ABSTRACTS OF ORAL PRESENTATIONS
October 28-30, 2001 Fargo, North Dakota

Editor's Note: The biennial meeting of the North American Pulse Improvement Association was held in Fargo, North Dakota, on October 28-30, 2001. This section of *Pisum Genetics* contains the abstracts of the papers and posters presented at this conference.

Nutritional significance of pulses: current assessment and future strategies for marketability

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Pulses are an important source of dietary nutrients for humans, and for other animals. Whereas pulse seeds can contribute greatly to the dietary energy and amino acid needs of the individual, through their starch, lipid, and protein content, they also contain a number of essential macronutrient (K, Ca, P, Mg, Na, Cl) and micronutrient (Fe, Mn, Zn, Cu, Se, Ni, I, Cr) minerals. Furthermore, depending on the crop and/or particular cultivar, they also can provide various water-soluble (C, niacin (B_3), pantothenic acid, thiamin (B_1), riboflavin (B_2), B_6, folate) or lipid-soluble (carotenoids (pro-vitamin A), tocopherols (E), phylloquinone (K_1)) vitamins, as well as certain non-nutritive, health-promoting phytochemicals (e.g., fiber, anti-oxidant carotenoids). In general, although most pulse seeds contain some amount of most of these phytonutrients, the concentrations present are rarely at levels that would provide one's total daily requirements in a single serving. And, because suboptimal intakes of certain essential nutrients are commonly observed in various population groups (both in developing and developed countries), the breeding of new cultivars with elevated mineral or vitamin levels would have promising consequences. In this presentation, we will review the current nutritional relevance of pulses in the provision of dietary nutrients. We will discuss the potential for manipulating these levels, and comment on which phytonutrients might be the best targets for this manipulation. Finally, we will discuss which aspects of pulse seed nutritional quality might be most relevant for the marketing of pulses.

Changes in the Canadian pulse industry – a strategy for pulse research in Canada

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The Canadian Pulse industry has expanded substantially in the last 10 years. Pea production has increased by 853%; lentil production has increased by 375%, bean production has increased by 291% and chickpea production has grown from non-existence to a production of 500,000 tonnes in 2001. Despite the large expansion in production of pulses, the investment into research has remained soft and far behind the importance of the crops. Not only do pulse crops provide Canadian producers with profitable economic returns, but additional benefits occur through during production but also there is the ability to gain extra returns through primary, secondary and tertiary processing.

In the last year a new research division in Pulse Canada has worked on the first stage of a national research strategy with pulse crop researchers from across Canada. A workshop will be held in November 2001 where the strategy ideas will be further developed and discussed with the Canadian pulse industry. The meeting will produce an outline of the infrastructure and personnel requirements for pulse research, and develop a profile of the priorities, costs and time requirements for strategic pulse research areas.

The research strategy will ensure that critical questions and problems are being addressed and provide a starting point for developing research networks and collaboration. For the next stage of planning, it is being suggested that many of the research areas such as quality, utilization, pathology, weed management/ pesticide registration, sustainable environment and genetic improvement be addressed by developing networks not only within Canada but internationally. The pulse industry is small even on a world scale. To advance our industry it will be necessary to work together.

Changes in the U.S. processing pea industry

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Although the acreage of processing peas grown in the United States has not significantly changed in the past 15 years, the processing industry, and *Pisum* research, has. Nationwide, pea production has remained relatively constant with 289,000 acres of peas grown in 1986 and 295,000 acres grown in 2000. However, investment in Pisum research has decreased in both the public and private sectors, and the focus of research within the public sector has significantly changed.

Among the researchers in public institutions, there are no longer any breeders 100% dedicated to peas, regional yield trials are not routinely conducted and the amount of research dedicated to pathology, IPM and associated fields has been greatly diminished. Research in molecular aspects of *Pisum* genetics and its application has helped reverse this trend. Within the private sector, the number of breeding and research programs has decreased by approximately 50% in the past 15 years. The private programs that remain are generally smaller and are extremely focused in scope.

The processing industry, itself, has also experienced changes, primarily in significant consolidations. In 1986 there were 92 processors in the US, in 2000 there were 58. The seasonal vegetable processing industry faces unique challenges among food processors. As a business, the growing, processing and earnings of seasonal vegetables is extremely unpredictable. It is a very capital intensive business (expensive, crop specific equipment is used for a few weeks each year) and the entire year's finished inventory is produced within those weeks and must be metered out for the remainder of the year.

The future of *Pisum* research in the US will be challenging due to its close ties to the processing industry. Improvements in stability and predictability of pea production will greatly benefit the industry and will help ensure future research. Continued successes will rely on 1) close communication and cooperation of researchers both between and within the public and private sectors and between researchers and the industry, 2) the development and strategic use of molecular and traditional tools and 3) the continued development of strategies in IPM and plant pathology.

Ascochyta blight of chickpea – present status and future prospects

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Ascochyta blight, caused by *Ascochyta rabiei*, is one of the most devastating diseases of chickpea in different chickpea growing areas in the world. Occasionally, in epidemic form, it causes heavy yield losses, sometimes leading to complete crop failure. Although various chemical and cultural practices have been identified to combat the disease, their usage has been reported as un-economical with the presently cultivated varieties having a low level of resistance. Thus, host resistance seems to be the only alternative. The *Ascochyta* *rabiei* pathosystem being sexual in nature seems to be very complex. Reports on inheritance pattern of resistance to Ascochyta blight in chickpea indicate that it is monogenic or digenic. Recent reports, however, indicate its complex nature and the inheritance pattern is unresolved. Existing variability in the ascochyta pathogen has been characterized into three pathotypes designated I, II, and III. Pathotype I and II are reported from most places whereas Pathotype III, which is more virulent is not widely distributed. Molecular markers have been developed to characterize the pathogenic variability, develop linkage maps and help in selection. Work on transformation of chickpea using Agrobacterium-mediated transfer of ascochyta blight resistance is in progress. The breeding program at ICARDA is pyramiding genes for resistance to ascochyta blight and has produced improved chickpea germplasm with relatively sustainable or horizontal resistance. There is a need to introgress resistance genes from wild *Cicer* species to the cultigen through innovative techniques.

Population structure of *Ascochyta rabiei* in the US Pacific Northwest

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Six hundred isolates of *Ascochyta rabiei* were sampled from commercial chickpea fields and the USDA-ARS ascochyta blight nursery during 1998, 1999 and 2000 to determine the population structure of the pathogen in the US Pacific Northwest (PNW). Two hundred twenty four isolates have been scored for allelic variation at 17 putative AFLP loci and this data used to estimate population structure. AFLP markers revealed high overall genetic and genotypic diversity and significant genetic differentiation among sampled locations. Maximum likelihood analysis of AFLP allele frequencies revealed 3 genetically distinct groups of isolates, each with high bootstrap support. Cluster 1 consisted of isolates from Walla Walla, WA in 1998 and 2000, Cluster 2 consisted of isolates from the Ascochyta blight nursery in 1998, 1999 and 2000, and Cluster 3 consisted of isolates from commercial chickpea fields near Genesee, ID. AFLP variation was also scored for 60 isolates collected in the Genesee area during 1983-87 by Dr. W.J. Kaiser. Isolates collected in 1983-1987 clustered with isolates from Walla Walla and were genetically distinct from the majority of contemporary PNW isolates. These results indicate that 1) substantial genetic differentiation exists among *A. rabiei* populations in the PNW, 2) the *A. rabiei* isolates in the blight nursery are distinct from isolates in commercial chickpea fields, and 3) that isolates collected from 1983-1987 have largely been replaced by other genotypes of the pathogen. The implications of this research for ascochyta blight management and resistance breeding will be discussed.

Evaluation of fungicides to control *Ascochyta* in chickpea

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Ascochyta blight continues to be a major limiting factor to chickpea production in the Northern Plains. Until suitable genetic resistance is available in commercial varieties, other control measures are needed. Based upon promising results with Quadris and Headline (BAS 500) in 2000, the objectives of this research were to evaluate the effectiveness of fungicide products, the number of applications, and application rates. Plots were established near Carrington, Hettinger, Minot, and Williston, ND, in a randomized complete block design with four replications. Bravo Ultrex, Quadris, Headline, BAS 516, Topsin M, and Scala were compared to an untreated check.

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Evaluation of fungicides to control *Ascochyta* in chickpea

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Under moderately high disease pressure in Hettinger, the best treatment (two applications of Headline at 7.2 fluid ounces/acre) reduced disease rating (0–9 scale) from 7.5 for the untreated check to 1.2 and increased yield from 461 to 1803 lbs/acre. Disease control and yield were significantly improved with one application and significantly improved further with a second application, but not by increasing the rate from 7.2 to 10.4 fluid ounces/acre. Quadris and BAS 516 were also effective products. A comparison of Bravo formulations at similar rates of active ingredient showed Zn and Weatherstik to be similar and more effective than Ultrex.

In Minot and Williston, disease pressure was higher, but Headline, Quadris, and BAS 516 were again superior to the other products tested. At both sites, one, two, and three applications of Headline resulted in incremental improvements in disease control and yield. Two applications at the 10.4 fluid ounce rate were better than two applications at the 7.2 ounce rate and similar to three applications at the 7.2 ounce rate.

Under very heavy disease pressure in Carrington, Headline and BAS 516 were superior to the other treatments, including Quadris. A second application of these products was more beneficial than one application at a higher rate. Yield of all treatments was very low.

The results across sites with varying levels of natural disease pressure consistently showed that reducing ascochyta infection proportionally increased chickpea grain yield and quality (seed size). Although the formulation of Bravo (the currently labeled product in the U.S.A.) influenced effectiveness, control was generally poor. Headline, BAS 516, and Quadris provided effective disease control under moderately-high to high disease pressure. Increasing the number of applications was more important than increasing the application rate.

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Improvement of ascochyta blight control in chickpea through spray application delivery method

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Increased chickpea acreage in Saskatchewan is placing new emphasis on the development of agronomic practices that maximize yield and product quality. This project is part of a new initiative into chickpea pathology that focuses development of effective fungicide application strategies for ground sprays and comparison of ground and aerial application methods on a field scale to help optimize carrier volumes and droplet sizes. In 2001, the fungicides chlorothalonil (1 kg a.i. ha^{-1}), azoxystrobin (125 g a.i. ha^{-1}), tebuconazole (187.5 g a.i. ha^{-1})and Headline® (100 g a.i. ha^{-1}) were used to study the effects of chickpea leaf type (compound and unifoliate), carrier volume (100, 200 and 300 L ha^{-1}) and droplet size (fine, medium, coarse)on ascochyta blight control at six locations. Each fungicide was applied once at the first sign of symptoms and again 10-14 days later. A treatment combination of chlorothalonil applied first, followed by azoxystrobin was also included. Disease rating was done at each fungicide application and 3 weeks after the last application. Ascochyta blight levels were very low in most parts of Saskatchewan as a result of severe drought conditions that prevailed over much of the province. Due to low disease pressure at 5 of 6 sites (< 25%), there were no significant effects of water volume or droplet size on blight control. At the site where chickpea received irrigation, up to 72-89% ascochyta blight developed in the untreated plots. Increasing water volume from 100 to 300 L ha^{-1} reduced blight severity across the four fungicides down to 38% at 100 L ha^{-1}, 22% at 200 L ha^{-1} and 17% at 300 L ha^{-1} probably due to better coverage. Fungicides also significantly differed in their disease control depending on cultivar. For each cultivar and fungicide combination, spray droplet size had no significant effect on blight control. These preliminary results indicate that fungicide spray carrier volume is more important than droplet size.

Morphological plasticity of chickpea vs. water availability

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Chickpea (*Cicer arietinum* L.) requires stresses late in the life cycle to terminate its indeterminate growth for maturity. Little is known regarding response of this annual legume to water availability during the growing season. This study was to determine the morphological plasticity of chickpea and its response to water availability in semiarid environment. Kabuli (both large-seeded and small-seeded) and desi chickpea were planted at various plant population densities (PPD) on wheat-stubble and summer-fallow fields. Field emergence rates (i.e., number of plants emerged per viable seeds planted) were decreased from 90% at low PPD (20 plants m^{-2}) to 72% at high PPD (50 plants m^{-2}) for kabuli chickpea, and from 81% to 70% for desi chickpea. The low emergence rates of chickpea at high PPD were probably due to poor seed-soil contact in the soil. Seed yields of kabuli chickpea increased significantly with the increase of PPD from 20 to 45 plants m^{-2}, but there were no further benefits with PPD beyond 45 plants m^{-2} when the crop was planted in wheat-stubble where water availability was low. Yield increases with higher PPD tended to continue for desi chickpea when the crop was grown on summer fallow where water availability was high. Response of seed yields to PPD followed a classical asymptotic curve in which PPD accounted for >60% of the variation in yields. Chickpea had great morphological plasticity, allowing the crop to compensate for potential yield losses due to plant-to-plant competition. Kabuli chickpea produced 28 pods per plant at low PPD (20 plants m^{-2}) and 13 pods per plant at high PPD (50 plants m^{-2}), but the crop produced a total of 670 fertile pods per m^{-2} at the high PPD that was 12% higher than those when the crop was grown at the low PPD. Similarly, desi chickpea reduced pods per plant from 63 at low PPD to 30 at high PPD, but the total number of fertile pods m^{-2} was increased from 1130 at low PPD to 1450 at high PPD. Although the number of pods per plant decreased in response to increasing PPD, the greater number of plants per unit area provided more podding sites, and consequently increased the number of pods and seed yields per unit area. Large-seeded kabuli cultivars ‘Sanford’ and ‘CDC Xena’ had a higher proportion (17 to 23%) of infertile pods, significantly higher than those (9 to 12%) with the small-seeded kabuli cultivars ‘B-90' or ‘CDC Chico’. The proportion of infertile pods increased significantly with increased PPD for kabuli chickpea cultivars but was consistently low (6%) across different PPD treatments for desi chickpea. More detailed studies of morphological plasticity among different genotypes would provide crucial information for improving the productivity of the annual legumes.

Managing drought and fusarium wilt in chickpea

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Several abiotic and biotic stresses reduce chickpea (*Cicer arietinum* L.) seed yield. Drought and Fusarium wilt (*Fusarium oxysporum* f.sp *ciceri*) are among the most important particularly in the sub-tropical and tropical regions of the world. These together may account for about 50% of the total losses. Breeding for resistance to drought has not been fruitful so far because of a large genotype x environment interaction affecting this trait. Large root trait has been related to drought resistance in this crop. Efforts are being made to link this trait to molecular markers to assist pyramiding genes to develop drought resistant varieties. However, reducing crop-duration through the use of *efl*-1 gene for early flowering and maturity has helped reduce damage by end-of season drought and raise mean productivity.

Major genes for resistance to fusarium wilt have been identified and used. Several races have been identified for this pathogen. Any two of the three genes h_1, h_2, and H_3, confer complete resistance to race 1. Individually each delays wilting symptoms. Resistances to other races have also been found and used. Some of these genes have been located on linkage group 6 of the chickpea genome map. Efforts are being made to sequence these genes. Use of the resistance genes, proper crop rotations and effective seed treatments have helped contain the wilt damage in the major chickpea growing areas. Development of chickpea map should help pyramid genes for more than one trait and help expedite chickpea varietal development.

Genes involved in the domestication of pea – implications for the use of wild germplasm in breeding programs

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The domestication of pea involved the modification of many traits, including pod dehiscence, seed dormancy, seed size, branching habit, and flowering time. Selection for desirable alleles at loci influencing these traits necessarily also involves selection against the undesirable alleles and alleles at closely linked loci. Significant emphasis is now being placed on the evaluation and use of accessions in pea germplasm collections. In many cases new, potentially useful genes are being identified along with their positions on the linkage map. It would also be helpful to identify the regions on the linkage map containing genes for the traits modified during domestication because other genes in these regions might be difficult to introgress into cultivars. We have examined the genetic basis of many of these characters and mapped QTLs affecting these characters. Two populations of F_2-derived recombinant inbred lines were developed from crosses between a *Pisum sativum* ssp. *elatius* var. *pumilio* Meikle line and domesticated (*P. s.* ssp. *sativum* L.) germplasm. The lines were scored for phenotypic segregation and the segregation of approximately 1000 molecular markers. Regions of the pea genome that displayed a segregation correlated with the inheritance of each trait were identified. In many cases a previously described gene appeared to be associated with the QTL. For the dehiscent pod character a region on linkage group III, presumably the locus *Dpo*, showed a strong correlation, but other genes (*gp*, *bt* and a region on linkage group VII) also appear to have an effect. One type of seed dormancy relies on the impermeability of the testa (hard-seeded phenotype), and genes affecting the thickness of the testa (*a*) or its susceptibility to cracking (*r*, *s*) affect this dormancy trait. Seed weight exhibited a more complex genetic foundation. The gene *r* and the gene *Np* both reduced 100 seed weight significantly. We suspect that other genes are primarily responsible for the change in seed weight during domestication. However, the influence of *r* and *Np* on seed weight apparently overwhelmed the effect of other genes. It is interesting that both *r* and *Np* have beneficial (seed quality and insect resistance, respectively) and deleterious (reduced yield) effects for pea breeding programs. Additional regions and genes were found to be associated with plant habit and flowering response. If we include other traits and markers that appear to have been selected during the domestication of pea, approximately half the known linkage map of pea is located within 10 cM of selected regions. With such a large proportion of the non-domesticated genome containing detrimental genes, introgression of desirable traits from wild to commercial germplasm appears to be best accomplished by recurrent backcrossing.

Root production of diverse pea accessions

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Pea has served as a model plant system for research on many aspects of plant physiology and development, but relatively little work has been reported on the morphology and production of root biomass. We report here preliminary findings on the range of variation in pea root growth and morphology on seedlings grown two weeks under artificial conditions. Three hundred twenty-nine accessions from the core collection of *Pisum* germplasm were grown for seed production at the WSU Spillman Research Farm in 1997 near Pullman, Washington, USA. Ten seeds of uniform size were germinated for three days in ragdolls. Moistened germination paper (9” x 12”) was folded in half and ten seeds of each accession were placed inside. The seed and germination paper were then rolled inside a sheet of wax paper. After three days, six uniform and representative seedlings were transferred to a germination paper “sandwich”. Three seeds were evenly distributed (approximately 4.5” apart) near the upper edge of two sheets of wet germination paper (12” x 18”). A blank sheet was placed over the top three seeds and the three sheets were fastened together using large paper clips. The sandwiches were placed in a lighted (12/12h photoperiod) germination chamber set at 22°C for 11 days. Fourteen days post germination the three most uniform seedlings were removed and analyzed. Physical data were collected on taproot and shoot length as well as dry weight of total root and shoot biomass. Following physical measurement the roots were excised from the shoot and scanned into a computer using an HP300C scanner and analyzed using the WinRHIZO^{TM} v. 5.0 program. Root morphology could be divided into groups according to taproot length, lateral root length and lateral root distribution along the taproot. Shoot length ranged from 59 – 380 mm and taproot length ranged from 181 – 433 mm. Shoot and root biomass dry weights ranged from 13 - 104 and 6 - 57 mg, respectively. Root:shoot weight ratios ranged widely from 0.20 to 0.89. Data collected through the WinRHIZO program included total root length, total surface area, root volume and average root diameter which ranged from 54 – 399 cm, 9 – 75 cm^2, 0.1 – 1.1 cm^3 and 0.39 – 0.81 mm for each of the variables, respectively. The wide range of variation for root biomass production indicates that the trait is heritable and gain through selection can be made. Several accessions, PI180692, PI180693, PI180695 and PI181800 in particular, had very profuse lateral root production along the full length of the taproot. Extensive lateral root production has been implicated in tolerance to soil borne fungal pathogens such as *Aphanomyces euteiches*. Specifically, PI180693 has been reported to have good tolerance to this pathogen. We are currently studying crosses among specific accessions and other adapted genotypes to gain a greater understanding of the genetic control governing root production and morphology. It is expected that improved pea crop production can be attained in both highly fertile and marginal lands through improved rooting ability.

Relationship between lodging, stem anatomy, and reaction to mycosphaerella blight in field pea

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Resistance to lodging and to mycosphaerella blight are two major objectives in field pea breeding programs in North America. Preliminary studies at the University of Saskatchewan suggested that a correlation exists between the cross-sectional area of xylem and the tendency for pea varieties to lodge (C.J. Stewart, personal communication). Lodging has also been associated with an increase in infection with Mycosphaerella pinodes (Wang, 1998). Higher disease severity can partly be attributed to a more favourable microclimate for the fungus in lodged peas, but may also be ascribed to differences in stem anatomy. The objective of this three-year (2000-2002) research project is to clarify the relationship between lodging, stem anatomy and reaction to mycosphaerella blight in field pea. Field experiments were conducted at Saskatoon (rainfed) and Outlook (irrigated) to evaluate 10 cultivars in 2000 and 20 cultivars in 2001 that varied in susceptibility to lodging and mycosphaerella blight. Stem samples from the 2nd to 3rd (C. Stewart, personal communication) and 8th to 9th (McPhee and Muehlbauer, 1999) internodes were collected for studies on stem anatomy at the seedling, early pod setting, and physiological maturity stages. Internode length and width were also measured for these internodes at these stages. Useful data were obtained from the Saskatoon site in 2000 and the Outlook site in 2001. In these experiments, mean lodging scores ranged from 4-7 on a scale of 1 = no lodging to 9 = complete lodging, while mean mycosphaerella blight scores ranged from 6-9 on a scale of 1=no disease to 9 = plants completely blighted. No significant correlation between these variables was detected in 2000, but correlations between disease ratings and lodging were highly significant in 2001 at Outlook ($P < .0001$). Lodging and disease ratings on the entire plants and stems, respectively, were correlated at $r^2 = 0.50$, while the correlation between lodging and pod ratings was stronger with $r^2 = 0.71$. An initial analysis of stem cross-sections from year 2000 samples was conducted on two cultivars which are relatively resistant to lodging (Carneval and Integra) and one cultivar which is relatively susceptible to lodging (Keoma). In general, Carneval and Integra had greater area of xylem, and greater area of hollow pith cavity in relation to the stem cross-sectional area compared to Keoma. Keoma had greater area of parenchymatous pith in relation to the stem cross-sectional area compared to Carneval and Integra. These factors may contribute to the relative differences among these cultivars in lodging resistance. Future studies planned include the following: repeating the field studies in 2002, examination of the stem anatomical features of all 20 cultivars including lignin assays, and evaluating the correlation between internode length and diameter on resistance to lodging and mycosphaerella blight.

McPhee, K. and Muehlbauer, F. 1999. Evaluation of stem strength in the core collection of *Pisum* germplasm. National Pea Improvement Association biennial meeting (Calgary).

Wang, T.-F. 1998 Evaluation of *Mycosphaerella* resistance in pea. MSc Thesis, Department of Plant Sciences, University of Saskatchewan.

How can Alberta producers consistently maximize field pea yield?

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Field pea (*Pisum sativum*) has become a well-established part of the cropping systems employed by western Canadian producers. Field pea plantings in Alberta have increased from 85,000 acres (1990) to

622,600 acres (2000). There are several benefits from field pea production which have fueled this growth, including the breaking disease cycles in crop rotations, nitrogen fixation, improvement of soil tilth and good cash returns. Despite this success, the problem of maintaining yield stability across sites and years still remains a serious problem for pea growers. Alberta yields (by census division) in 2000 ranged from 13.8 to –50.4 bu/acre. To maximize yield, producers are advised to seed early (before May 15), ensure plant stands of at least 7 plants per ft^2, spray herbicides as early as possible and use fungicides when deemed necessary. Several agronomic experiments were planted from 1998 to 2000 (19 site-years) to evaluate the relative yield benefit of certain agronomic management factors (seeding date, seeding rate, herbicide application timing and fungicide application) to pea yield in central and northern Alberta.

Pea variety trials for Delaware and harvest evaluation of afila type peas on Delmarva

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Pea variety trials have been conducted in Delaware since 1994. Average yields and other data will be presented for feedback from the seed industry.

Afila type peas have a plant habit in which very few leaves are produced and more tendrils appear throughout the plant. The high concentration of tendrils helps the plants remain more upright than standard varieties. It has been suggested that direct sunlight on the pods improves the color of the peas and less leaves reduces trash in the harvested product. It has also been suggested that afila type peas would mature quicker than standard types.

Growers and processors on Delmarva have been confronted with conflicting reports on the use of afilas in other regions, as well as their yield potential and harvestability. A field study was established in 1998 to gain experience in harvesting afila type peas and perhaps make recommendations for improving recovery at harvest.

Lower operating speeds with afila types were required in most cases to facilitate harvest of peas. These speeds were determined by the processing company personnel. Lower operating speeds resulted in lower acres per hour harvested and lbs./hour of product through the machine. Afila varieties with lower plant heights may facilitate a speedier, more efficient harvest. Commercial grades in five comparative fields indicated a higher trash content with afila types. Yields varied between locations, with no clear advantage between afila and standard types.

Thirty-four years of breeding, screening and selection of peas for resistance to root rot

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In this talk I will discuss the pea-breeding program that was conducted at Prosser from 1966 through 2000 to develop resistance to Fusarium and Aphanomyces root rot. I will discuss symptoms, some of the important factors that affect symptom development, screening techniques, disease resistant evaluations, pathogen inoculum levels, nature of resistance and factors affecting disease severity for these two important diseases. I will discuss my philosophy about germplasm exchange between private and public breeders/researchers. Lastly, I will discuss what I consider the important advances made in pea improvement during the last 35 years and considerations for the future of pea improvement.

Inheritance of resistance to anthracnose and marker identification for resistance in lentil (*Lens culinaris* Medik)

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Anthracnose caused by *Colletotrichum truncatum* (Schwein.) Andrus & W.D. Moore is a devastating disease of lentils in Canada. Results of previous study showed that resistance to anthracnose was controlled by one recessive and two major dominant genes (lct-1, LCt-2 and LCt-3) using F_2 plants and $F_{2:3}$ families of Indianhead, PI 320937 and PI345629, respectively. We used a cross between Eston (susceptible) and PI 320937 (resistant), to develop 152 recombinant inbred lines (RILs) to study resistance and identify markers associated to the resistance gene. The $F_{5:6}$ RILs were inoculated with *C. truncatum* isolate 95B36 at 10^5 conidia ml^{-1} and scored for anthracnose reactions over 2 replications in the greenhouse. Six hundred RAPD and few AFLP primers were screened. We used bulked segregant analysis for rapidly identifying markers using F_2 DNA and phenotypic data from $F_{2:3}$ families. These polymorphic markers were used to genotype RILs and make linkage analysis. Segregation data indicated that a single major gene confers resistance as expected. About 18% of the RAPD primers showed polymorphism. Two RAPD markers closely linked to the resistance gene in coupling and repulsion phase were identified. Preliminary mapping indicated that the closest flanking markers were 5 and 7 cM away from the resistance locus. These markers will be useful in lentil breeding via marker-assisted selection towards developing cultivars with anthracnose resistance.

Mechanistic assessment of calcium accretion in developing chickpea seeds

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Chickpea is an important staple in many Asian and Middle Eastern countries, and can serve as a significant source of dietary calcium for humans. Because calcium is often limiting in many diets, we have been interested in developing new chickpea cultivars with enhanced concentrations of calcium. To assist this effort, we have been attempting to understand the mechanistic processes responsible for calcium accretion in developing seeds. Because calcium delivery is not believed to occur via phloem transport, we tested the hypothesis that calcium accretion occurs via simple diffusion and moves through contact between the seed coat and the inner pod walls. If this hypothesis is true, then calcium accretion would not be observed until the expanding seed touches the inner wall of the inflated chickpea pod. Plants were grown under controlled conditions, with developing seeds and pods harvested throughout the period of seed development. Seed dry weights, seed calcium content, and pod wall calcium concentrations were determined for tissues of cultivar Green and the wild accession Cr231. Our results indicated that for both lines, seed calcium import occurred prior to seed-to-pod wall contact; this did not support our hypothesis. Instead, our results suggest that calcium enters seeds via diffusional movement through the funiculus. We will present these results, along with a general mechanistic model describing the factors/processes thought to control calcium accretion in developing chickpea seeds.

Potential for winter legumes for cold highland areas of the western U.S.

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Pea and lentil germplasm is available with sufficient winter hardiness to enable survival in most winters in the Palouse region of eastern Washington and northern Idaho. The prospect of winter dry peas and lentils is currently being studied and has attracted significant interest among growers of the region as a desired alternative to spring seeding. This interest is based on the potential of winter types to significantly increase yields while significantly reducing soil erosion. The yield advantages are derived from germination and establishment of the crop in the fall followed by early vegetative growth immediately after temperatures rise in spring. The crop therefore benefits by completing vegetative growth and reproductive stages during the cooler and more humid periods when evapotranspiration is minimal.

Winter type peas and lentils would be direct seeded into standing stubble from previous wheat or barley crops. This practice would enable growers to establish their legume crops in the fall when soil conditions are drier thereby limiting the degree of compaction of the fields from machinery traffic. Retaining the residue from the previous cereal crop on the soil surface is a proven practice that greatly reduces soil erosion. In preliminary evaluations of winter hardy peas and lentils, yields have been significantly improved over spring-sown crops. In the 1999-2000 winter season, winter legumes, particularly lentils, have shown over a 100% increase in yield when compared to lentils sown in the spring. Long-term averages indicate increased yields of 30 to 50% from fall sowing. However, improvements are needed in quality factors particularly seed size and coloration. For winter lentils, a large number of selections were evaluated in the past year and include small yellow cotyledon and small red cotyledon types that appear to be suitable for those market classes. We are continuing the development of winter type peas and lentils and have been concentrating on improvements in seed size, shape, color and other quality factors. Diseases of winter type peas and lentils also need to be carefully monitored.

The genetics of winter hardiness in lentil has been determined and as expected it acts as a quantitative trait. Mapping of the genes for winter hardiness in lentil has proceeded using a population of F_6 derived recombinant inbred lines. Mapping the genes for winter hardiness has been successful in identifying closely linked markers that we intend to use in marker assisted selection to accelerate germplasm development. Other aspects of the winter hardiness project for peas and lentils will be discussed.