# Association Business ABSTRACTS

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Adams, S.S., D.I. Rouse and R.L. Bowden. *Performance of Alternative Versions of POTWIL: A Computer Model that Simulates the Seasonal Growth of* Verticillium-*infected Potato Crops.*

The objective of our research is to predict the yields of potato crops grown in the presence of *Verticillium dahliae,* a major cause of early dying disease in Wisconsin. To this end, we have constructed a simple model of *Verticillium* development and coupled it to a detailed model of potato growth (Ng and Loomis, 1984). The combined host-pathogen model (POTWIL) requires site latitude, crop emergence and harvest dates, aerial density of host mainstems, initial soil inoculum density, and average weather data as inputs. To simulate crop growth after infection, it uses information on how pathogen development affects host physiological processes. Results from our field and controlled environment experiments indicate that lifespans and photosynthetic rates of leaves of infected plants are significantly less than those of control plants. The predictions of several alternative versions of POTWIL that incorporate disease loss mechanisms based on these findings are compared against plant growth data from field experiments conducted at Hancock, Wisconsin during 1983-1986.

Alsadon, A.A. and K.W. Knutson. *Yield Responses of Nine Cultivars of Micropropagated Potato Plants Grown in the Field Under Mulch and Bare Soil Conditions.*

Micropropagated plants of nine potato cultivars were transplanted to the field on June 24, 1986, after a 14-day hardening period. Fertilizers: preplant broadcast—67.2 kg $ha^{-1}$ N, and 168 kg $ha^{-1}$ P; at transplanting, liquid starter (15-30-15), diluted at 1.28 g $l^{-1}$ was applied at 200 cc/plant. Split plots: base soil vs. plastic mulch (opaque white, 3′ wide, 2 mil. thick). Furrow irrigation: 34′ row width. Vine killing was done mechanically on October 8 and harvesting completed on October 27.

All cultivars grown in bare soils consistently had a higher number and weight of tubers per plant than those grown under mulch. No significant differences were found between treatments in terms of the number of large

tubers per plant (>5 cm). However, the number of medium (3-5 cm) and small tubers (<3 cm) were higher under bare soil conditions. Kennebec and Spunta had the highest total yield followed by Desiree. Kennebec and Spunta had the highest number and weight of large tubers, whereas Alpha and Sangre had the highest number and weight of medium and small tubers. Ute Russet had the lowest yield among all cultivars.

Alsadon, A.A. and H. Timm. *Respiration and Sprout Growth Response of Seed Potato Pieces to Gibberellic Acid and Ethephon.*

The respiration and sprout growth of White Rose seed potato pieces were influenced more by an increase in temperature from 10 to 20 to 30 C than by exposure to a 5 minute soaking with 10 mg $l^{-1}$ GA or 1000 $\mu l$ $l^{1}$ ethephone alone or in combination. The magnitude of response varied among dormant, 50% sprouted, and fully sprouted-desprouted seed pieces. Respiration and evolution of $C_2H_4$ were of higher magnitude but with lesser sprout growth at 30 C than at 20 C. Evolution of $C_2H_4$ for 120 h was contributing to sprout growth inhibition. Sprout growth inhibition from ethephon was partially overcome by inclusion of GA. Best sprout growth response was present at 20 C with GA. Multiple sprouting per "eye" was increased with GA and with ethephon. A seed potato piece treated with either GA or ethephon and planted at soil temperature above 20 C would likely result in an increase in stem numbers and in stolon numbers, undesirable for production of a high yield of U.S. No. 1 Grade potatoes.

Amorós, W. and V. Otazú. *Potato Black Berry Formation Due to Boron Deficiency.*

An essential part of the potato breeding program in the International Potato Center is the utilization of flowering stem cuttings maintained in water. For many years relatively successful crosses were obtained; however, during the 1985-86 season when a deep well went into service and its water was used instead of that of a shallow well, a problem arose. Berries darkened and dropped off. Black berries contained sterile seeds. No pathogen was associated with damaged berries and only saprophytic bacteria were isolated from them.

Six water sources were compared, including potable water, water from a deep tubular well, water from a superficial well, Hoagland's solution, distilled, and deionized water. Flowering stems of cv. "Yungay" were cut and pollinated with pollen from clone R-128.6. The problem persisted in all treatments except the bottles with Hoagland's solution. Another experiment was designed to test deficiencies of 6 macro and 6 micro elements. Treatments containing B had the least number of black berries and treatments lacking B had the greatest number of black berries most of which dropped off prematurely. A solution of 0.1 ppm of B in the form of boric acid produced an average of 96% sound berries weighing 4.66 g each. Higher concentration (1 ppm of B) caused some phytotoxicity in leaves.

Bamberg, J.B. and R.E. Hanneman, Jr. *Characterization of a Gibberellic Acid Related Dwarfing Locus in* S. tuberosum *L.*

A clone of *S. tuberosum* Group Andigena (coded 11.1) produced compact, dark green, rosette plants among its progeny. Test crosses indicated that this dwarf phenotype is conferred by nulliplex status of a single locus (*g*). The cultivar 'Superior' was found to be triplex at this locus. The genotypes of 52 '11.1' x 'Superior' $F_1$ hybrid clones were determined to test for the presence of *g* locus mediated gametophytic selection. While no gametophytic selection was noted, tuber yields were highly correlated with their genotypes, such that simplex>duplex>triplex. 'New Superior,' a bolter of cultivar 'Superior,' was test crossed to determine if its phenotype was due to a genotypic change at the *g* locus. It appears to be triplex like 'Superior.' This locus may be of value for studying the genetics of GA status, its effect on tuberization, flowering, yield and spontaneous somatic mutants.

Bilski, J.J., D.C. Nelson, A. Maianu and R.L. Conlon. *Response of Potatoes and Related Wild Species to Salinity.*

Total yields of potatoes grown in a dryland production system were reduced 50% when the conductivity of a sulfatic-chlorodic soil was 2.16 mmhos $cm^{-1}$ and the conductivity of a sulfatic saline soil was 3.38 mmhos $cm^{-1}$. There was only a small non-significant difference among the yield response of five different cultivars to increasing salinity. Soil salinity had the same effect on U.S. No. 1 yields as on total yields. In a greenhouse study, small potato plants (cv. Russet Burbank, Red Pontiac, Norchip and Norgold Russet) were watered with solutions containing various rates of NaCl and $Na_2SO_4$ salts. On a mole basis $Na_2SO_4$ was more toxic than NaCl to plant growth. The addition of $CaSO_4$ reduced the deleterious effect of NaCl and $NA_2SO_4$. Of the four cultivars, Russet Burbank was the most adversely affected by NaCl and $Na_2SO_4$. Among six wild *Solanum* species, *S. chacoense* had the highest salt tolerance. Lesser tolerance was shown by *S. bulbocastanum, S. gourlayi, S. microdontum, S. papita* and *S. sparsipilum.*

Carlson, H., H. Ferris and B. Westerdahl. *Crop Rotation for Columbia Root-knot Management in Potatoes.*

A field experiment was conducted to measure the effects of varied crop rotation sequences on soil populations of Columbia Root-knot nematode (*Meloidogyne chitwoodi*). In 1984, barley, potatoes, onions, and alfalfa were each planted and maintained in two replicate plots, 40 feet wide by 200 feet long. In the spring of 1985, the plots were rotated to potatoes and barley. The alfalfa plots planted in 1984 were maintained throughout the 1985 season. In addition, half of each plot was disked and maintained as a relatively weed-free fallow throughout the 1985 growing season.

Alfalfa rotation or a summer fallow treatment each reduced soil nematode levels relative to those attained in the standard potato/barley rotations.

High nematode levels built up following potatoes, onions or potato/barley rotation.

In the fall of 1985, half of each plot was treated with Telone® at 20 gpa and in the spring of 1986, the trial area was planted uniformly to potatoes. The Telone treatment was only moderately effective in reducing nematode numbers or in protecting against nematode blemish. Significant, commercially acceptable, reductions in nematode blemish were measured in the potato crop which followed the alfalfa and summer fallow rotations.

Carter, C. *Differences in Pyrethroid Efficacy Among* Solanum *Clones Resistant and Susceptible to Colorado Potato Beetle.*

Larvae of Colorado potato beetle (CPB), *Leptinotarsa decemlineata* Say., were reared to 3rd instar on foliage of CPB-resistant and CPB susceptible *Solanum chacoense* and *S. tuberosum* clones. Fenvalerate was applied at 0, 6, and 12 $\mu$g per larva. The mixed-function oxidase inhibitor piperonyl butoxide (pb) was applied at 24 $\mu$g per larva alone and in combination with fenvalerate. CPB mortality was adjusted for mortality on controls for each clone. CPB mortality did not differ among clones at the low rate of fenvalerate with or without pb. However, at 12 $\mu$g fenvalerate per larva CPB mortality was 80% on CPB-susceptible clones, significantly greater than the 55% mortality of CPB on resistant clones. Pb reduced the percentage of larval development to 4th instar by 60% on the CPB-susceptible cultivar Katahdin and by 100% on the resistant clones. The results suggest that fenvalerate may be less effective on partially CPB-resistant plants than on susceptible lines, and the reduction in efficacy may be associated with greater mfo activity of CPB which have fed on resistant foliage.

Chungcharoen, A., J.H. von Elbe, R.M. Wheeler and T.W. Tibbitts. *Glycoalkaloids of Potato Tubers Grown Under Controlled Environments.*

Potato tubers were analyzed for total and individual glycoalkaloid content using high performance liquid chromatography. Results for 5 cultivars grown at 9 locations throughout the North Central Region were used to establish an average total (TGA) and individual glycoalkaloid content. The glycoalkaloid content varied greatly and the TGA ranged from 0.17 to 0.85 mg/g dry weight. Controlled environmental factors included length of photoperiod, growth temperature, level of $CO_2$ and relative humidity. Cultivars studied were Norland, Russet Burbank and Denali. The average TGA increased with increased light intensity and length of photoperiod. TGA for Norland tubers grown for 12 weeks increased from 0.34 to 0.39 mg/g dry weight (6.3 to 7.8 mg/100 g fresh weight) when the light intensity was increased from 400 to 800 $\mu$E; and from 0.33 to 0.38 mg/g (5.5 to 6.7 mg/100 g fresh weight) when the photoperiod increased from 12 to 24 hr. Growth temperature had a great effect on the TGA content of tubers. Minimum TGA levels were found in tubers grown at 16 C when compared

to tubers grown at 12 C. Increase of the level of $CO_2$ (350 to 1000 ppm) and relative humidity (50 to 80%) had little or no effect on the accumulation of TGA in tubers.

Darmo, E. and S.J. Peloquin. *Yield, Plant and Tuber Characteristics of 4x Clones from 4x x 2x Crosses.*

One hundred five 4x clones, 4x x 2x crosses and 9 cultivars were evaluated for yield, specific gravity and reducing sugars at two locations in Wisconsin. They were also evaluated for maturity, tuber appearance and tuber dormancy. The 2x parents of the 4x clones were hybrids between Tuberosum haploids and Phureja (53 clones), *S. tarijense* (46) and *S. microdontum* (6). The 4x clones with Phureja were previously selected; the others were unselected. From 20-50% of the 4x clones were equal or superior to the cultivars for the traits evaluated. Only 1 cultivar at Rhinelander and 2 at Hancock were among the 25 highest yielding entries. The 25 entries with highest specific gravity ($\geq$1.085) and low reducing sugars ($\leq$0.1% total glucose) were experimental 4x clones; the majority of the 4x clones with these qualities had *S. tarijense* as the 2x parent. The tuber appearance of the 4x clones was similar to that of cultivars; those with *S. tarijense* as the 2x parent had very good tuber type. This preliminary trial indicates that some of the clones from 4x x 2x crosses are equal or superior to cultivars of economic importance; further increase and evaluation of these 4x clones is merited.

Deahl, K.L. and S.L. Sinden. *1986 Screening of IR-1* Solanum *Accessions for Foliar Glycoalkaloid Level and Composition.*

Total foliar glycoalkaloid contents (TFGA) and glycoalkaloid compositions of one or more accessions from 61 *Solanum* species were determined by TLC and GLC analyses. Of the 283 accessions analyzed, only 13 had very high (>200 mg/100 g) TFGA contents. Eight of these 13 high TFGA accessions were collections of *S. chacoense,* a species known to synthesize very high levels of these potentially poisonous steroidal alkaloids. Most of the species (46 of the 61) analyzed synthesized levels of <100 mg/100 g foliage. Solanine and chaconine were the predominant glycoalkaloids found in the analyses of glycoalkaloid compositions; 142 of the 283 accessions synthesized only these two major glycoalkaloids. Solasonine and solamargine were the major glycoalkaloids in 67 of the accessions. Tomatine, the solamarines, commersonine + demissine, demissine only, and leptines were found in a few of the accessions; 13, 10, 9, 6, and 3 accessions, respectively. A few accessions synthesized major amounts of six or more different types of steroidal glycoalkaloids. This survey of *Solanum* accessions confirms the wide diversity of types and levels of glycoalkaloids in the *Solanum* species.

Dodd, J.B. and R.E. Hanneman, Jr. *An Examination of Reproductive Failure Following Inter-EBN Crosses Among Tetraploid, Tuber-bearing* Solanum *Species.*

According to the Endosperm Balance Number (EBN) hypothesis, crosses between tuber-bearing *Solanum* species with different EBN's fail. To further investigate inter-EBN seed failure, reciprocal crosses were made between 4x (2EBN) species (*S. fendleri* ssp *arizonicum, S. fendleri* ssp. *fendleri, S. polytrichon, S. stoloniferum*) and a 4X (4EBN) species (*S. tuberosum* Gp. Andigena). The 4x (2EBN) x 4x (4EBN) crosses yielded fruits with aborted seeds. Compared to normally developing seeds of the 4x (2EBN) species, the embryo sacs of the failed hybrid seeds were smaller and the embryo cells were larger. Within crosses, the number of cells comprising the hybrid embryos varied. However, none of the hybrid embryos developed beyond the globular stage. The reciprocal 4x (4EBN) x 4x (2EBN) crosses yielded no seed. Preliminary investigations indicate that the lack of seed set results from few pollen tubes reaching the ovary.

Douches, D.S. and C.F. Quiros. *Transmission of Heterozygosity Through Meiotic Mechanisms: Comparison of Theoretical and Experimental Data.*

The application of half-tetrad analysis (HTA) to the segregating tetraploid progenies obtained from 4x-2x and 2x-4x crosses has been useful in estimating gene-centromere map distances for eleven enzyme-coding loci and the yellow tuber flesh locus (*Y*) in the potato (Group Tuberosum). Estimates of gene-centromere linkages are simply another way of expressing the recombinational frequency for that chromosome segment. Assuming that these segments are randomly distributed throughout the potato genome, the pooled segregation data from either a set of 4x-2x or 2x-4x crosses were considered an estimate of the heterozygosity transmitted as a consequence of the meiotic mechanisms(s) operating. Segregation data from 4x-2x (FDR) (81.6%), 4x-2x (FDR, sy3) (98.0%), and 2x (SDR)-4x (39.1%) crosses are examined and compared to theoretical expectations.

Easton, G.D., M.E. Nagle and M.C. Seymour. *One and Two Years' Cropping to Immune Hosts on* Verticillium dahliae *Control and Potato Production of Russet Burbank Potato.*

Starting in 1982, plots were cropped for two consecutive years to Russet Burbank potatoes, and the *Verticillium*-immune crops, field corn, sweet corn, sudangrass, spring wheat or spring wheat plus late-season sudangrass. In 1984, all plots were planted to potatoes. Cropping had no effect on soil propagules of *V. dahliae.* Plant height and yields, but not % U.S. No. 1 tubers, were increased by the previous two years' cropping to immune crops. In 1985, plots were re-cropped as in 1982 and 1983. In the spring of 1986, one-half of each plot was fumigated (methyl bromide, 448 kg/ha) and tarped. All plots were planted to potatoes. No cropping or fumigation

treatment significantly affected soil propagules of *V. dahliae.* Fumigation reduced Verticillium wilt, reduced propagules in potato stems, and increased % U.S. No. 1 tubers. Percent U.S. No. 1 tubers was significantly less in nonfumigated plots previously cropped to sudangrass, spring wheat and spring wheat plus sudangrass than that from nonfumigated plots of sweet corn, field corn, and potatoes. One year's cropping did not reduce Verticillium wilt or increase yield. Plots previously cropped to potato and fumigated produced significantly lower yields than any other cropping treatment, fumigated or not fumigated.

Estrella, D., F. Munoz and H. Naranjo. *Production of Certified Seed from Tissue Culture. An Innovative Approach in Ecuador.*

Until 1983, the production of certified seed in Ecuador reached less than 0.5% of the total national needs and the seed produced at that time was not derived from pathogen-tested *in vitro* stocks.

On the basis of three cultivars cleaned by meristem culture and an integrated program of tissue culture and rapid propagation INIAP produced in 1986 3.2% of national seed needs with seed of extremely high quality.

The basic techniques of tissue culture, micropropagation and rapid propagation were modified to suit the conditions and genotypes of Ecuador. The scheme has also involved the integration of both the research station and private seed producers. On the basis of these experiences, plans exist to further enhance production and increase the number of clones cleaned through the meristem culture and thermotherapy.

Ewing, E.E., D. Heym, J. Schusdek, R.G. Snyder and A.G. Nicholson. *Evaluation of Plant Growth Models for Use in a Systems Analysis Approach to Potato IPM.*

Weather data and tuber yields from research plots in upstate New York (23 years) and on Long Island (30 years) have been compiled to compare the ability of five different models to predict potato yields. Yields in every case are from cv. Katahdin grown under irrigation and under what is assumed to be optimal cultural practices, since they represent "control" treatments in cultivar trials, fertilizer tests, or similar experiments. The five models were developed for other locations and cultivars; thus they require modification for New York conditions. The correlation between predicted and reported yields will provide one criterion for model selection. Other criteria will be ability to simulate defoliation and ease of linkage with pest models, pollution models, and decision models.

Ewing, L., S. McMurry and E.E. Ewing. *Cutting as a Method of Breaking Dormancy in Microtubers Produced.*

Microtubers formed *in vitro* often undergo long periods of dormancy.

A simple method of promoting sprouting is to cut the microtubers in half. The promotive effect is demonstrated over a wide range of cultivars.

Ezeta, F., J. Aguilar and N. Zuniga. *Micropropagation Techniques in the Peruvian Seed Program.*

A basic seed production program based on rapid multiplication techniques was started in Peru in 1982 by the National Potato Program. Initially, basic seed stocks were generated by transplanting rooted stem cuttings to seedbeds in screenhouses at high planting densities in order to produce large numbers of small, pathogen-free, pre-basic tubers. Also, a large number of rooted cuttings were transplanted directly to the field under favorable climatic conditions. Later, in 1985, laboratory facilities as well as expertise in micropropagation techniques were developed in several seed production centers throughout the country. Utilization of *in vitro* produced plantlets, instead of stem cuttings, in the seedbeds has significantly increased the rate of multiplication in terms of number of tubers produced per unit area of seedbed. A comparative cost analysis of both rapid multiplication techniques indicated that *in vitro* micropropagation of pathogen-free stocks is a better alternative for the Peruvian seed program.

Nevertheless, since manpower and initial costs of *in vitro* facilities limit the application of micropropagation in every regional production center, the national program maintains an integrated rapid multiplication scheme that combines laboratory, screenhouse, and field techniques.

Flanders, K.L. and E.B. Radcliffe. *Source of Potato Leafhopper Invasions in Potato and Snap Bean at Rosemount, Minnesota, 1984-85.*

Potato leafhopper (PLH) populations were routinely sampled in potato and snap bean that emerged after first PLH arrival in spring. Source of the first adults on potato and snap bean was uncertain because alfalfa harvests and short southerly wind events capable of carrying PLH from the mid-Mississippi Valley occurred concurrently. However, numbers were too few to appreciably contribute to short-term PLH population growth. Both years, significant invasions of potato and snap bean occurred between 355-494 CDD (base 8.4 C) after colonizing adults arrived on alfalfa. It was in these critical periods (3-14 July, 1984 and 20 June-1 July, 1985) that PLH adults were first consistently collected (1984) or when large increases in the number of PLH adults occurred (1985). The first local generation of PLH would have matured on undisturbed hosts at this time. Subsequent increases in numbers by age class were consistent with the interpretation that first major increases of nymphs on potato and snap bean represented progeny of adults arriving between 355-494 CDD. Too few PLH adults were collected in 1984 to give reliable information on sex ratios during this critical period,

but in 1985, ratios shifted from predominantly female to 50:50, reinforcing the hypothesis that the primary source of PLH on potato and snap bean was local.

Flewelling, H.S. and S.J. Peloquin. *Recovery of Tuberosum and Species Phenotypes Among Progeny from Crosses Between Haploid-species Hybrids.*

The genetic relationships between wild *Solanum* species and the cultivated potato are important in germplasm transfer between these two groups. $F_1$ hybrids between Tuberosum haploids and the wild species *S. berthaultii, S. canasense, S. chacoense, S. microdontum, S. sanctae-rosea* and *S. tarijense* were intercrossed to generate families of from 40 to over 500 plants. These plants were evaluated for vine type, leaf type, tuberization, and maturity on a scale of 1 to 3; 1 indicating a Tuberosum haploid phenotype, 3 a phenotype matching the species grandparent, and 2, intermediate forms. The data from each family were used to calculate simple correlations between all four morphological traits on a per plant basis, and to determine percent recovery of Tuberosum haploid and wild species phenotypes within each family. Correlations calculated were high (0.58-0.85), indicating the genes controlling these traits may be linked. Plants which received all "1's" or all "3's" for the four traits represented recovery of phenotypes of Tuberosum haploid or wild species grandparents. The average percent recovery of such phenotypes per family was 6.2%. This indicates that only a limited number of genes is involved in differences between cultivated potatoes and wild species.

Francl, L.J., L.V. Madden, R.C. Rowe and R.M. Riedel. *Validation of a Model that Discriminates Yield Reductions Due to Potato Early Dying.*

A discriminant model was developed using data from 3 yr of a factorial microplot study in which *Solanum tuberosum* cv. Superior was inoculated with *Verticillium dahliae* and *Pratylenchus penetrans*, pathogens that cause potato early dying. The model classified tuber yields as <80%, 80%-90%, and >90% of uninfected control yields based solely on the natural logs of the preplant population densities of *V. dahliae* and *V. dahliae* x *P. penetrans*. The model was evaluated on its misclassification of actual yields <80% as >90% and >90% as <80% on control yields. In the original data set, 6% of the observations were misclassified. The misclassification rates in validation studies were: 5% for data from a second location over 6 yr; 37% for data from 3 yr wherein yield reductions were small; and 7% for observations from 1985 and 1986 microplot studies in three soils and with two cultivars. Data collection in 1987 from commercial potato fields is planned for further model validation. Discriminant models share the concept of a threshold with applied integrated pest management. In this case, the threshold may be construed as being between 10% and 20% yield reduction.

Franc, G.D. and M.D. Harrison. *Infectivity Titration of* Corynebacterium sepedonicum *on Russet Burbank and Centennial Russet Potatoes in Colorado.*

Whole seed tubers were inoculated with different numbers ($10^1$, $10^2$, $10^4$, $10^6$, and ca $10^9$ cells per tuber) of the ringrot bacterium, *Corynebacterium sepedonicum,* and planted in the field in the San Luis Valley near Center, Colorado. Plants were rated visually for the appearance of primary ringrot symptoms. Healthy-appearing daughter tubers (generation 1) were harvested and replanted in the field during the following growing season. In addition, tuber subsamples were rated visually and assayed on eggplant for the presence of *C. sepedonicum.* Tubers and plants from generation 2 and generation 3 were also evaluated to determine if latent infections resulted from the initial inoculations. The entire experiment was repeated three times during 3 consecutive years. Results showed that as the number of *C. sepedonicum* cells per seed increased, progeny plants and tubers were more likely to have detectable *C. sepedonicum* present. At the lower inoculum levels, visual symptoms were sometimes not evident until the third generation after inoculation. Although unknown environmental ("seasonal") factors influenced symptom expression, there was a marked reduction in disease incidence in tubers and plants between the second and third generations.

Franc, G.D. and M.D. Harrison. *The Role of Contaminated Irrigation Water in the Recontamination of* Erwinia-*free Seed Potatoes.*

*Erwinia*-free microplants and cut seed pieces were planted in the field at Fort Collins and Center, Colorado in 1985 and 1986. Plants were watered with natural irrigation water or natural irrigation water infested with known numbers of *Erwinia carotovora* subsp. *carotovora* (Ecc) or *E. carotovora* subsp. *atroseptica* (Eca).

Data showed that as numbers of *Ecc* and *Eca* in the irrigation water increased, a concomitant increase in the number of infested tubers and latently infected stems occurred. Data also showed that naturally occurring "water" strains of *Erwinia carotovora* applied in irrigation water were able to establish internal stem populations similar to those for strains isolated from blackleg-infected plants.

Franc, G.D., M.D. Harrison and L.K. Lahman. *Day-Degree Model for Timing Early-blight Control in Colorado.*

A simple day-degree model was developed to predict the appearance of the first early blight (*Alternaria solani*) lesions in two potato production areas in Colorado. The model is based upon accumulated day-degrees above 7.2 C from the date of planting and effectively predicts the beginning of secondary spread of the pathogen. Accumulated day-degrees required for the appearance of first lesions is ca 650 in the San Luis Valley and ca 1125 in northeastern Colorado. Growers are using the information to time initial applications of fungicide to minimize the cost of early-blight control.

If the model is to be used in other production areas, different day-degree thresholds may need to be established. The model effectively reduces fungicide applications in Colorado where growers do not routinely apply fungicides for late blight (*Phytophthora infestans*) control.

Frève, A. *Modifications of a Two Row Holland Transplanter for Potato Experimental Plots.*

Many modifications of a two row Holland transplanter have been done to plant potato experimental plots and to transplant seedlings in peatmoss pots. The disc pocket arrangement is now controlled by the two wheel base of the transplanter to avoid slipping of the driving and packing wheels and to increase planting precision. The furrow base is larger to allow placing tubers at right angles with the row in order to get the stem end at a uniform distance so a constant parallel stem end orientation of tubers is obtained. Other modifications have been done and will be presented.

The speed of plantation or transplantation is four times faster than a single row planter. The space between hills is very accurate and it is easy to count the number of hills per plot.

Preparation of samples before going to the field will be presented.

Frève, A. *Stem Cutting Technique Increases Screening Pressure and Hastens Evaluation in a Potato Breeding Program.*

Production of true seeds is the first step in a conventional breeding program. The second one is to plant seeds and to see what the potatoes look like. This step is usually done in a greenhouse.

At La Pocatière, Québec, the seedlings are stem cut in the greenhouse and the cutting plus the plant are transplanted in the field for evaluation. This operation has been done since 1983 with excellent results. Each seedling produced, at least, two plants per hill. They are irrigated twice a week or when needed. In the autumn, selection can be done on tuber size, shape and susceptibility to common and powdery scabs and black scurf. With those two plants there are enough good sized seed tubers for the subsequent eight (8) hills' evaluation on two different soil types. The third and fourth year of evaluation, seedlings are in replicate trials on three different soils types and at three different locations respectively so after four years in the field, seedlings already have six location years of data. In the meantime, the seedlings are disease-freed and those disease-free seedlings are evaluated in regional trials.

Frève, A. and Y. Dubé. *Tackle-Scal-Uter: A System with Computer, Electronic Scale and Tackle for Measuring Specific Gravity and Other Weights of Potato.*

A weighing system was developed to simplify and accelerate the determination of specific gravity and to measure different grade size of potato samples using the same electronic scale. Samples weighed in air were

weighed directly on the electronic scale. Weights in water are taken using a tackle connected to the drop hook of the scale. A water tub is placed in a wash tank adjacent to the electronic balance to facilitate working conditions. The tackle is made with two 17.8 mm plastic pulleys and an 18.2 kg test nylon rope enclosed in a fiberglass and wooden frame. The weights are transmitted to a micro-computer which converts the data to specific gravity readings. Data are stored on both tapes and print-out.

The basket on the scale can be used with any sample weight even if the tackle is connected for specific gravity determinations. The data are stored on tape and on print-out also. Specific gravity readings can be processed at the rate of 120 per hour. When grade sizing samples of experimental plots, weighing and taking specific gravity are done in one operation and the rate can reach 130 samples per hour.

Golmirzaie, A.M. *Performance of True Potato Seed Synthetic Populations.*

One method of producing low-cost TPS is to create a synthetic population. The performance of a synthetic depends on the selfing rate and number of parents in the initial population.

During 1985 an experiment was conducted in San Ramon, Peru to determine the number of parents needed to develop the initial synthetic population. Seven populations were created each with either two or four parents. Results showed two-parent populations give as good a performance for reproductive and agronomic characters as four-parent populations.

In 1986 other experiments were conducted at San Ramon and Lima to determine the type of synthetic populations (natural or controlled) and the number of parents (2, 4, 6) that are needed in the base population. Seeds from the previous year were used for the natural synthetic populations with different parental combinations. For the controlled synthetic, crosses were made to produce two-parent populations and the multi-lines concept was followed for the four- and six-parent populations.

The two-parent populations in the natural and controlled types of synthetics performed the same or better than the four- and six-parent populations. Therefore, by selecting the right parental lines it is possible to obtain high performance TPS in a naturally produced synthetic population with only two parents.

Gould, W.A., S. Plimpton, A. Baroudi and J. Thomas. *Factors Affecting the Oil Content of Potato Chips.*

Previous studies have shown the significance of specific gravity on the oil content of potato chips with the oil content varying from 32% to 47%.

Emphasis in this study included the effects of specific gravity, slice thickness, style of slice (chip), and frying (drying) parameters on the oil content of the finished potato chip.

The data indicate that specific gravity of the raw potato accounts for some 43% of the oil content of the potato chip. Slice thickness, style of chip, and frying parameters account for 40% of the oil content of the potato chip. The unaccounted for difference (17%) is believed due to the washing practice and/or variations in the specific gravity of individual tubers or the variations in final moisture content of the potato chip. By drying the slice to 50% of its original moisture content prior to frying, the oil content can be more precisely controlled to the desired level of 30%±3%.

Gudmestad, N.C. and W.M. Bugbee. *Occurrence of* Corynebacterium sepedonicum *in Alternate Hosts.*

We previously reported the recovery of *Corynebacterium sepedonicum*, causal organism of bacterial ring rot of potato from sugar beet roots grown in the potato production area of the Red River Valley. Current research demonstrates the presence of the ring rot bacterium in sugar beet roots collected from population areas where potato production does not occur. In addition, *C. sepedonicum* was recovered from sugar beet seed produced in the United States but not from seed produced in Europe. The highest seed infection rate was 80% as determined by indirect immunofluorescence antibody staining. The population of *C. sepedonicum* in this seed lot was $1.7 \times 10^5$ cfu/gm of seed. All strains of *C. sepedonicum* isolated from sugar beet roots and seed were found to be pathogenic to eggplant and potato.

The infection of weed species by *C. sepedonicum* also was investigated. Plants of black nightshade (*Solanum nigrum* L.), lambsquarters (*Chenopodium album* L.) and russian thistle (*Salsola kali* L.) that had been root or stem inoculated with $10^8$ cfu/ml did not become infected with the ring rot bacterium.

Halseth, D. and W. Heym. *Field Data Collection Using a Portable Microcomputer.*

A data collection program has been developed for a handheld microcomputer to record field notes and measurements, transfer the experimental results to a desk-top computer for sorting and then uploading to a mainframe computer for statistical analysis and report generation. A TRS 80 Model 100 microcomputer (Radio Shack, Tandy Corporation) with 32 K of RAM uses a 9314 program written in Microsoft Basic which can be easily edited on site to collect data for specific parameters that are unique for the date or trial. This program requires that all parameters have values (or a " not available" symbol) entered for a plot before entering data for another experimental unit, as well as providing full data review and correction features.

Data are then transferred from the Model 100 to an IBM-PC using the PC-TALK communications program. A program (developed here using Turbo Pascal) uses the field experimental design to sort the data by treatment or variety, and merges it with the appropriate SAS program commands for the desired statistical analyses. Then the results are uploaded to a mainframe

IBM computer via the utility program KERMIT for the actual statistical computations and print out of data tables for reports.

Hanafi, D., D.W. Ragsdale and E.B. Radcliffe. *Secondary Spread of Potato Leafroll Virus in Relation to Aphid Numbers.*

Experiments were conducted to determine the role of green peach aphid (GPA) and potato aphid (PA) apterae and alatae in the secondary spread of potato leafroll virus (PLRV). Gradients of GPA and potato aphid population pressure were created by selective use of insecticides. Point sources of infection were provided by transplanting PLRV infected plants to the center of each plot. Apterae of both species were monitored weekly using stratified leaf samples. Incidence of PLRV was monitored 5 times (July 18-Sept. 5) using ELISA. In total, more than 50,000 plants were sampled. Spread of PLRV was found to be strongly correlated with cumulative aphid-days (apterae). Correlation coefficients of PLRV incidence by date ranged from 0.76-0.88 for GPA and 0.65-0.90 for PA. Cumulative aphid-days across treatments were 2.1-9.4 fold greater for GPA than for PA and populations were strongly correlated (0.53-0.91) on all sampling dates.

Hazel, W.J., G.A. Bean and R.W. Goth. *Effect of Sterols on Growth and Development of* Phytophthora infestans.

When detached leaves of *Solanum tuberosum* numbered selections, B6026-WV-5, B6039-WV-9 and B6086-WV-21 and the cultivars Irish Cobbler and Sebago were inoculated with zoospore suspensions of a R1234 isolate of *Phytophthora infestans*, sporangial production at the infection sites was correlated to their respective field resistances. However, the sterol content of the leaves did not correlate with either field resistance or sporulation. The sterols sitosterol and cycloartenol were most prevalent, but cholesterol, campesterol, stigmasterol, and 24-methylene cycloartenol were present in varying concentrations in all the foliar tissues assayed. When the sterol extracts from the foliar tissue and from purified sources were added to Elliott's defined medium at rates comparable to those present in foliar tissue, sporulation and zoospore production of this isolate of *P. infestans* were not affected.

Hertz, L.B. *Application of Several Herbicides Alone and as Tank Mixtures for Weed Control in Potatoes.*

Several herbicide treatments were evaluated for control of annual grass and broadleaf weeds in potatoes. 'Russet Burbank' potatoes were planted in a sandy loam soil. The preplant incorporated (PPI) treatments were incorporated to a depth of 7 cm. Early postemergence (EPO) treatments were applied when weeds were 3 to 5 cm, prior to potato emergence. Postemergence (PO) treatments were applied when potatoes were 15 to 18 cm high and weeds were 5 to 10 cm. All herbicides were applied using a $CO_2$ powered hand held sprayer in 28 gpa water at 39 psi. The weed population

was heavy and consisted of foxtail sp. (49%), common ragweed (30%), wild buckwheat (7%), carpetweed (13%), and Pennsylvania smartweed (1%).

EPTC alone or when tank mixed with cyanazine or pendimethalin gave excellent control of grass and broadleaf weeds. When applied alone, neither cyanazine or trifluralin controlled the weed complex. A tank mixture of bentazon and haloxyfop did not control foxtail sp. or carpetweed. A tank mixture of oxyfluorfen and haloxyfop resulted in excellent weed control, although oxyfluorfen severely injured potato plants and significantly reduced yield. Pendimethalin and metolachlor, when applied alone, gave poor weed control, but when tank-mixed with metribuzin, gave excellent weed control results.

Hiller, L.K. and D.C. Koller. *Foliar Nutrition of Russet Burbank Potatoes.*

Macro and micro nutrient foliar compounds were evaluated for yield and quality in the Russet Burbank cultivar. Commercially available materials were applied in three growers' fields in the Columbia Basin. The treatments were in addition to their regular production and fertilization programs.

Two products resulted in higher total yields per acre compared to the untreated control in all three locations. A third treatment was greater than the control at two locations and slightly higher at the third. The two highest yielding treatments contained significant amounts of sulfur. One compound was consistently higher compared to the control for percentage of tubers over 10 ounce, percentage of No. 1 tubers, and specific gravity. Reduction in the amount and severity of the internal disorders brown center and stem-end hollow heart resulted from some of the treatments. The two compounds containing significant amounts of calcium and boron resulted in a higher percentage of tubers with bud-end hollow heart. The implications of time of application in relation to mineral availability will be discussed.

Holm, D.G. *Sangre Selection Studies.*

Seventeen clonal selections of Sangre were made from a tuber-unit seed lot planted at the San Luis Valley Research Center in 1982. Seven selections were made for typical vine and 10 for larger vines. Progeny of each selection was grown for increase and observational purposes in 1983. During the three year interval from 1984-1986 comparative performance trials were conducted.

Total yield of the clones ranged from 37.4 to 49.0 t/ha. Clones 10, 11 and 14 yielded an average of 6.1 t/ha more than the standard clone. Yield of US #1 potatoes ranged from 31.5 to 43.3 t/ha. Clones 10, 11 and 14 yielded an average of 6.2 t/ha more than the standard. There were no significant differences among clones 10, 11 and 14 and the standard for percent US #1 potatoes.

Plant height ranged from 47 to 81 cm. Clones 10, 11 and 14 were an average of 14 cm taller than the standard. Also these three clones were classified as medium maturing compared to early for the standard.

Hung, Y.T. *Batch Anaerobic Digestion of Potato Wastewaters Mixed with Sugar Wastewaters with Bio-augmentation.*

A bench-scale laboratory study was conducted to determine the feasibility of batch anaerobic digestion process in the of potato wastewaters mixed with sugar wastewaters and to determine the effect of bio-augmentation on the treatment efficiency for organic pollutant removal. Three batch anaerobic digestion reactors were used in the study. The wastewaters had a feed TOC (total organic carbon) of 4406 mg/l and a COD (chemical oxygen demand) of 13,218 mg/l. Nitrogen and phosphorus were added to the feed to maintain a COD : N : P of 100 : 5 : 1. Reactors 2 and 3 had a bacterial culture product, LLMO (liquid live microorganism), addition of 50 and 500 mg/l, while reactor 1 without LLMO addition served as the control reactor. Reactor 2 was found to have the highest cumulative gas production of 17,340 ml over the 35 days of reactor run, while reactor 3 had 6575 ml and reactor 1 had 5130 ml cumulative gas production. The TOC removal efficiency varied from 63.2% for reactor 2 to 66.1% for reactor 3. Reactor 3 with the highest dosage of LLMO had the highest TOC removal.

Jansky, S.H. *Evaluation of 4x x 2x Hybrids for Yield, Maturity, and Tuber Traits.*

A yield trial containing 73 entries was conducted in 1986 at two locations in North Dakota, using a randomized complete block design. The entries included 4x cultivars and hybrid clones produced from 4x x 2x crosses. The 2x parents were derived from crosses between *Solanum tuberosum* haploids and *S. tuberosum* Group Phureja, *S. tarijense*, or *S. microdontum*. A number of 4x x 2x clones produced high yields, similar to those of the cultivars. High levels of total solids were common, especially among hybrids containing *S. tarijense*. Maturity scores of the highest-yielding entries were generally medium-early. Tuber set was highest among hybrids containing Phureja and lowest among the cultivars. Several hybrids from 4x x 2x crosses produced very smooth tubers of uniform size.

Johnson, K.B., R.L. Conlon, S.S. Adams, D.C. Nelson, D.I. Rouse and P.S. Teng. *Validation of a Simple Potato Growth Model in the North Central United States.*

A potato growth model developed by Johnson, *et al.* (Ag. Sys. 19:189-209) was validated in 1985 and 1986 at two dryland sites, Grand Forks, ND and Rosemount, MN, and one irrigated site, Hancock, WI. At each site, the cultivar Russet Burbank was grown and was managed to maximize yield. Leaf area index and leaf, stem, root, and tuber biomass data were collected from replicated experiments every two weeks. Daily soil matric potential, minimum and maximum temperatures, and solar radiation were also estimated or measured at each site. Among sites, average solar radiation and temperature

were similar but final tuber yields differed by as much as 35 Mg/ha. Except for Grand Forks in 1986, model predictions for leaf, stem, and tuber dry weights were similar to observed data both in terms of maximum values attained and temporal development. Regression of observed final tuber yield from these sites on the predicted values indicated one to one correspondence ($b$=0.99±0.14, $R^2$=0.88). However, for Grand Forks in 1986, the model when compared to observed data, over-estimated final tuber yield by 23 Mg/ha (115%). Soil salinity or aeration, factors not currently modeled, may account for this discrepancy.

Joyce, P.J. and B.H. McCown. *A System for Producing Uniform Microtubers.*

The development of microtubers as a feasible method for potato certified seed production is limited by low microtuber multiplication rates and the variability in size and dormancy of the microtubers. We have developed a system in which the uniformity of the microtubers is high, thus permitting well-designed research and evaluation studies.

Potato axillary buds derived from shoot cultures tuberize at a high percentage when placed on solid medium supplemented with 45 uM BA and 170 uM coumarin and grown at 15 C for 3 weeks in the dark. The timing of tuberization is uniform. For the cultivar Red Pontiac, a single large microtuber (6 mm diameter) forms on each explant. Red Pontiac microtubers show uniform emergence after 18 weeks of storage at 5 C. Many factors can affect the reproducibility and uniformity of the *in vitro* tuberization system. High quality shoot cultures as the source of explants is essential. Omission of hormones both reduces the percentage and the uniformity of the tuberization. Omission of the coumarin increases the variability in timing of tuberization and microtuber size.

Although this *in vitro* microtuber production system has not solved the major problem of low multiplication rates, it does offer a method of generating uniform propagules for research and small scale production.

Keim, W.A. *Expressing the Amount of Surface Applied CIPC (Isopropyl m-Chlorocarbanilate) Potato Sprout Inhibitor.*

CIPC is applied to potato surfaces in order to provide sprout growth inhibition during storage. Residue data for CIPC have been reported on both a weight basis and a surface basis (weight of CIPC in the peel). Both forms of the data have their uses. Usually, the variations for these data are not known. Reasonable data on both a weight basis and a surface area basis and with expected variation limits can be provided by the method described. This method 1) uses potatoes with a minimum size of 150 grams, 2) uses a potato sample of four or five potatoes, 3) converts normal weight data to a surface area basis through the use of individual potato weights and 4) typically uses one assay of an aliquot from the ground potato sample.

Kleinkopf, G.E., G.D. Kleinschmidt and D.T. Westermann. *A Versatile Potato Plot Planter.*

Field planting operations have been simplified by the construction of a potato planter that can be used even with complex experimental treatment requirements. Replicated studies involving seed spacing and chemical applications can be easily accomplished during the field operation. Both granular and liquid fertilizer and pesticides can be applied with, above or adjacent to seed piece placement. The two row planter is operated by a tractor driver and two seed placement operators. Detailed design and operational information will be presented.

Kotch, G.P. and S.J. Peloquin. *Variation Among Six Tuberosum Haploid Families for Several Traits.*

Haploids of Atlantic, Chippewa, Merrimack, Redsen, W231 and W760 were used to represent the gametic variation of the tetraploid parent for 1) total yield, 2) tuber weight, 3) specific gravity, 4) vine maturity and 5) tuber dormancy. The frequency distribution of the haploids for total yield and tuber weight reflects the loss of the parental heterozygosity and epistasis. The greatest mean yield and tuber weight of the haploid families was only 26% and 30% of the tetraploid parent. The frequency distribution for specific gravity, vine maturity and tuber dormancy may represent traits with greater additive gene effects. W760 (1.087), Atlantic (1.079), Merrimack (1.075), W231 (1.072), Redsen (1.069) and Chippewa (1.066) produced haploid families with a mean specific gravity of 1.080, 1.074, 1.070, 1.072, 1.061 and 1.062, respectively. W760 (5), Merrimack (5), Atlantic (4.7), Chippewa (4.7), W231 (3.6) and Redsen (2.8) produced haploid families with a mean maturity rating of 3.98, 3.54, 3.94, 3.74, 3.17 and 3.01, respectively (1=early, 5=late). Merrimack (108), Atlantic (92.2), Redsen (78.2), Chippewa (73.5), W760 (63) and W231 (61.8) produced haploid families with mean tuber dormancy (days after harvest) of 92.1, 93.3, 69.4, 80.4, 68.8, and 62.5, respectively.

Kozempel, M. and J.C. Craig. *Modelling and Simulating Potato Processing.*

Computer simulation provides the process engineer with the capability of optimizing a process with minimum risk. Provided the models are accurate, ideas can be tried on the computer before implementation to assure that the ideas give the expected results. We have developed a simulator using the potato flake process as a prototype process. The more important models are predominantly theoretically based. A minimum of models are empirical correlations. This permits more universal application. Its accuracy has been found to be within 10-20% error using potassium as a tracer or key component. We continue to develop new models such as the cooking model we are reporting on. Users can develop their own models—either theoretical or empirical for inclusion in the models' package. It is written in Fortran for

a mainframe computer. However, we have developed a user-friendly version which requires no knowledge of Fortran. It is available, without charge, on two floppy disks (360K) and is suitable for use on IBM compatible personal computers.

Lagnaoui, A. and E.B. Radcliffe. *Effects of Fungicides on Entomophthoraceous Fungi and the Population Dynamics of Green Peach Aphid on Potato.*

Five fungicides commonly used on potatoes: metalaxyl, captafol, mancozeb, cupric hydroxide, and chlorothalonil, were tested at recommended rates for effects on entomophthoraceous fungi and resulting influence on the population dynamics of green peach aphid (GPA). By late season, GPA were 119 to 162 fold more abundant in metalaxyl, captafol and mancozeb treatments than in the nonfungicidal controls, whereas GPA numbers were 2 and 11 fold more abundant in chlorothalonil and cupric hydroxide treatments, respectively. At peak GPA abundance, fungal infections in the control reached 52.9%. In the fungicidal treatments, infection ranged from 11.9% to 33.3%. Infection rates were correlated with GPA density. Relative occurrence of the pathogens was *Erynia neoaphidis* 66.7%, *Entomophthora planchoniana* 22.3%, *Conidiobolus obscurus* 8.5%, and other 2.5%. All fungicides tested inhibited mycelial growth of the 3 major fungal pathogens. Endemic fungal infections are common in GPA and with favorable weather conditions and high GPA densities can cause spectacular epizootics. It is evident that the choice of fungicide may have an important effect on GPA population dynamics.

Lopez, D.F., A.A. Boe, R.H. Johansen and S.H. Jansky. *Genotype x Environment Interactions, Correlations and Combining Ability for Six Traits in Potato.*

Intercrosses were made between ND860-2, ND2221-6, Norchip and Kennebec to produce 11 $F_1$ progeny families. Parents and families were entered in a yield trial at two locations in North Dakota in 1986. Parents were chosen for differences in maturity, but they were also variable for yield, plant height, average tuber weight, and specific gravity. Variability among progeny families was detected for maturity, yield, plant height, average tuber weight, and specific gravity. Significant positive correlations were detected between the following: plant height and tuber number, plant height and yield, plant height and tuber weight, maturity and yield, maturity and tuber weight, tuber number and yield, and tuber weight and yield. Significant negative correlations existed between plant height and specific gravity, maturity and tuber number, maturity and specific gravity, tuber number and tuber weight, yield and specific gravity, and tuber weight and specific gravity. Genotype x environment interactions were not detected and estimates of general and specific combining ability were nonsignificant.

Lorenzen, J.H. and E.E. Ewing. *Genotypic Differences in Maintenance Respiration in Potato.*

Respiration is one of the most important determinants of biomass production at high temperatures. However, respiration is not to be viewed as a strictly negative activity, but must be analyzed in terms of benefit/cost. Therefore, respiration is often separated into conceptual component parts of growth and maintenance respiration. It is often assumed that the efficiency of growth respiration varies little from genotype to genotype but that there may be room for improvement in biomass production by selecting for genotypes with low maintenance respiration requirements. The dark starvation method was used to estimate maintenance respiration for different clones. In experiment 1, nine varieties, including two Andigena, three Neo-tuberosum, and four Tuberosum types were compared at one temperature. In experiment 2, five of the above clones were compared at threee different temperatures. In both experiments, clone C1-884 had the lowest maintenance respiration rate of the clones tested at any temperature.

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MacGuidwin, A.E. *Abundance and Vertical Distribution of* Pratylenchus scribneri *Associated with Potato in Wisconsin.*

The incidence of *Pratylenchus scribneri* associated with Russet Burbank potato grown in a Plainfield loamy sand soil was monitored year-round from 1985-1987. Nematode population levels increased four-fold or more by mid-season, but rapidly declined by harvest to levels not significantly greater than preplant levels. Approximately 70 and 50% of the total population was recovered from roots during and after the growing season, respectively. The vertical distribution of *P. scribneri* was unchanged throughout the year, with most nematodes located at a depth of 15-30 cm. During 1985-86, most overwinter mortality occurred before the soil froze and was not related to vertical position in the soil profile. All life stages were recovered during the winter, although the fourth juvenile stage was generally the most abundant. Concurrent studies with *P. scribneri* associated with corn indicate that host crop has a significant influence on the within-generation dynamics of nematodes.

Martin, M.W. and D.E. Miller. *Advantages of Water-stress Resistant Genotypes in the Northwest.*

Interrupting irrigation for 10 days during tuber initiation differentiated genotypes that suffer drastic effects when exposed to water stress from those that are minimally affected. With this treatment, water-stress-sensitive clones had low yields and solids, poor grade, and excessive growth cracking, second

growths, malformed tubers, hollow heart, internal brown spot, sugar ends, and dark fry color. Effects on sensitive genotypes were so severe that the crop was sometimes unmarketable. Stress-resistant clones were also adversely affected by this interruption in irrigation, but reductions in yield and cooking quality, and increases in tuber defects were minimal. The threat of catastrophic losses that could drive a grower into bankruptcy is greatly reduced when using stress-resistant genotypes such as Nooksack and four lines (ND534-4, A74114-4, A74212-1, and HiLite) that are being released or being considered for release as possible replacements for Norgold Russet. Russet Burbank is the prime example of a stress-sensitive cultivar, but Lemhi and Norgold can also suffer serious, water-stress-induced hollow heart problems.

McComber, D.R. and E.M. Osman. *Influence of Some Basic Physical and Chemical Properties on the Eating Quality of Potatoes.*

The relation between the eating quality of potatoes and some of their fundamental physical and chemical properties was examined. Cohesion and coefficients of friction were measured with a double direct shear device. Starches from four cultivars were examined for such properties as granular size, gelatinization temperature range, swelling power, and amylograph viscosity curves.

Mohan, S.K. and J.R. Davis. *Pathogenic Potential of* Colletotrichum coccodes *to Potato: Some New Evidence.*

Historically, *Colletotrichum coccodes* has been commonly regarded as a weak pathogen of potato (acting primarily as a root pathogen). Our recent studies, however, provide evidence on some new aspects of the pathogenic potential of this fungus. Spray inoculations of plants (cv Russet Burbank) with conidial suspensions ($10^6$ conidia/ml) of *C. coccodes* showed that it can cause distinct symptoms of necrotic lesions on stems and petioles, vein and leaf necrosis, die-back, and premature vine death. Symptoms on aerial parts of the plant were produced by isolates obtained either from below-ground stems, aerial parts, or from tubers. Symptoms were similar to those occurring naturally in the field—dark necrotic stem lesions, die-back of stems, premature vine death, and formation of black sclerotia on the dead stem tissue. These symptoms were also reproduced in the field on cv Russet Burbank by spray inoculations with conidia. The delay of symptoms in the field until several weeks after inoculation and the frequent recovery of the fungus in earlier studies from the internal tissue of stem apices of symptomless plants suggest that this pathogen can remain as a latent endophyte within the potato plant. These observations support the view that *C. coccodes* is involved in the premature death of potato.

Moore, T.M., W.M. Iritani and L.D. Weller. *The Physiological Relationship Between Chronological- and Physiological-Age of Seed-tubers and the Subsequent Progeny in 'Russet Burbank.'*

Progeny tubers from chronologically and physiologically old mother seed tubers of 'Russet Burbank' were found to have physiological and biochemical characteristics that very closely mimic the physiological aging characteristics of the old mother seed tubers. This age related progeny carry-over effect from the mother tuber generation to the next generation has been found to be the case for the following characteristics: sprouting behavior, *i.e.*, sprout number, vigor, and length; electrolyte content and plasmalemma leakage; ion content and plasmalemma leakage of $Ca^{++}$, $K^{+}$, $H^{+}$, and $NO_3^{-}$; and total and water soluble protein content and protein leakage associated with less integral plasmalemmas. Several ion specific membrane carrier dysfunctions are indicated along with other age related mechanisms of this progeny carry-over effect.

Muneta, P. and G. Kalbfleisch. *Heat-induced Contact Discoloration in Boiled Potatoes.*

Heat-contact discoloration occurs in certain unpeeled potatoes which are boiled. The discoloration is the result of an enzymatic reaction which appears as an irregular grey-brown area within one inch of the contact surface of the potato and the pan. The discoloration shows varietal differences.

Russet Burbank and the experimental cultivar A7938-1 did not show the discoloration. Nooksack, Lemhi, White Rose, and the experimental cultivars TXA763-5 and ND860-2 exhibited the heat-induced contact discoloration. The discoloration can be prevented by soaking the potatoes in water for 30 minutes. The substrate for the enzyme reaction is probably removed in the soaking process.

Muneta, P. and G. Kalbfleisch. *Dopachrome Formation and Melanin Development During Subsequent Cooking.*

Dopachrome formation in potatoes ground in a blender and melanin development in the cooked potatoes were followed using a Gardner Color Difference Meter. Standardization for grinding times (particle size), cooking time, and sample thickness for the color meter was performed with potato samples treated with 0.1% sodium bisulfite. When dopachrome was present, melanin formation occurred immediately upon cooking compared to the much slower development of melanin in the uncooked potato. Whenever dopachrome formation occurs, a grey to black color will form when the potatoes are cooked in any way.

Otazú, V. and H. Pinedo. *Some Factors to Consider for Improvement of a Late Blight Seedling Screening.*

Essential factors for the success of a late blight seedling screening are the control of temperature and humidity for the optimum development of the pathogen. However, there are also some other factors that aid in the development of this program. We analyze some of them.

Zoospore and sporangial suspension, at known concentrations, were tested as inoculum. Zoospore suspensions caused significantly more disease than sporangia.

Substrates for growing the inoculum were also evaluated: V-8 agar medium (1 and 3 week old cultures) infected seedling leaves, infected tuber plant leaves and tuber slices. Inoculum grown in live plant material caused significantly more infection than inoculum grown on agar medium. The use of tuber slices is recommended for its practicality.

Inoculators were also tested for efficacy. Three General Electric vacuum-pressure pump inoculators calibrated at a pressure of .2 Kg/cm$^2$ and 1 knapsack sprayer were compared. Known spore concentrations were placed in each inoculator and the out-flow measured again. There was considerable variation among inoculators. The knapsack sprayer was the better inoculator allowing almost 100% of spore passage, while the pump inoculators yielded only 85% of the initial concentration. However, both types of inoculators delivered over 80% non-motile zoospores.

Otrysko, B. and G. Banville. *The Effect of the Presence of Underground Plant Parts on the Growth and Sclerotial Formation of* Rhizoctonia solani.

A multifactorial field experiment, carried out over 3 years, to determine which factors trigger sclerotial formation of *R. solani* AG 3 on daughter tubers, indicated that in plots where infested seed was planted, removal of the roots and rhizomes by handpulling significantly reduced the incidence of black scurf as compared with chemical or mechanical topkilling. The infestation index of control plots, where plants were left intact, increased only upon senescence of the mother plants.

In order to test the hypothesis that compounds present in the decomposing root and rhizome tissue trigger sclerotial formation of AG 3, we set up a trapping system to collect leachates from the underground parts of undisturbed plants grown in the greenhouse. Plants were either topkilled by cutting at the soil line or left intact (controls) at the time of attachment of the trapping system. An *in vitro* biological assay of the crude extract demonstrated that compounds present in the leachates inhibited mycelial growth of isolates of *R. solani* AG's 1-4, but did not trigger sclerotial formation. There was no differential effect due to anastomosis group.

Pallais, N., J.S. Rojas, N. Pong, R. García and C. Sandoval. *Effect of True Potato Seed Maturity and Storage on Seed Vigor.*

The objective was to investigate the effects of maturity and storage on true potato seed (TPS) vigor as influenced by presowing treatments. Progeny A (Atzimba x DTO-28) was harvested 7, 9 and 11 weeks and progeny B (Serrana x DTO-28) 10 and 12 weeks after pollination. TPS was treated with $GA_3$ at 1500 ppm (GA1500) and 150 ppm (GA150), $H_2O$ and untreated (DRY). TPS of progeny A was extracted at harvest and after 2 weeks of berry ripening in storage; that of progeny B was extracted at harvest. Vigor was evaluated 3 to 6 months after harvest; also used was TPS of progeny A harvested after 11 weeks, extracted after berry ripening and stored for 18 months under dry or ambient air.

Increasing berry development periods before harvest was found to result in more vigorous TPS. TPS extracted after ripening was more vigorous than at harvest. Stored TPS was higher in overall performance than recently harvested TPS, and TPS stored dry showed higher vigor than in ambient air. GA treatments enhanced vigor of recently harvested TPS of progeny A, and GA1500 was usually more effective. However, vigor of stored or 11-week-old ripened TPS kept in the light during inhibition was decreased by the use of GA. GA1500 was detrimental for 12-week-old TPS of progeny B as compared to $H_2O$; however, GA1500 or $H_2O$ were more effective than DRY regardless of TPS maturity.

Pierce, F.J. and R.W. Chase. *Zone Tillage for Improved Quality and Yield of Russet Burbank Potatoes.*

Field experiments were initiated in 1985 to develop and evaluate alternatives to existing tillage practices on sandy soils in Michigan that improve Russet Burbank quality and yield and reduce potential for soil erosion. Tillage tools (Paraplow and Bush-Hog No-till) designed to subsoil in-the-row were evaluated against conventional potato production methods. The intention was to restrict tillage in these systems to the zone in the potato row (zone tillage) and leave the interrow area untilled with a cover of standing rye as protection against wind and water erosion. While not significant ($p$ 0.05), results in 1985 showed trends for Russet Burbank yields to increase with the use of zone tillage with the paraplow showing the highest yields (385 cwt/ac) and conventional tillage lowest (348 cwt/ac). In 1986, yields of Russet Burbanks were significantly higher in all zone tillage treatments than in conventional tillage. The paraplow tillage treatment was highest with 424 cwt/ac and conventional tillage lowest at 346 cwt/ac. Although not significant, yields of number one potatoes were higher in zone tillage treatments in both years, 70 versus 63 percent in 1985 and 55 versus 49 percent in 1986.

Platt, H.W., M. Celletti and H.W. Johnston. *Potato Disease Organism Incidences as Influenced by Previous Crop.*

Soilborne pathogens were isolated from lower stems of potatoes and accompanying soil during the 1985 growing season. Six commercial potato fields were sampled for each of six different 1984-1985 crop sequences (potatoes-potatoes, peas-potatoes, soybean-potatoes, barley-potatoes, ryegrass-potatoes, and a forage crop that included clover-potatoes). The most frequently isolated pathogenic fungi included *Fusarium oxysporum, Rhizoctonia solani, Colletotrichum coccodes* and *Verticillium albo-atrum* while *Pratylenchus* sp. was the most frequently isolated parasitic nematode.

The presence and population levels of the various pathogenic organisms appeared to be influenced by the type of crop grown the previous year. For example, the incidences of *Rhizoctonia solani, Fusarium oxysporum* and *Verticillium* spp. on lower stems of potatoes were greatest when potatoes followed soybeans, potatoes and a forage crop containing clover, respectively. The root lesion nematode was isolated more frequently from soil when potatoes followed ryegrass, a forage with clover and barley than following peas, potatoes or soybeans. In addition, the previous crop seemed to affect the incidence of "severely" diseased potatoes.

Quiros, C., D. Douches, G. Huestis and S. Brush. *Genetic Survey of Cultivated Potatoes in the Andes: Species, Ploidy and Isozyme Polymorphism.*

Tubers of about 100 potato cultivars collected from 10 Andean fields located at altitudes of 3650 to 3850 m. were surveyed for isozymes, specific gravity, tuber skin and flesh color, and chromosome numbers. About 60% of the varieties were tetraploids, 30% diploids, and 20% triploids, corresponding to the species *S. tuberosum* ssp. *andigena, S. stenotomum, S. phureja,* and *S. chaucha.* A large array of genetic variability was observed in the collection. Variety misclassifications were often observed within and among fields, ranging from 2 to 36% depending on the farmer. The most frequent type of misclassification was the use of one name for more than one phenotype. In some instances it was justified by the similar morphology of these types which were only distinguishable by electrophoresis. In fewer instances a single variety was known by more than one name.

Radcliffe, E.B., W.M. Tingey, R.W. Gibson, L. Valencia and K.V. Raman. *Stability of Green Peach Aphid Resistance in Wild Potato Species.*

Relative resistance to green peach aphid was determined for 82 potato accessions representing 42 wild species in a series of 39 field and laboratory experiments. Field experiments were conducted at 2 locations in Minnesota and at one location each in New York and Peru. Laboratory experiments were conducted in Minnesota, England, and Peru. Aphid populations used were of 5 origins: Minnesota, New York, England, Puerto Rico, and Peru.

The stability of green peach aphid resistance was consistent across the 10 locations x GPA population comparisons tested. No accessions differed significantly from its overall mean resistance index in more than one test environment. Most significant deviations occurred in experiments with Peruvian and Puerto Rican populations, but even so there was little evidence that either population represented biotypes different from the GPA populations of Minnesota, New York or England. It appears that if GPA-resistant breeding lines were developed, they could be used widely and that this resistance would prove stable.

Ragsdale, D.W. *Effect of Storage Conditions and Time on Serological Evaluation of Potato Foliage for Potato Leafroll Virus.*

In excess of 20,000 foliage samples were planned to be taken for serological evaluation of PLRV infection, and it was anticipated that foliage would have to be stored for a variable period of time before analysis with ELISA. Here both method of storage and length of storage time on its effect in ELISA were evaluated. Infected field grown leaves were randomly distributed among three treatments: refrigeration (4 C), freezing (-20 C) and lyophilization (held at -20 C). The most consistent results in the ELISA over 180 days of storage were the lyophilized leaves followed by frozen leaves, with an average absorbance (405 nm) of 0.82 and 0.70, respectively. However, for the first 39 days of storage, leaves held at 4 C gave a significantly higher level of reaction than either frozen or lyophilized samples (absorbance=1.42). By day 49, refrigerated leaves had decomposed and average absorbance dropped to 0.11. Once leaves were frozen nearly half of the activity, as measured by ELISA, was immediately lost. It is evident that foliage samples can be refrigerated for short periods; but if samples are to be held for more than 1 month at 4 C that they should either be frozen or lyophilized.

Rahimi, F.R. and C.D. Carter. *Methods to Delay Abscission of Flowers After Pollination in* Solanum tuberosum.

Abscission of flowers in *Solanum tuberosum* cv Katahdin immediately after pollination and before fertilization was a barrier to crossing between *S. tuberosum* (2n=4x=48) and *S. chacoense* (2n=2x=24) in our greenhouse. Day and night temperature and daylength regimes were manipulated but premature flower abscission remained a problem. Three different methods for improving flower retention were evaluated. These were (1) spraying flower buds at early bud stage with 1% silver thiosulfate, (2) grafting potato scions onto tomato stocks, and (3) the cut-stem technique. Flowers on treated plants and control plants were emasculated the afternoon prior to pollination. Data were taken on flower longevity after pollination and on fruit set. Retention time of pollinated flowers averaged 15 days, 9 days and 7 days with the silver-treated, grafted, and cut-stem techniques, respectively, compared to only 2 days for control. None of the control flowers set fruit

(though over 400 were pollinated), but 130, 117 and 67 fruit were set on flowers in the silver, grafted and cut-stem treatments, respectively. The silver thiosulfate method is easily applicable and needs no special attention or extra care and skill.

Rhodes, D.J. and D.C. Gross. Pythium *as a Pathogen of Potato and Advances in its Biological Control.*

A severe outbreak of seedpiece decay, which resulted in nonemergence and poor growth of cv. Russet Burbank in field plots in south-central Washington in 1986, was associated with a fast-growing *Pythium* sp. This fungus was readily ioslated from the soil, even in adjacent unplanted areas, and from roots, especially if necrotic or discolored. A survey of potato crops throughout the Columbia Basin indicated that the pathogen was present on roots in 16 out of 21 crops examined, and in 19 out of 21 soil samples. Up to 90% of the roots was found to be infected, and propagule densities in air-dried soil varied between 0 and 500 per gram. In general, a direct relationship was noted between propagule density in soil and root infection. Sixteen *Pythium* strains from these fields were found to cause symptoms ranging from seedpiece decay to necrosis of up to 68% of root tips in greenhouse tests.

A number of root-colonizing *Pseudomonas* strains were found to suppress maceration of tuber tissue caused by *Pythium.* When two strongly inhibitory strains were applied to seedpieces just prior to planting in field trials, marketable yield was increased by over 18%. These results support the potential use of fluorescent pseudomonads for control of *Pythium* on potato.

Rivera, C.E., H. Ferris and R.E. Voss. In Vitro *Root Culture Assay for Resistance of Potatoes to Root-Knot Nematode.*

Excised roots of six potato cultivars were challenged with egg inoculum of four *Meloidogyne* species: *chitwoodi, javanica, incognita,* and *hapla.* The dual cultures were established under aseptic conditions in 60 x 15 mm petri plates on a defined agar medium. Egg hatch occurred within one week and galling within four weeks. All six cultivars, Russet Burbank, White Rose, PAS 3065, *S. sparsipilum* 365343.A19-12, *S. sparsipilum* x *S. phureja* 856D69-2, and NDTX8731-1R supported reproduction by at least two of the four *Meloidogyne* species tested. Corresponding greenhouse tests were run with each *in vitro* experiment to establish the efficacy of this screening technique compared to greenhouse methods.

Results from *in vitro* assays and greenhouse assays were similar. The *in vitro* assay is preferred to the greenhouse assay because of the lower cost in labor, time, and greenhouse facility management. In addition, the response of test plants to nematode inoculum in greenhouse is often confounded by the effects of other organisms and variable environmental conditions.

Scheidegger, U. and K. Luther. *Importance of Potato Viruses in the Peruvian Highlands.*

An investigation of viruses in terms of their distribution, symptom expression and yield reduction was conducted in the Peruvian Central Highlands as part of the Peruvian Potato Seed Program (data relate to altitudes 3200 and 3900 m).

In a survey of farmers' fields 37% of the plants were found to be infected with PVX, 29% with PVS and 13% with APMV by means of the ELISA test. PVY and PLRV were also detected but were found in less than 1% of plants. At the experimental station (3300 m), for each of two varieties, 20 seed samples obtained from farmers were planted in 1984. Regression analysis showed that yield was reduced by 0.75 t/ha for each 10% increase of plants with virus symptoms in the variety Mariva (tbr x adg). In the variety Yungay (tbr x adg) no yield reduction could be attributed to virus infection. In 1985 the progenies of the most infected samples were compared to the Program's basic seed (2% total virus infection) under different planting densities and fertilization levels. Interaction between cultural practices and seed quality occurred but yield advantage of basic seed never surpassed 16 percent.

It is concluded that for the Central Peruvian Highlands the viruses present are not strongly detrimental to yield over a wide range of different management and environmental conditions.

Scurrah, M. and J. Franco. *Contribution of* S. andigenum *and* S. vernei-S. tuberosum *in Potato Cyst Nematode Resistance for the Andean Region.*

Partial resistance to race P5A of *Globodera pallida* was found in a group of native *S. andigenum* cultivars. Progeny of these transgressed parental resistance and 6% was rated "0" on root ball readings, while 25% of the progeny had similar levels of resistance to the parental material (circa 15 to 20 cysts per root ball). Selections from these crosses yielded no more than 0.800 kg/pl. and were characterized by deep eyes, mixed skin colors, and irregular shapes.

Two native cultivars also *S. andigenum* from Bolivia were found with good levels of resistance to race P4A. In addition parental clones also resistant to race P4A and with *S. tuberosum-S. vernei* background became available from the Foundation for Plant Breeding in Wageningen, Netherlands. Both of these sources were crossed to the clones resistant to P5A. Remarkable improvement in tuber shape and yield was observed in the progeny.

All advanced clones currently selected for varietal trials for resistance and high yields both in Peru and Ecuador are hybrids in origin between resistant *S. andigena* on one side and resistant *S. vernei-S. tuberosum* on the other. In this case advanced breeding material with resistance, but with a different genetic background and adaptation, when crossed, made it possible

to select clones with varietal characteristics which also maintained their resistance.

Slack, S.A., C.J. Kostichka and D. Gakovich. *Basic Seed Potato Production in Wisconsin.*

The primary source of seed lots for the Wisconsin seed potato industry is the University Lelah Starks Elite Foundation Seed Potato Farm. Annually, over 10,000 cwt comprised of about 20 cultivars are produced for the seed industry. All cultivars are established as clonal lines initiated from *in vitro* plantlets. These plantlets constitute prenuclear stocks which must test free from the viruses A, M, S, X, Y and leafroll, the bacteria *Erwinia carotovora* and *Corynebacterium sepedonicum,* and fungi before propagation. Prenuclear stocks are the only stocks permitted entry to the farm. Plantlets are transplanted into peat pots and after a one-week acclimatization period, they are moved to two-gallon nursery pots containing a sterile soil mix. These plants constitute the nuclear plot which generates the tubers used for evaluation of tuber unit clonal lines. Tubers are green-sprouted under fluorescent lights prior to the first year of field increase. The field-production years are desired to assess true-to-type characteristics and productivity of clones. Visual inspections and ELISA tests are utilized to monitor health status of clones.

Slack, S.A., M.D. Peterson, M. Rott and S.H. Quinones. *Effect of Heat and Chemical Therapy Treatments on Potato Virus S Elimination in Desiree.*

A PVS-infected Desiree clone was established *in vitro* on Murashige-Skoog basal medium at 23 C with 16-hr light period. Plantlets maintained high PVS concentrations as determined by ELISA ($A_{490}$=0.84-1.16). Treatments included i) 23 C control, ii) 4-wk heat therapy (31 C & 35 C alternatively on a 4-hr cycle, iii) ribavirin in medium (5 mg/l), and iv) ribavirin + heat therapy. After treatment, plantlets were ELISA tested and axillary meristems were excised or transfers as nodal cuttings were made. Meristems were placed on hormone-amended media (+ or - ribavirin). Virus-free plantlets regenerated from meristems of all treatments, but the control group yielded the lowest percent of virus-free plantlets. Ribavirin slowed regeneration rates and did not enhance virus-freedom in the regeneration medium. Interestingly, ELISA tests did not detect PVS in 29% of the ribavirin + heat therapy and 8% of the heat therapy plantlets. Nodal cuttings from PVS (-) and PVS (+) ELISA-tested plantlets from ribavirin + heat therapy yielded 56% and 8% PVS-free plantlets, respectively, and from heat therapy yielded 33% and 4% PVS-free plantlets, respectively. Nodal cuttings from controls did not yield PVS-free plantlets. These data suggest that viruses can be eliminated from plantlets by heat and chemical treatments without a requisite meristem excision step. Experiments are in progress to enhance treatment efficiency and to include other cultivars and viruses.

Slimmon, T., V. Souza-Machado, R. Coffin and L. Peterson. *Thidiazuron for* In Vitro *Microtuberization of Potatoes.*

*In vitro* produced potato microtubers have a potential as an alternative form of plant material for germplasm conservation as well as for seed certification schemes. Modifications of the *in vitro* environment with growth regulators influence the level of microtuberization to optimize the production of microtubers. Benzyl adenine (BA) is the commonly used source of cytokinin in tuberization medium. Thidiazuron (N-phenyl-N'-1,2,3-thidiazol-5-ylurea), known to exhibit cytokinin-like activity, was compared to BA alone and in combination with anti-gibberellic acid agents ancymidol and triadimefon. The four cultivars treated were Red Pontiac, Yukon Gold, Kennebec, and Shepody. The concentrations of thidiazuron used in this experiment were not as effective as those of BA in influencing microtuber size and number.

Hand sections were taken from microtubers of all treatments and viewed with epifluorescence microscopy in order to observe the differences in the extent of the suberized cell layers occurring in the periderm.

Smith, J.A. and S.L. Desborough. *The Endosperm Seed Protein Solin: Biochemical Characterization, Induction by ABA and Species-specific Subunits.*

Endosperm storage protein subunits from single seeds of nineteen *Solanum* species were compared by isoelectric focusing. The glutelin nature of the protein was unusual for a dicotyledon genus; the name "Solin" was given to this major endosperm protein complex. Species-specific profiles of the subunits were evident and species relationships within a taxonomic series could be delineated. The identity of both intraspecific and interspecific hybrid seed may be possible from Solin subunit profiles. The Solin complex was studied in developing seeds and found to be present in seeds with embryos at the heart stage, 16 to 18 days after pollination. Excised seeds at the globular stage responded to the addition of ABA and synthesized Solin. This is the first report of the induction of seed protein in endosperm cells of *Solanum.*

Souza-Dias, J.A.C. and S.A. Slack. *Utilization of* In Vitro *Plantlets to Study the Response of Potatoes to Potato Leafroll Virus.*

To shorten the evaluation period required to assess cultivar responses to PLRV and to establish a reproducible test system, we have been evaluating *in vitro* plantlets. Nodal cuttings from Katahdin and Russet Burbank plantlets were placed in Petri dishes containing Murashige-Skoog basal medium for 5-7 days at 23 C with a 16-hr light period. Uniform rooted plantlets were transferred to techniculture trays (Castle & Cook, Salinas, CA) at 1-2.5 cm intervals. Aphid cages for transmission tests consisted of nylon screens for individual plants or plexiglass frames within nylon-covered

openings for several plants. After 7-10 days, PLRV-infected plantlets expressed secondary PLR symptoms. After 15-20 days, healthy plants exposed to viruliferous aphids developed PLR symptoms. Symptoms consisted of upright growth habit, chlorosis of young leaves and upward curling and purpling of abaxial leaf surfaces. Apterous *Myzus persicae* Sulz. were capable of acquiring and transmitting PLRV, plant-to-plant movement and reproduction. Desirable test features include (1) physiologically uniform test plants, (2) PLR symptom development within 3 wk, (3) over 100 plants can be grown in less than a 50 x 50 cm area and (4) different spatial arrangements can be designed depending on test objectives. We are utilizing spatial arrangements that mimic field test designs to determine whether or not PLRV infection and spread are simulated.

Souza-Dias, J.A.C. and S.A. Slack. *Relation of Potato Leafroll Virus Concentration in Potatoes to Virus Concentration in Aphids.*

Our studies have shown that potato leafroll virus (PLRV) concentration is lower in the field-resistant cv. Katahdin than in the susceptible cv. Russet Burbank. To determine whether or not concentration differences would be reflected in aphids, *Myzus persicae* Sulz. were allowed acquisition access periods (AAP) of 1.5, 3 and 9 hrs at 20 C on detached leaflets of these cultivars. Aphids acquired 18, 31 and 35% less PLRV on Katahdin than on Russet Burbank leaflets for their respective AAP. When aphids from the 9-hr AAP were placed on *Physalis* plants, a 17% decrease in PLRV transmission was observed with aphids from Katahdin rather than Russet Burbank leaflets. Aphid-infested leaflets were also collected from a field plot. For leaflets from plants with primary PLRV symptoms, a significantly lower PLRV concentration was found in leaflets (67.5%) and aphids (32.1%) collected from Katahdin rather than Russet Burbank plants. For leaflets from plants adjacent to secondarily infected PLRV source plants, a significantly lower PLRV concentration was found in leaflets (41.6%) and in aphids (38.2%) collected from Katahdin rather than from Russet Burbank plants. These data will be discussed in relation to the hypothesis that virus concentration in potato cultivars is directly related to the rate of PLRV field spread.

Sowokinos, J.R. *Variations in Glucose Forming Potential (GFP) Between Potato Clones.*

Thirteen genetically diverse potato clones were maintained at an intermediate temperature (8.9 C, 48 F) and under cold stress (3 C, 37 F) for eight months. Included in this study were white varieties and selections (Norchip, Monona, Kennebec, 860-2, 651-9, and 398-1); red varieties and selections (Red Pontiac, Norking and 8742); russet varieties (Agassiz and Norgold); and a clone of *Solanum tuberosum* group Andigena.

Differences in inverse activity and/or compartmentalization of substrate were reflected by the clones' efficiency to convert sucrose into glucose. Glucose is the primary reducing sugar found in most varieties during growth and storage. A glucose forming potential (GFP) of 1 indicates that 1 $\mu$mole of glucose is present per $\mu$mole of sucrose formed. GFP's at 8.9 C ranged from 0.2 (860-2) to 13.6 (8742).

The concentration of sucrose among all clones at 8.9 C was of a similar magnitude (range 1.1 to 3.0 $\mu$mole/g). When tubers were under stress (3 C), sucrose levels increased markedly and differed 10-fold among clones. A clone's efficiency in converting sucrose to glucose was a greater determining factor of processing quality than the clone's ability to produce sucrose in response to stress.

Sowokinos, J.R. *Cellular Regulation Influencing a Potato Clone's High or Low Sugar Potential in Storage.*

Thirteen clones which differed markedly in their free sugar levels in storage were maintained at an intermediate temperature (8.9 C, 48 F) and under cold stress (3 C, 37 F) for eight months. Enzymes involved in the pathway of sugar accumulation [phosphorylase (PL), UDPglucose pyrophosphorylase (UPPL) and sucrose-6-P synthase (SPS)] were assayed at each storage temperature to determine if there were correlations between coarse metabolic regulation (enzyme concentration) and sugar levels (sucrose and glucose).

All three activities showed a poor correlation to sugar content among clones at 8.9 C. Cold stress resulted in the majority of the clones demonstrating significantly higher SPS activity ($P<0.05$). SPS extracts were stabilized *in vitro* by mM levels of the substrate precursor glucose-6-P. Among clones SPS and UPPL activities showed a fair to good correlation to the final glucose concentration at 3 C ($r=0.706$ and 0.855, respectively). It is suggested that the availability of substrate and substrate precursors for the SPS reaction generated by cold stress (fine metabolic control), may be as important in determining sugar accumulation among clones as is the actual concentration of the enzyme itself (course metabolic control).

Tai, G., R. Coffin and R. Yada. *The Effect of Reciprocal and Autografting on Specific Gravity, Sugar Content and Chip Color of Potatoes.*

A chipping selection F5850 (high specific gravity, low sugar content) and a non-chipping cultivar Sable (low specific gravity, high sugar content) were autografted and reciprocally grafted to assess source-sink relationships on specific gravity, sugar content and chip color. When Sable was used as a scion on F5850 stock, chip color (Agtron values) was decreased and reducing sugar content increased compared to autografts of F5850, both at harvest and after storage at 12 C for 3 months. Similarly, but to a lesser extent, using

F5850 as a scion on Sable stock resulted in improved chip color and decreased reducing sugar content compared to autografting of Sable. Examination of specific gravity data indicated that reciprocal grafts resulted in an interaction.

Thornton, R.E. *Comparison of Single Row vs. 3 Row Plots for Cultivar Evaluation.*

During both 1985 and 1986 a comparison of the performance of four cultivars when bordered by themselves or bordered by one of the three others was conducted. The four cultivars represented two distant vine types (large and small). Russet Burbank and Lemhi cultivars were used to represent large vine type and Norgold and High Lite (78LC-1) represented small vine type. When cultivars were bordered by different varieties, yield and tuber size distribution were different than when bordered by itself. When small vined cultivars were bordered by large vined cultivars, yields were lowered. When large vined cultivars were bordered by small vined cultivars, yields were higher.

Thonrton, R.E. *A Comparison Among Rates of Suspension and Dry Fertilizer on Fumigated and Non-fumigated Land.*

A randomized split block experiment was designed to compare suspension fertilizers with dry fertilizers on fumigated and non-fumigated land. Potatoes had not been grown on the land previously. Tuber yield, grade, quality and petiole analyses were used to assess the treatment differences. On non-fumigated land, suspension fertilizers and dry fertilizers produced equal results; but on fumigated land, there was a very high statistically significant interaction. The yield response to dry fertilizer was linear, but the response to rates of suspension fertilizer was curvilinear. The levels of N-P-K-Ca and Mg were higher on fumigated land, but the tuber yields were lower suggesting that the levels in the petioles were high because of restricted utilization.

Tibbitts, T.W. and R.M. Wheeler. *Potato Growth in Controlled Environments for NASA.*

The growth and yield of potatoes are being studied intensively in controlled environments for application in life support systems of an orbiting space station or planetary colonies. Primary emphasis has been placed on maximizing productivity (*i.e.*, tuber yield per area per time), while minimizing production of inedible plant parts. Tuber productivities up to 22 g $m^{-2}$ $day^{-1}$ of dry weight have been obtained for cvs Russet Burbank and Norland grown in solid stands under continuous irradiation of 400 $\mu$mol $m^{-2}$ $s^{-1}$ (=2700 ft-c), 16 C and 1000 ppm $CO_2$. Such productivities translate into a needed volume of approximately 35 $m^3$ or 6 m x 6 m x 1 m to support one

human's energy requirements. Increasing irradiance levels beyond 400 $\mu$mol $m^{-2}$ $s^{-1}$ and/or utilization of "within-canopy" lighting systems should permit further increases in tuber productivity.

Tibbitts, T.W., R.M. Wheeler and A.H. Fitzpatrick. *Cultural Procedures for Growing Potatoes in Space.*

Cultural procedures are being developed to sustain potato growth in life support systems in space. Growing systems will likely involve recycling solutions in which nutrient concentrations, pH, and microbial populations can be closely controlled. Buffering of nutrient concentrations will be provided by resin exchange beds in the circulation system and calcined clay particles placed in the rooting zone. Gas exchange in the root-stolon-tuber zone will be a paramount concern, and options for approaching the unique problems of weightlessness will be discussed. To date, we have had good success in growing potatoes in a modified nutrient film system utilizing a 1 cm deep layer of calcined clay chips placed in 60-cm wide amd 90-cm long sloping trays, with nutrient solution constantly flowing in the upper end and out the lower end of the tray. Tuber yields from such systems have been comparable to those achieved in standard solid media studies.

Tovar, P., J.H. Dodds, R. Chandre and R. de Arcaute. *Effect of Medium Composition on* In Vitro *Tuberization.*

It is possible to induce tubers *in vitro* using Murashige and Skoog medium supplemented with 500 ppm chlorocholine chloride (CCC) 5 ppm Benzylamino purine (BAP) and 8% sucrose. We carried out various experiments in an attempt to increase both size and number of induced tubers. Lowering nitrogen concentration increased tuber size whilst beginning with single nodes and not stem segments increased the number of tubers required.

Data are presented on the effect of different growth regulators, including CCC, BAP, ABA (Abscisic acid) and Coumarin on tuber induction.

Data are also presented on the effect of different carbon sources, for example, sucrose, glucose and fructose at a range of concentrations.

We will also discuss how these *in vitro* tubers are useful within the International Potato Center's *in vitro* germplasm programs.

Valencia, L. *Effect of Chemical Leaf Compounds of* Lantana camara *L. on the Oviposition by the Potato Tuber Moth* Phthorimaea operculella *(Zeller).*

The effects of ethanolic extracts of shoots' and leaves' distillates of *Lantana camara* L. on the oviposition by the potato tuber moth (PTM), *Phthorimaea operculella* (Zeller) were studied in Lima, Peru under laboratory conditions. All tests were run in plastic "choice chambers" where 2 different substrates were offered for oviposition to five couples of moths, 48 hours old.

Ethanolic extracts of *Lantana* shoots did not influence the total number of eggs laid by the PTM. When different concentrations of the ethanolic

extract were tested, the highest concentration (0.84%) was an oviposition deterrent while one of the lower concentrations (0.11%) was an oviposition localizer. The *Lantana*'s oil obtained by distillation at atmospheric pressure and later separated by preparative TLC, showed that only the whole oil was a deterrent for oviposition, while the fractions individually increased the mean number of eggs laid, but without difference with the control.

These results show that the protectant action of the *Lantana*'s leaves, as described in the literature, is like a repellent for adults of the PTM.

van Ho, T., L.T. Tuyet and P. Vander Zaag. *Potato Production Using Sprouts in Vietnam.*

Sprout cutting research and extension were started in the Red River Delta to overcome shortage of planting material and to reduce production costs. Tuber seed stored for seven to nine months, although physiologically old, provided a good source of vigorous sprout cuttings. A system was developed for the efficient use of sprout cuttings. Three node sprout cuttings rooted in a medium of subsoil, maure, and ash provided vigorous plants that are best transplanted from late October going into the dry season. Yields from cuttings varied from 5 to 30 t/ha. The technology was successfully introduced to farmers for the past four years. Average yield during the 1986-87 season was 18 t/ha for 60 ha using certified seed tubers as the source of sprout cuttings. This system is permitting faster multiplication of clean seed. However, the cvs. Mariella and Ackersegen tend to tuberize too early under the short day growing conditions. This problem is now being countered by applying high doses of nitrogen. Research continues in the research for more adapted cultivars for sprout cutting use.

van Uyen, N. and P. Vander Zaag. *Rapid Propagation of Potatoes Using Tissue Culture in Vietnam.*

In the highlands of Dalat (1500 m asl), a clean source of planting material is not available. A system was developed whereby farmers could maintain three newly selected cultivars as test tube potato plantlets and multiply them both *in vitro* as well as by using cuttings. These cultivars are established as mother plants from which apical shoots are harvested continuously for up to six months. The apical shoots, after cutting, are rooted in potlets. After two weeks they are sold to interested farmers. Sometimes they are grown for transplanting by the farmer who produces the cuttings. After four years all potatoes in the Dalat area were grown with the three new cultivars. This system has now been ongoing for six years. The tubers obtained from cuttings are often kept for three generations as tuber seed.

The advantages of this system are that farmers can do it themselves; healthy stocks can be maintained indefinitely; farmers do not need to import costly healthy tuber seed and the system is cheaper with rooted cuttings

selling for 0.005 USD each. We believe that this system could also be adapted to other locations around the world with similar environmental conditions.

Watanabe, K. and S.J. Peloquin. *Occurrence and Frequency of 2n Pollen in Cultivated Groups and Related Wild Species.*

The gene frequency for parallel spindles (*ps*) was estimated from the frequency of plants producing 2n pollen in 3 cultivated Groups: 2x Phureja (phu), 2x Stenotomum (stn), and 4x Andigena (adg), and in 2 related wild species, 2x *Solanum sparsipilum* (spl) and 4x *S. gourlayi* (grl). Plants with more than 1% large pollen were considered as 2n pollen producers, and those with less than 5% stainable pollen as male sterile. Observations of meiosis in a sample of 2n pollen producing plants indicate parallel spindles is the mechanism of 2n pollen formation. The results in terms of number of plants with 2n pollen among the total examined and number of Plant Introductions were: 648 of 3015 from 114 P.I.'s of phu, 78 of 476 from 18 stn P.I.'s, 672 of 1353 from 67 adg P.I.'s, 231 of 1491 from 53 spl P.I.'s, and 627 of 1510 from 68 grl P.I.'s. The *ps* gene frequency, assuming Hardy-Weinberg equilibrium, were: phu 0.47, stn 0.41, adg 0.85, spl 0.41 and grl 0.81. The high gene frequency for *ps* in cultivated 2x and 4x Groups and in wild species closely related to them support the concept of the importance of a meiotic mutant "*ps*" in origin and evolution of polyploidy in tuber-bearing solanums.

Watrin, C.G. and E.B. Radcliffe. *Pyrethroid Resistance in Colorado Potato Beetle.*

In 1985, we found high levels of pyrethroid resistance present in Minnesota-North Dakota populations of Colorado potato beetle. Resistance ratios relative to values reported previously for susceptible CPB populations ranged from 23-132 fold for fenvalerate and 13-121 fold for permethrin. In 1986, resistance ratios ranged from 99-286 fold for fenvalerate and 3-231 fold for permethrin. Minnesota-North Dakota beetles were appreciably more resistant than beetles from Idaho, similar to beetles from Michigan, but less resistant than beetles from Long Island. In field experiments, larval control continued to be better than 99% with both fenvalerate and permethrin. On a per insect basis, adults were 7-28 times more resistant than 4th instar larvae. In the laboratory, addition of PBO synergized pyrethroid toxicity 2-11 fold. Minnesota beetles were more resistant (8-20 fold) to ES-fenvalerate, cypermethrin, and biphenthrin than were beetles from Idaho, but this cross-resistance did not extend to tralomethrin.

Weingartner, D.P. and J.R. Shumaker. *Development of Bacterial Wilt and Tuber Brown Rot in Six Potato Cultivars.*

Bacterial wilt (*Pseudomonas solanacearum*) resulting from natural soil-borne inoculum was followed in six potato cvs during 1986. The number of plants wilted in each plot was determined and percent wilt estimated for individual plants. The respective number of wilted plants/25 feet and mean % wilt/wilted plant for the six cvs were: Ontario 0.15 plants, 0.19%; Sebago, 1.77 plants, 18.03%; La Chipper, 3.31 plants, 21.60%; Atlantic, 6.96 plants, 27.73%; Red La Soda 10.69 plants, 45.13%; and Superior 16.69 plants, 72.13%. Incidence of brown rot in tubers was determined in each cv on 4 harvest dates made at 7 day intervals. Significant ($P=0.05$) cultivar, harvest date effects and harvest date x cv interaction were observed. Incidence of brown rot in tubers decreased in succeeding harvests, presumedly due to infected tubers rotting in the field. Tuber incidence followed the same order as wilted plants and varied from 0.2% in Ontario to 14.0% in Superior. Progressive decrease in tuber rot with harvest dates was significant in Superior, but not in the other cvs.

Werner, J.E. and S.J. Peloquin. *Modified Megagametogenesis in Haploid Tuberosum-Wild Species $F_1$ Hybrids and Technique for Counting Chromosome Number in Endosperm.*

An unusual variation during megagametogenesis in haploid Tuberosum-wild species $F_1$ hybrids was detected by microscopic observations using a stain-clearing technique. In the normal female gametophyte the size of nuclei and nucleoli of both the egg and polar nuclei is similar and typical for *1n* female gametophytes. Six clones had modified female gametophytes; the size of the nuclei of the egg and synergids remained unchanged representing *1n* gametophytes, while the size of polar nuclei and the number of the nucleoli were typical for *2n* female gametophytes. This indicates the possibility of endomitosis in polar nuclei which, according to the Endosperm Balance Number hypothesis, would result in triploid progeny from 2x x 4x crosses. It was found that the frequency of triploids following 2x x 4x crosses agreed with the frequency of ovules with enlarged polar nuclei. A new squash technique for counting the chromosome number in the potato endosperm was developed. The best results were obtained when fruits were collected 4-6 days post-pollination and treated with 0.29 g/l 8-hydroxyquinoline solution containing 7.5% sucrose for 6-8 hours with seration. The squashes obtained allowed for chromosome counting in the endosperm, maternal tissue and embryo.

Wheeler, R.M. and T.W. Tibbitts. *Potential Spaceflight Experiments with Potato.*

The selection of potato as a possible crop for space life support systems warrants early spaceflight testing with this species. Initial tests would likely

be limited by the available working volume ( 0.1 $m^3$) and flight duration (ca. 7 days). In addition, irradiance levels and gas exchange in the plant growing units would be limited. Leaf cuttings, with attached axillary buds, are excellent candidates for early testing and have been proposed to obtain information on tuber development under weightlessness. Subsequent whole-plant testing on free-flying "platforms" or in a module of a space station could be a next step where chamber volume, flight duration, and irradiance levels would be increased. Significant challenges remain in providing water, nutrients, and gas exchange to the root-stolon zone under weightlessness. The choice of lighting systems, electrical lamps or direct solar lighting, also presents unique problems of system design and plant culture. In the case of direct solar lighting for a space station in low-earth orbit, photoperiods would be cycled at 60 min L:30 min D.

Wheeler, R.M., T.W. Tibbitts and A.H. Fitzpatrick. *Response of Potato Cultivars to Continuous Light Environments.*

Despite inherent short-day tendencies, many cultivars of potato are capable of growing and tuberizing under continuous light. Cvs that grow well under continuous light include: Denali, Atlantic, and Snowchip. In contrast, cvs Superior and Kennebec generally show an intolerance to continuous lighting, where leaves become chlorotic and malformed, and necrotic lesions appear. This results in abscission of the oldest leaves and severe plant stunting. Norland and Russet Burbank exhibit an intermediate response, *i.e.*, leaves show heavy anthocyanin accumulation and can become upright and folded. Norchip shows a transient intolerance to continuous lighting, where main stem leaves become chlorotic and flecked, but axillary branch leaves stay green and healthy. High humidity levels tend to aggravate the injury, and elevated carbon dioxide levels also appear to aggravate the injury but only when lighting is near saturation for the plants. Continuous light encourages foliage growth; however, tuber yields can be equal to or better than those obtained under short photoperiods, provided light levels are maintained sufficiently high ($\geq$400 $\mu$mol $m^{-2}$ $s^{-1}$).

Yerk, G. and S.J. Peloquin. *2n Pollen in Wild* Solanum *Spp. and Their Tuberosum Haploid-Species Hybrid Derivatives.*

Screening of 65 plant introductions (P.I.'s) of 11 diploid (2n=2x=24) wild species of *Solanum* was conducted for 2n pollen using the acetocarmine glycerol stain method. The wild species were *S. bukasovii, S. canasense, S. gourlayi, S. infundibuliforme, S. kurtzianum, S. marinasense, S. multidissectum, S. sparsipilum, S. spegazzini, S. vernei* and *S. verrucosum.* Plants were rated for percent stainable pollen (0-5) and percent stainable pollen which was 2n (O-H). Twenty-seven P.I.'s were identified which possessed from 1 to 9 2n pollen producing plants per PI. Sixty-five 2n pollen producing plants were identified among all the PI's screened. The 2n pollen producing wild

species were used as males to generate 24 chromosome Tuberosum haploid-wild species hybrids. These hybrid families were then screened for 2n pollen as above. A total of 245 2n pollen producing hybrids was identified. For all haploids used except SS28 there were families produced where at least 50% of the plants expressed 2n pollen. *S. gourlayi, S. multidissectum, S. sparsipilum* and *S. verrucosum* had high percentages of their progeny with 2n pollen. These materials would be suitable for use in germplasm transfer from wild species to cultivated forms via uni- or bilateral sexual polyploidization.

Yerk, G. and S.J. Peloquin. *Evaluation of Germplasm Enhancement Potential of Wild* Solanum *Spp.*

Seventy-eight 24 chromosome Tuberosum haploid-wild species hybrid families were generated using male parents from ten different wild *Solanum* spp., selected for the expression of 2n pollen, and nineteen Tuberosum haploids. Thirty-six plants of each family were grown in a randomized complete block design with 4 replications. A subset of 17 of the 78 families was grown with 28 plants/family in a RCB with 4 reps at a second location. Individual plants were rated for 2n pollen production, percent stainable pollen, vigor, flowering, maturity, yield, specific gravity, general tuber appearance, tuber set, percent tuberization/family and dormancy. Variation was present for all traits examined making selection of desired characteristics from the population feasible in small sample sizes. All the families examined contained some progeny which tuberized making maintenance of the desired species traits possible. Yield of the hybrid families was influenced by species and haploid parent. Families with *S. kurtzianum* were highest and with *S. spegazzini* were lowest in mean yield. Specific gravity was affected by the species' parent. Families with *S. verrucosum* were highest and with *S. gourlayi* were lowest for specific gravity. This material has potential for use in germplasm enhancement and germplasm transfer.

Zaag, P. vander, V. Escobar and C. Montierro. *Potato Production Using Cuttings.*

In mid and low elevation areas of the tropics, managing seed potatoes is difficult because soil borne pathogens and viruses coupled with high temperatures make it almost impossible to keep seed tubers for replanting. A system is being developed whereby *in vitro* plantlets are transferred to soil media to become mother plants from which apical shoots are cut at a 5- to 7-day interval for up to one year. These cuttings are rooted in a local subsoil medium and are transplanted to the field for potato production. The field agronomic management used is similar to that used for tuber seed grown crops. The plant population is from 60 to 80,000 plants/ha. Extra P fertilizer gives the transplants a more rapid early growth. With cuttings, hilling is essential to cover more nodes thereby permitting greater tuberiza-

tion. Yield of over 20 t/ha is being obtained which is superior to crops grown from first generation tuber seed grown in the same location. Many cultivars have been evaluated. Among the better ones are: DTO-28, DTO-2, LT-2, I-1035, P-3, and Monza. Some preliminary on-farm trials have been conducted. Water shortage and excess rainfall depending on the season are two of the major constraints faced by farmers in growing potatoes from cuttings.