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*The application of molecular markers to monitor introgression of seed yield traits from *Trifolium nigrescens* into *T. repens* (white clover)*

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GATTON, AUSTRALIA

23-26 NOVEMBER 2003

**Herbage Seeds in the New Millennium -
New Markets, New Products, New Opportunities**

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A GLOBAL PERSPECTIVE ON FUTURE TRENDS AND OPPORTUNITIES IN HERBAGE SEED MARKETS

Michel H.J. Nas
Barenbrug Europe

Global view on the turf and forage seed business

[NO ABSTRACT – ONLY SOME HISTORY]

Some history. Already in the late 1800 grass and clover seed was exported from Holland to various European countries and the USA. In 1908, Mr. Josephus Theodore Barenbrug, who founded the Barenbrug company in 1904, wrote a book “Money in grasses” especially written for customers in the American market. The book shows interesting information how the herbage seed market did develop in Holland. I quote Mr. J.Th. Barenbrug who wrote this in 1908 (!): for several generations and long before a more systematic growing of Natural Grass-seeds was either started or even thought of, it was the habit of the poorer classes, to go out in the summer and collect wherever such was permitted, either in meadows or in woods or fields, and in accordance with the successive terms at which the various kinds do come to maturity, the different grass-seeds, the agricultural or other value of which was either known or intimated to them through the various agents whose hand these seeds had to pass through before they reached the foreign wholesale-dealers and cleaner.

From this primitive start, many seed companies in Holland, but at the same time in Germany and Denmark started their activities in the grass seed trade in the late 1800 and early 1900. Most of them family owned companies. In the continuous demand for a better farm output, the seed industry realised that new techniques were necessary. Not only for improving production and processing systems the seed, but also the genetical quality. The first steps in breeding were made. As a result of that, the first Dutch grass seed varieties were registered on the official Dutch variety list in the late 1930. The great breakthrough was directly after World War II where all over Europe, but also in the USA, Canada and New Zealand the herbage seed industry developed into a serious business. With, like in other industrial sectors, huge improvements and changes. From the handpicked seed with a yield of a few kilos a day to huge combine harvesters with a capacity of over 3.000 kg/hour. From simple manure to application of artificial fertilizers. From hand-seeding to GPS controlled machine drilling. From hand-cleaning and bagging to computer-controlled seed cleaners and robot-palletizers.

OVERVIEW OF THE AUSTRALIAN HERBAGE SEED INDUSTRY

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Abstract

Australia produces a wide range of herbage seeds, from temperate to tropical and humid to semi-arid. Domestically, the major herbage seed markets are for pasture grasses and legumes adapted to medium-low rainfall areas which are the major source of Australia's production from beef cattle and sheep. Substantial export markets have developed for Australian herbage seeds, but remain volatile even for major export crops like lucerne (*Medicago sativa*) from temperate areas and Rhodes grass (*Chloris gayana*) from subtropical/tropical areas. Turf and amenity cultivars have dominated herbage seed imports, but are now being increasingly grown by Australian producers. The impact of recent structural changes in the wider Australian seed industry is also discussed.

APOMIXIS BREEDING AND ITS IMPLICATIONS FOR HERBAGE SEED PRODUCTION

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Abstract

Apomixis has the potential to revolutionize crop production and the approaches used to improve plants. It would make hybrids economically possible in crops without good male sterile systems for producing hybrids. Apomixis has been used to produce cultivars in species where this reproductive mechanism exists. However, major impact of apomixis on crop production would be realized when the genes controlling this mechanism can be cloned and used to transform sexually reproducing crop species. Molecular research is providing valuable information on the size, location, and characteristics of the DNA controlling apospory.

MEETING THE NEED FOR HERBAGE SEEDS IN DEVELOPING COUNTRIES

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Abstract

The need for forage seeds in developing countries is very variable and is usually linked to forage research and development. For many species, demand remains limited to few well-known cultivars developed during the 1960s. Uncertain demand, which causes a high degree of risk to seed producers and sellers, has reduced investment in a more formal distribution seed system for herbage seeds in most developing countries. This has led to lack of seeds of new varieties and species and promotion of an informal integrated community-based seed supply system to fill the gap. However, new species are now available and farmers are adopting forages and demanding planting material. This paper reviews the current situation and future prospects for seed supply in developing countries.

PRODUCTION OF ROUNDUP RESISTANT CREEPING BENTGRASS SEED

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Abstract

Seed production of a genetically transformed creeping bentgrass (*Agrostis stolonifera* L. syn. *A. palustris* Huds) cultivar presents specific challenges. Specific cultural practices are required by the United States Department of Agriculture, Animal Plant Health Inspection Section (USDA-APHIS), as part of the approval to field test, the Oregon Department of Agriculture as well as the Scotts production contract. After a series of public hearings, Oregon Department of Agriculture has set up a Bentgrass Control Area in the Madras area in central Oregon. This control area prohibits non-transgenic bentgrass seed production within its borders. These regulatory and stewardship programs control all aspects of seed production, from planting the crop to seed sales to the consumer. The goals of these programs are to minimize the unwanted spread of the crop.

ORGANIC FORAGE SEED PRODUCTION

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Abstract

From January 2004 only organically produced seed can be used in organic farming systems within the EU. Optimal forage production relies on the access to improved cultivars of high quality clover and grass seed for forage mixtures. Currently the supply of organic forage seed in Europe is scarce. In Denmark a production of one of the main constituents of forage mixtures, perennial ryegrass (*Lolium perenne* L.) is established, however, another main constituent, white clover (*Trifolium repens* L.) is still in request.

In general seed yield in organic production is decreased compared to conventional production. In perennial ryegrass the seed yield reduction is approximately 25% whereas it similarly are 80% in white clover. Until now research initiatives has not been able to increase seed yields in white clover, whereas organic grass seed production in general are performed without larger difficulties. Currently the European Commission has put forward a proposal allowing derogations to use conventional grown seed if organic varieties are not available in species that will not be listed in an annex to the regulation.

RESTRICTIONS AND BALANCES IN THE USE OF NITROGEN FOR GRASS SEED PRODUCTION IN FRANCE, THE NETHERLANDS AND DENMARK; A REVIEW WITH CASE STUDIES

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Abstract

Restrictions on the use of nitrogen to agricultural crops in Europe were introduced in order to reduce the environmental impact of N. The positive correlation between N available for growth and grass seed yield is indisputable. Therefore, N restrictions in combination with the positive correlation between N and the seed yield necessitates the need for a better understanding of the N dynamics in grass seed crops in order to utilise the N applied in the most optimum way. Establishment of N balances to identify knowledge gaps or dominate processes are valuable. However, currently no N balances are available for grass seed production under French, Dutch or Danish growing conditions. N balances were therefore developed for different grass species and showed a surplus ranging from 29 kg ha⁻¹ in perennial ryegrass to 81 kg ha⁻¹ in orchard grass. Establishment of an N balance is, however, encumbered by a substantial error, which encompasses e.g. different national N application rates and different seed yields. Furthermore, an important factor for the N balance is the effect of removing or leaving the straw in the system. It is concluded that N application strategies should be further developed and that substantiation of the discussed N balance must be made.

**ANIMAL MANURE OR COMPANION CROPPING WITH HERBAGE LEGUMES AS
NITROGEN SOURCES IN ORGANIC SEED PRODUCTION OF TIMOTHY
(*PHLEUM PRATENSE*) AND MEADOW FESCUE (*FESTUCA PRATENSIS*)**

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Abstract

Organic seed crops of timothy (*Phleum pratense*) 'Grindstad' and meadow fescue (*Festuca pratensis*) 'Fure' were sown in pure stand or with a companion crop of white clover (*Trifolium repens*) 'Milkanova' (6 kg grass seed + 1 kg clover seed ha⁻¹) in six trials with a total of 15 (timothy) or 12 (meadow fescue) harvests from 1999 to 2001. In the ley years, crops received 0, 30 or 60 kg ha⁻¹ of total nitrogen (tot-N) in cattle slurry or dried chicken manure. Due to competition from white clover, first year seed yields were lower on plots sown with than on plots sown without white clover. Although this was partly compensated in the second and third ley year, the total grass seed yield over the ley period was not higher from mixed than from pure crops. Furthermore, contamination of clover seed, either from sown or voluntary plants, complicated certification of timothy seed lots in the first and, in most cases, second ley year. Optimal inputs of manure to seed crops of timothy and meadow fescue were, in turn, 30 and 0 kg tot-N ha⁻¹ in the first ley year, 60 and 30 kg tot-N ha⁻¹ in the second ley year, and 60 and 60 kg tot-N ha⁻¹ in the third ley year. Higher inputs of manure decreased the occurrence of white clover, but interactions between sowing with or without white clover and manure inputs were mostly insignificant.

In a series of still on-going trials (2002-2005), promising results have been obtained with the establishment of organic timothy seed crops with a companion crop of subterranean clover (*T. subterraneum*). Besides fixing nitrogen, this large-seeded and short-lived legume provides competition against weeds (including voluntary white clover and alsike clover) in the sowing year.

THE USE OF WHITE CLOVER AS A SOURCE OF NITROGEN FOR ORGANIC GRASS SEED CROPS

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Abstract

The demand for organically produced forage seed is increasing rapidly as organic livestock farming expands. From January 2004 EU regulation 2092/91 states seed used in organic systems must be produced to organic standards. The production of forage seed to comply with organic standards and to meet the current Seed Certification standards is a significant challenge to the seed producer. Conventional systems of grass seed production use inorganic nitrogen applied at specific stages of crop development and appropriate use of herbicides to produce high quality seed, reduce weed content and minimise seed cleaning costs. The development of organically acceptable methods of supplying nitrogen is one of the most important challenges for the organic grass seed producer. Current research on the potential of white clover as a companion crop, supplying nitrogen to the developing grass seed crop is described. Methods of knowledge transfer used to integrate these research findings into commercial farm practice are discussed.

APPLIED RESEARCH AND EXTENSION FOR NEW ZEALAND HERBAGE SEED PRODUCERS PROGRESS AND PROBLEMS

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Abstract

Progress in herbage seed research and extension in New Zealand is centred on applied research to provide near immediate benefits to seed producers. Excellent seed yield and quality gains have been achieved in ryegrass seed crops from the rapid application of new technology such as plant growth regulators, nitrogen and fungicides. In forage fescue and white clover yield and quality benefits have been achieved, not with the same consistency and often with limited understanding of why yields have increased. The constraints to achieving benefits to farmers in herbage seed crops are largely a limited understanding of the physiology of the plant and how best to manipulate the plant to increase yields. Improved understanding of plant physiology in areas such as nutrient uptake and utilisation in seed production, contribution of photosynthetic area to yield parameters, flower physiology and pollination biology could provide knowledge farmers need to increase productivity.

AUSTRALIAN NATIVE GRASSES – WHY? HOW?

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Abstract

Having been adapted to life under Australian conditions with shallow, acidic and infertile soils together with surviving low rainfall and frequent droughts makes Australian native grasses valuable under a range of applications. Applications include revegetation on degraded sites, amenity and passive recreation areas with low maintenance requirements, horticultural applications under vines and for grazing under low fertility conditions.

Seed production has been limited by the 'wild' nature of the seedhead and seed of many grasses that make harvesting difficult and low yielding, as well as by the paucity of good quality remnants from which seed can be harvested. Production efforts are now being based around cropping of these grasses using adaptations of normal commercial seed production procedures. The seed industry is still in its infant stages and faces numerous technical challenges, but is developing steadily.

INFLUENCE OF LATITUDE ON FLOWERING OF SWEETCLOVER IN TEXAS

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Abstract

New cultivars of white annual sweetclover with multi-stem crowns and low coumarin levels are being developed for the neutral to alkaline soils in central Texas. Hubam sweetclover and four maturities of Emerald sweetclover were evaluated in south (28.45°N), central (30.59°N), and north (32.46°N) Texas to identify the best maturity. Plant growth was earlier at the southern location because of milder winter temperatures, followed by the central and then the northern locations. At each location, the percentage of Emerald plants reaching the reproductive stage generally occurred according to maturity. At all locations the percentage of plants reaching the reproductive stage ranged from about 80% for Emerald maturity 2 to about 5% for Emerald maturity 10/11 until after April. Flowering of Hubam was slightly later than Emerald maturity 7. Emerald maturity 7 was the best entry for pasture or hay and Emerald maturity 2 was best suited as a winter cover crop in a summer crop rotation.

**THE APPLICATION OF MOLECULAR MARKERS TO MONITOR
INTROGRESSION OF SEED YIELD TRAITS FROM TRIFOLIUM NIGRESCENS
INTO TRIFOLIUM REPENS (WHITE CLOVER)**

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Abstract

Introgression of traits from closely related species is an important part of the white clover breeding programme at IGER. Hybrids between white clover and the annual, profusely flowering species *Trifolium nigrescens*, have been developed to introgress reproductive traits and improve the seed production potential of white clover. Backcross hybrids with resource allocation significantly different from the parental material have been produced. Bulked segregant analysis (BSA) using the amplified fragment length polymorphism (AFLP) technique has been used to identify molecular markers associated with increased seed yield resulting from the introgression of genes from *Trifolium nigrescens* (ball clover) into white clover (*T. repens*).

EVOLVING PROCEDURES FOR THE EVALUATION AND COMMERCIALISATION OF HERBAGE PLANTS IN QUEENSLAND

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Abstract

Queensland derives a significant part of its Gross Domestic Product from grazing-based livestock industries. The dairy industry and sectors within the beef and sheep industries depend on sown pastures using exotic germplasm as a primary or significant source of forage for the grazing animal. If these industries are to continue to play a part in the State's economy, it will be important to maintain processes within the State to provide forage varieties that are relevant to industry needs as these emerge. Forage varieties have also found application in cropping systems, horticulture, and soil conservation. Traditionally, public sector agencies, supported in part by industry funding bodies, bore the largest part of the responsibility for plant improvement research. As agricultural research moves more towards development of partnerships with the private sector, so too must the process of pasture plant improvement evolve to maintain a transparent and responsible system of plant release.

DEALING WITH DIVERSITY: SEED PRODUCTION STRATEGIES IN A FORAGE LEGUME GERMPLASM COLLECTION

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Abstract

Alfalfa and other forage legume crops make a significant, but largely unrecognized contribution to world food production. The U.S. National Temperate Forage Legume Germplasm Collection makes seed available to support the development of new cultivars, and development of new uses for cultivated species, as well as supporting basic and applied botanical research. A second important function is the conservation of crop biological diversity through the preservation of seed under ex situ conditions. The temperate forage legume germplasm collection houses over 7600 *Medicago* accessions, representing 79 species; 3500 *Trifolium* accessions (perennial species), representing 108 species and 900 *Lotus* accessions, representing 47 species. To maintain the seed collections, we produce seed on 350-400 accessions each year. We use procedures that minimize genetic change that may occur during the production of a new generation of seed. To maintain genetic integrity we isolate cross-pollinated accessions in cages, introduce bees as pollinators, grow as many individual plants as practical, attempt to minimize selection pressure and equalize parent contributions by using optimal growing and harvesting procedures. In this paper we outline our routine protocols, as well as specialized protocols that are being developed for recalcitrant wild species, and for seed lots that are degraded due to age.

EVALUATION OF SEED YIELD CHARACTERISTICS IN 29 ACCESSIONS OF COCKSFOOT (*DACTYLIS GLOMERATA*) THROUGH A MULTIVARIATE ANALYSIS

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Abstract

In order to study the genetic variation for seed yield and its components among 29 accessions of cocksfoot (*Dactylis glomerata* L.), an experiment was conducted under spaced plant condition over two consecutive years in Karaj, Iran. Principal component analysis and cluster analysis was used to group the accessions. Analysis of variance showed significant differences among accessions for heading date, plant height, fertile tiller number, seed yield, panicle length, seed yield panicle⁻¹, seed number panicle⁻¹, thousand grain weight, harvest index and forage dry matter yield.

Using principal component analysis, the most important variables for seed yield characters were identified. First three independent components accounted for 72% of total variation. The first principal component indicates that seed yield, harvest Index and seed number panicle⁻¹ were important characters for classification. Plant height and forage dry matter yield were important characters in the second component. Based on ward cluster analysis, 29 entries were divided into 5 groups. Accessions in clusters 5, and 3 averaged well above the overall mean for forage dry matter yield and seed yield, respectively. Majority of accessions in cluster 1 and 2 were originated from different parts of Iran, whereas, most of accessions in other clusters were originated from USA and European countries. Accessions from a defined geographic area tended to cluster, but some accessions from particular area spread among several cluster.

Keywords: *Dactylis glomerata*, seed yield, seed components, principal component and cluster analysis.

EVALUATION AND COMPARISON OF ALFALFA CULTIVARS FOR WILT DISEASE (*FUSARIUM* SPP.) RESISTANCE IN THE GREENHOUSE

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Abstract

The main objective of this experiment was to evaluate alfalfa varieties for susceptibility and resistance to *Fusarium* spp. under greenhouse conditions. A greenhouse experiment was established for twenty alfalfa varieties including both American and European varieties. Evaluation based on symptoms on the samples of these plants and cross sections of their roots showed significant differences between varieties. Some varieties showed resistance, while other varieties had medium susceptibility and some varieties showed high susceptibility.

Keywords: Alfalfa, *Fusarium* spp. susceptibility, *Fusarium* spp. resistance.

SEED PARTITIONING AND YIELD RESPONSES TO TRINEXAPAC-ETHYL IN PERENNIAL RYEGRASS

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Abstract

Trinexapac-ethyl (TE) plant growth regulatory impacts on seed partitioning and yield were examined in field trials over a 3-year period in perennial ryegrass (*Lolium perenne* L.). Seed yield was consistently increased by TE in each year, but seed yield declined as the stand aged regardless of treatment. TE-induced increases in seed yield resulted from improvements in floret production and seed set. TE increased seed number but had no effect on seed weight, seed germination, or subsequent seedling weight.

FORAGE TALL FESCUE SEED YIELDS ENHANCED BY PLANT GROWTH REGULATORS

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Abstract

The plant growth regulator (PGR) trinexapac-ethyl was evaluated over four years in seven field trials with forage tall fescue (*Festuca arundinacea* syn. *Schedonorus*). Average seed yield increase from 200 and 300 g ai (active ingredient) ha⁻¹ were 58 and 64% respectively. The 200 g ha⁻¹ treatment was significant (P<0.05) in six out of seven trials, while the 300 g ai treatment was significant in all trials. On average the 300 g ha⁻¹ rate was not significantly different from 200 g ha⁻¹. The responses were associated with a marked decrease in lodging and with stem shortening. Crop bulk at harvest was not reduced. A survey of 40 tall fescue seed growers two years after the introduction, found 100% adoption of the PGR trinexapac-ethyl.

MONITORING TRENDS IN WEEDS OF GRASS SEED CROPS USING GIS TOOLS

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Abstract

Geographic Information System (GIS) software contains powerful tools for displaying and interpreting spatial data, but information must first be geo-referenced. Oregon Seed Services routinely collects information on production practices of certified grass seed crops, including pre-harvest inspection reports on weed presence within fields. Access to data was granted under the stipulation that grower confidentiality be maintained in any public releases of maps or other summaries. A total of 71 grassy weeds and 136 broadleaves, sedges, and other types were found in 10 years of inspections of an average of 5,801 fields per year. The primary obstacle to importing data into ArcGIS was that fields were only localized to township/range/section (TRS) position, with an average of 4.2 and a maximum of 23 unique production fields per TRS. Somewhat arbitrary latitude/longitude values were assigned to each field using a procedure maximizing distances between fields within each TRS. Raster maps were generated with Inverse Distance Weighted (IDW) methods using weed abundance values of 0, 1, 10 or 100 for ratings of *absent*, *trace*, *many*, or *excessive* numbers of each species. Subtracting rasters for one year from the next identified regions in which weeds such as *Poa trivialis* were changing in prevalence over time.

POTASSIUM NUTRITION OF PERENNIAL RYEGRASS

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Abstract

Perennial ryegrass is grown for turf or forage seed on broad range of soil and landscape positions in western Oregon. Between two-thirds and three-quarters of the perennial ryegrass acreage has straw baled and removed. Baling and removing straw removes five to ten times more potassium than removing only seed. Unlike seed, the potassium concentration of perennial ryegrass straw increases as soil test potassium increases. The straw potassium concentration increase is not linear, it increases rapidly as soil test increases, and then becomes constant, about 1.5%, even though soil test potassium increases. To compensate for potassium removed in baled straw, recommendations for potassium fertilizer application vary with straw management.

EFFECT OF TIME AND METHOD OF ESTABLISHMENT ON SEED YIELD OF IRRIGATED PERENNIAL RYEGRASS

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Abstract

Perennial ryegrass (*Lolium perenne* L.) seed production is an opportunity to diversify agriculture in Alberta, but limiting factors for the species are its lack of drought tolerance and winter hardiness. Irrigated trials were established at Bow Island and Brooks in southern Alberta to determine profitable cropping options for seed production. Perennial ryegrass seed yields were highest at Bow Island when spring established with a barley companion crop harvested either for silage or grain with yields averaging 2220 and 2127 kg ha⁻¹ respectively. The barley companion crop treatment harvested as silage at Brooks resulted in the highest average perennial ryegrass seed yield at 1590 kg ha⁻¹. All treatments resulted in higher economic returns over two years when compared to clear spring seeded perennial ryegrass. Establishing perennial ryegrass with spring seeded companion crops or seeding in mid-summer following grain or silage harvest would be economically acceptable for subsequent perennial ryegrass seed production.

SPLIT NITROGEN APPLICATION TO SEED CROPS OF TIMOTHY (*PHLEUM PRATENSE*)

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Abstract

Split nitrogen application to seed crops of timothy was evaluated in 20 field trials (11 with cv. Grindstad and 9 with cv. Vega) in SE- and Mid-Norway during 1998-2000. Three different N-rates were applied in early spring (25, 50 and 75 kg ha⁻¹), combined with four N-rates at the start of tiller elongation (0, 25, 50 and 75 kg ha⁻¹). On average for all experiments, the highest seed yield was obtained when a total rate of 75 kg N ha⁻¹ was split into a main application in early spring (50 kg N ha⁻¹) and a supplemental application at the start of tiller elongation in mid May (25 kg ha⁻¹). The optimal strategy for split N-application, with the main portion of the total nitrogen rate applied in early spring, was in principal similar in the two cultivars. Chlorophyll-readings, using the handheld chlorophyll-meter Hydro N-Tester™, showed a relatively strong relationship with the optimal split N-applications rate at the start of tiller elongation in cv. Grindstad ($r^2 = 0.46$) but not in cv. Vega ($r^2 < 0.01$). In cv. Grindstad, it is concluded that chlorophyll-readings may be useful to determine the optimal split nitrogen application rate at the start of tiller elongation.

**EFFECT OF CEMENT DUST ON STRAW YIELD AND EAR YIELD OF BARLEY
(*HORDEUM VULGARE* CV WADI EL-KOUF) UNDER CONTROLLED
CONDITIONS**

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Abstract

Cement dust pollution reduced straw yield by 47.1% and ear yield by 42.1% in *Hordeum vulgare* cv Wadi el-Kouf. The reduction in ear yield was largely due to decrease in number of grains in the ear, and to lesser extent decrease in grain weight. The alkaline nature of cement dust was responsible for yield losses. In an earlier paper the author (Mohamed 1997) described the effect of cement factory dust on chlorophyll content of barley, a common cereal crop of coastal region of Libya. This crop is extensively grown in the vicinity of the Libyan Cement Factory and continuously subjected to cement dust pollution, adversely affecting its growth and yield. This paper reports on the effect of cement dust pollution on the phytomass and yield of barley.

ROOT PRODUCTIVITY AND SEED PRODUCTION IN COOL-SEASON GRASSES

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Abstract

Root productivity effects on flowering and seed yield was studied over a 3 year period in perennial ryegrass (*Lolium perenne* L.), tall fescue (*Festuca arundinacea* Schreb.), Chewings fescue (*F. rubra* var. *commutata* Gaud.), and creeping red fescue (*F. rubra* var. *rubra* L.). Root biomass was greater in narrow row spacings than in wider row spacings. Root biomass increased as stands aged in all species tested. Shallow root biomass density was related to seed yield in creeping red fescue, Chewings fescue, and perennial ryegrass, but not in tall fescue.

SPRING NITROGEN FERTILIZATION PRACTICES IN OREGON'S WILLAMETTE VALLEY GRASS SEED CROPS

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Abstract

Optimum levels of spring applied N for seed production were 150-200 kg N ha⁻¹ for perennial ryegrass, 100-150 kg N ha⁻¹ for tall fescue, 56 kg N ha⁻¹ for fine fescue, and 150 to 200 kg N ha⁻¹ for annual ryegrass as determined from site averages over several years. Results are summarized over three years for perennial ryegrass and tall fescue, four years in fine fescue, and two years in annual ryegrass. The study was designed to provide data and recommendations over the productive stand life of the three perennial crop species. The use of N rates above the recommended levels increased soil and plant N, but did not improve yield. Lower N rates resulted in reduced seed yield, which became more pronounced as the stand aged. These data are being used to rewrite OSU Extension fertilizer guides.

RESPONSE OF PERENNIAL RYEGRASS TO SPRING NITROGEN FERTILITY AND PLANT GROWTH REGULATOR APPLICATIONS

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Abstract

Recently registered plant growth regulators (PGR) used for control of excessive growth and lodging in perennial ryegrass were applied in conjunction with varied rates of spring-applied nitrogen (N) in 2002 to determine if seed yield can be increased with higher than recommended spring N rates. Though seed yields were increased by 38% from the use of PGR, higher rate of spring N was not a contributing factor to the increased seed yield. Thus, the spring N rate for optimum seed production in perennial ryegrass is the same with or without the use of PGRs.

EVALUATION OF TRINEXAPAC-ETHYL (PALISADE) ON KENTUCKY BLUEGRASS GROWN FOR SEED IN CENTRAL OREGON

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Abstract

The growth regulator, trinexapac-ethyl (Palisade), was evaluated on commercial Kentucky bluegrass seed fields (var. 'Geronimo' and 'Merit') near Madras, Oregon from 1999 to 2003. Trinexapac-ethyl was applied at rates from 200 to 600 g a.i. ha⁻¹ and at growth stages from two nodes detectable (Feekes 7) to pre-anthesis (Feekes 10.5). Compared to untreated plots, yields increased by an average of 31 percent across the five years of the study with the best-performing trinexapac-ethyl application. Applications at detection of the second node produced the greatest increase in yield. The effect of application rates varied over the years, but 400 g ai ha⁻¹ generally maximized yield increases. Application when the heads first became visible (Feekes 10.1) had the greatest effect on plant height and lodging.

PERFORMANCE OF POSTEMERGENCE HERBICIDES ON EIGHT NATIVE GRASS SPECIES GROWN FOR SEED IN CENTRAL OREGON, 2000-2002

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Abstract

Herbicide screenings were conducted over two seasons on eight native grass species: great basin wildrye, bluebunch wheatgrass, streambank wheatgrass, big bluegrass, Idaho fescue, Indian ricegrass, squirreltail and prairie Junegrass. Fall applications were made 18 October 2000 and 14 October 2001. These included 1x and 2x label rates of dicamba, dimethenamid, diuron, flufenacet + metribuzin, metribuzin, oryzalin, oxyfluorfen, primisulfuron, pronamide, sulfosulfuron, and terbacil. Treatments were applied to the same plots two years in a row to increase confidence related to crop safety. During 2002 treatments producing the most negative effect were 2x rates of terbacil at 1346 g ha⁻¹ and pronamide at 458 g ha⁻¹. Treatments with the least effect on both stand reduction and reduced heading across grass species were 1x rates of diuron at 1614 g ha⁻¹, oxyfluorfen at 175 g ha⁻¹ and metribuzin at 336 g ha⁻¹. Stand reduction across herbicide treatments was least for great basin wildrye, and was greatest for prairie Junegrass and squirreltail. The least herbicide impact on heading was observed with great basin wildrye and streambank wheatgrass, while it was most severe for squirreltail and prairie Junegrass.

RESPONSE OF COOL SEASON GRASS SEED CROPS TO BORON FERTILIZER IN THE WILLAMETTE VALLEY, OREGON

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Abstract

Field trials were conducted over a three-year period to evaluate the response of three cool season grass species to applications of B fertilizer on soils testing less than 0.5 mg kg^{-1} B, the critical level for B sensitive crops. Both liquid and granular applications of B increased both soil test levels and plant flag leaf tissue concentrations at all locations. However, an increase in seed yield was measured in only 2 of 17 field tests.

**VARIETY-SPECIFIC MANAGEMENT FOR SEED PRODUCTION OF CREEPING
RED FESCUE (*Festuca rubra* L. var. *rubra*)**

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Abstract

A study was conducted in the Peace River region of Canada with three varieties (Boreal, Jasper, Jasper E) of creeping red fescue to determine variety-specific management practices for seed production. Experimental treatments included four methods of establishment (Broadcast; 12"/30cm rows; 6"/15cm rows; 6"/15cm rows with sulfur [50 lb ac⁻¹ (56 kg ha⁻¹) SulFer 0-0-0-95]), three methods of post-harvest management (flail mowing and residue removal; disc mowing and residue removal; short-duration, intensive grazing with sheep) plus crop residue removal at seed harvest, and 10 nitrogen (N as 34-0-0) fertilizer treatments. Seed yield was greatest over two consecutive production years when sown on 12"/30cm rows. In the first, second and combined production years, Boreal produced 655, 372 and 1027 kg ha⁻¹, respectively; for the corresponding production years, Jasper produced 56, 65 and 60% of Boreal, and Jasper E produced 58, 76 and 65% of Boreal. For the year subsequent to the application of the post-harvest treatments, the effects of flail and disc mowing were similar (360 versus 347 kg ha⁻¹ seed, respectively) but grazing reduced seed yield to 188 kg ha⁻¹. A repeated fall application of 50 to 70 lb ac⁻¹ (56 to 78 kg ha⁻¹) N, in the establishment year and after the first year = s seed harvest, is sufficient to maximize the combined seed yield over two consecutive production years.

EFFECTS OF TRINEXAPAC-ETHYL (MODDUS) IN SEED PRODUCTION OF EIGHT TEMPERATE GRASSES

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Abstract

The plant growth regulator (PGR) trinexapac-ethyl (Moddus), was evaluated in 37 seed production trials from 1998 through 2002. On average for five timothy (*Phleum pratense*) trials in the relatively wet and cool climate of Central Norway (63-64°N), Moddus (150 g a.i. ha⁻¹ at the late flag leaf / early heading stage, GS 45-51) increased seed yields by 52% over the unsprayed control and 25% over CCC-sprayed plots. In the main seed production district in southeast (SE) Norway (58-61°N), average seed yield increases by Moddus (150 g a.i. ha⁻¹ at the first to second node stage, GS 31-32) were 18% in timothy, 43% in cocksfoot (*Dactylis glomerata*), 36% in common bent (*Agrostis capillaris*) and 21% in meadow fescue (*Festuca pratensis*). Compared to the effects of CCC (2.0 kg a.i. ha⁻¹ at GS 31-32), these increases were slightly lower in timothy, similar in cocksfoot and common bent, and significantly higher in meadow fescue. In creeping red fescue (*Festuca rubra* var. *rubra*) the combination of CCC at GS 31-32 and Moddus at GS 45-51 gave a higher seed yield increase, on average 41% over the unsprayed control, than the added increase by either PGR given alone. In smooth brome grass (*Bromus inermis*), Moddus was effective only when applied at GS 45-51, but the 33% seed yield increase was lower than for application of CCC at GS 31-32. Neither Moddus nor CCC had any significant effect on seed yield in reed canarygrass (*Phalaris arundinacea*) or smooth meadowgrass (*Poa pratensis*). Based on these trials, Moddus has now been approved in Norwegian seed production of timothy, meadow fescue, cocksfoot, red fescue, common bent and smooth brome grass.

RESIDUE MANAGEMENT AND SEED PRODUCTION IN DRYLAND KENTUCKY BLUEGRASS

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Abstract

Regulations banning burning of post-harvest residue from Kentucky bluegrass (*Poa pratensis* L.) seed fields in Washington State, USA, and health concerns from smoke requires development of alternative residue removal methods. The agronomic response of dryland bluegrass to mechanical residue alternatives was compared to open-field burning. Seed yield with several residue removal alternatives compared favourably to seed yield with burning of consecutive crops (crop years 2 and 3), but all were less than burning in crop year 4. Panicle density was not affected by residue left on the surface and was only correlated with seed yield in the fourth harvest. Compared to burning, all mechanical treatments essentially created more dust, had increased weeds, and increased soil erosion in the spring. In two of the three harvests, burning, in general, was more economical than the mechanical residue removal treatments.

THE EFFECT OF SEED SIZE ON THE EARLY GROWTH AND WATERLOGGING TOLERANCE OF RYEGRASS (*LOLIUM SPP.*)

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Abstract

Experiments were undertaken to investigate the variation between accessions of perennial ryegrass seedlings for waterlogging tolerance determined by the percentage decrease in shoot and root dry matter (DM) yields (average 21% and 33% respectively) during a period of waterlogging and recovery. Seed mass had a weak positive correlation with total plant DM yield under waterlogged or non-waterlogged conditions. The variation for root and shoot DM yield in these experiments highlights the possibility of the development of a waterlogging-tolerant cultivar.

THE INFLUENCE OF FRUCTAN ON SEED PRODUCTION

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Abstract

In a perennial grass seed crop an early development of tillers is necessary for obtaining a high seed yield. Spring growth likely depends upon the amount of available energy arising from stored carbohydrates during autumn. In temperate grasses different fructans are used as the energy source. The amount of fructan available in early spring is related to the amount accumulated in autumn and the amount mobilized during winter. Optimising the amount of fructan incorporation during autumn might be important for the spring development of the crop in relation to the development of reproductive organs and hence seed yield.

The ability to incorporate fructan during fall seems to vary between varieties of the same grass species and between species. Additionally the distribution of fructan between root and top seems to change during fall and according to variety.

The influence of establishment method and fall management (cutting, straw cutting, burning, trimming) of the crop on fructan accumulation and the relationship between fructan content and the amount of tillers in fall is being investigated. However, samples are still being analysed. Therefore no results are included in this abstract, however a poster will present the preliminary data.

THE MAIZE BILLBUG AND *DIATRAEA SPP.*: INSECTS AFFECTING THE SEED PRODUCTION OF EASTERN GAMAGRASS

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Abstract

The maize billbug, *Sphenophorus maidis* (Chittenden), southern cornstalk borer, *Diatraea crambidoides* (Grote), and southwestern corn borer, *Diatraea grandiosella* Dyar, reduce seed production of eastern gamagrass, *Tripsacum dactyloides* (L.) L., at Woodward, Oklahoma, USA. Adult maize billbugs feed on shoots leaving a transverse row of holes across the leaf blade. This feeding pattern commonly occurs in maize, *Zea mays* L., as well. Female billbugs chew small holes into the base of culms where they deposit eggs. The culm slowly dies as larvae begin to feed and complete their life cycle. Larvae of the southern cornstalk borer and southwestern corn borer cause damage by feeding on leaves and boring into the culms. Adults of these insects lay their eggs in the upper canopy of the plant. Once eggs hatch, the larvae feed in the local area where eggs were laid creating a "windowpane" effect on the leaf. Larvae move down the culm feeding on lateral inflorescences and eventually bore into the culm where they develop and complete their life cycle. As with the billbug, culms slowly die as the larvae develop, thus reducing over all plant vigor and seed production.

Eastern gamagrass is a highly productive and palatable perennial, warm-season grass used for pasture, hay, and conservation purposes (Dewald et al., 1996; Eaheart, 1992; Rechenthin, 1951). Its wide use, however, has been limited by its high seed costs due to low seed production and slow establishment from seed (Ahring & Frank, 1968; Dewald & Kindiger, 2000). As the number of hectares of eastern gamagrass increases in the United States the incidence of disease and insect pests has become more evident. Plant diseases and insects commonly found in maize are causing serious problems in eastern gamagrass. Cultural practices used to control many of these insects in maize will not work for eastern gamagrass due to its perennial habit. Chemical control measures generally are not labelled for gamagrass and if labelled may only drive seed costs higher. Knowledge of the life cycles of the maize billbug, southern cornstalk borer, and southwestern corn borer in maize may be useful for developing cultural practices for eastern gamagrass.

The USDA-ARS Southern Plains Rangeland Research Station maintains the largest collection of temperate eastern gamagrass germplasm in the United States. We surveyed our collection and found no resistance to these insects. Eastern gamagrass, a close relative of maize, has been used as a gene source for developing disease and insect resistant maize lines (Bergquist, 1981; de Wet, 1979; Moellenbeck et al., 1995). Maize lines with limited resistance to the southwestern corn borer are available and it is possible to move genes from maize into eastern gamagrass. Another alternative is to develop Bt gamagrass (Krizek et al., 2003).

The utilization of eastern gamagrass for pasture, hay, and soil stabilization is increasing every year and other uses such as grain for human consumption or pharmaceuticals from this amazing plant are being explored. As eastern gamagrass hectares increase, it will be very important to develop strategies to minimize the economic impact imposed on the crop by injurious insects and other organisms. We anticipate that these problems will be solved through an integrated approach of plant breeding and cultural practices.

EFFECTS OF CALCIUM ON THE CONTENT OF FREE PROLINE IN ALFALFA SEEDLINGS UNDER DROUGHT STRESS

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Abstract

The effects of calcium (Ca^{2+}) on content and accumulation of free proline were studied in seedlings of two Chinese alfalfa landraces, Aohan and Zhaodong, subject to drought stress in glasshouse conditions. The free proline content of seedlings increased under drought stress and showed differences between the two landraces. Calcium treatments reduced the proline content of both landraces in the early stages of drought stress but the response differed between the two landraces. These results show that proline content is involved in drought stress response in alfalfa. However, the extent to which the addition of Ca^{2+} reduced drought stress was minimal, and certainly negligible under severe drought stress.

SEED PRODUCTION AND MARKETING OF KANGAROO GRASS - A CASE STUDY

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Abstract

A series of studies aimed at promoting commercial availability and use of kangaroo grass (*Themeda triandra*) seed is described. These showed that demand, as well as supply, issues must be addressed if seed production of a new species is to be commercially viable.

ASPECTS OF HERBAGE SEED LOT QUALITY

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Abstract

Seed quality can be defined as a standard of excellence in certain characters or attributes that will determine the performance of the seed when sown or stored. In the herbage seed industry, seed quality reflects the overall value of seed for its intended purpose. This review examines herbage seed quality from four different perspectives: herbage seed quality standards; herbage seed quality as a specific requirement for modern crop production; herbage seed quality and biosecurity; and herbage seed quality in non-temperate environments.

COMPARISON OF SEED QUALITY OF OREGON VERSUS TEXAS PRODUCED ANNUAL RYEGRASS

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Abstract

Almost all annual ryegrass seed planted in the southern USA is produced in Oregon; however, some annual ryegrass seed is produced in Texas annually. This study was conducted to provide information on the quality of Oregon versus Texas produced seed.

Seed from six genotypes of annual ryegrass were grown and produced seed in both Oregon and Texas. This seed was tested for seed weight, % germination and for seedling vigor. Results indicated that Oregon produced seed had a higher 1000 seed weight, higher percent germination, and a slightly higher dry matter production from plants grown in the greenhouse for 50 d. Differences between genotypes for all of the above characters were observed and are discussed in this paper. This study confirmed the hypothesis that Oregon produced seed has higher quality and should continued to be planted in Texas.

GERMINATION AND VIGOUR IN STORED SEED OF *STYLOSANTHES HAMATA* AND *STYLOSANTHES SCABRA*

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Abstract

Levels of germinable, hard and dead seeds in locally harvested samples of *Stylosanthes hamata* and *Stylosanthes scabra* were determined in laboratory experiments at Dharwad, India, and a Seed Vigour Index (based on seedling measurements and germination) was calculated. Freshly harvested seed was compared with seed lots stored for one, two or three years under ambient conditions. Prior to testing, samples from each seed lot were de-podded by rubbing with a rubber pad or with sandpaper and compared to an untreated control sample.

The loss of viable seed (i.e. germinable + dead seeds) in storage was slower in *S. scabra* than in *S. hamata*. For optimum field establishment, seed of *S. hamata* should be sown soon after harvest, in contrast to *S. scabra* which germinated better after one year in storage. In both species, the seed should be de-podded to ensure optimum establishment and field performance.

Keywords: *Stylosanthes*, hardseededness, seed viability.

A BRITISH IDIOT'S GUIDE TO ENDOPHYTES

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Abstract

This paper discusses the known information about toxin producing endophyte fungi. It makes recommendations for British seed growers and suggests areas where grassland research is needed.

Old and permanent pasture in the UK has been shown from limited data to contain toxic producing fungi. Loss of livestock production, goes unnoticed in the UK because death or serious illness is not as common as in the USA and New Zealand. Future problems are predicted.