the crop yield.
**Phosphorus and potassium:** On soils with an intermediate phosphorus and potassium content, basic fertilization with manure (liquid or solid 15-25 tonnes/ha) is sufficient in autumn. For mineral fertilization, 40-60 kg/ha P₂O₅ and 60-100 kg/ha K₂O are recommended. **Nitrogen:** a sufficient supply of nitrogen in autumn guarantees a satisfactory tillering. It should be borne in mind that an excessive supply of nitrogen in late spring may cause decreased formation of the spermatophores. However, a certain amount of nitrogen is necessary for the formation of seeds: 50-70 kg/ha of N-total should be added in both autumn and early spring.

**MAINTENANCE AND WEED CONTROL**
Tufted hair grass has a slow juvenile development. Therefore, crop residues should be removed quickly. It is recommended that the stubbles are cut once more.

Before sowing, only contact herbicides should be used, up to three days before the beginning of sowing. Hormone-type and broad-spectrum herbicides should generally not be used until the species reaches the three leaf stage.

In order to obtain optimal development up to autumn of the seeding year, weed control has to start in time. This species is quite robust and resistant. However, specific control of weed grasses is not possible, as it is the case with the gender *Festuca*. The use of curry combs during mechanical weed control is well tolerated. Comparative experiments show that there will be higher yields in the second harvesting year if the board of the thresher is kept very high at the first harvest. This method also avoids the leaves being cut. Leaves die off over winter.

Legal regulations permit the cutting or burning of the biomass in early spring.

**HARVEST AND YIELDS**
**Resistance to lodging:** high.
**Shattering tendency:** intermediate.
**Ripeness:** the flower spikes change colour from greenish-yellow to bright yellow or straw-coloured. The seeds will shed if touched only lightly. As with most species common to the habitat, great attention should be paid to specifying the optimal harvest time. Daily or less frequent control of the population can help in deciding. At the time of complete ripeness almost all species are very sensitive to wind and heavy rainfall, and it is possible to lose up to 70 percent of the crop within a few minutes.

**Ripening period:** depending on climate and location, ripening takes place between the beginning and the middle of July.
**Harvesting technique:** for threshing it is recommended that the rotational speed of the drum be slightly increased and the settings of the concave narrowed substantially. The seeds have sufficient seed flow and can be cleaned easily.

**Crop yields:** yields can fluctuate considerably from year to year. As a rule, higher yields can be expected in the second harvesting year. Average yield is around 160 kg/ha, where as single yields can be noticeably higher.

*Image: Harvesting of tufted hair grass*
Alpine chewing's fescue

*Festuca nigrescens*

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**BOTANY**

Forms perennial dark green thickets, some young shoots growing intravaginal, short rhizomes, no stolons. Compared to fescue growing in lowlands, the leaves are narrow and wiry.

**Culms** are 20-55 cm high, slender, erect or geniculate, smooth and glabrous. **Leaf sheaths** of young shoots with margins connate for almost their entire length, no lateral auricles apically (leaves have short, rounded auricles), reddish, smooth, at least in the upper part densely pilose with soft hair, basal leaf sheaths disintegrating into fibres. **Leaf blades** of young shoots are 5-20 cm long, 0.5-0.7 mm wide, soft, keeled, undersurface smooth and glabrous, only the upper part scabrous, surface with scattered, short hair, cross-section folded in a V-shape, five to seven vascular bundles, on surface five ribs and four grooves.
Inflorescence a panicle, 3-12 cm long, before and after flowering period contracted and dense, slightly nodding, lanceolate shape, green, coated reddish or purple, lateral branches ramify individually from angular main axis. In flowering period expanded, ramified, rough and angular, along the 1-2 mm long rachis. Three to eight flowered spikelets, up to the top of the fourth floret 7-10 mm long.

Suitability for restoration
In the Alps this species can be found in montane, subalpine and alpine areas. Indifferent to soil type, it can therefore be found on almost any kind of rock. However, it prefers predominantly dry and sunny locations. In moist meadows and pastures it grows less. In the Alps it flourishes at altitudes higher than 2 600 m. All-purpose high-quality forage in montane to alpine regions; resistant to high nutrients, grazing and cutting.

Seeds
Fruit of the husk 3.5-6 mm long, 0.5-1 mm wide, 0.5-0.8 mm thick, oblong, acuminate, greyish-yellow to brown, often stained red.
Awn up to 2.5 mm long.
Lemma vaulted, keeled because of midvein, marginal veins indistinct, short hairs on margin and midvein, palea in a hollow. Fruit dark brown to red. Keels apically dentate, short. Rachis 1.2 mm long, straight, slightly expanding, distal surface broadening into a head shape. Fruit connate, 3.0-4.0 mm long up to 1 mm wide, 0.5 mm thick, apically lanceolate and round, base acuminate, ventrally grooved, dorsally ellipsoid, red to brown.
Thousand seed weight: 0.8-1.2 g.

Requirements (soil and climate)
Chewing's lescue has no special soil requirements. It roots deeply and therefore shows no sensitivity to dryness. It prefers intermediate to highly nutritious soil. The pH should be between 5.5 and 6.8. Moist or waterlogged soil, peat, ground that tends to grow weeds and light, dry soil should be avoided. Compared to other alpine plants it is more competitive towards weeds. Nonetheless, locations with a high presence of quack grass, meadow grass and crab grass should be avoided. Cultivation of seeds is possible up to an altitude of 1 000 m.

Cultivation
Open sowing is possible if carried out until the beginning of July or (in mild climates) middle of July.
Seeding below a cover crop in autumn is possible with thin cover crop populations. Cultivation under winter barley is therefore not recommended cover crops in spring are generally unproblematic. Seeding can be carried out underneath various summer cereals and linseed. Juvenile development is faster in comparison to most other site-specific grasses; nevertheless, seeding should be
done immediately after the seeding of the cover crop.

Seed depth: no more than 0.5 cm.
Seed rate: 6-8 kg, depending on experience and cover crop.
Row spacing: broadcast sowing or row spacing of 12-25 cm, depending on the construction of the seeder. The aim should be to grow well-developed and strong single plants.

FERTILIZATION
Chewing’s fescue is generally undemanding. To obtain a satisfactory yield, nutrient supply should be high.

Phosphorus and potassium: on soils with an intermediate phosphorus and potassium content, fertilization with manure (15-20 tonnes/ha) is sufficient. For mineral fertilization 70 kg/ha P₂O₅ and 80-120 kg/ha K₂O are recommended.

Nitrogen: a sufficient supply of nitrogen in autumn guarantees satisfactory tillering. An excessive supply of nitrogen in late spring may cause decreased formation of spermatophores. However, a certain amount of nitrogen is necessary for the formation of seeds and 70-100 kg/ha of N-total should be split and applied in autumn and early spring.

MAINTENANCE AND WEED CONTROL
Guidelines for the gender Festuca generally apply. However, since cespitose stands form only a few seeds, densely growing turfs should be thinned in late summer before the second harvest year. Various machines (e.g. disc harrows and grubbers) can be used to stimulate tillering in order to obtain a generous crop.

In well-developed populations, cutting is recommended in the first autumn, but is not necessary in the following one.

Removing biomass is usually not necessary. Weed control can be undertaken mechanically. For stands with 25-cm row spacing, a hoe or a brush can be used.

Application of fungicides against rust in late summer of the first harvest year is seldom required. As for all fescues, selective control of weed grasses is possible. The most intrusive grasses can be eradicated sufficiently without affecting the crop (see Table 3 on p. 109).

HARVEST AND YIELDS

Resistance to lodging: high (in small populations) to intermediate (in well-maintained seed populations with high crop yields).

Shattering tendency: low to intermediate. Where there is a satisfactory nutrient supply, the whole stand lodges after flowering, which strongly reduces the shattering tendency.

Ripeness: because of the low shattering tendency, fixing a time for flailing is not difficult. Culms change colour to yellow and seeds become firm and brown, often stained red. Threshing time is indicated by the number of shattering seeds when a
bunch of spikes is beaten against the palm of the hand.

**Ripening period:** ripeness is to be expected between the middle and end of June, depending on the origin of the plant material, climate and soil conditions.

**Harvesting techniques:** threshing has proved unproblematic. Seeds have a good seed flow and can be cleaned easily. As for all seeds, immediate and gentle drying is necessary.

**Crop yields:** between 600 and 1 000 kg/ha in the first year and 400 and 700 kg/ha in the second year, depending on practical experience.
East alpine violet fescue

*Festuca picturata*

*Festuca picturata* (Kiffmann, 1978)

**BOTANY**

Perennial, forming quite dense mats (or cushions), with numerous, extravaginal young shoots and without stolons. **Culms** are 25-45 cm high, mostly with soft hairs in the upper part, seldom completely glabrous. **Leaf sheaths** of the young shoots almost completely connate, devoid of lateral auricles, smooth; the basal ones disintegrating into fibres. **Ligule** collar-shaped, very short, glabrous. **Leaf blades** of the young shoots 10-25 cm long, 0.5-0.75 mm wide, folded (seldom flat). Cross-section irregularly hexagonal, keeled, with five vascular bundles and adaxially three to five ribs and four grooves. **Inflorescence** a panicle, 4-8 cm long, quite stiff, main axis and lateral branches softly pubescent. Three to four flowered spikelets, 6.4-7.6 mm long, green, dark purple mottled.
SUITABILITY FOR RESTORATION
In alpine to subalpine sites on pastures and meadows, on turf that is covered by snow for much of the year. On acidic (not on neutral or alkaline), nutrient-deficient soil with intermediate humus content. Indicates intermediate moisture, acid soil and light.
All-purpose grass for silicious sites, tolerant of nutrients but not dependent on them, tolerant of cutting.

SEEDS
Glumes dissimilar, membranous, glabrous, lower glume one-veined, 2.2-3.4 mm long; upper glume three-veined, 3.6-4.8 mm long, lanceolate, acuminate and pointed. Lemma five-veined, 4.3-4.7 mm long, lanceolate, glabrous, midvein scabrous in upper part, pointed, short-awned.
Awn 1-1.6 mm long.
Palea two-veined, as long as lemma.
Anther 2.3-2.8 mm long.
Ovary with scattered hair, seldom glabrous.
Fruit 2.6-3 mm long, elliptic or lanceolate outline, not connate with lemma and palea.
**Thousand seed weight:** 0.7-0.9 g.

REQUIREMENTS (soil and climate)
In seed production *Festuca picturata* has no special requirements. As for all fescues, moist or waterlogged soil, peat and light, dry soil and soils with high weed infestation should be avoided.
Competition with weeds is low. Locations with annual meadow grass and rough meadow grass (*Poa annua* and *Poa trivialis*) should therefore be avoided.
Seed production is unproblematic with a pH between 5 and 7.

CULTIVATION
Open sowing is possible if carried out until the end of June (or beginning of July in mild climates) at the latest. Irrigation must be available in case of late sowing.
Because of the plant’s slow juvenile development and low competition, nurse crops in autumn are not recommended.
Nurse crops in spring underneath summer cereals or linseed are unproblematic if the cover crop does not produce too much shade. The slow juvenile development means that seeding has to be done immediately after the seeding of the cover crop.
**Seed depth:** no more than 0.5 cm.
**Seed rate:** 8-10 kg/ha
**Row spacing:** 15-20 cm. Broadcast sowing is possible.

FERTILIZATION
*Festuca picturata* has no special requirements. An intermediate supply of nutrients is sufficient for a satisfactory crop yield.
**Phosphorus and potassium:** for soil with intermediate phosphorus and potassium content, fertilization with stable manure (15-20 tonnes/ha) is sufficient. For mineral fertilization, the amounts should be between 40 and 60 kg/ha P₂O₅ and 80 to 100 kg/ha K₂O.
Nitrogen: sufficient nitrogen in autumn guarantees satisfactory tillering. However, a surplus of nitrogen in late spring may decrease the development of spermatophores. The amount of nitrogen necessary for seed development is about 70 kg/ha N-total. This should be split and applied in autumn and early spring.

MAINTENANCE AND WEED CONTROL
Generally the same guidelines as for all fescues apply. Festuca picturata has an extremely slow juvenile development and grows very low. Stands can become cespitous after the first harvest. If second and third harvests are planned, stands need to be thinned (see chewing’s fescue). This species is generally tolerant of herbicides. For application of hormone-type and broad-spectrum herbicides see Table 3 on p. 109.

The use of herbicides is necessary even for low weed infestation. Early application is important because high weed competition has a disproportionately high impact on the crop yield. As for all fescues, there is a wide range of grass herbicides that can be used for weed control (see Table 3 on p. 109).

HARVEST AND YIELDS
Resistance to lodging: high, in well-maintained populations with high crop yields, to intermediate.
Shattering tendency: low to intermediate.
Ripeness: culms and panicles change colour to greyish-brown to yellow-brown. Seeds shatter easily when touched.
Ripening period: usually shortly before chewing’s fescue, under average conditions in the second half of June.
Harvesting techniques: unproblematic as for all fescues. Swath threshing is possible, but should only be done in years with damp or uncertain weather. Seeds have a good seed flow and can be cleaned easily.
Crop yields: crop yields may be higher in the second harvest year. In practice a harvest is between 150 and 250 kg/ha. However, the yield potential is estimated to be higher.
Thanks to various weed controls, up to three harvesting years are possible.
**Festuca pseudodura**

**BOTANY**
Perennial, forming low mats, numerous intravaginal young shoots, no stolons or rhizomes.  
**Culms** are 15-30 cm high, slim, in upper part glabrous or slightly pilose.  
**Leaf sheaths** of young shoots with margins connate for their entire length, brownish, often densely pilose, auricles on leaf sheaths short, positioned laterally, ciliated; old ones hardly disintegrating.  
**Leaf blades** of young shoots 5-15 cm long, 0.5-1.1 mm wide, stiff, shiny green, abaxially glabrous, adaxially pilose, cross section slim, V-shaped, folded, seven vascular bundles, adaxially three to five ribs, two to four grooves.  
**Inflorescence** a panicle, 4-7 cm long, contracted even in flowering period, lateral branches glabrous or pilose (with short hairs), basal branches four to six spikelets.  
Four to six flowered spikelets, broadly ovate, blue-green, seldom mottled purple.
SUITABILITY FOR RESTORATION

*Festuca pseudodura* is a central European montane plant that thrives mainly in the alpine zone between 1700 and 2800 m. It grows on dry, nutrient-deficient, rather acidic and mostly flat soil. It is a typical plant for rough meadows on purely silicious ground. Especially suitable for alpine restoration areas on silicate, pioneer plant, moderate tolerance of nutrients, low mass development.

SEEDS

Fruit of the husk 3.5-5 mm long, 0.8-1.2 mm wide, 0.5-0.8 mm thick, acuminate, light brown, coated red.
Awn 4-5 mm long.
Lemma vaulted, slightly keeled, marginal veins indistinct, palea usually covered by margins of lemma, hollow, fruit brown.
Rachis up to 1 mm long, cylindrical, broadened at the end.
Fruit connate, 2-3 mm long, 0.6-1 mm wide and thick, apically rounded, basally acuminate, ventrally grooved, dorsally vaulted, dark brown.
Thousand seed weight: 0.8-1.0 g.

REQUIREMENTS (soil and climate)

*Festuca pseudodura* has no special requirements. Moist or waterlogged soil, peat, ground with high weed infestation and light, dry soil should be avoided. Competition with weeds is low. Locations with a high presence of annual meadow grass and rough meadow grass (*Poa annua* and *Poa trivialis*) should therefore be avoided.

CULTIVATION

Open sowing is possible if carried out until the beginning of July at the latest (or middle of July in mild climates). In the latter case, irrigation must be possible. Because of the plant’s slow juvenile development, cover crops in autumn should be avoided.

Cultivation in spring under linseed or spring corn is unproblematic if the cover crop does not produce too much shade. The slow juvenile development means that cultivation must be carried out immediately after sowing the cover crop.

Seed depth: not more than 0.5 cm.

Seed rate: 8-10 kg/ha.

Row spacing: 15-20 cm. Broadcast sowing is possible.

FERTILIZATION

On new land *Festuca pseudodura* is undemanding. For a satisfactory crop yield nutrient requirement is intermediate.

Phosphorus and potassium: on soils with an intermediate content of phosphorus and potassium, fertilization with liquid or solid manure (15-20 tonnes/ha) is sufficient. For mineral fertilization amounts of 50-60 kg/ha P<sub>2</sub>O<sub>5</sub> and 80-100 kg/K<sub>2</sub>O are recommended.

Nitrogen: a sufficient supply of nitrogen ensures satisfactory tillering. However, a
surplus of nitrogen in late spring may decrease the development of spermatophores. The amount of nitrogen that is necessary for seed development is about 70 kg/ha N-total. This should be split and applied in autumn and early spring.

MAINTENANCE AND WEED CONTROL
Generally the same guidelines as for all fescues apply. However, densely growing populations can become cespitose, although, not to the same degree as Festuca nigrescens or Festuca picturata. For a second or third harvest the stands should therefore be thinned (see chewing’s fescue). Festuca pseudodura has a low sensitivity to rust and fungal leaf diseases and a high tolerance of herbicides. For application of hormone-type and broad-spectrum herbicides see Table 3 on p. 109. Generally, the use of herbicides is required even for low weed infestation. Early application is important because high weed competition has a disproportionally high impact on the harvest. As for all fescues, there is a wide range of grass herbicides that can be used for weed control (see Table 3 on p. 109).

HARVEST AND YIELDS
Resistance to lodging: high (in poor populations) to intermediate (in well-maintained, fruitful seed populations).
Shattering tendency: low to intermediate.
Ripeness: before ripeness culms and panicles have a typical red to light brown colour. Shortly before threshing, panicles change colour to light brown. Threshing time is indicated by the number of shattering seeds when a bunch of spikes against the palm of the hand is beaten.
Ripening period: Festuca pseudodura ripens approximately 7-14 days before chewing’s fescue, between the middle and end of June.
Harvesting techniques: threshing has proved unproblematic. Swath threshing is possible, but should only be done in
damp and uncertain weather because of the high shattering tendency when seeds are fully ripe. Short cutting is not well tolerated and may lead to a decrease in crop yields the following year. Seeds have a good seed flow and can be cleaned easily.

**Crop yields:** crop yields are highly dependent on the quality of weed control. In practice 100-300 kg/ha can be reached; yield potential is approximately 600 kg/ha. Thanks to various weed controls, up to three harvests are possible.
Tufted fescue

_Festuca supina_

**BOTANY**
Perennial, forms small, green mats with high density, numerous intravginal leaf sheaths, no rhizomes.

*Culms* are 10-20 mm high, slim, erect, grooved, underneath panicle scabrous or with short hairs.

*Leaf sheaths* of young shoots with margins connate in lower third or half, glabrous, heavily grooved, at aperture two lateral, small, rounded auricles.

*Leaf blades* of young shoots 3-10 cm long, 0.4-0.7 cm wide, limp, green, smooth, only apically slightly scabrous, cross-section folded, elliptic, heart – or Y-shaped, seven vascular bundles, adaxially one to three ribs with short, scattered hairs, two to four grooves.

*Inflorescence* a panicle, 2-6 cm long, oblong-ovate, contracted, dense, expanding only in flowering period, greyish-yellow,
usually coated purple, lateral branches ramify individually from main axis; lateral branches and main axis angular and scabrous because of prickle hair.

Three to four flowered spikelets, 6-7 mm long, blue-green, coated purple, angular, scabrous, often modified to foliar shoots.

**SUITABILITY FOR RESTORATION**

Tufted fescue is a central European montane plant found in the alpine and subalpine zone. It prefers arid, nutrient-deficient, acidic soil and therefore is a typical plant for alpine rough meadows, dry pastures and rock planes. In higher altitudes it supersedes mat grass (*Nardus stricta*). In the Alps, tufted fescue grows at altitudes up to 3 000 m.

All-purpose grass in dry and nutrient-deficient habitats in the subalpine and alpine zone. Can be used as a substitute for mat grass.

**SEEDS**

Fruit of the husk 2.5-3.5 mm long, 0.5-0.9 mm wide and thick, narrowly ovate acuminate, light brown to greyish-brown. Awn short, up to 1 mm long.

Lemma not veined, reflected margins, involute. Keels in upper third shortly dentate, palea and lemma have the same length, palea in hollow, fruit darkly translucent.

Rachilla 0.8 mm long, broadened at the end.

Fruit strongly connate, 2 mm long, 0.5 mm wide and thick, dark auburn.

**Thousand seed weight:** 0.4-0.6 g.

**REQUIREMENTS (soil and climate)**

In seed production tufted fescue has no special requirements. Moist or waterlogged soil, peat and light, dry soil and ground with high weed infestation should be avoided. Competition with weeds is low. Locations with a high presence of annual meadow grass and rough meadow grass (*Poa annua* and *Poa trivialis*) should be avoided. Seed production is unproblematic with a pH between 5 and 7.

**CULTIVATION**

Because of the small seed size it is important to have a well-prepared, flat, small crumbly seedbed. The plants do not grow very high and therefore the cutting bar of the harvester should be set rather low. This means that the ground must be free of stones.

Open sowing is possible if carried out until the end of June. However, best results are obtained using summer cereals as a cover crop. Because of the plant’s low tolerance to shade there should be a thin cover crop population.

**Seed depth:** no more than 0.5 cm.

**Seed rate:** 6-8 kg/ha.

**Row spacing:** 15-20 cm. Broadcast sowing is possible.
FERTILIZATION
Tufted fescue is very undemanding. Nutrient requirements for a satisfactory crop yield are intermediate.
**Phosphorus and potassium:** on soils with an intermediate supply of phosphorus and potassium, fertilization with manure in autumn is sufficient. For mineral fertilization, amounts should be 50-60 kg/ha P2O5 and 100 kg/ha K2O.
**Nitrogen:** a sufficient supply of nitrogen in autumn guarantees satisfactory tillering. However, a surplus of nitrogen in late spring may lead to a decreased development of spermatophores. The total amount of nitrogen necessary for seed development is about 70 kg/ha. This should be split and applied in autumn and early spring.

MAINTENANCE AND WEED CONTROL
Generally the same guidelines as for all fescues apply. Tufted Fescue has a rather slow juvenile development and stands do not grow very high.
Populations can become cespitous after the first harvest. If a second or third harvest is planned, stands have to be thinned (see chewing’s fescue).
The species is quite tolerant of herbicides. For application of hormone-type and broad-spectrum herbicides, see Table 3 on p. 109. The use of herbicides is necessary even for low weed infestation. Early application is important because high weed competition has a disproportionately high impact on the crop yield. As for all fescues, there is a wide range of grass herbicides that can be used for weed control (see Table 3 on p. 109).

HARVEST AND YIELDS
**Trendy to lodging:** high, even for well-maintained populations with high crop yields.
**Shattering tendency:** low to intermediate.
**Ripeness:** culms and panicles change colour to greyish-brown or tawny. Seeds shatter easily when touched.
**Ripening period:** seeds ripen shortly before chewing’s fescue, under average conditions at the beginning of July.
**Harvesting techniques:** unproblematic as for all fescues. The cutter bar should be set very low because ripe stands are only 15-20 cm high. Swath threshing is possible, but should only be done in years with damp or uncertain weather. Experience shows that these plants do not tolerate low cutting. This can lead to damaged plant stands on large areas and decreased crop yields the following year. Seeds have a good seed flow and can be cleaned easily.
**Crop yields:** usually higher in the second harvest year. In practice a harvest is between 150 and 450 kg/ha.
Thanks to various weed controls, three harvests are possible.

Ripe plants ready for harvest
Variable fescue

Festuca varia s. str.

Festuca varia s. str. (Kiffmann, 1978)

BOTANY
Perennial, forming small green mats, numerous intravaginal young shoots, no rhizomes or stolons.

Culms are 25-50 cm high, slim, upper part usually scabrous, glabrous, two glabrous nodes.

Leaf sheaths of young shoots with margins connate in the lower third, mostly puberulous, ending glabrous.

Ligule of young shoots is a 0.5-2 mm long, truncate, mostly disintegrating, membranous fringe; cauline leaves 1-3 mm long.

Leaf blades of young shoots up to 15 cm long, 0.6-1 mm in diameter, glabrous, pointed and stinging, cross-section folded, obovate, seven to nine vascular bundles, adaxially five to seven ribs and usually six grooves, ribs shortly pilose.

Inflorescence a panicle, 3.5-8 cm long, ovate, open, consisting of few spikelets only, lateral branches as well as main axis densely pilose with short hair, lower lateral branches about half as long as panicle. Four to seven flowered spikelets, 8-11 mm long, coated purple, rachilla scabrous and shortly pilose between florets.
Suitability for Restoration

Variable fescue is a European montane plant, found in alpine and subalpine areas, but seldom in montane zones. It usually grows in pure stands on fully exposed, steep, southeastern to southwestern upper and middle slopes. Its usual habitat is on dry basement complex rock in the upper forest zone.

It grows preferably on skeletal, deficient in lime ranker, poorly developed brown soils and semipodsol above granite as well as above para – and biotite – gneiss and phyllite with a pH between 4.2 and 6.2. It shows moderate aridity, acidity, low nutritional content, mineral soil and light (heliophyte).

For restoration of acidic, exposed, steep slopes in the subalpine to alpine zone, good protection against solifluction. Low tolerance of cutting. Not suitable for foraging or hay harvest (rigid, pointed leaves).

Requirements (Soil and Climate)

Festuca varia is very similar to Festuca pseudodura, in appearance as well as cultivation. Variable fescue has no special soil requirements. Moist or waterlogged soil, ground with high weed infestation, peat and light, dry soil should be avoided.

Competition with weeds is low. Locations with a high presence of annual meadow grass and rough meadow grass (Poa annua and Poa trivialis) should therefore be avoided.

Cultivation

Open sowing is possible if carried out until the end of June at the latest (or beginning of July in mild climates). In the latter case irrigation must be available.

Because of the plant’s slow juvenile development and low competition, cultivation below cover crops in autumn should be avoided.

Seeding in spring under linseed is unproblematic. Because of photosensitivity and slow juvenile development it is important to have a thin cover crop population. Seeding should be done immediately after the seeding of the cover crop.

Seed depth: no more than 0.5 cm.
Seed rate: 8-10 kg/ha.
Row spacing: 15-20 cm. Broadcast seeding is possible.
FERTILIZATION

Festuca varia has no special requirements. A low to intermediate supply of nutrients is sufficient for a satisfactory crop yield. **Phosphorus and potassium:** for soil with an intermediate supply of phosphorus and potassium, fertilization with stable manure (15-20 tonnes/ha) is sufficient. For mineral fertilization, amounts should be between 50 and 60 kg/ha P₂O₅ and 80 to 100 kg/ha K₂O. **Nitrogen:** sufficient nitrogen in autumn guarantees satisfactory tillering. However, a surplus of nitrogen in late spring may decrease the development of spermatophores. The amount of nitrogen necessary for seed development is about 70 kg/ha N-total. This should be split and applied in autumn (70 percent) and early spring (30 percent).

MAINTENANCE AND WEED CONTROL

Generally the same guidelines as for all fescues apply. However, dense propagation populations can become cespituous, although, not to the same degree as Festuca nigrescens or Festuca picturata. If a second and third harvesting year is planned, stands should be thinned (see chewing’s fescue). Variable fescue has a low sensitivity to rust and fungal leaf diseases and is tolerant to herbicides. For application of hormonetype and broad-spectrum herbicides, see Table 3 on p. 109. The use of herbicides is necessary even for low weed infestation. Early application is important because high weed competition has a disproportionately high impact on the crop yield. As for all fescues, there is a wide range of grass herbicides that can be used for weed control (see Table 3 on p. 109).

HARVEST AND YIELDS

**Resistance to lodging:** high, even for well-maintained populations with high crop yields. **Shattering tendency:** low to intermediate. **Ripeness:** before ripeness culms and panicles have a typical red to light brown colour. At the time of threshing, panicles change colour to a very light brown. Threshing time is indicated by numerous seeds shattering when a bunch of panicles is beaten against the palm of the hand. **Ripening period:** the species ripens approximately four days before chewing’s fescue, between the middle and end of June. **Harvesting techniques:** experience has shown that threshing is unproblematic. Swath threshing is possible but should only be done in years with damp or uncertain weather because of the high shattering tendency when the seeds are fully ripe. Short cutting is not well tolerated and may lead to a decrease in crop yields the following year. Seeds have a good seed flow and can be cleaned easily. **Crop yields:** crop yields are highly dependent on the quality of weed control. In first large-scale propagations, 100-250 kg/ha have been reached. Yield potential is approximately 400 kg/ha. Due to various weed controls, up to three harvests are possible.
June grass, crested hair grass

*Koeleria pyramidata*

*Koeleria pyramidata* (Kiffmann, 1978)

**BOTANY**

Perennial, forms thin turfs, long rhizomes and intravaginal young shoots that grow individually and have two to three well-developed leaves. Base of culms and young shoots not tuberously thickened.

**Culms** are 40-90 cm high, strong, smooth and glabrous or shortly and densely pilose underneath panicle, two to three-noded, underneath glabrous nodes there is often short hair.

**Leaf sheaths** of young shoots and cauline leaves grooved, glabrous to densely pilose, basal ones usually shortly pilose.

**Ligule** 0.5-1 mm long, collar-shaped, apical margin finely dentate.

**Leaf blades** of young shoots 5-20 cm long, 2-3 mm wide, flat, usually soft, grooved and glabrous or shortly pilose, on margins often 0.5-1.5 mm long, rigid, patulous cilia.

**Inflorescence** a panicle, 6-12 cm long, contracted and 10-20 mm wide, spread during flowering period, up to 30 mm wide and pyramid-shaped, basally often interrupted, slightly glomerate. Lateral branches ramifying strongly, villous as the 0.2-1 mm-long rachis. Two to three-flowered spikelets, 5.5-7 mm long, whitish-green or light brown, shiny.
SUITABILITY FOR RESTORATION

Very often on oligotrophic grassland and arid pastures as well as meadows, grass heaths and exposed hills, roadsides, in low-density stands of pine and oak forests, edges of forests and shrubs. On moderately arid, poor, usually limy, neutral, humus loess, loam or clay soil, seldom on sand. Indicates moderate aridity and poorness. Disappears with excessive fertilization and irrigation. From lowlands to subalpine zones, in the Alps up to 2300 m above sea level.

All-purpose species on poor and arid slopes and hillsides up to the subalpine and alpine zones.

SEEDS

Glumes dissimilar, keeled, smooth and glabrous or scabrous; patulous, short cilia on midvein; membranous, broad, finely membranous margins, lower glume one-veined, 4-5 mm long, lanceolate when viewed laterally, pointed, upper glume three-veined, 5-6 mm long, broadly lanceolate, pointed.

Lemma three-veined, 4-6 mm long, lanceolate, acuminate or ending in a short awn tip, glabrous, shortly pilose or seldom ciliated, membranous, with finely membranous margins.

Palea two-veined, 3.5-5.5 mm long, lanceolate, apically notched, with pointed lateral lobes.

Anther 2.2-2.5 mm long.

Fruit 2.5-3 mm long, glabrous, laterally contracted, outline narrowly elliptic.

Thousand seed weight: 0.4-0.5 g.

REQUIREMENTS (soil and climate)

Crested hair grass has no special soil requirements and is therefore not sensitive to aridity. It prefers an intermediate nutrient supply. The pH should be between 6.0 and 7.5. Moist or waterlogged soil, peat, ground with high weed infestation and light, dry, sandy soil should be avoided. Competition with weeds is low and juvenile development slow. Locations with a high presence of Agropyron repens, Digitaria sanguinalis, Poa annua and Poa trivialis are to be avoided.

CULTIVATION

Open sowing is possible if carried out early in the year (until the middle of June). A high expenditure for weed control is to be expected. Because of the plant’s slow juvenile development and low competition, seeding below cover crops should be avoided in autumn.

Spring seeding under summer cereals and linseed is unproblematic. Because of photosensitivity and slow juvenile development it is important to have a thin cover crop population. Seeding should be done immediately after the seeding of the cover crop.

Seed depth: no more than 0.5 cm.

Seed rate: 7.9 kg/ha.

Row spacing: 12-15 cm. Broadcast seeding is possible.
FERTILIZATION
Phosphorus and potassium: moderate fertilization with phosphorus (40-60 kg/ha P₂O₅) and potassium (80-100 kg/ha K₂O) has proved to be worthwhile although crested hair grass has low nutrient requirements. Timely fertilization with liquid or solid manure in late summer or early autumn stimulates the development of single plants until the resting season. Application of liquid manure in spring should be avoided because it may lead to the mobilization of nitrogen in disadvantageous periods of the growing season.

Nitrogen: total requirements for seed development are 60-70 kg/ha. In spring, nitrogen should only be applied as mineral fertilizer. The amount is 30-50 kg/ha, depending on climate and weather.

MAINTENANCE AND WEED CONTROL
Because of the plant's low growth height and the associated danger of being stalled by crop residues, it is important that the stubbles are cut and the straw removed immediately after harvesting the cover crop.

As for most grasses the following guidelines apply. Before sowing only contact herbicides should be used, up to three days before the beginning of sowing. Hormone-type and broad-spectrum herbicides should generally not be used until the species has reached the three leaf stage.

Even with good maintenance after harvesting the cover crop it is not possible to obtain a compact stand until autumn. The low growth height of this species means considerable effort in maintenance and weed control. Selective grass weed control is not feasible. Where weed grasses prevail, a specific application of Ethofumesate will control annual meadow grass in particular. However, an expert should be responsible for evaluation and composition.

National guidelines concerning the use of herbicides should be followed. Selective control with wick and total herbicides (Glyphosate) is possible during most periods of the growing season because of the different growth heights of wavy hair grass and other grasses.

HARVEST AND YIELDS
Resistance to lodging: high, in excellently maintained populations intermediate.

Shattering tendency: intermediate.

Ripeness: panicles and culms change colour to light tawny. Seeds adhere well to the panicle after ripeness.

To check ripeness: if a bunch of panicles is grasped, the seeds will fall off easily if ripe.

Flowering single plant
Ripening period: last decade of June to first decade of July.

Harvesting techniques: crested hair grass can easily be threshed from the root. The rotational speed of the threshing drum should be set low to avoid damage or dehusking of seeds. The air supply should be reduced. Seed flow is sufficient; seeds as well as the chaff in the sieve should be checked several times while threshing. Settings of the threshing concave should be close.

Cleaning of seeds is usually unproblematic.

Crop yields: yields can vary greatly (80-150 kg). Very little experience has been gained regarding the propagation of this species. With experience, 150 kg and more can be expected.

For optimally maintained populations three harvesting years are possible.
Rough hawkbit

*Leontodon hispidus s.l.*

**BOTANY**

Perennial, 10-60 cm high, with a rootstock that is shortly cylindrical, descending aslope or vertically and terminating abruptly.

**Single-or multistemmed.** with stems erect or ascending aslope or arched, simple, with one flowering head (rarely two) only slightly thickened below and with up to two floral bracts; with hairs or glabrous, capillarily or angularly grooved, mostly longer than the foliage leaves. Foliage leaves basal, forming a rosette, highly polymorphic, oblong to oblanceolate; contracted to a broad indistinct petiole, entire, sinuate-dentate or pinnately split, glabrous or with several forklike hairs (2-3-fid) or stellate hairs. Grass-green to grey-green, with soft to stiff hairs.

**Flowering heads** are quite large, nodding before flowering.
SUITABILITY FOR RESTORATION

European species that is extremely polymorphic, common and occurs in the Alps, from the foothills to the upper alpine zone. On (alpine) meadows and pastures that are moist to slightly alternating moist and dry, at low-density forest sites, on talus sites and sometimes on rocks.

Multifunctional use for restoration at all altitudes, good forage, filling gaps well. The glabrous subspecies *Leontodon hispidus* ssp. hastilis grows in the subalpine and alpine zones.

SEEDS

Achene 6-7.5 mm long, 0.7-0.9 mm wide and 0.5-0.7 mm thick; oblong-bacillar, only slightly tapered at both margins, slightly angularly compressed, with fine lateral grooves, highly cross-rugose.

Pappus brownish-white to yellowish, outer hairs are simple bristles, inner ones lanceolate leaflets fading to pinnate hairs, up to 10 mm long (disappearing when cleaned).

Surface auburn to dark brown, slightly glossy.

**Thousand seed weight:** 1.3-1.5 g.

REQUIREMENTS

(soil and climate)

Rough hawkbit has no special soil requirements. Because of its deep roots it is minimally sensitive to drought. It prefers an intermediate to good nutrient supply. The pH should range between 5.5 and 7.5. Soils that are wet, waterlogged, or tend to a high weed infestation should be avoided, as well as soils that are rich in peat, light, or dry.

CULTIVATION

Open sowing is unproblematic, if sowing is carried out by the beginning of July at the latest (at mild locations by the middle of July). In the latter case irrigation of the crop is recommended.

To date no experience has been gained with cover crops.

**Seed rate:** 10-12 kg/ha are necessary for a satisfactory population density (if the seed quality is good).

**Row spacing:** 15-25 cm. Depending on the construction of the seeder and the method of weed control there should be either dense populations or sufficient row spacing (for mechanical and/or chemical weed control).

Broadcast sowing is generally possible.

FERTILIZATION

**Phosphorus and potassium:** on soils with an intermediate phosphorus and potassium content, basic fertilization with solid or liquid manure is sufficient in
autumn. If the soil content is on high level, fertilization with 40 kg/ha $P_2O_5$ and 60-80 kg/ha $K_2O$ is considered sufficient, depending on the yield.

**Nitrogen**: at the sowing stage, fertilization with about 30 kg/ha of N-total is recommended in order to obtain the best development up to autumn. An application of 60-80 kg/ha of N-total is necessary per year, to be added in autumn, early spring and after the first harvest. If fertilization in spring is carried out too late, the principal outcome will be stimulation of the leaf mass.

**MAINTENANCE AND WEED CONTROL**

In early autumn before the crop year, cutting makes sense if the populations are densely grown.

If competition with weeds is low, mechanical weed control is sufficient. Rough hawkbit is not sensitive to the use of curry combs. As for all herbs, the control of weed grasses is relatively easy. On the other hand, herbicide control of dicotyledonous weed species is problematical. It is possible to control weeds, mainly in summer and autumn of the seeding year, as well as in spring of the harvesting year, by wiping wick and total herbicides ($\text{Glyphosate}$), and taking advantage of the differences in growth heights.

**Pests and diseases**: leaf diseases caused by fungal decay are possible, but do not generally lead to losses in crop yields.

At the first harvest, larvae of flies that mine in the flowering heads can cause significant problems. Ongoing control of the flowering heads is recommended. If there is decay, using a systemic insecticide against mining and sucking pests (such as 0.5 l/ha $\text{Deltamethrin}$) is imperative, in order to make the first harvest possible.

**HARVEST AND YIELDS**

**Resistance to lodging**: high.

**Shattering tendency**: high.

**Ripeness**: after flowering, the flowering heads close and open again after three to five days.

The seeds adhere to the flowering head quite firmly for one or two more days, after which they shed easily, even at a puff. Consequently, the seeds should be threshed, when only 40-50 percent of the flowering heads are open.

**Ripening period**: first harvest during the first and second decade of June; second harvest between the first decade of August and the beginning of September, depending on the weather.

**Harvesting technique**: direct threshing is possible. If ripening is unequal, very large sieves, a low rotational speed, and a wide gap between threshing drum and concave are recommended. In this way

![Flowering plants](image-url)
the withered but still closed flowering heads can also be harvested. After one or two days of cool air ventilation, seeds enter an after-ripening stage, which leads to a belated burst of the flowering heads. As an alternative, harvesting is possible using suction devices whereby the ripe seeds are harvested without destroying the mother plants. Because only completely open flowering heads ensure an efficient harvest, harvesting should take place on warm, sunny days with low air humidity. The first harvest is recommended when about 50 percent of the flowering heads are open. After most of the flowering heads have been harvested, cutting is recommended, in order to stimulate seed formation once again. Altogether up to eight harvests per season can be expected, using this method. Cleaning the seeds is a simple and easy task.

Crop yields: because of lack of experience regarding the cultivation of rough hawkbit, yield forecasts are difficult. Yields range between 60 and 180 kg/ha, where the amount of harvests per year are combined. Optimal maintenance allows up to three harvesting years.
Phleum hirsutum

BOTANY
Perennial, thin to dense cespitous grass with short rhizomes and numerous young shoots breaking though the base of the leaf sheath.
Culms are 20-60 cm high, slender, not branched, erect or geniculate, smooth and glabrous, two to four-noded, apical culm internode is approximately half to two-thirds of the length of the entire culm. Nodes grooved and glabrous.
Leaf sheaths clustered on base of culms, dense above nodes, 1 mm long, hair pointing downwards, in the end breaking up into irregular pieces, those at culms grooved and glabrous.
Ligule is a 1-3.5 mm long, membranous fringe that is acuminate or truncate at the upper end and shortly and finely ciliate on the outside.
Leaf blades 8-25 cm long, 2-6 mm wide, flat, both sides heavily grooved and scabrous, white margins with dense, spiky hair.
Inflorescence a panicle, 2-10 cm long,
8-12 mm wide, light green, often coated purple, cylindrical, both ends edgeless, loose when bent, often slightly interrupted; lateral branches as well as main axis shortly and densely pilose.
One-flowered spikelet, appendix of axis is about 1 mm long above floret, including awns 4.5-6 mm long.

**SUITABILITY FOR RESTORATION**

*Phleum hirsutum* is a central and south European montane plant. In the Alps it grows in the upper montane and subalpine zones, but seldom in lower alpine zones. The rhizomes enable this plant to disperse on stony soils with shallow layers. It prefers arid, well-aerated, exposed sites with light, alpine brown soil that is occasionally heated, rich in bases and moderately rich in nitrogen, having a limy bedrock and pararendzina with stones at very low to intermediate depth and with a pH between 5.9 and 6.8. In the central Alps the plant grows up to 2 400 m above sea level.
Important species for restoration of arid, sunny sites with limy bedrock.
High tolerance of nutrients, quite high tolerance of cutting, good and fruitful forage.

**SEEDS**

Fruit of the husk 2-3 mm long, 0.5-0.9 mm wide and thick, ovate-lanceolate. Lemma keeled, veined, glabrous, acuminate. Palea rather small, flimsy; only a narrow part can be seen through lemma. Surface tawny-brown, shiny. Fruit 1.5-2 mm long, 0.6 mm wide and thick, yellow (to brown), matt. **Thousand seed weight**: 0.25-0.4 g.

**REQUIREMENTS**

**(soil and climate)**

This species prefers a light, well aerated soil that is not too acid, and a pH of 5.9-7.5. Because of the plant's slow juvenile development and low competition with weeds, it requires soils with low weed infestation, especially regarding meadow grass, quack grass, loose silky bent and crab grass.

**CULTIVATION**

This species requires a thoroughly prepared seedbed.
Open sowing is possible until the end of June, if irrigation is available.
Positive experience has been gained with summer barley or linseed as a cover crop. A thin cover crop population is important.
Seeds have an excellent seed flow and seedlings are therefore unproblematic.
**Seed rate**: 8-10 kg/ha.
**Row spacing**: 15-20 cm. Broadcast seeding is possible.

**FERTILIZATION**

**Phosphorus and potassium**: on soils with an intermediate supply of phosphorus and potassium, fertilization with solid or liquid manure is sufficient. For soils with good nutritional content, amounts of 40-60 kg/ha \( P_2O_5 \) and 80-100 kg/ha \( K_2O \), depending on crop yields, are sufficient.
**Nitrogen**: after harvesting the cover crop and cutting the stubbles, an application of 30 kg/ha N-total is recommended, in order to achieve optimal development.
until autumn. The amount of nitrogen necessary for seed development is 70 kg/ha N-total, which should be applied in autumn and early spring. Late fertilization in spring mainly stimulates the development of leaves.

MAINTENANCE AND WEED CONTROL
This species is generally tolerant of herbicides. For application of hormone-type and broad-spectrum herbicides see Table 3 on p. 109. The use of herbicides is necessary even for low weed infestation. Early application is important because high weed competition has a disproportionately high impact on crop yields. A specific problem is weed infestation by *Poa annua* (annual meadow grass), which may lead to intense competition with young plants and subsequent contamination of seeds. Selective weed control with *Ethofumesate* is possible when weed infestation is low. However, it is not possible to give general instructions. An expert survey is necessary in order to recommend a specific composition. In summer and autumn after the first harvest, severe infestation of rust may occur. Constant inspection and the application of fungicides are necessary. Insufficient control can lead to a breakdown of the populations over wide areas. In any case the application of customary broad-spectrum fungicides for cereal cultivation is necessary to avoid substantial decreases in crop yields the following year. Cutting in late summer is helpful but it should not substitute the application of fungicides because this could lead to high weed infestation. *Phleum hirsutum* has low biomass production. Therefore its use as forage is not economical. However, cutting is necessary in autumn of the first growing year.

HARVEST AND YIELDS
Resistance to lodging: high.
Shattering tendency: low to intermediate.
Ripeness: spikes change colour to brown, culms to yellow. It is time for threshing when brown and rather hard seeds shatter when the spikes are rubbed. Seed producers often tend to thresh this species too early.
Ripening period: middle to end of July, seven to ten days after cat tail grass.
Harvesting techniques: threshing is done from the root and is unproblematic.
Crop yields: for well-maintained populations the crop yield in the second harvest year is usually higher. Crop yields are between 100 and 150 kg/ha in the first and 100-200 kg/ha in the second harvest year. Propagations with intensive weed control have produced yields of up to 500 kg/ha.
Alpine cat’s tail, cat tail grass

*Phleum rhaeticum*

**BOTANY**

Perennial, cespituous grass with long rhizomes and numerous young shoots breaking though the base of the leaf sheath and growing up intravaginally. **Culms** are 5-50 cm high, slender, erect or geniculate, grooved or glabrous; two to four-noded, apical culm internode is approximately half the length of the entire culm. Nodes grooved and glabrous. **Leaf sheaths** clustered on base of culms, disintegrating when ageing, grooved and glabrous, upper sheath at the culm clearly swollen. **Leaf blades** 2-15 cm long, 2-8 mm wide, grooved and glabrous on both sides, margins scabrous. **Inflorescence** a panicle, 1-5 cm long, 7-14 mm wide, globular, ovate or cylindrical, dense, not loose when bent, lateral branches totally connate with main axis. **Rachis** very short, glabrous. One-flowered spikelet, including awns 5.5-7.5 mm long.
SUITABILITY FOR RESTORATION

Phleum rhaeticum is a central and south European plant. In the Alps it grows in the upper montane, subalpine and lower alpine zones. It thrives in meadows and in richly manured alpine pastures, mostly in dells with a high nutrient input. Accordingly its habitat consists of moist, nutrient-rich, lime-deficient upper layers; in humus, brown soils, semipodsoils and alpine pseudogleys with a pH of 4.2-6.2. In the central Alps it grows up to 2500 m above sea level. One of the most important species for restoration in the subalpine and lower alpine zones, where it grows well. All-purpose grass, highly resistant, provides high-quality forage on alpine rich meadows and pastures.

SEEDS

Fruit of the husk 1.5-3 mm long, approximately 0.8 mm wide and thick, ovate, apically acuminate. Lemma flimsy, membranous, acuminate. Palea small, flimsy; fruit tightly clasped by two glumes, 1.5-3 mm long, 0.6-1 mm wide and thick. Glumes shaped like a lye, running into two 2-mm long awns, strongly keeled, long, white hair along midvein up to tip of awn. Fruit greyish-brown, partly red translucent. Surface silvery-grey, white to brown, matt. Thousand seed weight: 0.5-0.7 g.

REQUIREMENTS

(soil and climate)

For seed production of this species soil should not be arid or extremely light. The pH should be between 5.5 and 7.0. Regarding other parameters any soil is suitable. Because of the plant's slow juvenile development and low competition with weeds it requires soils with low weed infestation, especially regarding meadow grass, quack grass, loose silky bent and crab grass. Generally, it is important to choose areas with low weed infestation.

CULTIVATION

This species requires a thoroughly prepared seedbed. Open sowing is possible until the end of June if irrigation is available. Winter cereals as a cover crop are not suitable. Good results have been obtained with summer barley or linseed as a cover crop. A thin cover crop population is important. Seeds of cat tail grass are usually covered by glumes and seed flow is therefore bad. A possibility is to rub the seeds gently out of the glumes. In so doing, however, there may be losses through seeds breaking as well as a decreased germinative capacity. Seed rate: 8-12 kg/ha for seeding with glumes, depending on the quality of the seeds. When using seeds without glumes the seed rate can be reduced to 7-8 kg/ha. Row spacing: 20-25 cm. Broadcast seeding has also proved successful in practice.

FERTILIZATION

This species is quite demanding. For the satisfactory development of seeds a high nutrient supply is needed. Phosphorus and potassium: on soils with an intermediate supply of phosphorus
and potassium, fertilization with manure (15-25 tonnes/ha) is sufficient. For mineral fertilization, amounts should be 50-70 kg/ha P₂O₅ and 80-120 kg/ha K₂O. **Nitrogen:** sufficient nitrogen in autumn guarantees satisfactory tillering. However, a surplus of nitrogen in late spring may lead to a decreased development of spermatophores. The amount of nitrogen necessary for seed development is 70-100 kg/ha N-total. This should be split and applied in autumn and early spring. However, possible existing guidelines for appropriate fertilization have to be respected.

**MAINTENANCE AND WEED CONTROL**

Cat tail grass is generally tolerant of herbicides. For application of hormone-type and broad-spectrum herbicides, see *Table 3* on p. 109. Herbicides should be used even for low weed infestation. Early application is important because high weed competition has a disproportionately high impact on the crop yield.

A specific problem is weed infestation by *Poa annua* (annual meadow grass), which may lead to severe contamination of seeds and result in seed quality not being up to standard. Selective weed control (*Ethofumesate*) is possible when weed infestation is low. However, it is not possible to give general instructions. An expert survey is necessary in order to recommend a specific composition.

**Rust diseases** can be problematic beginning in summer. Frequent inspection and the timely application of fungicides are vital. Insufficient control can lead to breakdown of the populations on wide areas. Severe infestation of rust may occur especially in summer and autumn before the second harvest. Here too, the application of customary broad-spectrum fungicides for cereal cultivation is necessary to avoid substantial decreases in crop yields the following year. Cutting in late summer is helpful but should not substitute the application of fungicides because this could lead to high weed infestation. Cutting is indicated in the autumn of the first growing year. The use of biomass as forage is not economical.

**HARVEST AND YIELDS**

**Resistance to lodging:** high.

**Shattering tendency:** intermediate to high.

**Ripeness:** ripeness begins when the seeds at the top of the the greyish-brown spindles start to drop off. If the remaining seeds can be easily pulled off, the seeds are ripe (see figure below).

**Ripening period:** end of June to middle of July.

**Harvesting techniques:** in experiments with swath threshing, high losses have been observed from full ripeness onwards. Therefore, this technique is only recommended if ripeness is not at all compact. Direct threshing is usually unproblematic; the fan should be set very low in order to minimize losses. However, the seeds have a bad seed flow that may cause jams.

**Crop yields:** crop yields are highly dependent on experience. At the moment yields are between 100 and 300 kg/ha. With optimal maintenance, three harvest years are possible.

![Fourth panicle from the left shows optimal ripeness for harvesting](image-url)
Alpine meadow grass

Poa alpina

Poa alpina (Schröter, 1888)

BOTANY

Perennial, forms loose, usually grass-green (on dry soil greyish-green) tight thickets, young shoots intravaginal, no stolons.

Culms are 10-40 cm high, erect or geniculate, smooth, glabrous, two to four glabrous nodes.

Leaf sheaths at the base of culms and young shoots clustered, rounded dorsally; smooth, glabrous with white margins, those of young shoots with margins connate for almost their entire length.

Ligule of upper culm leaves to 2.5-5 mm long, ob lanceolate, with a membranous rim; those of young shoots 1-2 mm long, truncate, collar-shaped.

Leaf blades all growing at almost the same height, 3-12 cm long, 2-5 mm wide, flat-broadening, tip suddenly acuminating and shaped like a hood, glabrous, smooth, margins slightly scabrous. Ligule short and white.

Inflorescence a panicle, 3-7 cm long and up to 3 cm wide, loose to rather dense, in flowering period expanding, sometimes slightly nodding, pyramid-shaped. Lateral
branches ramify individually or in pairs from smooth main axes, in flowering period strongly expanding or hunching down, in lower part no spikelets, thin, angular and scabrous. Rachis 0.5-2 mm long, angular and scabrous. Five to ten flowered spikelets, 4-7 mm long, ovate, laterally compressed, green coated purple. Floret is a 5-10-cm long, loose panicle.

**SUITABILITY FOR RESTORATION**

Alpine meadow grass grows naturally on dry or moist topsoil that is rich in humus, Ca$^{2+}$ and bases with a pH between 5.6 and 7.2. In the Alps it grows at altitudes over 3,000 m. It is tolerant of high nutrients and shade. It is an excellent forage. Alpine meadow grass is the most important pioneer plant on graded sites, except on highly acidic soil. It flourishes even in cold and dry habitats and has a good fixing of soil because of its tough roots. High seed development and early ripening, developing dense swards, highly resistant to wind, grazing and high nutrient content make it one of the most precious forages in high altitudes.

**SEEDS**

Fruit of the husk 2-4 mm long, 0.6 mm wide and thick, ovate-lanceolate, pointed. Lemma veined, strongly keeled, margin membranous, dorsally and on marginal veins long, white, spiky hairs, adaxially pubescent. Palea hollow, tightly clasped by the lemmas. Rachis tapered basally, truncate angularly at the apex. Fruit 1-2 mm long, 0.6-0.8 mm wide, triangular, ventrally slightly recessed. Thousand seed weight: 0.5-0.7 g.

**REQUIREMENTS**

*(soil and climate)*

For seed production this species has no special soil requirements. However, the supply of bases and calcium should be sufficient. Moist, cold soil and soil that desiccates in summer should be avoided. It is important to choose a habitat with low weed competition. Alpine meadow grass has a very slow juvenile development and is not very competitive. Chemical weed control should only be used with parsimony. Sites with a high presence of annual meadow grass (*Poa annua*), rough meadow grass (*Poa trivialis*) and crab grass (*Digitaria sanguinalis*) should be avoided.

**CULTIVATION**

As is common in the cultivation of grass seeds, a fine, crumbly seedbed is required. Open sowing is possible but may result in high weed infestation in spring. Seeding should be carried out until the beginning of July in order to obtain a satisfactory development of single plants until autumn. Open sowing in summer requires irrigation in drought periods. Because of the plant's slow juvenile development, winter cereals are not suitable as a cover crop. A thin cover crop...
population (e.g. summer barley, durum) is important. If the population is too dense the development of single plants is suppressed which results in poor tillering in autumn. In this case increased weed infestation and reduced crop yields in the first harvesting year are to be expected. Linseed as a cover crop has proved worthwhile. Its slow juvenile development means that cultivation of alpine meadow grass should be undertaken immediately after seeding the cover crop.

Seeds have a good seed flow and are suitable for all common seeding systems. It is important that seeds are applied flat and evenly at a maximum depth of 0.5 cm. A compact topsoil is important for good germination.

**Seed rate:** 6-10, mean value 8 kg/ha with excellent seeding technique, otherwise higher amounts are required to obtain regular stands.

**Row spacing:** 12-15 cm depending on the construction of the sower. The sowing tubes are often removed for broadcast sowing on the surface, followed by currying.

**FERTILIZATION**

Alpine meadow grass is relatively undemanding. For a satisfactory crop a sufficient nutrient supply is necessary.

**Phosphorus and potassium:** on soils with an intermediate supply of phosphorus and potassium, fertilization with liquid or solid manure is sufficient. For soils with good nutritional content, amounts of 50-70 kg/ha P₂O₅ and 70-120 kg/ha K₂O are sufficient, depending on yield levels.

**Nitrogen:** after harvesting the cover crop and cutting the stubbles an application of 30 kg/ha N-total is recommended in order to achieve optimal development until autumn. The amount of nitrogen, necessary for seed development should be applied in autumn (70 percent) and in early spring (30 percent). Late fertilization in spring mainly stimulates the development of leaves. The total amount of nitrogen should be between 70-100 kg/ha, depending on climate and soil conditions.

**MAINTENANCE AND WEED CONTROL**

The cutter bar of the harvester should be set very low and stones should be removed beforehand.

Alpine meadow grass is tolerant of herbicides. For application of hormone-type and broad-spectrum herbicides see *Table 3* on p. 109. The use of herbicides is necessary even for low weed infestation. Early application is important because high weed competition has a disproportionately high impact on crop yields.

Weed infestation by *Poa annua* (annual meadow grass) is a specific problem, which may lead to severe contamination of seeds and result in poor seed quality. Selective weed control is possible when weed infestation is low. However, it is not possible to give general instructions. An expert survey is necessary in order to recommend a specific composition.

**Diseases:** particularly in autumn, before the second harvest, an accumulation of rust diseases may occur. In this case application of customary broad-spectrum fungicides for seed cultivation is necessary to avoid substantial decreases in yields the following year. Cutting in late summer is helpful but should not substitute the application of fungicides because this could lead to high weed infestation. Alpine meadow grass has a low biomass production. Therefore, its use as forage is not economical. However, cutting is necessary in the first growing year.
HARVEST AND YIELDS

Resistance to lodging: unproblematic.
Shattering tendency: very high.
Ripeness: branches of panicle and upper part of culm change colour to yellow or light brown. Grains change colour to greyish-brown and shatter easily when touched. Ripeness is not very compact. When 60-80 percent of the grains are fully ripe, threshing should be carried out. During this period, the state of ripeness should be checked up to twice a day.
Ripening period: beginning or middle of June depending on the site.

Threshing is usually done from the root. Swath threshing is possible, although, the amount of chaff and undesirable seeds will increase. The cutter bar should be set very low in order to take up the panicles close to the ground. The settings for threshing are usually unproblematic. The rotational speed of the threshing drum can vary between 800 and 1 000 U/min with close settings of the threshing concave. The fan should be set very low; the wind produced by the threshing drum is usually sufficient.

Crop yields: crop yields reach between 150 and 600 kg/ha in practice. Maintenance and weed control are crucial for yield levels. In existing seed production the average crop yield has been 300 kg/ha. In populations with low weed infestation a second and third harvest year are possible. In this case a decrease in crop yields of 20-40 percent is to be expected.
**Blue moor grass**

*Sesleria albicans*

**BOTANY**

Perennial, forming small cushions, with rhizomes. Young shoots numerous, intravaginal.

**Culms** are 10-40 cm high, erect, stiff, highly grooved, smooth and glabrous, compressed beneath the panicle, bearing leaves only at the basal part, with glabrous nodes arranged on top of one another.  
**Leaf sheaths** almost closed up to the apex, grooved, smooth and glabrous or the basal ones scabrous to tomentose; keeled at the apical part, the basal ones thin and long-lasting, covering the basal part of the culms as well as the young shoots.  
**Ligule** is a fringe that is 0.2-0.5 mm long, lacerate, ciliated at the apical margin, membranous.  
**Leaf blades** of the young shoots and the basal culm leaves are 10-25 cm long, 2.5-3 mm wide, flat or folded, equal width all over, apex round or acute; stiff, green, glabrous, not rimy, midrib conspicuously prominent and whitish, with scabrous margins that have spiky hair; abaxially green and glossy, adaxially sea-green and dull; leaf blades of the uppermost culm leaf up to 1 cm long.
Inflorescence: A panicle, 10-30 mm long, 4-10 mm wide, terete and often interrupted or oblong-ovate and dense, mostly glaucous or roan, also straw-coloured and coated purple. Basally with two bracts that are empty, scale-like, 2-3 mm long, broad, apically denticulate and ciliated. Lateral branches short, coming off the smooth and glabrous main axis solitary; with one to three spikelets that are thick, smooth and glabrous like the (0.5-1 mm long) rachis.

Spikelets: With two florets, 4.5-7 mm long.

Suitability for Restoration
This European species occurs in the foothills and the montane, subalpine and alpine zones. At higher (subalpine and alpine) altitudes it can often be found on rock or loose, stony ground as a pioneer plant. The roots spread extensively in its environment because of a high dryness protection factor. Thus, the plants are able to grow in stepped meadows that are built up with Carex sempervirens. Blue moor grass grows on bare soil as well as on rendzina and pararendzina with a pH of 5.2-7.9. The plant is an important pioneer on bare soil and on poor grasslands in the subalpine and alpine zone, especially for restoration on calcareous soils.

Seeds

Fruit: 4-6 mm long, 1.1-1.4 mm wide and 0.8-1.2 mm thick; acute-ovoid.

Lemma: Dorsally keeled, fading to several short peaks, covering the palea. Palea as long as the lemma.

Surface: Durnish to tawny, glossy.

Fruit: 2-2.5 mm long, 1 mm wide and 0.8 mm thick, durnish to auburn.

Thousand seed weight: 1.3-1.7 g.

Requirements (Soil and Climate)

Blue moor grass has no special soil requirements; however, there should be a good supply of bases and calcium. Moist, cold soils and sites that tend towards deep dehydration in summer should be avoided.

It is important to select sites with a low weed content, because of restrictions on the chemical weed control of grasses. Thus, locations infested in particular with Agropyron repens, Poa annua, Poa trivialis and Digitaria sanguinalis should be avoided at all costs.

Cultivation

Although the seeds of blue moor grass are quite large, the species requires a great deal of soil preparation. A fine, crumbly seedbed without stones is a precondition, with seed depths of 0.5 cm at most, as well as a sufficient compact topsoil.

Open sowing should be carried out by the beginning of May at the latest, in order to guarantee satisfactory yields in the first harvesting year. In line with the latest research, until spring of the first harvesting year single plants have to grow to a thicket diameter of at least 10 cm to obtain sufficient fertility.

Using a cover crop is possible. As regards sufficient development, only linseed (oil flax) should be used.
Seed rate: 14-16 kg/ha. Because of the large seeds there are no problems with the known sowing technique.
Row spacing: 12-25 cm. Depending on the construction of the seeder and the method of weed control, there should be either dense populations or sufficient row spacing (for mechanical and/or chemical weed control).

FERTILIZATION
Phosphorus and potassium: blue moor grass prefers nutrient-deficient soils. On soils with an intermediate phosphorus and potassium supply, additional fertilization is not necessary. There is no risk attached to the application of little fertilization-liquid or solid manure-even in autumn.
Nitrogen: should also be used economically. However, fertilization with nitrogen in autumn (30-40 kg/ha N, depending on the climate) provides a good seed crop. Fertilization in spring is too risky because of the early development of the seedlings.

MAINTENANCE AND WEED CONTROL
This species has a slow juvenile development. Therefore, intense maintenance and weed control should take place soon after the harvest of the cover crop. Mechanical methods of weed control (hoeing, brushing) are only helpful between rows. Hormone-type and broad-spectrum herbicides against dicotyledonous weeds are tolerated well but should generally not be used until the species reaches the three leaf stage.
It should be remembered that the herbicides mentioned in the Table 3 on p. 109 are not registered for use in seed cultivation in some countries.
Rust diseases: ecotypes from higher altitudes in particular are highly sensitive. Continuous monitoring and where climate permits, prophylactic spraying with a suitable fungicide are advisable. However, cutting should be avoided in the first year in order to achieve sufficient development of the juvenile plants. Ergot infections can occur temporarily, especially in the second half of the vegetation period.

HARVEST AND YIELDS
Resistance to lodging: high.
Shattering tendency: intermediate.
Ripeness: determination of the optimal harvest time is very difficult. Within a panicle the ripeness is relatively equal, but the emergence of the panicles takes place during the whole vegetation period. Threshing is recommended at the earliest possible opportunity. A second harvest in the same year is possible in theory but not practical because of ergot infections.
Ripening period: extremely early in the year, between the end of May and the beginning of June.
Harvesting technique: the board of the combine harvester should be kept low; apart from this consideration, threshing is unproblematic. The seeds have an excellent seed flow and can be cleaned easily.
Crop yields: cultivation already carried out - under organic farming conditions - only produced low crop yields up to 35 kg/ha. On small plots with potted plants that had been planted out, noticeably more than 100 kg/ha was harvested. Consequently, a potential crop yield of about 200 kg/ha should be possible.
Alpine clover

*Trifolium alpinum*

*Trifolium alpinum* (Schröter, 1888)

**BOTANY**

Perennial, with a taproot that can be more than 1 m long and very robust, 0.5-1 cm thick, fading to a thick, short rootstock, branched and covered with the remains of brown leaf sheaths. Above ground, stems are compressed, very short, ascending, with tight leaf sheaths because of the stipules of the distichous foliage leaves, appearing to form rosettes that are aggregated to dense turfs. Entire plant glabrous. Foliage leaves always ternate, petioles 2-7 cm long; leaflets lanceolate to linear, rarely broadly elliptic, 1-5 cm long and 3-7 mm wide, acute, freshly green (yellow in autumn), smooth, with a faint main vein and many lateral veins that are capillary, acute-angled, furcated up to three times and connected reticulately, almost entire; margin teeth a little thickened, scarcely prominent. Stipules up to 4 cm (exceptionally up to 9 cm) long, covering above ground stems entirely, highly connate with the petioles, membranous.

Flowers 18-21 mm long, slender, redolent and fragrant, at the beginning erect to horizontal, drooping after flowering. Corolla pink-incarnadine to light crimson, coated purple, scarcely yellowish-white, at the end light brown, scarious.
SUITABILITY FOR RESTORATION
This central and south European species occurs in the Alps, in the subalpine and alpine zone. It prefers soils that are lime-deficient, comparatively nutrient-deficient, deep, warm and not too wet. On lime-rich soils it only grows on a thick humus layer. It is typically found in Nardus pastures and poor alpine grasslands.

In the Alps, it is common between 1700 and 2500 m, sometimes below the timber line. Because of its suitability for sites with a low pH as well as its deep taproot, alpine clover is an important component (and nitrogen supplier) of grassland mixtures that are appropriate to the habitat.

Nutrient-rich forage with high digestibility.

REQUIREMENTS (soil and climate)
Alpine clover has special requirements regarding the suitability of a site for reproduction. There should be no pathogenic nematodes of the gender Pratylenchus in the soil; otherwise total losses in seed multiplication will occur.
The pH must be low, with an optimum range between 4.5 and 5.4. There should be sufficient phosphorus in the soil for rapid juvenile development.

Inoculation with soil from the site stimulates the growth rate, as demonstrated in experiments.

CULTIVATION
Scarification (e.g. mechanical carving of the testa with sandpaper) is necessary for a good, rapid germination.

Alpine clover requires a fine, crumbly seedbed with compact topsoil.

Seed depth: 1.5-2.0 cm.

Open sowing is possible by means of strip or row seeding. In order to guarantee a satisfactory crop yield the following year, seeds should be sown up to the end of May at the latest.

There is as yet no experience with cover crops.

Seed rate: 14-18 kg is necessary at least, in order to obtain satisfactory population density.

Row spacing: 12-25 cm. Depending on the construction of the seeder and the method of weed control there should be either dense populations or sufficient row spacing (for mechanical and/or chemical weed control).
FERTILIZATION
Phosphorus and potassium: alpine clover does not require many nutrients. In autumn before cultivation, basic fertilization with manure (15-20 tonnes/ha) is considered sufficient. Using mineral fertilizer, an application of 40-60 kg/ha P₂O₅ and 80-100 kg/ha K₂O is recommended, depending on soil content.
Nitrogen: alpine clover meets its nitrogen requirements by means of nitrogen-fixing bacteria. As for all legumes, fertilization with 20-30 kg/N is recommended for open sowing in order to stimulate juvenile development.

MAINTENANCE AND
WEED CONTROL
This species has a slow juvenile development and produces conspicuously little leaf mass. Thus, populations with acceptable weed infestation are only possible if there is mechanical weed control (weeding, brushing and hoeing between rows) optimally combined with chemical control.
As for all legumes, specific chemical weed control of grasses is possible. To date there has been no recorded experience of the specific chemical control of dicotyledonous plants.

HARVEST AND YIELDS
Resistance to lodging: high.
Shattering tendency: low.
Ripeness: at time of ripeness the pods change colour to brown. The seeds become firm (nail test) and change colour to a typical tawny or greenish-brown to brown. The ripeness of the population is quite compact.
Ripening period: at the end of June up to the beginning of July.
Harvesting technique: there has been little experience to date. However, the harvester board should be kept very low and threshing carried out with great care.
Crop yields: in the first experimental cultivation only a few plants flowered in the first harvesting year. Cultivation already carried out - where there were organic farming conditions - produced only low crop yields of a few kilograms per hectare. Future experiments will provide further information about potential yields.
**Brown clover**

*Trifolium badium*

*Trifolium badium* (Schröter, 1888)

**BOTANY**

Perennial to triennial, with a robust taproot and abundant tillering; besides numerous flower shoots there are also no budding leaf rosettes. The plant dies off after fruit ripeness.

**Stems** cespitose, mostly ascending to procumbent, seldom totally erect, more or less branched, mostly 10-20 cm long, with short appressed hairs, later becoming glabrous.

**Foliage leaves** with long petioles, yellowish to verdigris, glabrous, the topmost ones almost distichous. All leaflets similarly short-petiolate, but in various shapes and sizes, 1-2 cm long and half to a third times as wide; elliptic to deltoidic, mostly rounded or truncate, sometimes emarginate or blunt with a point, circumferentially with fine and sharp teeth; up to more than 20 pairs of lateral veins which are straight and non-furcate; scarcely ciliated only at the margins and on the midvein (if not glabrous at all).

**Stipules** herbaceous, ovate-lanceolate, acute, 1-1.5 cm long, highly connate with the petiole, mostly glabrous.
SUITABILITY FOR RESTORATION
This central and south European species occurs in the Alps, in the subalpine and alpine zone. It grows in moist meadows, pastures and alpine meadows. In the cooler parts of the Alps, it is found on alkaline soils, in warmer regions almost solely on lime-deficient soils.
Wide range of use, very hardy, low to intermediate resistance to drought, deep-rooting plant, accumulating nitrogen, fair tolerance of nutrients, low to densely grown, valuable forage.

SEEDS
Seeds 1.4-1.8 mm long, 1-1.4 mm wide and 0.4-0.8 mm thick; ovoid with an inclined kidney-shaped indentation. Radicle half as long as the cotyledons. Sulcus often indistinct. Hilium rounded, lying within the indentation, slightly darker than its surroundings. Surface two-coloured, yellow up to twothird, remaining part greenish with smooth transitions. Pods one-seeded with a long, thin, dark brown, glossy beak. Thousand seed weight: 0.70-0.85 g.

CULTIVATION
Because of the plant's low growth height and very slow juvenile development, it has extremely high requirements. The seedbed has to be fine, crumbly, compact, flat and without stones. According to recent experience, cultivation underneath spring corn is not recommended. Because of the absence of specific herbicides, the comparatively high competition of weed species and its slow development cultivation of brown clover often results in failure. Seeding at the middle of June to end of July at the latest has proved to be best.
Seed rate: 10-12 kg/ha.
Row spacing: 12-20 cm. depending on the seeder. Where there is specific weed control by means of band sprayers or mechanical machines the row spacing should be adjusted accordingly.

FERTILIZATION
Phosphorus and potassium: brown clover requires few nutrients. Before cultivation, basic fertilization with manure (15-20 tonnes/ha) is considered sufficient. Using mineral fertilizer, an application of 30-60 kg/ha P₂O₅ and 80-100 kg/ha K₂O is recommended, depending on soil content.
Nitrogen: brown clover meets its nitrogen requirements by means of nitrogen-fixing bacteria. As for all legumes, fertilization with 20-30 kg N is recommended for open sowing in order to stimulate juvenile development.

MAINTENANCE AND WEED CONTROL
Weed control starts with the selection of the site and the seeding time. Seeding in late summer (after the corn harvest) allows sufficient soil preparation; crop areas or parts of them should be

REQUIREMENTS
(soil and climate)
Intermediate, deep soils that are rich in humus, with a pH above 6 are preferred. Preference should be given to sites with as low a weed infestation as possible.
Single plants

preferred that are known to have a low weed infestation. Many species such as Veronica spp. and Viola arvensis cannot be sufficiently controlled by the few usable herbicides and may cause serious trouble in the populations. Because of the late sowing time it is advisable not to use a curry comb. Until autumn brown clover only grows up to 3-5 cm and mainly invests in its root system. The species is sensitive to alternating frost, especially in early spring. Rolling the population in time is therefore sometimes necessary. The following spring, brown clover needs a surprisingly long time to produce leaves and develop inflorescences. Therefore there is a short period when specific weed control should be carried out by means of wiping wick and total herbicides (Glyphosate). Controlling weed grasses is relatively trouble free.

Pathogens: serious problems caused by nematodes have not yet been observed.

HARVEST AND YIELDS

Resistance to lodging: high.

Shattering tendency: low to intermediate.

Ripeness: immediately after flowering the flowers change colour from yellow to brown, with a metallic gleam. Because of this quick change of colour, producers are tempted to harvest too early. The seeds are ripe when the flowers change colour to black-brown and appear to be dried up. Like kidney vetch, the seeds then become two-coloured. Until complete ripeness is reached there is a very low shattering tendency, which then increases considerably.

Ripening period: quite early, in the last decade of June to the beginning of July, depending on climate and location. In stable weather, harvesting can be carried out once 80 percent of the population is ripe, while under unstable conditions harvesting is recommended when 60 percent of the population is ready for threshing.

Harvesting technique: Because of the low growth height of 8-12 cm the harvester board should be kept very low. When there is a sufficient degree of ripeness and with proper settings of the thresher, almost all the seeds will be rubbed off the flowers without any trouble.

Crop yields: yields depend on the success of the weed control. Cultivation already carried out has led to yields between 40 and 120 kg/ha. Potential yields certainly exceed 200 kg/ha. Insufficient weed control can otherwise reduce the yield to zero. Only one harvesting year is possible.
Snow clover

Trifolium pratense ssp. nivale

BOTANY
Alpine subspecies of Trifolium pratense. Perennial, with a robust taproot up to 60 cm long, strong lateral roots and a short rootstock without rhizomes. Main axis compressed, procumbent or transversally ascending; basal leaf rosette.
Stems come off the axis of the lowest rosette leaves, mostly with three to five internodes, simple or with short branches, erect, ascending only basally, 20-50 cm high, often slightly compressed, grooved to angular, often coated red, with dense hairs. Hairs of entire plant are whitish. Basal foliage leaves with long petioles (15-20 cm), upper leaves with shorter ones or almost sessile.
Leaflets very short, petiolate, mostly 1.5-3 cm long, obovate to broadly elliptic,
mutually rounded or marginally blunt with a point or slightly emarginate, hairs appressed and soft. Adaxially (upper leaf surface) freshly green, often with light green or auburn spots or cross bands, abaxially (lower leaf surface) glaucous. Stipules ovate-lanceolate, highly connate with the petiole; with triangular, sharp apices, membranous; veins are green or red, connected reticulately, outwardly pilose.

**Flowering heads** white, pink or magenta, one to four per stem; the upper ones appear to be terminal, often close together in pairs, spherical to ovate, mostly covered by the stipules of reduced foliage leaves, rarely having longer petioles. 2 cm wide; with 30 to 60 flowers that are non-petiolate, 1.3-1.8 cm long and always erect.

**SUITABILITY FOR RESTORATION**

This plant of the central and southern European mountains occurs in the subalpine and alpine zone. It grows on rich meadows and pastures, in low-density stands and fields and also on poor alpine grasslands. Common and frequent, mainly on sunny slopes, on loam which is moist, not lime-deficient, slightly acid to neutral and sandy, or on raw soils with loam.

Suitable for restoration in the subalpine and alpine zones, on soils with a low humus content; deep root system (therefore a good protection against erosion) accumulating nitrogen, good tolerance of PK fertilization, valuable forage plant.

**SEEDS**

Seeds 1-2.3 mm long, 0.8-1.5 mm wide and 0.5-1 mm thick; inclined kidney-shaped (scarcey ovoid) to obtusely triangular in contour. Radicle half as long as the cotyledons, often distinctly contrasted by a groove on either side.

Hilum small, round, lying within the indentation.

Surface with different colours, mostly yellow or purple, smooth, glossy.

Pod one-seeded, ovoid, 2.5 mm long and 1.8 mm wide, always with a cap.

**Thousand seed weight:** 1.2-1.6 g.

**REQUIREMENTS**

(soil and climate)

Like *Trifolium pratense*, snow clover is not self-tolerant. In order to avoid so-called „clover tiredness“ (accumulation of nematodes and/or fungus pathogens) the plant should only be cultivated on the same field every six years.

Soils are preferred that are intermediate to medium heavy, deep, rich in humus, not too acid, and easily warmed.

Arable land that tends to drought should be avoided.

**CULTIVATION**

In order to minimize crossbreeding between snow clover and *Trifolium pratense*, a distance of at least 300 m between production fields and meadows should be maintained.

Snow clover needs a clean, line, crumbly seedbed with compact soil.

Normally the plant is cultivated below a cover crop in spring. Sowing is carried out by means of a seeder and the seed depth is 0.5 cm.

Open sowing after the corn harvest in summer is also possible. In order to guarantee sufficient plant development until autumn, sowing should be carried.
out up to the third week of August. Delays in germination caused by summer drought can be avoided by irrigation.

Seed rate: 8-12 kg/ha. By open sowing in summer, an increase of the seed rate up to 15 kg/ha can be obtained.

Row spacing: 15-20 cm.

FERTILIZATION

Phosphorus and potassium: nutrient requirements are intermediate. Before cultivation, basic fertilization with manure (20-25 tonnes/ha) is considered sufficient. Using mineral fertilizer, an application of 60-80 kg/ha P₂O₅ and 100-160 kg/ha K₂O is recommended, depending on soil content.

Nitrogen: snow clover meets its nitrogen requirements by means of nitrogen-fixing bacteria. Preceding crop effect is about 60-80 kg N/ha.

As for all legumes, fertilization with 20-30 kg N is recommended for open sowing in order to stimulate juvenile development.

MAINTENANCE AND WEED CONTROL

A general problem in cultivating snow clover is the risk of crossbreeding with the lowland *Trifolium pratense*.

When this occurs, the second or third generation cultivated in lowland regions changes the habitus. Plants grow taller and can partly be treated like ordinary *Trifolium pratense*. However, their particular suitability for restoration in high altitudes remains.

If growth conditions are optimal, one or two cleaning cuts in the seeding year have to be carried out. If necessary, weed control with herbicides should be carried out in the seeding year. Snow clover is not sensitive to the use of curry combs.

As snow clover is a long day plant, the first growth in the harvesting year is not used for seed cultivation. Depending on climate, the population (approximately 10 cm high) is cut in late April or the first decade of May. The following second growth is threshed, ensuring an optimal content of seedlings.

If the population is dense and has no weed species after the first year, optimal maintenance will allow a second harvesting year.
HARVEST AND YIELDS
Resistance to lodging: intermediate.
Shattering tendency: low, whereas continuous rainfall after ripeness increases the risk of outgrowth.
Ripeness: the beginning of ripeness is indicated by darkening of the population. The ripe flowering heads change colour to dark brown. If a flowering head rubbed between the hands releases firm clover seeds, the population can be threshed when 80 percent of the population reaches this stage.
Ripening period: from the last decade of July until the middle of August, depending on climate and cut of the first growth.
Harvesting technique: if weather conditions are sunny and dry, snow clover can be threshed directly. Swath threshing is not recommended. With unfavourable weather conditions at harvesting time, a so-called ripening spraying with Diquat (3-4 l/ha) can be carried out. Only the assimilating leaf area is killed by this contact herbicide and the plant will recover and grow again. The population dries quickly and can be harvested after one to three days; because of this, interference with germination is possible. In order to rub the clover seeds off the flowers successfully, the population should be as dry as possible.
Crop yields: yields are far below those of commercially cultivated Trifolium pratense. On an average, 150-200 kg/ha can be produced, whereas a yield increase can be expected only after several years of practical experience.
TABLE 1. Important characteristics of the described species

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>DISTRIBUTION</th>
<th>VEGETATION BELT</th>
<th>PARENT ROCK</th>
<th>MOISTURE</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Montane Subalpine Alpine Silicious Calcareous Dry Wet</td>
<td></td>
<td></td>
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<tr>
<td><strong>GRASSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthoxanthum odoratum</td>
<td>Europe</td>
<td>+ (4)</td>
<td>+</td>
<td>+ (+)</td>
</tr>
<tr>
<td>Avenella flexuosa</td>
<td>Worldwide</td>
<td>+</td>
<td>-</td>
<td>+ (+)</td>
</tr>
<tr>
<td>Broussonetia sarmentosa</td>
<td>Middle/south Europe</td>
<td>-</td>
<td>-</td>
<td>- -</td>
</tr>
<tr>
<td>Briza media</td>
<td>Europe</td>
<td>+ (4)</td>
<td>-</td>
<td>- (+)</td>
</tr>
<tr>
<td>Bromus erectus</td>
<td>Middle/south Europe, North Am</td>
<td>- (4)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bromus persicus</td>
<td>Europe, Asia, North America</td>
<td>+ (-)</td>
<td>-</td>
<td>- (+)</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>Europe, North America</td>
<td>- (4)</td>
<td>-</td>
<td>- (4)</td>
</tr>
<tr>
<td>Deschampsia cespitosa</td>
<td>Worldwide</td>
<td>-</td>
<td>+</td>
<td>+ (-)</td>
</tr>
<tr>
<td>Festuca argentea</td>
<td>Europe</td>
<td>-</td>
<td>+</td>
<td>- (+)</td>
</tr>
<tr>
<td>Festuca pratensis</td>
<td>Middle Europe</td>
<td>-</td>
<td>+</td>
<td>+ (+)</td>
</tr>
<tr>
<td>Festuca pseudosinuata</td>
<td>Middle Europe</td>
<td>- (4)</td>
<td>-</td>
<td>- (4)</td>
</tr>
<tr>
<td>Festuca riparia</td>
<td>North/middle Europe</td>
<td>- (-)</td>
<td>-</td>
<td>- (+)</td>
</tr>
<tr>
<td>Festuca varia satv.</td>
<td>Central Europe</td>
<td>- (4)</td>
<td>-</td>
<td>- (+)</td>
</tr>
<tr>
<td>Koeleria pyramidata</td>
<td>Europe</td>
<td>+</td>
<td>-</td>
<td>+ (-)</td>
</tr>
<tr>
<td>Phleum vivatum</td>
<td>Europe</td>
<td>+</td>
<td>-</td>
<td>+ (-)</td>
</tr>
<tr>
<td>Phleum pratenseae</td>
<td>Middle/south Europe</td>
<td>- (4)</td>
<td>-</td>
<td>- (4)</td>
</tr>
<tr>
<td>Poa alpina</td>
<td>Europe, Siberia, North America</td>
<td>- (4)</td>
<td>-</td>
<td>- (4)</td>
</tr>
<tr>
<td>Sesleria albicans</td>
<td>Europe</td>
<td>+</td>
<td>+</td>
<td>- (-)</td>
</tr>
<tr>
<td><strong>LEGUMINOSAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthyllis vulneraria</td>
<td>Middle/south Europe</td>
<td>- (4)</td>
<td>-</td>
<td>- (+)</td>
</tr>
<tr>
<td>Anthyllis vulneraria ssp. alpina</td>
<td>Middle/south Europe</td>
<td>- (4)</td>
<td>-</td>
<td>- (+)</td>
</tr>
<tr>
<td>Trifolium alpium</td>
<td>Middle/south/west Europe</td>
<td>- (4)</td>
<td>-</td>
<td>- (+)</td>
</tr>
<tr>
<td>Trifolium pratenseae</td>
<td>Europe, Siberia</td>
<td>- (4)</td>
<td>-</td>
<td>- (+)</td>
</tr>
<tr>
<td>Trifolium pratenseae ssp. nivea</td>
<td>Middle/south Europe</td>
<td>- (4)</td>
<td>-</td>
<td>- (+)</td>
</tr>
<tr>
<td><strong>HERBS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achillea millefolium s.l.</td>
<td>Europe, Siberia</td>
<td>+</td>
<td>+ (+)</td>
<td>+ (+)</td>
</tr>
<tr>
<td>Leontodon hispidus s.l.</td>
<td>Europe</td>
<td>+</td>
<td>+ (+)</td>
<td>+ (+)</td>
</tr>
</tbody>
</table>

+ = very good; (+) = good; (-) = poor; - = very poor.
<table>
<thead>
<tr>
<th>SPECIES</th>
<th>DISTRIBUTION</th>
<th>TOLERANCE AGAINST Fertilization</th>
<th>TOLERANCE AGAINST Cutting</th>
<th>TOLERANCE AGAINST Trampling</th>
<th>NUTRITIONAL VALUE</th>
<th>SWARD DENSITY</th>
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<tbody>
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<td></td>
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<tr>
<td>Anthoxanthum odorumatum</td>
<td>Europe</td>
<td>(+)</td>
<td>(-)</td>
<td>(+)</td>
<td>(-)</td>
<td></td>
</tr>
<tr>
<td>Avenella flexuosa</td>
<td>Worldwide</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
<td></td>
</tr>
<tr>
<td>Bellardia leucocarpa</td>
<td>Middle, south Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Briza media</td>
<td>Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Bromus erectus</td>
<td>Middle, south Europe, North Am.</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Bromus inermis</td>
<td>Europe, Asia, North America</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Onoclea crassata</td>
<td>Eurasia, North America</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Deschampsia cespitosa</td>
<td>Worldwide</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Festuca rubra</td>
<td>Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
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<tr>
<td>Festuca pratensis</td>
<td>Middle Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Festuca pseudaria</td>
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<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Festuca supina</td>
<td>North/middle Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
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<tr>
<td>Festuca vana</td>
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<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Koeleria pyramidata</td>
<td>Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Phleum arundinum</td>
<td>Middle, south Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Phleum pratense</td>
<td>Middle, south Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Poa alpina</td>
<td>Europe, Siberia, North America</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Sesleria albicans</td>
<td>Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td><strong>LEGUMINOSAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthyllis vulneraria</td>
<td>Middle, south Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Anthyllis vulneraria var. alpina</td>
<td>Middle, south Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Trifolium alpinum</td>
<td>Middle, south/west Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Trifolium hybridum</td>
<td>Europe, Siberia</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
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<tr>
<td>Trifolium pratense var.</td>
<td>Middle, south Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td><strong>HERBS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Achillea millefolium s.l.</td>
<td>Europe, Siberia</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Leonotis hispalus s.l.</td>
<td>Europe</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
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</table>
### TABLE 2. Characteristics for cultivation and fertilization

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>SEED RATE (kg/ha)</th>
<th>ROW SPACING (cm)</th>
<th>FERTILIZATION (kg ha)</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GRASSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthoxanthum odoratum</td>
<td>7-9</td>
<td>12-15</td>
<td>40 40 70</td>
<td></td>
</tr>
<tr>
<td>Avenella flexuosa</td>
<td>10-12</td>
<td>12-15</td>
<td>40 40 70</td>
<td>pH above 6 recommended</td>
</tr>
<tr>
<td>Betula nigra</td>
<td>8-10</td>
<td>12-15</td>
<td>70 60 100</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Betula alba</td>
<td>10-12</td>
<td>15-20</td>
<td>70 60 100</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Bromus media</td>
<td>12-10</td>
<td>25-30</td>
<td>80 70 120</td>
<td></td>
</tr>
<tr>
<td>Bromus rastrinus</td>
<td>12-15</td>
<td>25-30</td>
<td>100 70 120</td>
<td></td>
</tr>
<tr>
<td>Carex comosa</td>
<td>7-9</td>
<td>15-20</td>
<td>70 60 100</td>
<td></td>
</tr>
<tr>
<td>Deschampsia cespitosa</td>
<td>6-8</td>
<td>15-20</td>
<td>70 60 100</td>
<td>No cut after harvest</td>
</tr>
<tr>
<td>Festuca agrestis</td>
<td>5-8</td>
<td>15-25</td>
<td>100 70 120</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Festuca pratensis</td>
<td>8-10</td>
<td>15-20</td>
<td>70 60 100</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Festuca pseudovariformis</td>
<td>8-10</td>
<td>20</td>
<td>70 60 100</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Festuca scabrella</td>
<td>6-8</td>
<td>15-20</td>
<td>70 60 100</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Festuca verna ssp.</td>
<td>8-10</td>
<td>15-20</td>
<td>70 60 100</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Koeleria pyramidata</td>
<td>7-9</td>
<td>15-20</td>
<td>70 60 100</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Phleum bistatum</td>
<td>8-10</td>
<td>15-20</td>
<td>70 60 100</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Phleum ultratum</td>
<td>8-12</td>
<td>20-25</td>
<td>100 70 120</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Iris alpina</td>
<td>6-8</td>
<td>15-20</td>
<td>100 70 120</td>
<td>No cut between harvest and autumn</td>
</tr>
<tr>
<td>Salsola affinis</td>
<td>11-16</td>
<td>20-25</td>
<td>10 10 70</td>
<td>Low growth rate</td>
</tr>
<tr>
<td><strong>LEGUMINOSAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antirrhinum vulgare</td>
<td>8-10</td>
<td>20-45</td>
<td>- 80 140</td>
<td>No potassium chloride</td>
</tr>
<tr>
<td>Antirrhinum vulgare ssp. alpinus</td>
<td>8-10</td>
<td>20-45</td>
<td>- 80 140</td>
<td>No potassium chloride</td>
</tr>
<tr>
<td>Trifolium alpinum</td>
<td>10-14</td>
<td>12-24 or 45</td>
<td>- 60 100</td>
<td>Neutrode-free soils, pH above 5.5 recommended, no potassium chloride</td>
</tr>
<tr>
<td>Trifolium batalun</td>
<td>10-12</td>
<td>15-20</td>
<td>- 60 100</td>
<td>Low growth rate, no potassium chloride</td>
</tr>
<tr>
<td>Trifolium pratense ssp. nivea</td>
<td>8-12</td>
<td>15-20</td>
<td>- 60 100</td>
<td>Cut in spring recommended, no potassium chloride</td>
</tr>
<tr>
<td><strong>HERBS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achillea millefolium ssp.</td>
<td>2-3</td>
<td>20-25 or 45</td>
<td>60 60 100</td>
<td>Two harvests per year</td>
</tr>
<tr>
<td>Lolium temulentus ssp.</td>
<td>10-12</td>
<td>15-20</td>
<td>80 10 80</td>
<td></td>
</tr>
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</table>
**TABLE 3. Possibilities of chemical weed control in seed production of indigenous species**

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>DISTRIBUTION</th>
<th>EXAMPLE TRADE NAME</th>
<th>APPLICABLE RATE</th>
<th>TIME</th>
<th>APPLICATION</th>
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<tbody>
<tr>
<td><strong>Grasses</strong> in general</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bromoxynil + Ioxynil</td>
<td>Fluroxypyr + Starane 250 EC</td>
<td>Express + Starane 250 EC</td>
<td>15.0 g + 0.5 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>Bentazon</td>
<td>Basagran</td>
<td></td>
<td>2.0 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>Fluroxypyr</td>
<td>Starane 250</td>
<td></td>
<td>0.5 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>MCP + Bromoxynil + Ioxynil</td>
<td>Amaranthew</td>
<td></td>
<td>2.0 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>Bentazon + 2,4-D</td>
<td>Basagran DP</td>
<td></td>
<td>4.0 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>Dicamba + MCP</td>
<td>Bemar M</td>
<td></td>
<td>4.0 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>MCP + 2,4-D</td>
<td>Dicopur U’ 16 KV new</td>
<td></td>
<td>4.0 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>MCP</td>
<td>Duplosan KV</td>
<td></td>
<td>2.0 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>MCP</td>
<td>Dicopur M</td>
<td></td>
<td>2.0 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>2,4-D</td>
<td>Dicopur fluid</td>
<td></td>
<td>2.0 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>Clopyralid + Tebuthiuron</td>
<td>Garlon 1, 60</td>
<td></td>
<td>2.5 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>Ethofumesat</td>
<td>Gramat</td>
<td></td>
<td>1.5 l</td>
<td>p.e.</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td><strong>Festuca sp.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycloxydim</td>
<td>Focus ultra</td>
<td></td>
<td>2.0 - 3.0 l</td>
<td>p.e.</td>
<td>Grasses</td>
</tr>
<tr>
<td>Quinclorac</td>
<td>Targa super</td>
<td></td>
<td>1.0 l</td>
<td>p.e.</td>
<td>Grasses</td>
</tr>
<tr>
<td><strong>Ammathis sp.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bentazon + 2,4-D</td>
<td>Basagran DP</td>
<td></td>
<td>1.0 l</td>
<td>Plants &gt; 10 cm</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>Orasuluron</td>
<td></td>
<td></td>
<td>100.0 g</td>
<td>Over two to four leaves stadium</td>
<td>Grasses</td>
</tr>
<tr>
<td>Imazethapyr + ammonium sulphate</td>
<td></td>
<td></td>
<td>1.5 l + 4.0 l</td>
<td>Over two to four leaves stadium</td>
<td>Grasses</td>
</tr>
<tr>
<td>Veranoen</td>
<td></td>
<td></td>
<td>0.5 l</td>
<td>Over two to four leaves stadium</td>
<td>Grasses</td>
</tr>
<tr>
<td><strong>Trifolium pratense</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bentazon</td>
<td>Basagran</td>
<td></td>
<td>2.0 l</td>
<td>Two leaves stadium</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td><strong>Trifolium pratense sp. nivalis</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Quinclorac</td>
<td>Targa super</td>
<td></td>
<td>1.5 l</td>
<td>Over two to four leaves stadium</td>
<td>Grasses</td>
</tr>
<tr>
<td><strong>Trifolium hybridum</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Fluroxypyr-P</td>
<td>Festiva extra</td>
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<td>2.0 l</td>
<td>p.e.</td>
<td>Grasses</td>
</tr>
</tbody>
</table>

* p.e. = post emergence.
BIBLIOGRAPHY OF RELATED REFERENCES


International seed testing association 2001 International rules for seed testing, Annex to Chapter 7 Seed Health Test Methods, Edition 2001-1, Baselsdorf, Schweiz.


This publication describes 25 different grasses and herbs occurring naturally in the middle and high Alpine zones suitable for restoration. Primarily for nature protection rather than merely for forage production, site-specific grasses and herbs have gained significance in recent years. Large building projects (such as ski lifts, ski runs, snow-making facilities, reservoir power stations, roads and tourist infrastructure) must provide rapid surface protection, restoration stability and protection of biomes. Prerequisites for the successful realization of such aims are the production and availability of seeds of suitable site-specific species.

This book describes the possibility of lucrative, non-regulated seed production of selected species and is addressed to innovative farmers and seed producers.