ABSTRACTS

THIRD INTERNATIONAL HERBAGE SEED CONFERENCE

Martin-Luther-Universität Halle-Wittenberg

Halle (Saale), Germany

June 18-23, 1995

Physiological Limitations on Seed Filling in *Lolium perenne*

J.W. Warringa[1]

Actual seed yield of *Lolium perenne* L. seed crops is variable and much lower than the potential yield. This variability largely depends on the number of fertile florets that produce a harvestable seed. Before harvest 50 to 80% of the florets contain a seed. A great number of seeds are lost during harvest and cleaning because they are too light. Not enough assimilates accumulate into these seeds, because of a limited filling rate or duration. The pattern of flowering and ripening within the ear was determined, showing the time span of seed filling and the filling rate for each position in the ear. The total availability of assimilates did not seem limiting during the seed filling phase. The stem contains abundant reserves as shown in a shading experiment, and reported in the literature. Distribution of the available assimilates is determined by the activity of the sinks. The seeds might be in competition with the stem and tillers. Labelling with $^{13}CO_2$ from ear emergence onwards showed that the stem exported, and the seeds imported, an increasing fraction of label during the seed filling phase. However the water-soluble carbohydrate (WSC) content of the stem remained at 26%. These results show that the stem is not competing, but acts as a buffer. Furthermore the seeds do not seem able to utilize the available stem reserves. Competition between seed filling and new tiller growth after flowering was investigated by manipulation of tillering. Tillering was manipulated by removal, combined with shading of the plant base or red light emitting diodes placed around the plant base. Increasing tiller number by 3.5 to 7.5 fold, showed no detrimental effect on final seed yield. Finally competition for assimilates between seeds was also studied. Removal of 50% of the ovaries at flowering significantly increased the average seed weight of the remaining seeds by 12%. In view of the abundant availability of assimilates in the stem, this suggests that developing seeds in *Lolium perenne* L. influence one another in a hormonal way, and not through competition for assimilates.

[1] *Research Institute for Agrobiology and Soil Fertility, 6700AA Wageningen, The Netherlands.*

Climatic Effects on Components of Seed Yield in Italian Ryegrass

Uwe Simon[1]

Average seed yields of forage grasses differ greatly depending on the geographic area of seed production. If the cultivation practices are similar the differences in seed yields may be attributed to differences in the climate of the respective regions. The average seed yields of Italian ryegrass reported in the Netherlands exceed those obtained in Bavaria. An experiment was conducted in controlled climate conditions to study the effects of the temperature regimes and daylengths prevalent in Wageningen (Netherlands) and in Weihenstephan (Barvaria, Germany), respectively, on components of seed yield in Italian ryegrass. During the period from tillering to seed maturity, the climate of Amsterdam is characterized by higher average temperatures and daylengths as compared with Weihenstephan.

At "Amsterdam" the number of mature seed heads exceeded "Weihenstephan" by 36%, the number of mature seeds by 75%, the seed weight by 35%, and the 1000 seed weight by 4% resulting in a 44% increase in the yield of mature seeds. It is concluded that higher average temperature and extended daylength exert a beneficial effect on seed yield of Italian ryegrass.

[1] *Technische Universität München, Lehrstuhl für Grünlandlehre Freising-Weihenstephan, Germany.*

Effect of Vernalization on Heading Date, Tillering and Plant Biomass of *Lolium multiflorum*

L.R. Nelson, S.L. Ward and J. Crowder[1]

Annual ryegrass (*Lolium multiflorum* Lam.), a highly productive forage in the southern US, is planted in the autumn and grazed until about June 1. Even though it is an annual, a cold period is thought to be required to promote reproduction and heading of plants. The objective of this study was to determine the length of the cold period required before the ryegrass plant enters the reproductive stage. Nine ryegrass genotypes (5 released cultivars and 4 experimental lines) were subjected to 0, 7, 14, 21, 28, 35, and 42 days at 4°C in a lighted (13 $mEm^{-2}s^{-1}$) cold room. All plants were removed from the cold treatment on the same day and transplanted into soil in pots (7 x 7 cm) in a heated glass greenhouse, with supplemental lighting at a 16 h day length photoperiod. Three plants were planted in each pot, which were thinned to two plants after establishment. There were five replications of the experiment, for a total of 315 pots.

Results indicated significant differences for days to heading, genotype, vernalization time, and their interaction. Vernalization time also affected number of tillers per plant and total biomass per plant. All genotypes eventually headed out without any vernalization treatment. With no vernalization, 83 days (mean of all genotypes) were required for heading. However, each week of vernalization reduced heading date by about 5 days. Therefore, plants which had received six weeks of vernalization headed out after 59 days. Plants with little or no vernalization produced significantly more tillers and an increase in biomass per plant than those plants with a longer vernalization treatment. Mean wt per plant ranged from 9.5 g for no vernalization to 6.7g per plant for plants receiving 42 days vernalization. Number of tillers per plant were 11.2 for the 0 vernalization treatment, 11.3 (7 d), 9.8 (14 d), 8.5 (21 d), 8.2 (28 d), 9.3 (35 d), and 10.8 (42 d), respectively. These data indicate that a cold period of about 30 days will help initiate the reproductive stage with annual ryegrass. If the cold period has not occurred, plants tend to remain vegetative, continue to produce new tillers, and increase in total biomass. Variability in length of heading date between plants was extremely large when little or no vernalization had taken place. After 30 days of vernalization, heading date variability was reduced and most plants tended to head out uniformly. This information should be useful in planning experiments with annual ryegrass.

1 *Texas A&M University Agricultural Research & Extension Center, Overton, Texas 75684, USA.*

Effect of Cultivar, Time of Sowing and Fungicide Application on Seed Yield in Cocksfoot (*Dactylis glomerata* L.)

S.M. Wilson[1], J.G. Hampton[1], M.J. Hill[1] and M.P.Rolston[2]

Three New Zealand (Grasslands Wana, Grasslands Kara, Grasslands Tekapo) and two Japanese (Akimidori, Makibamidori) cocksfoot cultivars were sown in spring (23 September 1991) and again the following autumn (6 April 1992) at AgResearch Grassland's Aorangi Research Farm in the Manawatu. Seed was sown at 3 kg ha^{-1} with a 30 cm row spacing. Plot size was 1.2 x 3.0 m^2, with each plot containing 4 rows. A randomised block design was utilised with 8 replicates of each cultivar for each sowing time. For each cultivar and sowing time four of the eight replicates were sprayed with propiconazole (125 g a.i ha^{-1}) on 17 November 1992 and 8 December 1992. Spring sowings outyielded autumn sowings by 230 to 600 kg ha^{-1} depending on cultivar. Cv. Wana produced 680 kg seed ha^{-1} from the autumn sowing, and cv. Tekapo 230 kg seed ha^{-1} but yields for the other three cultivars were less than 100 kg ha^{-1} following autumn sowing. Spring sowing produced yields of 916, 868, 625, 637 and 468 kg ha^{-1} for cv. Wana, Tekapo, Kara, Akimidori and Makibamidori respectively. Fungicide application to autumn sown plots did not significantly increase seed yield, and similarly no differences were recorded for spring sown cv. Kara and Akimidori. However fungicide application significantly increased seed yield in cv.Wana, Tekapo and Makibamidori, the increases being 510(+72%), 573(+98%) and 315(+101%) kg ha^{-1} respectively.

1 *Seed Technology Centre, Department of Plant Science, Massey University, Palmerston North, New Zealand.*
2 *AgResearch, P O Box 60, Lincoln, New Zealand.*

Causes For Variable Yields in Seed Production of Arctic Cultivars of *Poa pratensis* L. at Lower Latitudes

Trygve S. Aamlid[1]

In the northernmost part of Norway (68-71°N), *Poa pratensis* L. is used not only for turf, but also for grazing and silage. The older cultivar 'Holt' and the new cultivar 'Lavang' have been bred specifically for these purposes.

Seed production of 'Holt' and 'Lavang' in Denmark (56°N) and Southeast Norway (58-61°N) has been characterised by low and irregular seed yields. When seed crops are spring sown without a cover crop, a fairly high yield in ley year 1 is often followed by a rather poor outcome in ley year 2. The variation between years seems to be most pronounced in regions with mild winters and no permanent snow cover. The objective of the present experiment was to find a physiological explanation for this phenomenon.

On 21 May 1992, a seed crop of 'Lavang' was sown without a cover crop on a sandy soil at Landvik Research Station (on the south coast of Norway, 58°N). The sowing rate and row spacing were 5 kg ha^{-1} and 33 cm, respectively. At approximately two month intervals from 15 Aug 1992 to 1 July 1994, four 20 x 33 x 8 cm sods were dug from the crop, washed and taken into the laboratory for tiller counting and the determination of dry weight and concentration of water soluble carbohydrates (WSC) and nitrogen (N) in tillers, panicles, rhizomes and roots. Fifteen large tillers (base diameter >1.5mm) from each sod were dissected and the apical development recorded.

Even though the winter 1993-94 had a stable snow cover from 20 Nov to 20 March, the characteristic drop in panicle formation from the first to the second ley year was very evident, the average numbers being 1603 m^{-2} in 1994. This drop was accompanied by (1) a much higher tiller number on 15 Aug in 1993 than on the same date in 1992 (11603 vs. 4595 m^{-2}); (2) less advanced apical development at the onset of winter in 1993 than in 1992 (2.9 vs 4.8 on a scale where 3.0 denotes double ridge); (3) almost twice as high root weight and three times higher rhizome weight during the winter of 1993-94 as compared to 1992-93 and (4) a slightly lower concentration of WSC and N in tillers and rhizomes during the second winter.

These observations indicate that the drop in seed yield from the first to the second ley year is primarily a result of increased tiller competition due to denser stands and 'sod binding', as often reported for temperate cultivars. Although high winter temperatures increase respiration without evoking photosynthesis of winter dormant Arctic cultivars, the size of the rhizome storage pool discounts the widely held belief that failing second years' crops are due to depletion of WSC.

1 *The Norwegian Crop Research Institute, Landvik, 4890 Grimstad, Norway.*

Aspects of the Amphicarpy of the Tropical Pasture Legume *Centrosema rotundifolium* Mart. Ex Bentham

A. Schmidt[1], R. Schultze-Kraft[1], B.L. Maass[2] and R. Herrmann[1]

Centrosema rotundifolium Mart. ex Bentham is a little-known species in the important tropical pasture legume genus *Centrosema*. It shows amphicarpy and originates from sandy soils in subhumid/semiarid Northeast and Central Brazil. The seed production mechanisms of the species were studied in field experiments in the eastern lowlands of Colombia and a detailed botanical and morphological description of the amphicarpic behaviour of *C. rotundifolium* was produced. There were significant soil texture and cutting intensity effects on the resource allocation between subterranean and aerial seed production: the former decreased and the latter increased on a heavier soil (loam) where in contrast to a sand soil subterranean peduncles could not penetrate the ground. In general, plants tended towards increased reproduction under higher intensity of use. Regarding seeds from the two positions, subterranean seeds are larger, heavier, darker in colour and at least in the first few days faster germinating than aerial seeds. But there were neither significant differences in total germination rate from different sowing depths (1-30 cm) nor in subsequent plant growth or yield parameters. The results confirm for *C. rotundifolium* the high capability, reported in literature for amphicarpic plants in general, to adapt to different environmental conditions through their seed production mechanisms. The reproductive strategy of the species, by which subterranean seeds ensure the persistence of a population at a given spot and aerial seeds provide the possibility to colonise other spots, improves the probability of survival and, thus, seed production under changing or unfavourable environmental conditions.

1 *Institute of Plant Production in the Tropics and Subtropics (380), University of Hohenheim, D-70593 Stuttgart, Germany.*
2 *Centro Internacional de Agricultura Tropical (CIAT), A.A. 6713, Cali, Colombia.*

Drought Stress Effects on Seed Yield and Quality of Four Annual Clovers

A. Iannucci, G. Ronga, N. Di Fonzo and P. Martinello[1]

Drought stress consistently reduced forage and seed yield in some annual legumes grown under Mediterranean environmental conditions. Little is known with respect to water stress effects on seed quality of these species in this region. Field experiments using four forage legumes, berseem (*Trifolium alexandrinum* L.), crimson clover (*Trifolium incarnatum* L.), Persian clover (*Trifolium resupinatum* L.) and squarrosum clover (*Trifolium squarrosum* L.), were conducted in 1993 and 1994 at Foggia, Italy to evaluate the influence of drought stress during the seed filling period on seed yield and its components and vigour of harvested seed. An irrigated control was compared with a water stress treatment; the development of stress was monitored by measuring leaf water potential (ψ_w) at midday with a Scholander pressure chamber. The results are related to the first year of evaluation. Seed yield reduced by 3.1 to 76.7% for the different species by drought. Seed yield components mainly influenced were the number of heads on the stem and the number of seeds on heads (a 20.7 and 43.6% mean reduction respectively). The effect of drought on germination percentage, germination rate index (GRI), seedling growth rates, seedling dry weight and electrical conductivity (EC) measurements were not statistically significant. Only the EC, determined after a 1 hour soaking interval, showed a significant difference between treatments for all species. Drought stress that occurred during seed growth reduced yield and its components, maintaining viable and vigorous seeds.

[1] *Istituto Sperimentale per le Colture Foraggere, Sezione Operativa di Foggia, Via Napoli, 52, Italy.*

The Use of Moisture Stress to Optimise Seed Yield and Quality in *Trifolium* Species.

A.A. Cowan and A.H. Marshall[1]

The water requirements of white clover for maximum seed yield can be less than that for maximum vegetative growth. In some instances seed production can be increased by imposing moisture stress during flowering. The balance between vegetative and reproductive growth is altered at the expense of vegetative growth. An experiment imposing different levels of moisture stress was used to influence the seed production of cv. Olwen, a large leafed white clover (*Trifolium repens* L.). This was completed in a controlled environment chamber with 16 h daylength at 20°C and 8 h at 10°C.

Two differing genotypes of cv. Olwen were subjected to three moisture regimes. The control level was kept at field capacity, an intermediate level which had a petiole extension rate at 60% of the control and a high stress level with a petiole extension rate at 30% of the control treatment. Inflorescences from each moisture regime were selected, reduced to 20 florets and hand pollinated with pollen from their corresponding genotype in the same moisture regime. These levels of moisture stress were maintained throughout seed filling. Various parameters of plant growth were measured. As the level of moisture stress increased the total biomass decreased but the proportion of reproductive biomass against total biomass increased.

Differences in seed yield and quality were observed due to the moisture regime experienced by the plant. Overall, increasing moisture stress was associated with an increased percentage of ovules forming seeds and an increased thousand seed weight. A range of seed sizes (large, medium and small) were observed and the proportions of each category varied due to moisture regime; in general as moisture stress increased the size of seeds increased. Seed quality was assessed by determining the hard seed content. Seed size and the moisture regime from which it was derived affected the occurrence of a hard seed coat. As moisture stress increased the incidence of hard seededness increased; small seeds had a greater proportion of hard seed coats.

This experiment shows it is possible to alter both the quality and quantity of seed yield of white clover by using moisture stress in controlled environments. The implications for seed production are discussed.

[1] *Institute of Grassland and Environmental Research, Plas Gogerddan, Aberystwyth, Dyfed, UK. SY23 3EB.*

The Use of Isoenzymes to Quantify the Efficiency of Insect Pollinators in Mediating Pollen Flow in White Clover (*Trifolium repens* L.) Seed Crops and Consequences for Seed Yield

A.H. Marshall[1], T.P.T. Michaelson-Yeates[1] and I.H. Williams[2]

Pollination by bees is an essential step for seed production by most insect-pollinated species. However the effectiveness with which bees transfer pollen from flower to flower depends upon their particular foraging behaviour. In

self-incompatible plant species, pollen must be transferred from the anthers of one genotype to the stigma of another. The efficiency with which this is achieved determines the success of cross-pollination and has important consequences for seed multiplication. Quantifying the effectiveness of pollen transfer presents some practical problems because, within a plant species, the pollen bears no obvious indication of parentage. An experiment is described in which isoenzymes have been used to quantify pollen flow. Genotypes containing five isoenzyme genetic markers within the white clover (*Trifolium repens* L.) cv. S100 were grown in clonal groups and used to compare the effectiveness of bees from three different genera as pollen vectors. The movement of the various isoenzyme alleles between plants was monitored by assaying the seedlings resulting from pollination and fertilization by starch gel electrophoresis to determine paternity. Results were interpreted in combination with observational data on inter- and intra-plant movements. *Apis*, *Bombus* and *Megachile* were equally efficient in effecting seed production when allowed free visitation to inflorescences throughout flowering. However, when allowed to visit an inflorescence only once, *Apis* and *Bombus* probed more florets than *Megachile*, more inflorescences visited by *Apis* and *Bombus* produced seed than those visited by *Megachile*, and *Apis* visits produced more seed per inflorescence and per floret than *Bombus* and *Megachile* visits. Variation was found in the proportions of the different gametes within florets. Florets pollinated by *Bombus* contained genetic material from more sources than those pollinated by *Apis*, but for both *Apis* and *Bombus* within an individual inflorescence and floret one paternal source dominated, indicating that pollination is sequential rather than random. The implications for seed production are discussed.

1 *Institute of Grassland and Environmental Research, Plas Gogerddan, Aberystwyth, Dyfed, UK, SY 23 3EB.*
2 *Institute of Arable Crops Research, Rothamsted, Harpenden, Herts, UK, AL5 2JQ.*

A Diagnostic Method for Prediction of Seed Yield in Perennial Ryegrass

J.S. Rowarth[1,2] and W.J. Archie[1]

Fertilizer trials in England and New Zealand have indicated that there is little response in seed yield of perennial ryegrass to additions of nitrogen (N) fertilizer greater than 130 kg ha^{-1} of N. However, in some trials no response was seen to additions of N greater than 60 kg ha^{-1}, probably due to availability of soil N. Release of plant-available soil N over a growing season is difficult to predict. As a consequence a predictive test has been developed to relate herbage N% in spring with seed yield.

One hundred single plants of perennial ryegrass were grown in 4-litre pots containing a free-draining mix of inert silica sand and gravel. Plants were fed with 50 ml of one of ten nutrient solutions containing between 30 and 1500 ug g^{-1} of N, and adequate supplies of all other nutrients, three times a week. Water was added as necessary to prevent moisture stress; pots were flushed monthly to prevent nutrient build-up. Three of the ten pots in each treatment were harvested in September (when growing actively and before stem elongation); dry matter was analysed for N. In December ripe heads were harvested, counted and, after dressing, seed yield, thousand seed weight and germination were measured.

Spring herbage N% was positively correlated (r^2 = 0.76) with seed yield. Seed yield was highly positively correlated (r^2 = 0.94) with head numbers. Nitrogen had a small positive effect on TSW; germination was not significantly affected, all samples having a germination of over 85%. The proportion of 'seconds' (20-25%), which had a TSW of 0.8-1.0 g, was also unaffected by N. These results indicate that measuring herbage N% in early spring can give a prediction of likely seed yield. They also suggest that maximum seed yield can be obtained by maximising reproductive tiller numbers. Work on manipulation of N, and the relationship of spring sulphur and phosphorus status with seed yield, is continuing.

1 *AgResearch Lincoln, PO Box 60, Lincoln, Canterbury, New Zealand.*
2 *Present Address: Plant Science Department, Lincoln University, PO Box 84, Canterbury, New Zealand.*

Nitrogen Nutrition, Plant Growth, Climatic Conditions and Seed Yield of Grasses

S.M. Griffith[1]

Nitrogen (N) is the most critical mineral element affecting grass seed yield in western Oregon. Since ammonium and nitrate balance may be expected to play a major role in grass seed cropping systems in western Oregon, a field study was initiated to manipulate soil ammonium and nitrate ratios by using calcium nitrate, ammonium nitrate, ammonium sulphate, ammonium chloride, and urea-dicyandiamide (cyanoguanidine, $CH_2H_4N_4$) (DCD) fertilizer applications and examining their effect on Italian ryegrass (*Lolium multiflorum* Lam cv. Marshall) growth and seed yield as a function of plant ontogeny and accumulated heat units (HU) (growing degree days). Field plots were established at Hyslop Experimental Research Farm near Corvallis, Oregon during September of 1991 and 1992. Fertilizer was surface broadcast in the autumn at 22.4 kg N ha^{-1} and a split application in the spring of 45 kg N ha^{-1} each. The 1992 crop year was warmer and drier than in 1991. Relative stages of plant ontogeny and HU related similarly for both years. There was no significant difference between root and shoot dry mass accumulation over time and N-source treatment by year, but

there was between years across N treatments. Greater tiller number per unit area in 1991 following 700 HU (just prior to tiller elongation) resulted from applied ammonium fertilizer treatments, while in 1992 there was no effect. Seed yield was not significantly different from check plots (no added N) in the higher precipitation year (1991). In the drier warmer year of 1992, seed yield was greater than in 1991 and greatest with applied ammonium nitrate and urea-DCD treatments. Percent germination of harvested seed was not affected by N-source treatments in either year. Temperature was the major regulator of growth and development under conditions of equal applied N. N-source treatments did not appear to affect plant development and seed yield near as much as between years. Although years showed contrasting climatic conditions growth data comparisons on a HU was a very effective way of comparing years. It was concluded that the cool wet season of 1991 limited growth and seed yield, in part, due to N limitation.

[1] *National Forage Seed Production Research Center, USDA-ARS, Corvallis, OR, U.S.A.*

The Effect of Plant Age on the Receptiveness for Primary Induction in *Festuca pratensis* Huds.

Lars T. Havstad[1]

The tillers of many grasses must pass through a juvenile phase, or reach a certain vegetative maturity, before they can be induced to flower. Little is known about this juvenile phase, and in particular, about factors controlling its length. Although many possibilities have been suggested, such as achievement of a certain apical volume or leaf number, leaf area or carbohydrate content per tiller, the physiological basis of juvenility in grasses is still poorly understood.

An experiment, concerning the juvenile phase in meadow fescue (*Festuca pratensis* Huds.), was carried out at NCRI (Landvik) and the Ås phytotron, during August 1993 through May 1994. The main purpose was to examine the effect of plant age on the receptiveness for primary induction. 180 plants of each of the cultivars 'Salten' (Northern Norway), 'Fure' (Southern Norway) and 'Senu Paiberg' (Denmark) were sown in 8 cm pots and raised for 2, 4 and 6 weeks at 20°C and continuous light before transfer to primary induction at 6°C and 8 h photoperiod. After 0, 9 and 18 weeks of primary induction, 30 plants per cultivar were destructively sampled, and leaf area, tiller size, dry weight and carbohydrate content for tillers and roots, were measured. Remaining plants were transferred to secondary induction, at 20°C and continuous light, after 12, 15 or 18 weeks of primary induction.

On average for cultivars, increasing plant age from 2 to 6 weeks at the onset of primary induction increased the number of tillers per plant from 2.1 to 14.6. The average number of leaves and the leaf area per tiller increased from 2.4 to 2.6, and from 2.7 to 13.9 cm^2, respectively. An average increase in the area per leaf, from 1.1 to 5.3 cm^2, and carbohydrate content per tiller, from 1.9 to 17.8 mg, was also measured. On average for 2, 4 and 6 week old plants, 'Fure' developed the highest tiller number (8.4) and carbohydrate content per tiller (8.5 mg) before primary induction. 'Salten' and 'Senu Paiberg' had approximately 7 tillers per plant, and 7.1 and 8 mg carbohydrates per tiller, respectively. The leaf area per tiller for 'Fure', 'Salten' and 'Senu Paiberg' was in turn 9, 6.9 and 8.4 cm^2.

There was a close relationship between plant age before primary induction and panicle development during secondary induction, the average panicle numbers being 10.5 and 19.8 for 2 and 6 week old plants, respectively. 'Salten' had significantly fewer panicles per plant than the two other cultivars.

[1] *The Norwegian Crop Research Institute, Landvik, 4890 Grimstad, Norway.*

Matriconditioning Grass Seed for Improved Stand Establishment

J.D. Maguire, W.J. Johnston, and M. Stannard[1]

Matriconditioning with Micro-Cel E (MCE), a hydrated synthetic calcium silicate, has been effective in improving germination, uniform emergence, and seedling vigour of vegetable seed. Little is known about variability in grass species, cultivars, or seed lots when matriconditioning to maximise seed and seedling performance. With Kentucky bluegrass (*Poa pratensis* L.), cultivars had different rates and percentages of germination at specific seed:MCE:H_20 matriconditioning ratios. High germinating seed lots showed a decrease in rate and percent germination. Low germinating seed lots responded better to matriconditioning and the best seed:MCE:H_20 ratio was 2:1:1. Following a spring field planting, one of four cultivars tested emerged better (numerically better, but not statistically significant) when matriconditioned prior to planting. Sheep fescue (*Festuca ovina* L.), a slow emerging field grass used for rehabilitation sites, responded to MCE matriconditioning. Rate of germination was significantly improved for matriconditioned seed (13.1) vs. untreated seed (8.2). Total (21 day) germinations were 65% and 54%, respectively. Priming sheep fescue for 3 days increased the rate of germination, but did little to increase the rate of emergence. Extending priming to 5 days appears to be more effective, indicating that longer periods of metabolic activity and embryo development during the pre-ger-

mination period are required in sheep fescue. Storage of these seeds for 60 days at 22°C maintained the matriconditioning effect better than storage at subfreezing temperatures (-15°C). Field and laboratory studies are underway to evaluate performance in competition with downy brome (*Bromus tectorum* L.).

1 *Crop and Soil Sciences and SCS Plant Materials Center, Washington State University, Pullman, WA 99164-6420, USA.*

Reproductive Abortion in Birdsfoot Trefoil (*Lotus corniculatus* L.)

M.J. Hill[1] and Supanjani[2]

Although reproductive abortion in *Lotus corniculatus* has been previously reported, the relative importance of various stages in the reproductive sequence as contributors to reproductive abortion have not been clearly described.

Flower buds consistently abort one floret bud before the flowerhead opens. However, throughout the flowering season only about 30% of the 47 (range 29-72) ovules in an ovary successfully develop seeds and only about half of the florets in an open flower successfully develop pods 30 days later. Since no live pods are found without full developed seeds, it is likely that seed is the main cause of pod abortion and that pods with fewer seeds tend to abort. The combined effects of floret, ovule, seed and pod abortion contribute to a likely total loss of 70-80% of seed yield potential in *Lotus corniculatus.*

1 *Seed Technology Centre, Department of Plant Science, Massey University, Palmerston North, New Zealand.*
2 *Agricultural Faculty, Bengkulu University, Limun, Bengkulu, Indonesia.*

Influence of Time of Tiller Emergence and N on Seed Yield Components of *Digitaria eriantha*

L. Ramírez-Avilés[1] and J.B. Hacker[2]

The pattern of tillering in *D. eriantha* during spring and autumn was described; the application of N had a limited effect. In both seasons, rate of tillering was maximal within the first week after cutting and declined rapidly thereafter, regardless of the application of N and the season. However, rate of tillering was in general higher in spring than in autumn.

Tiller survival decreased as tiller emergence was delayed; the application of N reduced the percentage of surviving tillers in both seasons. At seed harvest, the early emerged tillers were consistently taller, heavier, thicker, and had more nodes over both seasons. Nevertheless, the application of N had an inconsistent effect. Early-emerged tillers had the highest tiller fertility, and, consequently, contributed the major proportion of inflorescences. Tiller fertility of all tiller cohorts was increased by the application of N; this effect was more marked in spring than in autumn.

Seed yield and most of the components were larger in the early-emerged tillers. Inflorescences were larger in the early-emerged tillers; however, this was compensated by a reduction in the spikelet density. Although 1000-seed weight was higher in the early-emerged tillers, the effect was larger in autumn than in spring. Seed set, which also was higher in the early-emerged tillers, was larger in spring than in autumn. In general, the effect of N on seed yield components was not significant. Early-emerged tillers contributed more than 70% of the total seed yield in both seasons. There is scope, either by management or breeding, to increase seed yield further by increasing the number of the high yielding early-emerging tillers, and suppressing the late-emerging tillers.

1 *Universidad Autonoma de Yucatán, 97100 Mérida, Yucatán, México.*
2 *C.S.I.R.O., St Lucia, Queensland, Australia 4067.*

Breeding for Seed Yield - But How?

A.Elgersma[1]

In forage crops seed production is often low. Breeding efforts concentrate on vegetative characteristics, because the end-use is high quality herbage. Selected genotypes should, when combined into a cultivar, produce offspring with a desired agronomic or turf performance when grown in a sward; for economic reasons the cultivar should also have a high seed yield during multiplication, when grown in drill rows. Often seed yield potential is only assessed in later stages of the breeding process. Early selection for high seed yield carried out in spaced plants would be valuable for breeders, but only if this potential is later also expressed in derived progenies sown in drilled plots.

In a trial with nine perennial ryegrass cultivars the seed yield was assessed in drilled plots. Fifty genotypes were taken at random from each cultivar and also studied as spaced plants. The nine cultivars differed in seed yield in drilled plots, but

this was not related to spaced-plant traits. Instead of comparing cultivars and their random plant samples, from a breeder's point of view the relation between spaced plants and their progenies is more realistic. Therefore, spaced-plant traits assessed on clonal ramets of 31 genotypes in each of two cultivars in four environments, were related to seed production characteristics in drilled plots of open-pollinated progenies of these plants, to study possibilities for early selection.

Significant differences were found among these half-sib families for seed yield, thousand-seed weight, spring performance and earliness. Multiple regression analyses revealed, however, that no combinations of plant traits consistently explained a major portion of the variation for seed yield of the progenies.

The results indicate that in these cultivars spaced-plant data are of limited value in predicting seed production. Direct selection for seed yield in drill rows of progenies in later stages of the breeding program remains the best method for obtaining cultivars with sufficient seed production.

1. *Department of Agronomy, Agricultural University, Haarweg 333, 6709 RZ, Wageningen, The Netherlands.*

Breeding Strategies for Yield and Quality of Forage Grass Seeds in a Mediterranean Environment

M. Falcinelli, L. Russi and F. Lorenzetti[1]

In Italy, marginal lands and hill lands cropped with cereals could be suitable for permanent pastures due to a growing interest in agricultural systems based on low inputs and avoidance of soil erosion during the heavy rain season and fire damage during the dry season. The role of grass species which could be grown in mixtures with legumes is consequently increasing. Cultivars belonging to *Lolium perenne, Dactylis glomerata* and *Festuca arundinacea* adapted to dry, warm summers and wet, cold winters were registered in Italy several years ago with the aim of replacing foreign cultivars poorly persistent in a Mediterranean environment. Cultivars were obtained starting from local landraces, and the selection criteria were initially forage yield and persistence. Use of these cultivars on a large scale has failed primarily due to lack of knowledge about their importance on the part of the farmers and little interest on the part of seed companies to multiply genotypes not yet improved for seed yield and quality.

Therefore, in successive stages of forage grass improvement, seed yield and seed quality were improved. Yields were increased by selecting for seed setting and seed retention, two characters highly correlated with seed yield. Seed quality was improved by increasing seed size after several cycles of phenotypic selection for 1000-seed-weight; seed size was shown to be one of the most important characters during the pasture establishment in clay soils, typical of Central Italy. Successful seed retention was achieved in *Dactylis glomerata*.

Although these problems have been overcome, the lack of a solid seed industry is still a limiting factor to their adoption by farmers, because of the preference of seed companies to purchase seeds from abroad instead of producing them.

The most salient results of over 20 years of breeding for seed yield and quality at the Institute of Plant Breeding (University of Perugia) are reported together with a discussion on breeding and seed utilization.

1 *Istituto di Miglioramento Genetico Vegetale, University of Perugia, Italy.*

Breeding for Resistance to Seed Shattering in Forage Grasses

Uwe Simon[1]

The seeds of many forage grass species drop when they reach maturity. Consequently heavy losses due to seed shattering are reported from commercial seed production. Breeding programmes aiming at an increased resistance to seed shattering have been initiated in Germany. The results of successful breeding work in meadow foxtail (*Alopecurus pratensis* L.) and meadow fescue (*Festuca pratensis* Huds.) are reported.

Meadow foxtail. A breeding programme was initiated at the former Bayerische Landessaatzuchtanstalt Weihenstephan in 1959. Seeds were subjected to gamma-irradiation in order to induce seed shattering-resistant mutations. Of 6300 inbred progenies 38 shattering-resistant individuals were selected. From this material the cultivar Alko was created. It was officially registered in 1983. Tests have shown that the seed yield of cv. Alko exceeds that of the normal cv. Lipex by 50% to 100% when seed harvest is delayed for one to three weeks after the date of optimum seed yield.

Meadow fescue. Seed-shattering resistant material was initially obtained at the Max-Planck-Institut für Züchtungsforschung at Köln in the early 60s. This material was developed into the cultivar Fesco which was officially registered in 1982. The average reduction of seed yield due to shattering within three subsequent weeks after the date of optimum seed yield of cv. Fesko was 39% of that of the normal cv. Cosmos 11.

1 *Technische Universität München, Lehrstuhl für Grünlandlehre Freising-Weihenstephan, Germany.*

The Resistance of Kentucky Bluegrass (*Poa pratensis* L.) to Ergot (*Claviceps purpurea* (Fr.) Tull.)

Bohumír Cagas[1]

The present study was focused on physiological specialization of ergot, Kentucky bluegrass varietal resistance and development of a simple reliable method to increase the resistance level. Parallel trials were conducted at the Grassland Research Station (Roznov-Zubrí, Czech Republic) and in the Institute for Agricultural Research (Halle, Germany) using various Kentucky bluegrass cultivars as follows: Lovegreen, Cheba (high resistance), Haga, Moravanka (low resistance), Roznovs-ká, Krasa and Slezanka (local varieties). Other foreign cultivars and local ecotypes were also tested. Ergot isolates were obtained from the USA (2 specimens), Germany (2 specimens), and the Czech Republic (1 specimen). The cultivars and ecotypes were treated with the conidial suspensions under glasshouse conditions, and evaluation was made of the number and weight of sclerotia per 100 spikelets. Observations were made of the natural infection in the field. The results of the 3-year-trials have shown highly significant differences in the pathogenicity among the ergot isolates under study. The isolate originating from the USA evoked the most intense sclerotia formation (both quantity and weight) in all the cultivars, contrary to the isolate obtained from Halle. There were remarkable differences in ergot resistance among the cultivars (Lovegreen, Sheba, Slezanka - high resistance, Haga, Moravanka - high susceptibility). It seems realistic to develop a simple reliable method to assess the level of Kentucky bluegrass resistance to ergot.

[1] *OSEVA PRO Ltd. Grassland Research Station, Roznov-Zubrí, Czech Republic.*

Fall Dormancy and Sources of Germplasm in Alfalfa

Daphne T. Fairey[1]

A majority of the genetic diversity of North American alfalfa cultivars can be accounted for by nine germplasm sources (listed in descending order of winter hardiness) viz. *M falcata,* Ladak, *M. varia,* Turkistan, Flemish, Chilean, Peruvian, Indian and African.

Fall dormancy scores (1 = dormant...9 = nondormant), based on plant height in October after harvest in early September, are used to predict cultivar adaptation for the different regions. This study examines the relationship between germplasm composition and plant height, the equivalence of fall dormancy scores.

A multiple regression analysis of plant height on the proportional content of the nine sources of germplasm, showed that only four of the nine sources, *Falcata,* Ladak, Indian and African, made a significant contribution to the fall dormancy characteristics of the cultivars used in this analysis. A regression equation was developed to predict fall dormancy. Nine distinct classes were not recognisable, perhaps because of the lack of an exact equivalence between dormancy class and plant height, and because many of the nine germplasm sources are the result of hybridization of the original *M. falcata* and *M. sativa.*

[1] *Agriculture and Agri-Food Canada, Northern Agriculture Research Centre, Beaverlodge, Alberta, Canada.*

Recent Methodology for Improvement of Lucerne Seed Yield Capacity

Zygmunt Staszewski[1]

Lucerne breeding has long been directed to obtain maximal dry matter and protein yields. This method of selection has caused partial erosion of genes governing seed yield capacity, because of the concentration on vegetative organs. This has resulted in incomplete adaptation of lucerne to the climate conditions of the growing area: nondormant types in Southern Europe, and dormant ones in Central and Eastern Europe, cause seed yield to be unstable due to weather effects. Seed yield depends on a cultivar's potential and on many nongenetic factors, so that a direct selection for seed yield resulted in little progress. There are not many cultivars producing higher seed yields than Altfranken or Flamande lucerne.

This study used selection of clones displaying undisturbed seed setting under a temperature of 6-14°C which resulted in diminished cool susceptibility of the progeny. The positive action of original mutations transmitted by recessive single genes *lp* and *tf* on seed yield structure and plant habit was demonstrated. Long raceme petiole *lp* mutation caused inflorescences to grow twice or more longer than standard ones, so flower number per raceme was two or three times greater comparatively to the standard cultivars.

Top flowering *tf* mutation caused flower buds to grow on the stem tops, thus leading to the termination of stem growth. This character is positively correlated with seed setting and the number of ramifications, and negatively-with second shoot number in a plant crown. The *tf*-phenotype is characterized also by better standability and uniformity, and shorter period of flowering.

To obtain progress in lucerne seed potential, it is

necessary to change the plant habit and raceme morphology as well as diminish the warmth requirement of plants at the flowering phase. Quantitative plant characteristics can be changed in a qualitative manner due to *lp* and*tf* genes. That implies hopeful perspectives for lucerne improvement.

[1] *Plant Breeding and Acclimatization Institute, Radzikow, Poland.*

Long Inflorescence in Red Clover (*Trifolium pratense* L.) and its Significance for Seed Yield

Halina Góral and Ludwik Spiss[1]

Within a short-corolla tube population of red clover, selection for the number of seeds in flower heads was performed. As a result, characteristic morphotypes exhibiting long inflorescences were isolated. First inflorescences on these plants were on average 80% longer than respective heads of the control (cv. Nike). On these inflorescences 2.4 times more florets and 1.9 times more seeds compared to the control, were found. The inflorescence elongation was closely associated with the number of florets and seeds per head. This association makes it possible to select plants with a high number of seeds per head on the basis of the inflorescence size.

The plants with long inflorescences produced a lower number of flower heads compared to the control. The resulting seed yield per plant was similar in both forms. The isolated long-head plants represent a new source of variation of the number of florets and seeds per head. Possibilities for utilizing the trait of long inflorescence in red clover breeding programs will be discussed.

[1] *Department of Plant Breeding and Seed Science, Agricultural University, Kraków, Poland.*

Variety Testing for Fodderplants in Germany

Helga Fischer-Weyer and Hermann Freudenstein[1]

In Germany the Bundessortenamt (Federal Office of Plant Varieties) has the responsibility of testing varieties for grants of Plant Breeders' Rights (PBR) and for addition to the National List. Every new variety has to fulfill the following requirements:

1. For Plant Breeders' Rights it has to be distinct, uniform, stable (DUS) and new.
2. For the National List it must also be distinct, uniform, and stable and has to show a value for cultivation and use (VCU).

DUS-testing is done at one or two testing stations of the Bundessortenamt over a period of two years, in some cases up to three. The tests are carried out on the basis of guidelines set up by the UPOV-countries. According to the different species these guidelines contain a certain number of characteristics which have to be assessed on plots with single spaced plants and rows. A variety can be considered to be

- new, if at the time of application, seed of the variety has not yet been marketed,
- distinct, if it is clearly distinguishable from any other variety,
- uniform, if the variation within the variety does not significantly exceed the variation of comparable varieties,
- stable, if its relevant characteristics remain unchanged after repeated propagation.

Normally DUS- and VCU-testing start at the same time.

For VCU a variety has to be examined under different ecological conditions on 10-15 locations throughout Germany. The tests are conducted not only at stations of the Bundessortenamt but also by official institutions of the Federal States and Universities according to guidelines established by the Bundessortenamt. The period of VCU-tests is three years for perennial and two years for annual species. The most important agronomic criteria for all species are disease resistance, and dry matter yield. Additionally winter hardiness and persistence are required for perennial species.

From 100 applications about 70 fulfill the requirements for PBR, while only 10-15 show a sufficient agronomic value. For admission to the National List a candidate must be better than all comparable registered varieties. After registration by the Bundessoertenamt the Federal States are responsible for further trials in order to give advice and recommendations to the farmers.

[1] *Bundessortenamt, Hannover, Germany.*

Achieving Variety Identification of Seed Samples of *Festuca pratensis* Huds.

Heike Hahn and W. Schöberlein[1]

Because of the increasing number of grass varieties which are becoming more and more phenotypically similar, reliable variety identification is necessary for breeders, seed traders and customers. This problem focuses especially on *Lolium* and *Festuca* species, since varieties of *Festulolium* hybrids have been registered. Plants as well as seeds of *Festuca pratensis x Lolium multiflorum* hybrids for example, do not always differ morphologically from their crossing parents. Therefore, the aim of the present study has been to investigate methods for variety identification of *Festuca pratensis* on the basis of seed characters.

Bulked seed samples of 78 varieties and lines of *Festuca pratensis* were analysed by means of ultrathin-layer isoelectric focusing (UTLIEF) in polyacrylamide gels with the pH-gradient 2 - 11. Alcohol-soluble storage proteins provided useful biochemical markers for distinguishing varieties. 42 out of the 78 varieties tested showed distinctive banding patterns, the other 36 varieties were clustered in 8 groups. The protein banding patterns of UTLIEF were not affected by the level of endophyte infection or environmental conditions like year and site.

Due to the high degree of variability within a cultivar which was revealed by the banding patterns of single seeds, variety identification of outpollinating species like *Festuca pratensis* is achieved using bulked seed samples. In this approach information regarding single seeds gets lost because the banding patterns show an average protein profile of genotypes included in the investigated cultivar. However, the application of isozyme electrophoresis offers the possibility of distinguishing cultivars with consideration of single plants. About 100 plants of 10 diploid cultivars of *Festuca pratensis* were scored for 4 enzyme systems, and the results were evaluated with different statistical procedures comparing all varieties two by two. For the MDH-2 system in 37 out of 45 pairwise comparisons significant differences between the genotype frequencies were obtained, for GOT-2, GOT-3, PGI-2 and MEN in 28, 33, 23, and 35 comparisons, respectively. Significance in all possible comparisons occurred after combination of the four enzyme systems. Both electrophoretical methods proved to be suitable for distinguishing *Festuca pratensis* varieties for purposes of seed certification and registration. The UTLIEF is a rapid method, whereas the consideration of single plants is the advantage of the isozyme technique. These powerful methods might also be usefully applied in the breeding process and for taxonomic research.

[1] *Martin-Luther-University Halle-Wittenberg, Institute of Agronomy and Crop Science, Halle, Germany.*

Electrophoresis, a "Scotland Yard" Method to Prevent Fraud in the Herbage Seed Industry

Michel H.J. Nas[1]

Almost all breeding work in grasses and clover takes a period of 10 to 15 years and is expensive. The breeder tries by selection, crosses and other techniques to establish a group of homogeneous plants which together can be seen as a variety. The seed yield from these plants is used for official trials in which the improved value of the variety has to be proved. If successful, the good qualities of the variety are published officially and commercialization is started.

World-wide, breeding activities have increased considerably during the past 40 years. Although it differs from country to country, the originally leading role from state-breeding stations in many countries is now more and more taken over by private companies, who can only pay breeding expenses if the resulting varieties are well protected and if their customers are willing to pay a premium for the better genetic quality of this seed.

Unfortunately, the seed trade does not consist of angels only!

Some seed suppliers try to offer cheap inferior seed under the variety name of the protected variety. This is possible in countries where the certification methods are not waterproof, such as Germany and Italy. Such fraudulous practices can be very profitable since these seed suppliers do not have the high breeding costs. By selling inferior seed they harm our customers and the good reputation of the variety. Seed companies such as Barenbrug therefore are more and more checking suspect seed lots by means of electrophoresis.

When seed production of a protected variety is done under contract by third parties, there sometimes is a need to check varietal identity and purity by electrophoresis. When the contract price of the protected variety is high and stock prices of inferior varieties of the species are low, we need to check carefully according to our experience. Electrophoresis has proven to be valuable and effective in ensuring the quality of our product.

[1] *Director of Production, Barenbrug Holding B.V., Oosterhout, Gelderland, The Netherlands.*

Selection for Hulled and Unhulled Seeds in Timothy (*Phleum pratense* L.) and its Effect on Seed Value

Andrzej Binek[1]

The results of two sets of 3-year evaluations of reproductive ability of 5 timothy cultivars indicated 11.1% hulled seeds. Inter-plant variation of hulled seeds was observed and their content varied in years. On the basis of 2-year results concerning 300 plants, the first selection cycle was started in two directions for low (0.5%) and high (11.6%) hulled seeds content. Selected plants were self-pollinated and after seed harvest the plants were propagated vegetatively as a check. The group of clones and S_1 seedlings were planted in two isolated field experiments. The percentage of hulled seeds was recorded in seed samples of inflorescences in the same maturity stage.

The differences in hulled seed content between selected groups in three successive years (1991-1993) of the first cycle, for genotypes propagated vegetatively was 12.2, 21.2 and 16.1%, and for plants propagated generatively 2.9, 11.8 and 15.4%, respectively.

A second selection cycle started in 1993 on the basis of a two year analysis of hulled seed content in samples of the same individuals. Twenty six plants with low and nineteen plants with a high percentage (6.3 and 34.3, respectively) of hulled seed were selected. The increasing differences between selected groups in I and II cycle (11.1 and 28.0%, respectively) indicate that selection for these traits in timothy is possible.

The experiments confirmed results of many studies showing disadvantages of hulled seed content in sowing material of timothy. Hulled seeds were on average 9.6% heavier than unhulled and therefore were more frequently damaged mechanically during threshing and lost viability faster in storage. Germination ability of hulled compared to unhulled seeds stored for 2-3 years was 6.8 - 30.6% lower depending on the year of seed harvest. On the other hand the amount of healthy not germinated seeds increased.

Relationships between seed traits for the same individual plants in two years were calculated. Correlation coefficient for germination ability of hulled and unhulled seeds was r=0.379** and r=0.552**, but for healthy ungerminated seed r=0.552** and r=0.719**, respectively. The results of these studies show a good repeatability of results in successive years and a possibility to improve the value of timothy seeds by selection procedure.

[1] *Department of Plant Breeding and Seed Science, Agricultural University, Kraków, Poland.*

Self Fertility Levels in Different Forage Species

Carla Scotti[1]

The relative importance of selfing and cross pollination varies among as well as within species in many genera. Almost all the important forage species are allogamous. Nevertheless, within the species there is a great variability, in natural and in artificial conditions. In isolation conditions a significant number of populations of the different following species present many self-fertile plants: *Medicago sativa, Lotus corniculatus, Trifolium alexandrinum, T. resupinatum, T. pratense, T. repens, T. hybridum.* One can ask what is the degree of cross-fertility of such plants in natural conditions? We have to underline that, up to now, investigations with markers, on the natural reproductive systems of the different species are still infrequent. Such a gap should be closed if one wants to choose the model for the variety constitution on a sure basis.

[1] *Istituto Sperimentale per le Colture Foraggere, 20075 Lodi, Italy.*

Pod Fertility in Lucerne at Different Levels of Inbreeding

Carla Scotti[1]

Lucerne plants selected for dry matter production in two populations (cv. Lodi and Gilboa) were subjected to hand made crossing and selfing. The same was performed on S_2 plants originating from cv. Lodi by selection for dry matter production. At the S_0 level, the two populations differed for the following points:

(a) poor fertility in crossing and selfing was higher in cv. Lodi than in Gilboa;

(b) the variability of the character pod fertility was the same in crossing and selfing for cv. Lodi, while in cv. Gilboa it was larger for crossing than for selfing.

Cv. Lodi was produced at the Lodi Institute using a breeding method involving two generations of selfing and selection in a dense sward. At the S_2 level, a decrease in pod fertility both in crossing and selfing was observed, together with increasing variability.

[1] *Istituto Sperimentale per le Colture Foraggere 20075 Lodi, Italy.*

Medicago sativa: Evolution of Pod Fertility Through Subsequent Generations of Synthetics Based on Different Number of S_2 Clones

P. Rotili, G. Gnocchi and C. Scotti[1]

The objective of our breeding program was to verify the importance of the number of constituents on the evolution of synthetic varieties for dry matter and pod fertility. Thirty S_2 mother plants were combined into following synthetic varieties: Six 5-clone Syn, three 10-clone Syn and two 15-clone Syn.

An increase of pod fertility was observed from the first to the second generation, independently from the number of constituents of synthetics, in agreement with the theory concerning autotetraploids. The average pod fertility increased with the increasing number of constituents, 5-clone synthetics showing a significantly lower fertility than 10-clone and 15-clone synthetics.

1 *Istituto Sperimentale per le Colture Foraggere, 20075 Lodi, Italy.*

Morphology and GCA of Long Raceme Families Poly-Cross Progeny of Lucerne

Z. Bodzon, Z. Staszewski[1] and B. Tharel[2]

Lucerne families which were received from the 75 best selected long raceme *lp* plants were intercrossed. Two poly-crosses were set up in different locations: at Connantre, including 48 families of French origin, and at Radzików with 27 families of Polish origin. Seeds of seventy five progenies were gathered on plants in the poly-cross.

Two trials for seed yield evaluations were established at Radzików in spring 1993. The purpose of the trials was to study morphology traits, seed setting and GCA of the poly-cross progenies, which were being compared to the standard cultivars Radius, Sitel and Europe.

The means, including all poly-cross progenies, displayed a positive influence of the *lp* gene on several characters: raceme length was 150 per cent longer, pod number per raceme was 50 per cent greater, and seed number per raceme was 25 per cent greater compared to the best standard cultivar. However seed number per pod and TSW were 10 percent lower than the standards. Seed weight per 30 racemes was similar and seed weight per plot was 20 per cent lower than the best standard.

GCA for seed yield varied from -1.8 to +3.2 and according to the Duncan's test was divided into 11 groups. Groups A, B, C contained families significantly better than the standards. Poly-cross progeny dry matter yield was evaluated in a separate trial. Mean dry matter yield harvested in 3 cuts on poly-cross progeny plots was similar to the standard cultivars.

1 *Plant Breeding and Acclimatization Institute, Radzików, Poland.*
2 *Barenbrug-Tourneur Recherche, Connantre, France.*

Intraspecific Variability of Seed Productivity Characters in Alfalfa

N.I. Dzyubenko and M.A. Vishnyakova[1]

Variability of seed productivity in populations of *Medicago sativa* L. cultivated at Aral Research Station was established. In similar conditions with sufficient insect pollination, seed set in individual plants varied from 0 to nearly 100%. The gap between potential seed production (10.5-13.8 ovules/ovary) and actual (from 0 to 10-12 seeds/pod) was conditioned by the existence of sterile ovules and the degeneration of fertilized ovules. The level of each character was specific for the plant but the influence of the environment also has to be taken into account. Plants with high seed set were selected for breeding for seed production. Special attention was paid to plants with low seed production. Together with plants forming 14.6-38.2% of pods containing only 0.88-2.50 seeds per pod, totally seedless plants with pod abscission were found. Embryological studies established a high level of female sterility in this group of plants: 46.5-100% of ovules degenerated before pollination because of different structural abnormalities. In the ovaries of female-sterile plants, only a few pollen tubes were observed and only some of the fertile ovules were fertilized. A great number of very small seeds (38.5-95.4%) developed in these pods.

Plants with female sterility could be used in the breeding process as good pollen donors for the increase and stabilization of seed production. Selection of plants with a high number of fertile ovules together with characters of auto-fertility and autotripping will allow the increase of middle-population levels of seed productivion in usual varieties from 5 to 30% and in creating synthetic varieties from 40 to 80%.

1 *Vavilov Institute of Plant Industry, St. Petersburg, Russia.*

Poliploidy in Red Clover Selection

V.A. Pozdnyakov[1]

Eleven red clover diploid varieties (Suidinets, Moskowski 1, Kotlasski, Sever, Bijski, Kaskad, Rubin, Shimskoi, Suminski, Ratinski) were transformed by colchicine to tetraploids. A choice of the best plants by seed fertility and yield following open pollination, ripeness, pathogen resistance, by fixing marked attributes was conducted in tetraploid families for C_1-C_3. In 1991-1992 number 18 and 22 families were characterised by good all combinative ability (ACA) and in another nursery, the number 22 family had good ACA in 1992 only. Reliable differences in average seed yields of plants of tested families were not detected. F actuals were 1.0 (1991), 0.92 and 1.85 (1992), F theoreticals. were 2.32 (1991), 1.82 and 1.97 (1992). The accuracy of the experiments was 19% (1991), 59.3 and 21.1% (1992). Data obtained in the estimate of combinative properties of families were used to form six polycross nurseries in the three repetitions with the registration of other biological properties (ripeness, longevity, spring growing energy, pathogen resistance). Here the second half of the seeds were used. The best C_4-26 and C_4-27 plant populations for the variety test nursery have surpassed the registered red clover variety Volosovski by 14.6-19.5% for vegetative dry matter. Their winter hardness was 90.2-95.0%.

[1] *Department of Perennial Grass Selection, North-Western Agricultural Research Institute, 188231 Belogorka, Gatthina locality, St. Petersburg, Russia.*

Seed Yield Potential of Ladino White Clover Improvement by Head Selection

L. Staszewski and Z. Staszewski[1]

Ladino white clover (*F. giganteum* Lagr. et Fosset) has valuable characteristics and because winter hardy populations were bred, has spread all over Europe in recent decades. However, seed yield of Ladino clover is low compared to Dutch cultivars. This is especially so in Central and Eastern Europe and leads farmers to favour Dutch clover on seed plantations. Since Ladino type clover is a comparatively young crop, it seems easy to select for plants which are more efficient in seed production. A new breeding procedure employing the selection of single heads instead of selecting plants, is proposed. Very great variability of seed setting has been found in a sample of 2000 similar looking best heads selected out of basic material of a cultivar planted under field conditions.

Seed mass per head within the cultivar Radi varied as follows:

Selected (0.01-0.1g)	27.8% (0.11-0.2g)	44.4% (0.21-0.3g)	22.8% (0.31-0.5g)	5%
Unselected	64.1%	30.9%	4.0%	2%

Positive influence of selection has been observed in the progeny of the selected best heads.

[1] *Plant Breeding and Acclimatization Institute, Radzików, Poland.*

The Sowing Rate Effect on Seed Production of Determinate and Common (Indeterminate) Forms of Blue Lupin (*Lupinus angustifolius* L.)

V.I. Derbensky[1]

In the Non-Black Soil Zone of Russia, the long growing season and poor grain legume technology are the main limiting factors in cultivation of blue lupin. There are periodically years with high rainfall and low temperature conditions at the end of the growing season. This is the reason for non-limited growth processes and supplementary formation of fertile nodes and the long growing season for common varieties. The present determinate varieties possess genetically low growing ability and they develop flowers and pods directly in the axis instead of on some lateral branches.

Trials were conducted in 1991-1994 in Moscow region conditions on a sod-podzolic loam soil. We conducted a comparative seed production analysis in indeterminate (variety Nemchinovsky 846, k.VIR - 1981) and determinate forms (varieties Ladny, k. VIR-2648 and Dikaf) in eight variances (var.) of sowing rates in million seeds per ha (1 var. 0.6; 8 var. 2.0 with 0.2 interval between variances).

Seed productivity (percentage) of lateral branches of the indeterminate types was 78.0-2.0 for 1 var. and 64.4-4.0 for 8 var. The same index for determinate variety Ladny was from 40.0 5.0 up to 0.0 0.0 and for determinate variety Dikaf - 44.0 4.0 up to 0.0 0.0. Seed productivity of indeterminate and determinate varieties had a tendency of reducing (from 1 var. to 8 var.) and for increasing (from 43.6 cm for 1 var. to 54.1 cm for 8 var.) for variety Dikaf; the number of sterile plants (without seeds) increased, in the case of the common variety (up to 37%), and in the case of the determinate variety, up to 20%.

The highest yield of grain (t/ha) in the indeterminate variety was 3.7 (sowing rate - 1.2 mill/ha): for the determinate variety Ladny it was 3.5 (sowing rate -2.0 mill/ha) and for the determinate variety Dikaf it was 3.8 (sowing rate - 1.8 mill/ha).

Potential seed productivity was higher in indeterminate varieties, but because of a heavier sowing rate, determinate varieties have equal yield and ripen 7-15 days earlier.

[1] *The Research Agricultural Institute of the Non-Black Soil Zone, p/o Nemchinovka 1, Odinstosovsky District, Moscow Region, 143013, Russia.*

Common (Indeterminate) and Determinate Blue Lupin (*Lupinus angustifolius* L.) Forms: Particulars of Their Seed Productivity

G. Debely[1], V. Derbensky[1] and Z. Voronova[2]

Blue lupin common forms are indeterminate and therefore have lateral branches. This leads to competition for light and assimilates, and lengthens the period of seed ripening. Artificial and naturally determinate mutants with blocked lateral branches have scientific and commercial interest for the short vegetative growth period possible in the Russian Non-Chernozem Zone conditions.

A morphological analysis was conducted to study seed formation for determinate and indeterminate blue lupin forms. The seed productivity of indeterminate forms depended on pod and seed quantity on the lateral branches, and was very variable. At the same time seed productivity of determinate forms depended on pods and seed quantity on the main stem. As determinate forms have genetic variation for this productivity index, breeding progress is possible. The seed yield of these determinate forms was higher at high sowing rates (1.6-.8 million seeds per ha) and ranged from 3.5 up to 4.0 t ha^{-1}.

[1] *The Research Agricultural Institute of the Non-Chernozem Zone, p/0 Nemchinovka-1, Odintsovsky District, Moscow Region, Russia.*
[2] *Moscow State University.*

Investigation on Seed Transmission of Sugar Cane Mosaic Virus and Maize Dwarf Mosaic Virus in Maize

E. Fuchs and U. Hennig[1]

Recently an increasing level of virus diseases in maize crops in Germany has been found. This is mainly due to the sugar cane mosaic virus (SCMV). At present the maize dwarf mosaic virus (MDMV) occurs relatively seldom. Little is known about the ecology of these viruses in Germany. Until now no winter hosts have been known. Importation of the viruses by viruliferous aphids from southern regions seems unlikely because of the nonpersistent manner of transmission. Several authors have reported seed transmission, but the rates of transmissibility differ widely. Low rates of transmissibility, however, may be sufficient for a considerable attack of the crops, provided that the conditions for the development of an aphid population are favourable.

In the years 1989 to 1991 extensive investigations regarding seed transmission were carried out. Seeds harvested from infected plants were sown in the greenhouse and assessed at the 4-5 leaf stage. Seedlings with virus-like symptoms were tested serologically in a simultaneous variant of a DAS-ELISA. Out of 58 615 plants we found 14 with mosaic symptoms at the cotyledons. In all cases we could detect SCMV. This was equivalent to a transmission rate of 0.023%. MDMV-infected seed was less available so that only 16 120 plants could be tested. No infected seedlings appeared. To detect a possible latent infection of plants, seeds from plants inoculated mechanically at the 3-4 leaf stage with SCMV and MDMV, respectively were tested. All emerged seedlings (723 SCMV, 88 MDMV) were assayed by means of ELISA after 4 to 5 weeks. All were found to be virus-free. Serological investigations of dissected maize seeds from infected plants gave positive reactions for the pericarp, the endosperm and the embryo. The highest values were obtained for the pericarp and the lowest for the embryo. The extinction values decreased clearly during a storage period of the seeds of some months. A mechanical inoculation of maize with extracts of seeds from infected plants did not result in an infection. In electron microscopic investigations of homogenates of the pericarp and the embryo, however, fragments of polyviruses were rarely detected. Obviously all parts of the maize seeds from infected plants are contaminated with virus fragments but only in a few cases this leads to an infection of the developing seedling.

[1] *Martin-Luther-Universität Halle-Wittenberg, Institute of Plant Breeding and Plant Protection, Emil-Abderhalden-Str. 25, 06108 Halle (Saale), Germany.*

Breeding for Higher Seed Production in Fodder Crops in India

R.K. Batta[1], B.S. Sidhu[1], P.D. Mehndiratt[1] and C.R. Hazra[2]

Livestock productivity depends on availability of quality fodder. Seed is the major bottleneck in the cultivation of fodder crops. Though outstanding achievements have been made in seed production of major food crops, fodder seed production has remained a neglected area. Among the main forage resources in India, the cultivated fodders cover a greater area than the range grasses and legumes. About 6 m ha of land is under cultivated fodders. Forage seed production is carried out by National Seed Corporation (NSC) State Seed Corporations, IGFRI., NDDB., Central Seed Production Farms, State Agricultural University Farms, Private Seed Companies and Seed Growers. Seed yielding ability is increased by genetic manipulation to improve the reproductive system of plants, increasing viable seeds, inflorescence density, seed weight, seed retention and utilization of apomixis. The breeding efforts have led to the development and release of high forage and seed yielding varieties. In Guinea grass varieties PGG-19 and PGG-101 have been released. In seed production trials PGG-101 has out-yielded PGG-19 by 8.7% while the latter had surpassed the first introduced variety PGG-1 by 239% in seed yield. The multicut sorghum-sudangrass hybrid (Punjab Sudex Chari-1) is the first hybrid released by the public sector. Its seed production is carried out by Pb.Agri.UNi farms in North India and by NSC and seed companies in South India. Seed production of Alfalfa varieties, LLC-5 released for Punjab State & LLC-3 released at All India level, is being carried out by Pb.Agric. Univ.Farms. An outstanding high seed production area of alfalfa has been reported in Ferozepur Distt. of Punjab. Varieties PGG-9 and PGG-14 of Guinea Grass and OL-9 of Oats have been released by All India Co-ordination Programme on Forage Crops for different agroclimatic zones of India. The future breeding programme is aimed to develop high seed yielding fodder varieties by application of genetic engineering techniques. The availability of ample quantity of quality seed will augment fodder production per unit area and over time.

1 *Punjab Agricultural University, Ludhiana.*
2 *IGFRI, Jhansi, India.*

Herbage Seed Production in Russia

S. Sinizyna[1]

The Russian seed production system changed several times (in 1937, 1960, 1976 and 1994). The best results were achieved in 1976 when this branch of husbandry was concentrated in special large seed growing farms. In 1990 the country was almost self sufficient for herbage grass seeds and the problem of alfalfa zone seeding was solved. At present various programmes of farm privatisation are being implemented. However, agricultural production is currently falling. The old centralised system of seed-growing has been destroyed, but has not yet been replaced by a new one. The farms have no funds for the purchase of seeds and the seed market does not operate properly. Presently the draft law of the Russian Federation "On Seeds" is under discussion; it will regulate the relations between the seed producers, consumers and the State during seed growing, laying in and marketing. The seed-growing industry has been converted into a system of independent competing associations, with share-holding and other companies involved in the growing of original, elite, hybrid seeds of agricultural plants. Seed quality evaluation and certification of seeds is carried out according to the law "On the certification of products and services" (1992). Certification is conducted on the basis of a variety of characteristics. The law of the Russian Federation "On selection achievements" (1993) constitutes the legal basis for seed growing and selection in the Russian Federation. In 1994 the State Commission on Testing and Protection of Selection Achievements was established. It examines applications for selection achievements, carries out tests on them, keeps the State Register of selection achievements subject to protection and those allowed for utilisation, and issues patents and authorship certificates.

1 *St. Petersburg, Russia.*

Control of White Mould and Black Stem in Crimson Clover

J.A. Leffel, H.C. Olesen, P.A. Koepsell and W.C. Young III[1]

In Oregon, USA, crimson clover (*Trifolium incarnatum*) seed production fields can become severely infected with white mould (*Sclerotinia* spp.) and black stem (*Phoma* spp.) greatly affecting seed yields. From 1991 through 1993 Rovral brand iprodione fungicide was evaluated for the control of these diseases and to identify the potential for registration. Rovral and Ronilan were included in trials and both provided significant control of the diseases as well as

giving increased yields over the nontreated control. Over the three year period Rovral reduced the average level of white mould infection by 76% with one application, and 88% with two. Black stem infection responded similarly with a reduction of 49% with one application and 69% with two. The three year averages of yield increases were significant ($p=0.05$). Rovral gave an increase of 623 kg ha^{-1} over the nontreated control. The best control of white mould infection was obtained when applications were made as soon as detected. The results show that these diseases can be controlled with proper fungicide use and timing and seed yields can be significantly improved.

[1] *Oregon Clover Commission; Rhone-Poulenc Ag. Company; Oregon State University Extension Specialists. Hillsboro, Or. USA 97124.*

The Effect of Cover Crops on Undersown Grasses for Seed Production

B. Boelt[1]

Grasses for seed production have traditionally in Denmark been established undersown in spring barley. This method is suitable for the stronger growing grasses such as meadow fescue, cocksfoot and perennial ryegrass. However this method is less suitable for the weak growing grasses such as smooth stalked meadow grass and red fescue. Generally the proportion of autumn sown crops has increased markedly in Denmark, and there has been an increasing interest in testing their suitability as cover crops. In 1988 experiments were initiated to test the effect of five cover crops on five undersown grasses for seed production. The grass species were smooth stalked meadow grass (*Poa pratensis* L.), red fescue (*Festuca rubra* L.), meadow fescue (*Festuca pratensis* L.), cocksfoot (*Dactylis glomerata* L.) and perennial ryegrass (*Lolium perenne* L.). The cover crops trialed were winter rape, winter wheat, spring barley, field bean and field pea. The cover crops were established at three plant densities. Three nitrogen fertilizer levels were applied to the undersown grasses in the autumn before the first seed harvest year. Undersowing grasses for seed production resulted in a seed or grain yield depression in all cover crops. Yield depression was highest in peas by 11% and lowest in field bean by 4%. Undersowing of perennial ryegrass resulted in the highest yield depression (10%) and smooth stalked meadow grass resulted in the lowest yield depression (5%). An increased cover crop seed rate decreased the yield depression. First year seed yield of the undersown grasses was highest when established in winter rape. Undersowing in spring barley or field bean reduced average first year seed yield of the undersown grasses by 17%. Nitrogen applied in the autumn before the first seed harvest year increased the number of fertile tillers at harvest, and seed yield was increased in smooth stalked meadow grass, red fescue and cocksfoot when established in spring barley, winter wheat or field bean.

[1] *Danish Institute of Plant and Soil Science, Department of Cereal, Seed and Industrial Crops, Ledreborg Allé 100, 4000 Roskilde, Denmark.*

Crop Density Effects on Seed Production of Red Fescue

N.A. Fairey[1]

Seedhead formation in successive crops of creeping red fescue (*Festuca rubra* L. var. *rubra*) appears to be inhibited by the natural proliferation of tillers. A field study was conducted to evaluate whether seed yield of fescue can be optimized for one, two, or three consecutive crops by manipulating the initial population density and arrangement of plants. Individual seedlings were transplanted at seven population densities (1.6, 3.1, 6.3, 12.5, 25, 50, and 100 plants m^{-2}) and three row spacings 20, 40, and 80 cm). Characteristics of seed production were determined for three years (1991-3). Heading commenced at dates differing by 16 days in the 3 years, and was delayed progressively by up to 7 days as crop density increased. Seed maturity occurred in a 7-day period (July 15-22) in each year. The seed yield/plant, the number of seedheads/plant, and the number of seeds/plant decreased exponentially as the crop density increased. Increasing crop density also resulted in decreases in the weight proportion of cleaned-to-uncleaned seed (82-60%), in the thousand-seed weight (1.54-1.20 g), and in the specific seed weight (25-16 kg hl^{-1}), but did not affect the germination capacity of the seed. For a single harvest, seed yield was optimized by an initial crop density of 12-100 plants m^{-2} at a row spacing of 20 cm, or 12-50 plants m^{-2} at a row spacing of 40 cm. For two consecutive harvests, an initial crop density of 6-25 plants m^{-2} at a row spacing of 20 cm, or 6-50 plants m^{-2} at a row spacing of 40 cm, was required to optimize total seed yield. When either one or two seed crops were anticipated, a crop density of 12-25 plants m^{-2} at a row spacing of 40 cm or less resulted in optimal seed yields in each year. The probability of producing a third seed crop decreased markedly as the initial crop density increased, and as the row spacing decreased. It is probably uneconomic to harvest more than two consecutive seed crops of creeping red fescue in the Peace region of Canada.

[1] *Northern Agriculture Research Centre, Agriculture and Agri-Food Canada, P.O. Box 29, Beaverlodge, Alberta, Canada TOH OCO.*

Effect of Nitrogen Fertilizer Application Rate and Timing on Timothy Seed Crops in Northern Europe

O. Niemelainen[1] and A. Jarvi[2]

The effect of nitrogen (N) application rates, 50, 100 and 150 kg N ha^{-1} on loam soil and 25, 50 and 75 kg N ha^{-1} on *Carex*-peat soil on a seed crop of timothy (*Phleum pratense* L.) were studied in Central Finland (latitude 64°N). The timing of N application was included as subplots:B1) all N at the beginning of the growing season, B2) all N applied 3 weeks from the onset of the growing season, B3) half of the total N application in the previous autumn and half in the spring at the beginning of the growing season. On the loam soil the early N application in spring gave a higher yield with a lower variability in the yield than the two other timing treatments. When the stands aged, the positive effect of the higher N rates became obvious. The average seed yields (averages over application times) for 50 kg N ha^{-1} were 535, 415 and 271 kg ha^{-1} for the 1st, 2nd and 3rd year stands. Respective yields for 100 kg N ha^{-1} were 622, 512 and 334 kg ha^{-1}, and for 150 kg N ha^{-1} 591, 572 and 451 kg ha^{-1}. The higher N application rates increased lodging considerably and delayed maturation for 1-3 days. On the peat soil N rates exceeding 35 kg ha^{-1} did not increase yield. Average yields for 25, 50 and 75 kg N ha^{-1} were 437, 429 and 414 kg ha^{-1} respectively over three years period. Delay in N application in spring did not have a detrimental effect on yield on peat soil. Fertilizer recommendations were prepared in order to attain reasonably high seed yield combined with a low risk of harvesting difficulties. For mineral soils N application of 100 to 120 kg ha^{-1} at the beginning of the growing season is recommended. In organic soils, the recommendation is 25 kg N ha^{-1} in spring.

1 *Egypt-Finland Agric. Research Project, Ismailia, Egypt.*
2 *Agricultural Research Centre, Ylistaro, Finland.*

Fertilizer Experiments with ^{15}N Labelled Nitrogen in Perennial Seed Grasses For Studying N-Uptake at Varying Soil Depths

W. Schöberlein[1], M. Delling[2] and S. Müller[3]

In model trials with *Lolium perenne* (1), *Poa pratensis* (2), *Dactylis glomerata* (3), *Phleum pratense* (4) and *Festuca pratensis* (5) for seed growing, N-absorption was investigated on the basis of ^{15}N double-labelled ammonium nitrate solution (10%). The nitrogen fertilizer was placed at a depth of 30 cm in late summer of the sowing year, at 60 cm depth in autumn and again at a depth of 60 cm as well as on the surface in the following spring prior to the beginning of vegetative growth. The N-removal was determined by use of ^{15}N analyses of plant samples collected from an autumn cut on October 12, from the first cut of the following year on April 18, the second cut on May 23, the third cut on May 30 and the fourth cut for seed harvesting on July 13. The differences in the ^{15}N absorption from the 30 cm depth between the plant samples of the autumn cut indicated differential root penetration of the soil by the single grass species in autumn. The results obtained in the first seed cutting year underline that both autumn and spring doses, applied at 60 cm depth had been utilized; however these were clearly differentiated depending on the species. The ^{15}N absorption rates with (1), (4) and (3) at inflorescence reemergence, for example, reached rather high values (56.2 to 30.3%). (2) and (5) ranked very low with 3.5 and 12.9% respectively. The N-removal rates of grasses found in the case of surface application and nitrogen placed at the 30 cm depth, are comparable to the N-absorption rates of cereal crops (51 to 77%). The present results allow the conclusion that the nitrogen available at 60 cm depth is utilized by the tested grass species mainly at inflorescence emergence. An exemption is *Poa pratensis*. Therefore, when calculating the N-dose in spring on the basis of the N_{min}-content in the soil, soil sampling should include no less than 60 cm in depth before growth sets in. So, dosage of the first N-rate in spring must also consider the soil-N pool down to a depth of 60 cm.

1 *Martin-Luther-Universität Halle-Wittenberg, Landwirtschaftliche Fakultät, Institut für Acker- und Pflanzenbau, E.-Abderhalden-Str. 25, 06108 Halle.*
2 *Sächsische Landesantalt für Landwirtschaft, Fachbereich Sortenprüfung und Feldversuchswesen, Waldneimer Str. 219, 01683 Nossen.*
3 *Fachhochschule Erfurt, Fachbereich Gartenbau, Leipziger Str. 77, 99085 Erfurt, Germany.*

Effect of Grazing Termination Date on Annual Ryegrass Seed Production

G.W. Evers and L.R. Nelson[1]

Annual ryegrass (*Lolium multiflorum* Lam.) is the most widely grown cool-season annual grass in the United States at an estimated 1.2 million ha. About 90% of the ryegrass is overseeded on warm-season perennial grasses in the southeastern USA for livestock grazing. The influence of grazing termination date on potential seed production from these ryegrass pastures is not known. 'Gulf', 'TAM 90', 'Marshall', and breeding line TXR-89EN-1 ryegrass were overseeded on a 'Coastal' bermuda grass (*Cynodon dactylon* (L.) Pers.) sod on 6 October 1992. Entries were drilled in 17-cm rows at 28 kg ha^{-1} in 5 x 12 m plots. Experimental design was a randomized complete block with four replications. The study was fertilized with 67 kg ha^{-1} of N, P_2O_5, and K_2 after ryegrass emergence and with an additional 56 kg ha^{-1} of N on 13 January and 11 March 1993 for a total of 179 kg ha^{-1} of N. Cows and their calves in a surrounder pasture were allowed access to the study on 9 February 1993 when the ryegrass was approximately 15 cm tall. Grazing termination dates were 1 April, 15 April, 29 April, and 13 May 1993. Cattle were excluded by moving a temporary electric fence 3 m every 2 weeks across the 12 m length of the plots. In June 1993 plants from two 1 m row samples were collected from each plot. Seedheads were counted and seed hand threshed on a rub board. Seeds were weighed to determine seed yield and 100 seed weight. Data were analyzed with ANOVA and mean separation by Waller-Duncan Multiple Range Test. There were no significant differences ($P>0.05$) among varieties for seedhead density or seed yield. Grazing termination date and cultivar by grazing termination date interactions were significant. Seedhead densities (seedheads m^{-2}) averaged across cultivars were 1 April - 684, 15 April - 691, 29 April - 607, and 13 May - 424. Seed yields (g m^{-2}) averaged across cultivars were 1 April - 157, 15 April - 116, 29 April - 46, and 13 May - 21. Weight per 100 seed was significant ($P>0.01$) for the cultivar, grazing termination date, and cultivar by grazing termination date interaction. Cultivar seed weights (g/100 seed) were Gulf - 0.19, TXR-89-EN-1 - 0.18, TAM 90 - 0.17, and Marshall - 0.16. Weights/100 seed for grazing termination date were 1 April - 0.19, 15 April - 0.19, 29 April - 0.18, and 13 May 0.14. Seed yields of annual ryegrass decreased as the termination of grazing was delayed beyond 1 April.

[1] *Texas Agricultural Experiment Station, Overton, Texas, USA.*

Effect of Fungicides on Seed Yield and Disease Control in Perennial Ryegrass (*Lolium perenne* L.)

G. Rijckaert[1]

The simple extrapolation of the intensive cultural practice from cereal crops to grass seed crops seems too easy and is probably incorrect. The hypothesis that a healthier grass seed crop would also result in a higher seed yield was tested under Belgian conditions. The effects of fungicides on seed yield, yield components and disease control of crown rust (*Puccinia coronata*), powdery mildew (*Erysiphe graminis*) and leaf spots (caused by *Dreshlera sp.*) were investigated on first year seed crops of perennial ryegrass in two types of field experiments. In the first experiment (3 trials, resp. in 1989, 1990 and 1991) the timing of two fungicides was evaluated; namely propiconazol at 125 g ha^{-1} (Tilt) and fenpropimorf at 750 g ha^{-1} (Corbel). IN 1989, application times were : before flowering - after flowering - both stages. Trials in 1990 and 1991 included the following application times : t_1 = stem elongation - t_2 = before flowering - t_3 = after flowering - t_4 = t_1+ t_3. The second experiment (3 trials, resp. in 1992, 1993 and 1994) aimed at determining the efficiency of seven fungicides in relation to seed yield and disease control. These products were applied once before flowering in 1993 and 1994, but after flowering in 1992. In exp. 1, only the 1990-trial resulted in significant seed yield differences. On average, propiconazol increased seed yield by 26% against the control and the fenpropimorf-treatments. Spraying at the beginning of stem elongation was most effective. Yield responses could be attributed to disease control of an early attack of powdery mildew. In all other trials (5), the incidence of foliar pathogens was very low. Nevertheless seed yields differed significantly in the 1993-trial, where treatments with hexaconazol + carbenazim (Planete R) and flutriafol + carbendazim (Imact R) yielded 35% more than the untreated control. These treatments also resulted in the highest seed yields in 1994, but the differences were not significant. Seed yield increases were mostly associated with an increase in thousand seed weight, number of seeds m^{-2}, disease control, green leaf area of flag leaf and/or straw yield. Yield responses are discussed and explained in relation to different seasonal meteorological conditions.

[1] *Government Agriculture Research Centre-Gent, State Plant Breeding Station RvP, B-9820 Merelbeke, Belgium.*

Perfection of the Technology of Growing *Phalaris arundinacea* for Seed in the North-West of Russia

I. Lepkovitch, A. Gormin and N. Degunova[1]

Our investigations were conducted in 1991-94 in the Novgorod district, situated in the centre of North-West Russia. Natural conditions are favourable for grasses here, with a humid climate and 535 thousand ha of swamps being brought into production. On fertile dernovo-podzolic soil, there was a high correlation between agrotechnological methods (the rates of seed sowing, ways of sowing, levels of nitrogen fertilizer) and quantitative signs of plant maturity. A greater number of reproductive shoots was formed in more dense stands. Maximum seed yield (240-260 kg ha^{-1}) was obtained from stands with 15 or 30 cm between the rows and at a sowing rate of 2.4 kg ha^{-1}, 50-75% less than is usually recommended. These stands were fertilized with 68 kg N ha^{-1} early in spring. Seed yield of mixed stands of *Phalaris arundinacea* and *Trifolium hybridum*,(without nitrogen) was less, but protein content of the fodder was considerably higher. We started harvesting stands when the moisture content of seed was less than 50%. It was necessary to harvest seeds quickly, over 2-3 days.

1 *Novgorod, Russia.*

Seed Production of European White Clover Varieties in a Sheep Grazing System in a Mediterranean Environment

P.P. Roggero[1], C. Porqueddu[2] and L. Sulas[2]

The introduction of irrigated pastures and forage seed production could aid dairy/sheep farms to maintain flexibility in production (grazing + hay + seed yield), provide a high degree of environmental sustainability, and may also transform the seasonal sheep system into a continuous one. The multiplication of the best European varieties of white clover would allow a higher market price for the seed, thus improving the economic sustainability of a mixed system. In this paper the results of a series of experiments run at the farm level on white clover seed production are reported. The number of flowerheads per unit area was strongly influenced by the vegetative growth before seed yield. In the autumn sown crops seed yield was below potential, with the harvested seed yield never reaching 300 kg ha^{-1}. The seed set per floret and the 1,000 seed weight were negatively influenced by late grazing. The spring sown crop, where grazing was suspended at the beginning of flowering, reached a harvestable seed yield of over 800 kg ha^{-1}, and a harvested yield of about 600 kg ha^{-1}. Light grazing in May did not significantly depress seed yield, while late grazing (until mid June) allowed in one case development of C4 grass weeds that compromised the seed harvest. Grazed and cut forage production were lower than expected from other irrigated crops (e.g. alfalfa), but satisfactory in relation to the system needs. The harvesting efficiency was sometimes reduced by the presence of stones. The hard seed percentage at harvest was high (always above 80%) and was only partially reduced after mechanical harvest. This character was associated with the very low minimum relative humidity at seed ripening. The results confirmed a high potential for introduction of white clover seed production in the cereal-dairy/sheep farming system, particularly if seeding occurs in spring and grazing stops before flowering. The harvesting technology used proved to be appropriate to the purpose.

1 *Dipartimento biotecnologie agrarie ed ambientali dell'Universitá, Ancona, Italy.*
2 *Centro studio miglioramento della productivitá dei pascoli, CNR, Sassari, Italy.*

Effect of Irrigation and Forage Harvest Management on Seed Production in Perennial Forage Crops in Mediterranean Environments

P. Martiniello and G. D'Agnano[1]

Varieties of perennial legumes: alfalfa (*Medicago sativa* L., cv. "Equipe" and ecotype "Romagnola"), French honeysuckle (*Hedysarum coronarium* L., cv. "Bellante" and "S. Omero") and sainfoin (*Onobrychis viciifolia* Scop., cv. "Zeus" and "Vala") and grasses: tall fescue (*Festuca arundinacea* Schreb., cv. "Tanit" and "Sibilla"), cocksfoot (*Dactylis glomerata* L. cv. "Dora" and "Cesarina") and perennial ryegrass (*Lolium perenne* L., cv. "Vejo" and "Pamir") were investigated in a typical Mediterranean environment (Foggia, Southern Italy). The species were evaluated for seed and hay yield potential under different regimes of irrigation and forage harvest management. Treatments were no irrigation, and irrigating to 50 and 75% of the water holding capacity. The forage harvest was taken when the shoots of the varieties reached the 10 and 50% flowering and heading stage for legumes and grasses respectively. A split-split plot

experimental design was adapted. The parameters considered for forage production were: dry-matter, tiller density, leaf-stem ratio; and for seed production: seed yield, yield components (1000 seed weight and seeds per inflorescence) and harvest index. The preliminary results showed a significant difference among treatments. The species and the varieties showed a different adaptability to cope with the weather conditions. The treatments, irrigation and forage harvest management, resulted in agronomical factors able to increase seed yield in the Mediterranean areas.

[1] *Istituto Sperimentale per le Colture Foraggere, SOP di Foggia, Italy.*

Seed Production of Forage Amaranth Genotypes

R.K. Batta[1]

Amaranths are widely distributed pseudo cereals of the world. Many *Amaranthus* spp. are being utilized for grain, vegetable and ornamental purposes. Encouraging reports of exceptionally high fodder yields of 220 t ha^{-1} and grain yields of 5.5 t ha^{-1} from China have stimulated scientists to evaluate this under utilized C_4 plant as a potential fodder-cum-grain crop. Unlike most of the traditional fodder crops, seed is not a limiting factor in the production of amaranth. At Punjab Agricultural University three hundred and nine exotic as well as indigenous collections were evaluated over different months during 1991-1994. July sowing gave the maximum seed production as compared to crops sown during March to June. Variability was found for panicle length, number of branches of the panicles, seed size and other seed contributing traits. The percentage of crossing in different *Amaranthus* spp. is being determined. Seed production of promising fodder genotypes viz. K-436, LC-223644 and EC-13958 is being carried out in isolation at Research Farms of the fodder section of Department of Animal Nutrition and Forages, Punjab Agricultural University, Ludhiana.

[1] *Punjab Agricultural University, Ludhiana - 141004, India.*

Mechanisms of Pollination and Seed Productivity in *Lupinus polyphyllus* L.

M.A. Vishnyakova and B.S. Kurlovich[1]

A sample of 20 plants of *Lupinus polyphyllus* showed a variability in seed set. Isolation of inflorescences without any manipulation (natural self-pollination) showed a pod set of 0-4.7%. Isolation and hand pollination of flowers (artificial self-pollination) resulted in a pod set of 3.7-21.0%. After free (cross) pollination 20.8-73.7% of pods were set. A study of flower biology discovered some causes of self-sterility of the plants. The absence of self-pollination was conditioned partly by protandry and partly by herkogamy. Microscope analysis with cytochemical tests showed that pollen was viable and shed from the anthers in closed flowers at least three days before the stigma became receptive. The crown of turgid hairs around the stigma head prevented the presentation of own pollen to the stigma even when it became receptive. In 6-7 days these hairs lost their turgor and self-pollination became possible, as pollen was still viable. The third reason for self-sterility was the prevention of self-fertilization because of partial self-incompatibility. Pollen tubes in self-pollinated pistils grew slower, their number was much less than in cross pollinated flowers, and some of them stopped at the different regions of the pistil. As a result only part of the ovule was fertilized. *Lupinus polyphyllus* therefore has some mechanisms for preferential cross-pollination. The level of each character is specific for the plant. The reasons for the variability of seed set characters after cross-pollination have yet to be studied.

[1] *Vavilov Institute of Plant Industry, St. Petersburg, Russia.*

Influence of Inter row Spacing and Harvesting Method on *Desmodium intortum* Seed Yield

P. Lusembo[1] and E.N. Sabiiti[2]

The effect of interrow spacing and harvesting method on the seed yield of *Desmodium intortum* was investigated in two studies. In the first experiment planting was done in stations of 50 cm and at interrow spacings of 50, 75, 100 and 125 cm. Seed was harvested manually by repeated stripping of mature dry pods from the seedheads. Results did not show any significant ($P>0.05$) difference in seed yield among the various treatments. There was also no correlation between seed yield and interrow spacing. Maximum seed yield (120 kg ha^{-1}) was realised from a spacing of 50 cm x 50 cm. The second experiment compared two manual seed harvesting methods in terms of quality, quantity and time taken to harvest a seed crop that was planted at a spacing of 50 cm x 50 cm. In one method seed was harvested by stripping off only

mature dry pods (SM) while in the other method seed was harvested by complete cutting of the seedheads when 50% of the seeds had ripened (CM). Higher yield and less shrivelled seed percentage was realized in the SM than the CM treatment. It took significantly ($P<0.001$) more time in the SM than in the CM treatment. It was concluded that *D. intortum* seed was maximized from a spacing of 50 cm x 50 cm using the method of repeated stripping of mature dry pods.

[1] *Namulonge Agriculture and Animal Production Research Institute, P.O. 7084, Kampala, Uganda.*
[2] *Crop Science Department, Makerere University, P.O. Box 7062, Kampala.*

Germination in Perennial Ryegrass (*Lolium perenne* L.) Seed Lots From the 1993 New Zealand Harvest

J.G. Hampton[1], M.P. Rolston[2], N. Grbavac[3], K.A. Hill[1], M.J. Hill[1] and A.M. Finnerty[3]

Blind seed disease caused by the fungus *Gloeotinia granigena* was the major cause of poor germination in New Zealand perennial ryegrass seed lots from the 1993 harvest. The pathogen was recorded in 100% of seed lots tested, with a mean of 13.5% of seeds infected per seed lot. The incidence of the disease varied with regions of production and with cultivar, but this variation was considered to be most likely related to environmental conditions in spring. Second-harvest crops often, but not always, had lower germinations than first harvest crops, because of the incidence of blind seed disease. For the few seed lots where poor germination was not explained by the presence of the pathogen, heating damage was the cause. Seed dormancy was not a factor. Cleaning to a higher thousand seed weight did improve germination for some seed lots by removing infected (dead) seeds, but for other seed lots where blind seed disease occurrence was low, stricter cleaning simply removed small but viable seed. There was no relationship between seed size (thousand seed weight) and germination.

[1] *Seed Technology Centre, Department of Plant Science, Massey University, Palmerston North, New Zealand.*
[2] *AgResearch, P.O. Box 60, Lincoln, New Zealand.*
[3] *Official Seed Testing Station, P.O. Box 609, Palmerston North, New Zealand.*

Agronomical and Economical Aspects Involved in Forage Crop Seed Production in Mediterranean Environments

P. Martiniello[1]

The decreased use of forage crops observed in the last 25 years is mainly ascribed to production reasons and not to European policies. Therefore, seed of forage crop varieties or landraces well adapted to Mediterranean environments is scarce in the market. Seed production of the forage crops is linked to the availability of skilled farmers to produce certified seed. These aspects in the Mediterranean environments were not stimulated. As a consequence, the scientific benefits offered by new breeding releases are not transferred to agriculture. With the aim of evaluating the economic aspects of seed production of the most widespread annual and perennial forage crops in southern Italy, farmer data of 1992 and 1993 have been utilized for computing incomes. The analyses were carried out considering seed production from agricultural farms and aid derived from the governments for certified seed production. The species evaluated were annual legumes: berseem (*Trifolium alexandrinum* L., cv. Sacromonte) and Persian (*Trifolium resupinatum* L., cv. Accadia) clovers, common vetch (*Vicia sativa* L., cv. Mirabella) and field bean (*Vicia faba* L., cv. Manfredini and Vesuvio) and perennial legumes: alfalfa (*Medicago sativa* L., cv. Equipe), French honeysuckle (*Hedysarum coronarium* L., landraces) and sainfoin (*Onobrychis viciifolia* Scop., landraces). The results showed a positive economic potential threshold for French honeysuckle, clovers and common vetch. The agronomic difficulty during the harvest of the seed determined a reduction of the net incomes. This was lower than the gross income in common vetch (22%), in berseem and Persian clovers (44 and 75% respectively), 49% in sainfoin and 65% in alfalfa. The results suggest it is possible to obtain favourable net income from forage crops.

[1] *Istituto Sperimentale per le Colture Foraggere, Foggia, Italy.*

Possibilities of Mechanical Weed Control at Different Row Distances in Perennial Ryegrass Grown for Seed.

G.E.L. Borm and P.C.W. Baltus[1]

Mechanical weed control can reduce the input of herbicides. The possibilities of mechanical weed control are partly related to the row distance of the crop. Hoeing and brushing can only be put into practice when the row distance is at least 25 cm, while harrowing is not dependent upon the row distance. In order to assess the chances to reduce the input of herbicides in perennial ryegrass grown for seed the effects of row distance (25, 37.5, 50 cm) were studied in a field trial in 1989 and 1990. The weed control methods in these trials were hand weeding and the application of herbicides. In 1993 and 1994 the experiment was extended with the weed control methods of hoeing and harrowing and a non weeded treatment. In 1994, also the combination of hoeing and harrowing was included as well as the row distance of 12.5 cm. All the trials were conducted on sandy/peaty soils. In 1989 and 1990 the cultivar Jumbo (field type) was sown and in 1993 and 1994 the cultivar Flair (lawn type). In 1993 and 1994 the mechanical treatments were carried out twice in spring and for the 1994 crop also once in autumn. In the trials of 1993 and 1994, weed density was low. The estimated coverage of soil and crop by the weeds was reduced for some time by the different weed control methods. For the plots with only harrowing as a weed control method, there was a tendency that this period was shorter. Increasing the row distance resulted in a reduction of ear-density and seed yield. These reductions were not significant when the row distance was widened from 25 to 37.5 cm. Ear-density was reduced only by the combination of hoeing and harrowing in 1994 at a row distance of 25 cm. Harrowing and hoeing at a row distance of 25 cm resulted in 1993 in a significant decrease of seed yield. Further research is needed on several soil types to assess the effects of the different weed control methods on seed yield and on the effectiveness of weed control before final conclusions can be drawn.

[1] *Research Station for Arable Farming and Field Production of Vegetables (PAGV) Lelystad, The Netherlands.*

Control of Volunteer Wheat in *Poa pratensis* L.

P.C.W. Baltus and A.T. Zweep[1]

Smooth-stalked meadowgrass (*Poa pratensis* L.) is generally grown under a winter wheat cover crop in The Netherlands. Volunteer winter wheat used to be controlled in the past with TCA. However, use of this herbicide has not been permitted in the Netherlands since 1991. In a combined project of the PAGV and the Netherlands Grain Centre (NGC), research has been carried out into alternatives to TCA. Mechanical, physical and chemical methods have all been investigated. The effects of different brushing machines, a weed harrow and hoeing machinery on volunteer wheat were assessed over a period of two years. The brushing machine with a horizontal axle controlled about 50 per cent of the wheat plants, but this did not result in a lower percentage of the grass seed crop covered by volunteer wheat at harvest time. The harrow showed unsatisfactory volunteer wheat control, while hoeing resulted in a reduction of the number of tillers and panicles of smooth-stalked meadowgrass. Mechanical control of volunteer wheat is therefore difficult, particularly due to non optimum weather conditions in autumn for mechanical treatments. A propane burner with air support appeared to be able to eradicate small volunteer wheat plants (germ length 0.5-1 cm) in the autumn of 1992. Repetition of the operation is necessary, due to the long germination period of the wheat. The short sensitivity period of the wheat and the maximum driving speed of 1 km h^{-1} made the treatment a labour-intensive operation and caused high propane consumption. This makes the operation unpractical. Twenty two herbicides for selective control of volunteer wheat were screened in several field experiments in the autumns of 1990, 1991 and 1992. In only one trial, quizalofop-p-ethyl, asulam and ethofumesate - sprayed in the autumn of 1991 - controlled volunteer wheat reasonably well without affecting the crop visually. In addition, the sprout inhibiting property of three formulations of carvone (including slow release formulations) was tested in a pot experiment. None of the formulations appeared to be able to prevent sprouting or inhibit the growth of sprouts. New perspectives were opened up with a number of herbicides tested for the 1994 harvest. Further research is needed, however, before final conclusions can be drawn.

[1] *Research Station for Arable Farming and Field Production of Vegetables (PAGV), Lelystad, The Netherlands.*

Chemical Control of *Poa trivialis* L. in *Lolium perenne* L.

P.C. Baltus and R.Y. van der Weide[1]

Rough-stalked meadowgrass (*Poa trivialis* L.) is a grassy weed, which is causing increasing problems in Dutch grass seed production. This weed migrates from ditch banks into the plot and causes damage by competition and through pollution of the cleaned product. Use of methabenzthiazuron and ethofumesate is permitted in the Netherlands for the control of rough-stalked meadowgrass in perennial ryegrass (*Lolium perenne* L.). Practical experience with these herbicides, however, has shown them to be unreliable. Furthermore, the herbicides have to be sprayed preventively (combined soil and contact action), using a high dose of active ingredient. Research has been carried out into alternatives for these herbicides in a combined project of the PAGV and the Netherlands Grain Centre (NGC). The effectiveness and selectivity of methabenzthiazuron, ethofumesate, aclonifen, fenoxaprop-p-ethyl, carbetamide, metsulfuron methyl and asulam were assessed in field experiments for the 1991, 1992, 1993 and 1994 harvests. Not all the herbicides were tested every year. For the harvest years 1991 and 1992, rough-stalked meadowgrass was sown in perennial ryegrass, causing a high, uniform weed presence in the experimental field. This was not done in 1993 and 1994, resulting in a low weed density. In these trials it was possible to gain a more accurate assessment of the effects of the herbicides on the crop. Spraying was carried out in autumn or spring. Seed yields were determined for the 1992, 1993 and 1994 harvests. The contamination of the cleaned product with rough-stalked meadowgrass, the thousand grain weight and germinative capacity of perennial ryegrass were also determined. With respect to the permitted herbicides, methabenzthiazuron gave better control than ethofumesate. The spring application was more effective than the autumn application. The spring application of fenoxaprop-p-ethyl gave the best control in the field, even better than methabenzthiazuron. Although fenoxaprop-p-ethyl showed some growth inhibition in the crop, no significant reduction in yield was found in any year. Only carbetamide and metsulfuron methyl caused a significant reduction in perennial ryegrass seed yield. The weed control assessed in the field only moderately correlated with the contamination of the cleaned product. None of the herbicides tested reduced the thousand grain weight or germinative capacity of the perennial ryegrass.

[1] Research Station for Arable Farming and Field Production of Vegetables (PAGV), Lelystad, The Netherlands.

The Response of Selected Grass Species to Sulfonylurea Herbicides

J. Machác and B. Cagas[1]

Several years of trials were conducted at the Grassland Research Station (Roznov-Zubrí, Czech Republic) with the aim of testing the action of some sulfonylurea herbicides on selected grass species. The objective of the study was to assess the damage to grasses according to the international EWRC scale and the effect of the herbicides on the yield and its components. The grass species under study differed in their responses to the herbicidal treatment from complete resistance to maximum susceptibility. The following herbicides were used: Glean 75 DF (chlorsuphuron), Granstar 75DF (tribenuron), Logran 75 WG (triasulphuron), and Harmony 75 DF (thifenyslulphuron). Thifensulphuron and tribenuron demonstrated the highest tolerance to the grass species under study, whilst chlorsulphuron and triasulphuron were phytotoxic for most of them. In view of the grass species, red fescue (*Festuca rubra*), cocksfoot (*Dactylis glomerata*), tall oat-grass (*Arrhenatherum elatius*), and yellow oat-grass were resistant to all of the above herbicides. The highest susceptibility was recorded in meadow fescue (*Festuca pratensis*) and crested dog's tail (*Cynosurus cristatus*).

[1] *OSEVA PRO Ltd., Grassland Research Station Roznov-Zubrí, 756 54 Roznov-Zubrí, Czech Republic.*

The Joint Influence of Phytostimulators and Hydrogeles on Growth and Development of Perennial Grasses

G.L. Matevosjan and A.I. Drizhachenko[1]

The joint influence of phytostimulators and hydrogeles on initial growth, seed germination and productivity of fescue (*Festuca*) has been studied. Cytokinin (diphoset, tribiphos, BAP), gibberellin (GA, gibberseb) and auxin (IAA, NAA, HA) were tested at their optimum concentrations for preplant seed treatment during the investigations. Such water-sorbants as shtockosorb and agrosorb, which form hydrogeles when they absorb soil moisture, were applied in order to achieve the best irrigation regime, reduce watering rates and improving water supply to plants. The high rates of water-sorbents were found to depress seed germination energy as well as plant growth and development, due to excessive soil moistening. The seed treatment with cytokinin phytostimulators such as diphoset and tribiphos (1-10 mg l^{-1}) promoted lowering of the

phytotoxic effects of high hydrogel rates (0.4-0.5%). The low concentrations of the hydrogeles (0.05-0.08%) have no influence essentially on water supply of plants and their growth. The use of optimum hydrogele rates caused the hygroscopicity and water-holding capacity of light and sandy soils to increase, resulting in a decrease of relative transpiration and surface evaporation. As a consequence of this, the plant supply with water was enhanced, along with efficiency of fertilizer use, while the rates and frequency of watering could be reduced. The application of phytostimulators (1-20 mg l^{-1}) stimulated seed germination as well as the development of roots and growth of plant biomass; these indexes of treated plants exceeded the check ones by 18-41% depending on both the soil type, hydrogele rates and concentrations of the phytostimulators. In the trials with fescue the best results were obtained when diphoset and agrosorb were used together on light soils under water stress conditions.

1 St. Petersburg-Pushkin, Russia.

Enhancement of Flowering and Seed Production of *Bromus inermis* Leyss. by Autumn Application of CCC.

T.S. Aamlid[1] and R. Skuterud[2]

Bromus inermis is a typical short-long-day plant. As plants do not respond to low temperature vernalization, primary induction can only be accomplished by 5-10 weeks' exposure to short day conditions (<12 h). The average daily temperature during this treatment must exceed 6°C, the optimum being as high as 15-21°C. After primary induction, plants need long days (>15 h) for flower initiation and elongation of reproductive tillers. Since the early 1980s, Norway has developed seed production of *Bromus inermis*. Because of low temperatures in autumn, conditions are marginal for primary induction, and seed yields have therefore been low, averaging only 300 kg ha^{-1}. Experimental evidence that weekly sprayings with gibberellin during short day treatment inhibit flowering in *Bromus inermis* suggests that primary induction is inversely related to the endogenous gibberellin content in this species. The objective of the present trials was to elucidate whether autumn applications of the gibberellin biosynthesis inhibitor CCC might enhance primary induction and thus seed yields under marginally inductive conditions. Experiments were spring sown without a cover crop at one continental (61°N) and one coastal (58°N) location in South Norway. The crops were defoliated on 1 August or 1 September after which CCC was applied at 2 kg a.i. ha^{-1} on different dates until 1 October. At the coastal site, CCC applications in August or September were equally effective, raising seed yield in ley year 1 from 730 to an average of 833 kg ha^{-1}. At the inland site, CCC on 15 August increased the seed yield of the crop defoliated on 1 August from 372 to 542 kg ha^{-1}, but application after defoliation on 1 September had no effect. This difference can be explained by higher temperature at the coastal site, the normal average for September+October being 9.9°C as opposed to 6.9°C at the inland location. In a different set of trials, CCC was applied to first year seed crops shortly after seed harvest and removal of straw and stubble in late August. In contrast to the results mentioned above, CCC had no effect on seed yield in ley year 2, a fact which was possibly due to very little receptive foliage at CCC application. In conclusion, autumn applications of CCC seem to promote seed yields of *Bromus inermis* only when applied in the year of establishment. CCC probably acts through a reduction in the plants' internal content of gibberellin, which is also reflected in shorter leaves and fewer elongated vegetative culms after application.

1 *The Norwegian Crop Research Institute, Landvik, 4890 Grimstad.*
2 *The Norwegian Crop Research Institute, 1432 Ås, Norway.*

Effect of Paclobutrazol on Seed Yield of Lucerne (*Medicago sativa* L.) cv. Grasslands Oranga

M. Askarian[1,2], J.G. Hampton[1] and M.J. Hill[1]

The effects of the plant growth regulator paclobutrazol on lucerne seed yield and its components were investigated in two field experiments in 1991/93. Paclobutrazol applied at 1.0 kg a.i. ha^{-1} during active vegetative growth significantly increased seed yield by 36% in 1991/92 and 150% in 1992/93. This seed yield response came primarily from a significant increase in the number of harvestable racemes, but pods per raceme were also increased in both seasons, and thousand seed weight was increased in the second season only. Paclobutrazol applied at 1.0 kg a.i. ha^{-1} at first flower bud appearance in 1991/92, or at 0.5 kg a.i. ha^{-1} during active vegetative growth in 1992/93 did not increase seed yield. The implications of these results for lucerne seed production are briefly discussed.

1 *Seed Technology Centre, Department of Plant Science, Massey University, Palmerston North, New Zealand.*
2 *Ministry of Jihad-e-Sazandagi, Tehran, Iran.*

Nitrogen Fertilization, Nitrogen Uptake and Seed Yield in Perennial Ryegrass

G. Sicard[1]

The effects of different levels of nitrogen (applied between mid winter and mid spring) on seed yield and seed yield components of several cultivars of perennial ryegrass were assessed in two locations (Troyes, Brain sur l'Authion) during 6 growing seasons (1989 – 1994). The trials were carried out on first year crops, sown in the previous autumn. The determination of nitrogen uptake was obtained for each treatment at full ear emergence. The results showed a good relationship between the level of nitrogen uptake at ear emergence and seed yield ($r^2 = 0.84$), with maximum seed yield obtained for a nitrogen uptake of around 130 kg/ha. This optimum does not vary with the cultivars, but the yield of the late type cultivars is relatively more depreciated in case of nitrogen deficiency. For the cultivars tested in this study, yield increase was highly correlated with the number of panicles per m^2. Increasing amounts of nitrogen had no effect on the number of seeds per panicle, because the higher number of florets per panicle was balanced by a decrease in seed set. The optimum input of fertilizer depends on both soil-borne mineral nitrogen and the actual absorption of the commercial nitrogen. The soil born nitrogen, measured as the nitrogen uptake at ear emergence on the non fertilized treatments, varied from 19 to 106 kg ha^{-1} between trials. These results show the need to estimate the soil borne nitrogen, when looking for the right amount of fertilizer to be applied.

1 *Fédération Nationale des Agriculteurs Multiplicateurs de Semences, Le Verger, 49800 Brain sur l'Authion, France.*

Response of Perennial Ryegrass, Red Fescue and Smooth-Stalked Meadowgrass to Phosphate Fertilization

J.G.N. Wander[1]

In the Netherlands most arable soils are nowadays adequately provided with phosphate. Within a crop rotation phosphate is applied before growing potatoes and sugarbeet. Little was known about the response of grass seed crops to the application of phosphate fertilizer or to phosphate in the soil. Therefore research was started in cooperation with the IB-DLO between 1989-1991. Nine trials were carried out on fertile clay soils with rates of phosphate application ranging from 0 to 200 kg P_2O_5 ha^{-1}. Seed yield responses were recorded for smooth-stalked meadowgrass, red fescue and perennial ryegrass. Phosphate dressing did not affect the seed yields. In a trial with different phosphate levels in the soil, hardly any response on seed yield could be observed in a first and in a second year crop of red fescue and perennial ryegrass. The P-content of seed and straw were not influenced by the fertilization and the phosphate level in the soil.

1 *Research Station for Arable Farming and Field Production of Vegetables (PAGV) Lelystad, The Netherlands.*

Ryegrass 2000

M.P. Rolston[1]

To enable commercial seed growers to achieve perennial ryegrass (*Lolium perenne* L.) seed yields of 2000 kg ha^{-1} by the year 2000, a research and technology transfer (TT) programme was initiated in 1993. In the first year, hand-harvested field research plots produced seed yields of up to 2200 kg ha^{-1}, allowing the TT programme to begin while the research programme developed. The TT programme was based around the establishment of 5 Ryegrass 2000 Clubs, each with 20 seed growers, and involving seed company field representatives. A guiding principle was that the researchers did not have all the information, and that good growers had considerable experience and expertise to share that would assist each club achieve its objective; the flow of information would be both between growers and to and from researchers. The national seed growers organization contributed funds to establish the clubs, and each grower was charged a membership fee. Each club established a focus field used to demonstrate new technology emerging from research trials. In addition each club visited 2-5 members' seed fields to discuss operations to date, and to comment on the condition of the crop and future operations. Discussions focused on the operations for that period, with nitrogen and disease management being important in early spring, and harvesting methods in late spring. Growers were issued with notebooks to record the inputs, costs and activities for the crop. At the end of the season, the notebooks were analyzed and gross margins for each grower calculated. Growers received a list showing their yields and gross margins relative to other members of their club. Prizes and certificates were awarded to the top growers in each club. The Ryegrass 2000 programme has been received with enthusiasm and has injected renewed interest in ryegrass seed production and research which had been through a decade with little attention. Growers not in clubs will benefit from open field days to be held annually, and from updated grower guides to be produced annually from the programme. New research priorities identified on farms will be built into future research programmes.

1 AgResearch, P.O. Box 60, Lincoln, New Zealand.

Irrigated Grass Seed Production in Southern Alberta - Exploratory Endeavours

H.G. Najda and R.C. McKenzie[1]

At present, the majority of the North American seed production of Kentucky bluegrass, perennial and Italian ryegrass, tall and fine-leaved fescues occurs in the United States, in particular the Pacific Northwest states of Oregon, Washington and Idaho. Another major area of production, mainly of creeping red fescue seed, takes place in the Peace River region of British Columbia and Alberta, Canada. There is an opportunity for an irrigated grass seed industry in southern Alberta as a means of diversifying agriculture in this area. Predicted potential is 30-40,000 acres of production of Kentucky bluegrass and fine-leaved fescues. Contracting seed companies are interested in this area because the economic potential is favourable, in that land prices are competitive to other production areas, the region is close to export markets and there is a core of experienced producers who will be able to provide a consistent supply of quality product. This area of Southern Alberta (located between 49º and 51º Lat. and 111º and 113º Long.) differs from the US and other Canadian areas of production environmental conditions for rainfall, winter temperature, wind, day-length and soil type. Research trials have started to investigate the role of row spacing, seeding rate, irrigation scheduling, fertilizer requirements, herbicides and post-harvest management in regard to these different conditions.

[1] *Alberta Agriculture, Food and Rural Development Crop Diversification Centre, South, Brooks, Alberta, Canada T1R 1E6.*

Investigating the Reasons for White-Spikedness in Kentucky Bluegrass (*Poa pratensis* L.) Grown for Seed

G. Bürgés, G. Fischl, and K. Iványi[1]

White-spikedness, which leads to the wilt of the inflorescence in grasses, can be induced by several factors - a detailed description is available in the literature. It can often be found at different levels in grass grown for seed, does not usually result in considerable losses in seed production, but it can develop serious damage. One condition of protection or prevention is to identify the main diseases, which is not an easy task.In 1989 great damage was observed on fields of Kentucky bluegrass grown for seed in the West of Hungary. Several cases have been reported of the occurrence of white-spikedness, but an infection of this size has never been described in Hungary. In the above-mentioned stand a loss of seed exceeding 50 percent was found. The rate of damage increased during the following years. Similar damage was observed in neighbouring areas where grass was introduced some time later. These circumstances made it possible to explore the causes and work out possible ways of protection. In investigating the reasons for white-spikedness, we needed to consider phythopathological and entomological factors which might equally be responsible, so we conducted experiments involving both aspects for several years. We made complex investigations of soil- and plant-samples in situ and in labs, and studied the effects of various treatments (spring burning of parched grass, soil disinfection, the use of fungicides and insecticides) on the rates of white-spikedness. Of the causes described in the literature, several were identified as being responsible for the damage. *Fusarium poae* from the pathogen fungi was usually identified in the damaged tissues. Damage caused by phythophate mites (Acari), cornflies (Diptera) and thrips (Thysanoptera) was also found. Our investigations have proved that stinkbugs (Heteroptera: Miridae) are responsible for the high-rate of development of white-spikedness. An obvious correlation was found between the size of stinkbug populations and amount of white-spiked inflorescences. Besides the two dominant species (*Leptopterna dolobrata* and *Amblytylus nasutus*), 18 further plythophate aphids were identified. The possibilities of effective protection and prevention were also studied. Insecticides with high initial toxicity and long term effects are most important during ear emergence.

[1] *Pannon University of Agriculture, Georgikon Fakulty Keszthely, Hungary.*

Effects of Post-Harvest Residue Management on Kentucky Bluegrass Seed Yield and Seed Quality in Central Oregon

D.D. Coats, F.J. Crowe and M.Butler[1]

Post-harvest residue management methods were evaluated in a study initiated in 1991 on two commercial Kentucky bluegrass (*Poa pratensis* L.) fields in central Oregon which had been planted in the fall of 1990. One field was planted with an aggressive variety and the other field with a non-aggressive variety. [Aggressive varieties included those that were highly rhizominous and fill in between a 30 cm row spacing within a year or two. Non-aggressive varieties included those that were less rhizominous.] Additional locations including aggressive and non-aggressive varieties were added to the study each year through 1993 until a total of six locations were included. Per field, residue treatments were organized

in a randomized block design with four replications. Because the standard industry practice for residue management of grass seed fields began with baling the straw prior to open-field burning, all residue management treatments in this study included this practice. When averaged over all test sites, seed yield and fertile tiller numbers were highest with the open field burning treatment (100%). In comparison, for plots in which residue was removed by vacuum-sweep followed by propaning, vacuum-sweep alone, flail-only and bale-only, mean seed yields were 85, 85, 79, and 67% respectively per two fields in 1992; were 94, 90, 90, and 83% respectively per four fields in 1993; and were 94, 86, 80, and 75% respectfully per six fields in 1994. Wheel rake treatments were harvested in 1993 and 1994 with mean seed yields of 91 and 86% compared to open field burning. Seed yields were lowest for fields in the fourth year of harvest when compared to third and second year harvest. Statistical significance for data from individual fields will be discussed. Fertile tiller numbers followed the same trend as seed yields. Thousand seed weight and seed germination percentages were comparable among all treatments for each field ($P \leq 0.05$), and were unaffected by residue management. This study will continue through 1996.

[1] *Oregon State University, Central Oregon Agricultural Research Center Madras, Oregon, USA.*

Control of Ergot in Kentucky Bluegrass Seed Fields Using SDI Fungicides and a Surfactant

W.J. Johnston, C.T. Golob, and J.W. Sitton[1]

Ergot, caused by *Claviceps purpurea*, is currently the most serious disease in Kentucky bluegrass (*Poa pratensis* L.) seed production in eastern Washington and northern Idaho, USA. Sterol demethylation inhibiting (SDI) fungicides are systemic fungicides with broad spectrum fungicidal activity that have shown some control of ergot. The objective of this research was to determine the effectiveness of SDI fungicides tank-mixed with a surfactant for control of ergot in Kentucky bluegrass seed production. Trials were conducted on an irrigated 'Plush' Kentucky bluegrass seed field in northern Idaho during 1993 and 1994. Propiconazole (0.29 or 0.58 L product ha^{-1}) or tebuconazole, used only in 1994 (0.26 or 0.52 L product ha^{-1}), were applied alone or with surfactant Sylgard 309 (0.5, 1.0, or 2.0 L ha^{-1}). Treatments were applied preanthesis in late May with a CO_2 pressurized boom sprayer at 275 kPa using a 262 L ha^{-1} carrier (water) rate. Individual treatment plots were 3 x 6 m with four replications in a randomized complete-block design. Plots were rated for disease severity in early July by observing the amount of sclerotia and panicle exudate (honeydew). In early July, approximately 125 to 175 panicles per plot were hand harvested and the mean weight per panicle of clean seed and sclerotia, seed weight, and germination were determined. Disease, as measured by sclerotia and honeydew, was severe in non-treated control plots. In 1993 and 1994 studies with propiconazole, the least amount of disease was observed in plots treated with propiconazole tank-mixed with Sylgard 309. Intermediate control was observed with propiconazole alone. Treatments had no effect on seed yield, seed weight, or germination. In the 1994 study with tebuconazole, there was intermediate disease control with tebuconazole alone and good to excellent control when tebuconazole was tank-mixed with Sylgard 309. Tebuconazole treatments had no effect on seed yield or seed weight. In summary, Sylgard 309 markedly enhanced the efficacy of SDI fungicides for control of ergot.

[1] *Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164-6420, USA.*

Seed Production and Harvest of Annual Burr Medic (*Medicago polymorpha* L.): First Results in the South of France and Italy (Sardinia)

F. Lelievre[1], C. Porqueddu[2], G. Genier[3] and L. Sulas[2]

Burr medic (*Medicago polymorpha* L.) has been improved and widely spread as a pasture species in Australia, but only recently has received attention in southern Europe, where it is a promising species for diverse utilisation as a self-reseeding pasture or cover-crop in sub-humid and semi-arid northern Mediterranean environments. A few lines have been selected in CNR Sassari (S. Italy, semi-arid Mediterranean climate with mild winter) and INRA Montpellier (M, France, subhumid Mediterranean climate with cold winter). Five of them, later than the Australian standards Serena and Circlevalley, were evaluated in large plots (2 200 to 6 600 m^2) to test crop management on a farm field-scale for acceptable potential seed yield, and to get information about harvesting techniques before extension to farmers using the Australian Horwood Bagshaw harvester (HB). Three accessions (Aritzo, Villasalto and Sorso) were studied in S during one year (establishment: A1) and two (34 003 and ES 068) in M during 2 years (A1 + regeneration year A2). Actual seed yields, evaluated by carefully handharvested samples before general harvest, were very similar in 4 fields (1150 _ 100 kg.ha^{-1}); only the line Sorso had lower results, whereas it had been promising in previous studies in small plots. The decrease of yield in A2 compared to A1 in M was moderate (20%), which is interesting because the cost of the crop is lower than in A1. Because of the small size of seeds (2.2 to 3.1 mg $seed^{-1}$), the number of seeds was high, ranging from 30 000 m^{-2} to 56 000

m^{-2}, corresponding to the upper levels reported in the bibliography for medics, but similar to our previous results in small plots. This explains the good regeneration and seed production in M-A2, the loss of 10-20% at harvest corresponding to 3 000-12 000 seeds remaining in pods on the soil for regeneration. Mechanically harvested yields (HSYC) ranged from 510 to 880 kg ha^{-1} of cleaned seeds, except for Aritzo. Total HSYC for 2 years in M were 1581 and 1756 kg ha^{-1} respectively for lines 34 003 and ES 068. Indicators of harvest quality with the HB were established. They show that results depend on technical decisions: one can either try to harvest relatively clean seeds as was done in Sardinia, but many of the pods remain on the soil (less than 50% of ASY was collected in this situation); or one can try to pick up more than 80% of pods and seeds as was done in Montpellier, but the machine catches a lot of the remaining stubble and soil, and it requires a lot of labour for cleaning seeds without loss. We confirm the possibility to manage the crop for high potential seed yields on the scale of farm fields, but technical problems and costs for harvesting with HB and for post-harvest cleaning are important, which may be a real problem for developing this kind of production in southern Europe. Therefore, more rapid and efficient techniques should be investigated.

[1] *Unité d'Ecophysiologie-Agronomie INRA-ENSAM, 2 place Viala, 34 060 Montpellier, France.*
[2] *Centro Pascoli, CNR, via de Nicola, 07 100 Sassari, Italy.*
[3] *Station de Génénitque et Améioration des Plantes de Montpellier, INRA, 34130 Mauguio, France.*

Studies on the Seed Dormancy of the Tropical Forage Grass *Brachiaria dictyoneura*

M.Sánchez[1], J.E. Ferguson[2] and R. Schultze-Kraft[3]

The African species *Brachiaria dictyoneura* (Fig. & De Not.) Stapf has in recent years become an important forage grass in tropical America. Mainly because of its pest and disease tolerance and adaptation to acid, low-fertility soils, a cultivar known as "Llanero" in Colombia and Costa Rica, "Gualaca" in Panama, and "Ganadero" in Venezuela is increasingly being used in improved pastures. A major deficiency of the grass, however, consists of pasture establishment failures because of dormancy of seeds. In order to characterise this dormancy and its dynamics, samples from five different *B. dictyoneura* seed lots grown simultaneously in three different geographic regions of Colombia and harvested in the same season, were studied in a series of laboratory experiments. In these studies, complete spikelets, spikelets scarified during 30 minutes in sulphuric acid, and naked caryopses were exposed, at one and three months after harvest, to different dry-heat regimes (temperatures: ambient, 40º, and 60º C; exposure times: 0, 72, and 240 hours). Evaluation consisted of viability (tetrazolium), germination, and dormancy tests at one, three, six and nine months after harvest. Results showed that complete spikelets maintained high levels of dormancy (73-83%) even at nine months after harvest. Scarified spikelets showed a progressive decrease of dormancy with time, reaching a minimum at six months after harvest. For scarified spikelets, the most effective heat treatment was 40ºC for 72 and 240 hours. The naked caryopses had their lowest dormancy levels at six months after harvest. It is concluded that although there are obvious effects of physical treatments of *B. dictyoneura* seed, to further clarify the dynamics of physiological dormancy basic research at the biochemical level is required.

[1] *Universidad Nacional de Colombia, Palmira, Colombia.*
[2] *Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.*
[3] *University of Hohenheim, Stuttgart, Germany.*

Seed Production of Perennial Forage Peanut in Mixed Cropping With Maize and Beans

C.I. Cardozo[1], J.E. Ferguson[2] and R. Schultze-Kraft[3]

The perennial peanut species *Arachis pintoi* Krap. *et* Greg. is in several tropical countries considered to be a promising species for forage, ground cover in plantation agriculture, and erosion control. It produces high seed yields but mainly because of generally unmechanised, labour-intensive seed harvesting, costs of seed production in monoculture are very high and lead to often low and erratic seed availability on the market as well as to high prices. Alternative, non-monoculture seed production systems for forage *Arachis* seem to be required; they should be economically attractive to a wider range of producers and lead to a more constant seed supply at lower prices. One such alternative option was studied in the coffee zone of Colombia, a region that is very favourable for the production of *A. pintoi* seed, in the form of a mixed-cropping experiment in which seed production of forage *Arachis* was evaluated in monoculture and in association with the locally important small-holder crops maize and bush-beans. Seeding density for *Arachis*, maize, and beans was 20, 25, and 80 kg ha^{-1}, respectively, in both the respective monoculture and mixed-cropping treatments. Sowing was simultaneous and a complete fertiliser dressing was applied for crop establishment. Beans, maize, and *Arachis* were harvested 3, 4 and 12 months after sowing, respectively. Results showed a varying degree of competition effects of the associated crops. Seed yields of forage *Arachis* were in the mixtures significantly lower (5.2 and 5.4 t ha^{-1} for the association

with maize and beans, respectively) than in monoculture (6.3 t ha^{-1}). Bean yields suffered a significant 34% reduction when associated with forage *Arachis* in comparison with monoculture (630 vs. 960 kg ha-1. Maize yields, however, were not affected (4.6 vs. 4.8 t ha^{-1}). For each of the three crops, the mixed-cropping yields are well within the range of the respective monoculture yields reported for the Colombian coffee zone. It is therefore concluded that mixed cropping of maize or beans with forage *Arachis* is a feasible option of commercial seed production of the latter in the Colombian coffee zone; in addition to increasing the income of smallholders, such systems may well be conducive to a more steady supply of forage *Arachis* seed to the market, and lower seed prices.

[1] *Universidad Nacional de Colombia, Palmira, Colombia.*
[2] *Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.*
[3] *University of Hohenheim, Stuttgart, Germany.*

Establishing Fall-Seeded Red Clover for Seed Production With Cereal Cover Crops

W.C. Young III and H.W. Youngberg[1]

In Oregon, USA, red clover (*Trifolium pratense* L.) seed crops are usually established in late summer and early fall. Because of the initial slow growth of red clover, the potential for soil erosion during fall and winter months is high. There is an interest in establishing red clover with cereal cover crops to provide ground cover during the fall and winter until clover can produce sufficient vegetation to cover the soil surface. This study was conducted to investigate the response of red clover seed production when established with wheat (*Triticum aestivum* L.) or oat (*Avena sativa* L.) cover crops. Cover crops were inter-seeded with red clover in late summer and subsequently killed by herbicides during the following winter. In the two experiments conducted, red clover seed yields during the first and the second year after establishment were not reduced by the cover crops. Red clover hay yields during the first cutting in each year were also unaffected by the cover crops. These results suggest that red clover may be fall-seeded with wheat or oats as a cover crop without deleterious effects on seed productions. Some evidence also suggested that oat is less competitive with red clover than wheat.

[1] *Department of Crop and Soil Science, Oregon State University, Corvallis, OR, USA 97331-3002.*

Alfalfa (*Medicago sativa* L.) Seed Production Under Different Row Spacing and Plant Population in the Seeding Year.

R.B. Medeiros, A.V.A. Jacques and C. Nabinger[1]

Alfalfa is the main forage legume grown economically for hay in Rio Grande do Sul (RS). One of the major problems of alfalfa growers is the continual supply of sufficient high quality seed for sowing. Local seed production for this crop has always been low and unreliable. A lack of sufficient information about crop management could be one factor related with the success of growing alfalfa for seed. This research was designed to determine the response of potential seed yield (PSY) and agricultural realised seed yield (ARSY) to different row spacing and plant population of alfalfa in the seeding year. Interrelationships between seed yield and yield components and others agronomic traits were also looked for. The experiment was carried out at the University Agronomic Experimental Farm, located in Eldorado do Sul (30ºS, 51ºW), from September 4, 1992 to January 18, 1993. Climate is humid subtropical with hot summers (Cfa type) and the soil is a lateritic hydromorphic, Plinthaqualt (Plinthosols) type, with a sandy texture. Alfalfa cv. Crioula, a population well adapted in RS, was used in this study. A split plot experimental design with four replicates, with spacings of 30 and 90 cm between rows in the main plots and 17, 61 and 89 plants m^{-2} in the sub-plots, was used. Ten stems were chosen at random from each plot at the seed harvest to determine the seed yield components. Each stem was divided into main branch (MB) and other branches (OB). The seeds were separated into live seeds and water-damaged seeds and the yield components expressed in that way. The PSY and the ARSY were significantly ($P<0.05$) affected by plant population. The PSY were 5951, 4274 and 3733 kg^{-1} ha for 17, 61 and 89 plants m^{-2}, respectively. This relationship was expressed by a negative linear regression ($r^2=0.84$). The PSY and ARSY were positively related to the CGR of floral organs suggesting that plants subjected to a lower competition level allocate assimilates preferably to reproductive structures. Racemes and thousand seed weight of MB and OB were both negatively associated with populations and had the greatest effect on ARSY. Water damaged seeds represented 53, 65 and 63% of the live seeds for 17, 61 and 89 plants m^{-2}, respectively. Narrow row spaced plants favoured seed vigour, and low population enhanced seed germinability. The percentage of pod set (around 30%) and seed set (around 27% - including the water-damaged seeds) did not vary within treatments limiting any further increase in the ARSY. It is thought that high temperatures associated with excess of rain during flowering and seed formation could limit insect pollination and enhance physiological losses of pollinated flowers and embryo abortion. It is suggested that the plant growth and development was limited by uncontrolled factors that penalized the effect of the treatments. The leaf area duration and the LAI were low for the species. Nutrition, water uptake and other factors can be associated with it.

[1] *Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil.*

Current Status and Prospects of Alfalfa Seed Production and Use of Seed in Egypt

M.El-Nahrawy and A. Rammah[1]

Alfalfa seed production does not meet the high demand for cultivation in Egypt and neighbouring countries, despite the fact that the most ideal alfalfa ecotypes present in the oases (about 21,000 ha) have evolved under hot desert conditions where they lost their winter hardiness and became adapted to high temperatures. Frequently introduced cultivars from other countries are not as well adapted as local ones. Local cultivars forage productivity outyielded that of the best introduced cultivars by more than 26%, averaged over years and locations. Alfalfa seed production has usually been of secondary importance to forage production in Egypt. Demands for seed have increased since the expansion of cultivation in reclaimed desert areas (more than 63,000 ha) in response to the lack of forage production. Egypt is producing about 400 tons of alfalfa seed annually and about 90% of this quantity is exported to the Gulf Countries. High demand for Egyptian alfalfa seed is due mainly to the good forage performance in those countries. On the other hand Egypt is importing about 150 tons of alfalfa seed yearly to meet the high demand for cultivation of new land. The challenge of increasing the seed yield of alfalfa at a reasonable cost involves the mastering of all known principals and applying them under environmental and field conditions. Adequate pollination, proper insect control, proper irrigation practices, varieties with high seed yielding characteristics, the adjustment of cultural practices to local conditions and a harvest and seed moderation period relatively free from rain are the most fundamental factors influencing seed production. Even though most of these factors which influence alfalfa seed production exist in Egypt, seed production is considered very low (average about 100 kg ha^{-1}). Factors involved in this contradiction will be clarified. Moreover, the forage performance of already existing cultivars will be discussed in more detail.

1 *Forage Crops Research Institute, Agricultural Research Centre, Giza, Egypt.*

Perennial Grass Seed Production in Some Mountain Regions of Serbia

T. Zorica and R. Mladenovic[1]

In 1990-1992 the effect of sowing rate and fertilizer on seed yield of domestic perennial grass varieties was studied in the hill and mountain regions of Kopaonik at 1100 m altitude. Highest seed yield was registered for cocksfoot (*Dactylis glomerata* L) variety K-6 in the third experimental year, with a 3-year average of 545 kg ha^{-1} and NPK application in the ratio 120:60:60 kg ha^{-1} respectively at a 40 x 40 cm spacing. In the second experimental year the highest seed yield (610 kg ha^{-1}) was reported for timothy (*Phleum pratense* L.) variety K-15 at a sowing distance of 40 cm and NPK application in the ratio 100:50:50 kg ha^{-1} respectively. Red fescue (*Festuca rubra* L.) variety K-14 had a 3-year average seed yield of 642 kg ha^{-1} at a row spacing of 15 cm and NPK application in the ratio 80:50:50 kg ha^{-1} respectively. In the hill and mountain regions of Serbia seed production may be expected to be improved because the seed yields reported showed little difference compared with those from the lowland region.

1 *Agriculture Research Institute Srbija, Forage Crop Centre, Krusevac, Yugoslavia.*

Thinning of White Clover for Second Year Seed Harvest

A. Lomholt[1]

When growing white clover (*Trifolium repens* L.) in Denmark usually only one seed harvest is taken, because in the second year the yield drops below what is economically viable. An explanation for the low yield could be that fewer stolons and flowers can emerge when the plant density is high. An experiment was designed to try and clarify whether thinning could be a way of getting a higher seed yield in the second year harvest of white clover. Different kinds of thinning were tried and the yields were measured in years 1990-1993. The following treatments of the clover were applied: band spraying with MCPA in September or May; harrowing in September or May; spraying with Diquat-dibromid (Reglone) in May; defoliation in May; and a control (untreated). All the treatments affected the yield negatively. An 8% reduction was found after spraying with Diquat-dibromid and the defoliation in May. The most significant decrease (31%) was found after the harrowing in May. Drought during the three years of experimenting might have affected the yield. The results of this experiment show that thinning of white clover needs further investigation, before the method has any potential for second year seed production.

1 *Danish Institute of Plant and Soil Science, Department of Cereals, Seeds and Industrial crops, Ledreborg Allé 100, 4000 Roskilde, Denmark.*

Relationships Between Vegetative and Reproductive Growth in a Four Year Old Stand of Caucasian Clover (*Trifolium ambiguum*, M.Beib) cv. Monaro

P. Coolbear, M.J. Hill[1] and F. Efendi[2]

The potential of Caucasian clover as a perennial, stress tolerant pasture species has not been fully exploited in New Zealand owing to a shortage of available seed. This study was undertaken in order to increase understanding of the reproductive strategy of this plant as a basis for improving management practices in the seed crop. The protracted flowering pattern of this clover largely results from the continuous production of reproductive shoots from crowns; rhizomatous shoots remaining vegetative during the first year of production. Two classes of crowns were identified, the larger, main crowns producing an average of 7.4 reproductive shoots per crown at peak flowering compared to smaller, secondary crowns producing only 1.7 shoots. Inflorescences produced from main crowns gave higher seed yields than those from secondary crowns. These results give preliminary indications that, because of the nature of crown development, stands of Caucasian clover may take several years to reach their maximum reproductive potential, and inter-row cultivation is an inappropriate management practice for this seed crop.

1 *Seed Technology Centre, Department of Plant Science, Massey University, Palmerston North, New Zealand.*
2 *Faculty of Agriculture, Bengkulu University, Indonesia.*

Improvement of the Seed Yield in Alfalfa (*Medicago sativa* L., *M. varia* Mart.) and Fenugreek (*Trigonella foenum graecum* L.) by Means of Nodule Bacteria (*Rhizobium meliloti*) Inoculation.

N.A. Provorov[1], Y.D. Soskov[2] and B.V. Simarov[1]

A possibility to increase the seed yield in 22 alfalfa cultivars by means of the nodule bacteria (*Rhizobum meliloti*) inoculation was studied in four independent field trials. In two trials conducted at Crimea (South Ukraine) with the *Medicago varia* cultivar "Vesiolopodolanskaya", inoculation with *R. meliloti* strain CXM1-105 (UV-mutant of the commercial strain 425a selected for improved symbiotic efficiency) lead to an increase in seed yield over the uninoculated control by 39-60%, while with parent strain 425a this increase was only 18-28% ($P<0.05$). In the *M. varia* cv. "Kamalinskaya" (analysed at Krasnoyarsk, Central Siberia) the seed yield increased after inoculation with strain CZM1-105 by 33%, with strain 425a - by 24% ($P<0.05$). In the collection of 20 alfalfa cultivars (12 - *M. varia*, 8 - *M. sativa*) tested at Tumen, West Siberia, inoculation with strain CXM1-105 increased seed yield (on average) by 14%, and with strain 425a by 11%. In this experiment, intercultivar variation for the responsiveness to the *R. meliloti* inoculation was revealed: increases in seed yield ranged from 3% to +24% (after inoculation with strain CXM1-105). On the third year of alfalfa growth the increase in seed yield which resulted from rhizobia inoculation was higher than the second year (12% and 3% on average for 4 strains, 20 cultivars). In fenugreek (*Trigonella foenum graecum*) cv. Nakhichevanskaya (trial conducted at Azerbaijan), the highest increases of seed yield (by 60 - 83%) were obtained after inoculation with *R. meliloti* strains 851 and 852 which were isolated from nodules of this legume species. Inoculation with the *R. meliloti* strains isolated from the other host species (alfalfa and sweet clover) did not result in significant improvement of the fenugreek seed yield. When a collection of 30 wild-growing and cultivated fenugreek genotypes was grown in the field, a significant correlation was found between seed yield and number of root nodules ($r = +0.77$; $P<0.01$). The data suggested that the ability of the legume species to enhance their seed productivity as a result of rhizobia inoculation can be improved by selection of both plants and bacteria.

1 *Research Institute for Agricultural Microbiology, St. Petersburg, Russia.*
2 *Research Institute for Plant Breeding, St. Petersburg, Russia.*

Herbage Seed Research in the Past and the Present at the Agricultural Faculty of the Martin-Luther-University Halle-Wittenberg

W. Schöberlein[1], W. Lampeter[2], H. Matthies[3] and K. Förster[1]

Intensive forage cropping and the establishment of turf for different purposes presupposes that high-quality seed is available. However, efficient propagation of herbage crops and turf grasses requires specific production technologies and know-how to achieve high yields of good seed quality. This has always been the objective of over 35 years of grass seed

research at Halle University (from 1961 to 1969 also at the University of Leipzig). The present research projects continue with this tradition, but they include also aspects of seed and genotype testing, forage crop breeding and environmentally acceptable plant cultivation.

In the past research activities were mainly concentrated on the following experimental questions:

- optimum seed rate and nitrogen input
- influence of different harvesting methods on harvest losses and seed quality
- relationships between vegetative growth of the grass shoots in autumn and generative shoot development in spring as well as possibilities to control it
- effect of sowing methods on seed yield formation and of the cutting date on seed quality and losses
- relationships between seed moisture content at the moment of harvest and drying conditions on the germination capacity
- suitable cover crops and the effect of seedbed preparation
- application of growth regulators in grass seed production
- efficient N fertilization with consideration of the N_{min}-content in the soil
- N uptake by grasses from different soil layers (^{15}N experiments), precrop effects of seed grass stands
- reduction of the N-issue in field bean crops by grass undercrops.

The present research activities include:

- endophytes in grass seed material and grass crops in Central Europe
- electrophoretic methods for seed and variety descriptions and identification.

The field experiments required for these investigations have been preferably carried out in the experimental station of Seehausen (near Leipzig) which is also part of the Martin-Luther-University (northern latitude 51° 25', eastern longitude 12° 14").

1 *Martin-Luther-Universität Halle-Wittenberg, Landwirtschaftliche Fakultät, Institut für Acker- und Pflanzenbau, E.-Abderhalden-Str. 25, 061087 Halle, Germany.*
2 *Lausicker Str. 64, 04299 Leipzig, German.*
3 *Martin-Luther-Universität Halle-Wittenberg, Lehr-und Versuchsstation Seehausen, Str. d. Völkerfreundschaft, 04448 Leipzig, Germany.*

Seed Production of *Setaria sphacelata* in Corrientes, Argentina.

S.M. Altuve, M.A. Ramirez and R.R. Ramirez[1]

Setaria sphacelata cultivars Narok and Kazungula stand out among the tropical grasses, because of their fodder production capacity, in humid and semi-humid environments, with eventual frost and low fertility soils, characteristic of the subtropical Argentine. Nevertheless, their propagation is limited because of the scarce availability of seed. The objective of the present experiment was to evaluate the seed yield of both cultivars on red soils of the humid subtropics. The yields of pure germinable seed of S. Narok and S. Kazungula were 140 and 152 kg ha^{-1}, respectively. These results are considered satisfactory for these cultivars, and therefore, it can be concluded that the red soil areas of Corrientes province are suitable for the seed production of *Setaria* cultivars.

1 *Tecnicos E.E.A. INTA de Mercedes, Corrientes, Argentina C.C.Nº 38 (3470) Mercedes, Corrientes, Argentina.*

An Alternative for the Harvest of Tropical Forage Seeds

S.M. Altuve, M.A. Ramirez and R.R. Ramirez[1]

The development of seed production activity in cattle areas of the subtropics is limited because of the lack of infrastructure, principally the one relating to seed harvest and benefits. The objective of the present experimentation was to compare in *Setaria sphacelata* and *Paspalum guenoarum*, the quantity and quality of seed collected with the mechanical beater versus manual harvest. The results showed that the amount of seed collected manually was superior. But, nevertheless, the amount of pure germinable seed collected was similar in both methods. This result suggests that the mechanical beater is appropriate for these species, especially in areas where the availability of manual labour or automatic harvesters are expensive or scarce. The seed collected with a mechanical beater presents less problems for drying and cleaning.

1 *Tecnicos E.E.A. INTA de Mercedes, Corrientes, Argentina C.C.Nº 38 (3470) Mercedes, Corrientes, Argentina.*

Effective Technology for Cleaning Seed

H. Schwanz and K. Ribouni[1]

The continuing recession in agriculture requires the usage of all reserves. The processing of seeds after the harvest has been neglected. A minimization of the expenditure was not carried out with a necessary scientific reason. The PETKUS WUTHA company developed with long-term analysis of the process the basis for the minimization of technical equipment. The determination of the average demands on the quality of work of cleaning machines, and the reproducible performance testing of these machines, were the prerequisites for the development of universal cleaners. With these universal cleaners effective changes of the technology after the harvest are possible. Compact machines and variable technologies offer a better economy by means of a minimization of the used technique. The elements of the separation are equally strong in the complex. This allows smaller machine sizes with lower screen areas and simultaneously a powerful air suction in the seed processing. The PETKUS-universal cleaners facilitate the management of every cleaning grade, from the precleaning of damp, unprocessed grass seeds to the final seed-cleaning. This specific process allows a variable and effective technology. With this technology either the processing in one line, from precleaning via drying to the final seed cleaning, or a parallel processing from different species or sorts of seeds after the harvest are possible.

1 *PETKUS WUTHA GmbH, Eisenacher StraBe 42 99848 Wutha-Farnroda, Germany.*

Electrophoretical Characterization of Grass Seed

K. Förster[1]

Numerous grasses are out-pollinating species. Their individuals reveal different genetic, morphological and physiological forms within the species boundary. The breeding process leads to a phenotypical adjustment of the individuals within a cultivar as well as among different cultivars. In seed testing it can be difficult to determine purity and identity of grass cultivars by means of morphological traits. Electrophoretical methods which help to investigate proteins, i.e. the primary gene products, can be used successfully for discriminating of cultivars on the condition that bulked seed samples are tested. Testing bulked seed samples produces protein banding patterns which represents an "overall" combination of soluble single seed proteins. What happens if seeds of another cultivar are admixed to a defined sample? *Festuca ovina* cultivars A and B have similar seeds and thousand seed weights. Samples of well defined pure cultivars (A, B) and samples of B with 5 to 95% admixture of A were electrophoretically analysed. Isolelectric focusing of chlorethanol-soluble seed proteins (400 seeds per sample) was carried out at pH 2-11 in ultrathin-layer polyacrylamide gels (UTLEIF). Proteins were stained with Coomassie Blue. The banding patterns of the cultivars A and B differed in the range of pH 8 to 9.5 in five positions. Three of them, a single band, found only in B (pH 8.7), a single band, found only in A (pH 8.5), and a defined group of distinct bands between pH 8.3-8.5 in A could be used as a marker for the behaviour of the mixtures. Admixtures of 20% A in B and 10% B in A could be proved. If both cultivars were mixed 1:1, we got a "novel" banding pattern. With increasing content of A the typical protein bands of this cultivar dominate the mixture patterns. The investigation of bulked seed samples of out-pollinating species by means of UTLIEF allows the discrimination of cultivars. The banding pattern is the sum of single seed protein effects. The frequency of the single seed protein patterns changes among the cultivars. That is why a low percentage of admixtures is not definitely detectable in bulked seed samples. On the other hand, admixture rates can simulate another cultivar. Therefore, it seems to be interesting for seed testing to consider the single seed profile of grasses if there is a well-founded suspicion of mixture or admixture.

1 *Martin-Luther-Universität Halle-Wittenberg, Landwirtschaftliche Fakultät, Institut für Acker- und Pflanzenbau, E.-Abderhalden-Str. 25, 06108 Halle, Germany.*

Seed Quality and Yield of Forage Grasses

N.L. Polozova and V.V. Kostitsyn[1]

While analysing non-germinated seeds of forage grasses saprophytic fungal species are usually found: *Alternaria, Penicillium, Cladosporium, Epicoccum, Cephalosporium* etc. It is very difficult to draw conclusions about the reason for the non-germination of these seeds. Before seed treatment with fungicides, it is advisable to carry out a phytopathological examination e.g.: by germination of seeds in petri plates on solid agar medium. Experiments were carried out with the seeds of *Festuca pratensis* Huds. from the 1993 season. Strong infection of leaves by *Drechslera dictyoides* (Drechs.) Shoemaker in 1993 induced us to study the composition of fungi on seeds of *Festuca pratensis*. Seeds were soaked in water for 3 hours, then they were distributed in cuvettes in groups of 200 seeds on wet filter paper in two

variants: 1 - the cuvette was closed by glass; 2 - the cuvette was opened. The cuvettes were placed under the lamps LD-40 for 48 hours at 22-25ºC. Then they were tightly closed with light proof covers for 24 hours and incubated at 12-15ºC. The seeds were examined under the microscope after 4 and 10 days. The pathogenic species *Drechslera dictyoides* was detected "under glass" on 17.5%, "without glass" - on 7.5%, and with the standard method - on 4.5% of seeds. The mould fungi did not vary in all variants of the experiment. In selecting fungicides for seed treatment it is necessary to take into account their metabolic effect on inner infection, which can be fully revealed under the field conditions, and undoubtedly it influences increasing seed productivity.

1 *Agrarian University, St. Petersburg, Russia.*

Quality Parameters of Egyptian Clover Seed Lots Used on Newly Reclaimed Area in Egypt

M. El-Nahrawy[1], I.A. Hanna[2], E. El-Barougy[2], H. Yousri[2] and O. Niemelainen[3]

Egyptian clover (*Trifolium alexandrinum* L.) is the main forage in Egypt occupying about half (900000 ha) of the cultivated area in the winter season. Increasing the productivity of Egyptian clover per unit area is very important to overcome the shortage of forage in Egypt. Seed production of Egyptian clover has been of secondary importance to forage production. The production of certified seed is not practised. Most growers use their own farm-produced seed, or buy seed from local dealers who procure their supplies from country markets and mix it without proper attention to quality parameters and to the sources of origin of the seed lot. To highlight the quality characteristics and to evaluate the productivity performance of the seed used, a seed survey was conducted in Ismailia Governorate. Seed samples were collected just prior to the winter season in 1994. Thirty two samples were collected from farmers and from local seed traders. In addition two seed lots of certified seed from highly productive cultivars were included in the study for comparison. The study of the quality characteristics included the test of germination percentage, 1000 seed weight, weed seed content, test of insect infestation and test of disease infection. The productivity evaluation was conducted in a randomized block field trial on sandy soil. The yield and weed infestation were measured. The germination percentage was high in all samples (range from 85% to 100%). The purity (% weight clean seed) content of collected samples varied from 90% to 100%. In addition aborted seed was found and ranged from 0 to 2.5%. The most common seeds were of species of *Lactua, Brassica, Sinapis,* and *Melilotus*. The 1000 seed weight varied from 2.5 to 3.3 g. Fungal disease was detected in several samples. *Alternaria alternata, Aspergillus flavus,* and *A. niger* were detected with the highest frequency. Percentage of infestation with *Brucibius trifolii* Most. ranged form 0 to 7%. The quality parameters as well as results from the field study are presented in more detail.

1 *Forage Crops Research Institute, Giza, Egypt.*
2 *Ismailia Agricultural Research Station, Ismailia, Egypt.*
3 *Egypt-Finland Agricultural Research Project, Ismailia, Egypt.*

Determination of Viability and Longevity of Seeds by Luminescent Method

T.V. Veselova, V.A. Veselovskii[1] and W. Schoberlein[2]

Delayed luminescence (DL) of air-dry seeds can be used as an indicator of seed quality. This method allows measuring DL from individual seeds as well as from the seed lot. In seeds, seed fragments and biopolimers DL are known to decrease with moisture content. Changes in seeds which occur during natural and accelerated ageing were reflected in subsequent loss of vigour and DL increase. The increase of the luminescence is caused by changes in seed biopolimers, leading to a decrease in their ability to hold water. The relationship between germination and DL level is similar to the relationship between germination and electrolyte leakage. Correlation coefficients range from -0.78 to -0.98 for different seeds. Monitoring DL of seeds makes it possible to evaluate their quality and storage capability.

1 *Lomonosov State University, Biological Faculty, Department of Biophysics, 119899, Moscow, Russia.*
2 *Martin-Luther-Universitat Halle-Wittenberg, Institute fur Pflanzenzuchtung und Saatgutwirtschaft Emil Abderhalden Str., 25 D-06108, Halle (Saale) Germany.*

Processing Chaffy Grass Seeds for Improved Handling

D.S. Loch and G.L. Harvey[1]

Many useful herbage and amenity grasses, particularly tropical and subtropical species, have 'chaffy' seeds characterised by a range of appendages: awns, sterile spikelets, and surface hairs or bristles. Such seeds are light and bulky, and do not flow freely because the individual units tend to become entangled. These difficulties add to costs of seed harvesting, cleaning, testing, storage and transport, and make it impossible to deliver the individual seed units uniformly through conventional seeders. There is considerable diversity within the grass family *Poaceae* in the structure and form of dispersal units (diaspores, 'seeds'), particularly those of the more chaffy-seeded species or genera. There is also a range of equipment that can be used to process chaffy grass seeds, and which can be broadly grouped according to method into threshing and sizing, rubbing and winnowing, burning, and aerodynamic conditioning. Different methods however, suit different seed structures. The most difficult seeds to process satisfactorily are those with extremely long awns that tend to break up into shorter fragments (e.g. *Heteropogon, Spinifex*), with short surface hairs or bristles that are not easily removed without also taking all of the floral 'husk' surrounding the caryopsis (e.g. *Cenchrus, Danthonia, Monachather, Thyridolepis*), or from species that form complex floral structures such as involucres (e.g. *Cenchrus, Spinifex, Themeda*). Even within the structurally similar *Bothriochloa-Dichanthium* complex, species with more surface hairs (e.g. *D. sericeum*) contrast with less hairy species that are easier to process (e.g. *B. insculpta, B. pertusa, D. aristatum*) and may require different processing methods. Trimming of the normal chaffy seed units is generally preferable to the complete removal of caryopses, especially where caryopses are tightly held within the surrounding floral husk. Leaving protective husks around the caryopses reduces the risk of physical damage during processing and improves the reliability of field establishment under marginal moisture conditions. Processing also should be carried out at a sufficiently high rate per hour to minimise the cost of treatment and make it commercially viable. Market acceptance ultimately depends on the value that consumers place on convenience and ease of handling versus any costs added through processing.

[1] *Department of Primary Industries, Gympie, Queensland, Australia.*

Solar Drying of Grain and Seed

K. Ribouni[1]

A solar plant with air collectors was built in 1994 in Freising near Munich. This solar plant is used for the drying of grain and seeds. About fifty measuring instruments were installed and a monitoring program was started. This project is sponsored by the Ministry of Research and Technology and carried out by the PETKUS WUTHA company in cooperation with the Institute of Agricultural Engineering of the Technical University of Munich, the Institute of Agricultural Engineering of Bornim and IST Energietechnik Kandern-Wolbach. The solar plant has an area of 160 m^2. The single glazed collectors are an integrated part of the roof and conventional roofing tiles are not necessary. The inclination of the plant is 30º facing south-west. The collectors are equipped with under-airflow absorbers and with a back insulation. The solar plant heats outside air, which is used for a grain dryer. The dryer takes up to 10 tonnes of grain and has an output of 1-2 t h^{-1}. The system is designed for an airflow rate of approximately 8000 m^3 h^{-1}. The dryer does not work during the night. Initial results on the plant showed an increase of the ambient air temperature of 20-30 degrees. This corresponds with an efficiency of 40%. By a solar radiation of 800 W m^{-2}, the effect of the solar plant amounts to 50-55 kW. Calculations showed that the solar energy part was 37% of the energy demand for drying in 1994 (the rest coming from conventional sources).

[1] *PETKUS WUTHA GmbH, Eisenacher StraBe 42 99848 Wutha-Farnroda, Germany.*

X-Ray Radiography for Rapid Assessment of Seed Quality

M.J. Hill and K.A. Hill[1]

Standard laboratory methods for seed analysis of various crop plants are time consuming and several attempts have been made in the past to develop quicker seed testing procedures. The X-ray radiography method for analysis of seed quality is based on the principle that the different parts of a seed, such as the testa, endosperm and embryo, absorb soft X-rays to different extents and can consequently be differentiated in an X-ray photograph. It is therefore possible to recognise the structure and extent of development of the embryo and endosperm; to detect mechanical injuries such as internal cracking and embryo disorientation; and to detect damage caused by pests and pathogens. The small dose of X-rays delivered to the seeds does not affect their viability. By comparing the germination capacity with the structure of the seed, and particularly the effect on germination of any deviation found from the normal anatomy of the seed, it is

possible to assess the quality of the seed from X-ray photographs alone. X-ray analysis has been found to be very suitable for assessing both physical (anatomical potential) and physiological (germination potential) seed quality of most crops. This method is quick, accurate and causes no harm to the seeds. It can show the presence of various aspects of physical seed quality (*viz.* mechanical damage, weathering damage, insect damage and under-development) and seed can be analysed in a short time. Compared with other quick tests, such as the tetrazolium test, the X-ray radiography method is generally very accurate, repeatable and closely correlated with standard germination methods. It also has the advantage of being non-destructive, the same seeds being able to be used for a germination test after the analysis is complete, since no damage of any sort is caused. The use of a water presoak and barium chloride soaking prior to X-ray exposure can also be useful in estimating seed viability. This pretreatment creates a good contrast between impregnated (dead) and unimpregnated (viable) seeds. The pattern of barium chloride impregnation in seeds can also provide an estimate of seed vigour, as nectrotic areas can be correlated with the extent of living tissue in seed.

1 *Seed Technology Centre, Department of Plant Science, Massey University, Palmerston North, New Zealand.*

Scarification Methods for the Effective Reduction of Hardseededness in Leucaena (*Leucaena leucocephala* (Lam.) De Wit)

L.N. Merana[1], P. Coolbear, J. Hampton, C.R. McGill[2] and D.S. Loch[3]

The effectiveness of concentrated sulphuric acid and boiling water in reducing hardseededness in leucaena (*Leucaena leucocephala*) was compared in this study, using a range of seed lots of varying initial hardseededness and seed quality. Although immersion in boiling water was sufficient to remove some hardseededness in most lots, some seeds in the population became damaged when the treatment was prolonged to break the imposed dormancy of the harder seeds in the population. Sulphuric acid scarification was a slower process and works via the general erosion of the seed coat rather than a heat-shock effect causing eruption of the lens plug. Acid treatment was usually much safer in terms of preserving seed viability and vigour (measured by seedling growth or accelerated ageing techniques). Twenty minutes immersion in 98% sulphuric acid was effective in most cases and is recommended as a standard laboratory seed testing protocol. However, because of considerable variation in response among seed lots, a small sample from each lot should be pre-tested to ensure that this treatment time is appropriate.

1 *Department of Environmental and Natural Resources, Research Services, 1515 L & S Building, Roxas Boulevard, Ermita, Manila, The Philippines.*
2 *Seed Technology Centre, Department of Plant Science, Massey University, Palmerston North, New Zealand.*
3 *Department of Primary Industries, P.O. Box 395, Gympie, Queensland 4750, Australia.*

Stimulation of the Immune System of Cereals by Coherent Electromagnetic Radiation. Application of the Effect to Design a Safe Agricultural Technology.

A. Budagovskii, O. Budagovaskaya[1] V.A. Veselovskii and T.V. Veselova[2]

Administration of fungicides decreases the adaptive potential of plants and gives rise to fungicide-resistant races of pathogens. Hence, designing pesticide-free technologies for protecting plants against fungal pathogens is an actual problem. The pretreatment of seeds with the coherent radiation of gas lasers significantly decreased pathogen activity. For example, when oat seeds were challenged with the root rot fungal agent *Fusarium avenacium* before sowing, the number of nonviable plants increased twofold. This effect, however, was absent in plants grown from seeds that had been pretreated with laser radiation. It should be emphasized that laser radiation did not suppress the fungal pathogen, but enhanced the immune response elicited by the pathogenic organism, and thereby reduced the number of nonviable plants. Based on these data we have designed an agricultural laser device for presowing seed treatment without the use of fungicides. The field application of the device on a pilot scale has demonstrated its economic effectiveness, high reliability (life-time of 5 years), and performance (5 to 7 tons of seeds per h).

1 *Department of Biophysics, VNIIG, Michurinsk, Russia.*
2 *Biology Faculty, Moscow State University, Moscow, Russia.*

The Study of *Festuca* and *Lolium* Seeds by X-Ray and Accelerated Ageing Methods

V.N. Savin, M.V. Archipov and L.P. Gusakova[1]

Vitality and development of caryopsis in *Festuca* and *Lolium* were studied by X-Ray with straight X-Ray magnification, use of a densitometer and a morphonmeter for examination of X-Rays, and accelerated ageing of seeds. The seeds can be very different in the extent of caryopsis development. Seeds can be different in external sizes by up to 2 times, while the caryopsis can be different in the extent of development by 5-12 times. Densitometric analysis of X-Rays revealed 4 seed groups, distinguishing in the extent of development of the caryopsis - from "empty" seeds (without embryo and endosperm) to the seeds of biologically full value. There were up to 14% "empty" seeds within studied lots. The presence of internal cracks is characteristic of *Festuca* and *Lolium* seeds. In different lots the number of seeds with cracks in the caryopsis varied from 20% to 90%. Accelerated ageing of seeds had more influence on germination viability than on germination percentage. The seeds with low germination capacity aged faster than seeds with initially higher germination capacity.

[1] *Agrophysical Research Institute, St Petersburg, Russia.*

Electron Treatment of Seed, ETS process - an Alternative Technique for the Control of Seed-borne Pathogens

C. Pfitzner, R. Heinzmann and F. Scholze[1]

Electron Treatment of Seed (ETS process) is a new technique of physical seed dressing using the biocidal action of low-energetic electron beams for the control of seed-borne pathogens. The principle of this technique is to limit the action of the electrons to the near-surface layers of the caryopsis (pericarp and testa); the embryo situated underneath is not reached by the electrons. Existing research work is directed on the optimization of fungicidal but phytotoxically harmless parameters for electron treatment of wheat seed and their corroboration in laboratory, greenhouse, phytotrone and field trials. The controlled pathogens are *Tilletia caries* (DC.) Tul. and *Septoria nodorum* Berk.

[1] *06484 Quedlinburg, Germany.*

Aspects of endophyte in Ryegrass (*Lolium perenne*) Seed Production

M.P. Rolston and J.S. Rowarth[1]

The presence of endophyte within ryegrass confers resistance against attack by Argentine stem weevil (ASW). However, it also causes ryegrass staggers in stock at some times of the year. Thus it has become important to know the endophyte status of ryegrass (*Lolium perenne*) pasture, with high- and nil-endophyte seed being in demand. The production and maintenance of both high- and nil-endophyte ryegrass can be influenced by both field and post-harvest operations. The use of fungicides as a seed treatment or for rust control can reduce endophyte status. In field trials multiple applications (2 or 3 times) of tebuconazole (Folicur) reduced endophyte by 30% in some cultivars. Propiconozole (Tilt) or a single tebuconozole application has no effect on endophyte status. Endophyte status of "Grasslands Nui" perennial ryegrass did not affect seed yield in the first year of production, even with a moderate infestation by ASW. However in the second year, nil endophyte plots with a history of high nitrogen (120-180 kg ha^{-1}) and irrigation suffered severe vegetative tiller loss during winter. In contrast, high-endophyte plots and non-irrigated nil-endophyte plots with lower nitrogen inputs were not damaged. The damage was not attributable to ASW or any other insect pest. An alternative explanation is that there was an interaction between the damaged ryegrass (which was more vigorous than the ryegrass which had not received nitrogen and irrigation) and one or both of the two post-harvest herbicides used (atrazine and chlorpropham). Seed yield was reduced in these plots and research into the physiological aspects of the damage is continuing. Post-harvest operations, such as seed storage, influence endophyte viability, with rapid losses occurring when seed moisture content is above 11.5%, and temperature is above 5°. In a long term seed-storage trial, high endophyte was maintained for 10 years only when seed was stored at 8.5% SMC at 0 or -15°. Genebanks are recommended to renew high-endophyte seed stored in these conditions on a 10 year cycle. In commercial seed stores endophyte remains viable for from 0.5 to 5 years depending on SMC.

[1] *AgResearch, P.O. Box 60, Lincoln, New Zealand.*

Effects of Endophyte-Infected Varieties of *Festuca pratensis* on Seed Production

W. Schöberlein, St. Eggestein and M. Pfannmöller[1]

Meadow fescue (*Festuca pratensis*) was found to harbour an endophytic fungus, *Acremonium uncinatum*. An experiment was designed to evaluate the effect of the endophyte in three meadow fescue varieties under field conditions in Germany at our experimental station near Leipzig. In order to choose appropriate seed samples we screened numerous seed lots for the presence of the endophyte. Seed samples with at least one high and one low infection level from each of the three *F. pratensis* varieties were used. The field trial was established in August 1993. Eight weeks after sowing endophyte infection resulted in a greater plant number per plot, indicating that infected meadow fescue had a higher field emergence rate. The higher plant number led to higher tiller numbers in the following year. Visual evaluation of the plots after the winter showed that endophyte infestation led to a more densely established sward. Seed yield of the plots with endophyte infected meadow fescue in 1994 was significantly higher than the yield of endophyte-free plots. Microscopical screening of the seed harvested in 1994 showed that its infestation level was different from that of the material sown in 1993, but the factors influencing the infection levels have to be examined more in detail. Another experiment with single plants from 2 of the 3 *F. pratensis* varieties showed that the seed yield from endophyte-infected plants was significantly higher. There was also a trend that endophyte infection may lead to higher tiller numbers. In this study the effect of the different genotypes within the varieties was not separated from the endophyte status. There are, however, hints that meadow fescue plants infected with *Acremonium uncinatum* may be more resistant to pathogens and more vigorous than noninfected plants.

[1] *Institut für Acker-und Pflanzenbau, Martin-Luther-Universität Halle-Wittenberg, E.-Abderhalden-Str. 25, 06108 Halle, Germany.*

Effect of Endophyte on Seed Weight, Germination, Tillering, Biomass, Heading Date, and Forage Yield of Annual Ryegrass

L.R. Nelson, G.W. Evers, J. Crowder and S.L. Ward[1]

We have known for several years that the fungal endophyte (*Acremonium lolii*) could be found in annual ryegrass (*Lolium multiflorum* Lam.). The endophyte normally found in annual ryegrass is thought to be a different endophyte than the endophyte that is present in perennial ryegrass. Forage quality reduction of annual ryegrass due to presence of the endophyte (E^+) has not been reported in the literature. We have reported a slight, but significant reduction in greenbug (*Schizaphis graminum* Rondani) injury in E^+ annual ryegrass. This study was conducted to determine if some agronomic characters in annual ryegrass are affected by the presence of endophyte. For several years we have monitored and selected for and against endophyte in our annual ryegrass breeding populations. Therefore we now have populations (same genetic background), which vary from 7% E^+ to as high as 100% E^+ plants. Characters studied were percent germination, rate of germination, date to heading, interaction between vernalization and endophyte, tillers produced per plant, plant biomass in the greenhouse and total forage yield in the field. Results indicate little or no effect of the endophyte in our annual ryegrass for 100 seed weight, percent germination, germination rate, or total forage yield. In a greenhouse study there was a trend for increased tillering where E^- plants developed 9 tillers and E^+ plants produced 10 tillers/plant. An interaction between length of vernalization x presence of endophyte indicated that E^+ genotypes had a shorter time (9 days) to heading when subjected to no cold, or a short cold period. When these same genotypes were vernalized, the heading dates for the E^+ and E^- genotypes were similar. There was also a slight increase in weight/plant of E^+ genotypes compared to E^-genotypes.

[1] *Texas A&M Agricultural Research and Extension Center, Overton, TX 75684 USA.*

Alkaloid Production in Endophyte Infected *Lolium perenne*

E. Oldenburg[1]

Several studies on the occurrence of endophytic fungi in European ecotypes and varieties of grasses confirmed the presence of fungal endophytes in *Lolium* and *Festuca* species. However, only little information is available so far on the production of alkaloids in infected grasses from locations in Central Europe compared to New Zealand and USA, where enrichment of alkaloids in endophyte positive ryegrass and tall fescue is frequently observed. As these alkaloids may have beneficial effects on the resistance of grasses against fungal pathogens and herbivores, but detrimental effects on the health of grazing animals, more knowledge on the occurrence of these metabolites in grass-endophyte associations is necessary. Lolitrem B is a neurotoxic alkaloid produced by the endophytic fungus *Acremonium lolii* in ryegrass. Endophyte infected ecotypes of *Lolium perenne* (origin: Germany) and the variety Ellett of *Lolium perenne* (origin: New

Zealand, endophyte positive), all cultivated at an experimental field in Braunschweig (FAL), were examined for Lolitrem B in this work. The quantitative determination of Lolitrem B was carried out by high performance liquid chromatography (HPLC). In the German ryegrass ecotypes Lolitrem B was produced in similar amounts as compared to the variety Ellett of *Lolium perenne*. The values varied within the vegetation period, increasing in spring, being highest in July/August (maximum 1430 µg kg^{-1} dry matter) and declining afterwards. Possible effects of this alkaloid enrichment on animal health will be discussed.

1 Institute of Grassland and Forage Research, Federal Agricultural Research Centre (FAL), Braunschweig-Völkenrode, Germany.

Decline of Endophyte Viability During Seed Storage

V. Míka[1] and J. Bumerl[2]

The viability of *Acremonium coenophialum* Morgan et Gams, a naturally occurring endophyte in tall and meadow fescue varieties grown in this country, was followed regarding the conditions of seed storage. Storing seed in sealed polythene bags for 8 years at 5% moisture and ambient temperatures (5 - 20°C) did not affect endophyte viability nor seed germination. On the other hand, if the seed lots were stored in jute bags at the same temperature, 14% seed moisture (at the beginning), and 60 - 70% air relative humidity in a seed warehouse, the endophyte viability decreased from initial 72 to 8% and seed germination from 95 to 8% over 8 years. Commonly, the decline is accelerated by hot and humid conditions. It is concluded that special attention to the storage of seeds of turf or artificially inoculated grass varieties should be paid. Anyway, it would be useful to indicate the percentage of viable endophytes on a dated seed label.

1 *Grassland Research Station CZ-569 43 Jevícko, Czech Republic.*
2 *Plant Breeding Station, Cerveny Dvür, CZ-391 56 Tábor 4- Mésice, Czech Republic.*