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International Herbage Seed Group
IHSG

9TH INTERNATIONAL HERBAGE SEED CONFERENCE

Pergamino, Argentina

October 31 to November 2, 2017

PROCEEDINGS & ABSTRACTS

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WELCOME LETTERS

Dear colleagues,

I am very pleased to welcome you to the 9th International Herbage Seed Group Conference at Pergamino, Argentina.

This is a great opportunity to bring together producers, agronomist and researchers in the area of forage seed production from all over the world to share knowledge and experiences and to talk about common areas of interest.

Herbage Seed production in Argentina has increased in the last years. Our exports have been going up while the imports have descended. At the same time, the demand for good quality forages has increased since cattle raising activities have been improving. This imposes and opportunity and a challenge for seed producers to improve their production systems and to us, researchers, to find new ways to help and contribute to this goal.

We sincerely hope this conference will open the door to ideas and new areas of research and will give us, researchers and producers from South America, new insights to pursue further objectives to augment yield and quality of our seed production systems.

I am very grateful to the local organizing committee for the hard work, responsibility and commitment in getting things ready for the conference.

I am indebted to our sponsors for their support and contribution and to the organizing institutions for the possibility of putting together this conference.

We deeply hope this conference will come up to your expectations and that you all have a productive conference and an enjoyable stay at our wonderful country.

Yours sincerely,

Maria Andrea Tomás
President
Local Organizing Committee of the 9th IHSG Conference

Dear colleagues,

We welcome delegates to the 9th IHSG Conference at Pergamino. This is the first time the Conference has been held in South America and is the culmination of four year's work by Andrea Tomas and the local organizing committee. Our last conference was in 2015 at Lanzhou, China and these conferences were the first time that the IHSG had moved outside of Europe, North America and Australia/New Zealand. I have attended 7 of the previous 8 IHSG Conferences and a number of Workshops and I look forward to our time together in Pergamino.

The value of Conferences is not only in the ideas presented in formal presentations both conference oral and posters, but in the informal sharing of ideas with other researchers, extension workers and seed growers. I encourage all delegates to make contact with two or more other international delegates that are working in areas that interest you. I have seed industry friends in Argentina that I first met at the 1st IHSG Conference in Denmark in 1987 and have kept in contact over the following year.

I have been a regular visitor to Argentina and Uruguay over the past four years and have had the opportunity to visit many seed production farms/estancio's. The post conference tour will give you a taste of seed and crop production in Argentina. Seed production in Argentina is both well established and with considerable scale. Higher spring/summer temperatures and shorter daylengths than the traditional herbage seed production areas of Oregon, Denmark and New Zealand that presents management challenges for seed growers. I know you will enjoy both the culture of South America and your interaction with seed researchers, seed company agronomists and extension advisors and seed growers who you will meet and interact with this week.

Many thanks-muchas gracias to the Local Organizing Committee and sponsors who are helping to support the conference. Enjoy your week.

Best wishes

Phil Rolston
President IHSG

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ORAL PRESENTATION ABSTRACTS

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SESSION 1

SOUTH AMERICA FORAGE SEED PRODUCTION

EXPERIENCES IN URUGUAYAN SEED PRODUCTION

J.D Foley[1], S Mari[1], M.F Trejo[1], C Rossi[1*]

Herbage seed production in Uruguay, especially tall fescue and with less importance annual ryegrass, have played a key role in the development of the country's proprietary seed market. As markets for these crops as well as forage legumes and forage oats have grown, so too has a sophisticated seed production industry with considerable scale. Total Uruguayan herbage seed production in 2016 of all species was 60,000 ha, most of which was consumed in the domestic seed markets. Pioneering seed growers who have accepted the challenge of producing proprietary cultivars, instead of common varieties such as Estanzuela 284 and Estanzuela Tacuabé, are often rewarded with high quality forage and therefore greater meat per hectare. Similar to New Zealand, seed crops are grazed with livestock until closing (Zadock's Growth Stage 31). These growers' experiences became the benchmark for other local farmers to emulate; thereby creating the demand for proprietary seed. To a large extent, herbage seed production in Uruguay remains within pastoral farms and a vehicle to transition from low quality pastures to improved pastures. One of challenges has been to encourage farmers to think of their crops in two distinct phases: meat production and seed production – each requiring its' own investment. However, there are often conflicting opinions on where the investment should be made owing to climate variability. Adopting strategies to produce reliable seed yields in a high rainfall environment that can experience severe droughts and high temperatures during critical development phases often sways growers to favour meat production. As a consequence, ryegrass seed yields are similar to what they were 10 years ago with a range of 500-1200kg.ha^{-1} and an average yield of 700kg.ha^{-1}. Fescue seed yields although increased by near two or three times the historical average is still low and can be improved. Over a period of 15 years, a uniquely Uruguayan seed production system has evolved to become more reliable at producing higher quality seed. Key to this has been the development of infrastructure to support the industry, investment in technology and machinery, upskilling growers and developing specialist seed production agronomists. Central Government has further facilitated the growth of the industry by enacting certified seed legislation, having a robust seed certification processes and requiring winter cover crops to be grown in all agricultural areas. Today, farmers are optimistic about the future of the industry.

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EVOLUTION OF THE SEED MARKET OF TEMPERATE FORAGE SPECIES IN ARGENTINA.

J. González Bonorino*

The consumer market for temperate forage seeds has shown a significant change in the last two decades in Argentina, linked to a process of acquisition of new technologies in the activity. The form of seed supply today differs from the past. At the beginning of the series analyzed, the ratio between "imported seeds" and "certified domestic seed production" was 60/40, observing in recent years that this ratio is 20/80, mainly due to imports substitution. In this sense, the balance of foreign trade at the national level has become positive since the 2012/2013 cycle. At the starting point of the series, exported seed was 700 MT increasing to 6,840 MT at the end of the analysis. The volume of seed exports was 68% greater than imports at the end of the series. Argentina has a long tradition of participation of cultivars of public domain in its seed market. Today there are 944 varieties registered in the National Cultivars List of the National Institute of Seed (INASE). Of those, 45.1% (426 cultivars) belong to the species *Medicago sativa* L. (Alfalfa), 46.3% (437 cultivars) are grass species and 8.6% (81) are legumes such as clovers and *Lotus*. In terms of forage seed production, Argentina has made a substantial change in the last decade by adapting technologies developed and applied by the main producing countries, for each of the forage species. We must continue to develop access to international markets as well as expanding domestic consumer markets. Availability of new varieties and a further increase of seed yields are needed to compete with the most developed countries in the world.

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ALFALFA SEED PRODUCTION IN ARGENTINA

D. Basigalup*

With nearly 3.5 million ha, Argentina is at present one the largest alfalfa producers in the world. Approximately 80% of the total alfalfa area is cultivated under rain-fed conditions for dairy, beef and hay production in the Pampas Region, while the remaining 20% is devoted to hay and seed production under irrigation in the Patagonia (Río Colorado and Río Negro Valleys), Western (San Juan and Mendoza) and Northwestern (mostly Santiago del Estero) regions. In these regions, seed yields may range from 120 to 700 $kg.ha^{-1}$, with an average of 300 $kg.ha^{-1}$. There is also an eventual seed production under rain-fed conditions in some areas of La Pampa, Buenos Aires and Chaco provinces, where seed yields are quite variable and highly dependent upon climatic conditions (basically absence of rains), with a general average close to 150 $kg.ha^{-1}$. During the last 4 years, domestic seed production provided about 31% (2014/15) to 58% (2013/14) of the market needs. This is a remarkable difference from the historical figures, in which local production was providing only 20-25% of the market. The reasons for this change are related to some extent to the difficulties for importation imposed from previous government policies, the increases on international seed prices, and the fluctuation of the US dollar/Argentine peso exchange rate. In addition, the decrease in the planting area, particularly due to the crisis in the dairy sector, contributed to create a difficult scenario for the forage seed companies, preventing imports in several cases. Argentina imported 2,32, 2,78 and 1,17 MT of raw alfalfa seed in 2014, 2015 and 2016, respectively. Major countries of origin of these imports were Australia (48% in 2016, 51% in 2015 and 43% in 2014) and USA (29% in 2016, 36% in 2015 and 51% in 2014). Other seed providers were Canada, France and Italy. Total (domestic + imported) certified raw seed was 3,85 MT in 2016, 3,02 MT in 2015 and 4,03 MT in 2014. Since over 90% of the alfalfa sold in Argentina is coated seed (with an average of 35% weight increase), the previous figures become 5,20, 4,05 and 5,43 MT of total certified seed, respectively. In addition, an average of 0,9 MT of carry-over from previous year and an estimated 0,80 MT of illegal ("white bag") seed must be added for each season. Environmental conditions of alfalfa seed production in Argentina are not optimal mainly due to summer and fall rains. However, yields could be improved by increasing irrigation efficiency, using better pollination practices and more adequate harvesting equipment, utilizing a more efficient weed and insect control, and using more appropriate crop management practices.

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SUBTROPICAL FORAGE SPECIES IN ARGENTINA, CURRENT BACKGROUND AND FUTURE PERSPECTIVES.

R. Pemán*

Argentina has large areas located mainly in the North and Center of the country, with suitable environments for the forage production of subtropical species. Currently there are several research groups from INTA and Universities working on the development of new cultivars of grasses and legumes in agreement with Seeds Companies and with the support of official institutions. By doing so, Argentina has positioned itself among the countries that generate new forage cultivars of subtropical species. At present, there are 19 different subtropical forage species with 44 cultivars registered in the National Cultivars List of INASE (National Institute of Seeds). Regarding seed production, Argentina produces mainly P*anicum maximun* cv *gatton*, *Chloris gayana*, *Cenchrus ciliaris*, *Panicum coloratum*, *Digitaria eriantha* and *Setaria anceps*. The production of gatton panic seed is variable from year to year, and is generally carried out on the same lots destined to cattle grazing. This is mainly due to the low seed price. Other species of higher value in the market are produced in a professional way in environments where they compete with agricultural crops. Seed companies have adequate equipment for seed processing and important advances have been made in seed technology, improving the efficiency and speed of implantation of these forage species. The possibility of producing meat in environments with climatic and edaphic limitations through the use of these species, and the inclusion of new subtropical legumes, anticipates a growing demand of seed for the near future. However, it is necessary to continue the research and development of new technologies in order to increase the current seed production to meet the market demand.

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ADVANCES IN TALL FESCUE SEED PRODUCTION IN URUGUAY.

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Tall fescue (*Festuca arundinacea* Schreb.) as a naturalized plant has excellent heat and drought tolerance properties and modern plant breeding activities have greatly improved grazing preference and animal performance. As a result of its favourable characteristics, tall fescue is now a major component of perennial pastures in Uruguay. This forage adoption has transferred into a significant seed production opportunity for the country. Second only to annual ryegrass, tall fescue seed production is around 2.000 MT per year in Uruguay. Tall fescue is well adapted to producing reliable seed yields within a country which experiences extreme climatic variations – ranging from heavy rains to drought. Since 2005, Uruguayan seed producers and agronomists have successfully increased the average seed yield from 180 kg.ha^{-1} to 500 kg.ha^{-1} across all regions; while exceptional seed growers are consistently achieving greater than 1000 kg.ha^{-1}. The increase in seed yields has come about through the collaboration between growers, specialist seed production agronomists and research organizations – based both regionally and internationally. While the collaboration has increased the professionalism of seed producers, it has also helped facilitate the adoption of 'best management practices.' Changes in the crop management include strategies to improve seed purity and reduce cleaning losses via the use of herbicides and paddock selection. Moreover, a focus on lowering shattering/harvest losses has resulted in closely monitored crops at cutting/swathing time followed by investments in modern equipment. An improved understanding of the crops' nutritional requirements for seed yield, particularly the role of autumn nitrogen, grazing management and irrigation have all provided significant advancements in seed yield; while improving the reliability of Uruguayan tall fescue seed production.

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SEED PRODUCTION OF TEMPERATE FORAGE LEGUMES IN SOUTHERN BRAZIL

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The Campanha Region, located in the Pampa Biome, in southern Brazil, was known in the 70s for its great production of seeds of forage legumes, mainly birdsfoot trefoil (*Lotus corniculatus* L.), white clover (*Trifolium repens* L.) and red clover (*T. pratense* L.). Several factors contributed to the disruption of this production chain and disorganization of the formal market, such as the marketing of low-quality cheap seeds. The Brazilian Seed Law, published in 2005, strengthened programs for the genetic improvement of forages in public research institutions. Since 2010, the Embrapa team has started to establish partnerships to motivate the resumption of legume seed production, taking advantage of the experience accumulated by the producers of the Campanha Region, with the objective to improve the impact of the new forage cultivars on the livestock activity, by using seeds of high quality. Some producers have shown interest in production methods to improve seed quality, and are being followed by researchers. The objective of this interaction is to identify and prioritize the limiting factors, and overcome them with existing technologies or generating new knowledge through applied research. The main problem was the contamination of the production fields by plants of weed species, which made it difficult to obtain seed lots meeting legal quality standards. In this case, technology transfer actions were developed, related to the process of sowing and weed control. Additionally, the research focused on sowing methods and the biology of weed species. Another important aspect is the management of defoliation, which can help control weeds, standardize flowering, and also generate extra income from the sale of hay. There are currently producers within the official production system, and the seeds of temperate forage legumes produced in Brazil are beginning to move into the formal market.

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SESSION 2

SEED PRODUCTION SYSTEMS

TEMPERATE GRASS SEED PRODUCTION IN A MIXED FARMING SYSTEM IN ARGENTINA

M. L. Zapiola, H. Zapiola*

Los Húsares Viejo is the division of a family owned business that grows grass seed, both forage and turf, within a mixed farming system. We farm 1700 ha in two farms between Balcarce and Pieres, SE of Buenos Aires Province, Argentina. The region has a temperate humid-subhumid climate with an average rainfall of 950 mm, an annual average mean temperature of 13.8°C (annual average max of 19.7°C and annual average min of 8.2°C) and a frost-free period of about 150 days from October to May. Soil types are mainly Typic Argiudolls and Petrocalcic Argiudolls, with an organic matter content of 5-6.8%, 16-28 ppm available N and 9-26 ppm available P. Our crop rotation strategy includes wheat, barley, corn, soybean, sorghum, sunflower, canola, potatoes, perennial and annual ryegrass, orchardgrass, tall fescue, and perennial pastures for grazing cattle. In general, we have three to four years of perennial grass seed production or perennial pastures followed by four to five years of agriculture. The annual ryegrass seed crop is considered as an alternative to wheat or barley within the rotation. We use no-till or minimum tillage. Seed yields vary between 500-700, 300-400, 500-700 and 800-1200 $kg.ha^{-1}$ for perennial ryegrass, orchardgrass, tall fescue and annual ryegrass, respectively. One of the main challenges is weather, as late frosts in November and heavy rains during harvest season frequently occur. Another limitation is the availability of combines. Although we do most of the swathing with our own equipment, we contract for combining. Despite these challenges that some years affect our yields, we see grass seed production as a good alternative for our region and a good complement to the annual crops we have in the rotation.

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RECOGNITION OF SPECIES OF *STYLOSANTHES* (*LEGUMINOSAE*). STUDY TRIP TO HAINAN ISLAND, CHINA.

R. O. Vanni*

This consultancy, which originates the trip to Hainan Island, arises from the need of CATAS Chinese Academy of Tropical Agricultural Science, technicians to obtain good identifications of different species of *Stylosanthes* that they have incorporated and already have under cultivation. *Stylosanthes* is an American genus with 25 species, of intertropical distribution, with some extratropical species that arrive until the province of Cordoba (Argentina) and Uruguay. They are working with species like *Stylosanthes guianensis*, *Stylosanthes scabra*, both South American and of very wide distribution in America, called in our latitudes the "alfalfas of the subtropics". How do they use them? - They grow them between different leaves of perennial crops, fruit trees or not, thus avoid weeds, incorporate nitrogen, avoid erosion and at a time of growth they make cuts. They prepare a food with a protein base of 10% to feed goats, meat, poultry, ducks, chickens, pigs and fish. They have worked so far, mainly with *Stylosanthes guianensis*, but the program aims to include other South American *Stylosanthes* species that can live in the mainland of China, more adapted to temperate climates. Hainan Island is the only place in the country where they can grow megatermic legumes, tropical or subtropical, with average temperatures of 24ºC. Our collaboration was to indicate which species can be included, that live more in the South of our country like *Stylosanthes hippocampoides*, and *S. rostrata* , which has a distribution area that includes Cordoba in the case of the first species and northern? Uruguay, in the case of *S. rostrata*. As a final phase of our collaboration we were invited to write a book related to *Stylosanthes*, which will deal with two chapters on taxonomy, distribution and possible uses as fodder.

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INTERCROPPING OF ALFALFA FOR SEED PRODUCTION AND SUNFLOWER

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In the agroecological conditions of Serbia (southeastern Europe) alfalfa for seed production is most often sown as a sole crop in the spring with a seed rate of 15-17 kg.ha^{-1}. First year seed yields are usually very low and thus first year alfalfa is often used for hay, only. Alfalfa seeds can be harvested in the following years where the first cut is used for hay and seeds are harvested at the second cut. Weed control is an especially important issue in establishment of seed alfalfa stand. These are the reasons why there is almost no specialized broadcast sowing of seed alfalfa. The aim of this study was to assess the possibility of establishing seed alfalfa intercropped with sunflower. Sunflower was expected to provide economically satisfying yields in the first year and more efficient weed control. The plan for the following years is to produce alfalfa seeds. Imidazolinone-tolerant (IMI) sunflower hybrid Rimi PR was used for intercropping in order to provide effective weed control using Pulsar 40 herbicide. Sunflower was sown at a row distance of 70 cm, with crop density of 60,000 plants per hectare. After this, alfalfa was sown with grain drill at row distances of 25 cm, 50 cm, and 75 cm, and seeding rates of 8 kg.ha^{-1}, 4 kg.ha^{-1}, and 2.8 kg.ha^{-1}, respectively. Alfalfa stand was established in 2016 and 2017 using a split plot design in four replications. Crops were protected from broad-leaved weeds with the application of Pulsar 40 (1.0 l.ha^{-1}) when sunflower was at the phase of 4-6 leaves, and alfalfa was at the phase of the second trifoliate leaf. Sunflower and alfalfa seed yield components and seed yield were measured. Significant differences were recorded for alfalfa plant number per 1 m^2. There were 194.0, 95.2, and 72.8 alfalfa plants per 1 m^2, respectively.

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FORAGE SEED PRODUCTION. DOING ALL THE PROCESS, FROM BREEDING TO COMMERCIALIZATION: A CASE STUDY FROM THE UNIVERSITY OF THE NORTHEAST, ARGENTINA

M.H. Urbani*

The development of subtropical forage cultivars from wild materials is a long-lasting process with multiple phases, where the selection from natural variability, crosses and subsequent selection are outstanding. One of the most valuable grasses genera for its richness in variability and adaptation to grazing conditions is *Paspalum*. The collection of wild material, the knowledge of its variability and the forage production potential of some introductions, encouraged the selection and introduction to cultivation of some highlighted materials through different strategies. In the case of Cambá FCA (*P. atratum*) and Chané FCA (*P. guenoarum*), both cultivars were selected from natural populations, while cv. Boyero UNNE (*P. notatum*) was obtained by crosses between a sexual and an apomictic plant. The cultivars were selected by: forage production, seed production, apomictic reproduction, pest resistance and plasticity in forage use. In the case of cv. Cambá, license agreements were made with seed companies to produce and commercialize seeds, including own seed produced by FCA and other producers. For the cv. Chané, the FCA developed a project that involved seed producers with a small farmer's structure, thus integrating these producers into the FCA forage breeding plan. The development of new forage cultivars is of special interest for medium and large agricultural enterprises. The FCA, through this system, not only includes small agricultural establishments but also encourages productive diversification in the region of the Argentine Northeast. The FCA facilitates the initial seed and advises the small producers to produce seed demanded by farmers of larger productive scale. A new FCA agreement with a seed company, keeps these small producers as actors in the system.

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SEED YIELD OF BRACHIARIA HYBRIDS IN CORRIENTES PROVINCE.

G.D. Mc Lean, M.R. Tamborelli, R. Ramirez, M. Ramirez[*]

Some experiences in northeastern Argentina show that seed production of tropical and subtropical forage species is feasible in this area. This work had the objective to evaluate the phenology and seed production of some hybrids of Brachiaria in the East of Corrientes province. The assay was carried out in Alvear (Corrientes) during 2 years with 3 materials of Brachiaria (denominated experimental 1, 2 and 3). Field plot (randomized block design with 3 replications) were fertilized at 1st year with 48 kgN.ha^{-1}, 51 kgP_2O_5.ha^{-1} and 28 kgK_2O.ha^{-1} and in the 2nd year with 46 kg.P_2O_5.ha^{-1} y 46 kgN.ha^{-1}. Plant cover and flowering percentage (%Cov and % Flo), pure seed yield (PSY in Kg.ha^{-1}) and percentage of stripped inflorescences (%SI) at the harvest time were registered in both years. ANOVA and the Tuckey test were analyzed with INFOSTAT (2009). A mean of 80 %Cov was obtained on 1st year and 90% on 2nd year. On the 1st year the Exp. 2 had 50 % Flo 96 days after sowing date, Exp.1 after 127 days and Exp.3 at 188 days. The harvest in Exp. 2 was done in March and in Exp. 1 and 3 in June. The %SI was significantly different ($p <= 0.05$) between materials (16.2 % in Exp.2; 29.9 in Exp.3 and 42.5 % in Exp.1). In PSY the significant difference were between Exp.3 and 1 with Exp. 2 (170.3 and 102.2 kg.ha^{-1} vs. 8.2 kg.ha^{-1} respectively). In the 2nd year of the study, the % Flo was similar to the 1st year, with early and indeterminate flowering on Exp. 2 and late flowering on Exp. 3. Harvest of all materials at the 2nd year was done in June, and no statistical difference were observed between hybrids for % SI or PSY (34.1 kg.ha^{-1} of pure seed for Exp. 1; 37.5 in Exp. 2 and 80.1 for Exp. 3). It was concluded that is feasibly to obtain good seeds yields with these hybrids in this region, taking into account the percentage of stripped inflorescences and the extension and time of flowering of each material.

Key words: seed production, flowering, forage seeds, Northeastern Argentina

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OPTIMAL RADIATION DOSES TO INCREASE SEED AND FORAGE YIELD IN HYBRID *UROCHLOA*

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Radiation sensitivity studies were performed on hybrid *Urochloa* (H-2050) to determine optimal radiation doses to increase seed yield and improve fodder attributes of economic interest. The study was conducted in the experimental area of Semillas Papalotla SA de CV based in Oaxaca, México. The seed used for sowing was irradiated with cobalt-60 (Co60) at Instituto Nacional de Investigaciones Nucleares (ININ) using eight doses that constituted the treatments to be evaluated (0, 50, 100, 150, 200, 300, 450, 600 Gy). Three seeds per pots (20 x 20 cm) were sowing and 15 days later they were transplanted to another pot (40 x 40 cm) leaving only one plant per pot, finally, 30 days later they were transplanted to the field. A completely randomized design with balanced sub-sampling with five replicates was used and the data was analyzed using the statistical software SAS for Windows 9.4; the comparison of means was done using Tukey at 5% (A total of 528 plants with wide phenotypic diversity was observed between plants at different radiation doses treatment-1, plants outstanding were significantly ($P<0.05$) higher than control. The highest average plant height (186 cm) was observed at 150 Gy, while biomass production at doses of 50 Gy were higher ($P<0.05$) by 26 % than control. The highest seed production plant^{-1} (45 g) was determined at 200 Gy and was 18% higher than control. All variables showed a negative effect to irradiation with doses above 200 Gy, except for tiller density. Based on our results, we conclude that optimal radiation doses in hybrid *Urochloa* are between 50-200 Gy.

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EFFECT OF GIBBERELLIN (GA3) ON STIMULATION OF SEED GERMINATION IN ANNUAL RYEGRASS (*LOLIUM MULTIFLORUM*) AND WHITE CLOVER (*TRIFOLIUM REPENS*)

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Gibberellins are a type of plant growth regulator that are naturally present in plants in different concentrations and forms. They play an important role in plant growth and development such as seed germination, stem elongation, flowering and breaking of hardseededness in legumes. The objective of this assay was to determine how the use of gibberellic acid (GA3) affects germination and early development of seedlings. Two species were used, annual ryegrass (*Lolium multiflorum*) cv Bill Max and white clover (*Trifolium repens* L.) cv Aquiles. The germination percentage (GP) of the annual ryegrass and white clover seeds was determined using four replications of 100 seeds. Treatments included 1) seed irrigation with a concentration of 0.04% GA3; 2) seed irrigation with 0.08% of GA3; 3) seed soaking in 0.04% GA3 followed by rinsing and irrigation with water; 4) standard laboratory treatments to break dormancy specific for each species: watered with KNO_3 in ryegrass and CO_2 enriched environment in white clover both followed by 3 days at 5-7 °C; and 5) a water control. Temperature and humidity conditions were controlled throughout the experiment. Daily visual scores were carried out to determine the number of germinated seeds and seedling morphology in the germination chamber after 4 and 14 days at 20°C from the start of the experiment. After germination seeds were classified as either hard (white clover), fresh (annual ryegrass) or dead. Seedlings were evaluated and classified into "normal" and "abnormal" categories. Soaking annual ryegrass seed with 0.04% GA3 solution increased germination speed and development. In white clover, the standard laboratory treatment was the most effective at breaking seed dormancy. The use of GA3 at field level needs to be further assessed.

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EFFECT OF PRE-HARVEST DESICCANT APPLICATION ON THE PHYSIOLOGICAL QUALITY OF RYEGRASS SEEDS

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The desuniformity of the ryegrass seed maturation process makes it difficult to define the ideal time for harvesting. Pre-harvest desiccant application can minimize this problem, allowing better harvest planning, greater efficiency in the use of machines and control of weeds that persist at the end of the crop cycle. However, the effects of pre-harvest desiccant application on the physiological quality of ryegrass seeds are not fully understood. The objective of this study was to verify the effect of pre-harvest desiccant application on the physiological quality of ryegrass seeds. The seeds used came from a 6 ha area, established with ryegrass, BRS Ponteio cultivar, at Embrapa Pecuária Sul, in Bagé/RS, Brazil, in the 2015/2016 growing season. Four days prior to seed harvesting, 1.5 $l.ha^{-1}$ of paraquat was applied in half of the area. Four replications of 100 seeds were evaluated for germination at 0, 15, 30, 45, 60 and 90 days after harvest. The pre-harvest desiccant application impaired the physiological quality of ryegrass seeds, with a 40-50% reduction in germination when compared with the untreated check. This effect was not expected, as several seeds of other crops showed no reduction in their physiological quality in response to the paraquat application at pre-harvest.

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IMMERSION IN SODIUM HYPOCHLORITE AND AN IDEAL TIME TO EVALUATE THE PHYSIOLOGICAL QUALITY OF RYEGRASS SEEDS

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Italian ryegrass (*Lolium multiflorum*) is a widely-used grass for winter pastures in Southern Brazil. Seed dormancy, in this species, is fundamental for avoiding germination under unfavorable conditions. To manage seed production and use, seed quality tests, performed by a network of Official Seed Testing Laboratories are required. Laboratory methods to overcome dormancy are constantly perfected. The objective of this study was to evaluate the suitability of the sodium hypochlorite (NaOCl) method to overcome seed dormancy in ryegrass, and determine the best time to evaluate physiological quality. Seeds were produced at Embrapa Clima Temperado, Capão do Leão, RS, Brazil. Seeds were stored in the laboratory (min 19.3°C, max 28°C, mean 24°C). Evaluations were performed 10, 25, 40, 55 and 70 days after-harvest (DAH). The methods evaluated were: pre-chilling (5°C) for 7 days in KNO_3; soaking in 0.5% NaOCl for 24h, followed by drying at 45°C for 6h; soaking in distilled water for 24h, followed by drying at 45°C for 6h; and untreated control. There was an interaction between storage period and methods for seed germination percentage. At 10 DAH, no method was efficient to overcome dormancy, but after 25 DAH, both KNO_3 and NaOCl methods were. After 70 DAH, all methods, including the control, showed similar results, proving that dormancy was naturally overcome. The ideal time to evaluate physiological quality of ryegrass seeds is 25 DAH. Seed soaking in 0.5% sodium hypochlorite for 24h, followed by drying at 45°C for 6h was as effective as pre-chilling in KNO_3 to overcome seed dormancy in annual ryegrass after 25 DAH.

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SEED FUNCTIONAL TRAITS IN TALL FESCUE CULTIVARS AFFECTED BY THE SELECTED NON-TOXIC FUNGAL ENDOPHYTE AR584

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Tall fescue is one the most important forage grass in temperate regions worldwide. Its natural association with fungal endophytes (*Epichloë*) usually makes it unsuitable for livestock feeding due to toxic alkaloids. Since the symbiosis increases stand persistence and productivity, current breeding strategies involve re-inoculation with non-toxic or novel endophytes. As a vertically transmitted microorganism, the endophyte presence in the seed potentially affects functioning aspects relevant for farmers and seed companies. We conducted a set of experiments aimed at understanding the effects of the fungal endophyte AR584 on aspects of seed functioning of the tall fescue cultivars INIA-Aurora (LE14-84)§ and Taita£. Using highly infected (Aurora: 100% and Taita: 83%) and endophyte-free seed lots for each cultivar, we studied seed longevity through standard accelerated ageing experiment (40°C and 75% RH), and germination responses to temperature and water availability. Germination was evaluated under two alternating temperatures (10º-20º; 15º-25º; 12/12h), four constant temperatures (5º, 15º, 20º and 25º), and four water potentials (0, -0.5, -1.0 and -1.5MPa; PEG6000). Response to constant temperature and water availability was characterized by the thermal-time and hydro-time models, respectively. Endophyte presence only reduced seed longevity in Taita cultivar. In both cultivars, rate of seed germination was lower in endophyte-infected seeds than in endophyte-free seeds, except for Aurora at 5ºC which showed an opposite response. Base water potential was less negative in endophyte-infected seeds of both cultivars, resulting in lower rate and total germination as water limitation was higher. Our results show that the differential response of cultivar seeds to the inoculated endophyte should be considered to predict seed and endophyte viability decay under storage, and to select for the best "cultivar by endophyte" combination for a given ecological condition.

§INIA Aurora: GIL-INIA (GIL: Grasslands Innovation Technology, 50% AgResearch, 50% PGW) £Taita: Gentos.

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FUNGAL ENDOPHYTE (*EPICHLOË COENOPHIALA*) SURVIVAL IN SEED PELLETING TREATMENT OF FRIENDLY ENDOPHYTE-INFECTED TALL FESCUE (*SCHEDONORUS ARUNDINACEUS*) SEED

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Tall fescue is a temperate forage grass widely used in Argentina and Uruguay for perennial pastures. An experimental Gentos tall fescue line was inoculated by AgResearch with AR584, a novel, animal -friendly endophyte strain of *Epichloë coenophiala*. Fescue seed produced and marketed in Argentina and Uruguay is usually subjected to a process of pelleting. During the process, the seed is subjected to high levels of humidity (above 80%) and temperature (30°C). Exposure to these conditions may affect endophyte viability since it is more sensitive than seed viability to high levels of humidity and temperature. Because of this, it is necessary to assess the impact of pelleting to guarantee the future commercialization of animal-friendly endophyte-infected tall fescue cultivars in the Argentina and Uruguay market. The project took place at the Gentos experimental station in Pergamino, Buenos Aires. The objective was to determine if this cultivar inoculated with AR584 can be treated by pelleting without affecting the endophyte viability. Seeds of this line containing high levels of the endophyte AR584 (89%) were treated with standard pelleting methods used in commercial seeds. Endophyte levels in the seed were determined before and after seed pelleting by microscopy, and viability was assessed using the grow out method on tillers. Additionally, the seed had two treatments of pelleting, with and without fungicide. Endophyte levels in the seed were reduced in the seed from 89% to 79% in both pelleting treatments. In addition, endophyte viability was severely affected, decreasing from 79% to 10% in the treatment without fungicide and to 9% in the treatment with fungicide as determined by the grow out method. As the standard pelleting process compromised the novel endophyte viability in the seeds tested, different pelleting methods need to be evaluated.

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CENTRAL LABORATORY ANALYSIS SEEDS OF ARGENTINA

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The International Seed Testing Association (ISTA), based in Switzerland and founded in 1924, has as a vision the uniformity in seed quality evaluation worldwide. For this, ISTA develops and publishes standard procedures for seed testing and accredits laboratories worldwide following the premises of its accreditation standard. Currently, it has member laboratories in 70 countries, conforming a laboratory network that focus on the same aim. ISTA Rules for seed testing are internationally accepted for seed sampling and testing. This facilitates seed trading nationally and internationally, and also contributes to food security. In relation to the accreditation it grants, by definition, "accreditation" is the procedure by which an authorized organization formally recognizes the competence to carry out specific tasks. That is why ISTA verifies whether the audited laboratory is technically competent to perform seed testing. For this, the laboratory must show in addition to its technical competence that it has implemented a quality system that meets all the requirements established by the ISTA Accreditation Standard. When accredited, laboratories are authorized to issue seed lots certificates (Orange International Seed Lot Certificate) and seed sample certificates (Blue International Seed Sample Certificate). For this reason, when reporting the results of seed analysis on the Orange International Certificates, the issuing laboratory ensures that the sampling and analyzes have been carried out in accordance with International ISTA Rules. It is also worth mentioning that the methods included in the ISTA Rules have been previously validated internationally and approved by ISTA members.

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CONTROL OF CERTIFIED FORAGE AND LAWN SEEDS IN ARGENTINA

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The Certification and Control Directorate has among it functions, the National Certification of the varietal identity of all the propagation organisms, and the International Certification of seeds imported or exported according to the standards of the Organization for Economic Co-Operation and Development (OECD) and the Association of Official Seed Certifying Agencies (AOSCA). The seed certification is a legal process of production and multiplication of varieties registered on the National Registry of Cultivars and/or in the National Registry of Property. This seed complies the established minimum requirements in the rules of group or species procedure for its multiplication and commercialization. The species of the forage group that our country includes at the moment as certified are the following: *Bromus catharticus* Vahl., *Dactylis glomerata* L., *Festuca arundinacea* Schreber, *Lolium multiflorum* Lam., *Lolium perenne* L., *Medicago sativa* L., and Trifolium repens L. In Argentina, genetically modified seeds are under commerce since 1996, but no forage or lawn species has reached the permits of commercialization, nevertheless, during more than ten years field trials with genetically modified *Medicago sativa* and *Paspalum dilatatum* were carry out. To reach the commercial approval of any transformation event, almost four years of field trials must be completed in order to withdraw an environmental impact assessment, the evaluation of human and animal consumption aptitude, and obtain a favorable decision for market impact. Argentina does not grant partial permits for commercialization.

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HOW DO VARIABLE TEMPERATURES AFFECT SEED GERMINATION IN SHEEPGRASS?

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Sheepgrass (*Leymus chinensis* (Trin.) Tzvel) is one of the most important forage grasses in China. Based on different genotypes, we studied the optimal conditions for seed germination, and the regulation of seeds germination in variable temperature. The results indicated that germination rates were variable among different genotypes of Sheepgrass, ranging from 36.67% to 95%. The germination rates at constant temperatures of 16℃, 20℃, 22℃, 28℃ and 37℃ and variable temperature of 28℃ (12 h) / 16℃ (12 h) after 18 days were tested, and he results show that the optimum germination condition was 28℃ (12 h) / 16℃ (12 h). To further study the duration of variable temperatures affect seed germination, seeds were germinated under variable temperature conditions for 1, 2, 3 days, then transferred to constant temperature of 28℃, and the germination rates were also determined after 18 days. The results indicated the longer the variable temperature treatment, the higher germination rate was. Furthermore, the seed germination rate increased very significantly ($P<0.01$) after 1 day or 2 days of variable temperature treatment, and significantly ($P<0.05$) after 3 days. However, on the first day of germination, variable temperature less than 2 hours cannot significantly promote germination, and germination rate improve significantly in 8-12 hours' treatment.

Key words: Sheepgrass; Seed germination; Genotype; Variable and Constant temperature treatment

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SESSION 3

PLANT PROTECTION

INTEGRATED CONTROL OF WEEDS IN GRASS SEED PRODUCTION

P. Kryger Jensen*

In grass seed production purity of the final product is of main importance. Many annual grasses are difficult or impossible to control chemically in grass seed crops and seed characteristics make it difficult to separate the seeds from some of the cultivated grasses. At the same time, crop rotations with a large proportion of winter cereals favour the establishment and development of these grasses. In a crop rotation with grass seed crops it is important to focus on control of annual grasses in all crops where it is possible to control them efficiently in order to keep infestations at a low level. Different tools can be used to reduce the infestation level of grass weeds in the crop rotation. Furthermore, there are a number of options to reduce the possibilities of the annual grasses developing and setting seed in grass seed crops. A false seedbed technique can be applied prior to establishment to encourage early germination of grass weeds and reduce the seedbank. Also, a cover crop that does not favour the germination and establishment of troublesome grass species can be chosen. Changing the establishment method of red fescue from undersowing in a cover crop of winter wheat to a spring sown crop significantly reduces the problems with *Vulpia* spp.. During establishment of the grass seed crop and in the harvest years, annual grass weed problems can be reduced by keeping the cover crop and the grass seed crop dense and competitive against weeds. This is obtained by establishing the cover crop and grass seed in a way that secures a quick emergence and cover of the soil and especially to avoid gaps in the plant cover.

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EVOLUTION OF MANAGEMENT METHODS FOR THE CONTROL OF *PROTAPION TRIFOLII* IN RED CLOVER (*TRIFOLIUM PRATENSE* L.) SEED CROPS IN FRANCE

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The seed weevil *Protapion trifolii* L. (Coleoptera: Apionidae) causes major losses in seed production of red clover (*Trifolium pratense* L.). Because clover is mainly pollinated by insects, the use of pesticides in the management of this weevil is difficult to handle. The progressive disappearance of several active ingredients (lastest: bifentrine) has reduced the options to a restricted panel of effective products: acetamipride, thiaclopride + deltamethrine, and spinosad (usable in organic production). In 2016, the French government announced an end to the use of neo-nicotinoid active ingredients in agriculture by 2020. Because of this restriction of active ingredients and concern about extremely high rate of *Protapion trifolii* populations in some red clover seed production areas, research of new pesticides and global methods of management have become essential for maintaining economically competitive seed production. For many years, FNAMS has carried out numerous trials to evaluate efficacy of new pesticides for seed production. While many active ingredients used in agriculture lack efficacy on red clover weevil, studies conducted in 2013-2016 have shown some interesting results with cyantraliniprole. Field trial results show effective reduction of adult populations and an increased number of seeds in flower heads. Difficulties in managing *Protapion trifolii* were observed in some red clover seed production areas. From 2013 to 2016, field samplings showed increasing populations and a lack of efficacy of common pesticides. In order to identify potential resistance problems, red clover weevil populations were characterized, and pesticide efficacy was tested in laboratory conditions. The study showed that populations in this area are dominated by a major species (99% *Protapion trifolii*), and no evidence of lack of efficacy was observed with the pesticides tested in the laboratory. Several other hypotheses are currently being examined.

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IMPORTANCE OF RUST DISEASES IN SEED PRODUCTION OF PERENNIAL RYEGRASS

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Several rust diseases have proven to have significant effect on seed production of perennial ryegrass. Crown rust (*Puccinia coronata*) and stem rust (*Puccinia graminis*) are described as the two most serious rust diseases in ryegrass, but also leaf spot diseases like *Pyrenophora dictyoides* are found to be important. In Danish ryegrass seed production crown rust is recognized as the most serious rust, although unidentified *Puccinia* specie, which shows similar symptoms, has been found to also provide significant leaf attacks. Very positive yield responses have been obtained in perennial ryegrass from fungicide application using typically mixtures of azoles, SDHI's and strobilurins. Leaf rust diseases commonly reduce yields by approximately 250 kg/ha, which is more than yield reductions caused by other leaf spot diseases. These findings has led to common fungicide treatments in perennial ryegrass, where farmers typically apply once or twice per season (GS 32-45 & GS 61-65). A national monitoring system has been put in place by the Danish advisory service - SEGES and the seed industry for crown rust and stem rust, providing weekly guidance on the disease risk during the season. Significant attack of stem rust is relatively rare in Denmark, but expected to increase following better conditions for survival during milder winters. Specific trials with artificial inoculation, using spreader plants, which are "brushed" on to the plots around heading, have shown that stem rust can be a very yield reducing disease. Depending on season and susceptibility of the cultivar stem rust has reduced yields by approximately 15% in a worse-case scenario. If not sufficiently controlled the crop is more likely to suffer from early ripening and increased risk of seed shattering losses. Semi-field trials with inoculated plants have shown good control of both crown rust and stem rust using both triazoles and strobilurin fungicides. Data from these trials indicates that triazoles (tebuconazole, epoxiconazole) provided the biggest degree of flexibility regarding timing of control, but in practice mixtures of 2-3 modes of actions have provided the best results.

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INTEGRATED ERGOT DISEASE MANAGEMENT IN PERENNIAL GRASSES GROWN FOR SEED

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Ergot is a disease of economic importance in perennial ryegrass and Kentucky bluegrass seed production east of the Cascade Mountain Range in Oregon and Washington, USA. Ergot reduces seed yield, hinders seed certification efforts, and prohibits use of post-harvest residue as livestock feed. The fungal pathogen, *Claviceps purpurea*, infects the ovaries of flowering grass hosts prior to fertilization and forms sclerotia rather than viable seed. Disease suppression can be achieved with properly timed fungicide applications at anthesis initiation and/or during early stages of anthesis. The decision to apply fungicide(s) for ergot control, historically, has been a difficult process due to a lack of information regarding ascospore abundance or absence at the beginning of host anthesis; it is further complicated by the variation in timing and duration of anthesis among different cultivars. A multi-year, collaborative research and extension outreach project was implemented by Oregon State University and USDA-ARS to develop an integrated ergot forecasting, detection, and notification system to inform fungicide application decisions. First, a predictive degree day model was developed and validated and accounted for 76 to 96% of total spores trapped between 2008 and 2016. Second, a quantitative PCR protocol was developed that could detect as few as 4 spores and was correlated with spore trap samples collected from the field ($r = -0.68$; $P < 0.0001$). Lastly, a weekly "Ergot Alert" newsletter was delivered electronically to over 400 stakeholders which provided updates on spore trapping results, crop phenology, and timely integrated management strategies. In 2015, 52% of survey respondents reported that the newsletter helped them to make fungicide application decisions, which resulted in improved control (20% of respondents) and fewer fungicide applications (13% of respondents). When used together, this research and extension package provides growers with a decision-aid tool that can be used to make informed fungicide application decisions.

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RESIDUAL EFFECT OF METSULFURON AND ATRAZINE IN FOXTAIL MILLET [*SETARIA ITALICA* (L.) BEAUV.]

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Foxtail millet is an annual warm-season C4 grass and is characterized by its early maturity. Initial growth is slow so, to obtain an adequate initial plant stand, it is very important to maximize weed control efforts. In fact, the use of herbicides near the time of planting allows an avoidance of early interference of weeds. However, some commonly used herbicides may exhibit symptoms of crop toxicity. To determine the effect of the persistence of herbicides, an experiment was carried out where herbicide was applied in the soil, 1000 g i.a. ha^{-1} of atrazine and 7 g i.a. ha^{-1} of metsulfuron in plots of 50 m^2. Samples of 8 kg of soil were extracted from each plot with herbicide and a control plot, in 4 stages: 0, 15, 30 and 60 days after application. From each soil sample 4 trays were prepared, where 24 foxtail millet seeds were planted. Percentage of normal emerged seedlings (NS), plant height (PH) and aerial dry matter (ADM) were measured 14 days after seeding. Data was analyzed using the mixed model as a completely randomized design with repeated measurements. The results showed a significant time-herbicide interaction in all variables. The major differences between the herbicide treatments were produced at the moment 0. Immediately after applying atrazine and metsulfuron seeding foxtail millet reduced on average up to 34% the percentage of NS. Likewise, atrazine reduced up to 30% the PH and up to 62% the ADM, while metsulfuron reduced up to 23% and up to 37%, respectively.

Keywords: carry over, toxicity, herbicides, grass.

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INVESTIGATION INTO A NEW SDHI FUNGICIDE FOR STEM RUST CONTROL IN PERENNIAL RYEGRASS SEED CROPS

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Stem rust, caused by *Puccinia graminis* subsp. *graminicola*, is the major disease of perennial ryegrass seed crops in Oregon's Willamette Valley. Perennial ryegrass seed yield, seed weight and biomass can be reduced by stem rust. Seed producers currently use fungicides for stem rust management that contain a triazole, a demethylation inhibitor (DMI), and a strobilurin, a quinone outside inhibitor (QoI), often needing two or three applications when disease incidence and severity is greatest. The efficacy of newly available succinate dehydrogenase inhibitor (SDHI) fungicides in stem rust control and resistance management needs to be determined. Field trials were undertaken in 2016 and 2017 to evaluate Trivapro®, a SDHI (benzovindiflypyr) containing fungicide on a stem rust susceptible cultivar of perennial ryegrass. Four Trivapro® treatments were compared to the industry standard DMI + QoI fungicide and an untreated control. Trivapro® treatments ranged from 722 $g.ha^{-1}$ to 1920 $g.ha^{-1}$. Application was made at the first incidence of stem rust, and rust severity ratings were made weekly until harvest. Seed yield, biomass dry weight, and seed weight were determined. Results from 2016 indicate that all fungicide treatments reduced stem rust incidence and severity over the control. Rust incidence and severity was similar for all treatments in the first month, but late in the season, stem rust control appeared to break down with the DMI + QoI treatment and lower rates of Trivapro®, while higher rates maintained stem rust control. Seed yield and seed weight were significantly increased with all fungicides. These results suggest that stem rust control can be achieved with SDHI fungicides for a greater length of time than with DMI + QoI fungicides. Thus, the number of fungicide applications may be reduced while achieving higher seed yields and seed weights. Introducing a new fungicide mode of action may aid in reducing the potential for stem rust resistance in perennial ryegrass seed production.

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POTENTIAL PROTECTIVE TOXICITY TO HERBIVORES CONFERRED TO GRASSES BY ASEXUAL *EPICHLOË* SPECIES FROM ARGENTINA.

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Epichloë species are fungal systemic symbionts of cool-season grasses (*Poaceae* subfamily *Pooideae*) that can confer resistance to environmental stress, pests and diseases to their hosts. These characteristics have made endophytes a tool for grass forage breeding. Most of these symbionts can produce alkaloids that provide protection from herbivory, which can be insect deterrents (e.g. lolines and peramine) or toxic to livestock (e.g. the indole-diterpene lolitrem-B and the ergot alkaloid ergovaline). In Argentina only asexual *Epichloë* species have been found. We studied the diversity in alkaloid gene profiles of *Epichloë* isolates from 18 native hosts from Argentina. We screened for presence of alkaloid biosynthesis genes (perA, lolC, dmaW and idtG, K, B, Q, F, E) and assessed the potential alkaloid production of the endophyte, which is considered agronomically important for selection and future development of grass cultivars. Ten genotypes differing in the alkaloids gene profiles (presence/absence) were revealed across the eight lineages identified with the calM phylogenies. The ten genotypes reduced to seven different predicted chemotypes. All lineages are predicted to produce peramine, but only *E. cabralii*, *E. pampeana*, lineage A and some isolates of lineage C would likely synthesize lolines. Lineage B is predicted to synthesize the ergot alkaloid intermediate compound chanoclavine-I that is non-toxic to cattle. The genotypes with indole-diterpene biosynthesis genes showed greater genetic variation. E. typhina ssp. poae var. aonikenkana and lineages B, C, D, would likely produce paxiline and terpendole-I. Two different indole-diterpene chemotypes were predicted within E. tembladerae, some isolates would likely be terpendole-C producers while others would produce paspaline. According to the predicted alkaloid chemotypes, Argentinean endophytes have the potential to produce alkaloids with anti-insect activity but are likely safe for livestock, so they could be an adequate resource to improve the resistance of forage grasses to biotic stresses.

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CONTROL OF SMUT BROME (*USTILAGO BROMIVORA*) IN *BROMUS VALDIVIANUS* WITH FUNGICIDE SEED TREATMENT

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The genus *Bromus* comprises around 400 species worldwide and 24 of them grow naturally in Chile. Pasture brome (*B. valvivianus* Phil.) is native to Chile and is very well adapted to the south of the country; INIA- Chile started working with this native species in the early nineties and in 2008 released the first two Chilean cultivars. In 2006, the first cases of smut brome (*Ustilago bromivora*) were detected under field conditions, generating the necessity to search for technical solutions. The objective of this study was to evaluate the effect of 6 commercial seed fungicides (benomyl, fenbuconazole, tebuconazole, fuquinconazole + prochloraz, triadimenol and triticonazole), each one in two doses. Thirteen treatments (6 fungicides x 2 doses each + a control without fungicide) were applied to bromus infected seed to establish field trials in the spring of 2012 at INIA Carillanca, Chile (38°41'S; 72°25'W), under rain fed conditions in a randomized complete block design with four replicates. During the establishment season plant emergence rate was determined and forage production was measured three times. In the second season, forage production was measured in the first growth of the spring and afterwards the number of shoots.m^{-2}, percent of infected shoots and seed production (kg.ha^{-1}). According to the ANOVA and mean separation test (Duncan, 5%), establishment and forage yield was affected significantly by some treatments during the first season, but not in the first growth of the following spring. Fuquinconazole 167 g.l^{-1} + prochloraz 31 g.l^{-1} (doses 900 and 1800 g.100 kg^{-1} of seed) and triadimenol 150 g.l^{-1} (doses 800 g.100 kg^{-1} of seed) reduced forage production during the first season. All fungicides controlled 100% the smut, while the untreated control showed 89% of panicles infected. Average seed production was 1515 kg.ha^{-1} with no significant effect of the fungicide treatments on seed yield.

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RESPONSE OF CHICORY (*CICHORIUM INTYBUS* L.) TO POST-EMERGENCE HERBICIDES, IN THE VALLE BONAERENSE DEL RÍO COLORADO, ARGENTINA

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Chicory (*Cichorium intybus* L.) is a short-lived perennial warm season forb in the Asteraceae family. It is widely used in countries such as Uruguay and New Zealand as an alternative forage for livestock. A field trial was conducted in Pedro Luro, (south of Buenos Aires Province, Argentina), to assess weed control options for establishing chicory. The objectives were to determine the effect of various herbicides on crop injury. For scoring, the EWRS visual scale which ranges from 0 - 100% was used, where 0 = no crop injury and 100 = complete crop death. Chicory crop was established in the fall of 2015 and after one year (June 2016) eight different treatments were applied when the crop was winter dormant. The herbicide treatments were: flumetsulam 30 g a.i. ha^{-1}, imazethapyr 120 g a.i. ha^{-1}, metsulfuron 4.8 g a.i. ha^{-1}, imazethapyr + imazapyr 40 g a.i. ha^{-1}, metribuzin 288 g a.i. ha^{-1}, flurochloridone 250 g a.i. ha^{-1}, atrazine 1300 g a.i. ha^{-1}, sulfentrazone 200 g a.i. ha^{-1}, and untreated control. Crop injury was estimated as a percentage at 30 and 78 days after application (DAA). Metribuzin, flumetsulam and atrazine did not result in crop injury 30 and 78 DAA. Imazethapyr alone and flurochloridone, produced slight injury without significant differences from the control ($p>0.05$), at 30 and 78 DAA, respectively. Sulfentrazone, imazethapyr + imazapyr and metsulfuron caused the greatest crop injury to chicory, regardless of DAA. This study shows that the application of metribuzin, flumetsulam, atrazine, imazethapyr and flurochloridone could be safe options for broadleaf weed control in chicory crop.

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RESULTS OF HERBICIDE SCREENING TO CONTROL GRASS WEEDS IN SEVERAL GRASS SEED SPECIES IN THE NETHERLANDS

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Past years many herbicides and combinations have been tested for selectivity in the grass seed species perennial ryegrass (*Lolium perenne*) and tall fescue (*Festuca arundinaceae*) for seed production and in red fescue (*Festuca rubra*) and smooth stalked meadow-grass (Poa pratensis) for sod production. Tested grass species for efficacy were loose silky-bent (*Apera spica-venti*), common velvetgrass (*Holcus lanatus*), soft brome (*Bromus hordeaceus*), black grass (*Alopecurus myosuroides*), brome fescue (*Vulpia bromoides*), rough stalked meadow-grass (*Poa trivialis*) and annual bluegrass (*Poa annua*). We focussed on the efficacy of diflufenican, metsulfuron, mesosulfuron, sulfosulfuron, propyzamide, nicosulfuron, mesotrione, pinoxaden, iodosulfuron, tembotrione. Trials were conducted in three replicates. Results are based on visual observations. Brome fescue was best controlled by 250 g.ha^{-1} a.i. ethofumesate applied after drilling followed by 500 g.ha^{-1} a.i. ethofumesate after emergence. Mesotrione 100 g.ha^{-1} a.i. added to the first ethofumesate application did not improve the efficacy. Also a spring application of 0.1 kg.ha^{-1} Atlantis (0.6% iodosulfuron/3% mesosulfuron) did not contribute to the efficacy. Both red fescue and meadow-grass grown for sod production did not suffer by these applications. In perennial ryegrass efficacy of ethofumesate 100 g.ha^{-1} a.i. at drilling against black grass, loose silky-bent and annual bluegrass was improved by sulfosulfuron (7 g.ha^{-1} a.i.) in early spring. In tall fescue the efficacy against these 3 species was improved by a spring application of fenoxaprop-P-ethyl (83 g.ha^{-1} a.i.). After many years of research ethofumesate is still the most important herbicide in grass seed production.

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SESSION 4

BREEDING FOR SEED YIELD

PHENOTYPIC PLASTICITY FOR SEED RETENTION IN *PANICUM COLORATUM* VAR. *MAKARIKARIENSE*

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Panicum coloratum var. *makarikariense* is a warm-season perennial grass that produces high forage yield with good quality, although its use is limited by low seed retention. Phenotypic plasticity (PP)is the ability of an organism to modify its phenotype in response to environmental changes. Our objective was to investigate different aspects of PP for seed retention (SR) in response to differences in precipitation between years. We focused on three different aspects: 1) we quantified the amount of PP on seed retention, 2) we assessed whether genotypes differ for PP between them and 3) we looked at the correlation between PP and the mean value of seed retention. At INTA EAA Rafaela (31°11´41”S; 61°29´55”W), replicates of eleven genotypes clonally propagated were evaluated in the field for SR during two years with different precipitation regimes (2007: wet, 870,1mm; 2010: normal, 536 mm during the growing period). Seeds were collected and counted at7 dates along the growing season. Seed retention was estimated at each harvest date as the ratio of the number of seeds retained per panicle over the total number of seeds produced by each panicle. Phenotypic plasticity index (PI) was estimated at each collection date as PI=|(Xw -n)/(Xw+n)|were n is the mean value of SR of the clones in the normal year and Xw the value of SR of each clone in the wet year. Significant year effect denoted existence of PP. In addition, amount of PP, quantified by PI, showed differences among genotypes and between dates of harvest. PCA was performed with PI and SR at each harvest date as variables. Axis 1 and 2 explained 83,2% of the variability. Most of the variation opposed SR and PI at different dates. Pearson correlation coefficient between the amount of PI and SR per genotype was found to be negative (P=-0,88 p<0,01). In short, seed retention is highly plastic, genotypes show less retention in wet years, although amount of plasticity differ among genotypes. Phenotypic plasticity in SR is negatively associated with the mean value of the character. Therefore, it is possible to select with low plasticity and with high seed retention.

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BREEDING WARM-SEASON GRASSES TO IMPROVE SEED YIELD AND QUALITY

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Although most forage cultivars of warm-season perennial grasses are able to produce large amounts of biomass they conserve undesirable agronomic characteristics, which are common in undomesticated species. Low seed yield and quality are among them, and they limit the adoption and widespread of many species and cultivars. The objective of this presentation is to analyze different breeding attempts to genetically improved seed related traits in tropical and subtropical grasses. Long flowering periods and seed shattering are common in warm-season grasses, and they are determinant for low seed yields. Attempts have been made trying to shorten the reproductive phase resulting in forages with higher seed yield and longer vegetative phase. Germplasm with improved seed retention has been developed for several species and the involved physiological aspects will be discussed. Since many cultivated tropical forages are polyploid seed fertility tends to be low. The occurrence of apomixis in many of them seems to help to overcome this issue. The presence of dormancy is common in tropical grasses, and this characteristic result in a slow establishment. The main anatomical and physiological aspects related with seed dormancy will be considered. Cultivars with fast germination have been obtained for a few species with a successful outcome. Among the most influential biotic factors affecting seed quality is ergot (caused by *Claviceps* spp.). Although there is a marked environmental effect over the ergot occurrence, cultivars with an improved tolerance to this disease has been generated. The different degrees of success resulting from attempting to improve seed yield and quality will be considered for the most important genus among cultivated warm-season grasses, i.e., *Panicum*, *Brachiaria*, *Setaria*, *Chloris*, *Cenchrus*, and *Paspalum*.

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MASS SELECTION FOR REDUCED AWN LENGTH IN *BROMUS AULETICUS* TRINIUS

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The current demand for forage species suited for livestock production in high-stress environments such as Corrientes, Entre Ríos and West of La Pampa in Argentina and Tacuarembó in Uruguay leads to the use of native species which survive in tough conditions while maintaining the productive profitability. *Bromus auleticus* Trinius, commonly known as Cebadilla Chaqueña, is a perennial native species with high forage value due to its palatability, high autumn-winter production and excellent bromatological characteristics of digestibility and protein content. It is present in Argentina, Uruguay and southern Brazil. It has high tolerance to drought, high temperatures and high grazing intensity. However, some of the main challenges in the species are related to seed processing, mechanical harvesting, and mechanical planting due to the low weight of the seed and awn length which can range from 2 to7 mm. In 2016 a breeding program was initiated with the main goal of selecting plants with reduced awn length, because it was observed that it is a character that presents high variability and this could improve mechanical processes. The selection process was carried out at the Gentos experimental station, located in Pergamino, province of Buenos Aires. The initial population consisted of 750 isolated plants of *Bromus auleticus* from Gentos´ germplasm bank which were transplanted in June 2016. From this population, 26 individuals were selected because they presented a reduced awn length compared to the population mean. The individual plants were harvested in December 2016 and the seeds were threshed by hand in February 2017. Average awn length was measured in millimeters using a caliber and a magnifying glass in each of the genotypes, including a Gentos control cv. Texas and an ANOVA was performed. Five genotypes were selected that did not show significant differences between them in the length of the awn, but did present differences in relation to the rest of the genotypes, including the control line, which has, on average an awn length of 2.91 millimeters. The selected genotypes have an awn length 48-76% shorter than the control cultivar. Yield parameters such as number of panicles ranging from five to sixteen and total seed weight ranging from 1.08 g to 6.92 g were also measured in each genotype. A positive correlation was found between the number of panicles per plant and the seed yield of each genotype. The selected individuals will be cloned and polycrossed in isolation and effective reduction in awn length will be evaluated in 2017.

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THE CHALLENGES OF BREEDING FOR SEED PRODUCTION IN GRASSES: A NEW ZEALAND PERSPECTIVE

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In grass breeding programs, the major emphasis is placed on improving forage or turf performance, and selecting for seed yield is often a secondary concern with only a small proportion of breeding lines being discarded based on low seed yield. Nevertheless, ensuring seed growers achieve competitive returns is very important. Breeding for seed yield brings up the question of "how is the crop managed?". Management of ryegrass seed crops over the last 25 years has nearly doubled seed yield. The refinement of management practices has improved the realization of seed yield potential for low seed yielding cultivars – while adding additional income. It is common practice within New Zealand to graze seed crops up until closing – or the beginning of the reproductive phase. Cultivars which can be closed later can provide extra grazing potential which can dramatically increase profitability. Moreover, recent breeding efforts have resulted in cultivars with flexible sowing dates, i.e., late autumn, which are advantageous over those with less autumn vigour and/or higher vernalisation requirements that must be sown early. The ability to sow late is well suited within the overall farming system, without detrimentally punishing seed yield potential. Breeding for resistance to the common rust diseases, crown and stem rust in New Zealand is essential for forage use as well as for seed production. This provides additional benefits for seed growers by reducing costs spent on fungicides while increasing the reliability of seed production. However, the afore-mentioned breeding targets, while not directly breeding for seed yield, have been well received by New Zealand industry. Breeding for seed yield must be considered as part of any wider breeding program. Some methods for practically achieving this include: improving seed set per spikelet, and ensuring inflorescences are of a large, uniform size. Harvest losses should also be considered, as under New Zealand management conditions, seed losses at harvest are often in the magnitude of 15 - 30%. Identifying suitable genetic sources for seed retention may be able to be reduce harvest losses. Together, these methodologies may prove to be desirable method of breeding for seed yield within perennial ryegrass while considering the cost and reliability of seed production.

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PHENOLOGICAL CHARACTERIZATION AND EVALUATION OF FORAGE AND SEED PRODUCTION OF THE CV. BOYERO UNNE (*PASPALUM NOTATUM*) IN THE TEMPERATE REGION OF ARGENTINA

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The sowing of improved native forage species constitutes an important management tool to be considered in the current productive proposals, which involves a displacement of cattle to marginal zones, the utilization of natural grassland and the adaptation to the climate changes. For this goal, it is necessary analyze the evolution of the cultivar of interest in the agro-climatic area where it is intended to be introduced, with the purpose to obtain the best yield in terms of forage and/or seed. *Paspalum notatum* (bahiagrass), is a native species of South America. The tetraploid race (2n=4x=40), is widely spread in the subtropical regions of Argentina, Brazil and Paraguay. All natural tetraploid biotypes reproduce by aposporous apomixis. Recently, the first apomictic hybrid cultivar of the species, cv. Boyero UNNE, was released by the breeding program held at the Facultad de Ciencias Agrarias, Universidad Nacional del Nordeste (UNNE), Corrientes, Argentine. The objectives of this study were: i) to determine the average length of the phenological sub-periods Tillering - Stem elongation (Til-St), Stem elongation - Flowering (St-Fl) and Flowering - Physiological Maturity (Fl-PM), ii) to assess the forage production at the winter-end, and iii) to estimate the seed production, in the south region of Santa Fe province. The determinations were performed on an area of 1000 m2 located at the Campo Experimental Villarino, (33º 01' LS and 60° 53' LO and 50 m above the sea level). The experimental plot was sown on November 14th 2014. Evaluations were conducted during the growing seasons: 2014-2015, 2015-2016 and 2016-2017. Phenological determination showed that the average length of the phenological sub-periods were: Til-St 46 d, St-Fl 20 d and Fl-PM 21 d. On the other hand, the mean forage yield was 4,642 kg DM/ha and the seed yield estimation was of 381.20 kg/ha. Results of this work show that cv. Boyero UNNE is a promising material to be introduced by sowing in both, fertile and marginal areas of southern region of the Santa Fe province with double purpose of forage and seed production.

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ESTIMATION OF GENETIC CORRELATIONS AND CO-HERITABILITIES AMONG MORPHOLOGICAL AND SEED RETENTION IN *PANICUM COLORATUM* VAR. *MAKARIKARIENSE*

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Panicum coloratum is a tropical grass adapted to a wide range of climatic conditions, with potential use as forage in tropical and semi-arid regions around the world. No uniform development of the panicle and low seed retention cause big loses at seed harvest. Breeding strategies to increase seed yield requires a better understanding of the relationships between traits involved and detection of characters that may facilitate indirect selection. The objectives of this study were to estimate correlations and co-heritabilities between morphological characteristics that may allow improvement in seed retention by indirect selection. Thirteen progenies (half-sib families) were spaced-planted in the field (INTA-EEA Rafaela 31°11'41'' S; 61°29'55'' W) according to a randomized complete block design with five replications. The number of reproductive tillers/plant (PN), flag leaf area (cm2, FLA), leaves number/reproductive tillers (LN), seed number/panicle (SN), seed weight/panicle (mg, SW) and percentage of seed retention (SR) at 30 days post anthesis, were measured on 15 genotypes per family from January to March 2010. Genetic, environmental and phenotypic correlations were estimated by analysis of variance and covariance, and co-heritabilities were calculated according to Ghesquière et. al 1994. Moderate and significant positive genetic, environment and phenotypic correlations were found between FLA and LN (r=0.4), FLA and SW (r=0.3). Moderate but negative genetic, environment and phenotypic correlations (r=-0.3) were estimated among SN and PN, SN and SR. The rest of the correlations were very low. The value of co-heritabilities among FLA and PN was closer to the heritability estimated for FLA individually. The rest the values of co-heritabilities were insignificant. Given the difficulties in estimating seed retention in a plant, it would be desirable to find a way to make selection in an indirect way. However, none of the six morphological characters measured here would be suitable to do this. Nonetheless, the relatively good heritability found for seed retention (h2=0.55) might warrant good genetic gains by means of direct selection.

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EVALUATION OF SEED SHATTERING IN CULTIVARS OF *PANICUM COLORATUM*

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Panicum coloratum is a warm-season perennial forage grass introduced to Argentina in the 90s, able to tolerate both draughts and flooding periods. The species is not commonly used in the country at present, mostly due to shattering problems that impose difficulties to seed harvest and big proportions of immature seeds, eventually lowering seed quality. In this study, we compared seed retention and other seed related characteristics in 3 cultivars of *P. coloratum* in the field at Rafaela (31°11'41'' S; 61°29'55'' W). Seed traps were put in one panicle in plants a two-year old pasture of cv. Klein of var. coloratum and 2 cvs. of var. makarikariense, Bambatsi and the recently released Kapivera INTA. In a two-year old pasture, traps were set when inflorescences attained anthesis to ¾ of its length in 9 panicles per cultivar. Mean minimum and maximum temperatures registered at the site during the period of measurements (February and March 2017) were 17.9 and 29°C respectively; accumulated rainfall was 99 mm, about normal for the site. Seeds were collected every week and counted in the lab. At each collection date, a proportion of shattered seeds over the total number of seeds produced per panicle was used to calculate seed retention percentage per date (SR%). A thousand seeds weight, total number of seeds produced per panicle and proportion of empty seeds were also registered. Results showed a tendency of higher seed retention in cv. Kapivera although differences were not significant. Differences are more evident after the third harvest. Cultivar Klein produced seeds of lower weight and in a lower number than the cultivars of var. makarikariense. Additionally, cv. Kapivera INTA produced a higher proportion of mature seeds than the other two. Variability for traits related to seed production shows potential for the genetic improvement in the species.

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SEED PRODUCTION AND QUALITY IN NOVEL APOMICTIC HYBRIDS OF BAHIAGRASS

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Bahiagrass (*Paspalum notatum* Flügge) is a warm-season perennial grass native from South America. Seed propagation is the primary advantage of bahiagrass over vegetatively propagated grasses; therefore, a reliable source of high-quality seed is essential to successfully establish new fields. The objective of the present work was to evaluate the seed yield and quality in apomictic hybrids of *Paspalum notatum*. Seventeen tetroploid hybrids with high apospory expressivity, previously selected by agronomics characteristics, and two cultivar of bahigrass (cv Argentine and Boyero UNNE) were cultivated in plots of 1.5 x 1.5 m in a field near to Corrientes, Argentina. The experimental design was a randomized complete block with three replications. Seed yield was evaluated during summer of 2016, and then the seed was kept refrigerated at 18 ºC for 7 months between harvest and sowing. Eleven apomictic hybrids were not different than Argentine or Boyero UNNE for seed production. On the other hand, two hybrids showed better germination level (92%) than Argentine (68%) and Boyero (46%) when were evaluated 7 months after harvest. In addition, only 8 hybrids showed lower germination level than 70%. In conclusion, in *Paspalum notatum* is possible to obtain hybrids with similar seed yield and superior germination level than the used cultivars. In addition, it is possible to obtain good level of germination without scarification techniques.

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ANALYSIS OF EXPRESSED SEQUENCES TO CHARACTERIZE THE XENIA EFFECT ON SEEDS OF *PASPALUM NOTATUM*

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In a previous transcriptomic study about xenia in *Paspalum notatum* Flüggé, an unpollinated control mother plant was compared to two crosses with pollen donor distinction at ploidy level and mode of reproduction. Considering these results, the objectives of the present work are: 1- Analyze and assign a biological function to the sequences obtained from the transcriptomic analysis of crossings involving paternal genotypes with different level of ploidy and mode of reproduction. 2- Evaluate functions of the sequences during the development of the seed and check if this effect depends on the pollen genotype. cDNA-AFLP analysis from control mother plant ovaries (4x, apomictic pseudogamic) and from crosses with different pollen donor (2x, sexual and 4x, apomictic pseudogamic) was performed three hours after pollination. Thirtythree single differential expression bands were found for the analyzed crosses, 29 of them were sequenced, and assigned a possible biological function by blastn, blastx and blastp searches. The functional characterization of sequences showed that 4 of them (CG3, CG5, GA4 and GA6) presented homology with A. thaliana loci directly associated with embryo sac development, pollen tube development, double fertilization forming a zygote and endosperm. In addition to that, mutant phenotypes of A. thaliana for these loci present a decrease in the size of the siliques, seeds and seed set. These results show evidence of the xenia effect on the functions associated with reproduction in *P. notatum*. Also, they demonstrate that the genotype of the pollen grain is one of the factors determining the expression of different transcripts that could be related to grain yield.

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VARIABILITY FOR FERTILITY AND GERMINATION OF SEEDS IN THE SEXUAL TETRAPLOID GERMPLASM OF BAHIAGRASS

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Bahiagrass (*Paspalum notatum* Flüggé) is a warm-season perennial grass native to South America and used as utility forage and turf around the world. It has two cytotypes, the diploid reproduce sexually and the tetraploid by apomixis. In spite of its numerous desirable traits for forage, its adoption has been limited mainly due to low germination levels. A few experimental sexual tetraploid genotypes (ESTG) have been generated. Recently a sexual synthetic tetraploid population (SSTP) was generated offering a wide genetic background for improvement. The objective of this work was to characterize the seed fertility and germination of the SSTP, and to compare this germplasm with the ESTG. Fertility was measured in 3 ESTG and in a sample of 28 individuals from the SSTP, based on seed set under self- (SP) and open-pollination (OP). Seeds obtained from OP were sowed on November under a complete randomized design with two replicates of 50 seed each one. Germination was calculated 21 d after sowing (G). Germinative energy (GE) was calculated based on germination 8 d (G8) after sowing (GE= GxG8/100). The SSTP showed 18.4% (Coefficient of variation (CV) = 54.2) and 30.6% (CV= 43.2) of seed set under SP and OP respectively, whereas ESTG showed 9.9% (CV= 58) and 22.5 % (CV= 41.1) of seed set under SP and OP respectively. The SSTP showed a G of 51.1% (CV= 43.2), significantly higher than the 26% (CV= 121) obtained in ESTG. The GE of the SSTP was 11.4% (CV= 115.2), significantly higher than the 4.5% (CV= 151.9) obtained in ESTG. There were not statistical differences between fertility of the two groups of genotypes; however, G and GE were improved on the SSTP with respect to ESTP. The high CV observed in all evaluated traits indicate high variation between genotypes, which will be useful in breeding programs.

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SEED YIELD COMPONENTS OF DIPLOID ANNUAL RYEGRASS (*LOLIUM MULTIFLORUM* LAM.)

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Diploid annual ryegrass (*Lolium multiflorum* Lam.) is one of the most important annual grasses in Argentinian livestock forage systems. Annual ryegrass has high value due to its high forage yield potential and fast ground cover i.e. rapid emergence and excellent seedling vigour. These agronomic traits need to be coupled with high seed yield in a breeding programme. The aim of this study was to evaluate seed component differences among 23 half-sib families (HSF), corresponding to a breeding programme in the third selection cycle (C03). The experiment was conducted using spaced plants in a complete randomized design with four replicates at Pergamino (north of Buenos Aires Province: 33°56' S; 60°33' W). The traits evaluated were those associated with seed yield component including number of inflorescences, number of spikelets, length of inflorescences (cm), seed production (g) and 1000-seed weight (g). The data were analysed using a mixed model analysis of variance using R in a simple interface with Infostat® statistical program, as well as a multivariate analysis (principal components analysis=PCA). There were significant differences (P<0.001) for all traits among the 23 HSF, and in the PCA 71% of the variability was explained by two components (PC1=48% and PC2=23%). PC1 was weighted for seed production and PC2 was weighted for number of inflorescences. As a consequence, five HSF with the highest seed production traits were selected to be continued in the breeding programme.

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DUAL PURPOSE EVALUATION, FORAGE AND SEED PRODUCTION, FOR ARGENTINE TRITICALE CULTIVARS

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Triticale (x *Triticosecale* Wittmack) is a winter cereals that is used as a forage resource in Argentina. Also, there is a big move towards cover crops and triticale is one of the species used. The objective of this work was to produce information about triticale cultivars and management. At INTA EEA Marcos Juárez nine evaluation trials were conducted, including five commercial cultivars during nine years (2005-16). Trials were conducted in a randomized complete block design with three replicates. Forage production through dry matter and seed production were analyzed by ANOVA considering cultivar, environment (year) and interaction cultivar by environment as sources of variation, and the results showed a significant interaction ($p < 0.0001$) suggesting differences between cultivars in different years of evaluation. Shukla stability analysis for each variable was performed to understand the interaction, using SAS statistical software. Mean forage production was 4480 kg DM.ha^{-1} and the mean comparison test showed a significant minimum difference (LSD at 5%) of 440 kgDM.ha^{-1}. No significant differences were observed between YAGAN INTA (4701 kgDM.ha^{-1}) and ÑINCA (4526 kgDM.ha^{-1}), cultivars that performed above the average dry matter production, with higher stability than QUIÑE, TEHUELCHE INTA and ESPINILLO INTA (4432 kgDM.ha^{-1}, 4415 kgDM.ha^{-1}, 4326 kgDM.ha^{-1} respectively). Mean seed production was 1531 kg.ha^{-1}, with a minimum significant difference of 278 kg.ha^{-1}. ESPINILLO INTA seed production of 1856 kg.ha^{-1} and TEHUELCHE INTA seed production of 1690 kg.ha^{-1} performed above the other cultivars production but showed some instability. Results indicate multi-environment trials are good in predicting triticale cultivars forage and seed production and are efficient to adjust a regional recommendation of cultivars.

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GENETIC DIVERSITY IN SEED YIELD OF ARGENTINIAN COLLECTION OF TALL FESCUE (*FESTUCA ARUNDINÁCEA* SCHREB.)

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Tall fescue (*Festuca arundinácea* Schreb.) is a cool season forage grass of significant agricultural importance in different grassland countries. In Argentina the species grows spontaneously on the roadsides of the Humid Pampas region, and minimum temperatures (2.6°C-3.2°C) and dry conditions (100 mm) are both variables that define its realized niche. The aim of this work was to study the genetic diversity among nine populations collected at the edges of the ecological niche. They were characterized based on molecular and morphological characters related with seed yield. Molecular analysis determined three groups of genotypes with genetic distance between them. Each group (40 genotypes/group) was grown as spaced plants at Pergamino location (north of Buenos Aires Province), and were allowed to polycross (pool). The attributes evaluated within each pool were flowering date, total seed weight and 1000 seed weight. Analysis of variance was performed using SAS statistical program (proc. ANOVA and LSD) and genetic parameters were estimated. There were significant differences ($P<0.001$) between the pools for all the attributes. The heritability was high for total seed weight and 1000 seed weight. These results indicate the possibility of increasing seed yield by family selection within each pool.

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CHARACTERIZATION AND EVALUATION OF DIFFERENT TALL FESCUE (*SCHEDONORUS PHOENIX* SCOP. HOLUB) GERMPLASM AND *FESTUCA LETOURNEUXIANA* BY ATTRIBUTES OF SEED PRODUCTION

B.S. Rosso, J.J. Lanzillotta*

Tall fescue is the most widely grown cool-season grass in Argentina, making up 30% of the total cultivated pasture area. Within this species three morphotypes are recognized: continental (c), Mediterranean (m) and rhizomatous (r), each of which has different adaptations to agroclimatic regions. The objective of this work was to evaluate seed production of twelve populations of tall fescue from different origin and morphotypes, plus a decaploid germplasm of *Festuca letourneuxiana* (fl) and two control cultivars, Lujan INTA (c) and Flecha (m), conserved at the Germplasm Bank of the EEA-INTA Pergamino. The attributes considered were days to flowering, number of inflorescences.plant^{-1}, plant height at harvest, seed yield.plant^{-1}, and 1000 seeds weight. Days to 50% flowering (from September 1st) ranged from 19 to 54. The average number of inflorescences.plant^{-1} was 46.7 within a range of 25.9 to 74.7. Higher values were found for the accessions ARFA 341 (r), ARFA 224 (c), and ARFA 553 (c). Populations ARFA 115 (m), ARFA 375 (fl) and cultivar Flecha (m) had the tallest plants at harvest time. Mean seed yield.plant^{-1} was 7.9 g, ranging from 1.8 g to 16.1 g. The most productive populations were ARFA 553 (c) and Luján INTA. Seed yield.plant^{-1} in *F. letourneuxiana* was similar to cultivar Flecha. Mean 1000 seed weight (g) was 1.83 g ranging from 1.3 g and 2.5 g. Lowest 1000 seed weight was observed in Mediterranean populations. Significant correlations were found between the variables studied. There is phenotypic variability for seed attributes in this collection, which will allow us to identify materials to be included in future breeding programs.

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COMPONENTS OF SEED PRODUCTION IN DIFFERENT MORPHOTYPES OF *SCHENODORUS PHOENIX* SCOP HOLUB. IN THE NORTH OF BUENOS AIRES PROVINCE

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Certified tall fescue seed is the most sown perennial forage grass in Argentina. The objective of this work was to determine morphological and phenological variables associated with seed production of continental and Mediterranean morphotypes from a collection at the EEA-INTA Pergamino germplasm bank. Four wild populations from different origins were evaluated together with two commercial cultivars (one Mediterranean and one continental). Days to flowering, plant height at harvest, number of inflorescences.plant^{-1}, inflorescence length, seed yield.plant^{-1}, weight of 1000 seeds and number of seeds.plant^{-1} were measured. Significant differences were observed among Mediterranean and continental morphotypes, in terms of number of seeds.plant^{-1}, weight of 1000 seeds and seed yield.plant^{-1}. Flowering started around 15th to 22nd September. Continental morphotypes showed an average of 28.2 days to 50% flowering (from September 1st) and Mediterranean types 37 days. Seed was harvested from 5th to 14th November 2014. Average seed yield.plant^{-1} was 8.8 g for continental types and 7.8 g for Mediterranean types. Number of seeds.plant^{-1} varied from 3472 for bank accession ARFA 334 (continental) to 7749 for cultivar Flecha (Mediterranean). Average weight of 1000 seeds was 1.96 g for continental and 1.43 g for Mediterranean types. The greatest number of inflorescences.plant^{-1} (53.2) was found in bank accession ARFA 547 naturalized from Argentina (continental), while accession ARFA 385 (Mediterranean) had the least (28.5). Morphological and phenological differences in seed production were evident in the North of Buenos Aires province, for the morphotypes considered.

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SEED PRODUCTION IN HALF SIBS FAMILIES OF *MELILOTUS ALBUS* MEDIK. SELECTED FOR SALINITY TOLERANCE

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The amount of salt affected agricultural land is increasing globally and, therefore, new varieties are needed to be grown in these affected soils. Seed yield, including quality and quantity of seed, is an essential trait that warrants the potential to spread the varieties obtained by breeding. *Melilotus albus* Medik, commonly known as white trefoil, is a forage legume sown in Argentina in soils where other legumes cannot be grown. In this study, 5 half sib families (HSF), selected in a breeding program to increase biomass production and tolerance to salinity, were evaluated for seed production in a field setting at Pergamino, Buenos Aires province (33º 56' S, 60º 33´ W). Fifteen plants on each HSF were evaluated in a randomized polycross block, totalizing 75 plants. Plants were sown in spidlings and transplanted to the field the 28th of July, 2015, in a non saline soil (typical argiudol) and then harvest individually. Evaluated traits were height (cm) at 81 days after the transplant, seed number, and weight of 1000 seeds. Correlations between variables were studied and a path analysis was performed. Results showed that seed number was the character that directly affected seed production. In addition, plant height showed a negative correlation to seed production through seed number. A principal component analysis and a cluster analysis showed that 2 HSF had higher number of seeds while 2 others had heavier seeds. We report enough variability for seed production even in materials that have been previously exposed to selection for salinity tolerance. However, differences in seed production seemed not to be related to any specific characteristic of the material. Additionally, the most influencing character on seed production is seed number. Further evaluations including other accessions and commercial materials will be performed in other faces of the program, considering both vegetative and reproductive characters.

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SEED YIELD COMPONENTS IN NATURALIZED POPULATIONS OF TALL WHEATGRASS (THINOPYRUM PONTICUM)

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Tall wheatgrass (*Thinopyrum ponticum* (Podp.) Barworth et Dewey) has been adapted to poorly drained, saline and alkaline soils in Buenos Aires province, Argentina. For breeding purposes it is very important to characterize seed yield components so that wild populations can be used in breeding crosses. The main objective of this research was to evaluate seed yield components in seven wild populations of tall wheatgrass collected in the Buenos Aires province (ARTH), and obtained from Pergamino Active Germplasm Bank, together with a check cultivar (cv Tobiano INTA). Planting was done in sward plots in a randomized block design with three replications on May 17th, 2010. The sward plots were formed by two rows of 5 m length and 0.5 m between rows with a seeding rate of 30 kg.ha^{-1}. Field measurements included days to beginning of 50% and 100% flowering, plant height (cm) at 50% flowering, number of spikes.m^{-2}, spike length (cm), number of spikelets.spike^{-1}, 1000-seed weight (g) and seed yield (kg.ha^{-1}). Data were analyzed using Infostat® statistical program, ANOVA, mean comparison by Duncan test (α = 0.05) and the Pearson's correlation coefficient were estimated. There were significant differences among populations ($p<0.05$) for days to beginning of 50% flowering and for number of spikes.m^{-2}. ARTH 66 and Tobiano INTA were the earliest to reach 50% flowering, meanwhile ARTH 56, ARTH 67, ARTH 68 were the latest. ARTH 67 showed the highest number of spikes.m^{-2}, and ARTH68 had the lowest. There were no significant differences for the others traits. The mean seed yield for all wild populations was 343.1 kg.ha^{-1}, in a year with precipitation lower than historical means. There was a positive correlation between days to beginning of 50% flowering and spikes.m^{-2}, and a negative correlation between days to beginning of 50% flowering with 1000-seed weight. Variability in days to beginning of 50% flowering and number of spikes.m^{-2} could be explored in breeding programs of tall wheatgrass.

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CHARACTERIZATION OF TALL WHEATGRASS FAMILIES WITH DIFFERENT SALT TOLERANCE

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Tall wheatgrass (*Thinopyrum ponticum* [Podp.] Barkworth et Dewey) is a valuable forage resource to use in marginal environments with saline soils. Salinity is one of the major stresses that severely limit crop production. To overcome this problem, salinity tolerance of crop plants needs to be increased to enable them to grow on marginal areas already affected by salinity. Tall wheatgrass families (HSF) with contrasting response to salinity were previously reported, both growing in hydroponic and in potted-saline soil (CE= 5dS.m^{-1}, pH= 7.5) in greenhouse conditions. These reports provided useful information for selecting salt tolerant genotypes. Three groups (3HSF/group) with different salinity tolerance (Tolerant; Susceptible; Intermediate) were conformed and tested under spaced plant conditions to assess seed yield potential. Characterization was carried on in a randomized block design with four replicates, at Pergamino, north of Buenos Aires Province, Argentina. Attributes evaluated within each group were: flowering date, plant height, leaf width and length, spike number, spikelet/spike number, spike length, total seed weight, and 1000 seed weight. Analysis of variance was performed using SAS statistical program and genetic parameters were estimated. There were differences (P<0.001) between groups for most attributes, but there were no differences between HSF within group. Means were compared by LSD test. The tolerant group had earliest flowering, greatest spike number, greatest spikelet/spike number, greatest total seed weight and greatest 1000 seed weight. The narrow sense heritability was intermediate for most of the attributes. These results indicate the possibility of progress by selection between groups.

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CONSERVATION AND UTILIZATION OF FORAGE GRASS AND LEGUME SPECIES AT PERGAMINO INTA GERMPLASM BANK, ARGENTINA

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High demand of forage grass and legume species adapted to different environments has increased germplasm research for used in genetic breeding. A Network of Gene Banks is located at INTA, preserving germplasm of species used mainly in agriculture. It is formed by active banks, field collections and a base bank for duplicate accessions. At Pergamino active bank a collection of 12 grass and legume species is conserved with around 1400 accessions originating from different countries around the world. Local collection efforts of native and naturalized populations were performed to obtain adapted forage germplasm. Additionally, diversity was increased by seed exchange with international germplasm institutes and seed companies. In different trials these collections are being characterized and evaluated for forage and seed attributes, in order to be successfully used in breeding programs. Passport data of accessions are included in a database named DBGermo web, developed for plant genetic resources. Germplasm conserved in the collection belong mainly to the following species: tall fescue (*Schenodorus phoenix*), prairie grass (*Bromus catharticus*), ryegrass (Lolium multiflorum), tall wheatgrass (*Thynopirum ponticum*), foxtail millet (*Setaria italic*), slender birdfoot clover (*Lotus tenuis*), harding grass (*Phalaris aquatic*), orchardgrass (*Dactylis glomerata*), red clover (*Trifolium pratense*), white sweet clover (*Melilotus albus*) and white clover (*Trifolium repens*).

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SEED YIELD VARIATION OF OAT VARIETIES IN DIFFERENT AREAS OF GANSU PROVINCE

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Oat is a traditional and main feed crop in Gansu Province, mainly distributed in higher altitude areas including eastern Qinghai-Tibet Plateau, Qilian Mountains and some arid and semiarid regions. Wide fluctuation in altitude, precipitation and temperature in these areas made it difficult for oat seed production, adaptable and high yield varieties should be selected for different regions. Eight oat varieties (LY1, LY2, LY3, QH444, Sweet, GN1, QY1 and QY2) were seed in five environments: Tianzhu (2594m altitude), Tongwei (2243m), Anding (1898m), Lanzhou (1517m) and Hezuo (2957m), in spring 2015. Plots were 15 m^2 with 3 replicates in a randomized complete block design, with 20 cm row space and 180 $kg.ha^{-1}$ seeding rate. Plants were harvested at maturity and grain yield, effective tillers, panicle length, spikelet and kernels per spike were measured. GGE-biplot method was used for analysis. The variety×environment interaction effect on yield variation was 4.02 times greater than that of the variety. LY2 and LY3 gave better performances across the 5 experimental sites, their average seed yield were 4136 $kg.ha^{-1}$ and 4055 $kg.ha^{-1}$, respectively. The five experimental sites could be grouped into two according to altitude, precipitation and temperature; Lanzhou and Anding belong to arid and semiarid region, while the other three belong to cool and high elevation group. The best variety for arid and semiarid region was LY1, while LY3 was most suitable for the second group. A positive correlation was observed between seed yield and: effective tillers (r=0.826), panicle length (r=0.912), and kernels per spike (r=0.817). Among the six variables that characterized the environments, average annual precipitation was significantly correlated to seed yield, and ≥100C annual accumulated temperature was significantly correlated to spikelet and kernels per spike. As far as environment representativeness and variety discrimination were concerned, Tongwei was most suitable for oat production and Tianzhu had the best variety discrimination.

Key words: Oat; GGE biplot; Genotype×environment interaction; Seed yield

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CHALLENGES FOR THE RELEASE OF TRANSGENIC PERENNIAL FORAGE SPECIES

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Genetically engineered (GE) perennial species present some unique challenges for release into the environment. The perennial nature and the biology of the species provide avenues for movement of the transgenic trait in the environment. Many of the species are wind pollinated and have sexually compatible relatives with which they hybridize, most species are small seeded and spread easily via equipment and natural dispersal. Many perennial forages establish and persist outside of cultivation. The perennial nature ensures that the transgene will remain in the environment for multiple generations. To date, alfalfa is the only transgenic forage that has been deregulated in the USA. Glyphosate resistant alfalfa is planted on approximately 1 million hectares. Feral transgenic glyphosate resistant alfalfa populations were identified during recent surveys. Reduced lignin transgenic alfalfa has been deregulated and was available for planning in 2017. From the agronomic aspect, a transgenic perennial forage species could have the same impact as if the trait were to be obtained through traditional breeding. However, the release of transgenic perennial forages could have an economical (or market) impact. If a market is sensitive to the presence of a transgene, it will be difficult to maintain nonGE seed production of forages if grown in near proximity to GE forages.

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SESSION 5

AGRONOMY AND EXTENSION

BENCHMARKING HERBAGE SEED PRODUCTION IN NEW ZEALAND

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The productivity of herbage seed production varies markedly between growers in New Zealand in relation to both inputs and yield. ProductionWise is a cloud based paddock recording system which is freely available to New Zealand growers through the Foundation for Arable Research (FAR) for recording inputs and management practices. Individual growers can look at their data and can examine costs, yields and determine gross margins across individual paddocks on their farms or collectively by cultivar, soil type or management practices. The farmer can also export data from ProductionWise for use in Farm Environment Plans, nutrient budget tools and vendor declarations. FAR can compile paddock data, retaining farmer anonymity, and benchmark growers on a crop, regional or management practices basis. Benchmarking data from a number of farmers paddocks for the 2015/16 season had average perennial ryegrass yields of 1500 kg.ha^{-1} and 2100 kg.ha^{-1} for dryland and irrigated paddocks respectively. White clover average yields were 560 kg.ha^{-1} and 700 kg.ha^{-1} for dryland and irrigated paddocks respectively. The average gross margin ranged from just below NZ$2000.ha^{-1} to nearly NZ$3000.ha^{-1}. This paper outlines the ProductionWise paddock recording and benchmarking system and benchmarks ryegrass and white clover seed production in New Zealand.

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EFFECTS OF PLANT GROWTH REGULATORS ON CLOVER SEED CROPS IN OREGON

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Clover seed crops are a vital part of seed production enterprises and valuable rotation crops for grass seed growers in Oregon, USA. Plant growth regulator (PGR) use in seed production aims to reduce lodging and increase the number of seeds produced. Numerous studies have demonstrated that PGRs are an important tool for increasing seed yield in grass crops; however, there is limited information available on their effects in forage legumes. Field trials were conducted between 2011 and 2016 to determine the effect of PGRs on red clover (*Trifolium pratense* L.), crimson clover (*T. incarnatum* L.), and white clover (*T. repens* L.) seed crops in the Willamette Valley, Oregon. Three PGRs, trinexapac-ethyl (TE), prohexadione calcium (PC) and paclobutrazol (PB), were applied at various product rates at BBCH growth stages 32 and 51. Interaction between PGRs and irrigation (100 mm) was evaluated in red and white clover and stand age effects were determined in red clover. Seed yield was significantly increased by TE applied at BBCH 32 in crimson and second-year red clover by 9-24% and 9-19%, respectively. Seed yield was not affected by PC in red or crimson clover. White clover seed yield was not affected by TE or PB. There was no interaction between irrigation and PGR in red or white clover. Seed weight in all clover species was significantly reduced by TE at all timings and reductions were proportional to the application rate. Inflorescences m^{-2} were significantly increased in all clovers with TE, but not with PC or PB. A combination of increased inflorescences m^{-2} and reduced crop height in red and crimson clover likely contributed to seed yield enhancement by TE. The timely use of TE PGR is a practice that has broad applicability in crimson clover and second-year red clover seed crops but not in white clover or first-year red clover.

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STRATEGIES FOR N-FERTILIZATION AND GROWTH REGULATION OF MEADOW FESCUE (*FESTUCA PRATENSIS*) SEED CROPS

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The effect of three spring N rates, either 60, 90 and 120 kg ha^{-1} (6 trials) or 90, 120 and 150 kg ha^{-1} (2 trials) and four trinexapac-ethyl (Moddus) rates (150, 250, 350 and 450 g a.i. ha^{-1}) was evaluated in eight meadow fescue seed production trials in SE Norway during 2014-2016. Moddus was applied in all trials in the period from early tiller elongation to flag leaf emergence (GS 31-40). The recommended N rate in Norwegian meadow fescue seed production is 70 – 90 kg N ha^{-1}. However, in all trials, the highest seed yield was always from plots receiving the highest N-rate (120 or 150 kg ha^{-1}). Optimal Moddus rate depended on the lodging pressure in each trial. In three trials with minimal lodging at flowering (0-13%), no gain in seed yield was obtained by increasing the Moddus rate beyond the standard rate (150 g a.i. ha^{-1}), while the highest Moddus rates (250-450 g a.i. ha^{-1}) were required in four trials with a moderate to strong lodging pressure (37-80 % lodging at flowering). In one trial at an inland location, increasing rates of Moddus reduced seed yield, which was probably due to freezing stress after low night temperatures soon after application. It is concluded that meadow fescue seed crops should receive more N than the current standard rate (70-90 N ha^{-1}), and that an increase beyond the standard Moddus rate of 150 g a.i. ha^{-1} would be beneficial in seed crops that are in risk of lodging. However, the results also indicate that spraying of high Moddus rates to meadow fescue seed crops that are stressed in any way (drought, frost etc.) should be avoided.

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IF WE WERE STARTING OUR SEED RESEARCH CAREERS AGAIN – WHERE ARE THE OPPORTUNITIES?

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Seeds are the delivery vehicle for new plant genetics. Thirty years ago it seemed that the need for seed production agronomists might be replaced by the development of synthetic seeds, but that technology has stalled. Internationally there is no shortage of people with molecular genetic skills who are very proficient in the laboratory. In our experience few of these people can actually grow a plant in the greenhouse, let alone in the field. The world is now short of agronomists who can grow and manipulate plants to maximise seed yield and seed quality, and who can convey this information to seed producers. The seed production agronomist of the future must be able to talk and understand the language and science of molecular genetics and to know when it is a tool to solve problems. A good understanding of whole crop physiology and cellular level physiology, especially hormonal regulation in plants is essential. Equally the agronomist also needs to understand production systems and the environmental consequences of using various inputs, from herbicide resistance to carbon footprints and nitrogen leakage consequences. There are many opportunities for people with good "old fashioned" field agronomy skills, attuned to emerging environmental constraints on sustainability and emerging precision agriculture technologies but also able to communicate with seed growers, plant breeders and researchers in plant molecular genetics.

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EFFECTS OF PLANT GROWTH REGULATOR AND FORAGE CUTS ON DEMOGRAPHY OF REPRODUCTIVE TILLERS IN A WARM-SEASON GRASS

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In crops grown for seed production, the management of forage cuts is justified because it stimulates the formation of high-density tillers, retards and synchronizes the flowering, and aids the harvest process due to the reduction of vegetative mass. The use of plant growth regulators (PGR) has been reported to enhance seed yield in several forage species, but not in a subtropical forage grass such as *Panicum coloratum*. This study examined the interaction of PGR and forage cuts at different times on tiller demography and the recruitment of reproductive tillers in a monoculture stand of *P. coloratum var. makarikariense cv. Kapivera INTA*. Two field trials were established in Rafaela (31°11'41'' S; 61°29'55'' W) and Jesús María (30°56´2.79"S; 54°04´43.02"W).Treatments consisted of the combination of application of chlorocholine chloride(3 l/ha-1) before panicle emergence and forage cuts (no cut and cuts when 30 and 60% of tillers were elongated) in a split plot design. Quadrats of 1/16 m2 were harvest 9 times in each of three- 5 m2- plots per treatment. To see changes in tiller demography, MSC (mean stage count) and MSW (mean stage weight), quantified estimates of tiller population maturity, were calculated at each harvest. Differences in MSC and MSW showed a reduction after the cuts, indicating the appearance of more vegetative tillers, although differences were significant only after the cut at 60%. Application of PGR presented no significant differentiation in tiller demography even though the PGR seemed to reduce differences after the 30% cut with the control. The number of reproductive tillers substantially declined after the cut at 60% but differences were not apparent when cut was done at 30% of tillers were elongated. Forage cuts after tiller elongation might reduce seed production by decreasing the number of tillers attaining reproductive stage.

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CAN UREASE INHIBITORS INCREASE SEED YIELD IN GRASS SEED CROPS?

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Nitrogen (N) increases seed yield in grass seed crops by increasing seed number and seed weight. Nitrogen use efficiency is reduced by ammonia volatilization losses; thus, seed growers may not receive maximum benefit from all of the N they apply. A commercially available urease inhibitor [N-(n-butyl) thiophosphoric triamide] (NBPT) has shown considerable efficacy in reducing N losses due to volatilization and increasing yield in several agronomic crops, but little is known regarding its use in grass seed crops. Trials were conducted in first-year perennial ryegrass (*Lolium perenne* L.) seed fields at six on-farm sites in 2014 and 2015 in western Oregon. Ammonia volatilization losses of 5 to 25% have been measured in this temperate high rainfall region. Fertilizer treatments included two N rates applied as 40-0-0-6, representing the range of recommended rates for perennial ryegrass seed crops in Oregon (135 and 180 kgN.ha^{-1}), with and without NBPT. A split application of 180 kgN.ha^{-1}, with 50% applied as 40-0-0-6 with NBPT and 50% applied as liquid urea ammonium nitrate (UAN) was also included. Above-ground biomass, total tissue N, seed yield, and seed weight were measured. Seed yield was significantly increased by N rate in 2014 but not in 2015. The addition of NBPT significantly increased seed yield by 6% when 135 kgN.ha^{-1} was applied, but only in 2014. NBPT had no effects on seed weight, above-ground biomass, or total tissue N across sites. Nitrogen tissue concentration was 12% higher in 2015 than in 2014 which may explain differences in seed yield response between the two years. These results indicate that NBPT urease inhibitor products have potential for improving N fertilizer use efficiency and grass seed yield when conditions are favorable for ammonia volatilization and when plant N is a limiting factor.

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ANNUAL RYEGRASS (*LOLIUM MULTIFLORUM*) AND CONTINENTAL TALL FESCUE (*SCHEDONORUS ARUNDINACEUS*) HARVESTING: COMPARISON OF DIFFERENT METHODS TO REDUCE SEED LOSS

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Both annual ryegrass (*Lolium multiflorum* L.) and tall fescue (*Schedonorus arundinaceus* Shcreb.) are very susceptible to seed shattering, which is why it is key to work on management practices focused on reducing harvesting losses to achieve high seed yields. Seed crops can be harvested by two different methods: direct combining or windrowing. When direct combining, seed moisture content (SMC) must be under 30% and it is necessary to have appropriate machinery to dry the harvested seed immediately until SMC reaches 12%. When windrowing, SMC should be approximately 45%. No matter which is the chosen method, it is important to determine the optimum moment for each of them. The objective of this work was to determine which harvesting method minimizes the gap between potential seed yield and obtained seed yield in these two species in different locations, Balcarce and Pergamino, located 600 km apart in the Buenos Aires Province, and Ombucito, Río Negro Department, Uruguay and in different years. The harvest methods tested for annual ryegrass in Pergamino were direct combining, morning windrowing with dew and afternoon windrowing, using a windrower with belts in a 0.8 ha plot. Seed loss was estimated as the difference between potential seed yield and the final harvested yield. In Balcarce, 1 ha sized plots were direct combined and windrowed followed by harvest at two different SMC levels (20-18 % and traditional SMC 12%). The harvest methods tested in Balcarce were replicated for tall fescue. Seed loss was measured by quantifying seed on the ground before and after each mechanical treatment. In Uruguay windrowing and harvesting at two different SMC levels was assessed in tall fescue. As in direct combining, windrowing and harvesting at 20% SMC requires access to seed drying facilities. For annual ryegrass, the lowest seed loss was reported in the direct combining method and between both windrowing methods, harvest losses were lower when the crop was windrowed with dew, early in the morning. For tall fescue, seed loss was lower when the crop was windrowed and harvested 18% SMC. In general, lower losses are observed when time between windrowing and combine harvesting is reduced.

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COUPLING EFFECT OF IRRIGATION AND NITROGEN TO INCREASE SEED YIELD AND YIELD COMPONENTS IN WESTERN WHEATGRASS (*PASCOPYRUM SMITHII*) UNDER FIELD CONDITIONS.

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Western wheatgrass (*Pascopyrum smithii* Rydb.) is a primary cool-season forage and turfgrass used throughout temperate regions of the world. As scarce resources, water and nutrient management systems need to be improved to increase efficiency. The objective of this 3-year study was to investigate the response of seed yield and yield components to irrigation and nitrogen use in Jiuquan, Gansu province, China. Six multi-factor orthogonally designed field experiments with 143 treatments, and 380 experimental plots were used. The field management treatments included eleven rates of surface drip irrigation (X2), ranging from 0 to 148 mm, and 18/16 rates of nitrogen (N)/phousphrous (P) fertilizer (X3, X4), ranging from 0 to 480 kgN.ha^{-1} and 0 to 240 kgP.ha^{-1}, respectively. In each plot, the seed yield components: fertile tillers/m^2 (Y1), spikelets/fertile tillers (Y2), florets/spikelet (Y3), seed number/spikelet (Y4), seed weight (Y5) and seed yield (Z) were determined by hand. The interactive effect of N rates and irrigation was considered the main factor. The maximum Z and Y1 production in the three years, (1153 kg.ha^{-1} and 1525), respectively occurred in 110-115 mm and 275-285 kgN.ha^{-1}. The results showed that Z responded positively to increased applied N at rates up to 285 kg.ha^{-1} N. Pearson correlation coefficients showed Z and Y1 significantly correlat with X3, Y2 significantly correlated with X2, and Y3 significantly correlated with X5. Y1 and Y3 development were decisive for the high Z. The ridgeline figures showed that X3=-1.48*X2-0.003. The linear model implied irrigation and N rate had antagonistic effects on Y1. The optimal applications of X2 and X3 were obtained using response surface methods. Where water is a limiting factor in arid regions, the optimal N rate is associated with the irrigation rate. Adjusting N rates to meet crop requirements would get the benefits of recognizing the interaction between nitrogen and irrigation. A linear model of N rates to irrigation rates found antagonism for fertile tiller number. The optimal N range and irrigation rates was 108 to144 kg.ha^{-1} and 115 to 146 mm, respectively. This finding not only prevents a negative environmental impact, but also increases the seed yield and conserves agricultural inputs for western wheatgrass grown in an arid region.

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LATE SEASON PERENNIAL RYEGRASS SEED CROPS REQUIRE HIGHER PLANT GROWTH REGULATOR INPUTS

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The plant growth regulator, trinexapac-ethyl (TE, Moddus®) increased New Zealand (NZ) perennial ryegrass seed yields by up to 70% compared with untreated controls. Prior to 2007, application rate trials demonstrated that approximately 400 gTE.ha^{-1} was optimum with 50% yield increases resulting from increasing harvest index. These results were largely generated on standard flowering, New Zealand bred, cultivars which internationally are early flowering. With the introduction of many later flowering cultivars, both selected locally and grown for multiplication from Europe, many growers reported low, or inconsistent, yields when standard NZ management was used. On later season cultivars, single applications of TE at Zadoks growth stage 32 increase seed yield by approximately 22% at 400 g.ha^{-1} compared with 44% at 800 g.ha^{-1}. When a total of 600 g TE was split in three and applied in sequences (Zadoks growth stages 30/31, 32 and 39) seed yield could be increased by up to 59%. The increased TE requirements of late season cultivars is a result of increased crop mass, and the associated increased lodging pressure. Increased crop mass is associated with higher growth rates from increase solar radiation and the higher air temperatures that occur when stem extension is delayed from early October to mid-November.

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COMPUTATIONAL MODELS FOR IMPROVING SEED YIELD IN TIMOTHY (*PHLEUM PRATENSE* L.) BASED ON FIELD EXPERIMENTS.

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Timothy (*Phleum pratense* L.) is a high digestibility, good palatability and quality forage used throughout the world. This study aimed to test and verify two hypotheses: (1) all four seed yield components and the seed yield are inter-correlated, and all seed yield components positively contribute to seed yield and (2) there should be steady computational model between seed yield and its components that can closely estimate the seed yield. Four groups of multi-factor orthogonally designed field experiments, totally 102 experimental plots, under various field managements of 6 experimental factors (X1 through X6): fertilization timming, quantity of irrigation, applied N, applied P2O5, plant density and plant growth regulator Paclobutrazol spray, were used in this analysis. Seed yield components: fertile tillers.m^{-2} (Y1), spikelets/fertile tillers (Y2), seed number/spikelet (Y4), seed weight (Y5) and seed yield (Z) were determined by hand for each plot during three successive years. The algorithmic models were developed between the seed yield and its components to improve the seed yield using path analysis, ridge regression and grey relation entropy modelling. The correlations among Y1, Y2, Y4 to Y5 and their direct and indirect effects on Z were investigated. Correlation analysis indicated that Y2 and Y1 were the most important seed yield components describing Z, and Y5 was the least important. Total effects (directs plus indirects) of Y1, Y2, Y4 and Y5 on Z were positive, the contributions of the four components to the seed yield in decreasing order are Y2 > Y1 > Y4> Y5 (1.54, 1.37, 0.71, and 0.07, respectively). Seed yield components Y2, Y1, Y4 and Y5 were significantly ($P<0.001$) correlated with the Z for the 3 years totally, while in the individual years, and the inter-correlations among the components Y1 and Y2, Y1 and Y5, Y4 and Y2 were significant at two years, respectively. After ridge regression and grey relation entropy analysis, an algorithmic model of seed yield with its four components was found as: Z= e1.33•Y10.24•Y20.56•Y4-0.12•Y50.59, it could closely estimate seed yield. So, selection for high seed yield through direct selection for large Y2, Y1 and Y4 would be effective for better understanding how seed yield is created and referred breeding in the grass.

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LOTUS PEDUNCULATUS (CV MAKU) SEED PRODUCTION RESPONSE TO IRRIGATION

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This experiment was conducted in 2012 at INIA Treinta y Tres research station (Uruguay), on a second year Lotus Maku stand. The experimental design was a split-plot with three replications. The size of the plots receiving the 8 treatments was 10 x 15m. The objective was to determine Lotus Maku seed production response to different irrigation levels. Treatments consisted of two re-growth periods, called "early" or "late" closing (October 5 or November 9) and four irrigation amounts (0, 15, 30 and 45 mm). Irrigation was applied using a linear pivot. After grazing and mowing were completed (closing), irrigation was applied each time plant available water was depleted in the top 45 mm. Plots receiving 45 mm of irrigation always reached field capacity, while treatments receiving 30 and 15 mm experienced some water deficit. Seed yield and above ground biomass production were evaluated by harvesting six 0.5 x 0.2 m samples from each plot. Above-ground biomass was weighed and harvested seeds were threshed, cleaned and weighed. All variables were evaluated with analysis of variance (LSD). Irrigation increased above-ground biomass production (7129 vs. 5383 kg DM.ha^{-1}) and there was no difference between irrigation levels. Also irrigation increased seed yield by 68% (404 vs. 249 kg seed.ha^{-1}). There was no difference in seed yield between 30 and 45 mm irrigation treatments. Meanwhile, closing date affected only seed yield in non-irrigated treatments, 198 vs 300 kg seed.ha^{-1} for early and late closing date, respectively. In conclusion irrigation increased seed production and there was no response to different irrigation levels.

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FORAGE AND SEED YIELD OF RYEGRASS CULTIVARS IN THE VALLE BONAERENSE DEL RÍO COLORADO, ARGENTINA

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Italian ryegrass (*Lolium multiflorum* L.) and perennial ryegrass (*L. perenne* L.) are grown for seed and forage in the valle bonaerense del Río Colorado (VBRC), south of Buenos Aires, Argentina. Ryegrasses are important crops in the rotation of arable farming within VBRC. Seed yield and forage were determined for two annual and eight perennial ryegrass cultivars (5 turf and 3 forage types). The study was conducted in 2016 in an experimental field at INTA EEA Ascasubi. The soil at the site was an *Entic haplustoll*, sandy loam, slightly alkaline (pH 7.5), high in P content (30.6 ppm P) and low organic matter content (1.2%). The experiment was arranged in a complete randomized design with three replications. Plot dimensions were 2 m^2. Seeds were conventionally sown in contiguous plots on 27 April at a seeding rate of 500 seeds m^2. Above-ground biomass was measured at the end of winter (21 September). Seed yield, total biomass and crop height was estimated at crop maturity. Analyses of variance (ANOVA) and regression were performed using InfoStat software (2014). Treatment means were compared by Fisher's protected least significant difference test. The most productive cultivars during winter were Italian ryegrass ssp. *Italicum* and *Festulolium braunii*; *L. multiflorum* x *F. pratensis* followed by L. Lam. var. *Westerwoldicum*. Italian ryegrass seed yield was higher (221±52 $g.m^{-2}$) than perennial ryegrass (89±80 $g.m^{-2}$) ($p< 0.001$). Seed yield was linearly associated with total biomass ($r2 = 0.87$; $p< 0.01$) and crop height ($r2 = 0.76$; $p< 0.01$) at harvest. The results suggest that Italian ryegrass ssp. *Italicum* (255 g m2) and *Festulolium braunii* (254 $g.m^{-2}$) showed the best performance for seed production in VBRC, followed by L. Lam. var. *Westerwoldicum* (188 $g.m^{-2}$). For perennial ryegrass cultivars the RP-UE#1 (154 $g.m^{-2}$) and RP-UE#2 (103 $g.m^{-2}$) were more productive, these two European turf cultivars (RP-UE) without difference with forage *L. hibridum* (68 $g.m^{-2}$). The least seed productive were Nui, RP-UE#3, RP-UE#4 and RP-UE#5 (< 55 g m^2). All of the cultivars studied reached at maturity between 6 and 30 December.

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MODELLING SEED YIELD COMPONENTS CONTRIBUTING TO SEED YIELD IN ORCHARDGRASS (*DACTYLIS GLOMERATA* L.) BASED ON FIELD EXPERIMENTS.

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Orchardgrass (*Dactylis glomerata* L.) is a high quality forage species used throughout the world. This study aimed to test and verify two hypotheses: (1) all of the five seed yield components and the seed yield are inter-correlated, and contribute to seed yield and (2) the relationship between seed yield and its components should be a steady algorithmic model that can closely estimate the seed yield. We used multi-factor orthogonally designed field experiments with a total of 112 experimental plots. There were 10 experimental factors (X1 through X10), including fertilizer rate and timing, irrigation, plant density and use of plant regulators. For each plot the seed yield components : fertile tiller.m^{-2} (Y1), spikelets / fertile tillers (Y2), florets / spikelet (Y3), seed numbers/spikelet (Y4), seed weight (Y5) and seed yield (Z) were assessed with a big sample size (n = 3120) from three years of field experiments. The algorithmic models used to determine the relationship between the seed yield and its components included path analysis, grey relation entropy modelling and ridge regression. Correlation analysis indicated that Y1 and Y4 were the most important seed yield components describing seed yield (Z) and Y2 was the least important. The correlations among Y1 to Y5 and their direct and indirect effects on Z were investigated. The direct and indirect effects of Y1, Y4, and Y5 to Z were positive while Y3 and Y2 were weakly negative. The contributions of the five components to seed yield in decreasing order were Y1 > Y4 > Y5 > Y3 > Y2. The seed yield components Y1, Y4 and Y5 were significantly ($P<0.001$) correlated with Z for the three years overall, while in individual years, there were significant pair wised interactions among the components Y1 through Y5 on Z after modelling. Using ridge regression analysis, a steady algorithmic model of seed yield with its five components was found: Z= e3.64•Y10.20•Y20.03•Y3.08•Y40.12•Y51.58. It could closely estimate the seed yield. High yield components of Y1 and Y4 would be effective for increasing seed yield.

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THE SYNERGIES GAINED FROM NITROGEN-PHOSPHORUS APPLICATION INCREASE SEED YIELD IN ORCHARDGRASS (DACTYLIS GLOMERATA L.) UNDER FIELD CONDITIONS.

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Orchardgrass (*Dactylis glomerata* L.) is a high yielding forage grass that has good palatability, high digestibility and strong shade-resistance. This study aimed to test and verify two hypotheses: (1) the synergies gained from nitrogen-phosphorus increase seed yield through the yield components and (2) there should be steady algorithmic models demonstrating the synergic effects on seed yield and its componests, which can be used to closely estimate the seed yield. Multi-factor orthogonally designed field experiments, a total of 112 experimental plots under various field management factors that included fertilization regime (nitrogen (N)-X1; phosphorus (P)-X2), irrigation (X3), planted density (X4) and plant growth regulators applications (X5) were used. In each plot, the seed yield components: fertile tillers/m^2 (Y1), spikelets/fertile tiller (Y2), florets/spikelet (Y3), seed number/spikelet (Y4), seed weight (Y5) and seed yield (Z) were determined by hand for three successive years. The algorithmic models were developed between seed yield and its components to improve seed yield using path analyses, ridge regression and grey relation entropy analyses on N and P. The correlations among X1 through X5, Y1 through Y5 and Z were estimated. The direct and indirect effects from Y1 to Y5 on Z were investigated. Correlation analysis indicated that Y1 and Y5 were the most important seed yield component describing the Z and Y3 was the least important one. The total effects (direct and indirect) of X1 through X5 on Y1 to Y5 and Z were calculated. The overall contribution of the five factors to seed yield components and yield in decreasing order are X1 > X4 > X2 > X3 > X5. There were significant synergies from pair wised factors among X1 to X5 on seed yield and its components. The highest synergy on Z was between X1 and X2. Steady algorithmic models of seed yield with its five components and the five factors were found. The model of synergy from N and P could closely estimate the seed yield. Effective coefficient of N-P would promote seed yield in orchardgrass.

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CHALLENGES IN LARGE SCALE SEED PRODUCTION OF FRIENDLY ENDOPHYTE-INFECTED TALL FESCUE (*SCHEDONORUS ARUNDINACEUS*)

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One important plant-microbe symbiosis occurs between grasses such as tall fescue and the asexual fungal *Epichloë endophyte*. Unfortunately, tall fescue wildly spread in Argentina harbors a variety of this endophyte that can cause toxicity to grazing livestock due to the production of ergot alkaloids. For this reason, 3% of toxic endophytes is the maximum level allowed for commercialization of certified seed of tall fescue in Argentina. AgResearch developed the strain AR584, an endophyte that does not produce toxic alkaloids but still provides benefits to its plant host. The numerous steps during the crop cycle, seed harvest, seed processing and storage challenge the viability of the endophyte in the seed. Previous tests conducted at Gentos showed that endophyte levels were reduced from 87% to 61% after two months of storage in a warehouse while storage in a cold room showed a reduction of 2%. The future commercialization of a friendly endophyte-infected tall fescue cultivar depends on the ability to maintain high levels (>70%) of viable endophyte in the seed. The objective of this work was to produce a large-scale seed increase of an advanced tall fescue experimental line inoculated with AR584. Twenty hectares were sown in March 2016 in Pergamino, Buenos Aires Province. Seeding rate used was 5 $kg.ha^{-1}$ and space between rows was 21 cm. At the time of sowing 90 $kg.ha^{-1}$ of DAP and 300 $kg.ha^{-1}$ of urea were applied during the development of the crop. Fungicide spraying, a standard practice in seed production fields, was not performed to prevent endophyte levels dropping in the field. Cutting and windrowing were done in November 2016, when seed moisture content (SMC) was on average 42%. After 4 days in the field, seed was harvested at 22% moisture content and put immediately into a forced air dryer, without heat, for 10 days until SMC reached 11 %. Finally, seed was cleaned, bagged and stored under controlled conditions (between 5 and 8 °C and 60-70 % RH). The crop yield achieved was 420 $kg.ha^{-1}$ of clean seed. Vertical transmission and endophyte viability was checked throughout the process and during cool storage, and encouraging results were obtained. Endophyte level in the seed was 89% and endophyte grow out tests indicated that viability was 90%. These results suggest that seed-plant-seed endophyte transmission was successful and that the endophyte viability was maintained during the crop´s management and final storage.

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RESPONSE OF CREEPING RED FESCUE (*FESTUCA RUBRA* L.) SEED CROP TO TIMING, RATE AND FORMS OF NITROGEN APPLICATION IN THE PEACE REGION OF WESTERN CANADA

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Nitrogen (N) is considered one of the major limiting factors in persistent grass seed productivity in the Peace Region of Canada. For the convenience of operation, nitrogen fertilizers are applied in the stubbles of grass seed stands in the fall season that precedes the seed harvest year. On-station and on-farm field experiments were conducted near Beaverlodge from 2014 to 2016 to evaluate the response of creeping red fescue to different timing, rates and forms of N application. Conventional urea (CU), Agrotain®-treated urea (ATU), ESN® polymer-coated urea (EPCU) and a blend of CU and EPCU were broadcast at 65 and 100 kg N ha-1 in the crop stubbles in mid-September and mid-October. Grey luvisol with acidic reaction typifies the soils at the trial sites. The growing season (May to October) was much drier in 2014 and much wetter in 2015 and 2016 than the long-term average of 30 years. Response of creeping red fescue to N application in the fall was variable over the years, signifying the weather effects on crop physiology and N dynamics in the soil. In most of the trials, N treatments produced significantly higher seed yield than the unfertilized control. However, there was no significant yield advantage of increasing N rates from 65 to 100 kg ha-1. Relative yield of mid-September or mid-October application was also variable over the years and sites. Based on both on-station and on-farm results, fall application of N stabilizer or slow release forms had no incremental effect on seed yield over conventional urea. The fescue seed crop response to N application in relation to soil quality variables will be discussed and gross-margin analysis will also be presented.

Key words: Creeping red fescue, nitrogen, urea, agrotian, ENS

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ANNUAL RYEGRASS SEED YIELD RESPONSE TO TRINEXAPAC-ETHYL IN NEW ZEALAND

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The plant growth regulator, trinexapac-ethyl (TE, Moddus®) was evaluated in 11 field experiments, mostly on commercial seed production farms. The experiments involved 6 cultivars at 7 locations in the Canterbury region with trials covering the years 2002 to 2016. Seed yields were increased by 400 g TE/ha applied at Zadoks growth stage 32 by 54%, an average seed yield increase of 870 kg/ha over the untreated control. In Europe and Oregon seed yield of annual ryegrass treated with TE have been small, usually <15%. The paper examines management differences between New Zealand and other locations that may contribute to the differences in TE responsiveness between countries/regions. New Zealand annual ryegrass crops are usually defoliated in spring and grown with irrigation, allowing the TE treated plots to maximize light interception without a moisture stress during seed fill.

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EFFECT OF TRINEXAPAC-ETHYL APPLIED AT THREE RATES AND TWO STAGES ON TIMOTHY, MEADOW BROMEGRASS AND CREEPING RED FESCUE SEED STANDS IN THE PEACE RIVER REGION OF ALBERTA, CANADA

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In Canada, trinexapac-ethyl (TE) plant growth regulator is registered for use only on perennial ryegrass (*Lolium perenne* L.) for seed production and managing growth of turfgrass on golf courses and commercial sod farms. Three years (2015-2017) of replicated small plot trials were conducted at Beaverlodge, Alberta to determine the effects of TE applied at three rates (200, 300 and 400 g ai.ha^{-1}) and two growth stages (2-node and early heading) on plant height, lodging, seed yields, seed weight and germination on first year stands of timothy (*Phleum pratensis*), meadow bromegrass (*Bromus biebersteinii*) and creeping red fescue (*Festuca rubra*). Spring topdressing of 35 kg.ha^{-1} of nitrogen (N) in the form of UAN (28-0-0) was also applied with and without TE at 300 g ai.ha^{-1}. Precipitation during the growing season at Beaverlodge in 2015 and 2016 was 1.2 and 1.7 times the long term average (30.2 cm). TE reduced plant heights of timothy in both years and reduced lodging in 2016. TE applied at two-node stage increased seed yields by fifty percent in 2015 and thirty percent at both timings in 2016. Plant heights and lodging were reduced by TE on meadow bromegrass in both years but had no effect on seed yield. The application of TE at early heading reduced plant heights of creeping red fescue but did not reduce lodging or improve seed yield. TE had no effect on seed weight or germination on any of the species. Additional N applied with and without TE does not appear to increase seed yields over the same treatments applied alone. It appears TE has potential for use on some grass species grown for seed in Canada.

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PRE-HARVEST MANAGEMENT OF SEED LEGUME FORAGE CROPS: EVALUATION OF SEED LOSSES WITH SWATHING METHOD ON ALFAFA (*MEDICAGO SATIVA*), RED CLOVER (*TRIFOLIUM PRATENSE*), AND CRIMSON CLOVER (*TRIFOLIMUM INCARNATUM*) UNDER FRENCH CLIMATE CONDITIONS

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Harvest is a delicate step in forage legume seed production, because of the effect of plant moisture on effective threshing, and the risk of seed shattering. Except in cases of exceptional climate conditions that enable growers to direct combine, most legume seed fields in France are desiccated by chemical methods before harvesting. Very few chemicals are effective to desiccate legume seed crops, and increasing health and environmental regulations in Europe could possibly lead to their restriction of use. Remaining methods for harvesting would be direct combining or swathing (windrow harvesting). Most reports about swathing agree that seed losses can be important (up to 30% or more), depending on timing, maturity of the crop and hygrometry during swathing, and meteorological risks (wind/rain/hail). Globally, the optimum timing for swathing legume seed crops is when 2/3 to ¾ of pods/capitulum are brown. Because there were no references under French climate conditions, FNAMS conducted numerous trials for many years (2011-2016) to determine potential seed losses for pre-harvest swathing of alfalfa, red clover and crimson clover seed production. Seed losses were measured in crop fields, with different machinery (windrowing/swathing), and compared, when possible, to direct combining or chemical desiccation. Swathing, under optimum conditions (good timing for both maturity and weather), resulted in seed losses under 5% for alfalfa, and 10% for clovers. Seed losses in clover increased to 30% when swathing on advanced maturity stage or during a dry day. Plant and seed moisture decreased faster with swathing than with chemical desiccation, and moisture level at harvest day was lower for swathing (10%) than for chemical desiccation (30-35%). Maturity stage at swathing was also investigated in clover for 2 years, to minimise seed shattering and evaluate its effect on germination and seed weight. Swathing before advanced stage of maturity significantly reduces seeds loss, but effects on seed quality have to be confirmed.

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MODELLING OF NITROGEN (N) FERTILIZER LEVEL EFFECTS ON PERENNIAL RYEGRASS (*LOLIUM PERENNE* L.) SEED- AND BIOMASS PRODUCTION AND ON N LEACHING.

J. Gyldengren, B. Boelt, R. Gislum*

Agroecosystem modelling offers possibilities for analysing and improving production systems – typically with an emphasis on crop rotation, soil management and water- and nutrient use efficiency. However, grass seed production has rarely been the subject for crop modellers. In most cases, grass crops have been applied in modelling studies of crop rotation and leaching (eg. Berntsen et al., 2006), climate change impact (eg. Holden & Brereton, 2002) or soil organic matter development (eg. Taghizadeh-toosi & Olesen, 2016), and in such studies, seed production is not the area of interest. In this study, the soil-water-crop-atmosphere-model Daisy (Abrahamsen and Hansen 2000) was used for modelling of ryegrass seed production. The aim of the study was to assess the productivity and environmental impact of a cropping system, with perennial ryegrass (*Lolium perenne* L.) for first year seed harvest (2014) and biomass for protein production in the following year (2015). The study included two levels of N-fertilizer in 2014 (170/220 kg N ha^{-1}) and five levels of N in 2015 (0/120/220/320/420 kg N ha^{-1}) applied in three splits in decreasing amounts during the spring growing season. Biomass was cut three times from May to October in 2015. Results showed that seed yield did not differ between fertilizer levels in 2014 (average seed harvest of 1925 kg ha^{-1}). In 2015, biomass yields increased until a fertilizer level of 320 kg N ha^{-1}, while N-yield increased until 420 kg N ha^{-1}. Model simulation results showed that perennial ryegrass in this cropping system is very efficient in retaining N in the soil and crop (including roots), with only minor N leaching losses as a consequence - even at high N-input levels. Thus, this cropping system has the potential to produce both seeds and raw protein with little adverse environmental impact in terms of N loss. By retaining substantial amounts of N in the soil and roots, this system also provide an interesting component in rotations including crops with high N demands.

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SESSION 6

PHYSIOLOGY FOR UNDERSTANDING SEED YIELD POTENTIAL

THE USE OF PRECISION AGRICULTURE IN HERBAGE SEED PRODUCTION - A CASE STUDY CONCERNING NITROGEN APPLICATION

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Denmark is a world leading grass seed exporter that is striving to keep this position by increasing the efficiency of the production system while minimizing the negative environmental impact. One way to increase efficiency while minimizing environmental impact is to use sensor technologies when nitrogen (N) is applied. Several new technologies, such as satellites, reflectance sensors and drone mounted cameras are available today, and they all claim to contribute to applying N according to plant need. The purpose of this project is to push the drone mounted camera technology out to the farmers and test if this technology can make N application maps that are economically and environmentally profitable for the seed grower and the environment. To establish a variable N application map, a synthesis of multiple information layers is required. Satellite and drone sensor technologies generate crop index and multispectral imagery that is used to model crop growth and productivity in a field. Cross referencing strategic crop samples to analyze biomass, N status and uptake to crop indices and imagery is combined with critical N dilution curves to develop N application algorithms and N application maps. Crop samples are taken and biomass ($kg.ha^{-1}$) and N% are measured and compared with the critical N dilution curve for grass seed crop. The possibility of replacing the time-consuming crop sampling, including chemical measurement of N%, with imagery and concomitant calculation of crop indices is furthermore tested. The results will be used to develop N application algorithms and N application maps. A key parameter is to have in-field crop variability well characterized. However, the crop variability can often be correlated to soil textural and other soil physical/chemical properties. Soil variability, defined by DUALEM sensor technology, topographical information and physical soil samples taken is incorporated as an additional explanatory variable to the N application map. To comprehend and execute the N application map, an advanced N spreader will be developed in 2018. We are confident that the use of images from a drone mounted camera, combined with site specific fertilization, will be able to increase the efficiency and minimize the environmental impact from N applications.

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SEED YIELD COMPONENTS IN WHITE CLOVER

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Forage legume species have a low floral fertility resulting in a low number of seeds per pod – in general white clover has two seeds from five ovules. Thus, increasing ovule and floral fertility seems to have an obvious potential for improving seed yield without compromising the vegetative development in forage legumes. In field trials we studied seed yield and yield components in white clover as affected by defoliation during the years 2014-16. The seed yield did not differ between the untreated control and defoliation at bud appearance with an average yield of 963 $kg.ha^{-1}$. It was decreased by approximately 150 $kg.ha^{-1}$ by defoliation two weeks after the first flowerbuds appeared, which was correlated with the number of flowerheads contributing to the seed yield. Among the seed yield components we analysed the number of seeds per floret in individual flowerheads and found a great variability between flowerheads. The number of seeds per floret varied from 0.50 to 5.20. Since pollination immediately after the floret opens results in more seeds per floret our future perspective is to try and identify management factors which may attract pollinators to the white clover seed crop. One method may be to plant pollinator attracting flower strips (eg. Phacelia) around the white clover seed crop, and this is being investigated.

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EFFECTS OF STAND AGE ON SEED PRODUCTION IN TALL FESCUE

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Tall fescue [*Schedonorus arundinaceus* (Shreb.) Dumort.] seed crops produce only a fraction of the crop's seed yield potential and the reasons for this yield gap are poorly understood. Seed yield declines with increasing stand age in several perennial grasses but little information is available on the aging process in tall fescue. The objective of this study was to document the incidence and severity of seed yield loss in aging stands of tall fescue and to examine factors associated with this loss in seed yield. A meta-analysis was conducted on nine Oregon State University tall fescue seed production field studies located at 11 sites throughout Oregon's Willamette Valley from 1985 to 2012. Stand age was considered to be a fixed effect while experimental agronomic treatments (32) and cultivars (21) were treated as random effects in the mixed model analysis of variance. Seed yield did not differ among 1st and 2nd year stands; however, seed yield was reduced by 26% in 3rd year stands. A reduction in seed weight in 3rd year stands contributed to this loss in seed yield, but no effects of stand age on seeds m^{-2} were observed. The number of florets m^{-2}, a fundamental measure of seed yield potential, was reduced in 3rd year stands. Since florets $spikelet^{-1}$ were not affected by stand age, contributors to the loss in seed yield potential in 3rd year stands were found to be significant reductions in panicles m^{-2} and in spikelets $panicle^{-1}$. Partitioning to seed in relation to other parts of the plant was also affected by stand age as harvest index was reduced in 3rd year stands. Among vegetative characteristics, only biomass at peak anthesis was affected by stand age. The results suggest that crop management can be fine-tuned to include age-specific practices in tall fescue seed production.

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RESPONSES OF SEED WEIGHT AND NUMBER TO DIFFERENT SOURCE-SINK RATIOS IN SIBERIAN WILDRYE

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In order to analyze the roles of nitrogen fertilization and reserve accumulation on seed weight and seed number of Siberian wildrye (*Elymus sibiricus* L.), a split plot experiment with four replications was carried out from 2012 to 2015. The main plots were nitrogen application rates (0, 90, 180 kg N ha^{-1}) and sub-plots were source-sink ratios including half trimming (all spikelets from the upper half of the spike were cut) and no trimming. Nitrogen application increased single seed weight in three successive years and seed setting rate of spikelets (the percentage between the number of seeds and florets in the spikelet) in 2013 and 2014. Moreover, single seed weight and seed setting rate were significantly increased by trimming spikes across nitrogen application rates. Difference of stem dry weight (average difference of dry weight between maturity and anthesis stages) increased from anthesis to seed maturity, while difference of leaf dry weight decreased. Difference of stem dry weight increased significantly with nitrogen application in 2013 and 2014, and increased with trimming in 2013. However, seed germination and vigor level did not change under these treatments. Results suggested that treatments of increasing nitrogen application rate and spike trimming were benefit for seed sink, and seed setting rate could be used as an indicator to evaluate the source or sink limitation. Stems in the perennial grass considered as other sink could compete the reserve accumulation with seed sink during seed maturity which was different with annual crop species. Furthermore, the main reason causing seed yield fluctuation was the decrease of seed weight and seed setting rate with prolonged stand age. Our results are helpful for the understanding on nitrogen management and nutrient material reserves in the perennial grass seed production.

Keywords: Siberian wildrye; single seed weight; seed setting rate; source-sink ratio.

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AN INTRODUCTION TO PREDICTION OF KEY DEVELOPMENT STAGE IN HERBAGE GRASSES.

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The time of anthesis signals the start of seed filling in annual and perennial seed crops. The time of anthesis can be predicted empirically from metadata in an environment or more mechanistically as a function of temperature accumulation and its modification by photoperiod and vernalisation requirements. Empirical models often work well within their original location while mechanistic models have the potential to be unifying across environments if they account for the abiotic factors that drive flowering. For annual and perennial grasses, the prediction of anthesis usually requires accurate estimation of the final number of main stem leaves. Delays in development are observed as an increase in the number of main stem leaves above a species defined minimum. Thus, the number of days from sowing to anthesis is a function of the final number of main-stem leaves produced (FLN) and the time required for each leaf to appear (phyllochron) followed by the period from final leaf emergence until anthesis. Both the phyllochron and final leaf emergence until anthesis may decrease with increasing temperature so can be treated as temperature accumulation targets. These targets can be modified by cold temperature requirements (vernalisation) and photoperiod (Pp) which interact with developmental genes. As a consequence simple temperature accumulation targets for different developmental stages can be used to predict anthesis but are unlikely to be accurate unless they account for Pp and vernalisation requirements. Many forage and turf grass species have duel requirements that involve either exposure to cool temperatures and/or short days (vernalisation) followed by exposure to long days. Vernalisation minimizes the FLN as saturation is reached (under long days) and flowering will not be delayed. A similar response occurs for increasing Pp where flowering is delayed under decreasing or short photoperiods. For modelling, these responses are converted into a rate of development for incorporating into crop simulation models. Vernalisation is saturated in the major seed producing areas of Oregon and Denmark allowing for a model of Pp effects to predict anthesis. However, further work is required to predict anthesis in warmer regions e.g. Australia and South America, where an understanding of how vernalisation, Pp and daily spring temperatures interact to influence FLN.

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UNDERSTANDING THE SHATTERING PROCESS: DIFFERENCES ON SEEDS SHATTERED AT DIFFERENT TIMES IN *PANICUM COLORATUM VAR.MAKARIKARIENSE*

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Panicum coloratum var. makarikariense is a warm-season perennial grass potentially used as forage on heavy clay soils with low drainage. Due to non-uniform development of the panicle and low seed retention, poor quality and quantity of seed are usually harvested. The aim was to of evaluate whether there is a change in weight and germination in seeds shattered at different times. We conducted an experiment comparing seeds shattered at 2 and 4 weeks after anthesis. We further studied the relationship of morphological characters of the mother plant with seed traits. Fifteen spaced-plants from 13 half-sib families in a complete randomized block design with 5 replications were measured at INTA EEA Rafaela (31°11'41'' S; 61°29'55'' W) totalizing 195 plants. Shattered seeds were harvest weekly for two months from a specially designed seed trap. Seed retention (SR) was estimated as the relative number of seeds retained over the total seed number by panicle (SN). We focused on seeds shattered 15 (2) and 30 (4) days after anthesis. At these dates, seed weight (mg, SW2 and SW4) and germination percentage (%, PG2 and PG4) of seeds were evaluated. Number of panicles by plant (PN), flag leaf area (cm2, FLA) and number of leaves perpanicle (LN) were also measured. Variability among families was analyzed by ANOVA. Differences on average PG and SW at each harvest date were compared by the t student test. Results showed that families significantly ($p<0.01$) differed in SW2, SW4, PG4, SN, SR4 and PN. No significant differences were detected for PG2, SR2, LN y FLA. Additionally, both PG and SW were significantly ($0<0.01$) higher at the 2nd harvest than at the 4th one. Correlations between variables were always low ($r<0.20$); only some were significant (positive for SN-PG4 and LN-FLA); and negative for SN-PN, SN-PR4 and PN-PG4). Differences in seeds characteristics among families as well as differences between seeds shattered at different times should be further studied to increase understanding of the shattering process.

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INHIBITION OF PHOTOSYNTHETIC ACTIVITY IN GLUMELS AND FLAG LEAVES AFFECTS SEED FILLING IN *PANICUM COLORATUM VAR. MAKARIKARIENSE.*

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Photo-assimilates stored in leaves and stems may be a source of carbohydrates during the seed filling period. Competition for photo-assimilates between seed and remaining vegetative structures is important to understand changes in seed production parameters. The aim of this study was to determine the relative importance of the flag leaf and the glumels in contributing to seed yield in panicles of *Panicum coloratum var. makarikariense cv. Kapivera INTA*. An experiment was conducted at INTA EEA Rafaela (31°11'41'' S; 61°29'55'' W) with 3 treatments: 1) control, 2) the flag leaf covered by aluminon foil and 3) all glumels covered by a black cloth enclosing the entire seed head. Experiments were conducted in a completely randomized block design, with 3 replicates of each treatment per block totalizing 27 panicles. Seed heads were enclosed in a seed trap to preclude seed losses by shattering. Treatments were established at anthesis. After 6 weeks, all seeds produced per panicle were collected, counted and weighted. Percentage of mature and empty seeds, weight of 1000 seeds (1000 SW) and total number of mature seeds were measured. The yield components were consistently reduced by covering the glumes resulting in discolored, lighter seeds (0.45 g) and a higher percentage of empty seeds (73%) than control plants (1.19 g and 0.27% for 1000 SW and % empty seeds, respectively). By contrast, the flag leaf covered result in normal color brown seeds and no differences in seed weight and number of mature seeds with the control treatment. Although differences were not significant, panicles with the flag leaf covered produced a higher percentage of empty seeds (38%) than the control (27%). Results suggest the suppression of the photosynthetic activity of the glumes had a negative effect on seed filling, as the seeds had less weight and absence of normal coloration. Additionally, the flag leaf may have no effect on the developing seeds while light incidence on the entire panicle may play an important role on the seed development.

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REPRODUCTIVE PHENOLOGICAL SCALE IN *PANICUM COLORATUM VAR. MAKARIKARIENSE*

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Phenological studies and time elapsed in phenological development are critical to plan an optimal method of harvesting; however, they have been scarce in *Panicum coloratum var. makarikariense*. With the aim to develop a phenological reproductive scale, we compared three populations (DF, ER and BR) and a recently released cultivar (Kapivera INTA). Ten plants from each material were clonally replicated in 5 blocks in the field. Plants were cut at the end of spring and a tiller was chosen per plant. That was considered day 0 to initiate the phenological scale. Additionally, seed traps were mounted in 3 clones per genotype to evaluate yield components. The phenological scale developed comprises four periods: inflorescence emergence, anthesis, development of the fruit and fruit shattering. Each period has different stages and all of them have their own description. We found that ER and BR required 521 growing degree days (GDD) to complete the first period and initiate anthesis, while Kapivera and DF needed 548 GDD. Population BR needed 609 GDD to complete the second period while all the others required 654. Kapivera, DF and ER finished period III after 766 GDD and began seed shattering but BR only required 654 to reach this point. However, all populations completed the last period after 1140 GGD. Regarding seed yield components, Kapivera was the one that produced the largest number of seeds with the highest weight and presented highest proportion of mature over empty seeds, while BR was the one that had the lightest seeds in the smallest number and presented highest proportion of empty seeds.

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MATHEMATICAL MODELS BETWEEN SEED YIELD AND ITS COMPONENTS IN WESTERN WHEATGRASS (*PASCOPYRUM SMITHII*) UNDER FIELD CONDITIONS.

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Western wheatgrass (*Pascopyrum smithii* Rydb.) is a primary cool-season forage and turfgrass used throughout temperate regions of the world. This study aimed to test and verify two hypotheses: (1) seed yield components and seed yield are inter-correlated, with seed yield components positively contributing to seed yield and (2) the relationship between seed yield and its components should be a steady algorithmic model that can closely estimate seed yield from the components. Six trials of multi-factor orthogonally designed experimental field plots (380) were established with various field management factors. Two trials had 3 and 4 replicates, respectively; the other four trials were mathematically designed replicates in the orthogonal design (inner included). The factors were: different regimes of nitrogen, phosphrous, irrigation, plant density, plant growth regulators, time of fertilizing, quantity of irrigation, irrigation time, density manipulation, time of post-harvest stubble cutting, and burning post-harvest residue. Seed yield components, fertile tillers/m^2 (Y1), spikelets/fertile tiller (Y2), florets/spikelet (Y3), seed number/spikelet (Y4), seed weight (Y5) and seed yield (Z) were determined over three successive years. The algorithmic models were developed between seed yield and its components using path analysis and ridge regression analyisis. The correlations among Y1 to Y5 and their direct and indirect effects on Z were investigated. Correlation analysis indicated that Y1 was the most important seed yield component describing Z, and Y2 was the least. The total effects (directs plus indirects) of Y1, Y2, Y3 and Y5 on Z were positive, while effect of Y4 was weakly negative. The contributions of the five components to seed yield in decreasing order are Y1 > Y2 > Y3 > Y5 > Y4 (1.68, 0.2667, 0.2272, 0.05 and -0.2907, respectively). Seed yield components Y1, Y2 and Y5 were significantly ($P<0.001$) correlated with Z for the all 3 years, while in individual years, and the inter-correlations among the components, Y1 to Y5 were significant at least 2 of the years. Ridge regression analysis of seed yield and its components was successful in closely estimating seed yield. Therefore, selection for high seed yield through direct selection for large Y1, Y2 and Y3 could be an effective tool to be used in grass breeding.

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CHARACTERIZATION OF YIELD COMPONENTS AND SEED YIELD POTENTIAL ON DIFFERENT CULTIVARS OF WHITE CLOVER (*TRIFOLIUM REPENS* L.)

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White clover (*Trifolium repens* L.) is one of the most important forage legumes of temperate climate areas. It is known that the number of inflorescences per unit area and the number of seeds per floret are the main components in defining seed yields and that, as the number of flowers of each inflorescence increases, the potential yield increases as well. The objective of this project was to determine seed yield potential of different white clover lines and to quantify yield components which may be contributing to seed yield. A seed yield trial was carried out at the Gentos experimental station located in Pergamino, Buenos Aires. Five experimental lines and three commercial Gentos cultivars were planted on March 21st 2016 at a density of 4 $kg.ha^{-1}$ in four-row plots with three reps. Standard commercial seed production management protocols were used including application of desiccant before harvesting. Plots were hand harvested. In every rep and line seed yield potential was estimated by harvesting 0.25 m^2, threshing and weighing the seed, and yield components were measured (number of seeds in ten flowers, number of flowers in five inflorescences and number of inflorescences: total, mature and immature, in 0.25 m^2). An ANOVA was performed for each of these variables. For this trial, there were significant differences between lines for number of seeds/flower, number of flowers/inflorescence and seed yield potential. The experimental line with the greatest seed yield potential (285 $kg.ha^{-1}$) also had the greatest number of seeds/flower (three seeds on average) and number of inflorescences (80 in total, 65% were mature heads). Uniformity at the time of desiccation played a big role in determining seed yield potential. From the data collected both total number of inflorescences and mature heads need to be accounted for. Frosts in late Spring and heavy rains in November and December may have reduced total yield in the trial.

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SEED SHATTERING AND RELEVANT TRAITS OF SHEEPGRASS

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Sheepgrass (*Leymus chinensis* (Trin.) Tzvel), a perennial forage grass with seed-shattering phenomena was chosen as a species to reveal the relative factors of seed shattering. Microscopic observations indicated the formation of abscission layers between spikelet pedicels and seed stalks during the course of seed maturity which was an important reason for seed shattering. Although there were full developed abscissions layers in the seed stalks of base spikelets, seed were not ready to shatter. Various Sheepgrass accessions showed a wide variation of seed-shatter rate. The rate of seed shattering was in the range of 22.8%-79.9% and the rate of fruit setting was in the range of 23.1% to 98.4%. The width of caryopsis and rate of seed shattering showed positive significant correlation ($P<0.05$), while the seed weight and caryopsis length had no significant correlation with the seed shattering. Furthermore, the seeds of some accessions, such as S4-3 and S5-3, shattered and germinated under natural conditions soon after maturity showing no dormancy.

Key words: Sheepgrass; Seed-shattering; Abscission layer; Relevant traits; Seed setting rate

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SESSION 7

SEED QUALITY AND TECHNOLOGY

GENERAL VIEW OF TECHNOLOGY APPLIED TO TEMPERATE FORAGES IN ARGENTINA

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In the last decades in Argentina the traditional cattle raising system based on natural grazing has been changing. Cattle raising has been relocated to areas that are not so fertile. Soil classes I, II and III, used for cattle raising, now are being used for agriculture. The relocation of livestock in soils of lesser agronomic capacity has changed the order of importance of temperate forage species and the botanical composition of pastures too. There are less species of monophytic pastures participating in forage availability. The most demanding soil fertility grasses, such as canarygrass (*Phalaris bulbosa*) and rescuegrass (*Bromus unioloides*), were the most affected in the displacement of livestock. Other species, more adapted to the new areas such as tall wheatgrass (*Thinopyrum ponticum* ex. *Elytrigia elongata*) and slender trefoil (*Lotus tenuis*) became important in the pastures. New varieties were developed in the market for these new grazing areas. Livestock farming in the new, more restrictive environments, have incorporated other strategies such as nutritional supplementation or/and feed-lot systems in some late finishing stages. Currently, the same technology applied to agriculture is also being applied to cattle husbandry:

- Species with new varieties adapted to each region generally obtained by local improvement and testing.
- Seed production derived from technology application, instead of seed production as a complementary activity of other primary farm productions.
- Implementation of pastures with adapted varieties to subtropical regions.
- Good seed quality incrusted or pelleted with pesticides and inoculants will allow high efficiency in establishment stages.
- Plant density control, variable fertilization and preventive weed control; all these will finally result in increased yield and good forage quality and quantity.

Traditionally, animal production based on natural grazing was an Argentine trade mark in the world's beef market. This status could be kept and boosted in the future with natural grazing in the new areas of cattle production.

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EPICHLOË FUNGAL ENDOPHYTES AFFECT GERMINATION RESPONSES OF *BROMUS AULETICUS* SEEDS TO TEMPERATURE AND WATER AVAILABILITY

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Bromus auleticus is high-quality forage and drought-resistance cool-season perennial grass, distributed in the Pampas region (Argentina), Uruguay and southern Brazil. Seeds ripen in December and remain dormant during summer. Aiming to evaluate the role of *Epichloë* on seed germination under different environmental conditions, endophyte-infected (E+) and endophyte-free (E−) seeds from ecotypes La Pampa (LP) and El Palmar (EP), associated with E. pampeana and Epichloë sp., respectively, were subjected to different temperatures (15, 20, 25, 30 and alternated 15/25°C) and water potentials (Ψw) (0, −0.5, −1.0 and −1.5 MPa). Final germination percentage and germination rate were recorded. Response to water availability was characterized by fitting a hydrotime model. According to this, germination rate is correlated to Ψw. Biological time can be calculated by the amount by which Ψw exceeds base water potential. Endophyte transmission to seedling was also checked. Germination response to temperature depended on the ecotype (being higher for EP) and E+ seeds presented significantly higher germination percentage than E− ones at 15/25°C for both ecotypes and at 25°C for LP. At 30°C secondary dormancy was induced and germinated when transferred to 20ºC, although the transmission of the endophyte to the seedlings was negatively affected. For the Ψw experiments, germination decreased as medium Ψw decreased. For EP seeds, Ψw −1.0 and −1.5 MPa inhibited germination more in E+ seeds than in E− ones and endophyte presence was associated with a higher base Ψw. Germination percentage at low Ψw for LP seeds was not significantly different between E+ and E−. Dormancy release and promoting germination could be an endophyte strategy, since it loses viability faster than the seed. Alternatively, the endophyte inhibitory effect at low Ψw may be a safeguard to prevent germination under limiting water levels, ensuring seedling emergence and establishment when environmental conditions are appropriate.

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HIGH QUALITY SEED STARTS WITH QUALITY HIGH GRADE SEED

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The multiplication of high grade seed from seed provided by plant breeders requires very high quality standard of seed production to ensure the genetic integrity, endophyte status (for ryegrass and tall fescue), and freedom from weeds and seed borne diseases. The paper outlines the processes developed at Grasslanz for the annual production of over 40 high grade seedlines, from spaced plant blocks (mini-multiplications) set in ryecorn/triticale pollen trapping blocks for grasses or tunnel houses for insect pollinated forage legumes to small areas 0.2 to 0.5 ha with 400 m isolation distances and an 8+ year crop rotation. Hand rouging is an important adjunct to chemical weed control. Modifications to combine harvesters to ensure easier cleaning and machine hygiene and seed cleaning equipment and approaches to minimize seed contamination are described. Finally seed storage at 3oC and 30% RH% ensures seed germination is maintained for up to 10 years.

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THE MULTIPLE FACES OF ENDOPHYTE SYMBIOSIS WITH ANNUAL RYEGRASS

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Besides their pivotal roles in plant growth, reproduction and herbivory, asexual fungal endophytes of grasses (*Epichloë* spp., Clavicipitacea) have emerged as ecosystem engineers, with key functions belowground. Evidence on their effects in different soil components and processes indicates that symbioses with safe endophytes for livestock (which produce non-toxic alkaloids) can be a viable agronomic source of other ecosystem services and environmental benefits. *Lolium multiflorum*, annual o Italian ryegrass, is currently distributed worldwide along with its natural safe endophyte *E. occultans*. In South America, it's been disseminated with agriculture and cattle husbandry, at least for the last two centuries. Previous surveys carried out in pampean grasslands and oldfields showed that naturalized populations of *L. multiflorum* have high endophyte incidence (>90%), suggesting that its use as an annual winter forage likely boosts symbiosis maintenance and regional expansion. By taking advantage of a naturalized L. multiflorum population, we investigate the complexity of biotic interactions to address the question: how does grass-endophyte symbiosis change the host neighborhood and maximize both forage production and protection? Here, we will discuss recent findings on endophyte effects on *L. multiflorum* ability to establish under different conditions and on the responses of non-host neighboring plants to beneficial and harmful microbes.

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TEMPERATURE, WATER DEFICIENCY AND SALINITY IN GERMINATION AND EARLY GROWTH OF *DIGITARIA ERIANTHA* CV. IRENE

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Growing livestock production demands an increase in the supply of summer pastures, however, in the southwest of Buenos Aires province there are few warm-season native perennial palatable species. *Digitaria eriantha* is an african perennial grass with C_4 photosynthetic metabolism. It is characterized by its high resistance to drought, high summer forage production and adaptability to different soils. However, it is particularly susceptible to water deficit during germination and seedling establishment. The effects of temperature, water deficiency and salinity on germination (G), germination coefficient of velocity (CV) and early seedling growth were analyzed to determine its ability to establish in this region. Temperature treatments applied were: continuous 30°C or 35°C, and alternate 30°C/10°C or 35°/10°C during 14/10 hs, respectively. In other trials water deficiency treatments (π: 0, -0.4, -0.6, -0.8, -1.0, -1.2, -1.5 and -2.0 MPa) or salinity (0, 50, 100, 150 and 250 mmol l^{-1} solutions of NaCl) were applied, at constant temperature. Seedling growth was evaluated as aerial and root length. During the first 24 hours, the G at constant temperatures exceeded in 50% the observed with alternating temperatures. The accumulated G was approximately 80% in all treatments. The CV was 20% higher at constant than alternate temperatures. As the available water decreased the G diminished from 80% to 12%. Germination was similar under salinity or water deficiency, primarily by osmotic effects. The initial seedling height without deficiency was 15 mm. A deficiency of -0.6 MPa reduced its length by 50%. Seedling's length did not exceed 2 mm at potentials less than -0.8 MPa. The establishment of this species would be favored by high temperatures and water availability over -0.6 MPa in the soil.

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SELECTING THE BEST HOSTING GENOTYPES IN A FRIENDLY ENDOPHYTE-INFECTED TALL FESCUE (*SCHEDONORUS ARUNDINACEUS*) POPULATION

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One primary objective of breeding programs in forage grasses is to improve persistence and tolerance to biotic and abiotic stresses. Fungal endophytes are plant symbionts which are known to provide both biotic and abiotic stress tolerance benefits to its plant hosts. These endophyte fungi colonize stems and basal leaves and then migrate to the panicle to colonize seeds when the plants begin flowering, disseminating through vertical transmission to the seeds and not by pollen. AgResearch Ltd developed the endophyte (*Epichloë coenophiala*) strain AR584 which has been used to inoculate tall fescue. This strain does not produce toxic alkaloids found in wild strains. However, there is evidence that not all genotypes are good hosts and that endophyte viability levels can be reduced at different stages throughout the plant's life. Endophyte survival, vertical transmission and viability of the seed are key to the development of a commercially useful endophyte-infected tall fescue cultivar. To guarantee high infection and transmission levels and high persistence in stored seed, the best hosting genotypes were selected within a population of AR584 infected tall fescue. In 2013 one thousand plants were transplanted to a spaced plant block maintaining individual plant identity. For three years, each plant was tested for endophyte presence during growth using blotting paper on five vegetative tillers per plant and agronomic characteristics such as plant phenotype, regrowth after grazing, rust tolerance and summer growth were recorded for each genotype. Plants that did not show positive staining in the five tillers tested were removed from the trial. In 2016 twenty-five plants were selected and polycrossed based on endophyte presence and individual agronomic data. Endophyte levels in the seed harvested was tested to evaluate the ability of the selected genotypes to transmit endophyte to the seed successfully. As a result, an improved population has now been selected for its agronomic characteristics, ability to host the endophyte in plant throughout the years, and ability to transmit the endophyte to the seed. The next step will be to evaluate the agronomic performance of this population in the field.

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EFFECTS OF PREGERMINATIVE TREATMENTS ON *PANICUM COLORATUM CV. BAMBATSI* SEEDS

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The perennial millet is a suitable fodder for the semi-arid region due to its nutritive value, its long persistance and its great capacity of natural reseeding. In spite of this, the establishment has some difficulties mainly because of the low seed germination (G), not greater than 50%, and their small size. Therefore farmers need to increase sowing density. The application of different pregerminative treatments, as priming and hardening, has been shown to increase G and germination rate. Priming pretreatments were conducted: hydropriming, with distilled water; osmopriming, with Polyethylene glycol 6000 solutions (π: -0.25; -0.5 and -1 MPa). These treatments were applied during 12 or 24 h, under 25 or 30 °C. Then seeds were allowed to dry at room temperature. Hardening, a double sequence of conditioning, was applied to another pool of seeds. First imbibition hydro or osmopriming was performed, while in the second cycle different filter speed papers were used (matripriming).The germination test was performed in a chamber with temperatures of 30°C / 20°C (day/night) and photoperiod of 12 hours. Significant differences in GP with the combination of 24 hs and 25°C were found, especially for osmopriming with -0.5 MPa and hydropriming that increased 30% G. Hardening, combining hidropriming and matripriming (with medium paper) had a 42% increase in G. The use of 30°C is discarded for pretreatments, since it did not provide a significant improvement. These results show the effectiveness of priming and hardening techniques in the G increase, that would allow reducing the amount of seed to be sowed and the costs of pasture implantation since seed is the main input.

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GERMINATION OF *PASPALUM NOTATUM* CV. BOYERO UNNE SEEDS AT DIFFERENT MATURATION STAGES

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Paspalum notatum Flüggé is a perennial subtropical forage grass native to South America. The tetraploid race (2n=4x=40) (common bahiagrass) is widely distributed on the natural pastures of northeaster Argentina, Uruguay, Paraguay and southern Brazil. Their persistence under low fertility, flooding and continuous grazing conditions makes this species an important source for low input beef cattle production. All natural biotypes reproduced by aposporous apomixis. Typically, common bahiagrass seeds show dormancy and germination occurs slowly over an extended period of time. Acid scarification has traditionally been used to accelerate germination. The objective of this work was to evaluate the germination of seeds from cultivar Boyero UNNE at different post-harvest periods and maturity stages, with and without acid scarification. At harvest, three maturity stages were defined according to the seed-coat color: G (green= immature with milky endosperm), B (pale brown = mature with hard endosperm) and D (dark brown = mature with endosperm desiccated).Germination assays were carried out after 3, 6 and 12 months after harvest. Scarification was performed using 98% HS04 for10 min and three rising with sterile distilled water. Three replications of 30 seeds were set up for each treatment on Petri dishes (150 x 15 mm) according to the ISTA recommendations. Seeds were incubated at 30°/20°C (day/night) with 14 hours of photoperiod for 30 days. Germination percentages were transformed by using the arcsinfunction and analyzed with ANOVA. The Tukey's test ($p<0.05$) was used for estimating the significance of the differences between means. Results showed that the highest percentages of germination were obtained with seeds 12 months after harvest in the maturity stage B. In this case, a maximum of 70% ±6.24 and 48.9%± 1.53 of germination were obtained, with and without scarification, respectively. Seeds assayed six months after harvest showed the lowest germination ranging from 0.00 – 4.4% ± 0-1,53and seeds germinated after three months of harvest showed germination ranging from 0.00 – 14.44% ± 0-9 considering all maturity stages and the scarification treatment. Comparison of the average germination percentages of seeds assayed after 12 months of harvest showed significant differences between maturity stages (G vs B and D)($p < 0.0004$) and scarification treatment ($p < 0.0004$). Seeds analyzed after 6 months of harvest showed no differences, among neither maturity stages nor the scarification treatments. Seeds germinated at 3 months post-harvest showed no-significant differences between maturity stages, but showed differences between scarified and no-scarified at the maturity stage B ($p < 0.0291$). Results presented in this work indicate that dormancy diminished with the time after harvest and seeds at maturation stage B have the maximal potential for germination.

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GERMINATION AND ESTABLISHMENT OF KLEINGRASS (*PANICUM COLORATUM CV. VERDE*) UNDER WATER DEFICIT AND SALINITY

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Establishment of kleingrass finds its greatest difficulty in the small seed size with scarce reserves and even more under edaphoclimatic limiting conditions. The response to water deficit and salinity during germination and seedling development of four different seed lots was evaluated in this work. The water deficiency condition during germination was imposed by the application of polyethylene glycol 6000 solutions (π: 0; -0.25; -0.50 and -1 MPa) in the germination medium. The salinity was applied by NaCl solutions with increasing electrical conductivities (3, 6 and 9 dS m^{-1}). Germination (G) with a slight water deficiency (-0.25 MPa) did not differ from the control treatment. G decreased from 24 to 92% with a moderate water deficiency (-0.50 MPa). A severe deficit (-1 MPa) in the medium inhibited germination. Salinity also had an effect on G, moderate salinity (3 dS m^{-1}) reduced G between 5 and 18%, an intermediate level (6 dS m^{-1}) reduced G up to 48%, and in the highest conductivity (9 dS m^{-1}) resulted in the decline of GP up to 74% regarding to control. In the greenhouse, 2 months establishment trials were conducted. The lowest water availability (25% of field capacity) caused a decrease of 40% of plant height, 47% in leaf number and 72% in the aerial biomass. In this treatment the radical/aerial weight ratio was about 3, indicating a strategy for severe water deficiency toleration. Irrigation with 50% of field capacity and salinity solutions showed moderate reductions in different growth parameters. Therefore, the establishment of the perennial millet showed that water deficiency was more harmful than soil salinity at the evaluated levels.

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EVALUATION OF THE PRODUCTION AND VIABILITY OF SEEDS OF THREE CULTIVARS OF RHODES GRASS (*CHLORIS GAYANA*) INTRODUCED IN THE PAMPAS REGION

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Rhodes grass (*Chloris gayana*) is a species that has shown high adaptability to a wide range of environments; however, production of seeds with high viability to achieve suitable germination rates remains a major challenge. The aim of this work was to evaluate both the seasonal distribution of seed production of three cultivars of Rhodes grass and their viability in three-year-old plants. The materials evaluated were three commercial cultivars of Rhodes grass: 'Santana', 'Recleimer', and 'Finecut'. The parameters evaluated were production of seeds (number of seeds per inflorescence) and seed viability three years after sowing. Two traps with 3 inflorescences in each were placed in every block at two different dates between 10th March and 22nd May. We used a completely randomized block design with 10x10 blocks and three replications per cultivar. Seeds were analyzed following the ISTA methodology to determine total viability, which was assessed on % of full seeds only. The results were analyzed by ANOVA, and means were compared with the Tukey Test (p <0, 05) to determine significant differences among the different cultivars. Seed production differed significantly between dates, being higher in May regardless of cultivar. However, no significant differences were found with regard to total viability. It is necessary to emphasize that the % of full seeds was around 10 % for both sampling dates, with differences between cultivars: 'Santana' showed the lowest value (5.83 %), followed by 'Recleimer' (9.17 %) and 'Finecut' (10.50 %). Regarding total viability per cultivar, 'Finecut' (10.50 %) and 'Recleimer' (8.83 %) differed significantly from 'Santana', which had an average value of 5.67 %. In relation to viability, no significant differences were found during the whole period evaluated as the average value of this parameter remained fairly constant at about 10 % for all cultivars.

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TOLERANCE TO SALINITY AND WATER DEFICIENCY OF RHODES GRASS (*CHLORIS GAYANA* KUNTH)

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Rhodes grass is a pasture characterized by its tolerance to salinity. However, very high salinity level and drought can affect its establishment, reducing the optimal stand of plants. In order to analyze the response of this species to salinity and water deficiency tests of germination and establishment were conducted. Low water potential in the germination media (-0.50 and -1 MPa) reduced the germination (G) significantly, 40% to 87% less in comparison to the Control. High electrical conductivities (8 to 14 dS m^{-1}) delayed the onset of germination (4 days on average) and their G decreased up to 70%. Seedlings height was more affected by water deficiency than by salinity, with drops of 20 to 30%. The root length was higher with salinities of 2.5, 4 and 6 dS m^{-1}. In seedling establishment trials the water deficiency reduced approximately 30% the aerial biomass more than the salinity treatment. The ratio between radical and aerial biomass was 6.14 for the lowest water availability, which shows an adaptive strategy. The membrane stability index was lower with water deficit than with high salinity, 50% and 30% regarding to the control, respectively, indicating a greater damage caused by water scarcity. Leaves relative water content (RWC) was very low in water deficit treatments. Plants under saline irrigations had slight change in the RWC by reducing their osmotic potential 3 times. Therefore, Rhodes grass is an important forage resource for the saline soils of south-west of Buenos Aires province, although it is advisable to avoid environments with severe water deficit.

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PRECONDITIONING OF PERENNIAL MILLET (*PANICUM COLORATUM* L. VAR. VERDE) SEEDS

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The perennial millet seed has low and variable germination, related to the unevenness maturity of the panicle. It has few reserves in the seed and the seedling has a slow initial growth, which threatens its field implantation. These problems were solved through priming, a technique that allows to improve emergency speed and uniformity of germination. It consists of the partial hydration of seeds without occurrence of radicular emergency. Different priming trials were applied: *hydropriming* (with distilled water), *osmopriming* with Polietienglicol 6000 solutions (π: -0.25; -0.50, -1 and -1.5 MPa) or $CaCl_2$ (2%); and *matripriming* (variable filter paper speed). In this work germination (G) of different age (1 or 2 years old) commercial seeds was evaluated after priming and hardening (two equal or distinct sequences of priming). These treatments were applied during 12 or 24 h, under 25 or 30 °C. Osmopriming increased 20 to 32% the GP and $CaCl_2$ caused an increment from 30 to 47%. By application of matripriming, at 25°C with fast paper, regardless of the exposure time, the highest G (62% increase) was obtained. Improvements in germination were observed in recent harvested seeds (51% higher), with low G, but in seeds of 2 years old, without dormancy, the effect was very significant, obtaining absolute P above 80%, by means of matripriming and hardening effectiveness.

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SALINITY EFFECTS ON SEED GERMINATION OF *CENCHRUS CILIARIS* L.

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The phenotypic variabilityamong seven *Cenchrus ciliaris* L. genotypes was evaluated under salinity conditions at germination stage as part of a breeding program. The aim of this program, is obtaining new germplasm with incremented salt tolerance. Seven genotypes: Biloela, Texas-4464, Nueces, Nunbank and Molopo cultivars, one sexual line (SL) and a new cultivar, Lucero INTA Pemán (Lu) (SL x Biloela) were evaluated. The seedof each genotype (1.5 g per genotype) were sown on towel paper in plastic trays and germinated with alterning light and darkness (8 and 16 h, respectively) and temperature (30-20ºC), at different salt concentrations (0, 50,75 and 100mM NaCl). The experiment was carried out ina completely randomized block design with three replications. Germination (GP) was evaluated at day 28, and seeds that did not germinate under the different salt concentrations were transferred to distilled water to study germination recovery and recovery percentage (RP) was calculated. The data were subject to ANOVA and DGC test to compare means. Interaction genotype x treatment was not significant ($p>0.05$) and the results indicated variability among cultivars and treatments for G. At 50mM, G ranged from 30 to 76% and Lu germinated as well as the condition without stress. At 75mM, the variability was high (94.55 to 21.77%) and four genotypes (Nunbank, Molopo, Lu and SL) germinated above 50%. At the maximum concentration tested, the last three genotypes had a germination greater than 70%. In the rest of the genotypes, G varied from 36 to 18%. For RP, although no differences among the materials or between treatments were observed, means were very low in all genotypes, including the materials of low G. This would indicate that NaCl would exert a toxic effect on them. Lu, Molopo and SL would be useful to be included in a breeding program and 100mM NaCl could be an adequate concentration for selecting germplasm.

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CHARACTERIZATION OF SEEDS OF SPECIES OF THE GENUS *PASPALUM*

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The natural pastures of the Cone Sur are recognized throughout the world for their productivity, quality and diversity. The genus *Paspalum* is the most important and groups grass species of summer growth, good forage and palatable for cattle and sheep. The objective of this work was to characterize the seeds of eleven species of this genus to be used in the recovery of areas of degraded natural pastures. For this, the potential of germination of seeds harvested on2013 was evaluated and the parameters for germination tests were established. The experiments were carried out at the Embrapa Pecuária Sul Seed Analysis Laboratory, located in Bagé/RS/Brazil. The treatments applied to the germination: I - constant temperature (30 °C) and permanent light (24h); II - constant temperature and alternating light (8 h light and 16 h dark); III - alternating temperature (8 h 35 °C and 16 h 20 °C) and permanent light; And IV - alternating temperature and alternating light. The percentage of germination (PG) and the rate of germination (IVG) in each treatment were evaluated. The seeds were soaked in water for 96 h to obtain the soaking curves. The weight of one thousand seeds and the mass / volume ratio were obtained by the test of the test tube and by gaseous pycnometer. Measurements were also made on the three dimensions of the seeds and sphericity was calculated. Differences were observed among the species for all the evaluated characteristics. This fact suggests that the use of seeds of this genus will require studies for each of the individual species, both for the harvest of seeds and practices for planting.

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EFFECT OF HYDRATION-DEHYDRATION PRE GERMINATION TREATMENTS ON *SETARIA SPHACELATA* SEEDS.

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Setaria sphacelata is a warm-season forage grass widely sown in Corrientes province. Tropical and subtropical forage species usually have a slow implantation leaving a low percentage of plants established. Hydration-dehydration treatment (HD) of seeds is a physiological procedure that improves germination, establishment and productivity of plants in adverse conditions. The objective of this study was to evaluate the effect of that pre germination treatment (HD) on *Setaria sphacelata* seeds with 12 and 24 months of storage. The experiment was conducted in the Seeds Laboratory of EEA INTA Mercedes and the design was completely randomized with factorial treatment structure of 2x3. First factor was the imbibition agent: distilled water (W) and a solution of KNO_3 at 2% (N). The second factor was the time of soaking: 24, 48 and 72 hours. After the period of soaking, seeds were dried to its initial weight and were seedling in four replications of 50 seeds per treatment and test (T) following ISTA rules methods. Registered variables were: first count percentage (1°count) and final germination percentage (%G). The statistical analysis was done with Infostat (2016), ANOVA and comparison of means (LSD Fisher 5%). On seeds stored for 24 months, the %G in all treatments were superior ($p<0,05$) to the T except with N72. Best treatments were N24 (55% A) and W48 (52,5% A) having 20 points more than T. In the 1°count variable, a rapid emergence was reached with water treatments. On seeds stored for 12 months, both variables were superior to T with water treatments (and without significant differences inside the factor). We concluded that the pre germination HD treatment with water enhance the rapid emergence and %G in both stored seeds of *Setaria sphacelata*, as well as more than 24 hours immersion in KNO_3 at 2% affect germination.

Key words: priming, germination, forage.

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EVALUATION OF TRAITS RELATED TO SEED QUALITY IN *ACROCERAS MACRUM* (NILE GRASS)

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Acroceras macrum is a warm-season perennial grass native to tropical and subtropical regions of Africa. Its value as forage is due to the C3 photosynthetic pathway, offering higher nutritive value than C4 grasses. *A. macrum* is well adapted to wet or flooded Alfisols and vertisols of the northeastern region of Argentina (NEA), where its use allows higher and more intense production in comparison to the natural grasslands. Its adoption on production systems is limited because the unavailability of commercial seed, although vegetative implantation through rhizomes and stolons can be achieved with excellent persistence. The tetraploid (2n = 4x = 36) cytotype of *A. macrum* available in Argentina presents wide genetic variability. The species is sexual, and it is possible to achieve viable seed by crosses between different 4x genotypes, with averages between 0 and 69%. Our objective was to study some features related to *A. macrum* seed quality. Sixteen families (a total of 160 hybrids) obtained by crossing different 4x genotype were studied. Seeds were collected throughout the flowering period. Seed varied on size, maturation degree and pigmentation (brown) degree. The largest (2.8 mm) and heaviest seeds (2.6g / 1000 seeds) had a germination (G) of 60% and a germinative energy (GE) of 30%, these were predominantly pigmented seeds. The lightest (1.2g / 1000 seeds) and smallest seed (2.2mm) had a G of 1.4% and an EG of 0%. Seeds with inmature aspect had G and EG of 0%. Significant differences in weight, seed filling and number of inflorescences produced per plant at peak flowering (mean 500-100 panicles) were found among families. Based on these results, we have initiated a breeding program based in selection against seed quality features.

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