Changes In Disease Incidence Over The Last Decade In The US And Around The World, And Research To Address These New Challenges

Thomas J. Gulya[1], Brent Hulke[1], Gerald J. Seiler[1], Samuel Markell[2], and Hans Kandel[3]
[1]USDA-ARS, Northern Crop Science Laboratory, 1605 Albrecht Blvd. N., Fargo, ND, 58102 USA, E-mail: thomas.gulya@ars.usda.gov; brent.hulke@ars.usda.gov; gerald.seiler@ars.usda.gov
[2]North Dakota State University, Department of Plant Pathology, Fargo, ND, 58108 USA, Email: Samuel.Markell@ndsu.edu
[3]North Dakota State University, Department of Plant Science, Fargo, ND, 58108 USA, Email: Hans.Kandel@ndsu.edu

ABSTRACT

- Sunflower diseases were, and continue to be a major challenge to producers and researchers worldwide. Periodic surveys are needed to document changes in pathogens, their distribution and severity, and their impact upon the crop. Newer technologies need to be used, and shared internationally to maximize this information and thus help researchers globally, and not just within individual countries.
- Annual, large scale surveys are conducted in the United States, under the sponsorship of the National Sunflower Association (NSA), which tabulate agronomic practices, yield, diseases, insects and weeds. This data is publically available and is used by both private companies and public researchers to proactively plan research efforts to help make sunflower production profitable by minimizing losses due to diseases, insects and weeds.
- Using data from the NSA surveys, we have observed how some diseases, such as Phomopsis stem canker and red rust, have increased dramatically in the U.S., other diseases such as Sclerotinia head rot and stalk rot have remained relatively constant and significant, and other diseases, such as charcoal rot and Albugo white rust have either been relatively minor or non-existent.
- Sunflower pathogens have continued to evolve new races and/or develop resistance to pesticides, and new pathogens have been identified, creating a repeating challenge to both pathologists, breeders and other researchers. W.E. Sackston, in 1992, likened this never-ending effort to running on a treadmill, and his conclusions are just as valid in the 21st century.
- The combined effort by the NSA, universities, USDA and private companies to annually collect data on diseases, insects and weeds has helped to make U.S. researchers more proactive to deal with emerging problems, and to assign funding to the most important topics. Coordination of this type of annual data collection with researchers in other countries would strengthen the international research effort and make the combined effort synergistic.

Key words: Disease surveys – pathogen identification – sources of disease resistance

INTRODUCTION

Monitoring and documenting the incidence, severity and distribution of plant diseases is a fundamental tool which lays the groundwork for not only understanding the impact of plant diseases on crop production, but also provides a logical means of proactive research planning. For sunflower, one of the pioneering individuals in this area was W.E. Sackston, who not only monitored sunflower diseases in his native Canada, but coordinated international efforts, starting in the 1970's (Sackston, 1978). His efforts were continued for a short while (Acimovic, 1989), but this large-scale, coordinated project was discontinued. There are infrequent instances of a published study documenting diseases in an individual country, or even on an individual disease, but for the most part, there is no continuing effort to publish disease incidence data. Thus, one can find a single account of all sunflower diseases in China (Liu & Li, 1988), Pakistan (Rauf Bhutta et al, 1993) or Romania (Csep, 2007), or a detailed description of downy mildew races in Bulgaria (Shindrova, 2010), but seldom a continuous string of publications documenting changes in all diseases in a given country over time. One notable exception is the example set by Sackston (1959) in Canada, continued by Hoes and Huang (1976), and most recently by Rashid, in which annual surveys are conducted and are available online (Rashid & Desjardins, 2011). In the United States, periodic, but infrequent disease surveys were done (Gulya & MacArthur, 1984, Gulya, 1996) but with a large production area, it was impractical to conduct annual surveys. This changed at the beginning of the 21st century when the National Sunflower Association (NSA) took the initiative to expand their annual yield survey to include data collection on agronomic issues, weeds, insects and diseases (Lamey et al., 2002). This survey has continued since 2001 annually, with the exception of 2004, and has made a significant quantity of information available (http://www.sunflowernsa.com/growers/yield-and-survey/sunflower-crop-survey/), which is used by both public and private researchers.

MATERIALS AND METHODS

In 2001, the National Sunflower Association took the initiative to organize a survey of U.S. sunflower fields across the entire production area, which now encompasses eight states (North Dakota, South Dakota, Minnesota, Nebraska, Colorado, Kansas, Texas and Oklahoma) and also includes the adjacent Canadian province of Manitoba. With the input of University,USDA researchers, and the sunflower industry, a standard methodology was agreed upon, to include (1) weighting the survey to be proportional to the sunflower area within each county and state, (2) a list of the diseases, insects and weeds to be monitored, (3) the exact sampling procedure to be followed, to include the reporting forms to aid in data collation. Details of the initial procedure and subsequent modifications are published (Lamey et al., 2002; Kandel, 2010), and are now available online, to include training videos (http://www.sunflowernsa.com/growers/yield-and-survey/sunflower-crop-survey/). In 2001 only North Dakota (ND) and South Dakota (SD) fields were surveyed, at a rate of 1 field per 2,000 ha of sunflower in a county. This necessitated surveying over 400 fields, so the sampling intensity was decreased to 1 field for every 4,000 ha of sunflower. With the expansion of the survey in subsequent years to include more states, the number of fields sampled per year varies from approximately 150 to 200. Diseases which are monitored include Sclerotinia head rot, stalk rot and mid-stem rot, Phomopsis stem canker, Phoma black stem, Rhizopus head rot, Verticillium wilt, Charcoal rot, downy mildew, red rust (*Puccinia*) and white rust (*Albugo).* Agronomic information is also recorded to include plant population, row spacing, irrigated or dryland, previous crop, tillage type, confection or oilseed, and yield estimates. The teams also assess the most limiting production factor and record the GPS coordinates for each field. Spacial maps are produced for the main factors recorded. The survey is traditionally done in late September at physiological maturity. Survey teams are composed of 3 to 4 individuals who survey an assigned area that can be covered in one day. Thus, as many as 35 teams are assembled each year, and training sessions are held by entomologists, agronomists and pathologists to insure that each survey team can confidently and accurately rate all the weeds, insects and diseases being monitored.

RESULTS

In 2001, the major diseases affecting U.S. sunflower fields in ND and SD were Sclerotinia head and stalk rot, Phomopsis stem canker, rust, and Rhizopus head rot, each found in ~ 30% of surveyed fields. Downy mildew was of minimal consequence with only 1% incidence, as was Verticillium wilt (Table 1).

If one were to skip the intervening years' data and simply look at 2011 data, one would miss the variation apparent in each year. Thus, the incidence of rust was 28% in 2001 and 31% in 2011, which would suggest a stable disease. However, by monitoring disease annually, it is obvious that rust became a significant disease from 2005 through 2009, with over 75% of surveyed fields having rust. Declining incidence of rust in the U.S. is most likely due to increased use of recently registered foliar fungicides and the introduction of more resistant hybrids. Knowledge of weather conditions and management practices is helpful to understand the annual variation in disease incidence, exemplified by the downy mildew situation in 2005 and 2006. In 2005, the rainfall immediately after planting in ND and SD was up to 300% of normal, while in 2006, for the same area was less than 50% of normal, thus accounting for the 26% downy mildew incidence in 2005 compared to the 3% incidence in 2006. The relatively dry conditions in 2006 also led to a low level of Sclerotinia head rot, which rebounded again in 2007. The state of North Dakota has a system of automated weather stations, monitored by computer, and this data is archived and publically available (http://ndawn.ndsu.nodak.edu/), so it is possible to make accurate assessments of the influence of weather on diseases when sunflower fields are in proximity to these 72 weather stations.

Table 1. Incidence and severity of diseases between occurring in sunflower fields between 2001 and 2011. Data collected from the U.S. National Sunflower Association sponsored survey.

Disease		Year									
		2001	2002	2003	2005	2006	2007	2008	2009	2010	2011
Sclerotinia Head Rot	Incidence[1]	35	51	33	43	9	26	28	29	29	21
	Severity[2]	*1.7*	*4.7*	*3.4*	*2.3*	*0.3*	*2.7*	*3.2*	*4.2*	*2.0*	*1.5*
Sclerotinia Stalk Rot	Incidence	*35*	*29*	*21*	*18*	*16*	*30*	*26*	*22*	*20*	*7.6*
	Severity	1.1	2.4	1.7	1.6	0.9	1.3	3.1	1.8	1.0	0.4
Sclerotinia Mid-Stem Rot	Incidence	13	8	6	7	3	8	18	26	21	30
	Severity	*0.4*	*0.4*	*0.7*	*0.5*	*0.4*	*0.3*	*0.7*	*3.3*	*1.9*	*3.1*
Phomopsis Stem Canker	Incidence	33	16	15	21	16	39	29	41	46	60
	Severity	*1.6*	*1.6*	*1.5*	*3.5*	*2.6*	*6.4*	*5.1*	*8.5*	*8.7*	*17.9*
Downy Mildew	Incidence	1	5	6	26	3	13	16	13	8	34
	Severity	*0.1*	*0.2*	*0.4*	*2.4*	*0.1*	*0.7*	*1.1*	*1.4*	*0.4*	*2.7*
Rust	Incidence	28	17	44	60	68	77	64	64	55	31
	Severity	*0.9*	*2.5*	*1.4*	*1.9*	*2.5*	*2.2*	*1.7*	*1.8*	*1.2*	*0.1*
Verticillium Wilt	Incidence	10	10	19	11	2	6	24	11	15	21
	Severity	*0.9*	*0.8*	*5.4*	*1.1*	*0.2*	*2.0*	*7.5*	*0.6*	*4.2*	*5.1*
Rhizopus Head Rot	Incidence	31	33	21	16	18	31	18	19	18	24
	Severity	*1.7*	*4.3*	*3.8*	*2.1*	*2.8*	*3.1*	*3.4*	*2.1*	*2.0*	*2.6*

[1]Incidence indicates the percent of surveyed fields with the disease

[2]Severity is the percent of the crop affected by the disease in fields with the disease present.

DISCUSSION

Shortcomings of current surveys-

a) Accuracy of data relative to experience of surveyors,
b) Single, late season survey will miss seedling diseases and underestimate foliar diseases if plants near senesce,
c) Emphasis on surveying large #s of fields to gather regional data, and thus sacrificing precision on individual fields.
d) Regular monitoring of pathogens, and public availability of data
e) Biosecurity/phytosanitary issues.
f) Remote sensing

g) Soil bioassays
h) DNA sequencing for accurate species IDs
i) New, standardized differentials needed to identify downy mildew, rust and Verticillium.

The last ten years have seen a surge in the use of DNA sequences as another tool (in complement with traditional morphological traits) to identify fungi to genus and species. The most frequently sequenced region for such purposes is the internal transcribed spacer (*ITS*) region of the nuclear ribosomal DNA.

ACKNOWLEDGEMENTS

The authors would like to acknowledge all of the participants of the United States National Sunflower Association sponsored survey and acknowledge the National Sunflower Association for continued funding and support.

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