Plant & Pest Diagnostic Laboratory

Annual Report 2007

Purdue University Cooperative Extension Service

PURDUE UNIVERSITY

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ACKNOWLEDGMENTS

Purdue's Plant and Pest Diagnostic Lab (P&PDL) is recognized as a source of unbiased, quality, diagnostic information. This recognition is a result of the hard work and dedication of P&PDL diagnosticians and volunteer faculty and staff. A special thanks to all of you.

We are indebted to our computer support specialist for his database expertise, to our departmental extension Administrative Professional for her webmaster and database assistance and to our P&PDL secretary whose patience and friendly phone etiquette provides a welcome introduction to our clientele.

To the administration at Purdue University, we thank you for recognizing the vital role of the P&PDL in addressing Indiana's plant and pest diagnostic needs, especially during this time of heightened agro-biosecurity concerns.

Gail E. Ruhl
P&PDL Interim Director

"…to enable people to improve their lives and communities through learning partnerships that put knowledge to work" (Extension mission as per the National Association of State Universities and Land Grant Colleges, 2001)

MISSION

The Plant and Pest Diagnostic Laboratory (P&PDL) at Purdue University is an interdisciplinary laboratory that was established in 1990 with funding from the Crossroads initiative to integrate the existing plant disease and weed diagnostic lab in the Department of Botany & Plant Pathology (est. 1979) with the identification services provided by the Departments of Entomology, Horticulture and Landscape Architecture, Agronomy and Forestry. The mission of the P&PDL is to provide accurate and rapid identification of plants, pests, and plant problems; suggest management strategies, when requested; and serve as a source of unbiased information for plant and pest related problems.

The Laboratory provides technical expertise to specialists and county extension educators of the Purdue University Cooperative Extension Service (CES); to University research faculty and staff; to the Office of the State Chemist; to the Director of the Entomology and Plant Pathology Division of the Indiana Department of Natural Resources (IDNR) and associated nursery inspectors. The laboratory also provides routine pest and plant problem diagnoses for private businesses and citizens of Indiana.

HOMELAND SECURITY AND THE NATIONAL PLANT DIAGNOSTIC NETWORK

As a result of the 9-11-01 terrorist attacks on the World Trade Centers and the Pentagon, Congress created a new U.S. Department of Homeland Security. With heightened awareness and concern for potential acts of bioterrorism directed at U.S. food and agricultural systems, the Department of Homeland Security provided funds for USDA/CSREES to develop the National Plant Diagnostic Network (NPDN). Land grant university plant diagnostic laboratories comprise the backbone of the system. The nation is divided into five regions, with a regional center designated for each region. The P&PDL, as part of the North Central Plant Diagnostic Network (NCPDN) region has been working with counterparts at other land grant institutions to prepare for plant disease and pest introductions that might pose a threat to American agriculture. Part of this response includes providing training protocols for threat pathogens for the "first detectors." First detectors typically include individuals such as county extension educators, growers, crop consultants and regulatory field inspectors. Once trained, first detectors are on the look-out for unusual or new diseases to submit to the diagnostic laboratories. This greatly reduces the time between introduction of plant pests and diseases and their detection.

The P&PDL conducts IP video training sessions for ANR educators with the intent of improving their surveillance capabilities for invasive plant diseases and pests in Indiana. The training in 2007 included updated information on Ramorum blight, and how to submit secure samples.

The P&PDL, as part of another NPDN initiative, was involved with the reporting of SBR sentinel plot surveillance data to the National Plant Diagnostic Network data repository. Late in the 2007 growing season, soybean rust was confirmed in a sample from Owen county and reported through the National Plant Diagnostic Network data repository.

Southern Wilt, caused by *Ralstonia solanacearum* was isolated from Mandevilla (Dipladenia) and as per protocol for a suspect select agent, was sent to Beltsville for Race/Biovar confirmation. The bacterium was identified via PCR and advanced carbohydrate utilization testing as *Ralstonia solanacearum* (Biovar 3). This is a new host record for North America.

P&PDL AND THE INDIANA DEPARTMENT OF NATURAL RESOURCES

The Plant and Pest Diagnostic Laboratory serves as the plant disease diagnostic facility for the Indiana Department of Natural Resources (IDNR). The IDNR and the Purdue Plant and Pest Diagnostic Laboratory work together during outbreaks of diseases of regulatory concern.

The P&PDL provided disease diagnosis on: corn and soybean samples for the IDNR Phytosanitary Certification Program, as well as disease diagnosis of foliar pathogens on corn for entry into the National Agricultural Plant Information System (NAPIS) database, and diagnosis of 54 ornamental samples submitted by IDNR Nursery Inspectors.

STAFF

Purdue faculty and staff from the departments of Agronomy, Botany and Plant Pathology, Entomology, Forestry and Natural Resources, and Horticulture and Landscape Architecture serve as diagnosticians for the P&PDL on a part-time basis as a portion of their total commitment to their respective departments. Staffing responsibilities in the P&PDL and the department to which they belong, are listed below.

Botany and Plant Pathology	
Co-Directors	Gail Ruhl, Karen Rane
Secretary and Receptionist	Janet Whaley
Webmaster and Extension Administrative Professional	Amy Deitrich
Disease diagnosis and control	Gail Ruhl, Karen Rane
Weed identification, control, and diagnosis of herbicide injury on field crops	Glenn Nice
Computer support	Robert Mitchell
Entomology	
Invertebrate and other pest identification and control	Timothy Gibb, Clifford Sadof
Horticulture & Landscape Architecture	
Identification of horticultural plants and plant problems	B. Rosie Lerner
Agronomy	
Fertility, soil and environmentally related problems of corn	Robert Nielsen
Turfgrass management	Zac Reicher, Glenn Hardebeck
Forestry & Natural Resources	
Tree identification	Rita McKenzie

The P&PDL is fortunate to have the support and assistance of numerous faculty and staff in the School of Agriculture. During 2007, more than 30 additional faculty and staff members assisted with sample diagnoses **(Table 1)**. The P&PDL also employs a student hourly worker throughout the year to help with logging in samples, sample distribution, filing and other general laboratory duties.

Table 1. Departmental faculty and staff that assisted with diagnoses of samples submitted to the Plant and Pest Diagnostic Laboratory during 2007.[1]

Faculty/Staff	Number of Diagnoses	Faculty/Staff	Number of Diagnoses
Agronomy	**181 (5%)**	**Entomology**	**278 (8%)**
J. Anderson	22	L. Bledsoe	3
J. Camberato	32	B. Brown	3
S. Conley	7	J. Faghihi	8
G. Hardebeck[2]	30	R. Foster	9
K. Johnson	36	**T. Gibb**	153
R. Nielsen	20	C. Krupke	1
B. Portwood	26	J. Loven	2
Z. Reicher	8	J. Obermeyer	10
		C. Sadof	89
Botany & Plant Pathology	**2905 (80%)**		
J. Beckerman	11	**Horticulture & Landscape Architecture**	**124 (3%)**
C. Britton	2	B. Bordelon	5
G. Buechley	24	M. Dana	66
L. Dunkle	1	P. Hirst	2
D. Egel	2	**R. Lerner**	24
L. Johal	821[3]	R. Lopez	1
R. Latin	15	E. Maynard	1
C. Lembi	12	M. Mickelbart	21
G. Nice	91	S. Weller	4
K. Rane	561		
G. Ruhl	1298[4]	**Student Workers**	**137 (4%)**
G. Shaner	27	C. Fuhs	104[3]
C. Speers	36	D. Patterson	33[3]
I. Thompson	3		
M. A. Webb	1	**Other**	**5 (<1%)**
		E. Christmas, Ret. Fac. AGRY	1
		C. Gunter, Horticulture-SWPAC	2
		L. Levy, USDA	1
		R. Williams, FNR	1
		Total Diagnoses	**3630**

[1] The total number of diagnoses exceeds the total number of samples due to multiple problems/diagnoses per sample. More than one person may assist with a diagnosis.
[2] Names in bold type were designated by departments as 2007 P&PDL diagnosticians.
[3] Diagnoses were for Asian soybean rust sentinel plots only.
[4] 431 additional sample diagnoses were provided for *P. ramorum* nursery survey samples

ADVISORY COMMITTEES

The inter-departmental nature of the P&PDL demands frequent and free-flowing exchange of information among the participating departments. This communication takes place on at least three different levels.

The Steering Committee

The Steering Committee provides a forum to discuss matters that relate to the daily operation of the P&PDL. Input from the diagnosticians is considered essential for smooth functioning of the Lab. The Committee meets as needed and reports periodically to the Operations Committee. The Committee is chaired by the Co-Directors of the P&PDL and is composed of diagnosticians, the Extension Administrative Professional and the P&PDL secretary.

The Operations Committee

The Operations Committee provides a forum for discussion of operational matters and facilitates communication among diagnosticians and other specialists. The Committee meets as needed and reports periodically to the Management and Policy Committee. The Committee is chaired by the Co-Directors of the P&PDL and is composed of the Steering Committee, one Extension specialist from each participating department and the Department Head charged with administrative overview of the laboratory. Departmental Extension Specialists are appointed on a three-year rotating basis.

The Management and Policy Committee

The Management and Policy Committee provides administrative overview for the P&PDL. The Committee is composed of the Heads of the participating Departments and administrators from the Cooperative Extension Service and the Agricultural Experiment Station, and the Co-Directors of the P&PDL. The Committee is chaired by the P&PDL Co-Directors. The Committee meets as needed.

2007 COMMITTEE STRUCTURE

The Steering Committee: Gail Ruhl (Co-Chair, Co-Director of P&PDL; plant disease diagnosis and control), Karen Rane (Co-Chair, Co-Director of P&PDL; plant disease diagnosis and control), Glenn Nice (Weed identification and control, and diagnosis of herbicide injury on field crops), Tim Gibb and Cliff Sadof (Arthropod identification and control), B. Rosie Lerner (Identification of horticultural plants), Bob Nielsen (Fertility and soil-related problems of corn), Zac Reicher and Glenn Hardebeck (Turfgrass management), Rita McKenzie (Forestry), Bob Mitchell (Database programming, web page management and computer support), Janet Whaley (Receptionist and accounts), Amy Deitrich (Webmaster and Extension Administrative Professional)

The Operations Committee: Gail Ruhl and Karen Rane (Chairs, Co-Directors of P&PDL), Steering Committee members, Peter Goldsbrough (Head, Department of Botany and Plant Pathology) (administrative overview), Keith Johnson (Agronomy), Greg Shaner (Botany and Plant Pathology), Rick Foster (Entomology), Rita McKenzie (Forestry and Natural Resources), Mike Dana (Horticulture and Landscape Architecture)

The Management and Policy Committee: Gail Ruhl and Karen Rane (P&PDL Co-Chairs, Co-Directors), Chuck Hibberd (Director of CES & Agriculture and Natural Resources), Tom Jordan

(Assistant Director of CES & Agriculture and Natural Resources), Marshall Martin (Associate Director of Agriculture Research Programs), Craig Beyrouty (Head, Department of Agronomy), Peter Goldsbrough (Head, Department of Botany and Plant Pathology), Steve Yaninek (Head, Department of Entomology), Bob Jolly (Head, Department of Horticulture), Robert Swihart (Head, Department of Forestry and Natural Resources), and Gail Ruhl and Karen Rane (Chairs, Co-Directors of P&PDL)

LABORATORY OPERATIONS

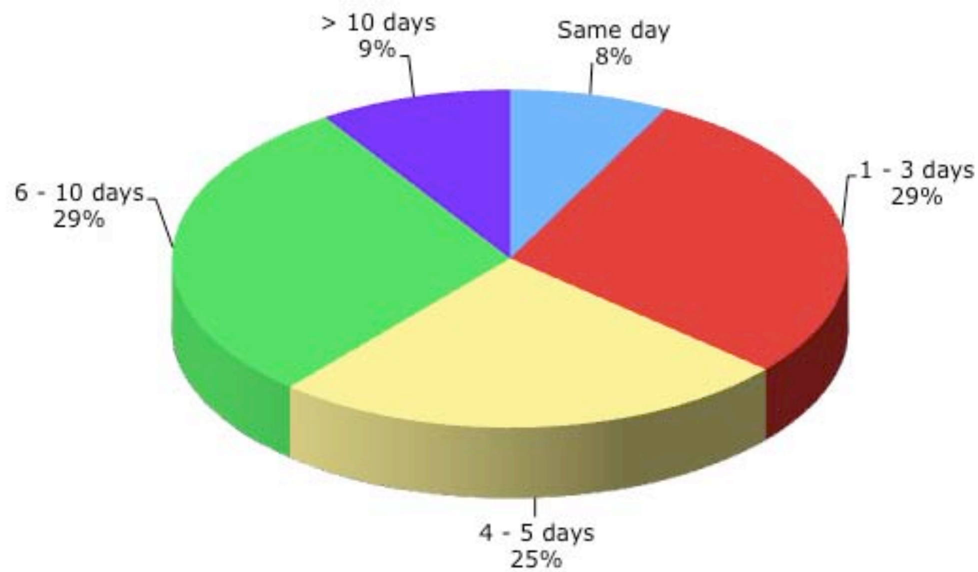
County offices of the Cooperative Extension Service (CES) are provided with a supply of sample submission forms, alcohol vials and mailing boxes to facilitate the submission of plant specimens and insects to the P&PDL. Submission forms are available online and may be downloaded from the P&PDL web page. Completed submission forms are to accompany all sample submissions. Digital images may be submitted, from the P&PDL web page (http://www.ppdl.purdue.edu).

Diagnosis Process

Information from the sample submission form is logged into the P&PDL computer database as well as the NPDN Plant Diagnostic Information System (PDIS), and the sample is assigned a unique number in both databases. Samples are then distributed to the appropriate diagnostician. If the diagnosis requires pathogen isolation or some other lengthy procedure (determined by the diagnostician), a preliminary reply, including a tentative diagnosis and projected final completion date, is returned to the client. When the diagnosis has been completed the identification and management recommendations (when requested) are entered into the database, printed, and the final response along with any supporting information is returned to the client and/or submitter via electronic mail and/or FAX, and US mail (as requested by the submitter on the submission form).

Turn-around time
Turn-around time is the length of time between when a sample is received and when the final diagnosis is returned. Same day service was provided for 8% of the samples received during 2007 and 37% of the samples were completed in three days or less. A total of 62% of the samples received during 2007 were diagnosed within five working days and 91% of all samples received were answered within 10 working days. An extended turn-around time of greater than 10 days (9% of samples) was documented for those samples requiring more extensive culture work and laboratory testing **(Figure 1)**. Preliminary reports were sent for samples requiring additional time for pathogen confirmation.

Figure 1. Turn around time for routine samples received in 2007*



*Excludes *P. ramorum* National Nursery Survey, NAPIS survey, Phytosanitary inspection, and Asian Soybean Rust sentinel samples

Sample Breakdown

As per Table 2, approximately four percent (97) of the total number of routine samples diagnosed by P&PDL diagnosticians in 2007 were submitted electronically, as digital samples. In addition to the 1366 routine samples diagnosed, 431 nursery samples were tested for the presence of *Phytophthora ramorum* as part of the Sudden Oak Death (Ramorum blight) National Survey. A total of 86 corn and soybean samples were submitted for disease diagnosis for phytosanitary certification (ICIA and IDNR) and 68 additional corn samples were submitted for disease diagnosis to contribute to the collection of Indiana data for the NAPIS database.

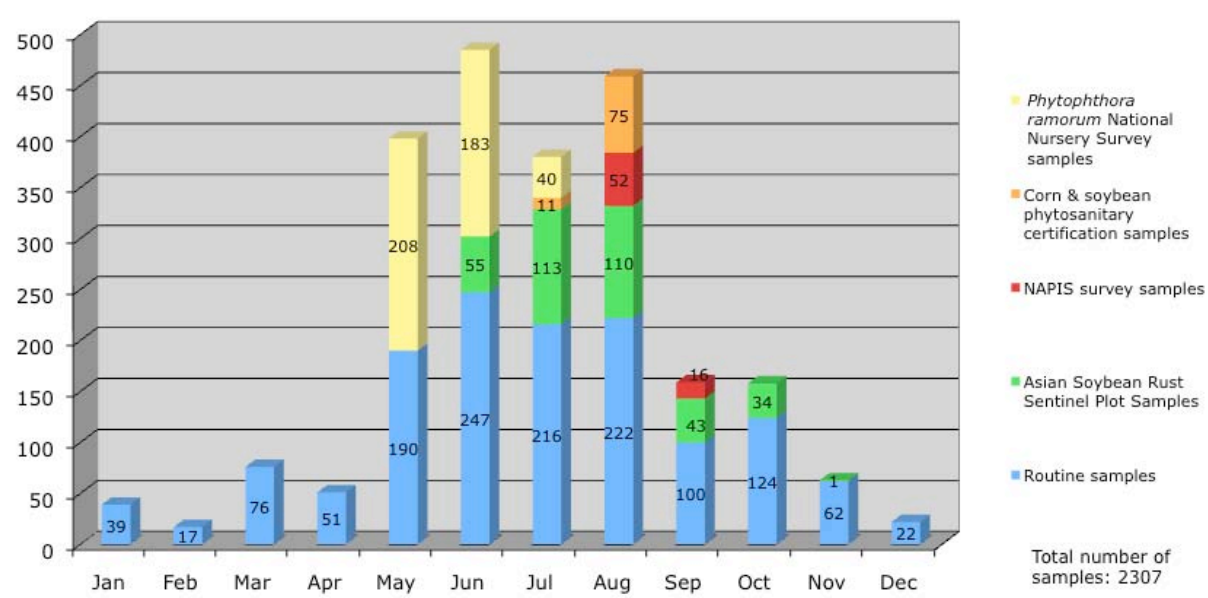
Table 2. Breakdown of total samples for 2007	
Routine samples	**1366**
Physical samples	*1269*
Digital samples	*67*
Digital samples with physical follow-up	*30*
Regulatory/survey samples	**941**
Asian Soybean Rust sentinel samples	*356*
P. ramorum national survey samples	*431*
Phytosanitary certification samples (IDNR/ICIA)	*86*
NAPIS corn survey	*68*
Total number of samples	**2,307**

Diagnoses and Samples

Monthly Activity

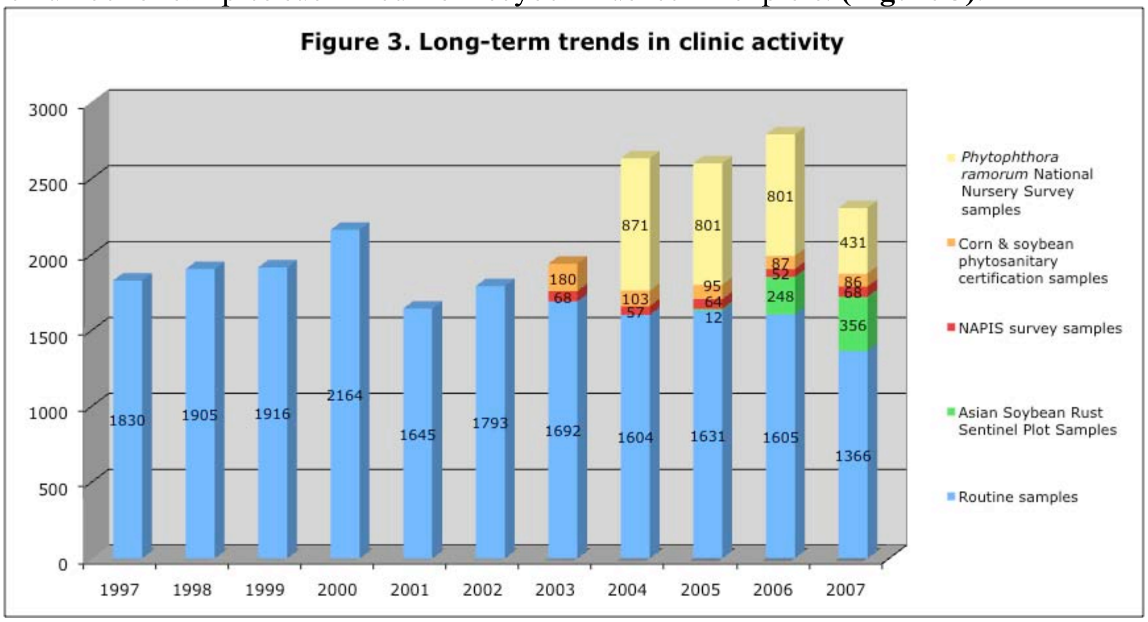
During 2007, the Laboratory diagnosed a total of 1366 routine samples. As illustrated in Figure 2, almost half of the year's routine samples were processed in the lab during the three months of June, July and August. The majority of the 2007 *Phytophthora ramorum* National Nursery Survey samples were submitted during May for diagnosis of the presence or absence of *P. ramorum*, the causal agent of Ramorum blight. During the months of July and August, ICIA and IDNR field inspectors submitted corn and soybean foliar samples to the P&PDL for disease diagnosis required for phytosanitary certification of seed. Corn samples were submitted in August and September for collection of NAPIS information.

Figure 2. Number of samples received per month in 2007



Long-Term Trends

Routine sample submissions have remained relatively stable for the past nine years. In 2007, the extended drought conditions and subsequent lack of favorable conditions for disease development correlate with a slight reduction in routine sample submissions. The reduction in *Phytophthora ramorum* National Nursery Survey Sample submissions was due to a change in collection protocol (40 samples per nursery no longer required). There was, however, an increase in the number of samples submitted from soybean rust sentinel plots. **(Figure 3)**.



Commodities Diagnosed

Figure 4 and **Table 3** show the number of specimens submitted in each commodity group, for 2007. The majority of samples submitted for diagnosis (47%) were from the ornamentals commodity group. In descending order, agronomic crops (28%), vegetables (6%), turfgrass/yard (5%), and insects infesting homes and other buildings (5%) comprised the other major commodities submitted for routine diagnosis. Several other minor commodity groups comprised the remaining 9% of the submitted samples **(Figure 4** and **Table 3)**.

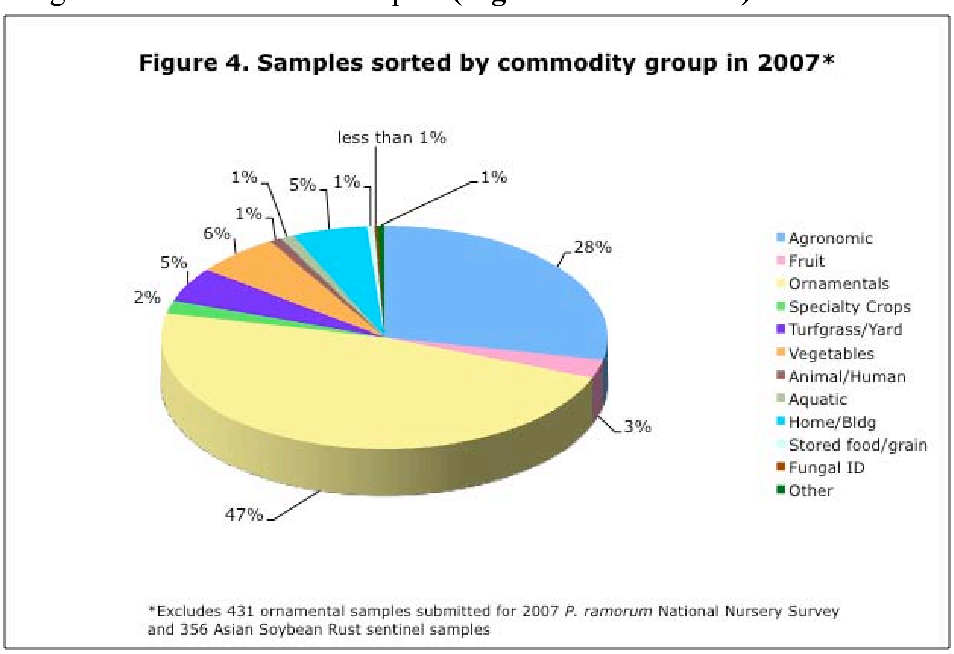


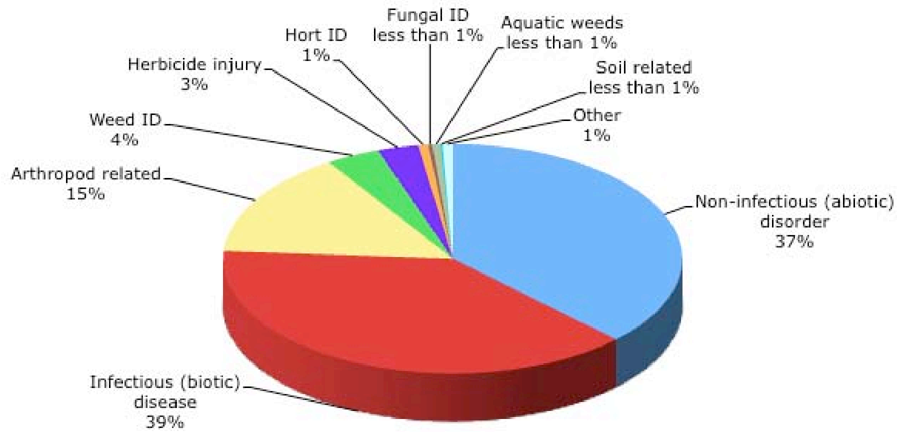
Table 3. Samples sorted by commodity group[1]

	2007	
Commodity	**Number of Specimens**	**%[2]**
Agronomic	**430**	**28**
Alfalfa	7	*
Corn	236	16
Forage	1	*
Pasture	14	1
Plant ID	15	1
Sorghum	2	*
Soybeans	80	8
Wheat	37	2
Fruit	**40**	**3**
Small Fruit	15	1
Tree Fruit	25	2
Ornamentals	**722**	**47**
Flowers	213	14
Grnd Cvrs/Vines	21	1
Interior Plants	14	1
Shrubs	128	8
Trees	346	23
Specialty Crops	**29**	**2**
Field	9	1
Hort	20	1
Turfgrass/Yard	**76**	**5**
Vegetables	**93**	**6**
Miscellaneous	**130**	**9**
Animal/Human	13	1
Aquatic	15	1
Home/Bldg	83	5
Stored Foods/Grains	8	*
Fungal ID	3	*
Other	8	*
Total Specimens	**1520**	**100**

[1] Excludes 431 ornamental samples submitted for 2007 *P. ramorum* National Nursery Survey and 356 samples submitted for Asian soybean rust sentinel plots
[2] Percent of total samples submitted during the year
* Less than 1%

Type of Diagnosis
Many of the 2007 samples received multiple diagnoses due to the presence of more than one causal agent. The most frequently diagnosed group of causal agents, determined by the type of diagnoses made, were infectious diseases (39%), followed by noninfectious (abiotic) disorders (37%), arthropods (15%), and weeds (5%). Herbicide injury, horticultural and fungal ID, and soil related problem diagnoses each comprised 4% or less of the primary diagnoses of samples submitted in 2007 **(Figure 5)**.

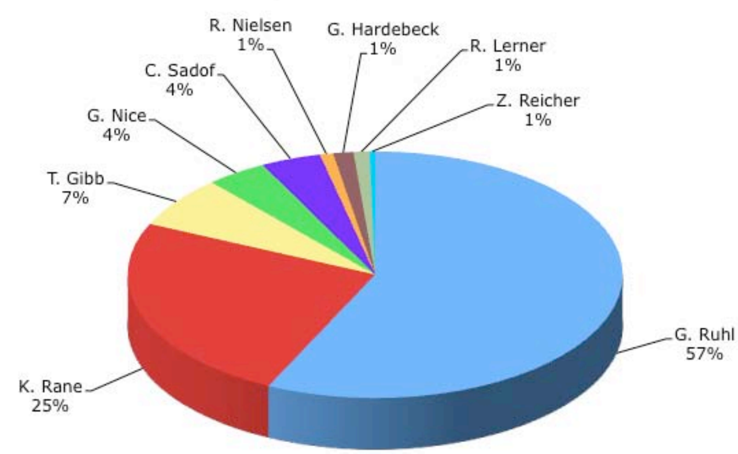
Figure 5. Proportion of primary diagnoses of samples submitted in 2007*



*Excludes 431 ornamental samples submitted for 2007 *P. ramorum* National Nursery Survey and 356 Asian Soybean Rust sentinel samples

Diagnoses per Diagnostician
A comparison of the proportion of total 2007 diagnoses of routine (non-survey) samples made according to diagnostician is given in **Figure 6**.

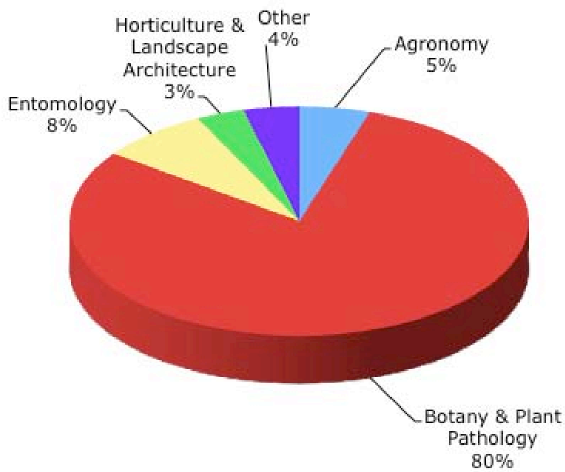
Figure 6. Percentage of diagnoses made by each P&PDL diagnostician in 2007*



*Excludes 431 ornamental samples submitted for 2007 *P. ramorum* National Nursery Survey

Diagnoses per Department
A comparison of the proportion of total 2007 diagnoses made according to participating departments is shown in **Figure 7**. The faculty and staff in the Department of Botany & Plant Pathology diagnosed the majority (80%) of samples.

Figure 7. Proportion of total diagnoses made by faculty and staff in participating departments in 2007*



*Excludes 431 ornamental samples submitted for 2007 *P. ramorum* National Nursery Survey

SAMPLE ORIGIN

Clientele Groups

Samples are submitted to the P&PDL by commercial and non-commercial clientele as well as by IDNR/USDA/APHIS personnel for regulatory and survey work **(Table 4).**

Table 4. Affiliation of persons submitting samples to the P&PDL in 2007[1]

Affiliation	**Number of samples**	**%**
Commercial	**837**	**44**
Consultant	87	5
Dealer/Industry Rep	227	12
Garden Center	6	*
Golf Course	16	1
Greenhouse	149	8
Growers – Agronomic	18	1
Growers – Fruit/Vegetables	21	1
Growers – Ornamentals/Turf	5	*
Landscaper	37	2
Lawn/Tree Care[2]	148	8
Nursery	62	3
Pest Control	61	3
Non-Commercial	**747**	**42**
Extension Educator	386	21
Homeowner	135	7
Purdue – not Educator	226	12
Other	32	2
Regulatory/Survey	**260**	**14**
ICIA	138	7
IDNR	82	5
State Chemist	40	2
Totals	**1876**	**100**

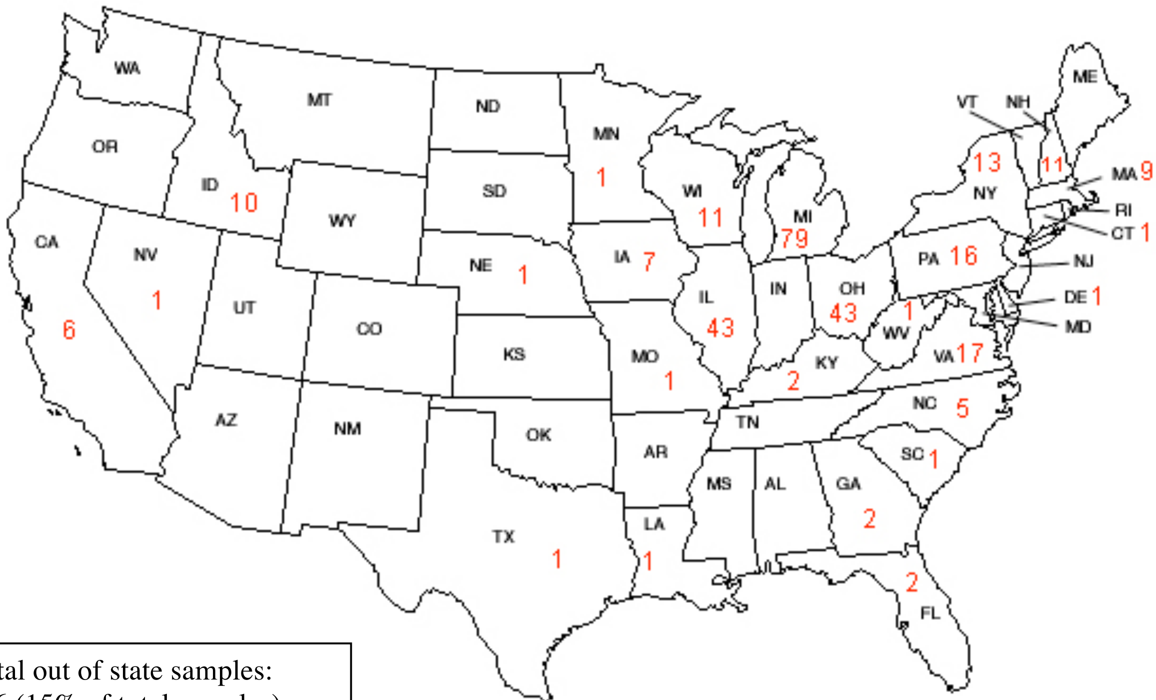
[1] Excludes 431 ornamental samples submitted for 2007 *P. ramorum* National Nursery Survey

[2] Includes lawn/tree care companies and museum/park grounds departments

* Less than 1%

Out of State Submissions
The Laboratory was established to serve residents of Indiana, however, due to the P&PDL's national reputation, diagnostic services were also provided for 286 samples (21% of total routine samples) submitted from 26 other states during 2007*.

Figure 8. Distribution of samples received from outside Indiana by the Plant and Pest Diagnostic Laboratory in 2007.



Total out of state samples:
286 (15% of total samples)

* The P&PDL has a permit issued by USDA/APHIS/PPQ to receive out-of-state samples for diagnosis from the lower 48 states. No out-of-country samples are accepted.

AN INFORMATION SOURCE

The P&PDL staff not only provide accurate and timely diagnosis of samples, but also serve as a resource of information for plant and pest-related problems. The team cooperates with university personnel to provide accurate and up-to-date information to clientele.

Webpage

The Virtual Plant and Pest Diagnostic Laboratory, the P&PDL World Wide Web Home Page, (URL: http://www.ppdl.purdue.edu) was put "on-line" in June of 1995. The web server, now maintained by Bob Mitchell, IT manager for the Department of Botany and Plant Pathology and Amy Deitrich as webmaster, serves as an invaluable educational tool accessible not only to the citizens of Indiana, but people throughout the United States and the world. The P&PDL web site provides information and links on species invasive to Indiana, up to date soybean rust information, a "Picture of the Week," information on "What's Hot" in the P&PDL, and many featured links. There is a keyword searchable database, a digital library and a link for submitting digital samples to the P&PDL. Web server statistics for the Plant and Pest Diagnostic Laboratory reported an average of 17,676 requests per day for P&PDL web pages from January 1 through December 31, 2007 – **up 5,000 'hits' from 2006.**

Extension Activities

P&PDL staff members participate in a variety of Purdue University sponsored events and first detector educational programs. Some of these programs in 2007 included Master Gardener Training, Turf and Ornamentals Workshops, Arborist training, ANR educator hands-on training, IDNR Nursery Inspector *P. ramorum* Survey Training and training of IDNR and Indiana Crop Improvement Association (ICIA) inspectors for Phytosanitary Field Inspection of corn and soybeans.

Plant Disease Diagnostic Discoveries

Phytophthora citricola, a serious canker disease of European Beech, was confirmed in Indiana by Gail Ruhl, Senior Plant Disease Diagnostician. The fungal-like pathogen was isolated from a 100 year old European Beech in Lafayette, Indiana. Species identification was confirmed by Angela Nelson, a graduate student of Dr. George Hudler, Cornell University. Dr. Hudler noted that this first report for Indiana is the farthest west confirmation of this disease.

Southern Wilt, caused by *Ralstonia solanacearum* was confirmed by Gail Ruhl, Senior Plant Disease Diagnostician, on a host not previously reported. The bacterium was isolated from Mandevilla (Dipladenia) and as per protocol for a suspect select agent, was sent to Beltsville for Race/Biovar confirmation. The bacterium was identified via PCR and advanced carbohydrate utilization testing as *Ralstonia solanacearum* (Biovar 3). This is a new record for North America.

Appendix A: Commodity Related Summaries

Agronomic Insects, *Larry Bledsoe, Department of Entomology*

Primary crop pests in 2007 were corn rootworm and soybean aphid. Second stage western corn rootworm, *Diabrotica virgifera*, (WCR) larvae were first detected in Tippecanoe County in corn roots on 23 May. First stage larvae were likely present by 18 May. This emergence estimate was about 10 days earlier than observed in 2006 and was probably related to the warm spring temperatures. WCR adults were first detected in emergence traps in northwest Indiana in late June. WCR adult abundance was average. The variant WCR was still a primary concern in counties north of Indianapolis. The incidence of first and second-generation European corn borer, *Ostrinia nubilalis*, (ECB) infestations followed the pattern of decline observed for several years. The pervasive use of ECB-resistant corn hybrids has markedly diminished the pest status of this insect.

Soybean aphid, *Aphis glycines*, (SBA) abundance in the fall of 2006 was abnormally high which suggested a potential outbreak in 2007. The host plant, *Rhamnus cathartica* and SBA broke dormancy during the abnormal warm March temperatures. This was followed by extreme cold in early April. SBA surveys conducted before and after the aberrant weather suggested that the SBA population in northern Indiana had diminished greatly from the levels detected in the previous fall. The abnormally hot late summer temperatures were associated with reduced SBA fecundity and/or increased mortality. Natural control agents may also be adjusting to the presence of SBA and contributing to the stabilization of regional populations. Very few localized SBA outbreaks occurred requiring pesticide application. Japanese beetle, *Popillia japonica*, adult and larval injury to field crops was very localized and the overall impact was minimal.

Corn earworm, *Helicoverpa zea*, adults were present in high numbers late in the season, however, only trivial injury to field corn was reported. Alfalfa weevil, *Hypera postica*, injury to alfalfa was moderated by the below freezing temperatures that occurred in early April and never recovered to significant pest status.

Potato leafhopper, *Emposaca fabae*, injury tended to be severe at midsummer in areas where droughty conditions reduced alfalfa growth and recovery. Several new crop pests reached levels in Indiana in 2007 that warranted greater consideration. The western bean cutworm, *Striacosta albicosta*, became more prominent in field corn in several north-central and northwestern counties. The level of infestation of corn ears was reported to range from trivial to a few reports of about 25% in localized areas of fields. Asiatic garden beetle, *Maladera castanea*, larvae were found to be damaging corn roots in very localized areas within fields with sandy soils in several northeast counties.

Insects on Fruit, *Rick Foster, Department of Entomology*

The most important factor affecting insect activity in fruit and insect management decisions in 2007 was the weather. The problem was that it was both hotter than normal and colder than normal in the same year. The early heat and the Easter freeze caused short crops, which had dramatic effects on insect management decisions. The hot weather during most of the season changed the timing of the appearance of a number of insects and prolonged the time when the pests needed to be managed.

For example, potato leafhoppers, which migrate from the South each year, showed up at least 2 weeks earlier than usual. This meant that many crops did not have as much leaf area at the time of their arrival, and the possibility for damage was increased. Japanese beetles usually emerge in the Lafayette area around June 20. In 2007, the first beetles were observed on June 3, and fully 2 weeks earlier than normal. It also appeared that Japanese beetle populations dwindled earlier than normal.

Codling moth usually has two generations in most of the state in most years, with at least a partial 3rd generation in the southern part of the state or in warmer than normal years. In 2007, I think it is fair to say that we had a 3rd generation throughout the state. At Lafayette, it appears that the 3rd generation peaked around September 10. That allowed plenty of opportunity for damage in varieties that matured after that date.

Given the hot weather, I expected that we would have a lot of problems with mites. However, not too many growers reported problems. I attribute this to two factors: the good mite management chemicals that we have available today, and good mite management skills exhibited by our growers.

Plant Pathology, *Janna Beckerman, Department of Botany & Plant Pathology*

This was a year only a plant pathologist could love. I think I said that last year, but I really, really mean it for this year. The year began with a warm streak of 90+ degrees F in March, only to have a freeze a few weeks later, in April. The Easter Freeze of 2007 wasn't any old freeze: nighttime temperatures hovered around 20 degrees for up to five straight days. For almost 2/3 of the state, we predicted tremendous loss of apples, peaches, and grapes. Although our predictions were accurate with respect to the peaches, curiously, the losses weren't as bad as we anticipated on grapes or apples, but they were still pretty devastating. Despite the potential loss of crops, disease management, particularly for fire blight, became a key issue, and remains a key issue for next year as well. Freeze injury, much like hail injury, results in damage to young and succulent shoots and leaves, providing a means for the fire blight bacterium to cause shoot blight. The only redeeming feature of the subsequent drought that occurred over most of the state is that it prevented a perfect storm of fire blight.

Fire blight wasn't the only problem that resulted from the freeze - or the drought. Physiological stresses, especially drought stress, or possibly freeze damage, predispose trees to cankers caused by Botryosphaeria. This uptick in disease incidence may be just one more side effect of our spring freeze coupled with drought. As we head into winter, careful observation of trees for cankers as a source of inoculum should be high on every growers list to mark for spring pruning and removal! This is something that can be done on a nice fall day, by walking the rows with a handy can of spray paint in a bright, obvious color. This scouting can also be done with scouting for fire blight. Symptoms are more obvious right now, than in the spring. Besides, do you really want to spend twice as much time out in the orchard in February, when the weather isn't nice, looking for branches to remove, or would you just like to head out there and begin pruning?

Botryosphaeria, like many plant pathogens, creates a management dilemma: By the time you find the problem it is too late to do anything for this year. However, sanitation in the form of mummy clean-up and cankered limb removal is something to consider during spring pruning. Apples that are mummified due to chemical thinning, or fire blighted twigs, serve as an easy site of colonization. Piles of prunings are another important reservoir of this disease. Prunings can be left if they are debarked during any sort of flail mowing. Otherwise, haul them away or burn them.

Last but not least, if freeze damage, drought damage, fire blight, and Botryosphaeria haven't brought a smile to your face, at least it was a bad year for scab, right? Wrong! Even though scab in the orchard wasn't a huge issue (especially if you didn't have a crop), a new race of scab was found in North America, at the Purdue Hort Farm, that has the potential to profoundly impact organic, or low spray apples in North America. In May, Ryan Deford and I found scab on Malus floribunda 821 in the Old Hort Farm. M.f. 821 serves as the resistant parent for almost all of the scab resistant varieties like 'Williams' Pride', 'Enterprise', 'Prima', 'Priscilla', 'Scarlett O'Hara', and 'GoldRush.' Fortunately, continued monitoring of this orchard has NOT revealed scab on these cultivars to date. Our preliminary data suggests we've identified a new race of the pathogen. We'll keep you posted.

Although it is impossible to predict the outcome with this new race of scab, I would state that as of right now, the other shoe hasn't dropped-yet. However, for organic or sustainable apple production, it is essential to rigorously apply fungicides to prevent primary infection during key scab periods in spring 2008 when the weather is cool and wet, while the tissue is young and susceptible to infection. The simple, but conscientious application of one to three sprays to prevent primary infection in the spring should keep resistant cultivars free of scab for the entire season. To date, these minimal, or organic practices to control other diseases like powdery mildew and cedar-apple rust may have contributed to the preservation of scab resistance in these lines.

Small Fruits, *Bruce Bordelon, Department of Horticulture & Landscape Architecture*

The 2006-07 winter was slightly warmer than normal and winter injury to small fruit and grapes was minor. Coldest temperatures occurred early to mid-February and ranged from 0 in southern, to -12°F in northern Indiana. Despite the mild winter, cold injury was a major issue for this growing season. The Midwest experienced a very warm March followed by the "Easter Freeze" in early April. Most small fruit crops were damaged severely by 3 to 4 days of freezing temperatures. Brambles suffered essentially 100% losses in southern Indiana, and up to 50% in northern areas. Blueberry damage was similar with complete losses in southern Indiana, but only 40% losses in the major growing region of northern Indiana. Strawberries were hurt in southern areas, but still managed to produce a good crop. Grapes were damaged severely across the southern part of the state where shoots were between 1 and 6 inches long on most varieties at the time of the freeze. All exposed shoots were killed, so the 2007 crop was borne on secondary shoots in these areas. In most cases the secondary shoots were very fruitful, and yields were not off significantly. In central and northern Indiana only early varieties were past bud break at the time of the freeze so damage was limited to those varieties. Yields were nearly normal for the rest of the varieties. In areas where primary shoots were damaged, growers did not have to thin clusters to adjust yields as would be the normal practice.

The summer months were hot and very dry. Growing degree day accumulation was about 25% above average. Rainfall was about 75% of normal in central Indiana, and less than 50% of normal in southeast Indiana. Some parts of northern Indiana had over 10 inches of rainfall in August that nullified an otherwise dry summer. Fungal disease pressure was minimal due to the dry conditions. Powdery mildew was a problem for some grape growers, especially on vinifera varieties. Grape harvest dates were about normal for early grape varieties, but the season was compressed with many of the mid and late season varieties harvested 7-14 days earlier than normal. Blueberries, brambles and strawberries were also early.

Tree Fruits, *Peter Hirst, Department of Horticulture & Landscape Architecture*

There were two big stories this year in terms of weather. The first was the spring freeze on April 6-8 that saw temperatures drop to 20-25°F resulting in severe damage to many flowering fruit crops across the state. The cold temperatures were only part of the problem. Contributing to the damage were warm temperatures experienced in many parts of the state during March. These warm temperatures accelerated crop development, pushing trees into a more vulnerable stage earlier than normal. So at the time the frost hit, apples were in bloom and were among the most affected crops. Bloom is generally the most frost-tender stage of development. The temperature is only one factor that determines the amount of damage. Another important factor is the duration of the cold. The freeze that hit us this year was unusual in that it lasted so long - many hours to several days. The fact it lasted so long no doubt contributed to the widespread damage we saw. Some growers were completely wiped out while others escaped with minimal loss. Over the whole state, the apple crop was about 50% of normal.

The other unusual event this year was a lack of rain. It seems that the drought took hold earlier in more southern parts of the state, and in fact some more northern areas received more rain than normal. In Vincennes the drought was apparent from early spring, and intensified over the season. During the fall, the total rain received for the year was 15" down on the normal amount of rainfall. In more northern areas like Plymouth, rainfall was about normal for much of the year then slightly above normal during the fall.

Summer temperatures were about normal for much of the state, but the warm summer temperatures remained for much of the fall, leading to some problems with coloring of early apple varieties. This was especially apparent in more southern areas.

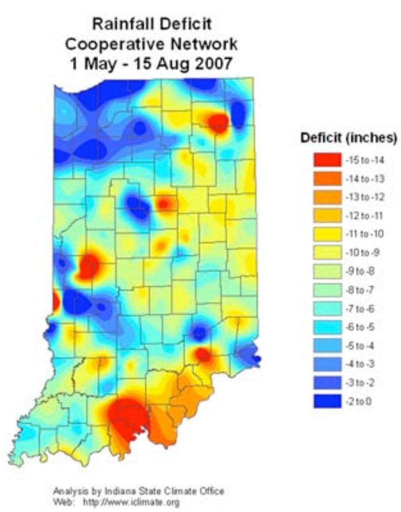
Fruit quality was mostly good this year, although some growers experienced some severe problems with bitter pit. Lighter crops from the cold blast in the spring, and dry summer conditions set the stage for these problems. Bitter pit will be addressed at the Hort Congress in January by Dr. Chris Watkins of Cornell University, one of the leading authorities on the disorder.

Vegetable Diseases, *Dan Egel, SWPAC, Department of Botany & Plant Pathology*

Hot and dry will be how most growers remember the 2007-growing season. May in particular was one of the hottest and driest on record (Table 1). August brought scattered rains, but a renewal of hot temperatures. Some areas of Indiana remained dry throughout most of the growing season-this is particularly true of south-central Indiana (See map).

Table 1: The Indiana monthly precipitation and temperature data for May through September and the rank of each period out of the 112-year average.						
	Precipitation			**Temperature**		
Month	**2007**	**112 yr. average**	**Rank**	**2007**	**112 yr. average**	**Rank**
May	1.83	4.22	9	66.1	61.55	102
June	3.27	4.06	35	72.0	70.68	82
July	3.29	3.86	42	71.7	74.66	7
August	3.80	3.52	77	76.8	72.94	106
September	2.38	3.26	36	69.1	66.05	95
May-September	2.91	3.78	39.8	71.1	69.18	78.4

The weather pattern described above produced difficult growing conditions for most vegetable producers. At the same time, the lack of moisture was correlated with relatively low amounts of foliar disease compared to most years. The foliar diseases that were not severe because of the low rainfall include early blight of tomato, gummy stem blight of watermelon and Phytophthora blight of pumpkin. Powdery mildew of pumpkin is a foliar disease that does not require leaf wetness-it was widely observed in Indiana in 2007.



Diseases that do not require leaf wetness were unaffected by the relatively dry weather. These diseases were at normal levels this year and include Fusarium wilt of watermelon and mosaic (Poty) viruses of pumpkin.

Although foliar diseases that require leaf wetness were not severe in 2007, soilborne diseases such as Fusarium wilt of watermelon (left) and viruses vectored by aphids such as pumpkin mosaic viruses (right) remained common.

Recent rains will help to replenish aquifers. Although this will help growers that are able to irrigate their crops, many Indiana vegetable growers are not able to irrigate.

Weed Science, *Glenn Nice, Weed Diagnostician, Botany & Plant Pathology*
Bill Johnson, Assistant Professor, Botany & Plant Pathology

Growth Regulator Injury and Drift. In 2007, 91 samples were diagnosed by the Weed Science Team. Of these 91 samples, 61 (67%) had symptoms that were characteristic of injury induced by the growth regulator (also known as the synthetic auxins - Group 1 herbicides) family of herbicides. The growth regulator herbicides are herbicides that have activity predominantly on the broadleaf group of plants; however, in rare circumstances or if used improperly, this family of herbicides can cause injury to grass plants such as corn. As the name 'growth regulator' herbicide suggests, these herbicides mimic plant growth hormones causing abnormalities in growth. These abnormalities interfere with the plant's vascular tissues, disrupting the flow of water and nutrients in the plant. These herbicides are labeled in corn, pasture, right-of-ways (roads, railway, hydro lines), and lawns. This family of herbicides includes the products 2,4-D, Banvel, Clarity, Crossbow, Stinger, and many more. For a more complete list of herbicides in this family please see 'Herbicide Families for Corn and Soybean[1]'. The symptoms tend to be similar across the herbicides in this family.

Sensitive crops include soybean, tomatoes, grapes, and several trees and ornamental plants. Symptoms in soybean include 'cupping' and 'strapping' of leaves, stunting of the soybean plant, and misshapen pods and twisting of stems and petioles. For images and descriptions of growth regulator injury to soybean see the University of Illinois article 'Plant Growth Regulator Injury to Soybean[2]' or the above mentioned 'Herbicide Families for Corn and Soybean[1]' web page. These symptoms are not uncommon in Indiana's growing season. Growth regulator herbicides can come in contact with soybean in three ways; through particle drift, vapor drift, or tank contamination.

To complicate matters, other factors may cause similar symptoms that, at first glance, look similar to growth regulator injury. Virus diseases such as bean pod mottle virus, soybean mosaic virus, and soybean dwarf virus can cause soybean leaves to appear puckered, cup-shaped, and mottled in color. These symptoms are often difficult to distinguish from growth regulator type injury. During stressful environmental conditions for soybean, postemergence applications have been identified as a possible causes of growth regulator type symptoms. The causes of leaf distortion are not always textbook clear and diagnosis is difficult. However, in many cases, a growth regulator herbicide is often involved.

Resistant Weeds in the State of Indiana. Development of herbicide-resistant weed populations results from over dependence on a specific herbicide mode of action. Triazine or ALS resistance in weeds is expressed at high levels in plants, which usually means that field use rates will have little or no effect on resistant plants while susceptible plants will be killed. Thus, it is usually fairly obvious when resistant populations develop in a field, and as a result, the use of specific products becomes obsolete in controlling the specific herbicide-resistant weed. However, glyphosate resistance is typically expressed at much lower levels, and in many instances poor application techniques or low rates are considered the primary cause of poor weed control with glyphosate. However, detailed greenhouse and field investigations by University researchers across the U.S. have shown that there are indeed a number of weeds that have evolved low levels of glyphosate resistance and we can no longer blame poor application techniques on all cases of poor weed control with glyphosate. In Indiana we have confirmed glyphosate-resistant horseweed (aka marestail) and giant ragweed. We have strong suspicions that there are populations of common ragweed that have developed resistance to glyphosate. A number of other weeds are routinely problematic to control with glyphosate and those include common lambsquarter, common waterhemp, and morningglories.

Glyphosate-resistant horseweed has been documented in most Midwestern states that grow soybean and corn. The first documented case of glyphosate-resistant (GR) horseweed was found in Delaware following two years of exclusive glyphosate use for preplant and in crop weed control in glyphosate-resistant soybeans. In Indiana, glyphosate-resistant horseweed was first noticed in southeast Indiana, where continuous soybeans are grown more frequently than in other parts of the state. On our main glyphosate-resistant horseweed research site, horseweed which shows a 6 fold level of resistance was documented in 2003. The history of this field was no-till and a corn-soybean rotation with conventional (non-glyphosate) herbicide programs used for postemergence weed control from 1996 to 1999. In 2000 GR soybeans were grown for the first time, and glyphosate was used for burndown and postemergence weed control. In 2001 glyphosate was used for the burndown treatment prior to no-till corn establishment and conventional herbicides were used for postemergence weed control. No-till GR soybeans were then grown in both 2002 and 2003 with glyphosate used as the burndown and postemergence treatments in both years. Thus, there were a total of five glyphosate applications over a three-year period prior to the evolution of GR horseweed at that site. Horseweed is not considered to be highly competitive, but it can affect soybean establishment, yields, and harvest. Several options exist to manage glyphosate-resistant horseweed in soybean. The added cost to control horseweed prior to planting can be relative low for 2,4-D ($2/a) or moderately expensive with Gramoxone plus Sencor ($13/a). However, horseweed with multiple-resistance can evolve. Several counties in Indiana and Ohio have horseweed that is resistant to both glyphosate and ALS-inhibiting herbicides like FirstRate and Classic, which limits that option when growers wish to avoid the plant back time restrictions with preplant applications of 2,4-D or use a tankmix partner with glyphosate after soybeans emerge. When multiple-resistant horseweed exists (glyphosate and ALS), 2,4-D or Gramoxone are basically the only preplant herbicide options to control existing plants other than tillage, and others in crop postemergence soybean herbicides are not effective.

Giant ragweed is one of the most competitive weeds in the Midwest and is a challenge to control even in Roundup Ready crops. Glyphosate-resistant biotypes have been recently confirmed in Ohio and Indiana giant ragweed populations and ALS-inhibitor resistance has been reported in several states. In the first Indiana population, which was document to be glyphosate resistant, the field history included glyphosate-resistant soybeans the last 8 out of 9 years with at least one or two POST glyphosate applications. Giant ragweed is currently managed with burndown glyphosate applications plus one or two in-season glyphosate applications. With evolved glyphosate resistance, PPO- and ALS inhibitor herbicides become the principle options. However, there is a strong likelihood that multiple resistance to glyphosate plus ALS-inhibitor herbicides will evolve, leaving PPO-inhibitor herbicides as the primary remaining option given that preemergence herbicide options are inadequate.

While multiple herbicide resistance increases the challenge to manage specific weed species, the potential also exists for multiple glyphosate-resistant weeds in the same field. Glyphosate-resistant horseweed and giant ragweed have been confirmed in one field where a glyphosate-'tolerant' common lambsquarters is also being investigated. The history of this field included use of non-transgenic corn (i.e. no glyphosate use in corn) and glyphosate-resistant soybean in a 1:1 rotation. The soybeans were grown without tillage and utilized two to three glyphosate applications during the soybean growing seasons for weed control. The soybean weed management program of this field will now require the grower to utilize a soil applied residual herbicide for common lambsquarter control + 2,4-D to control existing giant ragweed and horseweed and higher rates of glyphosate postemergence to effectively protect yield. The result of two glyphosate-resistant weeds and glyphosate-tolerant common lambsquarter resulted in weed control expenses which increased from $18/A to $37/A.

Plant Identification. Of the 91 samples submitted, 30 (33%) involved plant identification. Several plant ID's were requested with regard to veterinary investigations of injured or dead animals. Indiana has several plants that are toxic to animals and humans. For more information on Indiana's toxic plants please see the following Purdue publications; 'Indiana Crop Improvement Association Certified Forage Program Toxic Plant Guide[3]' and 'Indiana Plants Poisonous to Livestock and Pets[4]'. The first publication is presently being revised and will be available in print and on the web in 2008. In some cases, Indiana's toxic plants can find their way into pastures and hay, where, when present in large enough quantities, can cause problems with livestock. For the most part, these plants are inconspicuous bystanders in row crop production, but a few, such as poison hemlock (*Conium maculatum*), pokeweed (*Phytolacca americana*), and the horsetails (*Equisetum spp*.) have had an increased impact. These three plants historically have been problems outside of the row crop field, but with the large adoption of no-till practices and possible environmental changes, these plants have started to invade producers' fields. For information on plants that are toxic to the touch see 'The Don't Touch Me Plants[5].'

Invasive Species. The P&PDL has been identified as a central contact for invasive reports. Thus, in cooperation with the P&PDL and the Indiana Cooperative Agricultural Pest Survey (CAPS) Program, several suspect cases of invasive plants were investigated in 2007. Most cases involved the following three species.

Cutleaf teasel (*Dipsaucus laciniatus*), presently reported in five counties, was a frequently investigated suspected invasive. This teasel is similar to the common teasel that can be found thoughout the state, but can be identified by its white flower and broad bracts. Common teasel's flowers are typically lilac colored. For more information regarding cutleaf teasel see the article 'Cutleaf Teasel[6].'

The second suspect invasive species that was frequently investigated was Chinese yam (*Dioscorea batatas* aka *D. oppositifolia*), also known as air potato. This invasive plant has been reported in 20 Indiana counties. Chinese yam is a vine that can climb or creep across the ground. Its leaves are heart-shaped and have 7 to 9 distinct veins that radiate from the base of the leaf. Its vine-like nature and shape of the leaves can be confused for other weeds. In 2007 several suspect cases reported and investigated were identified as one of the bindweeds (*Calystegia sepium* or *Convolvulus arvensis*). Distinctive characteristics are the small aerial tubers that are produced in the axils of the leaves and the characteristic veins.

The third most investigated suspect invasive in 2007 was Japanese knotweed (*Polygonum cuspidatum*). This perennial is often mistaken for bamboo because, when mature, its stems can get tall and are hollow. Japanese knotweed, however, is a dicot and bamboo is a grass (a monocot). This plant can spread though underground rhizomes that can be up to 30 feet long. Spread of Japanese knotweed is most likely through the movement of soil and plant parts. Seed dispersal is probably not as common for there are male and female plants and both sexes are not usually in close enough proximity for pollination. One such plant produces flowers every year, but does not appear to produce seeds. In communications with landowners who have this plant, introduction appears to be predominantly by the movement of soil and/or by planting it as an ornamental or wind break. For more information on Japanese knotweed please see the article 'Japanese Knotweed (*Polygonum cuspidatum*)[7]'.

Reference articles:

[1]Herbicide Families for Corn and Soybean - [http://www.btny.purdue.edu/weedscience/inj/MOAinjury.html]

[2]Plant Growth Regulator Injury to Soybean -[http://www.ipm.uiuc.edu/bulletin/pdf/PGR.pdf]

[3]Indiana Crop Improvement Association Certified Forage Program Toxic Plant Guide - [http://www.btny.purdue.edu/weedscience/2006/ToxicWeedsCertFor06.pdf]

[4]Indiana Plants Poisonous to Livestock and Pets - [http://www.vet.purdue.edu/depts/addl/toxic/cover1.htm]

[5]The 'Don't Touch Me Plants' - [http://www.btny.purdue.edu/weedscience/2007/DontTouchMePlants.pdf]

[6]Cutleaf Teasel - [http://www.btny.purdue.edu/weedscience/2007/CutleafTeasel07.pdf]

[7] Japanese Knotweed (*Polygonum cuspidatum*) - [http://www.btny.purdue.edu/weedscience/2007/JapaneseKnotweed07.pdf]