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Alphabetized by first author's last name.

CHANGES IN PINE CELL NUCLEI IN INCOMPATIBLE REACTIONS WITH CRONARTIUM FURCENII F. SP. FUSSIFORME, Vernon Ammon, and Charles H. Wiltshire, Department of Plant Pathology and Weed Science, P.O. Drawer PG, Mississippi State, MS 39762, and So. Forest Exp. Sta., Gulfport, MS 39505.

Cellular changes were detected in rust resistant slash pine seedlings nine days after inoculation with the fusiform rust fungus. Nuclear alterations were observed in cortical parenchyma cells 14 to 21 days after inoculation. Hypothesis grew into the outer cortex and then stopped. Haustoria and tannin accumulations were seen only at the site of penetration. Reddish-purple lesions occurred on affected stem tissues, but galls failed to develop. Hypothesis were enlarged and many nuclei did not stain like those in unaffected cortical cells. Basophilic of chromatin were faded and stained abnormally. Pycnosis, nuclear vacuolization and swelling of nuclei were common. In dying cells, nuclei and associated nucleoli often could not be observed, necrotic cells stained acidophilic and lacked nuclei, and a variety of pigments were produced.

EVALUATION OF A NEW RAPID IMMUNOASSAY FORMAT FOR THE DETECTION OF PYTHIUM AND RHIZOCTONIA SPECIES IN TURFGRASSES, E. Bernstein and R. A. Haygood, Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634.

A rapid, field usable, ELISA format (Agri-Diagnostics Assoc., 2611 Branch Pike, Cinnaminson, NJ 08077) was compared with isolations for the accurate detection of two fungal pathogens of turfgrasses. Soft basal sheaths of St. Augustinegrass and centipedegrass infected with Rhizoctonia solani AG2T2 and blighted leaves of tall fescue infected with Pythium aphanidermatum were tested. An average of 9 minutes was required to conduct immunoassays after plant tissues were collected and ground up. Isolation and identification of these pathogens in pure culture confirmed the accuracy of the rapid ELISA format. No false positives or negatives were obtained in 30 assays.

YIELD REDUCTIONS DUE TO PENDERY MILDEW AND LEAF RUST ON WINTER WHEAT IN NORTH CAROLINA, K. L. Bowen and S. Leath, USDA-ARS, Department of Plant Pathology, North Carolina State University, Raleigh 27695-7616.

Plots of the winter wheat cvs. Saluda and Coker 983 were established at two locations in the fall of 1987 to determine yield reductions caused by Corynebacterium graminis f. sp. tritici (Ept) and Puccinia recondita f. sp. tritici (Ptr). Plots were arranged in five randomized complete blocks. Disease levels were established by applying fungicides on two inoculations of Ptr. At one location, mildew symptoms were observed in February during tillering in Saluda and tillers/m row were reduced 9.6% in untreated plots compared to disease-free plots. No rust developed at this location but kernels/seed, 500 kernel weight, and yield were reduced 2.4, 6.4, and 10.5%, respectively, in untreated plots. At the other location, where rust epidemics became severe, only 500 kernel weights and yields were reduced. Effective disease control also was observed in Coker 983 plots, but consistent yield effects were not detected.

EFFECTS OF OILS AND FUNGICIDE FORMULATIONS ON DEPOSITION OF CHLOROTHALONIL APPLIED VIA SPRINKLER IRRIGATION TO PEANUT FOLIAGE, T. D. Brennerman, Plant Pathology Dept., T. Sumner, IBREML, USDA/ARS, Coastal Plain Station, Tifton, GA 31793, and G. W. Harrison, Fermenta Plant Protection, P.O. Box 70665, Albany, GA 31707.

Chlorothalonil (CTL) was applied at 1.25 kg/ha to peanut foliage via chemigation to compare formulations with and without oil additives ( Soyoil or 1 1 nonemulsifiable oil) with regard to fungicide deposition and retention. Treatments were applied in 25.4 k/ha of water. Leaf discs were collected before treatment and at 0, 5, 9 and 14 days posttreatment and surface stripped with toluene Addition of either oil to Bravo 720 resulted in highest initial deposition followed by Bravo 500 and Bravo 720 alone. Rates of CTL dissipation, as found by regression analysis, were highly correlated with initial concentrations (r = 0.97). By day 14, concentrations of CTL had decreased by more than 93% in all treatments.


A bacterial leaf spot and blight was observed on greenhouse plantings of Abelmoschus moschatus, an ornamental bedding plant recently introduced from India. A fluorescent pseudomonad was consistently isolated from diseased tissue, and Koch's postulates were fulfilled. Optimum temperature for disease development was 20-25 C. The bacterium tested ++ for levan, oxidase, potato soft rot, arginine dihydrolase, and tobacco hypersensitivity (LOPAT). It utilized erythritol, L(+)-tartarate, and succrose but not D(-)-tartarate and DL-lactate. In a host range study in the Malvaceae, the bacterium caused foliar lesions on hibiscus, okra, and cotton. Nine strains of F. g. pv. syringae from okra and eight other hosts and a strain of F. g. pv. hibiscii were not pathogenic on A. moschatus. The Abelmoschus strain appears to be closely related to but pathologically different from F. g. pv. hibiscii. Streptomycin was the best of four bactericides tested for control.

RELATIONSHIPS AMONG VIRUSES DEDUCED FROM OUCHTERLONY SEROLOGICAL REACTIONS, P. M. Burrows and O. W. Barnett, Clemson University, Clemson, SC 29634.

There is a logical connection between various types of precipitin reaction lines, exhibited in an Ouchterlony gel diffusion test, and the presence or absence of presumptive common epitopes on the antigens tested. The minimum number of distinct epitopes necessary to account for observed reactions can be deduced for each antiserum. Minimal epitope compositions of antigens, and the complementary epitope compositions of antisera, are deducible after combining results from several antisera. Epitope compositions can be converted to a pair-wise similarity index for hierarchical clustering of relationships among antigens. This method has been used to investigate relationships among antigens presented by five isolates in the Arabis mosaic virus subgroup of nepoviruses.
Four plants of peanut cv. ‘Early Bunch’ in 2000 cc pots were grown in a plastic isolator under gnotobiotic conditions. Pests from each plant were randomly placed in 100 cc cups filled with a 3:1:1 mixture of peat moss, vermiculite, and perlite. Each cup contained calcium sulfate equivalent to 0, 280, 560, or 1120 kg gypsite/ha. At harvest, 2 of 20 pericarps at 0 kg/ha, and 1 of 24 pericarps at 280 kg/ha had surface discoloration of 20–75%. All other pericarps were not discolored. Maximum calcium content of pericars was 0.09–0.39%. Pericarp calcium was positively correlated (0.71) with the amount of calcium sulfate added. A significant (P<0.05) increase in calcium content was only found between 0 and 1120 kg/ha. Magnesium content in pericarps was positively correlated (0.79) with pericarp calcium. Variation occurred in magnesium and potassium contents in pericarps across treatments, but no significant differences were found.


Localization and quantification of juglone, isouqueritin and condensed tannins from peanut can be accomplished with use of two separate stains and a microspectrophotometer. Condensed tannins were detected with butanol-HCl (95:5) heated to near 100°C over boiling water. Juglone and isouqueritin were detected by the Hoechst-Vorstvattz test. Standard curves of ethanolic solutions were run at 316 nm using a filter 0.02, 0.1 or 1 mm. In palisade parenchyma leaf tissue of greenhouse grown seedling peanuts, the concentrations of juglone, isouqueritin, and condensed tannins were 26.6 µg/g, 11.0 µg/g and 4.5 µg/g, respectively. Previous studies have shown that juglone, isouqueritin and condensed tannins inhibit growth of Closirasperus carinulum in vitro at 0.05 µg/g, 4 µg/g and 4 µg/g, respectively. Thus, in situ concentrations of these phenolics should be sufficient for fungal inhibition.

EVALUATION OF BROCCOLI CULTIVAR REACTIONS TO BACTERIAL SOFT ROT. C. H. Canaday, J. E. Wyatt, and J. A. Mullins, University of Tennessee, West Tennessee Experiment Station, 605 Airways Blvd., Jackson, TN 38301.

Broccoli cultivars with different maturities were evaluated in field studies for their reactions to bacterial soft rot caused by Pseudomonas marginalis and Erwinia carotovora. Transplanting dates of cultivars were staggered to obtain simultaneous disease. Overhead irrigation was used to briefly wet plants 3–5 times/day during heading to create disease conducive conditions. Plants were inoculated. A quantitative 0–5 scale (0=no rot; 5=100% rotted) was used to rate each heading for soft rot severity at harvest. Six cultivars were evaluated in 1986, 1987, 1988, and 25 in 1988. There were significant inverse correlations between soft rot severity and days to maturity in all studies. Disease incidence and severity were consistently lowest with cv. 'Shogun' and 'Green Defender'. These two cultivars appear highly tolerant to bacterial soft rot.

EFFECTS OF CULTIVAR AND TILLAGE ON SEVERITY OF ANTHRACNOSE OF GRAIN SORGHUM. Albert Y. Chambers, Department of Entomology and Plant Pathology, University of Tennessee, Jackson, 38301.

Severity of anthracnose caused by the fungus Colletotrichum graminicola was greatly reduced in grain sorghum grown at Milan under no-tillage conditions compared to conventional tillage in 1985–87. Anthracnose injury was also much lower in plots of 'Sculb 6K64' than in those of 'Funk's G-522BD'. In 1988, four cultivars were evaluated in no-tillage and conventional-tillage plantings. Results were similar to the first three years. Anthracnose severity was greatly decreased in no-tillage plots, and disease varied in reaction to disease. Funk's 'G-522BD' and 'Paymaster R1090' had high levels of injury while DeKalb '6K64' and 'Paymaster 1022' had low levels of injury. In two no-tillage experiments in 1986 and 1987, disease severity was again much lower in no-tillage plots of Funk's 'G-522BD' than in conventional-tillage plots. However, yield increases did not result from reduced anthracnose injury in all four years, and moisture content of grain from plots with less disease was 1–2 percent higher.

A HIGHLY SELECTIVE MEDIUM FOR ISOLATING XANTHOMONAS CAMPESTRIS PY CAMPESTRIS FROM CRUCIFER SEEDS. C. J. Chang, R. Donaldson, M. Crowley, and D. Finnaw. Dept. Plant Pathology, University of Georgia and 2Seed Laboratory, Georgia Department of Agriculture, Griffin, GA 30223-1797.

CS20AB medium, containing soy peptone, tryptone, glutamine, histidine, dextrose, starch, (NH4)2HP04, KH2PO4, MgSO4, 7H2O, and water, was modified for isolating Xanthomonas campestris pv. campestris (Xcc) from crucifer seeds. Samples of 50,000 seeds per lot were washed for 2 hours, the washings centrifuged, and the resuspended pellets were diluted. Dilutions were plated onto NSCA, NSCAA, BSCAA (Phytopath. 74:268-272) and CS20AB. Saprobiotic bacteria were too numerous to count and overgrew Xcc on all media except CS20AB where CSU’s range from 66-97 per plate at 107-109 CFU per plate. Burial of seed into SCS20AB were Xcc and colony size was 4-6 and 5-10 times that on NSCAA and NSCA, respectively. Influence of calcium in the fruiting zone on the elemental composition of peanut pericarps under gnotobiotic conditions. T. E. Clemente and A. B. Flinow. Department of Plant Pathology, Oklahoma State University, Stillwater, OK. 74078.
Infection was determined by symptoms and by indirect ELISA. Symptoms were observed 10 days after inoculation, and the first symptoms were observed in the spread-test soybeans 38 days later. After another 26 days, spread was observed up to 80 ft. from infected spread hails occurred. Significant yield reduction was observed in Henderson bush Lima bean, but no reduction was observed in Fordhook Lima bean or soybeans in preliminary tests. No seed transmission was observed in preliminary tests of seeds from infected Lima bean or soybean.

GAS-LIQUID CHROMATOGRAPHY OF FATTY ACIDS FROM TOMATO STEMS USED FOR EARLY DIAGNOSIS OF BACTERIAL CANKER OF TOMATO. D.R. Dittrich and R.W. Beaver. Dept. of Plant Pathology, Coastal Plain Experiment Station, University of Georgia, Tifton, GA 31793

Fatty acids of tomato (L-722) stems that had terminal ends clipped with a bladed clamshell (Potentilla fruticosa, michiganensis subsp. michiganensis) were analyzed by gas-liquid chromatography. Anteisopentadecanoic, anteisopentadecenoic, and anteisohexadecanoic fatty acids commonly found in CMM but not tomato stem tissue, were evident in 33.4% and 66.7% of inoculated tomato stems after 1, 3, and 7 days, respectively. However, first signs of bacterial canker were not evident until 13-15 days after inoculation. Variability of fatty acid content during early stages of infection could be related to CMM populations which varied initially but by 7 days averaged 1.4 x 103 colony-forming units of bacteria/ml/cm of tomato stem tissue.

RESTRICTED TRANSLLOCATION OF COPPER CHLOROTIC MOTTLE VIRUS IN NON-HYPERSENSITIVE RESISTANT SУВІІАК, Р.Г. Goodrick, C.W. Kuhl, and H.R. Boerner, Dept. of Plant Pathology and Agronomy, University of Georgia, Athens 30602.

Resistance in soybean plant introduction 366304 (PI) to copper chlorotic mottle virus (soybean strain) is related to restricted translational of the virus. When uninfected leaves on 10-day-old seedlings are mechanically inoculated and inoculated at 7% or 32% PI and susceptible cultivar Davis develop local chlorosis and accumulate similar quantities of virions in inoculated tissue. Virus translational to and subsequent replication in roots and new un inoculated leaves is greatly restricted in PI (O-10% as much as in 32% PI) when un inoculated leaves of infected PI plants are inoculated, virus accumulates to quantities similar to initials inoculated uninfected leaves, thus indicating no induction of resistance. Host genetic studies indicate that resistance in PI is controlled by two recessive genes. Classification of the F2 population was based on symptomatology and virus concentration.

POTENTIAL FOR BACILLUS SUBTILIS AS A BIOPROTECTANT OF COTTON SEEDLINGS IN SOIL INFESTED WITH RHIZOCTONIA SOLANI. D.R. Greenough and W.E. Batson, Dept. of Plant Pathology and Weed Science, Mississippi State University, Starkville, MS 39762.

Cotton seeds coated with an experimental preparation of Bacillus subtilis were planted into three soil regimes (auto claved soil, soil from a cotton field, and autoclaved soil artificially infested with Rhizoctonia solani) and kept in controlled environment test chambers for 24 days. Seedlings from treated with B. subtilis planted in the pathogen-infested soils had better stands, showed no visible stunt, and had healthy well-developed root systems with very few lesions as contrasted with seedlings from untreated seeds planted into the same soil regimes. These findings suggest that B. subtilis may protect seedlings from R. solani.

SEASONAL VARIATION OF SYSTEMIC AGROBACTERIUM SPP. IN VITIS ROTUNDIFOLIA. D.E. Griffin and C.H. Graves, Jr., Dept. of Plant Pathology and Weed Science, Miss. State, MS 39762, and C.P. Hegwood, Jr., Truck Crops Branch Ext. Sta., Crystal Springs, MS 39059.

Surveys among symptomatic muscadine (Vitis rotundifolia) suggest a widespread systemic presence of Agrobacterium spp., although the level of pathogenic forms among these is yet to be determined. A. tumefaciens has been previously demonstrated in muscadine, and new occurrences of crown gall were noted in 1988. To determine dynamics of Agrobacterium presence, 23 mature vines were sampled from the same 12 relative positions per plant five times over two growing seasons. Agrobacterium, although isolated from all plants in the study at some time, was not consistently found in all plants at every reading nor in all positions within plants. Overall incidence at its highest level during 1987, decreased in the fall, and continued to be comparatively low during the 1988 summer sampling periods.

STRAINS OF SUGARCANE MOSAIC VIRUS (SCMV) IN LOUISIANA SUGARCANE. Michael P. Grisham, USDA-ARS, Sugarcane Research Unit, Houma, Louisiana 70361.

The strains of SCMV found in Louisiana sugarcane during the past 10 years have been W, I, and M. Based on all samples during the period, the distribution of the strains within the sugarcane belt was as follows: eastern region H=96%, I=2% and M=2%; central region H=98%, I=1% and M=1%; and western region H=82%, I=14%, and M=4%. Strains were identified annually by inoculating differential hosts and sugarcane cultivars (PI 31-294 and CP 31-588, sweet sorghum cv. Rio, and Johnson grass) with sap from diseased sugarcane plants. The highest incidence of strain I (13%) occurred in the central region during 1978-1982. The subsequent decline in incidence of strain I in this region corresponded with phasing-out cv. NC1031. Strain M appeared intermittently at low levels in all areas; but in 1987 and 1988 in the western region, strain M appeared in 13% and 13%, respectively, of the samples - most often among samples of the recently released cv. CP 79-318.

INFLUENCE OF CROP ROTATION ON THE POPULATION DYNAMICS OF ROTYLENCHULUS RENIFORMIS, K.C. Hadden, and E. C. McGawley, Dept. of Plant Pathology and Crop Physiology, L. State University, Baton Rouge, LA. 70803.

Population development of the reniform nematode (RN) on continuous soybean (S-S) was compared with soybean alternated on 60 d rotations with corn (S-C), grain sorghum (S-G), or wheat (S-W). Reproductive values at 300 d for the S-S, S-C, S-G, and S-W rotations were 361, 106, 75, and 94, respectively. Nematode numbers for all life stages in soil and roots were significantly in the S-C, S-W, and S-G rounds when compared to those in the S-S rotation. At 300 d, fresh shoot and root weights and root volume (260,109 g and 134 ml, respectively) of soybean in the S-W rotation were significantly greater than those in the S-S rotation (165, 59 g and 80 ml, respectively). Allelopathic influences on RN were evaluated by incubating eggs in root exudates concentrated by rotary evaporation. After 12 d, 1% of eggs in com root exudates hatched compared to those hatched in a distilled water control, suggesting a role for exudates in the population reductions observed in the S-C rotation.

SURVIVAL OF BACILLUS SUBTILIS IN ACER SACCHARUM AND A. SACCHARINUM LINER STOCK. T. J. Half and W. E. Davis, School of Agriculture, Tennessee Technological University, Cookeville, TN 38505.

A serum cap technique was used to inoculate potted bare root liners (30-45 cm tall) of Acer saccharum and A. saccharinum at the full leaf stage with Bacillus subtilis marked with resistance to the antibiotic Rifampicin (RF). Plants were grown in a lathe house at ambient temperature and watered as needed. After one and two complete growth periods, stems were harvested, deleafed, cut into sections, and frozen. Each section was dipped in boiling water (1-2 sec), halved, and cultured at 24 C on media amended with RF. RF resistant, growth promoting bacteria were induced in the same cultural morphology as the introduced bacterial isolate were recovered from xylem tissue above the initial wound site after one and two growth periods. B. subtilis colonized new stem tissue in both A. saccharum and A. saccharinum after introduction of RF resistant, growth promoting bacteria.

INFLUENCE OF PH AND WATER STRESS ON THE SUSCEPTIBILITY OF CENTPEDE GRASS TO RHIZOCTONIA SOLANI. R. A. Haygood, R. M. Light, A. R. Mazur, and L. C. Mitter, Department of Plant Pathology and Physiology, Department of Agricultural Chemical Services, and Department of Horticulture, respectively. Clemson University, Clemson, SC 29634.

Centipede grass (Eremochloa ophiuroides) was grown at pH levels of 4, 5, 6, 7, and 8 on a Cecil sandy loam soil in a greenhouse. One-half of the plants were stressed by applying water daily after watering. Average soil moisture of well watered plants and stressed plants prior to each irrigation were 19% and 4%, respectively. After 3 months, all plants were watered well and inoculated with a Rhizoctonia solani isolate. The pH had no significant effect on disease severity at either moisture level. Disease severity ratings of water stressed grass at all pH levels were

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significantly lower (ave. 16% on a 1-100 scale based on percent sheath rot) than grass grown at higher moisture levels (ave. 73%).

EFFECTS OF CULTURE FILTRATES OF TRICHOMEURA SPP. ON GROWTH AND REPRODUCTION OF PYTHIUM NUNN AND PYTHIUM ULTIMUM. D. Henley and M. Windham. Department of Entomology and Plant Pathology, Univ. of Tennessee, P.O. Box 1071, Knoxville, TN 37901-1071.

Isolates of Trichomeura koningii, T. harzianum, T. viride, and T. pseudokoningii were tested for their abilities to inhibit growth and/or stimulate reproduction of Pythium nunn (53) and P. ultimum (N1). Culture filtrates of the isolates, sterilized by cold filtration or autoclaving, were seeded with agar plugs of N1 or N3. All filtrates tested inhibited growth of N1 and N3. Two isolates induced growth and/or formation of N1 to a greater extent than did the other Trichomeura spp. There was no difference in inhibition of growth and/or formation with autoclaved or cold filtrates. Stimulation of reproductive structures in N1 and N3 by filtrates of Trichomeura species was not observed. Inhibition of growth of N3 in filtrates of Trichomeura reduces the possibility of integrating P. nunn with Trichomeura as an effective biocontrol management system.


Protein A-gold (5 nm) labelling of two BYMV-subgroup polyviruses, clover yellow vein virus-Pratt (CYYV-Pratt) and pea mosaic virus-204-1 (PMV-204-1), was conducted with a monoclonal antibody produced to CYYV-Pratt. Virus particles in various buffers were allowed to attach to polyclonal membranes on nickel grids. Virus particles appeared intact when suspended in 0.03 M sodium phosphate buffer, pH 7.35 or 0.3 M NaCl, but dissociated when in 0.05 M sodium carbonate buffer pH 9.6 or 0.1 M glycine, pH 10. With buffers in which the virus particles remained intact, heavy gold labelling of CYYV-Pratt particles occurred, but there was no specific labelling of PMV-204-1 particles. Outlines of labelled CYYV particles were irregular, while outlines of unlabelled PMV-204-1 particles were clearly delimited.


After a long-term monoculture of watermelon cultivars, most of the highly wilt-resistant cultivars expressed aggressiveness. The incidence levels that were similar to susceptible cultivars. When pathogen isolates were obtained from wilted plants and tested in the greenhouse, 75% of the isolates from highly resistant Calhoun Gray were from the remaining 25% of the watermelon cultivars tested, whereas, only 20-25% of the isolates from moderately resistant Charleston Gray and susceptible Florida Giant were highly aggressive. Total populations of Fusarium oxysporum f. sp. niveum were similar in plots of resistant and susceptible cultivars. Monoculture of the highly resistant cultivars apparently resulted in selection for the highly aggressive race 2 of the pathogen.


Tall fescue (Festuca arundinacea) plants, infected (E+) or not infected (E-) with the endophyte Acremonium coenophialum, were evaluated for resistance to Pratylenchus scribneri (a lesion nematode) and Meloidogyne graminis (grass root-knot nematode) in greenhouse experiments. Presence or absence of endophyte in plants was determined with PAS-ELISA. In separate experiments, plants were inoculated with 1,200 P. scribneri adults and juveniles or 3,400 M. graminis eggs. After 4 weeks, P. scribneri populations increased or maintained themselves on E- fescue but disappeared from E+ roots and their rhizospheres. After 8 weeks, numbers of M. graminis egg masses and eggs were significantly higher on E- fescue than on E+ fescue.

EPISTEDIOLOGICAL STUDIES OF ERYSIPHE GRAMINIS F. SP. TRICTICI IN SOUTH CAROLINA. Graydon Kingland, Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377.

Infection of wheat (Triticum aestivum var. 'Blueboy') by E. graminis f. sp. tritici (Egt) on or about 24 Feb. in the field was attributable to conidial inoculum from Egt-infected, glasshouse-grown seedlings in pots placed in field plots in 6 replicates on 2 Jan. New lesions (ave. of 4, 2 and 10 per 14.1 cm² on 2, 8 and 21 Mar, respectively) identified through 21 Mar were limited to a 14.1 cm semi-circle with a radius of 3 m described by the SE to NW compass points from the source of inoculum. Five lesions were detected in one control plot on 21 Mar, but none earlier. On 30 Mar disease incidence of about 8% was recorded on the plots and 28.3 m plots from the original inoculum sources, in all control plots and in wheat 27 m downwind from the nearest known source of inoculum. These data support the hypothesis that fall and winter infection by Egt in South Carolina may supply primary inoculum in the spring.

STUDIES ON CONTROL OF ERYSIPHE GRAMINIS F. SP. TRICTICI BY TRIADIMENOL. Graydon Kingland, Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377.

The systemic fungicide Baytan 300L (8-4-chlorophenoxoxy)-a-(1,4-dimethylphenyl)-1H-1,2,4-triazole-1-ethanol (tridimenol) at 21.1, 26.4 and 31.2 g (a.i.) per 100 kg of seed provided control of powdery mildew (pm) on wheat (Triticum aestivum var. 'Blueboy') seedlings in the greenhouse for 68 days, as estimated by disease severity (< 12) and compared with severity (115) on leaves of plants from untreated seeds. The symptoms on seedlings from treated seeds were chlorotic lesions without sclerotia. Plants with pm severity ratings of 2 produced fewer tillers than plants with low ratings (2.6 and 4.1, respectively). Severity of infection in the field was lower on plants from treated seeds (2, 28 and 10% for three years) than on plants from untreated seeds (40, 38 and 41% through April). Grain yields (3158, 2890 and 5040 kg/ha for three years) from the plots planted with treated seeds were not significantly greater than yields (3024, 2621 and 4906 kg/ha) from the plots seeded with untreated seeds.


In field tests, labeled rates (1.2-2.3 lha) of Ricimol applied once to the soil surface reduced the number of plants with R. solani-induced lesions (RIL). For beans and soybeans, a post-seeding, preemergent spray was made as a 3-m band (74 lha) along the row. For cucumber, a 1.2-m band (187 lha) was sprayed at first true leaf formation. In two field tests, Ricimol reduced RIL in soybean stems by 36 and 24.4% and when combined with flutolanil reductions were 48 and 27%, respectively. In beans, these reductions were, respectively less and 9 and 38% (39) for fruits on the (b) row) were reduced by 52, 80, and 89%, respectively by Ricimol, flutolanil, and Ricimol plus flutolanil, respectively. In vitro, Ricimol significantly reduced the growth of two isolates of R. solani and one of S. rolfsii at 68 hr. 50, 17, and 14% at the 0.1 dilution rate which is 16.7 and 13.2% of that used in the field for the legume and cucumber crops, respectively. Sclerotial development of S. rolfs at 116 hr was reduced 100%.

REACTION OF PEANUT CULTIVARS TO POD ROT AND THEIR INFLUENCE ON PYTHIUM POPULATIONS IN SOIL. P. J. Lewis and A. B. Fillon, Department of Plant Pathology, Oklahoma State University, Stillwater, OK. 74078.

Peanuts. Pronto, Snanco, Okrun, Langley, Gx-7, Flournamer, Florigiant, and NC-7 were grown in two locations in Oklahoma in 1988. Pods were sampled 3 times during the season and rated for pod rot severity. Populations of Pythium spp. in field soil were estimated monthly from Acremonium coenophialum, and Meloidogyne graminis (grass root-knot nematode) in greenhouse experiments. Presence or absence of endophyte in plants was determined with PAS-ELISA. In separate experiments, plants were inoculated with 1,200 P. scribneri adults and juveniles or 3,400 M. graminis eggs. After 4 weeks, P. scribneri populations increased or maintained themselves on E- fescue but disappeared from E+ roots and their rhizospheres. After 8 weeks, numbers of M. graminis egg masses and eggs were significantly higher on E- fescue than on E+ fescue.

EFFECT OF PHOSPHORUS ON ROOT COLORIZATION AND SPORULATION OF GLOMUS ETUNICATUM ON FOUR HOST SPECIES IN SAND VERMICULATE CULTURE. H. D. Linyane and N. C. Schenck, Department of Plant Pathology, University of Florida, Gainesville, FL 32611.
Alfalfa, bahiagrass, onion and wheat were inoculated with the VA mycorrhizal fungus Glomus etunicatum (isolate LETC 329) and grown in acid-washed sterile sand:vermiculite (3:1, v/v) mixture. Plants were irrigated with eight P levels, 0.05, 0.1, 0.5, 1, 2, 4, 10 and 20 mm of 100 normal Long Ashton II nitrate type solution. After 12 weeks the sporeulation over P levels was bimodal with a high peak (39500-43400 spores per plant) at 0.5 ppm P and a low peak (7500-10500) at 20 ppm P in all the six sand plants. Bahiagrass supported good sporeulation in a wide range of applied P levels. Sporeulation was significantly and positively correlated with colonized root length and percent colonization. Percent shoot tissue P was significantly and negatively correlated with spore production. This method provided excellent colonization and sporeulation on 3 of 4 hosts evaluated and would be good for rapid multiplication of VA mycorrhizal fungi.

**EFFECT OF CHEMICAL TREATMENTS ON YIELDS OF PEPPER GENOTYPES WITH DIFFERENT LEVELS OF RESISTANCE TO BACTERIAL SPOT AND ON POPULATIONS OF CONTROLLED FACTORS**

E.M. MacDougall, Dept. Plant Pathology, Univ. of Georgia, Athens 30602.

Bacterial spot caused by Xanthomonas campestris pv. vesicatoria causes serious defoliation of pepper in the mountainous areas of Georgia but is less damaging in the Piedmont. At Blairsville (mountain area) weekly applications of mancozeb (1.8 g/l) + cupric hydroxide (3.0 g/l) increased yields of the highly susceptible cultivar Yolo Wonder B by 9% and the moderately resistant genotype C4V-V22 by 1% but had no effect on the yield of the highly resistant genotype C4V-4C. Similar results were obtained with streptomycin (1.0 g/l). At Athens (Piedmont) yields of Yolo B, C4V-V22, and C4V-4C were reduced 15, 30, and 31% by the mancozeb + cupric hydroxide treatment. Streptomycin increased yield of Yolo B by 12% but had no effect on yields of C4V-V22 and C4V-4C. The mancozeb + cupric hydroxide treatment markedly increased populations of the green peach aphid at Blairsville and fall armyworm at Athens whereas mancozeb or streptomycin alone had no effect.

**RESISTANCE TO SHREATH BLIGHT IN U.S. LONG-GRAIN RICE CULTIVARS.**

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Replanted yield trials were conducted on 7 rice cultivars, including 3 semi-dwarfs (SD), during 1969-1988 to quantify (1) impact of sheath blight caused by Rhizoctonia solani on yield and (2) varietal differences in resistance. Percent yield loss (YL) for inoculated plots was based on yields of adjacent noninoculated plots. Disease index (DI) was calculated from percentages of harvested area rated 2. Yield loss, obtained with, was 96% (C4V-4C) and 90% (C4V-V22) resistant genotypes. YL for inoculated plots compared to noninoculated plots was 13-34% (C4V-4C) and 24-47% (C4V-V22) for SDgenotypes. YL for inoculated plots compared to noninoculated plots was 13-34% (C4V-4C) and 24-47% (C4V-V22) for SDgenotypes.

**THERMAL INACTIVATION IN SOIL OF MACROPHOMINA PHASEOLINA AND PYTHIUM IRREGULARE.**

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Initial densities of M. phaseolina (Mp) (280 sclerotia/g soil) and P. irregulare (Pi) (260 oospores/g soil) were mixed separately into pasteurized sandy loam soil (pH 6.0) and then placed in terracotta pots. Pots were watered daily and fertilized weekly with 50 ppm NH4NO3 until Oct 15, 1988. Temperature and relative humidity were monitored by recording hygrothermograph. Typical Sclerotinia symptoms, appeared on plants in mid Sept. DI was recorded at five times, with highest DI values of 0.9, 1.0, 1.5, 2.5, and 3.5 recorded for 1988, 1977, 1974, and 1988, respectively. ONION BULB ROT CAUSED BY GEOTRICHUM CANDIDUM IN TEXAS.**

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Geotrichum candidum links: R. A. Seifert Gnomon, Texas A&M University, College Station 77843. Isolated from rotting bulbs of onion (Allium cepa L.) cv. Texas Grano 1015Y (TG 1015) in south Texas. A watery soft rot started on the bulb neck and progressed down the outer scale. TG 1015 bulbs injected with 0.5 ml of a 30,000 conidia ml-1 aqueous suspension of the isolate developed typical symptoms within 3 days. Taxonomical distinction among Geotrichum species is currently based on both morphological characteristics and growth rates on different carbon sources. Although growth of this isolate on L-arabinose, lactose, raffinose, salicin, and sucrose varies from G. candidum isolates from citrus, combined characteristics suggest that the onion isolate should be assigned to this species.

**EPIDEMIOLOGICAL IMPORTANCE OF SIX SOLANACEAE WEED HOSTS IN THE FUSARIUM ECHINOCARDII VIRUS/BELL PEPPER PATHOSYSTEM.**

F. W. Nutter, Jr., and C. W. Kuhns, Department of Plant Pathology, University of Georgia, Athens 30602.

Of the epidemological components studied in the tobacco etch virus (TEV)/pepper aphid/pepper host pathosystem, factors involving the weed hosts are the least understood. Using ELISA for diagnosis, TEV incidence was monitored in six solanaceous weed species throughout the cropping season. These included: Datura stramonium L., Nicandra physalodes L., Physalis angulata L., E. virginiana Mill., Solanum carolinense L., and S. tuberosum L. Important were the role of various weeds as both vertical and horizontal avenues of virus transmission and as a possible means to the perennial life strategy, (ii) time of emergence of the weed populations, (iii) TEV incidence in weed populations at peak transplant time, (iv) aphid preferences for specific weed species, and (v) whether TEV is naturally occurring weed host populations. TEV disease epidemics progressed faster when weeds were planted in the same plot arrangements as experimental pepper plots than in naturally occurring weed populations.

**DISEASE SEVERITY AND EPIDEMIC COMPONENTS OF LEPTOSPHAERULINA LEAFSPOTS ON ALFALFA AND WHITE CLOVER.**

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Isolates of Leptosphaeria brunigiana from alfalfa and L. trifolii from white clover were pathogenic on both alfalfa and white clover. Slightly higher disease severity occurred with alfalfa at 15 and 22 C than at 30 C. Incubation period (3-
4 da) on intact plants and latent period (14-17 da), infectious period (18-21 day), sporulation rate, and date of peak sporulation on detached leaves were similar for all pathogen-host combinations. Temperature during the development did not affect latent or infectious period. Sporulation did not appear to be related to level of disease severity. Total number of aeciospores expected 2 wk after leaf detachment was slightly higher on alfalfa inoculated with L. longspora than on clover inoculated with S. trifolii. Sporulation occurred in a series of peaks over time indicating a possible difference in maturity of pseudospora on Penstemon leaves; 85% of all aeciospores were ejected within 7 da of leaf detachment.

PRESENCE OF SOYBEAN CYST NEMATODE RACE 5 IN MADISON COUNTY, ALABAMA. P. P. Panopoulos, Department of Plant Science, Alabama A&M University, Normal, AL 35762.

Race determination of soybean cyst nematode (SCN), Heterodera glycines, indicates that race 3 was present in Huntsville (Madison County) and Scottsboro (Jackson County), but absent in the Talladega (Elmore County) and Marion Junction (Dallas County) study sites. Race 5 was identified for the first time in Madison County, Alabama. The size of nodules of soybean cultivars Essex and Lee grown in non-SCN-infested soil was significantly bigger compared with the size of nodules of the same cultivars grown in SCN race 5-infested soil. The number of nodules of the same soybean cultivars grown in SCN race 5-infested soil was significantly more than the number of nodules of the same cultivars grown in non-SCN-infested soil. The size of Essex and Lee was significantly higher than the yields of the same soybean cultivars grown in SCN race 5-infested soil. Soybean nodulation seemed to be influenced by soybean cultivars, rhizobium strains, and races of SCN.

PRIMARY INFECTIOUS LOCUS OF TWO VIRUSES TRANSMITTED BY LEAP-FEEDING BEETLES. C. Patterson and S. Gerberich, Dept. of Plant Pathology, Univ. of Arkansas, Fayetteville, AR 72701.

Fluorescent-labelled antibodies were used to detect the primary infectious loci of two beetles—transmissible viruses, southern bean mosaic (SBMV) and bean pod mottle (BPMV). Transmission of SBMV by Ceratoma trifurcata (Forst) to Phaseolus vulgaris 'Black Valentine' was retarded in detectable fluorescence in veins radiating from the feeding site, but not in portions of the vein adjacent to it. The fluorescence was limited to vein cells even at eight days post-inoculation. When BPMV was transmitted in the same manner, the fluorescence was detected in cells adjacent to the feeding site. Although the initial fluorescence was located in the veins leading from the feeding site, it eventually spread to mesophyll cells surrounding the fluorescing veins. These results suggest that BPMV and SBMV, two beetles-transmissible viruses from different virus groups, differ in the manner in which they establish infection following beetle transmission.

EFFECT OF NITROGEN SOURCE AND LEVEL ON THE SEVERITY OF STRAWBERRY ANTHRACNOSE CROWN ROT. Barbara J. Smith, USDA-ARS, Small Fruit Research, P. O. Box 287, Poplarville, MS 39470.

The influence of N source on the severity of anthracnose crown rot (caused by Glomerella cingulata f. sp. fragariae) on strawberry was investigated by applying N from five sources (NH₄NO₃, NH₄Cl, (NH₄)₂SO₄, NaNO₃, Ca(NO₃)₂) at 3 rates (20, 40, and 160 ppm) to strawberry plants grown in 10 cm pots. The plants were fertilized 3 times weekly with a complete nutrient solution containing the N treatment, and inoculated with 1.5 x 10⁷ conidia/ml of G. cingulata. Each plant was rated for disease severity (DS) on a scale of 0 to 6. Plants receiving 3 ppm N were more susceptible than plants receiving 160 ppm N. Plants treated with 40 ppm N were more resistant (DS=2.9) than all others, and plants treated with a nitrate N source including NH₄NO₃ were more resistant than plants receiving N from other ammonium sources. There was no difference in DS due to N source among plants receiving 40 ppm N.


Fatty acids from strains of the citrus canker bacterium were separated by gas chromatography and the profiles were compared with those from known bacteria using the Hewlett-Packard Microbial Identification System (MID). All strains were identified as Xanthomonas campestris. Of 77 strains from the Nursery canker, 52% and 22% were identified as pv. vignicola and as pv. alfaianus, respectively. Of 25 strains from the Asiatic canker, 48% and 36% were identified as pv. malvastrum and as pv. manihotis, respectively. Since the similarity indices of the identifications were low (<0.75), the strains isolated in Florida were different from those cataloged in the MID system.

BIOLOGICAL CONTROL OF RHIZOCTONIA SOLANI AG-2 TYPE 2 IN A CORN-SNAP BEAN-Peanut ROTATION IN MICROPLANTS. Donald R. Sumner and D. K. Bell, University of Georgia, Coastal Plain Experiment Station, Tifton, GA 31793-0740.

Field microplots were noninfested or infested separately with Rhizoctonia solani anastomosis group (AG) 2 type (T) 2, and AG-2-722 plus Rhizoctonia solani AG-2+CAG-4, or CAG-5; Laetisaria arvalis; or an unidentified orange basidiomycete (OBB) 12 April 1983. Microplots were planted to a corn-snap bean double crop in 1985, peanut in 1986, and corn-snap bean in 1987. Crown and brace root rot (CBRR) was decreased and foliage weight increased by CBG-5 in 5-10 old plants in 1985 in infested soil. There were no differences in grain yield in infested soil, and all corn in infested soil yielded less than corn in noninfested soil. In 1987 there were no differences in CBRR among treatments, but grain yield in CBG-5 and CB-8 treatments was similar to noninfested soil, and greater than that of CBG-4 and CBG-2. Soil in these indigenous soil fungi have the potential of reducing CBRR.

FUNGAL DEVELOPMENT IN SUSCEPTIBLE AND RUST RESISTANT PEARL MILLET. J. Mierek, and J. M. Mims, Department of Plant Pathology, University of Georgia, Athens, GA 30602.

Fungal development in leaves of pearl millet (Pennisetum americanum) inoculated with ureidiospores of the rust fungus Puccinia striiformis was monitored using epifluorescence light microscopy and transmission electronic microscopy. In a susceptible cultivar (Tift 239B) the fungus colonized the tissue extensively and produced ureidina by 8 days after inoculation. In a moderately resistant cultivar (86-8770) fungal growth was confined to the tissue adjacent to the infection site with no macroscopic symptoms. In a highly resistant cultivar (Tift 850D) fungal growth was confined to the tissue adjacent to the infection site with no macroscopic symptoms. In a highly resistant cultivar (Tift 850D) fungal growth was confined to the tissue adjacent to the infection site with no macroscopic symptoms. The tissue adjacent to the infection site in the resistant cultivar became intensively autofluorescent, indicating necrosis. This was confirmed by ultrastructural observations. Thus, the timing and effectiveness of resistance mechanisms in the two cultivars differed substantially.

ULTRASTRUCTURE OF THE INFECTION PROCESS IN PEANUT RUST. J. Taylor, B. A. Richardson, and C. W. Mims, Department of Plant Pathology, University of Georgia, Athens, GA 30602.

Early stages of infection of peanut (Arachis hypogaea) leaves by ureidiospores of Puccinia arachidis were examined using electron microscopy. Appressoria that developed over stomata produced penetration pegs that entered the leaf via stomatal pores. A penetration peg was initially small and thin-walled, but became thick-walled and wedge-shaped as it appeared to push its way through the stomatal pore. Once inside the leaf the penetration peg expanded to form a substomatal vesicle that produced an intercellular infection hypha (IH) that grew until its tip contacted a mesophyll cell. A septum developed to delimit a terminal haustorial mother cell (HM) from the remainder of the IH. The HM became attached to the host cell wall by an extracellular matrix material that formed a typical dikaryotic haustorium with a smaller neck region and an expanded haustorial body separated from the host cell cytoplasm by an extrahaustorial matrix and membrane.

EFFECT OF MAINTENANCE HOST ON VIRULENCE IN PSEUDOPERDONOSA CUBENSIS. C. E. Thomas and E. L. Jourdan, USDA, ARS, U. S. Vegetable Laboratory, Charleston, SC 29414.

A field isolate of Pseudoperdonospora cubensis pathotype 5 was obtained from squash (Cucurbita pepo). Pathotype 5 is virulent to both squash and melon (Cucumis melo). Subpopulations of the isolate were maintained on each host for 18 generations. After each generation, each subpopulation was inoculated to both squash and muskmelon and the subsequent sporulation rate (SP) for each host was determined as an index of virulence. The subpopulation maintained on muskmelon showed a marked reduction in virulence against squash, 99.7% decrease in SR, and a marked increase in virulence against muskmelon, 226.12
increase in SM, from generations five through 18. Virulence against squash in this subpopulation returned to the original level after two generations of continuous culture on that host. This study illustrates the important effects of cucurbit host species in the selection of virulence factors in this pathogen.

DEVELOPMENT OF MULTIPLE VIRUS RESISTANT JALAPENO PEPPERS, B. Villalon, Texas Agricultural Experiment Station, 2415 E. Hwy 83, Weslaco, TX. 78596.

Demand for pungent and mildly pungent jalapeno peppers (Capsicum annuum L.) for fresh market and processing has increased during the past 15 years. Viruses are the limiting factor in most production areas because all known commercial jalapeno are susceptible to virus diseases. The et, y, L, and p genes which confer resistance to tobacco etch virus, potato virus Y, tobacco mosaic virus and pepper mottle virus, respectively, were incorporated into commercial types via the pedigree-backcross method. Sources of these genes included: 'Aviara', 'Agronomico', 'Casca Dura', PI 342947, PI 264281 and AC 2120. Over 3,400 breeding lines with varying levels of capsacin have been developed with multiple virus resistance. Selections for high yielding, early concentrated fruit set on a single stemmed plant for mechanical harvesting are being made.

PATHOGENICITY OF FIVE FUNGI TO ROOTS OF CORN, SORGHUM, PEARL MILLET, ABRUZI RYE AND FIVE FORAGE BERMUDAGRASSES. H. D. Wells, J. F. Wilson, B. K. Bell and D. R. Sumner, USDA-ARS and University of Georgia, Coastal Plain Experiment Station, Tifton, GA 31933-0748.

Five fungi [a sterile white basidiomycete (SWB), Rhizoctonia solani AG-2 type 2, Bipolaris trisepatum, Exserohilum rostratum, and Fusarium roseum var. equiseti], from Tifton 44 bermudagrass, from Cordele, GA, and a SWB from soil were evaluated for pathogenicity to corn (Pioneer 3369A), sorghum (Pioneer 8330), pearl millet (Tifleaf 2), Abuzri rye, and bermudagrasses (Coastal, Coastcross 1, Tifton 44, Tifton 78, and Tifton 85). Root disease index ratings showed that both isolates of the SWB and the R. solani AG-2 type 2 were highly virulent on all crops. Pearl millet, sorghum and the five bermudagrass hybrids were susceptible to all pathogens whereas corn and abruzzi rye were resistant to B. trisepatum, E. rostratum and F. roseum var. equiseti.

REDUCED PATHOGENICITY AFTER SUBCULTURING AND A METHOD FOR PRESERVING CULTURES OF MOESZIOMYCYES PENICILLARIAE. J. F. Wilson and H. D. Wells, USDA-ARS, Coastal Plain Experiment Station, Tifton, GA 31933-0745.

Moesziomycyes penicillariae causes smut of pearl millet inflorescences, and is often maintained as sporidial cultures. Bulk sporidial cultures were established from teliospores collected from inoculated heads of cytoplasmic male-sterile inbred B7. Each of eight cultures maintained for 1, 11, 21, or 31 subcultures were used to inoculate 10 heads of field-grown inbred Tift 85DR. Mean smut severities decreased 51% (from 20.4 to 10.0% severity) and seed yields increased 78% (from 12.0 to 21.3 g/10 heads) when inoculations were performed with cultures maintained for 31 subcultures rather than with the newly established cultures. These results indicate the need for developing a method for long-term storage of cultures. Storage of sporidia in 40, 60, 80 and 100% glycerin at 4C, -7C, and -73C was evaluated. Survival was greatest at -73C for all concentrations and 80% glycerin was the optimum concentration for storage.

A HISTOLOGICAL COMPARISON OF MECHANICALLY WOUNDED TREES AND TREES WITH DOGWOOD CANKER. M. T. Windham and E. Graham, Department of Entomology & Plant Pathology, Univ. of Tennessee, P.O. Box 1071, Knoxville, TN 37901-1071.

Forty 3-year-old dogwood stems with symptoms of dogwood canker, 30 nonsymptomatic stems, and 20 stems wounded with a 3 mm drill bit were examined histologically. Differences in anatomy were noted among sample types. Cambium death was observed in all trees with dogwood canker symptoms and callus formation was not observed. In wounded trees, tree wounds were filled with actively growing callus within one growing season. Cambium death and lack of compartmentalization of diseased tissue associated with dogwood canker could serve as entry points for secondary invading organisms and may account for diverse mycflora (Fusarium, Curvularia, Peniatiolula, and Botryodiplodia) that is found in diseased tissue.

DISEASE INCIDENCE AND SEVERITY OF DOGWOOD ANTHRACNOSE IN THE GREAT SMOKY MOUNTAIN NATIONAL PARK. M. Windham, M. Montgomery, and K. Landon, Dept. of Entomology and Plant Pathology, Univ. of Tennessee, P.O. Box 1071, Knoxville, TN 37901.

Eighty-three permanent plots were established in the GSMNP on a 3 km grid pattern. At each plot ten flowering dogwood trees (Cornus florida) were tagged and rated for dogwood anthracnose incidence and symptom severity. Tree diameters, elevation of plot, type of trees in the canopy, and proximity of the plot to water (creek or lake) were examined. Ten additional pairs of plots were established in which one plot of each pair was in disturbed areas of GSMNP (campgrounds, visitor centers, etc.) and the other member of each pair was approximately 200 m into the woods that were adjacent to the disturbed plots. Dogwood anthracnose was found in over twenty remote plots in the GSMNP. Symptom severity ranged from few individual lesions to trees with large cankers at epicormic shoots. Disease incidence was much lower in the disturbed plots than in plots established 200 m into the woods.

DISTRIBUTION OF PRUNUS NECROTIC RINGSPOT VIRUS IN PEACH TREES AFTER GRAFT INOCULATION OF SHOOTS OR ROOTS. Wuglao Yuan, O. W. Barnett and Simon Scott, Department of Plant Pathology & Physiology, Clemson University, Clemson, SC 29634.

Two-year-old dormant peach trees, with Red Haven or Loring scions and Lovell or Nemagus rootstocks, were grafted with twig tissue from healthy or infected sources of 4 Prunus necrotic ringspot virus (PNRSV) isolates. Three trees of each of 4 scion/rootstock combinations were grafted with each source near the top and three on major roots. Trees leafed out after 1-2 wks in a greenhouse and weekly assays were by ELISA. PNRSV was first detected in leaves near the top of shoot-grafted trees 2-3 wks after grafting. PNRSV was systemic in these trees, including roots, at this time or 1-2 wks later although virus was not detected in some branches until 6-14 wks after grafting or not at all in 1/4 of the branches. PNRSV was not detected in any root-grafted trees or in trees grafted with healthy tissue. Few differences were found among virus isolates or cultivars. Thus, soil-borne transmission of PNRSV may not be an important means of natural spread.