Disease and Insect Management Using New Crop Rotations for Sustainable Production of Row Crops in the Southeastern United States

Final Report for LS94-057

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Project Information

Abstract:

Take-all was severe in continuous wheat rotations throughout the study. Take-all was just as severe following millet as after soybean. Results from the 1996 and 1997 showed that a one year rotation with canola prior to wheat had a significant effect on suppression of take-all root rot. Wheat grain yield was the same, and in most rotations test weight, and 1,000 kernel weight were the same as the non-diseased controls following canola. This was a greater yield improvement than anticipated because of the severe damage from take-all in continuous wheat during all three years. Yield components were significantly lower in rotations with continuous wheat. The possibility that the rapid decline in take-all after canola may be due to compounds released during decay of canola tissues is being investigated. Assays in a controlled environment chamber for take-all on wheat seedlings grown in soil from field plots were similar to results from field trials. The incidence of infected plants and root rot severity were greatly reduced on seedlings grown in soil from rotations with canola. Data for disease incidence and severity from the field prior to wheat harvest were similar to data from seedling assays. The beneficial value of canola in wheat rotations for take-all control has been incorporated into Extension recommendations in Georgia.

The population of Hessian fly on wheat was below economic thresholds during 1995. During 1996 and 1997, winter infestations were significantly lower when canola was rotated with wheat. By 1997 Hessian fly infestations were greater following millet than after soybean. Spring infestations were not affected by the previous crop. False chinch bugs were present in canola in the first season but could not be assessed in 1996 due to the severe winter freeze which killed canola. Millet stands were reduced by false chinch bugs following canola in 1996 and 1997. True chinch bugs, which often damage millet seedlings after small grains, were not found. Thrips populations were higher on soybean seedlings after canola than after wheat, but thrips are not...
damaging to soybean. Fall armyworm, southern green stink bug, and leaffooted bug attacked whorls and seed of millet but their populations were not influenced by crop rotation. Insect pest populations on soybeans were not affected by the preceding winter crop. Only soybean loopers and velvetbean caterpillars were above economic thresholds. More lepidopterans were found on soybeans following rye. The primary effect of rotation sequence was on seedling insect pests.

The stand of soybeans was reduced 20% or more following canola each year which could not associated with insect damage. Pearl millet stands were also significantly lower after canola but not wheat. This is the first evidence that canola may have an allelopathic effect from breakdown products in canola stubble on these crops in a doublecrop rotation.

Rotation effects were significant for pearl millet panicle counts, leaf blight, and stalk and neck rot during the 1996 season. There was a trend for leaf blight and stalk and neck rot to be less severe in pearl millet following canola than following wheat. Seedling stand was positively correlated with leaf blight and stalk rot. Rotation effects on pearl millet diseases may have been obscured by variation in stand density within subplots. Minor effects on pearl millet stand establishment, retention of green foliage, stalk and neck rot, smut, and yield were observed in these rotations. Seedling stands 3 weeks after planting were lower following canola than wheat in 1995 and 1997. Foliar chlorosis and necrosis were slightly less severe in pearl millet following canola than wheat in 1995 and 1996. Stalk and neck rot was also less severe following canola in 1996. Grain yield was highest following canola in 1997 but may be an artifact of excessive stand density. A trend toward increased smut severity in plots continuously planted to pearl millet was observed in 1997.

Canola diseases were not significant during 1995 and could not be assessed because the crop was killed by low winter temperatures in 1996. After two seasons, there were no differences in severity of stem canker on soybeans due to crop rotation or the inclusion of canola or pearl millet in the rotation. Sclerotia stem rot and black leg did not become serious during the three-year period, probably as a result of loss of the crop in 1996. The rotations will be continued in 1998 to assess rotation effects on these diseases.

Soybean yield was reduced following canola probably because of allelopathic effects from the decaying canola stems and roots. Various foliar diseases were present but did not cause economic loss in any year. Stem canker increased in severity early in the 1997 season in continuous soybean rotations but did not affect seed yields. Additional data will be collected in 1998 on rotation effects on stem canker. Canola and pearl millet were compatible with soybean in the rotation. No changes in disease management is foreseen to incorporate these crops into rotations with soybean.

Analyses of the income returns from the rotations was done by developing cost and return budgets for each crop by year using plot yields and field operation and input costs realized by the Southwest Georgia Branch Experiment Station. The analysis shows that crop failure and crop prices influence rotation effects on returns. These influences can magnify negative relationships such as reduced yields of soybeans behind canola, and/or shrink positive benefits such as take-all reduction on wheat from having canola in the rotation. High soybean prices and wheat prices may make the reduction in soybean returns following canola less than the increase in wheat returns from having canola in the rotation ahead of wheat. In contrast, beneficial but costly winter cover crops with no income (rye) and/or low income potential neutral crops such as millet can make a rotation unprofitable or add no positive economic benefits. However, the low income of millet could be an improvement over soybeans after canola. The results indicate the current vulnerability of the new crops canola
and pearl millet. Improvements in varieties adapted to the region and improved yield potential will make these crops more profitable.

Video footage showing the results of the rotations on diseases and insect pests to date in field plots have been made. Information on the procedures used and the biology and damage caused by the various pests have been documented. Aerial footage showing the plots during May to document the effect of rotation on take-all of wheat has been recorded. Film will be edited to complete the educational video based on the study. Several training programs and presentations at various meetings have been completed and additional presentations will be made in 1998. Audiences varied from small acreage to large-scale growers, extension specialists, and researchers throughout the Southeast. Several technical and nontechnical publications have been completed. Refereed journal publications are being prepared from the research on rotation effects on take-all, insect populations, and pearl millet diseases and crop yields. A comprehensive publication on the project will be prepared as a College of Agriculture Research Bulletin.

Project Objectives:

Disease and insect pests became serious problems in the Southeast when wheat and soybean were grown in continuous double cropping and minimum tillage systems. Therefore, the objectives of the project are to:

1. Enhance double cropping systems with minimum tillage in the southeastern U.S. by expanding crop rotations which can be profitable and which can reduce diseases and insects.
2. Incorporate improved cultivars of the emerging crops canola and grain pearl millet into minimum tillage systems.
3. Determine the optimal rotation system to manage diseases and insects in canola, pearl millet, soybeans, and wheat.
4. Demonstrate the usefulness of these rotations to growers on a commercial farm and at a major regional farm exposition site.

Introduction:

Wheat acreage increased from

Research

Materials and methods:

Twelve rotation sequences instead of ten described in the proposal were included in the study. Rotation sequences for are presented for three years. The first crop was planted in the fall and the second crop in each set was the summer-planted crop. Each sequence was planted at the Southwest Branch Station (Plains) as a randomized complete block with four replications (each plot 40 X 40 ft), and as a single replicate (each plot 20 X 200 ft) at the Speir farm (Plains) and at Sunbelt Expo (Moultrie).

Take-all on wheat and rye. The take-all fungus Gaeumannomyces graminis var. tritici was grown on autoclaved oats and the cultures were air-dried. This inoculum was ground with a hammermill to pass through a 7 mm mesh within one week before application to the field plots. The dry inoculum was spread on the surface of each plot at the rate of 3.6 g/m2 at the Southwest Branch Station at Plains, GA. A 6X40 ft area on the far right side of each plot was not inoculated to serve as a
control. The inoculum was incorporated into the soil to a depth of 15 cm just prior to planting.

Savannah wheat and Wrens Abruzzi rye were planted November 9, 1994 and November 10, 1995. Savannah wheat was planted November 12, 1996. Seed was planted in a 7-inch row width with a Hege small-plot grain drill at 2 bu/acre. Rye was removed from plots on March 10, 1995 and March 3, 1996 to simulate winter grazing and its use as a winter cover crop. Plots were killed with a herbicide.

Wheat and rye plants were dug for evaluation of take-all damage when plants were at the seed milky ripe stage. Plants were removed from randomly selected sites determined by specifying a distance from the end of each of five sections of a plot using a random number table. Thirty-five plants of each crop were collected from seven noninfested sites in each plot. Soil was washed from roots and each plant was rated visually for root and crown rot using the 0-4 scale (Shipton, 1972). Data were collected from a minimum of 146 plants per rotation sequence from sites with Ggt-infested soil. The percentage of diseased plants and disease severity rating was assessed.

The number of tillers per meter of row was counted when seed was near dough stage of maturity (early May) about two weeks before wheat harvest. Five random row lengths in each plot were sampled using the same procedure used for collecting root samples. Counts were made in Ggt-infested and non-infested areas. These subsamples were used to determine the average number of tillers per replication of each rotation. Grain from a 1,000 square foot area in each plot was harvested with a Hege plot combine. Grain yield, test weight, and 1,000 kernel weight were determined for each plot. Grain weight was adjusted to 13% moisture.

Soil was collected during the spring when wheat was at the heading stage and when Ggt was actively parasitizing the roots and basal stems. A second sample was collected each year in late summer when the summer crops were approaching maturity. Soil and associated plant roots in the upper 20 cm were collected randomly within the portion of each plot infested with Ggt, the noninfested portion of each plot, and from a nearby area outside the plots. Soil from each plot was dried and homogenized by grinding. In the first two assays (1995), field soil was placed into pots at two rates: 100% field soil or soil diluted 10-fold with soil collected in the same field but from a site not infested with Ggt (10% field soil). This was done to have at least one assay that would exhibit a quantitative differential between treatments. Disease severity was greater in the 100% soil, and the relative differential between treatments was the same. In subsequent assays only 100% field soil was used. Soil samples were collected March 15 and August 30, 1995, April 18 and September 19, 1996, and April 1 and September 16, 1997. Data from the September 1997 assay are not yet available. Summary data are presented for the first five assays (Table 3). Data in all tests were analyzed by analysis of variance and means separation tests.

Insects. 'Iris' canola was planted in assigned plots on November 8, 1994, November 7, 1995, and November 11, 1996. Canola was planted in 7-inch row with a Hege small-plot grain drill at 6 lb/acre. Canola stands were killed in 1995 by cold temperatures in December and were replanted on March 5, 1996. Canola grain yield was measured in plots on May 23, 1995 and May 15, 1997 by harvesting a 5 x 40 ft area of each plot with a Hege small-plot combine. Seed was weighed, and moisture content and test weight measured. Grain yields were adjusted to 8.5% moisture. Canola grain yield was not measured in 1996 because plants from the second planting were beginning to flower in late May. Plants were killed with gramoxone and mowed with a rotary mower before planting summer crops. Hessian fly infestations were sampled in wheat plots February 1 and May 9 in 1995,
January 26 and April 18 in 1996, and February 5 and April 24 in 1997 by collecting plants in 2 subsamples of 1-ft of row per plot. Tillers were dissected and the number of larvae plus puparia were counted; the percentage of infested tillers (stems) was determined.

Soybean and grain millet plant numbers were counted at 20, 21, and 20 days after planting in 1995, 1996 and 1997, respectively, by counting plants in two 10-ft sections of row in each plot. Numbers of false chinch bug, Nysius raphanus Howard, were determined in each plot from three 1-ft2 areas of ground centered over a row of plants. Soybean seedlings were examined for thrips by collecting 20 plants per plot in 1995. Plants were placed in berlesse funnels for 72 hr to extract thrips and counted. Foliage-inhabiting insects were sampled in soybean using the shake-cloth method (Kogan & Pitre 1980). Beginning in early July of each year and every two weeks until harvest, two 60-cm of row shake-cloth sampled were collected per plot. The method consists of placing a white, plastic cloth between two rows and vigorously shaking plants in two 30-cm sections of row over the cloth for 15 sec. All important phytophagous and predatory arthropods are counted.

Grain millet was sampled for whorl damage by the fall armyworm, Spodoptera frugiperda (J.E. Smith), on August 8, 1995 and September 5, 1996 by counting plants with whorl defoliation in 10-ft of row per plot. Insects feeding on seed were sampled on August 31 and September 20, 1995 and September 5 and 19, 1996 by inspecting 10 seed heads per plot and counting all insects observed. In 1997, 20 seed heads were sampled per plot September 4 and 17 and October 1.

Plant stand and insect counts were averaged among plots with similar winter crops. Means were analyzed by sample date with an analysis of variance for a randomized complete block design. Means were separated with a protected least significant difference test (LSD). Single degree of freedom contrasts also were used to compare the effect of previous crop combinations.

Pearl millet diseases. Soil borne pathogens of pearl millet Sclerotium rolfsii, Bipolaris setariae, and Exserohilum rostrata were cultured individually in flasks containing sterile oat grains for 4 weeks. After removing from flasks and drying, approximately equal quantities of inoculum of each of the pathogens were mixed, and inoculum (250 grams, approximately 1 liter) was distributed throughout each plot area on June 7, 1995.

Pearl millet HGM 100 was planted on June 8, 1995, June 19, 1996 at 2.8 kg seed/ha. A calibration error resulted in planting rate on 24 June 97 of approximately 13.5 kg seed/ha. Rows were spaced 0.9 m apart. Four 3 m long, two row subsample areas were marked within each plot. Stand counts within subsamples were made on July 5, 1995, July 10, 1996, and July 15, 1997. Final panicle counts were made on September 19, 1995, September 3, 1996, and September 23, 1997.

Disease assessments were made within subsample areas. Visual estimates of leaf blight severity (percent leaf area chlorotic or necrotic) were made on September 19, 1995, and August 26, 1996. Culms with stalk and neck rot and total culms were counted September 20, 1996. Smut severities (% infected florets within panicles) were estimated on September 23, 1997. Four rows (12.2 m long) of the main plots were harvested on September 21, 1995, September 20, 1996, and September 23, 1997 with a Hege combine. Harvested grain was dried in a forced air oven for four days at 38 C prior to determining yield. Twenty panicles were harvested from each subsample area in 1996, threshed, and average panicle yield was calculated. Subsample yield was calculated as the product of panicle number and average panicle yield.

Data were analyzed within each year. Mean squares for analysis of stand counts,
panicle counts, leaf blight, percentage stalk and neck rot, and smut severity were partitioned into effects due to replication, rotation, and subsample. Mean squares for analysis of plot yield were partitioned into replication and rotation effects. Correlations between stand and panicle counts, panicle yield, subsample yield, leaf blight, and percentage stalk and neck rot were calculated.

Canola diseases. Canola was monitored during the rosette, the flowering, and the pod filling stages for symptoms of Sclerotinia stem rot.

Soybean diseases. Soybeans, varieties Brim and Ga 81-2057, were planted on June 15, 1995. The variety Deltapine 105 was planted on June 19, 1996. The soybeans were planted into standing residue of the previous crop. Soybeans were monitored for symptoms of stem canker, from flowering until harvest. Final stem canker ratings were made near physiological maturity each year. The plots of both crops were also periodically observed for the presence of any unexpected diseases. Soybean plots were harvested on October 20, 1995 and on October 16, 1996. A 200 square foot area of each plot of each variety was harvested in 1995 and a 400 square foot area was harvested in 1996. Reported yields were adjusted to 13% moisture content.

Research results and discussion:

Take-all. Take-all was severe during the first year with wheat yield reduced >75% below that of the healthy controls. The percentage of infected wheat plants in 1996 was reduced significantly in rotations where canola was planted in 1994. The average root disease severity score was about one-half as much as with canola planted the previous year as continuous wheat. Disease severity was less in the continuous wheat rotation in 1996 with pearl millet as the summer crop in place of soybean, but the difference was not statistically significant. Incidence of disease (percent infected plants) was not affected with nearly 100% of plants infected for both rotations (Table 1).

The incidence of infected rye plants was one-half that of wheat and disease severity was much reduced in 1996 (Table 1). After two years of rye (rotation 12), the incidence and severity of take-all in wheat in 1997 did not differ from continuous wheat (Table 2). This agrees with previous results for the susceptibility of rye. However, wheat grain yield was significantly higher following rye grown as a winter cover crop than continuous wheat. Previous research (Rothrock and Cunfer, 1991) showed that wheat following a rye grain crop had as much damage as continuous wheat. Additional data from other rotations were not available in this study. Therefore, these results need further validation. Take-all incidence and severity on wheat and rye plants increased each year in the noninfested control area, but were similar to rotations with canola the previous year. Rye, whether grown as a grain or a cover crop in fields with severe take-all, is less reliable to reduce take-all than other non-host crops.

Take-all caused severe yield reduction in the continuous wheat rotation sequences (rotations 1 and 9) in 1996 and 1997 (Tables 1 and 2). Grain yield in rotations in which canola was grown as the winter crop in 1995 did not differ from the controls, ie wheat harvested from portions of the test site not infested with Ggt. Similar results were found for grain test weight and 1,000 kernel weight (Table 2). These results show that canola can be planted as a cash crop for one season in sites heavily-infested with the take-all fungus and reduce inoculum levels below an economic threshold. Currently oats is the only fall-planted small grain that reduces take-all damage in a following wheat crop. Oats is a much less profitable crop than canola is expected to be. Therefore, canola can diversify crop choices for a grower with a potential increase in profitability and serve to control take-all in wheat.
Soybean maintains Ggt inoculum at a high level. Comparisons are made in this study to compare pearl millet to soybean as the summer crop for their influence on survival of Ggt and yield components in continuous wheat production. In 1995 no differences in yield components were found when wheat followed pearl millet or soybeans. In 1996 grain yield was not higher following millet but test weight and 1,000 kernel weight were significantly higher compared with soybeans as the summer crop (Table 2). However, in 1997 there were no differences in wheat yield or disease parameters between the two continuous wheat treatments with either continuous soybean (rotation 1) or continuous millet (rotation 9) as the summer crop (Table 2). Millet in the rotation does not reduce take-all.

Data from the field on take-all were corroborated with assays for development of take-all on wheat seedlings grown in soil collected from field plots on five sampling dates (Table 3). Data from the fourth sample date are lower than expected, possibly because seedlings were removed from growth chambers before symptoms were at the maximum. Results from April, 1997 (date 5) are more comparable to earlier results. Where no wheat or rye has been grown during the first two years (rotations 2, 4, and 6), take-all severity declined to less than 0.7 compared with 3.2 with continuous wheat (0-4 scale with 4 being most severe) in 1996. Disease severity for wheat in 1996 following canola in 1995 (rotations 3, 8, and 11) declined to 1.9 or less. Disease severity also declined in the seeding assay to 1.1 or less in rotations with wheat in 1995 and canola in 1996 (rotations 5 and 7). Incidence and severity has stabilized in continuous wheat (rotation 1 and 9) with incidence remaining >90%. Similar to field results, millet or soybean did not differ in their effect on Ggt survival and take-all severity.

Winter crops did not significantly affect populations of any phytophagous taxa any sample date in 1995 (data not presented). However, when averaged across the entire season in 1995, more soybean loopers and consequently total lepidopterans occurred on soybean following rye than canola (Table 11). Numbers on soybean following wheat were not different from numbers on soybean following canola or rye. Likewise, soybean predator populations also were not significantly affected by winter crop on any sample date, except damsel bugs were more abundant following canola and wheat than rye on the first date that damsel bugs were collected in 1995. In 1996, winter crop did not significantly affect the seasonal average number of any arthropod taxa except that southern green stink bugs were were less abundant following rye and canola than following wheat (Table 12). However, stink bug number were very low in all plots in 1996. In 1997, winter cover crop also did not significantly affect seasonal average number of any arthropod taxa (Table 13). Over all years, winter crop did not consistently affect any foliage-inhabiting arthropod taxa on soybean.

Pearl millet diseases - 1995. Rotation had a significant effect on stand counts (P
**PARTICIPATION SUMMARY:**

Education/outreach description:

**Publications**


**Education and Outreach**

The project was discussed and the field site visited during the Small Grains and Forages Field Day at the Plains Station, in April 1995. Demonstration plots were on display at Sunbelt Expo for visitors during October 1995 and 1996. During July, 1996 David Buntin and Barry Cunfer discussed the project and showed the field plots at Plains to a group of 50 farm managers from the People's Republic of China during a tour of farms and applied agricultural research programs in Georgia.

As more data were generated, educational activities were expanded in 1997. These included posters and oral presentations at the Georgia Wheat-Soybean Expo (Macon, January 28), the Southern Canola Information Exchange (SCIE) tour at Plains (March 21), the Southern Small Grain Workers Conference (Gulf Shores, AL, April 27-30), the UGA College of Agriculture and Environmental Science Ag Showcase (Tifton, August 28), the Carolina Farm Stewardship Association Sustainable Agriculture Conference (Flat Rock - Hendersonville, NC, Nov 14-16), and various county agent training meetings throughout Georgia. A technical poster on take-all was presented by Barry Cunfer at the annual meeting of the American Phytopathological Society (APS) (Rochester, NY, August 9-13). A disease management guide which incorporates conclusions from this project was distributed to county agents in Georgia. This publication is also available on the University of Georgia Extension Service World Wide Web site. Citations to publications completed are listed in section F and are attached to this report.

The venues where information was presented provided opportunities to reach
various audiences. The Wheat-Soybean Expo was attended by 40 farmers using conventional practices on large acreages whereas the Carolina Sustainable Agriculture was attended by over 300 part-time and small acreage farmers using both conventional and organic farming practices. Twenty-five research and extension specialists from the Southeast participated in the SCIE tour. The Ag Showcase had about 500 participants including farmers, students, university research and extension personnel, legislators, and the general public. About 80 and 1500 research and extension scientists attended the Small Grain Workers conference and the APS meeting, respectively. The project results will be presented at the 1998 Wheat-Soybean Expo and county agent training meetings.

Presentations:


Project Outcomes

Project outcomes:

Take-all. The results show important implications for the incorporation of canola and pearl millet into double cropping rotations in the Southeast with wheat and soybean. A one year rotation with canola reduces take-all root rot in fields where the disease is severe. Grain yield was the same following one year of canola as in control plots with no take-all. However, wheat roots are still partially diseased and will provide inoculum of Ggt if a second consecutive wheat crop is planted. Continuous wheat had severe take-all which resulted in yield reductions up to 75% below the controls. This will allow growers to plant a crop with the potential to increase profitability significantly above planting oats or a fallow rotation which are the only winter crop alternatives now available to reduce take-all in rotation with wheat. Pearl millet fit well into the rotation with wheat, but take-all was just as severe following millet as following soybean. Rye as a cover crop had variable effects on take-all in a following wheat crop and needs further investigation.

Insects. Hessian fly infestations generally were enhanced by continuous wheat whereas rotation with winter canola reduced infestations in the subsequent wheat crop. Previous summer host also may influence Hessian fly infestations with wheat following millet having greater infestations than wheat following soybean. False chinch bug damage to seedlings of the summer crops grain millet and possibly soybean may be a problem following canola. This was somewhat unexpected, because it has long been known that true chinch bugs, Blissus leucopterus leucopterus (Say), will damage seedlings of summer grass crops of corn, sorghum and millet after infesting winter small grains (Metcalf et al. 1962). However, true chinch bugs were not collected in this study. Furthermore, soybean stands were 18-25% lower following canola than following small grains in all years. The cause of this stand reduction is not known. False chinch bugs were more numerous following canola than winter wheat or rye, but injury from chinch bugs does not explain the reduction in the number of soybean seedlings. Soybean stand losses most likely were caused by physical interference of the canola stubble with planter performance or possibly by undetermined chemical of biological parameters.
associated with canola stubble.

Except for false chinch bugs, previous winter crop had very little consistent effect on populations of insects on soybean or pearl millet. One exception was that thrips populations were greater on soybean seedlings following canola, but thrips usually are not economically important on soybean. These results show that continuous planting of a crop can enhance a host specific pest such as Hessian fly in wheat. Polyphagous pests which includes all insects pests collected in canola, soybean, and millet were not greatly affected by rotational sequence. When rotational effects occurred they were with seedling pests whose abundance was influenced by the immediate previous crop. Longer term rotational effects were not observed.

Pearl millet diseases. The $2 billion poultry industry in Georgia has eagerly accepted pearl millet as a new high-quality feed grain but current production is limited. The crop can be successfully grown in rotations with wheat or canola with no detrimental effects on diseases or yield of any of the crops. Some potential problems in pearl millet following canola, such as reduced seedling stands and increased populations of false chinch bugs, tend to be compensated for by reduced foliar disease and reduced stalk rot. Because yields of wheat, canola, and pearl millet are unaffected by rotations, the demands of the regional poultry industry can be addressed by introducing pearl millet into diversified agricultural production systems.

Canola and soybean diseases. The major diseases of canola have not developed as rapidly as expected. The other crops in the rotation have not had any measurable adverse influence on disease control in canola and no special disease control procedures will be needed for double cropped canola.

The expected soybean diseases have developed in the study. Foliar diseases have been erratic in incidence and have not been influenced by cropping history. Root and stem diseases, except stem canker, have a low incidence and have not increased significantly. Stem canker increased in incidence and severity each year and in 1997 was partially responsible for the very low seed yields. Apparent early season differences due to previous winter and summer crops did not last throughout the season and were not reflected in seed yields. To date there has been no clear influence of cropping history on stem canker or any other soybean disease. This indicates that the other crops in the rotations are compatible with soybeans and the addition of millet and canola to the doublecropping system will not adversely influence soybean disease control. Addition of these crops to the double cropping system will not require any major changes in soybean cultivar resistance or other disease control procedures.

Economic Analysis

Economic analyses. Comparisons of the rotation effects on returns were performed by using performance rates for the field operations recorded on specific crops from field operations at the branch experiment stations. The field operations were then costed using costs previously estimated for the equipment utilized to perform these operations. These costs were determined utilizing annual usage rates of the equipment at the branch experiment stations and repair costs relationships and equipment total use hours available estimated from ASAE EP 391.l (ASAE, 1986) and Rotig (1987).

Average prices received by Georgia farmers for the respective crops were used as the crop price for estimating revenue. Prices paid for plant nutrients and other chemicals by the branch experiment station were used for non-machinery inputs. Yields used in the crop and rotation budgeting were the means within statistical significant yield grouping, i.e., all yields of treatments not statistically significantly different were averaged and a single cost and return budget for the group was
calculated. The return measure used was returns to land and management, i.e., land and management were not costed.

The returns by treatment and crop show that rye without any returns provides a costly winter cover crop and wheat significantly infected with take-all also provides costly segment of a crop rotation (Table 20). Higher weed control costs in the 1997 wheat crop and 20% lower yields removed the profitability of wheat compared to the 1995 year which had comparable wheat prices. Because of a crop freeze in the winter of 1995-1996, the returns for the 1996 canola crop were highly negative. Lower canola prices in 1997 made canola barely profitable in 1997. Drought caused lower millet yields in 1997 reduced the profitability of a low profitable crop. The yield reductions in soybeans following canola removes the profitability of soybeans in 1995 and 1996 and in 1997 doubled the loss caused by the drought. In 1997 soybeans in continuous wheat soybean rotations showed the same increase in negative returns as did soybeans after canola.

The rotation returns were computed under two assumptions; 1) take-all infection all years and 2) no take-all infection (Table 21). Under the assumption of take-all, all canola rotations but three show a positive return over three years, two (R-S, C-M, W-S and W-S, C-M, W-S) only had canola during the 1995-1996 winter in which canola froze and the third (W-M, R-S, C-S) had rye a negative income winter crop and canola in the third year which had low returns ($6.56/acre). Wheat rotations where take-all was severe were only profitable if canola was in the rotation. The wheat:millet rotations with severe take-all was the highest negative rotation ($283) with the rye:millet, wheat:soybean, and rye:soybean next (Table 21). With high take-all, the highest income rotations were wheat:canola and had a chance factor in them in that wheat was grown in the second year in which canola failed. If no or low take-all was present, the wheat and canola-wheat rotations were comparable if wheat happened to be the winter crop in the rotation during 1995-1996.

In the three year rotation sequences there were no economic benefits from rye as a winter cover crop. All rotations which included rye average negative incomes ranging from $-6/acre to $-150/acre with no take-all and from $-116/acre to $-206/acre with severe take-all.

Attempting to remove the "luck" results of the C-S, W-M, C-M, or the C-S, W-M, C-S rotations, the reverse of the rotations could be synthesized and an average of the reverse sequences (W-M, C-S, W-M, or W-M, C-M, W-M) compared with the results of the observed rotations. These estimated 3-year averages would be $79.58/acre for the C-S, W-M, C-M rotation and $104.87/acre for the C-S, W-M, C-S rotation. These computed averages should be compared with a synthesized rotation using gained knowledge of beneficial and elemental relationships and relative returns. The synthesized rotation would be C-M, W-S, C-M and the reverse W-S, C-M, W-S and the average 3-year income would be $156.10/acre. This synthesized rotation would have the take-all control by canola and would substitute the lower income of millet for the negative effect of canola and soybean.

Recommendations:

Areas needing additional study

Bibliography

populations of soybean arthropods. p. 30-60. In M. Koan & D.C. Herzog (ed.), Sampling methods in soybean Entomology. Springer-Verlag, N.Y.


Information Products

- [Effect of Twelve Crop Rotation Sequences on TakeAll of Wheat](#) (Conference/Presentation Material)

- [Effect of Crop Rotation on TakeAll Toot Rot of Wheat](#) (Conference/Presentation Material)

- [1997 Southern Small Grain Workers Conference Effect of Crop Rotation on Takeall Root Rot of Wheat](#) (Conference Proceeding)

- [Proceedings AG Showcase 97 Pest Management in Sustainable RowCrop Systems for the Southeast](#) (Conference Proceeding)

- [Small Grain Canola and Forages Field Day](#) (Conference/Presentation Material)

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture or SARE.

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