The impact of Cropping Systems and Cultural Practices on Asian Soybean Rust

D. Narvaez[1], J. Marois[1], D. Wright[1], E. De Wolf[2], Nick Dufault[3], S. Isard[3], P. Esker[4]

[1]North Florida Research and Education Center, Quincy, FL 32351 USA
[2]Department of Plant Pathology, Kansas State University, Manhattan, KS 66506 USA
[3]Department of Plant Pathology, Penn State University, State College, PA 16802 USA
[4]Department of Plant Pathology, Iowa State University, Ames, IA 50011 USA

INTRODUCTION

Soybean farmers are switching to reduced tillage and other cultural practices to reduce soil erosion and input costs. This allows them to manage more acres with less labor and comply with the government conservation programs.

Cultural practices have been shown to affect the incidence and severity of many pests, including plant pathogens. The use of lowered seed rates, increased row widths, and proper row orientation to the sun (to help minimize leaf wetness duration) have been prescribed as environmental modifications that create a microclimate less conducive to foliar disease development (Cook and Yarham, 1998).

Row spacing, for example, has the potential to alter canopy architecture, canopy closure, canopy microclimate, leaf area index and solar radiation at the soil and canopy level and have proven to maximize yield, reduce herbicide usage, and create a more favorable environment that affect disease incidence and severity (Blad, Steadman et al., 1978; Grau and Radke, 1984; Marois et al., 2004).

Growers leave crop residues on the soil surface rather than incorporating them in. However, with the arrival of *Phakopsora pachyrhizi*, causal agent of Asian Soybean Rust (ASR), many crop advisers and farmers have expressed concern regarding the appropriate use of these cultural practices to avoid or reduce the development of ASR on soybean fields.

With its arrival on the continental United States in 2004, ASR has the potential to be an economic threat to U.S. soybean producers, (Schneider, Hollier et al., 2005). Soybean rust has been a prevalent tropical and subtropical foliar disease throughout the world.

Our objectives are to review and address the impact of cropping systems and cultural practices use to produce the highest yielding, most profitable crop on the development of Asian Soybean Rust

CONSERVATION TILLAGE

Conservation tillage, defined as a system that leaves 30% or more of the soil surface covered by crop residue after planting, helps to reduce soil erosion, conserve energy and soil moisture, and increase crop yields. However, many soilborne plant pathogens survive in the previous year's crop residue making disease more problematic under reduced-tillage conditions. Reduced tillage can favor pathogens of soybean by such mechanisms as protecting the pathogen's refuge in the residue from microbial degradation, lowering soil temperature, increasing soil moisture, and leaving soil undisturbed. Tillage can spread Soybean cyst nematode within and in between fields. White mold disease can be favored by tillage because this fungus produces sclerotia (overwinters up to 7 yrs in deep soil) that can be brought up to the surface and germinate. Tillage can reduce infection of other diseases such *Phytophthora,* Sudden Death Syndrome by increasing soil temperature in the planting season. Even so, the national average difference in soybean yield between no-tillage and conventional tillage was found to be negligible with a 0.7 percent advantage to no till while little difference has been found in the southeast http://agroecology.clemson.edu/soybean.htm except to in row subsoiling to break the compaction layer. Soybean yields tended to benefit more from crop rotation in no-till compared to continuous cropping

It is thought that *Phakopsora pachyrhizi* cannot survive in crop residue. However, ASR spores may survive on their own about 40 days, and the probability that spores would survive the winter likely depends on the location. Soybean rust will most likely come to the field on air currents from south; there is no reason to think tillage (or absence of tillage) would influence rust likelihood or severity. However, most of the soybeans planted in the SE are planted behind a crop of small grain for grain and conservation tillage is widely used in the double cropped fields. Therefore, in those situations tillage may affect the number of volunteer soybeans that can serve as overwintering host in south; which was the case of the first finding of ASR on a soybean volunteer plant in GA in 2005.

ROW SPACING

Row spacing has been used effectively to reduce the disease incidence and severity of several diseases. In cotton, the use of ultra-narrow rows (7 inches or 17.8cm) in comparison to regular row width (36 inches or 91.4 cm) caused reduced canopy temperature and vapor pressure deficit along with increased relative humidity within the plant canopy prior to reaching 1 meter in height (Marois et al., 2004).

Although row spacing has been shown to affect disease incidence and severity, there are many reasons to vary row spacing. Environmental factors often dictate what row spacing is adopted by farmers. In the South-Eastern U.S., the sandy loam soil compacts easily requiring the use of subsoiling equipment to ensure a compaction-reduced root zone (David Wright, personal communication). Since most row crops (cotton, peanuts) are grown on wide rows (36"), the adaptation of equipment for planting soybeans at narrow rows is not economical due to lower-than-average soybean yields compared to northern and western states.

In the Southern and Mid-Southern states, soybean research has focused on the effects of cultural practices, mainly row spacing, cultivar selection, and plant population, on regions that experience droughts in August. Wide row spacing has been shown to reduce leaf size and reduce canopy closure when compared to narrow row soybeans in the arid region of North Texas, but these results seem inconsistent with insignificant effects on yield (Heitholt, Farr et al., 2005).

The LAI of a crop canopy is altered by row spacing and has been shown to impact herbicide and fungicide applications in many row crops. In peanut studies an inverse correlation has been found that as the LAI increases the penetration of fungicides within the canopy decreases substantially(Zhu, Rowland et al., 2002). In glyphosate resistant varieties of soybeans, the use of narrow row practices encourages early canopy closure, reducing weed pressure and allowing for a single application of glyphosate to control most weeds without the use of a residual herbicide (Norsworthy, 2004).

There are no significant differences in ASR incidence and severity among different row spacing. In a wide-row situation, it is thought that there is more turbulence within the rows during a rain-storm, which could result in greater dispersal of spores throughout the canopy and field. Narrow rows create more favored microenvironments for rust development because longer periods of high relative humidity compared to wide-row spacing. The reduction in temperature, increase in free moisture, and increased relatively humidity are often implicated in increased disease pressure.

In a series of experiments begun in 2006 at Quincy, Fl, row spacing was manipulated to determine its effect on soybean canopy microclimate and disease spread from a point source of inoculation.

Materials and Methods

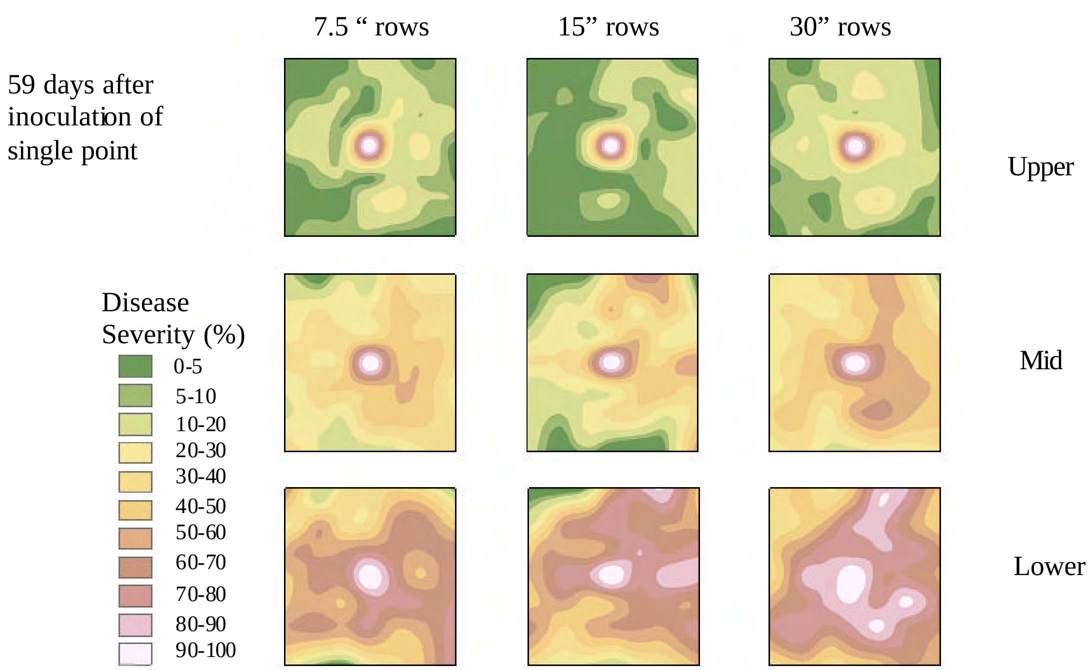
A field (216' x 680') was at the North Florida Research and Education Center (NFREC) (University of Florida, Quincy, FL). This experiment was planted in a randomized block design, with two replications and row spacing as treatments (7.5", 15", and 30") and planted at 172,500 seeds per acre to achieve 150,000 plants per acre population, regardless of row spacing. Treatment plots were triplicate 80' x 80', with adjacent fungicide plots 30' x 80', and 10' boarders surrounding the field to reduce potential edge effect. The fungicide controls were used as "disease-free" control plots for the microclimate analysis and also to quantify the yield impact of soybean rust on the inoculated treatments.

The soybean rust epidemic was induced once the field reached a early reproductive stage (R1-R2) by placing one severely infected soybean plants in the center of each designated foci. Each of the 9 treatment plots has been divided into 49 10'x10' grids. Plants will be sampled from the corner of each grid. Incidence and severity were evaluated at 5 leaves from each the low, mid, and high canopy at each of the grids except for the inoculated foci (coordinates 44 (XY). The foci were not sampled to prevent interfering with the natural disease spread. Assessments was made 23, 30, 40, 44, 51 & 59 days after inoculation and distance was calculated as Euclidian distance from point of inoculation, and observations in all directions (no directional component)

The canopy microclimate analysis was monitored assessing air temperature at low, mid, and upper canopy locations; leaf wetness duration at low, mid, and upper canopy locations; solar irradiance above and below the canopy, relative humidity at mid canopy, wind speed at mid canopy and above the canopy, and soil temperature.

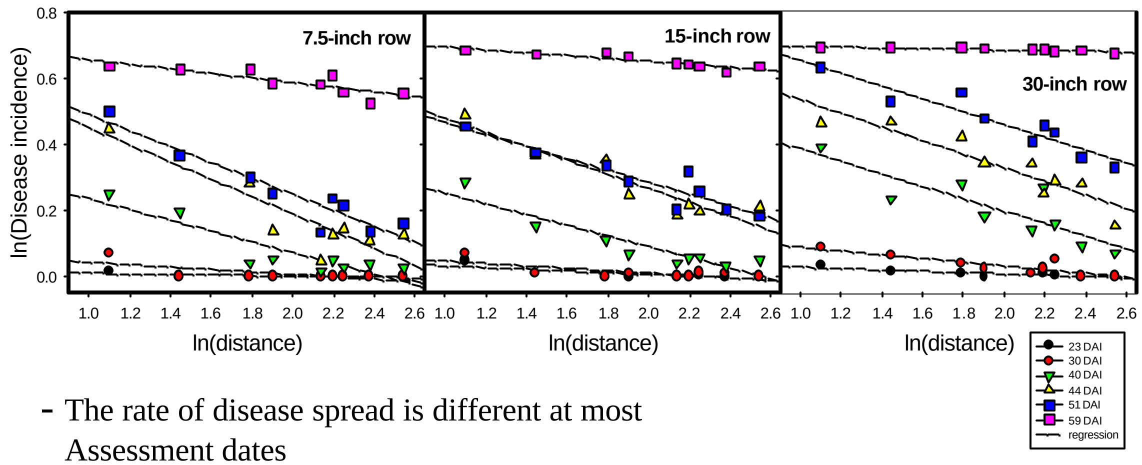
Fig 1. Soybean planted at 30 inch row spacing

Fig 2. Spatial Distribution of Soybean Rust



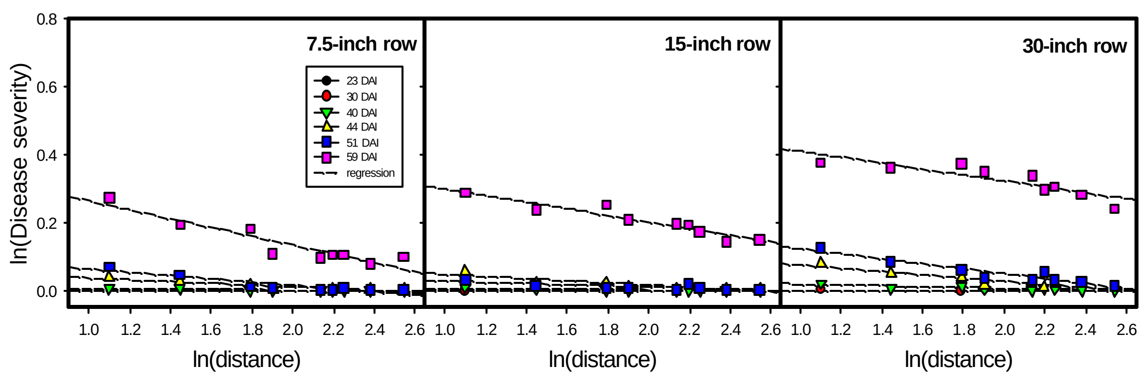
Annalisa Ariatti, Penn State

Fig 3. Rate of Disease Spread as Influenced by Row Spacing (Disease Incidence)



- The rate of disease spread is different at most Assessment dates
- The rate of disease spread does not differ with row spacing for most assessment dates

Fig 4. Rate of Disease Spread as Influenced by Row Spacing (Disease Severity)



-Similar patterns in rate of disease spread observed with disease severity.

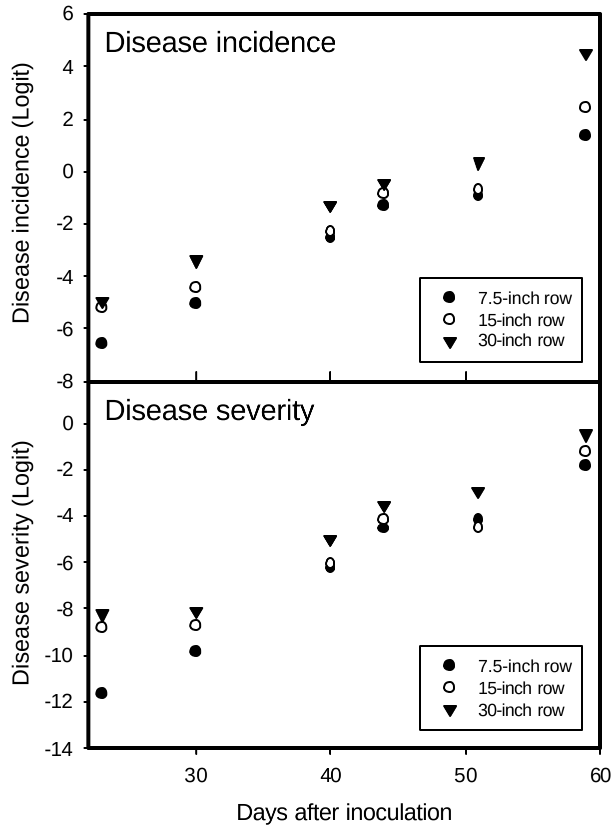


Fig 5. Disease progress over time with different row spacing

The rate of disease spread is different at most assessment dates

The rate of disease spread does not differ with row spacing for most assessment dates

- ? Growing soybeans in 7.5, 15 or 30 inch rows did not significantly alter the rate of disease spread or disease increase over time
- ? Significant differences of disease at discrete time periods will likely not translate into meaningful management since it will be quickly eliminated by rapid increase of disease (less than 5 days)
- ? Explosive rate of progress will make scouting for disease difficult but our best chance is with disease incidence
- ? Rate of disease increase does not vary among 7.5, 15 and 30 inch row spacings

Preliminary results of conducting wet and dry deposition field studies of *Phakopsora pachyrhizi* urediniospores indicate that spores deposited by short durations of simulated rainfall and dry depositions are distributed evenly throughout a soybean canopy.

Fig 6. Wet Deposition: Rainfall Washout Simulation

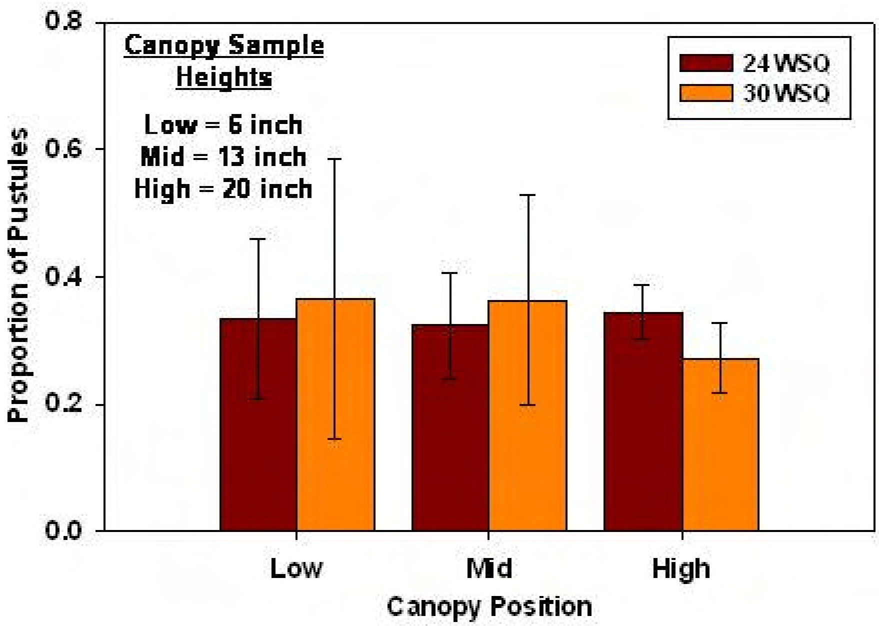
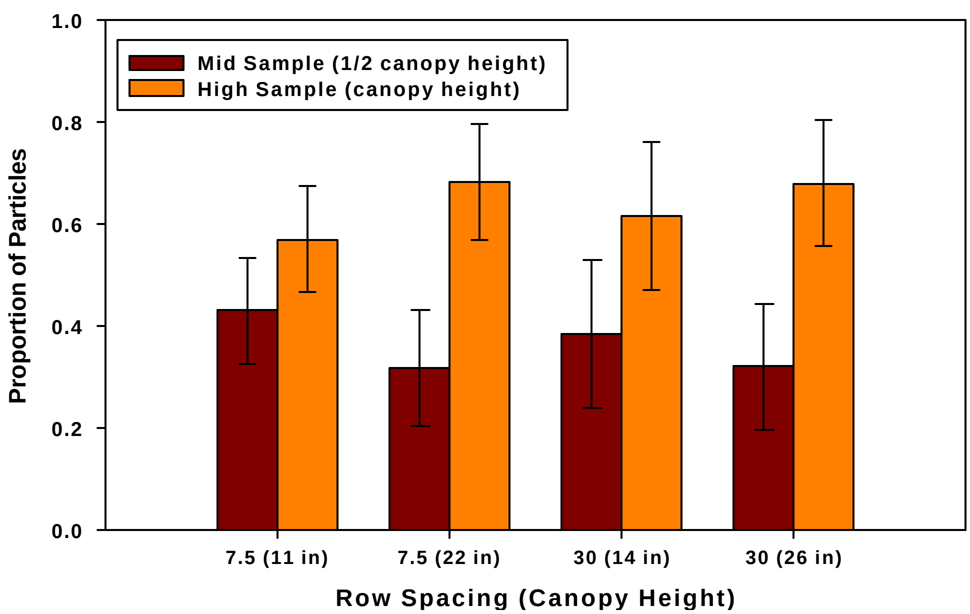


Fig 7 Dry deposition (Impaction)



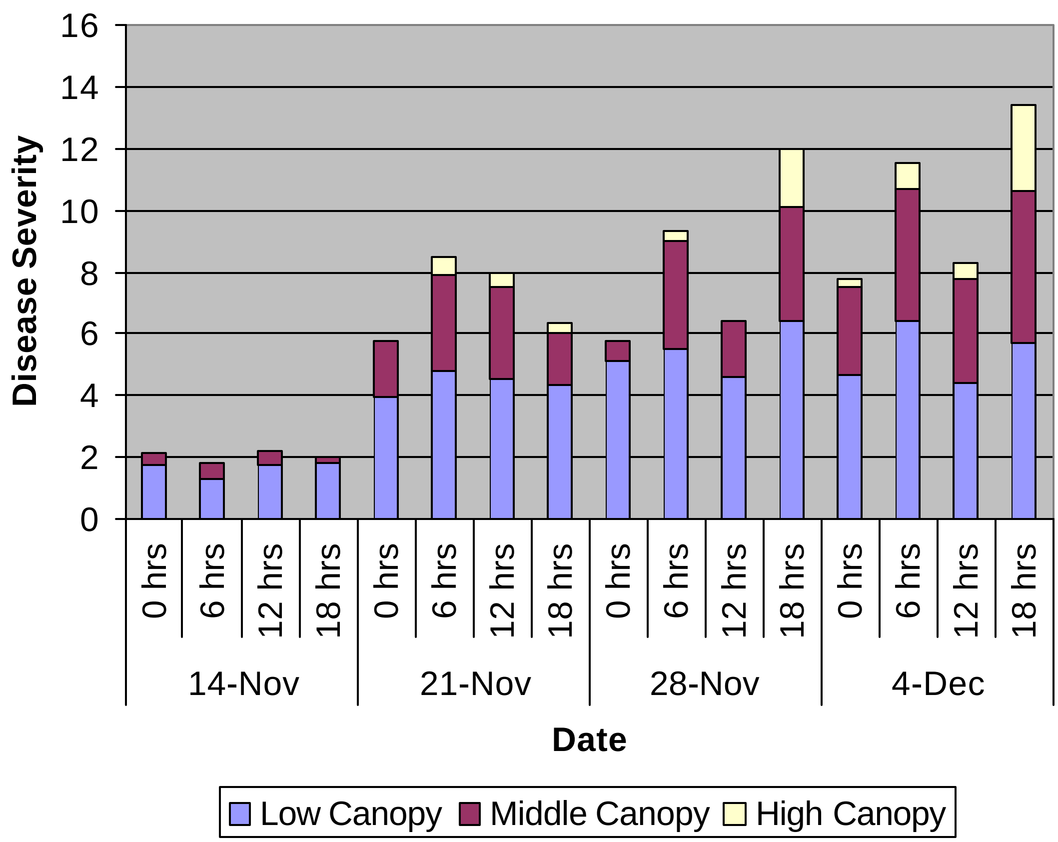
IRRIGATION AND LEAF WETNESS

Crops suffer from periods of drought each year in Florida. Soybeans require little early irrigation except to get good plant height and provide canopy closure. Soybeans require the highest amount of water during late flowering through pod fill. Irrigation helps stabilize yields and makes more dependable marketing strategies. ASR begins germination after 1.5 hrs of leaf wetness/dew, and a period of 6 hrs of leaf wetness/dew is sufficient for ASR infection.

A misting irrigation system on MG5 implemented at one of the sentinel plots in Quincy, Fl to evaluate the effect of leaf wetness duration on the development of ASR, showed that not only did longer periods of leaf wetness increase disease severity but also the speed of the incidence/spread of the disease to upper leaves. (Fig 8)

Misting irrigation was applied for 1 minute on 30 minutes intervals for a 0, 6, 12 and 18 hr periods. Micro-environmental changes within the soybean canopy, caused by the different misting periods were recorded with Log Tag card microloggers from MicroDAQ.com, Ltd. PO Box 439 Contoocook, NH 03229 U.S.A.

Fig 8. Effect of Leaf Wetness on Soybean Rust Development



PLANTING DATE

Planting date does not directly affect rust incidence or severity. However, by planting early, the crop matures earlier. This potentially reduces the time the crop is exposed to ASR, since spore numbers usually increase throughout the season. Therefore, more disease would be expected on later planted soybeans. Additionally, planting seed into cold soils will delay germination and increase the risk of seedling disease, which could reduce stand and yield. I don't know of this problem in the SE. We have Lesser corn stalk borere problems in dry soils and we normally treat for velvet bean caterpillar late in the season along with stinkbug. Planting date usually does not influence these.

DOUBLE-CROP SOYBEAN SYSTEMS

Double-crop soybean are not inherently more susceptible to ASR than full season soybeans; however double-crop soybean face more disease pressure due to later maturity dates, compared to the full-season soybeans. Since double-cropped soybeans are planted at the end of May or the first of June. They are likely to be at an earlier development stage when colonized by ASR and would, therefore, be exposed to the pathogen for longer period of time.

ASR could affect both systems equally if ASR were to arrive early in the season when full-season soybeans are in the R1 to R2 stage. However, since double-crop soybeans lag 10-15 days in development, they present a higher risk of exposure to higher inoculum levels of ASR. However, dry and hot weather could greatly decreased establishment/development/movement of ASR. Also, the canopy in double-crop soybean is smaller and less dense and will not support disease development as well as the larger, denser canopy of full-season soybeans

PLANTING OF MATURITY GROUPS

The susceptibility or predisposition of a maturity group to ASR pathogen depends on the overwintering of ASR in the region. In regions where ASR cannot over winter ASR must move in from somewhere else in the south. Later maturity groups are more likely to be exposed to ASR and have higher inoculum levels than early maturity groups. Early maturity groups will initiate reproductive process sooner; therefore, these cultivars are likely to be in the later growth stages when ASR arrives. Yield loses will vary depending on the soybean growth stage at which the ASR attack occurs.

CONCLUSIONS

Most cropping systems and cultural practices such as narrow-row or wide-row planting, planting date, double-crop soybean, maturity group, tillage system does not directly affect

ASR incidence or severity; however some cropping systems and cultural practices may vary in the disease pressure due to extended time that the crop is exposed in the field. Furthermore, what challenges most cropping systems and cultural practices is that, alternative host plants grow year round resulting in continuous spore production. The selection of the most suitable crop system or cultural practice should not only be considered in terms of efficacy to control/reduce the impact of ASR but also to manage other soybean diseases and also in terms of the efficacy related to the forecast weather conditions.

One should choose the planting date that will give the best yield and then implement ASR control measurements if needed

Scouting during pot stages (R4-R5) for ASR incidence is still necessary regardless of when the soybean is planted

The amount of canopy and weather may have more impact on disease development than planting date or maturity group.

Continue to use recommended practices to produce the highest yielding, most profitable crop. A healthy crop will tolerate ASR better than a stressed crop

REFERENCES AND ASR SOURCES

Asian Soybean Rust website at Virginia Tech-
http://www.ppws.vt..edu/ipm/soybeanrust/index.html

Asian Soybean Rust- Frenquently Asked Questions IV: Cropping Systems and Cultural practices. Virginia Cooperative extension 450-304

USDA Soybean Rust Tracking site-
http://www.sbrusa.net

The Southern Plant Disease Network-
http://spdn.ifas.ufl.edu/soybean_rust.html

Influence of Tillage on Soybean Yield in the United States and Canada. M. DeFelice, P. Carter, S. Mitchel. CROP INSIGHTS. Vol. 16- 11.

Bean leaf beetles and soybean planting date. INTEGRATED CROP MANAGEMENT (ICM) IC-490 (6). April 28, 2003.

Blad, B. L., J. R. Steadman, et al. (1978). Canopy structure and irrigation influence white mold disease and microclimate of dry edible beans. Phytopathology **68**: 1431-1437.

Cook, R. J. and D. J. Yarham (1998). Epidemiology in sustainable systems. The Epidemiology of Plant Diseases. D. G. Jones. Norwell, MA, Kluwar Academic Publishers.

Grau, C. R. and V. L. Radke (1984). Effects of cultivars and cultural practices on *Sclerotinia* stem rot of soybean. Plant Disease **68**(1): 56-58.

Heitholt, J. J., J. B. Farr, et al. (2005). Planting configuration x cultivar effects on soybean production in low-yielding environments. Crop Science **45**: 1800-1808.

Marois, J. J., D. L. Wright, et al. (2004). Effect of row width and nitrogen on cotton morphology and canopy microclimate. Crop Science **44**(3): 870-877.

Norsworthy, J. K. (2004). Soil-applied herbicide use in wide- and narrow-row glyphosate-resistant soybean (*Glycine max*). Crop Protection **23**: 1237-1244.

Schneider, R. W., C. A. Hollier, et al. (2005). First report of soybean rust caused by *Phakopsora pachyrhizi* in the continental United States. Plant Disease **89**: 774.

Zhu, H., D. L. Rowland, et al. (2002). Influence of plant structure, orifice size, and nozzle inclination on spray penetration into peanut canopy. Transactions of the ASAE **45**(5): 1295-1301.