ABSTRACT

HURT, CHRISTIE ANNE. Evaluation of Cultural Practices to Reduce the Incidence of Tomato Spotted Wilt Virus in North Carolina Peanut *(Arachis hypogaea)*. (Under the direction of Rick L. Brandenburg.)

Tomato spotted wilt virus (TSWV), a thrips-vectored *tospovirus*, has recently become one of the most devastating pathogens of peanut (*Arachis hypogaea* L.) in North Carolina. North Carolina peanut growers saw a dramatic increase in infestations of TSWV in 2000 compared with previous years. Certain cultural practices in Georgia have shown to reduce the incidence of virus, and these were evaluated to determine their effect on TSWV incidence in North Carolina. The production systems are discrete between the runner-type peanuts grown in Georgia and the virginia-type peanuts in North Carolina, thereby requiring that these practices be evaluated in the North Carolina. Treatments included plant populations, cultivars, tillage systems, planting dates, and in-furrow insecticides. During the growing seasons of 2001 and 2002, treatments compared were plant populations of 7, 13, and 17 plants/m-row; cultivars Gregory, NC V-11, and Perry; conventional tillage and strip tillage; early and late planting dates; and aldicarb [O-methylcarbamoyl)oxime], acephate (O, S-Dimethyl acetylphophoramidothioate), and phorate {O, O-Diethyl S-[(ethylthio)methyl]phosphodithioate}. Research plots were scouted for thrips feeding damage, percentage of plants infected with TSWV, and estimates of severity of TSWV. Yields and market grades were recorded for research plots at harvest. High plant populations had less incidence of virus than lower plant populations, Gregory was infected with fewer infected plants than either NC V-11 or Perry, preliminarily strip tillage has had less infected plants than conventional tillage, and peanut treated with in-furrow phorate had less incidence of virus than those treated in-

furrow with aldicarb. Pod yield increased as plant populations increased regardless of other treatments. The cultivar Gregory had the higher percentage of extra large kernels (%ELK) and of fancy pods (%FP) across treatments and locations.

EVALUATION OF CULTURAL PRACTICES TO REDUCE THE INCIDENCE OF TOMATO SPOTTED WILT VIRUS IN NORTH CAROLINA PEANUT (*ARACHIS HYPOGAEA*)

by
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BIOGRAPHY

My name is Christie Anne Hurt and I was born March 10, 1979, in Elkton, Maryland. I grew up in Cecil County and graduated from Elkton High School in 1997. I enrolled at University of Delaware, Newark and received a Bachelor of Science degree with a major in Plant Protection and minors in Plant Science and Entomology in May 2001. In August 2001 I began work at North Carolina State University, Raleigh, on a Master of Science degree under the direction of Dr. Rick L. Brandenburg.

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Introduction

Spotted wilt of peanut (*Arachis hypogaea* L.), caused by tomato spotted wilt virus (TSWV), a *tospovirus,* has increasingly become a limiting factor for peanut growers in northeastern North Carolina during recent years. In Texas, TSWV first reached levels that cause yield losses in peanut the mid-1980's (Black and Smith 1987, Black et al. 1993), and then in Georgia in the early 1990's (Pappu et al. 1999, Kresta et al. 1995, Camann et al. 1995, Mulder et al. 1991). In 1989, TSWV was present in all peanut producing areas of GA at an average incidence of infection of 2%, and by 1996 levels of infection were as high as 100% in some areas (Brown et al. 1996). In 1997, the worst year for TSWV abundance in GA, peanut growers lost an estimated $43 million (Bertrand 1998). Losses to TSWV in 1997 were estimated to be about 12% of the entire state of Georgia's peanut crop; this exceeded losses to other peanut diseases such as leaf spot [*Cercospora arachidicola* S. Hori and *Cercosporidium personatum* (Berk. And M. A. Curtis) Arx], and Cylindrocladium black rot (*Cylindrocladium parasiticum* Crous, M. J. WIngfield and Alfenas) (Bertrand 1998). In North Carolina, TSWV was present in all peanut producing areas by 1995 (Garcia and Brandenburg 2000). During the 2002 growing season, North Carolina peanut growers saw an average of 47% of their acres infected with TSWV; this estimate was for incidence of TSWV and not for severity.

In addition to peanut, TSWV causes an economically significant disease on tobacco (*Nicotiana tabacum* L.), tomato (*Lycopersicon esculentum* L.) and pepper (*Capsicum annum* L.), all of which are significant crops in the southeastern US (Pappu et al. 1999, Jain et al. 1998, Chamberlin et al. 1992, Magbanua et al. 2000). Annual yield losses for all crops affected by TSWV in GA alone have been estimated around $100 million (Bertrand 1998). In North Carolina, individual fields of flue-cured tobacco have suffered yield losses of about 30-50%; individual tomato, pepper, and tobacco fields have also had losses of around 25-50% (Groves 2001). A monetary value has not yet been placed on the losses to crops from TSWV in NC.

Tomato spotted wilt virus is a *Tospovirus* in the family Bunyaviridae. Virus tends to concentrate in areas of meristematic tissue within the plant (Kresta et al. 1995, Hoffman et al. 1998). While symptoms may be present on the seed, the virus has not been found in the cotyledons and has not been shown to spread by seed (Pappu et al. 1999). TSWV is transmitted by at least eight species of thrips and replicates within the body of its vector. TSWV is transmitted in a persistent manner (Sakimura 1962b, Ullman 1993, 1996). After acquisition by thrips larvae, the virus binds to the membrane of the brush border of the midgut (Ullman et al. 1995). The virus then replicates in the midgut epithelium, and the muscle fibers around the midgut (Assis Filho et al. 2002). Compared to other insect vectored viruses, TSWV is less efficiently transmitted to its host. Wijkamp and Peters (1993) found transmission rates of 43.0 to 55.1% for TSWV, whereas impatiens necrotic spot virus (INSV), a similar thrips-vectored virus, had transmission rates of up to 92.5%.

Symptoms of the virus in peanut represent a wide range of visual plant responses. Most often, the early foliar symptoms include chlorotic spots that develop into concentric ring patterns, and sometimes leaves become chlorotic or bronzed (Hoffman et al. 1998). Later symptoms of TSWV in peanut consist of stunting of leaves or entire branches, and distortion of petioles that can become wilted and necrotic at high temperatures (Kresta et al. 1995, Hoffman et al. 1998, Llamas-Llamas et al. 1998). Llamas-Llamas et al. (1998) have shown that high temperatures favor movement of the virus within the plant, whereas low temperatures increase replication of TSWV in the plant. In some cases, whole plants can become chlorotic; this symptom resembles other root rot diseases and is present without any other indication of the virus (Culbreath et al. 1991). Of these chlorotic plants, Culbreath, et al. (1991) confirmed presence of the virus using enzyme-linked immunosorbent assay (ELISA) in 92, 70, 92, and 88% of root samples, and in 0, 0, 32, and 8% of foliar samples from four locations in Georgia. While this phenomenon is not completely understood, most examples of these chlorotic plants have high concentrations of virus within the taproot and not the foliage. When infected with TSWV, peanut seeds are often smaller than those from non-infected plants, and can be pink and cracked (Shew 2003).

Asymptomatic plants are also common within infected fields, and have been shown to test positive for the presence of the virus (Culbreath et al. 1991). Culbreath et al. (1991) found 23% of root samples and 0% of foliar samples from asymptomatic peanut plants tested positive for TSWV using ELISA. Pappu et al. (1999) obtained similar results with ELISA. Visual detection of symptoms in older plants may not be accurate because symptoms are only produced in new growth (Kresta et al. 1995). Older plants are not generating as much new growth as younger plants, and therefore symptoms may not be expressed even though the plant is infected with TSWV.

Frankliniella fusca (Hinds), the tobacco thrips, *F. occidentalis* (Pergande), the western flower thrips, and *Thrips tabaci* Lindeman, the onion thrips, are the most common thrips infesting crops in NC and the southeast (Eckel et al. 1996, Chamberlin et al. 1992, Kresta et al. 1995, Cho et al. 1995) that vector TSWV (Sakimura 1962a, 1962b, 1963). The onion thrips have recently been shown to be unable to vector TSWV (Wijkamp et al. 1995). In peanut producing areas of NC, *F. fusca*, the tobacco thrips, is the most prevalent, normally accounting for about 95% of the TSWV-vectoring thrips (Cho et al. 1995, Eckel et al. 1996), whereas the others occur much less frequently at about 2% of the population (Cho et al. 1995, Barbour and Brandenburg 1994, Groves

2001, Groves et al. 2003). Tobacco thrips are one of the most important pests in peanut (Jordan et al. 1999). Brecke, et al. (1996) found that while thrips damage alone may not cause long-term losses of peanut growth and yield in Florida, when combined with herbicide damage there is often a multiple stress interaction. In some areas of the Southeast, feeding damage alone inflicts little more than cosmetic damage to peanut. In North Carolina, however, the economic threshold for leaf damage by thrips is 25% (Brandenburg 2003). However, the greatest danger thrips present to peanut growers is the potential to vector TSWV to crops.

Eckel (1996) showed no difference in transmission efficiency between *F. fusca* and *F. occidentalis* for spread of TSWV on the host *Emilia sonchifolia* from the Asteraceae family. Assis Filho et al. (2002) supported this finding with research concluding that there were no differences in the dynamics of TSWV replication in *F. fusca* and *F. occidentalis.* Also, there was no significant difference in rate of symptom expression of TSWV in plants infested with *F. fusca* and *F. occidentalis* (Eckel et al. 1996). Populations of *F. fusca* were more abundant early in the growing season, and then decreased later as numbers of *F. occidentalis* stayed constant (Eckel et al. 1996). For these reasons, both species are likely vectors of TSWV to a variety of hosts, although, spatial, temporal, and host-preference differences cause *F. fusca* to be the more common pest of peanut in northeastern NC. *F. fusca* is more frequently found in the eastern piedmont and coastal regions, whereas *F. occidentalis* is more numerous in the mountains of NC (Eckel et al. 1996, Groves et al. 2003). Also, peanut is a much better host for *F. fusca* than the western flower thrips in terms of fecundity, survival, longevity, and reproduction (Lowry et al. 1992). Todd et al. (1995) found that while the tobacco thrips can reproduce on the leaves or flowers of peanut, the western flower thrips does not.

Thrips must acquire the virus as larvae from infected host plants but typically do not transmit the virus until after a latent period. Adult *F. fusca* can transmit TSWV in as little as 15 min of feeding on a host plant (Sakimura 1962b, 1963). Research by Wijkamp and Peters (1993) found that 80 to 85% of infective thrips transmitting TSWV were second stadium larvae, leaving relatively few thrips that only transmitted the virus as adults. Secondary spread by larvae can occur more quickly when compared to adults due to the molting time. Two additional molts are required for second stadium larvae to reach the adult stage. TSWV has not been reported to be transmitted transovarially to offspring from adults (Sakimura 1963, Ullman 1993). There is an average latent period of TSWV of nine days in the tobacco thrips with a range of 4 to 12 days (Sakimura 1963). The latent period is often shorter when temperatures are higher (Wijkamp and Peters 1993). After the thrips has acquired the virus, it normally retains the virus until death (Sakimura 1963, Ullman 1993). Transmission of TSWV can either be continuous or sporadic for the length of retention within the thrips (Sakimura 1963, Todd et al. 1990).

Tobacco thrips reproduce on peanut or summer annual weeds throughout the growing season, and then relocate to winter annual or perennial weeds after the first freeze (Groves et al. 2003). Groves et al. (2003) showed that within two to five days after the first freeze, thrips moved from maturing summer annuals and perennial weeds to other perennial or young winter annual weeds. Cho et al. (1995) failed to detect *F. fusca* overwintering in the soil in North Carolina. Propagation of TSWV within the thrips allows the virus to remain active throughout the winter and into the spring, either within the body of the thrips or within an alternate plant host, such as a winter annual or perennial weed (Chaisuekul and Riley 2000, Ullman 1993). Weed species vary greatly in their ability to sustain reproduction of thrips, even though there are numerous species that harbor adult thrips throughout of the winter (Groves 2001). A plant is a source for TSWV spread when reproducing populations of thrips can be sustained, and when the plant is susceptible to infection by the virus (Ullman 1993); locally, there are weed species that serve as sources of virus inoculum (Groves 2001).

After overwintering on susceptible weed hosts as primarily brachypterous females (Chamberlin et al. 1992, Cho et al. 1995, Brown et al. 1996), thrips begin dispersing to new hosts in early April (Groves et al. 2003). Peak flights of tobacco thrips occur in mid to late May after increasing on weed hosts (Eckel et al. 1996). Todd et al. (1995) found that in Georgia, peak populations of tobacco thrips were on peanut 10 to 20 days after planting in April. Peak numbers of larvae caused the greatest feeding injury at about 28 to 35 days after planting (Todd et al. 1995). Thrips moving into the field in the springtime are mostly from nearby locations, and provide the primary source of infection (Camann et al. 1995, Chamberlin et al. 1992, Chamberlin et al. 1993, Brown et al. 1996, Todd et al. 1989). Thrips may also migrate into fields, blown by wind currents (Mound 1996, Todd et al. 1989).

Movement of TSWV from crops to weeds is not usually a concern, except for peanut, where thrips reproduce and where the virus is maintained in the plant (Groves 2001, Chamberlin et al. 1992). The time of greatest reproduction occurs towards the end of April to early May in North Carolina, making the situation very unfavorable to early planted, TSWV-susceptible crops (Groves 2001). Mulder et al. (1991) showed that the thrips populations in border areas of peanut fields peaked before peanut emergence, declined, and then peaked again as peanut plants were starting to flower. Groves et al. (2003) also showed that summer annual weeds can serve as a bridge between various cropping systems up until times of harvest, but they play a minor role in the TSWV infection cycle. Mulder et al. (1991) found that in Texas *Frankliniella fusca and F. occidentalis* move from weed hosts to peanut in early July in response to plant senescence. Groves et al. (2003) corroborated these findings when he showed the time of thrips dispersal in the fall was strongly correlated with the first hard freeze.

F. fusca was found on 30 plant species in 14 families in NC during the winter season (Cho et al. 1995). Cho et al. (1995) found that *F. fusca* was found to commonly overwinter on the foliage of rabbit tobacco (*Gnaphalium obtusifolim* L.), dandelion (*Taraxacum officinale* Wiggers), shepherds purse [*Capsella bursa-pastoris* (L.) Medic.], and buckhorn plantain (*Plantago lanceolata* L.). Of these, dandelion and shepherds purse were confirmed TSWV susceptible wild hosts (Cho et al. 1995). Groves (2001) found that the wild hosts knawel (*Scleranthus annus* L.), annual sowthistle [*Sonchus asper* (L.) Hill], common chickweed [*Stellaria media* (L.) Cyrillo], and dandelion (*Taraxacum officianale* Wiggers) consistently sustained the largest numbers of *F. fusca* in NC. Wild hosts with the highest chance of supporting both thrips populations and TSWV include mouseear chickweed (*Cerastium vulgatum* L.), broadleaf plantain (*Plantago rugelli* Dene.), annual sowthistle [*Sonchus asper* (L.) Hill], common chickweed [*Stellaria media* (L.) Cyrillo], and dandelion (*Taraxacum officianale* Wiggers) (Groves 2001). Groves (2001) calculated these values by interpreting the number of TSWV-infected plants of the species, the proportion of the species infected with the virus, and the total of immature *F. fusca* on the species. Some wild sources of TSWV for either early or late season crop infection include the perennials broadleaf plantain (*Plantago rugelli),* and dandelion (*Taraxacum officianale*); winter annuals include mouseear chickweed (*Cerastium vulgatum*), small-flower buttercup (*Ranunculus sardous*), annual sowthistle (*Sonchus asper*), common chickweed (*Stellaria media*); and summer annuals include common ragweed (*Ambrosia artemisiifolia* L.), carpetweed (*Mollugo verticillata* L.), and Pennsylvania smartweed (*Polygonum pensylvanicum* L.) (Groves 2001).

Groves et al. (2003) also determined the two periods of time when thrips most often spread TSWV to be from early April to mid-May, and from early October to mid-November. These time periods have the most possibility for TSWV suppression by either thrips or weed control. However, to utilize this information for greater virus suppression a thorough understanding of this relationship of vector and host is necessary.

Thrips primarily oviposit into the terminals of peanut plants. After hatching, larvae feed on terminals during the peanut growing season (Kresta et al. 1995, Todd et al. 1995). There are two larval and two pupal stages after hatching; the total life cycle taking about 20 days from egg to adult in optimal conditions (Mound 1996). Being haplo-diploid, male thrips develop from unfertilized eggs with half of the number of chromosomes of female *F. fusca*. However, females can produce offspring by thelytoky, or chromosome doubling, and can reproduce without the occurrence of males (Mound 1996). Sakimura (1962a) showed no difference in the efficiency of either male or female thrips as vectors of TSWV; however, Wijkamp et al. (1995) showed females of *F. occidentalis* to be more efficient vectors than males. What is interesting to note is that thrips feeding and reproducing in peanut infected with TSWV are likely to have a shorter developmental time and an increased mortality rate (Puche and Funderburk 1992, Garcia et al. 2000).

When a peanut plant is infected with spotted wilt, the quality and vigor are affected negatively. Pods from TSWV-infected plants have reduced oil content and the amount of oil diminishes with the length of viral infection (Ali and Rao 1982). Work done by Ali and Rao (1982) in India found that peanut plants infected with TSWV at 60 d had a 27.5% reduction in oil content. Peanut infected with TSWV suffer yield loss (Pappu et al. 1999, Culbreath et al. 1992). The level of yield reduction is often strongly correlated with the time of symptom appearance (Culbreath et al. 1992). The yield loss is due to both decreased weight of seeds and overall lower seed production in infected plants (Culbreath et al. 1992). Culbreath et al. (1992) showed that in an average year, the difference between healthy and TSWV infected plants for number of seed was 85.4 and 33.1, for seed weight (g/seed) was 0.42 and 0.31, and for yield (g) was 35.1 and 11.0, respectively.

Controlling thrips by use of insecticides does not sufficiently reduce TSWV due to the short feeding time of thrips necessary to vector the virus in peanut (Culbreath et al. 1999, Brown et al. 1996, Todd et al. 1993). In addition, insecticides may agitate the thrips and cause them to fly to another plant, thereby spreading the virus to another host (Broadbent and Allen 1995). TSWV outbreaks in peanut have been devastating in peanut production areas other than North Carolina and researchers have focused on evaluating cultural practices to manage TSWV in peanut. A valuable source of information from the University of Georgia is the Spotted Wilt Risk Index (Brown et al. 2003). The Spotted Wilt Risk Index is a compilation of the research on TSWV in Georgia using a point system to help growers modify their production to reduce the risk of TSWV. Specific cultural practices within the index include peanut variety, planting date, plant population, insecticide, row pattern, tillage, and herbicide. This index was first developed in 1996 and has since been updated annually with continuing research for reducing TSWV in peanut. The publication also provides several scenarios or situations that put growers at low, moderate or high risk for losses. The findings from this research have allowed growers in areas with outbreaks to select the most appropriate management tactics to reduce virus incidence. A similar Advisory Index has been developed for North Carolina (Hurt et al. 2003).

Cultivar selection is an extremely valuable tool in managing TSWV in peanut production. This control option has been described as having the greatest and most consistent effect (Brown et al. 1996). The University of Georgia's Spotted Wilt Risk Index indicates that cultivar choice allows for the broadest range of points for any category (Brown et al. 2003). Cultivar selection is such an important factor, that more than 75% of the acreage in GA was planted to Georgia Green since it has been shown to have moderate resistance to TSWV (Culbreath et al. 1999). Cultivars that have moderate resistance to TSWV are not less attractive to thrips. Rather, there appears to be a mechanism within the plant to tolerate virus infection better than other cultivars of peanut (Culbreath et al. 2000).

Gregory is a virginia market type cultivar that has a semi-runner growth habit crossed between runner and bunch types (Jordan 2003). Along with particularly high percentage of extra large kernels and fancy pods, Gregory is considered to have the best resistance to TSWV compared with all other commercially available virginia-type cultivars (Jordan 2003). NC-V 11, with its high yielding potential, has been shown to be moderately resistant to TSWV (Jordan et al. 1999, Huber 2002), as well as one of the top five cultivars in production acreage in NC (Garcia and Brandenburg 2000). Results of resistance of NC-V 11 to TSWV were sometimes conflicting (Culbreath et al. 2000). With resistance to CBR and some tolerance to Sclerotinia blight, Perry is a large-seeded variety that has a semi-runner growth habit (Huber 2002). Perry is considered to be susceptible to TSWV under significant disease pressure (Huber 2002, Jordan 2003).

Cultivar resistance consists of a reduced disease occurrence, and cultivar tolerance is a reduced severity in infected plants (Brown et al. 2003). When a cultivar showing some resistance or tolerance to TSWV is used, it requires no other investment, no additional machinery, and no additional input throughout the growing season as compared to other management practices. Incorporating disease resistant cultivars into plant production systems is a preferred choice for growers to help reduce losses to TSWV in their fields with little other input. Nonetheless, there are no varieties of peanut with complete resistance to TSWV (Culbreath et al. 2000), leaving even the moderately resistant cultivars susceptible to serious damage. Therefore, it is important to incorporate multiple management strategies into a production plan to reduce losses to virus in peanut.

While the use of insecticide has not been adequate to control spotted wilt in peanut, the insecticide phorate {O, O-Diethyl S-[(ethylthio)methyl]phosphodithioate} has shown low-level suppression of TSWV (Culbreath et al. 1999, Brown et al. 2003). Phorate controls of thrips less effectively when compared to other insecticides (Brown et al. 2003). The phytotoxic properties of phorate may likely explain the disease suppression more than the actual insecticidal properties (Culbreath et al. 1999). Research in Florida has shown higher yields (by 32%) in phorate-treated plots and reduced TSWV infection (by 18%) (Butler 2003). Peanut leaves of plants treated with phorate often will exhibit marginal chlorosis and then necrosis on young plants, which may stimulate a host defense reaction within the plant (Culbreath et al. 1999, Brown et al. 2003). When used in small research plots, peanut treated with phorate had less incidence of TSWV than did those treated with other insecticides (Todd et al. 1996).

When thrips are in the process of choosing a host, first long-range cues, then short-range cues such as colors, volatiles, and plant size and shape are used to distinguish potential hosts (Terry 1997). Any changes in the appearance of a typical peanut field may influence the probability of thrips landing in that field. Therefore, altering the peanut canopy may mean that the field is less attractive as a potential host.

The use of higher plant populations may only reduce the percentage of plants infected in a field due to the higher number of plants available for infection (Culbreath et al. 1999, Brown et al. 1996). When the seeding rate of peanut is increased, the amount of TSWV is decreased, and simultaneously yield is increased (Wehtje et al. 1994). The higher plant population may also provide a higher number of healthy plants, allowing for compensation of diseased plants within rows (Brown et al. 2003). Gorbet and Shokes (1993) found that when the spacing between peanut plants is reduced, there is a strong correlation with reduced percentage of virus. When plants were spaced at 7.6, 15.2, 30.5, 45.7, and 61.0 cm, the resulting amounts of virus were 9, 22, 55, 67, and 70% respectively for the cultivar Sunrunner (Gorbet and Shokes 1993). For the same plant spacing as listed in the above test, Southern Runner had 5, 10, 22, 36, and 45% TSWV infected plants. However, cost is increased due to the higher seeding rate used to establish the larger plant populations. In North Carolina, growers are recommended to plant 7 to 13 seeds per meter of row (Jordan 2003). Higher plant populations suggested for peanut growers are up to 17 plants per meter of row for reduction of TSWV (Jordan 2003). Since seed size varies, it is important to compensate for larger seeds. The variety Gregory requires 109 kg/ha of seed at the seeding rate of 7 seeds/row-meter ($63.05); whereas the same variety at the seeding rate of 17 seeds/row-meter is 180 kg/ha ($104.65). This increase of over 70 kg/ha could cost $41.60/ha for Gregory (Jordan 2003).

Peanut planted to twin rows spaced 17 cm with 90 cm middles frequently have higher yields and better grades when compared to single rows (Culbreath et al. 1999, Baldwin and Williams 2002). Levels of TSWV in fields planted to twin rows are also reduced (Brown et al. 1996), which may be in part to the earlier canopy cover that may impact the migrating thrips and identification of peanut hosts (Culbreath et al. 1999). Seeding rates are measured across the twin row; for example, a twin row planting of 16 seeds/m-row would consist of two closely planted rows with a seeding rate of 8 seeds/m-row. This means a field planted to single rows with a seeding rate of 16 seeds/m-row would require the same amount of seed as a field planted to twin rows with a seeding rate of 16 seeds/m-row.

Results from research that indicates reduced virus with use of twin row planting has encouraged peanut growers in Georgia to incorporate this practice into their production systems. In 1999 Georgia peanut growers were planting 35% of peanut acres in twin rows, however, in 2002, twin row planting increased to 50% of the acres (Baldwin and Williams 2002). A study conducted in Georgia from 1996 through 2001 shows an average increase in yield of 549 kg/ha, and 7 to 10% less TSWV when fields were planted to twin rows on conventional plantings (Baldwin and Williams 2002). Although twin row plantings have shown a reduction in incidence of virus, the change from production of single rows to twin rows requires investment in equipment. The increase in return may not outweigh the cost of the investment if risk of virus pressure is low.

Similar to twin row plantings, a change to reduced tillage from conventional tillage may change the appearance of a field and subsequent movement of thrips into fields. Brandenburg et al. (1998) found that in most cases, peanut planted into reduced tilled fields had less thrips damage than peanut planted into conventionally tilled fields. This change in tillage may keep the thrips from recognizing a peanut field (Culbreath et al. 1999). Fewer thrips tend to prefer peanut in reduced-till fields (Marois and Wright 2003). Levels of TSWV are lower in fields with reduced tillage when compared with conventionally tilled fields (Baldwin and Williams, 2002, Jordan, et al., 2003). A study from Georgia shows that the percentage of peanut plants infected with the virus is decreased by 42% when using reduced tillage compared with conventional tillage (Johnson, et al. 2001). Similarly, Jordan et al. (2003) found a 50% reduction in TSWV levels in strip tillage (7% infection) when compared with conventional tillage (14%

infection). Furthermore, during years of drought and heat stress, Marois and Wright (2003) at the University of Florida found higher yields and lower levels of TSWV in strip-tilled peanut than conventional-tilled. In addition to the benefits of TSWV reduction, reduced tillage helps to conserve soil and water (Marois and Wright 2003).

Timing of emergence of the peanut crop can play an important role in the amount of thrips feeding, and subsequently the amount of virus introduced in a field. In the southern US, planting date has been shown to affect virus incidence, although results have not been consistent from year to year (Culbreath et al. 1999). This could be explained by the temporal difference of thrips movement into fields, which is variable from one year to the next. Mitchell and Smith (1991) established that planting too early may increase the chance of infection because peanut plants are growing slower as a result of slow accumulation of heat units, and that planting too late is risky because of the secondary spread of TSWV that is already introduced to the field. Corresponding to these findings, planting dates in the southeast US that are least favorable for thrips-avoidance are generally early (April) and late (June) (Brown et al. 1996). Farther north, in the Virginia-Carolina peanut growing region, planting dates are even less flexible due to a shorter growing season (Jordan et al. 2000), but altered planting dates can still be a valuable tool for reduction of TSWV in peanut.

No single practice provides complete control of TSWV in peanut. Several methods must be incorporated into a management program to reasonably suppress this disease (Brown et al. 1996, Culbreath et al. 1999, Hurt et al. 2003). Preventative methods are the only effective means to combat the disease, because once the crop has been planted there are no other control options (Brown et al. 2003). Additionally, management of the virus in peanut as well as other crops has been demonstrated to be extremely complex due to the extensive host ranges of the virus and the thrips vectors.

When used together, several cultural controls can be additive. As more strategies are used, the result is a greater reduction of TSWV in fields.

While these methods have been successful in the southeastern and southwestern US, there is a need to evaluate these practices to determine whether they will provide the same positive effects in the Virginia-Carolina region. Traditionally, the virginia market-type peanut (virginia peanut) is grown in North Carolina and Virginia, whereas the runner market-type peanut (runner peanut) and valencia peanut are grown in the southeastern and southwestern areas of the US (Jordan et al. 2000). The virginia peanut has a larger pod than runner and valencia peanut, and generally a higher yield. Early maturity is an important factor in the Virginia-Carolina region as a result of the shorter grower season compared to the southeastern US states (Jordan et al. 2000). The objectives of this research were to determine the impact of the cultural practices shown to reduce TSWV in other states on virginia peanuts grown in the Virginia-Carolina growing region.

Materials and Methods

Five tests were developed to evaluate the impact and interactions of cultivar selection, plant population, planting date, tillage system and in-furrow insecticide treatments on the incidence of TSWV in peanut in the North Carolina. The objectives of this research were 1) determining the effects of these practices on TSWV incidence in peanut, 2) gaining a better understanding of the mechanisms associated with various cultural practices in influencing TSWV and peanut yield, such as thrips feeding, in peanut, and 3) developing a comprehensive TSWV risk management program for peanut growers.

Influence of Cultivar, Planting Pattern, and Plant Population on TSWV Incidence.

Experiments in 2001 were conducted in North Carolina on private farms located on Hart's Mill Road near Williamston in Edgecombe County and on Wildcat Road near Tarboro in Martin County. In 2002, experiments were conducted at the Upper Coastal Plain Research Station located near Rocky Mount and in two separate fields at the Peanut Belt Research Station located near Lewiston-Woodville. Soil at Williamston, Tarboro, and Field 1 at Lewiston-Woodville was a Norfolk sandy loam (fine-loamy, siliceous, thermic Aquic Paleudalts). Soil in Field 2 in Lewiston-Woodville and Rocky Mount was a Goldsboro sandy loam (fine-loamy, siliceous, thermic Aquic Paleudalts). Peanut was planted on raised beds in conventionally-prepared seed beds. Plot size was 2 rows (91-cm spacing) by 12 m long. Peanut was planted at Edgecombe County on 1 May 2001 and at Martin County on 4 May 2001. Peanut was planted at Rocky Mount on 10 May 2002, and on 3 and 8 May 2002 at Fields 1 and 2, respectively, at Lewiston-Woodville.

Treatments consisted of three levels of plant population (7, 13, or 17 plants/meter-row) three levels of cultivar (Gregory, NC V-11, or Perry), and five levels of location. Plant populations corresponding to 7 and 13 plants/meter-row were established using a White® vacuum planter in single rows spaced 91 cm apart. A twin row spaced 18 cm apart on 91 cm centers was used to establish the 17 plant/meter-row population. Seed was placed 5 to 8 cm deep depending on soil moisture. Aldicarb was applied at 7.9 kg ai/ha in-furrow at planting as a granular formulation for each row in either the single or twin row planting patterns. Fields were maintained weed-free using the following herbicides: pendimethalin (preplant incorporated at 0.84 kg ai/ha), metolachor (preemergence at 1.1 kg ai/ha), bentazon (postemergence at 0.56 kg ai/ha), acifluorfen (postemergence at 0.28 kg ai/ha), 2,4-DB (postemergence at 0.28 kg ai/ha), and clethodim (postemergence at 0.14 kg ai/ha). The cultivars Gregory, NC V-11, and Perry offer various levels of resistance to tomato spotted wilt virus (Shew 2003) and pod characteristics (Jordan 2003a). Seed count for Gregory, NC V-11, and Perry is 1000, 1388, and 1166 seed/kg, respectively (Jordan 2003a). To generate 7 plants/m-row, a minimum weight of 109, 79, and 93 kg/ha must be planted for the cultivars Gregory, NC V-11, and Perry, respectively. For the plant population of 17 plants/m-row, the weights for Gregory, NC V-11, and Perry are 144, 104, and 124 kg/ha respectively. All other production and pest management practices were held constant over the entire test area (Brandenburg 2003, Jordan 2003a, Shew 2003). The experimental design was a randomized complete block with treatments replicated four times.

Thrips damage counts were recorded at 33 days after planting. By randomly examining 25 plants within each plot for thrips feeding on the most recently emerged leaves. Leaflets were considered damaged when any portion of the youngest leaves had scarring; ranging from a few tiny speckles to significantly scarred leaflets. A positive (+)

or negative (-) result was recorded for each of the 25 plants with data transformed to percentage of plants with feeding damage.

In 2001, scouting was conducted monthly for foliar symptoms of TSWV (June, 21 July, 23 August, and 18 September). In 2002, scouting was conducted weekly for foliar symptoms starting one week after cracking through late September (10 June, 17 June, 24 June, 4 July, 11 July, 16 July, 22 July, 1 August, 6 August, 23 August, 27 September). Foliar symptoms included ring spotting on leaves, stunting of entire plant or individual branches, wilting or twisting of petioles, and general chlorosis or bronzing (Shew 2003). Symptoms were observed while walking slowly between two rows and inspecting every plant. For both years, symptomatic plants exhibiting any combination of the described symptoms were marked with a survey flag. A different color was used for each month during 2001 to distinguish when the symptoms were first observed for ease of recording the number of infected plants observed for each month. The colors used for 2001 flags are as follows: June-yellow, July-blue, August-white, and September-red. For 2002, a different color also indicated the month symptoms appeared, but a hole was punched into the flag to indicate which week within the month for ease of recording the number of infected plants observed for each week. The colors used for 2002 are as follows: June-blue, July-red, August-white, and September-yellow. The first week in a month was indicated by one hole punched into the plastic flag, two holes punched were the second week, and so on.

At the end of the growing season, but before harvest, foliar samples from each flagged, symptomatic plant were removed in 2001. Each foliar sample consisted of at least 3 symptomatic leaflets that were hand-pulled from a symptomatic plant and placed into a re-sealable plastic bag labeled with the corresponding plot number. Each bag was put on ice in a cooler until placed into the refrigerator in the laboratory. Samples were tested for presence of TSWV within one week of removing from the field.

These samples were tested for confirmation of the presence of TSWV using the ImmunoStrip test from Agdia (STX 39300, ACC 00936, Elkhart, IN). This test kit is an efficient and reliable version of the DAS ELISA protocol and is produced by the same company that manufactures the DAS ELISA. Because the results of this procedure are rapid and consistent, it was more desirable than the standard ELISA test for processing the nearly 4,000 samples. The kit consists of an extraction pouch made of thick plastic surrounding two layers of plastic mesh submersed in buffer. Foliar samples are placed between the two mesh layers and ground using a tissue homogenizer from Agdia (ACC 00900, Elkhart, IN), ink pen, or another blunt instrument. After grinding the sample in the liquid buffer, the test strip is placed into the buffer-sample mixture for several minutes, and then checked for the presence of either one or two horizontal dark lines across the strip. The presence of two lines indicates a positive viral sample, and one line indicates a negative viral sample.

Peanut vines were inverted to dry 1 October at Williamston and Tarboro, 3 October at Rocky Mount, and 1 October at both Fields 1 and 2 at Lewiston-Woodville. Stand counts were taken on the day of inversion by counting the number of taproots in each plot from the first replication of each treatment for each test. Plants that were necrotic, but still identifiable were included in the stand count; however, plants that died early in the season were not accounted for. Percent disease was derived from the number of symptomatic plants out of the total number from the stand count for each plot within an experiment. Within 1 wk prior to vine inversion, visual estimates of TSWV severity in the peanut canopy were recorded using a scale where 0 = no symptoms and 100 = all plants in a plot exhibiting symptoms. These ratings were kept separate from actual counts of symptomatic plants and used as discrete data in the analyses.

Peanut was harvested after pods and vines were allowed to air dry for approximately one week after vine inversion. On 8 and 9 October, peanut was harvested using conventional harvesting equipment at Edgecombe and Martin counties, respectively. On 10 October peanut at Rocky Mount was harvested; Fields 1 and 2 at Lewiston-Woodville were harvested 8 October. Market grade characteristics were determined by collecting a 1-kg sample of pods. Percentages of total sound mature kernels (%TSMK), extra large kernels (%ELK), and fancy pods (%FP) were determined using Cooperative Grading service criteria for quota peanut (Peanut Loan Schedule, 1997-2001, USDA-FSA-101-3).

Data for thrips damage, percent disease based on counts, visual estimates of percent severity, pod yield, and market grade characteristics were subjected to analyses of variance for a five (experiment) by three (plant population) by three (cultivar) factorial arrangement of treatments (SAS Institute 1998). Means for significant main effects and interactions were separated using Fisher's Protected LSD Test at $p \leq 0.05$ (Steel et al. 1997).

Influence of Planting Date, Cultivar, Planting Pattern, and Insecticide on TSWV Incidence.

The experiment was conducted in North Carolina at the Peanut Belt Research Station near Lewiston-Woodville during 2001 and 2002. Soil at this site was a Norfolk sandy loam. Peanut was planted on raised beds in conventionally-prepared seed beds. Plot size was 2 rows (91-cm spacing) by 12 m long. Peanut was planted 2 May 2001 and 3 May 2002 as the early planting date, and 22 May 2001 and 23 May 2002 as the late planting date. Peanut in North Carolina are generally planted during the first two weeks of May (Jordan 2003a).

The experimental design was a split plot with four replications. Planting date (early May or late May) was the main plot with cultivars (NC V-11 or Perry), planting patterns (twin rows or single rows), and in-furrow insecticides (aldicarb at 7.9kg ai/ha or phorate 5.6kg ai/ha) combinations serving as subplots. Plant populations corresponding to 7, 13, and 17 plants/meter-row were established as described previously in single, single, and twin row planting patterns, respectively. Insecticides at appropriate rates were applied in-furrow at planting as a granular formulation. Fields were maintained weed-free as previously described. All other production and pest management practices were held constant over the entire test area (Brandenburg 2003, Jordan 2003a, Shew 2003).

Thrips damage ratings were taken 20 days post planting for both the early and late planted peanut using the technique described previously. Foliar symptoms of TSWV were documented as described previously. Data were recorded as described previously for the percent disease based on counts and stand counts.

At the end of the growing season, but before harvest, tap root samples from each flagged, symptomatic plant were taken in 2001. Peanut plants showing foliar symptoms of TSWV were uprooted using a pitchfork, and then taproots were cut off at the crown. Taproots were placed into re-sealable plastic bags and labeled with corresponding plot numbers. Samples were tested as described previously. Visual estimates of percent severity were recorded as previously stated.

Peanut plants were inverted 5 October 2001. Early planted peanut were inverted 8 September 2002, and late planted peanut were inverted on 5 October 2002. Peanut was harvested using conventional harvesting equipment on 12 October 2001. For the early planting, peanut was harvested 4 October 2002, and the late planted peanut was harvest 12 October 2002. Market grade characteristics were determined as described previously.

Data for thrips damage, percent disease based on counts, visual estimates of percent severity, pod yield, and market grade characteristics were subjected to analyses of variance for a split block design with mixed factors (SAS Institute 1998). Means for significant main effects and interactions were separated using Fisher's Protected LSD Test at $p \leq 0.05$ (Steel et al. 1997).

Influence of Insecticide (aldicarb, phorate) Rates Applied in Twin Rows Planting Patterns on TSWV Incidence.

In 2002, experiments were conducted in North Carolina at the Peanut Belt Research station near Lewiston-Woodville and at the Upper Coastal Plain Research Station near Rocky Mount on soils described previously for these experiments. Peanut was planted on raised beds in conventionally-prepared seedbeds. Plot size was 2 rows (91-cm spacing) by 12 m long. Peanut was planted 3 May at Lewiston-Woodville, and 10 May at Rocky Mount.

Treatments consisted of two levels of insecticide (aldicarb or phorate), three levels of insecticide rates (0.5, 1.0 or 1.5 times the suggested use rate), and two levels of experiment (Lewiston-Woodville and Rocky Mount). Aldicarb was applied in the seed-furrow at 5.6, 7.9, 11.2 kg ai/ha. Phorate was applied in the seed-furrow at 4.0, 5.6, and 8.0 kg ai/ha. All treatments were planted into a twin row planting pattern designed to establish 17 plants/meter-row using a White® vacuum planter. A control plot was also included. Seed was placed 5 to 8 cm deep depending on soil moisture. The cultivar at Lewiston-Woodville was Gregory, and at Rocky Mount, NC V-11 was planted. Fields were maintained weed-free as previously described. All other production and pest management practices were held constant over the entire test area (Brandenburg 2003, Jordan 2003a, Shew 2003). The experimental design was a randomized complete block with treatments replicated four times.

Thrips damage counts were recorded 20 days after planting using the technique described previously. Foliar symptoms of TSWV were documented as described previously. Foliar samples from symptomatic plants were tested as described previously and the data were recorded for the percent disease based on counts. Visual estimates of percent severity were recorded as previously stated.

Plants were inverted 1 October at Lewiston-Woodville and 3 October at Rocky Mount. Total counts of symptomatic plants were taken on the day of inversion and used as the amount of TSWV in the analyses. Stand counts were not taken because all treatments had the same planting density and were assumed to be relatively similar. Total counts, instead of percentages, were used in the analyses of this test. Visual estimates of disease severity were recorded as previously described.

Peanut was harvested using conventional harvesting equipment on 8 October at Lewiston-Woodville and 10 October at Rocky Mount. Peanut quality was not determined for this test at either location.

Data for thrips damage, percent disease based on counts, visual estimates of percent severity, and pod yield were subjected to analysis of variance for a two (experiment) by two (insecticide) by three (rate) factorial arrangement of treatments (SAS Institute 1998). Means for significant main effects and interactions were separated using Fisher's Protected LSD Test at $p \leq 0.05$ (Steel et al. 1997).

Influence of Insecticide (acephate, aldicarb) Rate and Planting Pattern on TSWV Incidence.

The experiment was conducted in North Carolina near Sunbury in Gates County in 2000. In 2001, the experiments were conducted in North Carolina at the Peanut Belt Research Station near Lewiston-Woodville; Bladenboro near Bladen County; near Goldsboro; and at the Upper Coastal Plain Research Station near Rocky Mount. At the Sunbury experiment, the soil was a Pantego series, which is loamy sand (DESIGNATION??). Soil at Lewiston-Woodville and Bladenboro was a Norfolk sandy loam (fine-loamy, siliceous, thermic Aquic Paleudalts). At the Goldsboro experiment, the soil was a Wickham loamy sand. In Rocky Mount, the soil was as previously described. Peanut was planted on raised beds in conventionally-prepared seedbeds. Plot size was 2 rows (91-cm spacing) by 12 m long. Peanut was planted 7 May at Sunbury. Peanut was planted 1 May at Lewiston-Woodville, 19 May at Bladen County, 14 May at Goldsboro, and 8 May at Rocky Mount.

Treatments consisted of two levels of insecticide (aldicarb or acephate), two levels of insecticide rates (0.6 or 1.0 times the manufacturer's suggested use rate), and two levels of planting pattern (single or twin rows). Aldicarb was applied as a granular formulation in the seed-furrow at 4.5, and 7.8 kg ai/ha for each single row or each individual row of the twin row planting pattern. Acephate was applied at rates of 0.7, and 1.1 kg ai/ha for each single row or each individual row of the twin row planting pattern. Acephate was applied using an 8002 flat fan nozzle in the seed furrow following seed drop at 93.5 L/ha total spray volume. Aldicarb was applied at the appropriate rates as in-furrow at planting as a granular formulation. Controls received no insecticide treatment, and were planted into both single and twin row patterns. A White® vacuum planter was used to achieve the desired seeding rate of 13 and 17 plants/meter-row for single and twin row patterns respectively. The variety planted for this experiment was NC V-11 for each experiment over both years. Seed was placed 5 to 8 cm deep depending on soil moisture. Fields were maintained weed-free using the methods previously described. All other production and pest management practices were held constant over the entire test area (Brandenburg 2003, Jordan 2003a, Shew 2003). The experimental design was a randomized complete block with treatments replicated four times.

Thrips damage ratings were taken at 20 days post plant at the Lewiston-Woodville, Bladenboro, Goldsboro, and Rocky Mount experiments as described previously, but not at the Sunbury experiment. Foliar symptoms of TSWV were documented as described previously. Foliar samples from symptomatic plants were tested as described previously, and the data were recorded as previously stated for the percent disease based on counts and stand counts. Visual estimates of percent severity were recorded as previously stated.

Plants were inverted 3 October at Sunbury, 4 October at Lewiston-Woodville, 12 October at Bladenboro, 8 October at Goldsboro, and 27 September at Rocky Mount. Peanut was harvested using conventional harvesting equipment on 10 October at Sunbury, 11 October at Lewiston-Woodville, 19 October at Bladenboro, 15 October at Goldsboro, and 4 October at Rocky Mount. Market grade characteristics were determined as described previously.

Data for thrips damage, percent disease based on counts, pod yield, and market grade characteristics were subjected to analyses of variance for a two (insecticide) by two (insecticide rate) by two (planting pattern) by five (experiment) factorial arrangement of treatments (SAS Institute 1998). Means for significant main effects and interactions were separated using Fisher's Protected LSD Test at $p \leq 0.05$ (Steel et al. 1997).

Influence of Tillage, Cultivar, Planting Pattern, and Insecticide on Incidence of TSWV.

The experiment was conducted in North Carolina at the Peanut Belt Research Station near Lewiston-Woodville in 2002 on soil previously described. Tillage practices compared were conventional and strip tillage into a rye cover. The conventionally tilled plots were disked, and the rows were established using a ripper/bedder. Peanut was strip tilled into the stale seedbeds and the stubble from the previous rye crop. Beds were established the previous fall with rye seeded with a drill with 20-cm spacing at 90 kg/ha in early October. Glyphosate was applied at 1.1 kg ai/ha 2 wks before planting. A strip till implement (KMC Manufacturing Corp.) was used consisting of in-row subsoiler followed by two sets of coulters and two basket attachments to smooth the tilled zone. The tilled zone was approximately 51 cm wide. The plot size was 2 rows (91-cm row spacing) by 12 m long. Peanut was planted immediately after strip-tilling 7 May.

The experimental design was a split plot with four replications. Tillage (conventional or strip) was the main plot and cultivar (Gregory or Perry), planting pattern (single rows or twin rows), and insecticide (aldicarb 7.9 kg/ha or phorate 5.7 kg/ha) were subplots. Insecticides were applied in-furrow at planting as a granular formulation. Plant populations corresponding to 7 and 13 plants/meter-row were established using a Cole® vacuum planter in single rows spaced 91 cm apart. Twin row seeding (18-cm twin rows on 91-cm centers) was used to establish the 17 plants/meter-row population with a vacuum planter. Seed was placed 5 to 8 cm deep depending on soil moisture. Fields were maintained weed-free using the techniques described previously. All other production and pest management practices were held constant over the entire test area (Brandenburg 2003, Jordan 2003a, Shew 2003).

Thrips damage counts were taken at 20 days after planting as described previously. Foliar symptoms of TSWV were documented as described previously. Data were recorded as previously stated for the percent disease based on counts and stand counts. Visual estimates of percent severity were recorded as previously stated.

Plants were inverted 1 October. Peanut was harvested using conventional harvesting equipment on 8 October.

Data for thrips damage, percent disease based on counts, visual estimates of percent severity, and pod yield were evaluated by analyses of variance for a split block design with mixed factors (SAS Institute 1998). Means for significant main effects and interactions were separated using Fisher's Protected LSD Test at $p \leq 0.05$ (Steel et al. 1997).

Results and Discussion

Influence of Cultivar, Planting Pattern, and Plant Population on TSWV Incidence.

The interaction of experiment by cultivar by plant population (plants/meter-row) was not significant for any of the parameters (Table 1). However, the interaction of experiment by population was significant for the percentage of plants infected with tomato spotted wilt virus (TSWV incidence), the percentage of total sound mature kernels (%TSMK), and the percentage of peanut leaflet damage by thrips (Table 1). Also, the interaction of experiment by cultivar was significant for incidence of TSWV, the percentage of the peanut canopy expressing symptoms of TSWV as a visual estimation of TSWV present (severity of TSWV), the percentage of extra large kernels (%ELK), the percentage of fancy pods (%FP), and the percentage of peanut leaflet damage by thrips (Table 1). Interaction of cultivar by population was significant for thrips damage (Table 1). The main effect of population was significant for severity of TSWV (Table 1). Also, the main effect of cultivar was significant for pod yield, %ELK, and %FP (Table 1).

The interaction of experiment by plant population was significant ($p \leq 0.05$) for thrips damage 33 days after planting. With the exception of Field 1 at Lewiston-Woodville, the highest percentage of leaflets damaged by thrips generally occurred when peanut was seeded at the lowest plant population of 7 plants/meter-row, with decreasing levels of damage as the plant population increased to 13 and 17 plants/m-row (Figure 1). The most dramatic example of this trend was at the Williamston experiment where the mean values were 55, 44, and 32% damaged leaflets at 7, 13, and 17 plants/m-row, respectively (Figure 1). For the Williamston site, each level of plant population was significant from the other, demonstrating that a lower plant population had greater thrips damage than any other plant population, and populations of 17 plants/m-row lower thrips damage. Field 2 at Lewiston-Woodville and Rocky Mount had the same thrips damage with 33, 24, and 21% at the plant populations of 7, 13, and 17 plants/m-row, respectively (Figure 1). The Tarboro site had very similar damage of 29, 21, and 19% at the 7, 13, and 17 plants/m-row, respectively (Figure 1). For these three experiments, the plant population of 7 plants/m-row had higher thrips damage, while the populations 13 and 17 plants/m-row were not different. This is in agreement with previous findings from Brown et al. (1996) that lower plant populations often attract thrips and have a better chance of becoming infected with TSWV. Different results were obtained at Field 1 at Lewiston-Woodville, where the ratings were 21, 33, and 30% for 7, 13, and 17 plants/m-row, respectively (Figure 1). A possible explanation for this result is the experiment of this field in regards to the surrounding crops. While Field 2 at Lewiston-Woodville was surrounded by other peanuts, potatoes, and a tree-line full of weeds, Field 1 was in the middle of the research station and surrounded by corn and cotton. Perhaps thrips moved later in to Field 1 and the effect of the canopy was no longer the same as when thrips are moving into a newly-planted peanut field such as Field 2.

The interaction of experiment by cultivar gave similar results of thrips damage for most experiments; the trend was for the highest percentage of thrips damage to be on cultivar NC V-11 (Figure 2). Although the results were different at each experiment, the trend remained consistent for the greatest thrips damage to be on NC V-11. Thrips damage to cultivars Gregory and Perry were not different at most locations (Figure 2). At Williamston, the highest percentage of thrips damage was on NC V-11, but Gregory had higher percentages of thrips damage than Perry (Figure 2). Thrips feeding damage was generally greatest at the Williamston experiment, and may have allowed for the separation of means to be significant for this experiment. At Field 1 at Lewiston-Woodville, NC V-11 also had the highest percentage of thrips damage, but Gregory was not different from either NC V-11 or Perry (Figure 2). Cultivars Gregory and Perry had lower thrips damage than NC V-11 at Field 2 at Lewiston-Woodville, and the experiments at Tarboro and Rocky Mount.

The interaction of cultivar by plant population was not different across experiments. NC V-11 and Perry both had highest percentage of thrips damage on the lowest plant population of 7 plants/m-row (Table 2). This is consistent with the findings that more thrips damage occurs on lower plant populations (Gorbet and Shokes 1993). The plant populations 13 and 17 plants/m-row (41 and 40% for NC V-11, and 16 and 14% for Perry, respectively) were different from the plant population of 7 plants/m-row for NC V-11 and Perry (52% and 32%, respectively) (Table 2). For Gregory, the highest percentage of thrips damage (31%) was on the plant population of 13 plants/m-row, which was different from both plant populations 7 and 17 plants/m-row (20% for both) (Table 2).

The significant interaction of experiment by plant population revealed similar trends across the five experiments for the percentage of plants infected with TSWV. At every experiment, the plant population of 7 plants/m-row had the greatest percentage of TSWV incidence (Figure 3). As supported by Brown et al. (1996), a low plant population often results in higher TSWV incidence. The plant population of 13 plants/m-row had lower TSWV incidence than 7 or 17 plants/m-row in all experiments except for Field 1 at Lewiston-Woodville, which still followed the same trend of decreasing TSWV incidence with increasing plant population (Figure 3). In Williamston and Tarboro, the plant population of 17 plants/m-row had lower incidence of TSWV than both of the other planting populations (Figure 3). The greatest range of values for percent infection was at the Tarboro experiment. 51, 33, and 19% of plants were infected with respective populations of 7, 13, and 17 plants/m-row (Figure 3). These data suggest that establishing a higher plant population is more critical when incidence of TSWV is high than when incidence of TSWV is low. Regardless of the severity of TSWV, the greatest amount of TSWV was noted when the plant population was 7 plants/m-row.

The interaction of experiment by cultivar was significant for the incidence of TSWV. Consistent with other research (Jordan 2003a), Perry had higher incidence of TSWV than Gregory or NC V-11 (Table 3). At Tarboro, NC V-11 and Gregory were not different, and both had lower TSWV incidence than Perry (Figure 4). At all other experiments, the percentage of NC V-11 plants infected with TSWV was not different from Perry (Figure 4). Gregory had a lower TSWV incidence than did NC V-11 and Perry in all experiments except for Field 1 of Lewiston-Woodville, which had no significant differences in cultivars (Figure 4). All experiments followed the same basic trend of the lowest incidence of TSWV with the cultivar Gregory, then NC V-11, and the highest incidence of TSWV with Perry. Even though NC V-11 had the most thrips damage, Perry had the highest incidence of TSWV overall. Higher thrips feeding damage does not always lead to higher TSWV incidence (Broadbent and Allen 1995). In general, Gregory had the lowest thrips feeding damage and the least TSWV incidence. Gregory is considered to be one of the most resistant virginia-type cultivars of peanut to TSWV (Jordan 2003a). There were no significant differences for the percentage of plants infected with TSWV in the interaction of cultivar by plant population. Even though there are differences among the cultivars, plant population affected TSWV independent of cultivar.

For the interaction of experiment by cultivar, the percentage of the peanut canopy expressing symptoms of TSWV (TSWV severity) had similar trends. At every experiment, Perry had the highest TSWV severity rating, and was higher than the other Gregory and NC V-11 at Williamston and Tarboro (Figure 5). At Fields 1 and 2 at

Lewiston-Woodville, Gregory had a lower TSWV severity rating than did NC V-11 or Perry (Figure 5). While NC V-11 had higher thrips damage, Perry had the highest TSWV incidence and severity of TSWV at most experiments. There were no significant differences at Rocky Mount (Figure 5), which may be attributable to lower virus pressure at this experiment. At the Rocky Mount experiment, TSWV incidence was different for the cultivars. The percent TSWV was not significant for cultivars at Field 1 at Lewiston-Woodville, but TSWV severity was different at this experiment. The main difference for Field 1 is the TSWV severity for Gregory was much lower than the TSWV incidence. This implies that there were nearly as many infected plants in all three cultivars, but Gregory did not express the severity of infection as much as NC V-11 or Perry.

The main effect of plant population indicates significant differences for the TSWV severity ratings. The mean values for 7, 13, and 17 plants/m-row were 14, 9, and 7% respectively (data not shown). A plant population of 17 plants/m-row resulted in lower severity ratings than a plant population of 13 plants/m-row, which was lower than 7 plants/m-row (data not shown). This trend is similar to that of TSWV incidence, with the increasing plant population having a decreasing percent TSWV. Results for TSWV severity were more consistent and could be averaged over all treatments and experiments. However, the TSWV incidence, or actual number of infected plants out of the total plants, was not as consistent for each experiment. This would indicate that while the exact percentage of plants infected with TSWV is not the same across experiments, the effect on the severity of disease expression in the peanut canopy is the same. This corresponds with the findings of Brown et al. (1996).

The main effect of cultivar caused significant pod yield differences. The mean pod yields for Gregory, NC V-11, and Perry were 6240, 4770, and 4930 kg/ha, respectively (data not shown). Gregory had higher mean pod yields than NC V-11 and

Perry, which were not different from each other (data not shown). Gregory had the lowest thrips damage and the lowest incidence of TSWV across all experiments, which could have led to the higher pod yield. The effect of plant population did not cause differences in pod yield. However, the range of pod yield was 4880, 5050, and 6000 kg/ha for 7, 13, and 17 plants/m-row respectively (data not shown). This trend is in keeping with other results that virus incidence is reduced as the plant populations increase. Also, with increased plant populations, pod yields have been increased (Wehtje et al. 1994). While the main effect of experiment was not significant, the range of pod yields were 5470 kg/ha (Williamston), 5720 kg/ha (Field 1 at Lewiston-Woodville), 4570 kg/ha (Field 2 at Lewiston-Woodville), 5670 kg/ha (Tarboro), and 5150 kg/ha (Rocky Mount). Incidence of TSWV and severity of TSWV were highest at Field 2 at Lewiston-Woodville, and at this experiment we found the lowest pod yield. However, the highest pod yield was at Field 1 at Lewiston-Woodville, which did not have the lowest incidence of TSWV or severity of TSWV. While pod yield may not be directly linked to the percentage of plants infected with TSWV in a given field, Culbreath et al. (1992) found that peanut infected with TSWV have reduced pod yield.

Using Spearman's coefficient correlation (N=180), the relationship between the following pairs of data were examined: TSWV incidence and TSWV severity (0.41662, $p \leq 0.0001$); TSWV incidence and thrips damage (0.17364, $p=0.0197$); TSWV incidence and pod yield (0.02643, $p=0.7247$); and TSWV severity and pod yield (-0.37368, $p \leq 0.0001$) (Steel et al. 1997). Falling in the range of -1 to 1, the r-value indicates a strong positive linear relationship the closer the value to 1, and a negative linear relationship the closer the value to -1 (Steel et al. 1997). None of the pairs had an especially high r-value or correlation, indicating that there is not a strong relationship between any of the parameters. The highest r-value was the correlation of TSWV incidence to TSWV severity, which indicates that the number of plants infected is predictable by taking a visual estimate of the percent of the peanut canopy expressing symptoms of TSWV. There was no correlation between the TSWV incidence and the amount of thrips damage to leaflets, suggesting that it cannot be predicted how much virus will be present by evaluating thrips feeding damage alone. Also, there was not a correlation between the pod yield and TSWV incidence for this test. This would signify that the loss of pod yield is not a direct result of the percentage of plants infected with TSWV, and perhaps is a more complex relationship of the magnitude of infection including the time of infection and the expression of the symptoms. This idea is somewhat supported by the stronger correlation of TSWV severity and pod yield with the r-value -0.37368; the negative value indicates that for the increase in severity of TSWV, there is a decrease in pod yield. From the results of this test, the TSWV severity may be more appropriate for estimating pod yield loss in peanut.

The interaction of experiment by plant population was significant for the percentage of total sound mature kernels. There were no differences in %TSMK at Rocky Mount regardless of plant population (Figure 6). At Williamston and in Field 2 at Lewiston-Woodville, the %TSMK was higher when plant population was 17 plants/m-row than when plant populations were 13 and 7 plants/m-row (Figure 6). Field 1 at Lewiston-Woodville had a lower %TSMK for the high plant population than for the middle and low plant populations (Figure 6). At Tarboro, %TSMK was similar when the plant population was 13 or 17 plants/m-row. Additionally, while %TSMK was similar at plant population of 13 and 17 plants/m-row, %TSMK for the highest plant population exceeded that of the lowest plant population. There were no differences for the main effect of cultivar for %TSMK, with all values equaling 73% (data not shown).

The interaction of experiment by cultivar was significant for the percentage of extra large kernels. For all experiments except for Rocky Mount, the %ELK was higher for Gregory than for NC V-11 or Perry (Figure 7). At Rocky Mount, there were no differences for %ELK for any cultivar, with a range of 40 to 46% (Figure 7). Gregory is a large-seeded virginia market-type cultivar, and it generally produces a higher %ELK than NC V-11 or Perry (Jordan 2003a). Peanut at Lewiston-Woodville were irrigated regularly, whereas those at Rocky Mount were not. During 2002, drought may have contributed to lower %ELK for Gregory by preventing Gregory from reaching its full potential. The cultivar NC V-11, which has smaller seeds than Gregory or Perry, would not have been affected as much by dry weather as Gregory or Perry.

The main effect of plant population was not significant for %ELK with a range of 45 to 46% (data not shown). The interaction of experiment by cultivar was significant for the percentage of fancy pods. At all experiments except for Rocky Mount, Gregory had a higher %FP than both NC V-11 and Perry (Figure 8). At Rocky Mount there were no significant differences between cultivars for %FP. This corresponds with Gregory having a larger seed than both NC V-11 and Perry, and the drier conditions at Rocky Mount.

Because virus counts were taken monthly in 2001 and weekly in 2002, charts with cumulative counts of TSWV could be assembled. At the Williamston and Tarboro sites, virus incidence started out slow throughout the months of June, July, and August of 2001 (Figures 9 and 10). However, the number of plants/meter-row infected with TSWV increased dramatically during September 2001. This pattern is due to the large number of chlorotic plants that appeared very late in the season before harvest. Testing of the taproots verified the presence of TSWV for the chlorotic plants even though no other foliar symptoms were present. During 2002, the chlorotic plants were observed at very low numbers or not at all in some fields. The accumulation virus incidence was much steadier throughout the growing season of 2002, and leveled off after early August (Figures 11, 12, and 13).

Influence of Planting Date, Cultivar, Plant Population, and Insecticide on TSWV Incidence.

The interaction of year by planting date by cultivar by insecticide by plant population (plants/meter-row) was not significant for any of the parameters (Table 3). However, the interaction of planting date by cultivar by insecticide by plant population was significant for the percentage of peanut leaflet damage by thrips at 20 days after planting (Table 3). The interaction of year by planting date by insecticide by plant population was significant for pod yield (kg/ha). Values for thrips damage and the percentage of plants infected with TSWV (TSWV incidence) were significant for the interaction of year by planting date by cultivar (Table 3). The interaction of planting date by plant population was significant for TSWV incidence (Table 3). The interaction of cultivar by plant population was significant for the percentage of total sound mature kernels (%TSMK) (Table 3). The percentage of extra large kernels (%ELK) was significant for the interaction of year by plant population and also for the interaction of year by cultivar (Table 3). The main effect of plant population was significant for the percentage of peanut canopy expressing symptoms of TSWV (TSWV severity) (Table 3). Also, the main effect of insecticide was significant for the TSWV severity and the TSWV incidence (Table 3). The main effect of cultivar was significant for the TSWV severity, pod yield, and %TSMK (Table 3). The main effect of year was significant for the TSWV severity, and the percentage of fancy pods (%FP) (Table 3).

The interaction of planting date by cultivar by insecticide by plant population was significant for thrips feeding damage to leaflets at 20 days after planting (Table 4). When the cultivar Perry was treated with aldicarb with a plant population of 13 and 17 plants/meter-row and planted in early May, the percentage of thrips damage was higher than any other treatment (Table 4). Less thrips damage was noted for this cultivar by plant population by insecticide combination when planted in late May (Table 4). In most cases, peanut planted in late May had lower percentages of thrips damage than the same treatment planted in early May. Eckel et al. (1996) found thrips populations peak from mid-May through early June in North Carolina. This would be around the time the early-planted peanut was at an early growth stage and the late-planted peanut was just emerging. The cultivar NC V-11 planted in late May and treated with phorate at the planting population of 13 and 17 plants/m-row had the next lower rate of thrips feeding damage (6 and 9% respectively) when compared to the same treatments planted early (27% for both) (Table 4). Planting date can have considerable impact on thrips feeding damage.

The interaction of year by planting date by cultivar was significant for thrips feeding damage. For 2001, the cultivar Perry that was planted in early May had the highest percentage of thrips feeding damage; the cultivars NC V-11 and Perry that were planted in late May had the lowest thrips damage (Table 5). During 2002, the cultivar Perry that was planted early had the highest percentage of thrips feeding damage, and late-planted NC V-11 had the lowest percentage of thrips damage (Table 5). In both years, the thrips damage was highest for the peanut that was planted in early May than for the peanut that was planted in late May. Also, NC V-11 had less thrips damage than Perry, which is the contrary to what was found in the test "*Influence of Cultivar, Planting Pattern, and Seeding Rate on TSWV Incidence*."

The interaction of year by planting date by cultivar was significant for the incidence of TSWV (Table 5). For 2001, Perry that was planted in early May had higher incidences of TSWV than other treatments, and the cultivars NC V-11 and Perry that were planted in late May had the lowest TSWV incidence (Table 5). These values follow the same trend as those of the thrips damage. With higher thrips damage, there was higher incidence TSWV. This is contrary to the findings of the test "*Influence of Cultivar, Planting Pattern, and Plant Population on TSWV Incidence*" where NC V-11 had the most thrips damage but not the highest incidence of TSWV. In 2002, the cultivar NC V-11 that was planted in early May had higher TSWV incidence, and the other treatments were not different (Table 5), although Perry that was planted in early May had the highest thrips damage. Even though the thrips fed more heavily upon Perry during 2002, early-planted NC V-11 had more incidences of TSWV than the other treatments.

The interaction of planting date by planting population was significant for incidence of TSWV (Table 6). Early-planted peanuts at 7 plants/m-row had higher incidence of TSWV than any other treatment at 19% (Table 6). Peanuts planted in late May at plant populations of 13 and 17 plants/m-row had lower incidences of TSWV than any other treatment (Table 6). The general trend was for peanut planted early to have higher incidences of TSWV than its counterpart of the same treatment that was planted late. Also, the incidence of TSWV was progressively decreasing as the plant population was increasing from 7 to 17 plants/m-row.

The main effect of insecticide was significant for incidence TSWV. When treated with aldicarb, peanut had higher incidences of TSWV (13%) than did peanut treated with phorate (9%) (data not shown). This is in agreement with the findings of Culbreath et al. (1999) who describes that phorate provides some control of TSWV. Although the main effect of plant population was not significant for incidence of TSWV, the values for 7, 13, and 17 plants/m-row were 15, 11, and 7% respectively (data not shown) and follow the trend of decreasing TSWV incidence with an increasing plant population.

The main effect of plant population was significant for the percentage of peanut canopy expressing symptoms of TSWV, or the severity of TSWV. As described by Brown et al. (1996), lower plant populations have an increased probability of being infected with TSWV. Plant populations of 7, 13, and 17 plants/m-row had TSWV severity of 21, 14, and 7% respectively, each of which was significant from the other (data not shown). Again following the trend of decreasing virus with increasing plant population, the TSWV severity is similar to the TSWV incidence found from actual counts of infected peanut plants. The main effect of insecticide was significant for TSWV severity. When treated with aldicarb, peanut had higher severity of TSWV (17%) than those treated with phorate (11%) (data not shown). These values correspond with those of TSWV incidence for insecticide values. TSWV severity for Perry had higher mean values (15%) than those for NC V-11 (12%) (data not shown). The main effect of year was significant for TSWV severity, with 2002 (17%) having higher percentages of severity of TSWV than 2001 (10%) (data not shown). While the main effect of planting date was not significant for TSWV severity, the values for early and late planting date were 17 and 11%, respectively (data not shown).

The interaction of year by planting date by insecticide by plant population was significant for pod yield. In 2001, the peanuts with the highest significant pod yield were planted at 17 plants/m-row, treated with phorate, and planted during either early or late May (Table 7). During 2001, pod yield was not affected much by the planting date as long as the plant populations were kept at 13 or 17 plants/m-row. The lowest pod yields for 2001 were peanuts planted in early May at 7 plants/m-row and treated with aldicarb, and peanut planted in late May at 7 plants/m-row and treated with either aldicarb or phorate (Table 7). Generally, peanut planted at a plant population of 7 plants/m-row resulted with lower pod yields than peanuts planted at higher plant populations no matter the treatment. In 2002, the peanuts with the highest pod yield were planted in early May at 13 plants/m-row and treated with phorate (Table 7). Though not at the highest plant population, 13 plants/m-row is still a higher plant density than 7 plants/m-row, and phorate has been shown to decrease TSWV in peanut. The lowest pod yields for 2002 were peanuts planted in late May at a plant population of 7 plants/m-row and treated with aldicarb (Table 7). Lower plant populations led to lower pod yields, while higher plant populations led to higher pod yields; this supports the findings of Wehtje et al. (1994).

The interaction of cultivar by plant population was significant for pod yield. Perry and NC V-11 planted at 17 plants/m-row had the highest mean value for pod yield at 4740 and 4480 kg/ha, respectively (Table 8). The higher plant population seemed to lead to higher pod yields, whereas the effect of the cultivar was not so important. The lowest pod yields were peanuts planted as the cultivar NC V-11 at the plant populations of 7 and 13 plants/m-row (3770 and 4030 kg/ha, respectively) and the cultivar Perry at the plant population of 7 plants/m-row (3980 kg/ha) (Table 8). Again, lower plant populations resulted in lower pod yields for both NC V-11 and Perry. The main effect of cultivar was significant for pod yield. Perry had higher pod yields (4350 kg/ha) than NC V-11 (4090 kg/ha) (data not shown), even though Perry had higher severity of TSWV. The cultivar NC V-11 has a higher susceptibility to web blotch than Perry, and this factor could have led to lower yields for NC V-11 due to levels of web blotch in the field.

Using Spearman's coefficient correlation (N=192), the relationship between the following pairs of data were examined: TSWV incidence and TSWV severity (0.55504, $p \leq 0.0001$); TSWV incidence and thrips damage (0.17655, p=0.0143); TSWV incidence and pod yield (-0.23811, p=0.0009); and TSWV severity and pod yield (-0.11841, p=0.1019) (Steel et al. 1997). Falling in the range of -1 to 1, the r-value indicates a strong positive linear relationship the closer the value to 1, and a negative linear relationship the closer the value to -1 (Steel et al. 1997). There was not a strong relationship between the thrips feeding damage to leaflets and TSWV incidence. While none of the r-values for this test were particularly strong, the correlation of TSWV incidence and severity of TSWV was the strongest, suggesting that there is a positive relationship as the percentage of plants infected with TSWV increase, so does the severity. The r-value for the relationship between TSWV incidence and pod yield was stronger than that for the TSWV severity and pod yield, but both were negative values indicating that the pod yield decreases as the incidence of TSWV increases.

The interaction of cultivar by plant population was significant for the percentage of total sound mature kernels (%TSMK). NC V-11 planted at 7 plants/m-row (72%) had lower %TSMK than any other treatment (from 74 to 75%) (Table 8). The interaction of year by planting date was significant for %TSMK. Peanuts planted in late May of 2001 had lower %TSMK (72%) than did any other treatment (from 74 to 75%) (Table 9). There was no significant difference for the %TSMK for the main effect of insecticide with values equaling 74% (data not shown).

The interaction of year by planting date by cultivar by insecticide was significant for the percentage of extra large kernels (%ELK). In 2001, the %ELK was higher for Perry planted early and treated with phorate (51%), and %ELK was lower for NC V-11 planted late and treated with aldicarb (Table 10). In 2002, the %ELK was higher for both the early and late-planted Perry treated with either aldicarb or phorate, and the %ELK was lower for both the early and late-planted NC V-11 treated with either aldicarb or phorate (Table 10). Generally, the %ELK is larger for Perry than for NC V-11, and is not impacted by the other treatments. The interaction of year by planting population was significant for %ELK. In 2001, the %ELK was highest for peanut planted at 17 plants/m-row, and lowest for 7 plants/m-row (Table 11). In 2002, the %ELK was highest for 13 plants/m-row than for 7 and 17 plants/m-row (Table 11). Gorbet and Shokes (1993) from the University of Florida found that grades were not commonly affected by plant density, but seed size and %TSMK were lower for lower plant densities.

The main effect of planting date was significant for the percentage of fancy pods (%FP). Late-planted peanuts had higher %FP (76%) than did early-planted peanuts (71%) (data not shown). The main effect of year was significant for %FP. In 2001, the %FP (77%) was higher than in 2002 (70%) (data not shown). The main effects of cultivar, insecticide, and plant population were not significant for %FP with mean values ranging from 73-74%, 73-74%, and 72-75%, respectively (data not shown).

Monthly virus counts in 2001 and weekly counts in 2002 allowed charts with cumulative counts to be assembled. In 2001, counts were not taken for the early planted treatments. The trend for accumulation of virus incidence of the peanut planted in late May was more gradual than the accumulation from the test *"Influence of Cultivar, Planting Pattern, and Plant Population on TSWV Incidence"* (Figure 14). Far fewer of the chlorotic plants were seen in the treatments planted in late May than in those planted in early May. Similarly, in 2002, the accumulation of virus was gradual over the entire season (Figures 15 and 16). In 2002, accumulation of virus was steady until early August (Figures 15 and 16). The late planted treatments continued having plants expressing symptoms until harvest (Figure 16); whereas the early treatments leveled off considerably after the first week in August (Figure 14).

Influence of Insecticide (aldicarb, phorate) Rates Applied in Twin Rows on TSWV Incidence.

The interaction of experiment by insecticide by rate was not significant for any of the parameters (Table 12). The interactions of insecticide by rate, and experiment by rate were not significant for any of the parameters (Table 12). However, the main effect of rate was significant for the percentage of thrips damage to peanut leaflets at 20 days after planting was significant (Table 12). The interaction of experiment by insecticide was significant for the total number of plants infected with tomato spotted wilt virus (TSWV) (Table 12). The main effect of insecticide was significant for thrips damage and for pod yield (Table 12). The main effect of experiment was significant for the thrips damage, the percentage of the peanut canopy expressing symptoms of TSWV (TSWV severity) and pod yield (Table 12).

When averaged over insecticide, the main effect of rate was significant for the percent of thrips damage to peanut leaflets at (Figure 17). The 0.5X the manufacturer's suggested rate of insecticide had a higher percentage (22%) of thrips damage than the 1.5X (11%) or 1.0X (13%) rate of insecticide (Table 20). Economically, 1.0X rates of insecticides are most practical, resulting in reduced thrips feeding relative to the 0.5X rate and comparable to the 1.5X rate. Costs are lower for application of 1.0X rates compared with application of 1.5X rate.

When averaged over the three levels of rates, the main effect of insecticide was significant for thrips damage 20 days after planting. Peanuts treated with aldicarb had a higher percentage (21%) of thrips damage than when treated with phorate (10%) (data not shown). These results for thrips feeding are consistent with the finding of the University of Georgia (Culbreath et al. 1999), and also with the results from the test "*Influence of Planting Date, Cultivar, Planting Pattern, and Insecticide on TSWV*

Incidence." The main effect of experiment was significant for thrips damage (Table 13). Lewiston-Woodville had higher percentages (19%) of thrips damage than Rocky Mount (12%) (Table 13).

The interaction of experiment by insecticide was significant for the number of plants infected with TSWV (Figure 18). Peanut treated with aldicarb (24%) and phorate (23%) at Lewiston-Woodville were not different. At Rocky Mount, peanut treated with aldicarb had higher thrips damage (17%) than those treated with phorate (8%) (Figure 18). With the higher pressure of virus at Lewiston-Woodville, the effect of the insecticides was not apparent. Because the thrips population was so high, there was no separation of treatment means. When thrips populations were lower at Rocky Mount many more plants were available for feeding and plants treated with phorate in-furrow had lower TSWV than those treated with aldicarb. The main effect of insecticide rate was not significant for TSWV, but the values for 0.5, 1.0, and 1.5X the manufacturer's suggested rate of insecticides were 16, 21, and 17 plants infected per plot respectively (data not shown). These values follow the same trend as with the thrips damage with the 0.5X rate having the highest incidence of TSWV, whereas the 1.5X and 1.0X rates have similarly lower incidences of TSWV.

The main effect of experiment was significant for the TSWV severity. Lewiston-Woodville had higher percentages (16%) of TSWV severity than Rocky Mount (7%) (Table 13), which was the same pattern as with the incidence of TSWV. The main effect of rate was not significant for TSWV severity, with the mean percentages for 0.5, 1.0, and 1.0X rates being 15, 11, and 9% respectively (data not shown). The trend is again evident with the highest incidence of TSWV from the 0.5X rate of insecticide, whereas the 1.5X and 1.0X are similar with lower percentages. The main effect of insecticide was not significant for TSWV severity, with the mean percentages for aldicarb and phorate being

14 and 9% respectively (data not shown). The numerical trend is still similar to previous findings of lower incidence of TSWV in fields treated with phorate when compared with aldicarb.

The main effect of insecticide was significant for pod yield. Peanut treated with aldicarb had lower pod yields (4070 kg/ha) than when treated with phorate (4390 kg/ha) (data not shown). This supports the idea that pod yields are lower for fields with higher rates of TSWV infection (Culbreath et al. 1992). Phorate led to lower incidence of TSWV and TSWV severity, and subsequently higher pod yields. The main effect of experiment was significant for pod yield. Peanut at Lewiston-Woodville had higher pod yields (4490 kg/ha) than Rocky Mount (3960 kg/ha) (Table 13), even though there was incidence of TSWV present at Lewiston-Woodville. The main effect of rate was not significant for pod yield with mean rates for 1.5, 1.0, and 0.5X insecticide rates being 4290, 4190, and 4200 kg/ha, respectively (data not shown).

Using Spearman's coefficient correlation (N=64), the relationship between the following pairs of data were examined: TSWV counts and TSWV severity (0.73953, $p \leq 0.0001$); TSWV counts and thrips damage (0.56114, $p \leq 0.0001$); TSWV counts and pod yield (-0.15806, $p=0.2122$); and TSWV severity and pod yield (-0.16218, $p=0.1019$) (Steel et al. 1997). Falling in the range of -1 to 1, the r-value indicates a strong positive linear relationship the closer the value to 1, and a negative linear relationship the closer the value to -1 (Steel et al. 1997). There was a strong correlation between the total numbers of plants infected with TSWV and the TSWV severity for this test. These test results indicate that the estimation of virus is an acceptable way to evaluate peanut for TSWV infection. The r-value for the relationship between the total number of plants infected with TSWV and thrips damage to leaflets was a weaker value, suggesting that thrips damage ratings are not a good indication of the threat of a TSWV outbreak in a field. Though values for relationships for pod yield and total plants with TSWV, and pod yield and TSWV severity were not very strong, both were negative revealing that an increase in the number of plants infected with TSWV causes a decrease in pod yield.

Weekly virus counts in 2002 allowed charts with cumulative counts to be assembled. At the Lewiston-Woodville site in 2002, the treatments all followed a gradual increase in virus accumulation over the growing season (Figure 19). At the Rocky Mount site in 2002, the virus accumulation was gradual, but the untreated plots had a much faster increase than the other treatments (Figure 20). At both sites, virus accumulated steadily until early August; then the appearance of new symptomatic plants slowed dramatically.

Influence of Insecticide (acephate, aldicarb) Rate and Planting Pattern on TSWV Incidence.

Significant interactions of experiment by treatment factors prevented pooling of data over experiments. After evaluating experiments separately, the interaction of insecticide by rate by planting pattern was significant for the percentage of plants infected with TSWV (TSWV incidence) at Lewiston-Woodville and Goldsboro, and the percentage of extra large kernels (%ELK) was significant at Bladenboro (Table 14). The interaction of insecticide rate by planting pattern was not significant for any parameter; however, the interaction of insecticide by planting pattern was significant for the percentage thrips damage to peanut leaflets at 20 days after planting (Table 14). The interaction of insecticide by insecticide rate was significant for thrips damage at Goldsboro and Rocky Mount, and for TSWV incidence at Bladenboro and Rocky Mount (Table 14). The main effect of planting pattern was significant for TSWV incidence at Rocky Mount, and for pod yield at Sunbury (Table 14). The main effect of rate was significant for thrips damage at Lewiston-Woodville (Table 14). The main effect of insecticide was significant for pod yield at Goldsboro (Table 14).

The interaction of insecticide by planting pattern was significant for thrips damage at Goldsboro. Peanut treated with aldicarb and planted into single rows had higher percentages (85%) of thrips damage than when planted into twin rows (50%) or when treated with phorate and planted into either single (42%) or twin rows (38%) (Figure 21). At the Goldsboro experiment, the peanut planted as a twin row planting pattern compensated for the increased thrips feeding when using acephate for thrips control. However, when planted as a single row planting pattern and treated with acephate, peanut had higher levels of thrips damage. If acephate is used for thrips control, another control strategy should be used to compensate for the loss to thrips feeding. When aldicarb was used there was no difference between single and twin row planting patterns.

The interaction of insecticide by insecticide rate was significant for thrips damage at Goldsboro and Rocky Mount. At both experiments, when peanut was treated with aldicarb at the 1.0X rate, there less thrips damage than any other treatment (Table 15). At Goldsboro, peanut treated with the 1.0X rate of acephate had higher percentages of thrips damage than any other treatment (Table 15). At Goldsboro, there was no significant difference between the 0.6X rates of aldicarb and acephate, and at Rocky Mount, there was no significant difference between both rates of acephate and the 0.6X rate of aldicarb (Table 15). Using aldicarb at the 1.0X rate would be the safest method to control thrips feeding damage, when compared with either 0.6X rate of aldicarb and acephate at 1.0 or 0.6X rates.

The main effect of insecticide rate was significant at Lewiston-Woodville for thrips damage. When insecticides were applied at the 1.0X rate, peanut had more thrips damage (22%) than when insecticides were applied at the 0.6X rate (11%) (data not shown). While at the other experiments, it seems that 1.0X rate of insecticides were more effective against thrips damage, at the Lewiston-Woodville experiment the peanut treated with the 1.0X rate had twice as much thrips damage. Although thrips damage ratings were taken at Bladenboro, there were no significant differences between parameters.

The interaction of insecticide by rate by planting pattern was significant for TSWV incidence at Lewistown-Woodville and Goldsboro. For both experiments, under each rate of each insecticide, the single row peanuts all had higher TSWV incidence than the twin row peanuts (Table 16). Brown et al. (1996) reported that twin row plantings frequently result in less TSWV. At Goldsboro the highest incidence of TSWV was in peanut treated with acephate at a 1.0X rate and planted into single rows (11%), whereas at Lewiston-Woodville, the highest TSWV incidence was in peanut treated with aldicarb at the 1.0X rate in single rows (7%) (Table 16). Again in contrast, the Lewiston-Woodville experiment had TSWV incidence with peanut treated with 1.0X rates of insecticide than peanut treated with low rates. The lowest incidence of TSWV at Goldsboro was peanut treated with aldicarb at the 0.6X rate and planted into twin rows (3%). At Lewiston-Woodville the lowest TSWV incidence was in peanut treated with both the 0.6X and 1.0X rates of acephate and planted into twin rows (both 2%) (Table 16).

The interaction of insecticide by insecticide rate was significant for TSWV incidence at Bladenboro and Rocky Mount. At both Bladenboro and Rocky Mount, the highest incidence TSWV was in peanut treated with acephate at the 0.6X rate (0.8 and 5%, respectively) (Table 15). At Bladenboro, peanut treated with acephate at the 1.0X rate (0.2%) did not differ from the 0.6X (0.4%) or 1.0X (0.4%) rates of aldicarb in regards to TSWV incidence (Table 15). At Rocky Mount, the 1.0X rate of acephate (3%) and the 0.6X rate of aldicarb (3%) had the lowest incidence of TSWV (Table 15). The incidence of TSWV was very low at both experiments which did not allow for treatment separation.

The main effect of planting pattern was significant for TSWV incidence at Rocky Mount. At Rocky Mount, peanut planted into single rows had higher incidence of TSWV (5%) than peanut planted into twin rows (3%) (data not shown). These findings are consistent with a recent six year study from the University of Georgia where twin row planting patterns had lower incidence of TSWV than single row patterns (Baldwin and Williams 2002).

The main effect of planting pattern was significant for pod yield at Sunbury. Peanut planted into twin rows at Sunbury had higher pod yields (4700 kg/ha) than peanut planted into single rows (4210 kg/ha) (data not shown). Although at different experiments, the TSWV incidence was higher for peanut planted into single row planting patterns at Rocky Mount, and the pod yield was decreased for peanut planted into a single row planting pattern at Sunbury. Baldwin and Williams (2002) also found an average pod yield increase of 550 kg/ha for peanut planted in twin rows compared to single rows. The main effect of insecticide was significant for pod yield at Goldsboro. Peanut treated with aldicarb at Goldsboro had higher pod yields (4900 kg/ha) than peanut treated with acephate (4420 kg/ha) (data not shown). When treated with aldicarb, the damage from thrips feeding at was lower than when treated with acephate at Goldsboro, this coincides with the higher pod yield when using aldicarb.

Using Spearman's coefficient correlation (N=64), the relationship between the following pairs of data were examined: TSWV incidence and thrips damage (0.56303, $p \leq 0.0001$); and TSWV incidence and pod yield (0.28263, $p=0.0003$) (Steel et al. 1997). Falling in the range of -1 to 1, the r-value indicates a strong positive linear relationship the closer the value to 1, and a negative linear relationship the closer the value to -1 (Steel et al. 1997). The r-value between TSWV incidence and thrips damage at was not very strong, but there is a small positive correlation between the increase of TSWV incidence with the increase of thrips feeding damage. The relationship between TSWV incidence and pod yield was not very strong for this test, indicating that pod yield is not correlated with the incidence of TSWV.

There were no significant differences in %TSMK and %FP for any experiment. However, the interaction of insecticide by insecticide rate by planting pattern was significant for the percentage of extra large kernels (%ELK) at Bladenboro. The highest %ELK was in peanut treated with acephate at the 1.0X rate and planted in single rows (53%) (Table 17). The lowest %ELK was in peanut treated with either acephate or aldicarb at the 0.6X rate and planted into twin rows (38 and 30% respectively) or treated with aldicarb at the 1.0X rate and planted into single rows (30%) (Table 17).

Influence of Tillage, Cultivar, Planting Pattern, and Insecticide on TSWV Incidence.

The interactions of tillage by cultivar by insecticide by planting pattern, and tillage by insecticide by planting pattern were not significant for any parameter (Table 18). However, the interaction of tillage by cultivar by insecticide was significant for the percentage of plants infected with TSWV (TSWV incidence) and the percentage of the peanut canopy expressing symptoms of TSWV (TSWV severity) (Table 18). The interaction of tillage by cultivar by planting pattern was significant for TSWV incidence (Table 18). The interaction of insecticide by planting pattern was significant for TSWV incidence and TSWV severity (Table 18). The interaction of tillage by cultivar was significant for the percentage of peanut leaflets damaged by thrips feeding 20 days after planting and pod yield (Table 18). The interaction of cultivar by planting pattern was significant for TSWV severity (Table 18). The main effect of planting pattern was significant for thrips damage and pod yield; and the main effect of insecticide was significant for thrips damage (Table 18).

The interaction of tillage by cultivar was significant for thrips damage 20 days after planting. When planted into a conventionally-tilled field, peanut had higher percentages of thrips damage than when planted into a strip-tilled field (Table 19). This is in agreement with the findings of Brandenburg et al. (1998), who found that in most minimum-tilled peanut, there was a reduction in thrips damage. The main effect of planting pattern was significant for thrips damage. Peanut planted into the twin row pattern had more thrips damage (29%) than single row peanuts (22%) (data not shown). This is not consistent with the findings from previous tests. The main effect of insecticide was significant for thrips damage. Peanut treated with aldicarb had less thrips damage (22%) than did peanut treated with phorate (29%) (data not shown). This is consistent with the finding of Culbreath et al. (1999) who state that phorate does not provide any better thrips control than most other insecticides.

The interaction of tillage by cultivar by insecticide was significant for the incidence of TSWV. When planted in a conventionally-tilled field, and treated with aldicarb or phorate, Perry had higher incidence of TSWV (22 and 16% respectively) than any other treatment (Table 20). When planted into a strip-tilled field, and treated with phorate, Perry and Gregory had less incidence of virus than any other treatment (8 and 6% respectively) (Table 20). In general, the peanut planted into strip-tilled fields had lower TSWV incidence than peanut planted into conventionally-tilled fields. Research has shown that strip-tilled fields can have up to 42% reduction in TSWV when compared to conventionally-tilled fields (Johnson et al. 2001, Baldwin and Williams 2002). Thrips damage to peanut in the strip-tilled fields was lower than peanut in conventionally-tilled fields, and may correspond to the lower levels of TSWV in strip-tilled fields. The best possible scenario to reduce the risk for TSWV in this case would be to plant Gregory into a strip-tilled field and apply phorate in-furrow. If a grower wants to use Perry, a significant reduction in risk for virus can be attained by planting into a strip-tilled field and using phorate in-furrow.

The interaction of tillage by cultivar by planting pattern was significant for TSWV incidence. When planted into conventionally-tilled fields as single rows, Perry had higher TSWV incidence (26%) than any other treatment (Table 21). When planted into strip-tilled fields as twin rows, both Gregory and Perry had lower TSWV incidence (7 and 7%) than any other treatment (Table 21). The interaction of insecticide by planting pattern was significant for TSWV incidence. When treated with aldicarb and planted into single rows, peanut had higher TSWV incidence than other treatments (Table 22). When treated with phorate and planted into twin rows, peanut had lower TSWV incidence than other treatments (Table 22). The results that phorate and twin rows have reduced virus incidence compared with aldicarb and single rows are consistent with the results found in the previous tests "*Influence of Planting Date, Cultivar, Plant Population, and Insecticide on TSWV Incidence*," "*Influence of Insecticide (aldicarb, phorate) Rates Applied in Twin Rows on TSWV Incidence*," and "*Influence of Insecticide (acephate, aldicarb) Rate and Planting Pattern on TSWV Incidence*."

The interaction of tillage by cultivar by insecticide was significant for the percentage of the peanut canopy expressing symptoms of TSWV (severity of TSWV). When planted in conventionally-tilled fields and treated with aldicarb, Perry had higher TSWV severity (33%) (Table 20). These results are parallel with those for TSWV incidence. Conventionally- or strip-tilled fields planted with Gregory treated with either aldicarb or phorate, and strip-tilled fields planted with Perry treated with phorate had the lowest TSWV severity (Table 20). TSWV severity ratings allowed more grouping of the treatments, but generally followed the same findings for TSWV incidence. In this test TSWV severity ratings have allowed for a more general overview of field treatments.

The interaction of insecticide by planting pattern was significant for TSWV severity. Peanut planted in single rows and treated with aldicarb had higher severity of TSWV (20%) than those in twin rows (10%) or those treated with phorate in single (10%) or twin rows (9%) (Table 22). These data are in keeping with the previously reported data that observed peanut planted in single rows and treated with aldicarb to result in higher incidence TSWV when compared to peanut planted in twin rows and treated with phorate (Culbreath et al. 1999). The interaction of cultivar by planting pattern was significant for severity of TSWV. When planted into single rows, Perry had higher severity of TSWV (23%) than when planted into twin rows (14%) (Figure 22). Gregory had lower TSWV severity when planted into single or twin rows (both 6%) than Perry (Figure 22). Gregory generally tends to have lower incidence of virus than Perry, and in this case, the planting pattern did not influence the incidence of virus present in Gregory, but it did in Perry. This would need to be considered when preparing to plant for the year. If a grower wants to use Perry, twin rows would be a safer approach. If already planting Gregory, either single or twin row plantings would be appropriate.

The interaction of tillage by cultivar was significant for pod yield. When conventionally-tilled fields are planted as Perry, the pod yields were lower (4710 kg/ha) than when planted into strip-tilled fields (5460 kg/ha) or as Gregory into conventionally- (5280 kg/ha) or strip-tilled fields (5410 kg/ha) (Table 19). Studies have shown strip-tillage to increase pod yields when compared to conventional tillage when virus is present (Marois and Wright 2003). The main effect of planting pattern was significant for pod yield. Peanut planted into single rows had lower pod yields (4940 kg/ha) than peanut planted into twin rows (5490 kg/ha) (Table 19). This is consistent with the findings of Baldwin and Williams (2002).

Using Spearman's coefficient correlation (N=64), the relationship between the following pairs of data were examined: TSWV incidence and TSWV severity (0.56646, $p \leq 0.0001$); TSWV incidence and thrips damage (-0.02683, p=0.8333); TSWV incidence and pod yield (-0.56884, $p \leq 0.0001$); and TSWV severity and pod yield (-0.44135, p=0.0003) (Steel et al. 1997). Falling in the range of -1 to 1, the r-value indicates a strong positive linear relationship the closer the value to 1, and a negative linear relationship the closer the value to -1 (Steel et al. 1997). There was a slight correlation between the TSWV incidence and the TSWV severity. The relationship between TSWV incidence and thrips damage was very weak and shows that the thrips feeding damage alone cannot be used as guide to how much virus will be present in peanut. The values for the relationships between pod yield with both TSWV incidence and severity were both slightly correlated and negative, showing that as the amount of virus increases in a field, the pod yield decreases. These values indicate a strong relationship similar to the results found in the test *"Influence of Planting Date, Cultivar, Plant Population, and Insecticide on TSWV Incidence."* The remaining tests *"Influence of Cultivar, Planting Pattern, and Plant Population on TSWV Incidence," "Influence of Insecticide (aldicarb, phorate) Rates Applied in Twin Rows on TSWV Incidence,"* and *"Influence of Insecticide (acephate, aldicarb) Rate and Planting Pattern on TSWV Incidence"* did not have as strong correlation values for TSWV incidence and pod yield. The planting date study and the reduced tillage study both included many cultural controls which may have impacted pod yield. The remaining three tests involved more insecticide testing, and may not have impacted pod yield in the same way as the multiple cultural controls.

Weekly virus counts in 2002 allowed a chart with cumulative counts to be assembled. Accumulation of virus was gradual for this test, which is similar to the other cumulative charts for 2002 in the tests *"Influence of Cultivar, Planting Pattern, and Plant Population on TSWV Incidence," "Influence of Planting Date, Cultivar, Planting Pattern, and Insecticide on TSWV Incidence,"* and *"Influence of Insecticide (aldicarb, phorate) Rates Applied in Twin Rows on TSWV Incidence."* Also, similar to the above listed tests, virus accumulation greatly slowed after the first week in August (Figure 23).

Table 1. Analyses of variance (*p* values) for percentage of plants with thrips damage, tomato spotted wilt virus (TSWV) incidence, TSWV severity, pod yield, and the percentages of total sound mature kernels (%TSMK), extra large kernels (%ELK), and fancy pods (%FP)[a].

Treatment Factor	df	Thrips Damage (%)	TSWV Incidence (%)	TSWV Severity (%)	Pod Yield (kg/ha)	%TSMK	%ELK	%FP
Location (LOC)	4	<0.0001	<0.0001	<0.0001	0.4905	<0.0001	<0.0001	<0.0001
Error	15	-	-	-	-	-	-	-
Variety (VAR)	2	0.0010	0.0160	0.0637	0.0435	0.7541	0.0189	0.0175
Population (POP)	2	0.1155	0.0038	0.0054	0.1934	0.8280	0.7718	0.7529
VAR X POP	4	0.0038	0.0877	0.4355	0.4112	0.1705	0.5776	0.1934
LOC X VAR	8	0.0265	0.0005	<0.0001	0.5237	0.3739	0.0020	0.0014
LOC X POP	8	0.0250	<0.0001	0.2847	0.1977	0.0067	0.2252	0.3098
LOC X VAR X POP	16	0.7832	0.3017	0.5105	0.3845	0.1866	0.9565	0.9517
Coefficient of Variation, %	-	51.2	30.9	77.9	57.5	2.9	10.9	8.6

[a]Shaded cells indicate $p \leq 0.05$.

Table 2. Interaction of cultivar and plant population on thrips damage[a].

	Thrips damage[b]		
	In-row plant population (plants/m-row)		
Cultivar	7	13	17
		%	
Gregory	20c	31b	20c
NC V-11	52a	41b	40b
Perry	32b	16c	14c

[a]Means followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over locations.

[b]Thrips damage recorded 33 days after planting.

Table 3. Analyses of variance (*p* values) for percentage of plants with thrips damage, tomato spotted wilt virus (TSWV) incidence, TSWV severity, pod yield, and the percentages of total sound mature kernels (%TSMK), extra large kernels (%ELK), and fancy pods (%FP).

Treatment Factor	df	Thrips Damage (%)	TSWV Incidence (%)	TSWV Severity (%)	Pod Yield kg/ha	%TSMK	%ELK	%FP
Year	1	0.6077	0.7879	0.0352	0.0082	0.0506	0.0674	0.0043
Error A	6	-	-	-	-	-	-	-
Date	1	<0.0001	<0.0001	0.0197	0.4559	0.0311	0.1102	0.0478
Year X Date	1	0.3048	0.0002	0.1927	0.2959	0.0244	0.0282	0.3353
Error B	6	-	-	-	-	-	-	-
Variety (VAR)	1	<0.0001	0.0259	0.0163	0.0015	0.0013	<0.0001	0.3072
Insecticide (INS)	1	<0.0001	<0.0001	<0.0001	<0.0001	0.5429	0.0852	0.4280
Population (POP)	2	0.3370	<0.0001	<0.0001	<0.0001	0.1189	0.0878	0.1360
Year X VAR	1	0.3383	<0.0001	0.4344	0.2345	0.9722	0.0028	0.3495
Year X INS	1	0.5838	0.5723	0.3220	0.5834	0.8209	0.1302	0.5719
Year X POP	2	0.4876	0.1760	0.2969	0.0012	0.5318	0.0030	0.7363
VAR X INS	1	0.0006	0.3537	0.2306	0.6078	0.9514	0.5914	0.2927
VAR X POP	2	0.6763	0.6149	0.9348	0.9341	0.0055	0.3679	0.8742
Date X VAR	1	0.0885	0.5182	0.1693	0.6894	0.8754	0.3603	0.4782
INS X POP	2	0.9439	0.4326	0.2723	0.4646	0.7711	0.5352	0.7261
Date X INS	1	0.7320	0.1091	0.1954	0.3882	0.8209	0.5545	0.1738
Date X POP	2	0.0073	0.0396	0.1150	0.1604	0.3776	0.6407	0.2789
Year X VAR X INS	1	0.1721	0.0804	0.0619	0.4718	0.4817	0.4513	0.1128
Year X INS X POP	2	0.9918	0.0656	0.5660	0.1073	0.7488	0.6280	0.4230
Year X VAR X POP	2	0.2974	0.2151	0.8846	0.9981	0.5608	0.7469	0.8632
Year X Date X VAR	1	<0.0001	0.0004	0.5780	0.4921	0.8754	0.7910	0.9433
Year X Date XINS	1	0.4936	0.3815	0.7167	0.6045	0.8754	0.8760	0.4606
Year X Date X POP	2	0.6972	0.0594	0.1433	0.1689	0.7406	0.3860	0.3128
VAR X INS X POP	2	0.0412	0.3181	0.3451	0.1930	0.2755	0.5798	0.4009
Date X VAR X POP	2	0.7694	0.8516	0.5793	0.2226	0.8868	0.1736	0.5645
Date X VAR X INS	1	0.5378	0.9065	0.7046	0.6395	0.4817	0.4112	0.6969

Table 3 (Continued). Analyses of variance (*p* values) for percentage of plants with thrips damage, tomato spotted wilt virus (TSWV) incidence, TSWV severity, pod yield, and the percentages of total sound mature kernels (%TSMK), extra large kernels (%ELK), and fancy pods (%FP).

Treatment Factor	df	Thrips Damage (%)	TSWV Incidence (%)	TSWV Severity (%)	Yield kg/ha	%TSMK	%ELK	%FP
Date X INS X POP	2	0.3015	0.0752	0.6299	0.7623	0.7002	0.4390	0.2304
Year X VAR X INS X POP	2	0.2643	0.4190	0.2732	0.7866	0.9101	0.1010	0.3988
Year X Date X VAR X INS	1	0.0568	0.1391	0.2245	0.4665	0.4098	0.0303	0.0709
Year X Date X VAR X POP	2	0.5303	0.0851	0.9285	0.3203	0.5727	0.8212	0.3007
Year X Date X INS X POP	2	0.1009	0.2805	0.3203	0.0219	0.8584	0.5431	0.8079
Date X VAR X INS X POP	2	0.0020	0.3593	0.5309	0.9151	0.4810	0.9715	0.5968
Year X Date X VAR X INS X POP	2	0.7376	0.3277	0.2829	0.3642	0.7711	0.2576	0.8349
Coefficient of Variation, %	-	34.4	43.1	65.1	12.9	2.8	8.4	9.4

[a]Shaded cells indicate $p \leq 0.05$.

Table 4. Interaction of planting date, cultivar, insecticide, and plant population on thrips damage[a,b].

	Planting Date							
	Early May				Late May			
	NC V-11		Perry		NC V-11		Perry	
In-row plant population[b]	aldicarb[c]	phorate[c]	aldicarb	phorate	aldicarb	phorate	aldicarb	phorate
Plants/m-row	%							
7	32bc	19c	38ab	34b	17cd	16d	36ab	16cd
13	28bc	27bc	44a	36ab	17cd	6e	24c	13d
17	24c	27bc	43a	23c	16cd	9de	33bc	15d

[a]Means within a planting date followed by the same letter are not significantly different according to Fisher's Protected LSD test at p≤0.05. Data are pooled over years.

[b]Plant populations of 7 and 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

[c]Aldicarb and phorate applied at 7.9 and 5.6 kg/ha, respectively.

Table 5. Interaction of year, planting date, and cultivar on thrips damage and tomato spotted wilt virus (TSWV) incidence[a].

	Planting Date			
	2001		2002	
Cultivar	Early May	Late May	Early May	Late May
	%			
Thrips Damage[b]				
NC V-11	10ab	9b	19b	11c
Perry	14a	8b	24a	14bc
TSWV Incidence[c]				
NC V-11	13b	4c	15a	10b
Perry	21a	6c	11b	10b

[a]Means within a planting date followed by the same letter are not significantly different according to Fisher's Protected LSD test at p≤0.05. Data are pooled over plant populations.

[b]Thrips damage recorded 33 days after planting.

[c]TSWV incidence from late May through late September as the percentage of total plants at harvest exhibiting TSWV symptoms at some point throughout the growing season.

Table 6. Interaction of planting date and plant population on tomato spotted wilt virus (TSWV) incidence[a].

	TSWV Incidence[b]	
	Planting Date	
In-row plant population[c]	Early May	Late May
Plants/m-row	%	
7	19a	11c
13	16b	6d
17	9c	4d

[a]Means folled by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over years and cultivars.

[b]Cumulative TSWV incidence from late May through late September as the percentage of total plants at harvest exhibiting TSWV symptoms at some point throughout the growing season.

[c]Plant populations of 7 and 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

Table 7. Interaction of year, planting date, insecticide, and plant population on pod yield (kg/ha)[a,b].

	Planting Date							
	2001				2002			
	Early May		Late May		Early May		Late May	
In-row plant population[b]	aldicarb[c]	phorate[c]	aldicarb	phorate	aldicarb	phorate	aldicarb	phorate
Plants/m-row	kg/ha							
7	3040c	3770bc	3170c	3280c	4270bc	4830ab	4000cd	4660b
13	3620bc	3850b	3200c	3990b	4410bc	5280a	4330bc	4680b
17	3700bc	4600a	4460ab	4780a	5010ab	4930ab	4610b	4800ab

[a]Means within a planting date followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over cultivars.

[b]Plant populations of 7 and 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

[c]Aldicarb and phorate applied at 7.9 and 5.6 kg/ha, respectively.

Table 8. Interaction of cultivar and plant population on pod yield, and the percentage of total sound mature kernels (%TSMK)[a].

In-row plant population[b]	Pod Yield		%TSMK	
Plants/m-row	NC V-11	Perry	NC V-11	Perry
7	3770c	3980c	72b	75a
13	4030c	4310b	74a	74a
17	4480ab	4740a	74a	74a

[a]Means for pod yield or %TSMK followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over years and insecticide treatments.

[b]Plant populations of 7 and 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

Table 9. Interaction of year and planting date on the percentage of total sound mature kernels (%TSMK)[a].

Planting Date	2001	2002
Early May	75a	74a
Late May	72b	74a

[a]Means within a year followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over plant populations and cultivars.

Table 10. Interaction of year, planting date, cultivar, and insecticide on the percentage of extra large kernels (%ELK)[a].

	Planting Date							
	2001				2002			
	Early May		Late May		Early May		Late May	
	aldicarb[b]	phorate[b]	aldicarb	phorate	aldicarb	phorate	aldicarb	phorate
NC V-11	38c	39c	32d	35cd	42b	44b	46b	45b
Perry	47ab	51a	41bc	44b	50a	47a	49a	52a

[a]Means within a planting date followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over planting populations.

[b]Aldicarb and phorate applied at 7.9 and 5.6 kg/ha, respectively.

Table 11. Interaction of year and plant population on the percentage of extra large kernels (%ELK)[a].

	%ELK	
In-row plant population[b]	2001	2002
Plants/m-row	%	
7	40b	45b
13	41ab	49a
17	43a	46b

[a]Means within a year followed by the same letter are not significantly different according to Fisher's Protected LSD test at p<0.05. Data are pooled over planting dates, cultivars, and insecticides.

[b]Plant populations of 7 and 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

Table 12. Analyses of variance (*p* values) for the percentage of plants with thrips damage, number of plants infected with tomato spotted wilt virus (TSWV), TSWV severity, and pod yield.

Treatment Factor	df	Thrips Damage (%)	TSWV Incidence	TSWV Severity (%)	Pod Yield (kg/ha)
Error	3	-	-	-	-
Location (LOC)	1	0.0073	<.0001	0.0057	0.0001
Insecticide (INS)	1	<.0001	0.0121	0.1643	0.0118
LOC X INS	1	0.1827	0.0459	0.8034	0.5823
Rate	2	0.0031	0.0924	0.2409	0.7457
LOC X Rate	2	0.9460	0.5304	0.4708	0.5372
INS X Rate	2	0.7873	0.3871	0.3801	0.0873
LOC X INS X Rate	2	0.0518	0.1540	0.5805	0.6631
Coefficient of Variation, %	-	55.9	36.8	90.0	9.9

[a]Shaded cells indicate p<0.05.

Table 13. Main effect of location on thrips damage, tomato spotted wilt virus (TSWV) severity, and pod yield[a].

	Thrips damage	TSWV Severity	Pod Yield
	%	# infected	kg/ha
Lewiston-Woodville	19a	16a	4490a
Rocky Mount	12b	7b	3960b

[a]Means for thrips damage, TSWV severity, and pod yield followed by the same letter are not significantly different according to Fisher's Protected LSD test at p<0.05. Data are pooled over insecticides, and insecticide rates.

Table 14. Analyses of variance (*p* values) for plants with thrips damage, tomato spotted wilt virus incidence (TSWV) , pod yield, and the percentages of total sound mature kernels (%TSMK), extra large kernels (%ELK), and fancy pods (%FP).

		Thrips Damage (%)				TSWV Incidence (%)			
Treatment Factor	df	Lewiston-Woodville	Bladenboro	Goldsboro	Rocky Mount	Lewiston-Woodville	Bladenboro	Goldsboro	Rocky Mount
Error	3	-	-	-	-	-	-	-	-
Insecticide (INS)	1	0.2865	0.5301	0.0003	0.0731	<0.0001	0.4480	<0.0001	0.1981
Rate	1	0.0144	0.7871	0.5402	0.0041	0.1192	0.0145	0.0023	0.7860
Planting Pattern (ROW)	1	0.0739	0.1858	0.0053	0.5363	<0.0001	0.1175	<0.0001	<0.0001
INS X Rate	1	0.3258	0.2490	<0.0001	0.0406	0.0038	0.0212	0.1998	0.0180
INS X ROW	1	0.2507	0.9282	0.0250	0.3293	0.1838	0.0856	<0.0001	0.6195
Rate X ROW	1	0.8968	0.5301	0.1015	0.0633	0.0120	0.1175	<0.0001	0.7860
INS X Rate X ROW	1	0.5756	0.3272	0.1540	0.4899	0.0016	0.1175	<0.0001	0.0567
Coefficient of Variation, %	-	26.7	50.4	34.0	39.3	12.2	72.4	5.2	35.0

		Pod Yield (kg/ha)				
Treatment Factor	df	Sunbury	Lewiston-Woodville	Bladenboro	Goldsboro	Rocky Mount
Error	3	-	-	-	-	-
Insecticide (INS)	1	0.0951	0.6418	0.5899	0.0092	0.5024
Rate	1	0.6430	0.9632	0.9185	0.5504	0.8132
Planting Pattern (ROW)	1	0.0167	0.3486	0.7129	0.0574	0.9850
INS X Rate	1	0.2867	0.6691	0.9776	0.1745	0.9299
INS X ROW	1	0.2459	0.7148	0.2294	0.9753	0.6239
Rate X ROW	1	0.1032	0.5783	0.1624	0.2253	0.6230
INS X Rate X ROW	1	0.8266	0.4803	0.1118	0.3365	0.3527
Coefficient of Variation, %	-	11.9	16.3	35.1	10.2	13.4

[a]Shaded cells indicate $p \leq 0.05$.

Table 14 (Continued). Analyses of variance (*p* values) for plants with thrips damage, tomato spotted wilt virus incidence (TSWV) , pod yield, and the percentages of total sound mature kernels (%TSMK), extra large kernels (%ELK), and fancy pods (%FP).

		%TSMK			%ELK			%FP		
Treatment Factor	df	Lewiston-Woodville	Bladenboro	Rocky Mount	Lewiston-Woodville	Bladenboro	Rocky Mount	Lewiston-Woodville	Bladenboro	Rocky Mount
Error	3	-	-	-	-	-	-	-	-	-
Insecticide (INS)	1	0.5029	0.0823	0.7939	0.2620	0.1753	0.2886	0.1795	0.9208	0.2640
Rate	1	0.4248	0.3733	0.7939	0.4428	0.3580	0.9647	0.2065	0.6969	0.6097
Planting Pattern (ROW)	1	0.7858	0.5211	0.6040	0.3743	0.3580	0.3259	0.5696	0.5832	0.2018
INS X Rate	1	0.6845	0.5823	0.3135	0.1214	0.2399	0.5131	0.9236	0.4165	0.6752
INS X ROW	1	0.8917	0.5823	0.7939	0.7941	0.4742	0.8250	0.9236	0.7928	0.1759
Rate X ROW	1	0.2958	0.9847	0.0992	0.6045	0.0689	0.8250	0.4525	0.1419	0.3417
INS X Rate X ROW	1	0.5029	0.1214	1.0000	0.5197	0.0397	0.6917	0.9236	0.5832	0.4362
Coefficient of Variation, %	-	4.9	5.9	2.5	23.1	16.2	17.0	6.8	14.5	6.9

[a]Shaded cells indicate p≤0.05.

Table 15. Interaction of insecticide and insecticide rate on thrips damage and tomato spotted wilt virus (TSWV) incidence[a].

	acephate		aldicarb	
Insecticide Rate	0.6X	1.0X	0.6X	1.0X
Thrips Damage[b]		%		
Goldsboro	47b	88a	56b	24c
Rocky Mount	59a	52a	61a	24b
TSWV Incidence[c]				
Bladenboro	0.8a	0.2b	0.4b	0.4b
Rocky Mount	5a	3b	3b	4ab

[a]Means for thrips damage and TSWV incidence followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over planting patterns.

[b]Thrips damage recorded 20 days after planting.

[c]Cumulative TSWV incidence from late May through late September as the percentage of total plants at harvest exhibiting TSWV symptoms at some point throughout the growing season.

Table 16. Interaction of insecticide, insecticide rate, and planting pattern on tomato spotted wilt virus (TSWV) incidence[a].

	acephate				aldicarb			
	0.6X		1.0X		0.6X		1.0X	
TSWV Incidence[b]	Single	Twin	Single	Twin	Single	Twin	Single	Twin
Wagram,NC	8c	7d	11a	4e	10b	3f	8c	4e
Lewiston-Woodville	5b	2d	5b	2d	5b	3c	7a	2c

[a]Means for TSWV incidence followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$.

[b]Cumulative TSWV incidence from late May through late September as the percentage of total plants at harvest exhibiting TSWV symptoms at some point throughout the growing season.

Table 17. Interaction of insecticide, insecticide rate, and planting pattern on the percentage of extra large kernels (%ELK)[a].

	acephate				aldicarb			
	0.6X		1.0X		0.6X		1.0X	
	Single	Twin	Single	Twin	Single	Twin	Single	Twin
%ELK	43ab	38b	53a	45ab	49ab	30b	30b	47ab

[a]Means for %ELK followed by the same letter are not significantly different according to Fisher's Protected LSD test at p≤0.05. Data are from Bladenboro, NC.

Table 18. Analyses of variance (*p* values) for the percentage of plants with thrips damage, tomato spotted wilt virus (TSWV) incidence, TSWV severity, and pod yield[a].

Treatment Factor	df	Thrips Damage (%)	TSWV Incidence (%)	TSWV Severity (%)	Pod Yield (kg/ha)
Tillage (TIL)	1	<0.0001	<0.0001	0.0008	0.0065
Error	6	n/a	n/a	n/a	n/a
Variety (VAR)	1	0.8898	<0.0001	<0.0001	0.1027
Insecticide (INS)	1	0.0090	<0.0001	0.0005	0.1299
Rows (ROW)	1	0.0055	<0.0001	0.0021	0.0009
VAR X INS	1	0.0930	0.9226	<0.0001	0.9335
VAR X ROW	1	0.5492	0.0014	0.0064	0.3119
TIL X VAR	1	0.0143	<0.0001	0.0008	0.0495
INS X ROW	1	0.1328	0.0054	0.0051	0.1132
TIL X INS	1	0.3349	0.9645	0.3307	0.9872
TIL X ROW	1	0.7467	0.0071	0.2575	0.9969
VAR X INS X ROW	1	0.0637	0.8656	0.0557	0.5995
TIL X VAR X ROW	1	0.2915	<0.0001	0.0924	0.3121
TIL X VAR X INS	1	0.0772	0.0042	0.0466	0.8062
TIL X INS X ROW	1	0.6780	0.6928	0.5154	0.8747
TIL X VAR X INS X ROW	1	0.6121	0.4649	0.8705	0.2340
Coefficient of Variation, %	1	42.3	28.1	50.3	11.8

[a]Shaded cells indicate p≤0.05.

Table 19. Interaction of tillage and cultivar on thrips damage and pod yield[a].

	Conventional		Strip	
	Gregory	Perry	Gregory	Perry
Thrips Damage (%)[b]	28ab	35a	23bc	16c
Pod Yield (kg/ha)	5280a	4710b	5410a	5460a

[a]Means for thrips damage and pod yield followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over planting patterns and insecticides.

[b]Thrips damage recorded 20 days after planting.

Table 20. Interaction of tillage, cultivar, and insecticide on tomato spotted wilt virus (TSWV) incidence and TSWV severity[a].

	Conventional				Strip			
	Gregory		Perry		Gregory		Perry	
	aldicarb[b]	phorate[b]	aldicarb	phorate	aldicarb	phorate	aldicarb	phorate
TSWV Incidence (%)[c]	11bc	10bc	22a	16b	13b	6d	9bcd	8cd
TSWV severity (%)[d]	5c	8c	33a	15b	6c	6c	17b	9c

[a]Means for TSWV incidence and TSWV severity followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over planting pattern.

[b]Aldicarb and phorate applied at 7.9 and 5.6 kg/ha, respectively.

[c]Cumulative TSWV incidence from late May through late September as the percentage of total plants at harvest exhibiting TSWV symptoms at some point throughout the growing season.

[d]Severity of TSWV measure in late September using a scale of 0 to 100%, where 0 = no symptoms of TSWV and 100 = the entire peanut canopy expressing symptoms of TSWV.

Table 21. Interaction of tillage, cultivar, and planting pattern on tomato spotted wilt virus (TSWV) incidence[a].

	Conventional				Strip			
	Gregory		Perry		Gregory		Perry	
	Single[b]	Twin[b]	Single	Twin	Single	Twin	Single	Twin
TSWV Incidence (%)[c]	12b	10bc	26a	12b	12b	7c	10bc	7c

[a]Means for TSWV incidence followed by the same letter are not significantly different according to Fisher's Protected LSD test at p≤0.05. Data are pooled over planting pattern.

[b]Plant populations of 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

[c]Cumulative TSWV incidence from late May through late September as the percentage of total plants at harvest exhibiting TSWV symptoms at some point throughout the growing season.

Table 22. Interaction of insecticide and planting pattern on tomato spotted wilt virus (TSWV) incidence and TSWV severity[a].

	aldicarb[b]		phorate[b]	
	Single[c]	Twin[c]	Single	Twin
TSWV Incidence (%)[d]	18a	10bc	12b	8c
TSWV Severity (%)[e]	20a	10b	10b	9b

[a]Means for TSWV incidence and TSWV severity followed by the same letter are not significantly different according to Fisher's Protected LSD test at p≤0.05. Data are pooled over cultivar and tillage.

[b]Aldicarb and phorate applied at 7.9 and 5.6 kg/ha, respectively.

[c]Plant populations of 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

[d]Cumulative TSWV incidence from late May through late September as the percentage of total plants at harvest exhibiting TSWV symptoms at some point throughout the growing season.

[e]Severity of TSWV measure in late September using a scale of 0 to 100%, where 0 = no symptoms of TSWV and 100 = the entire peanut canopy expressing symptoms of TSWV.

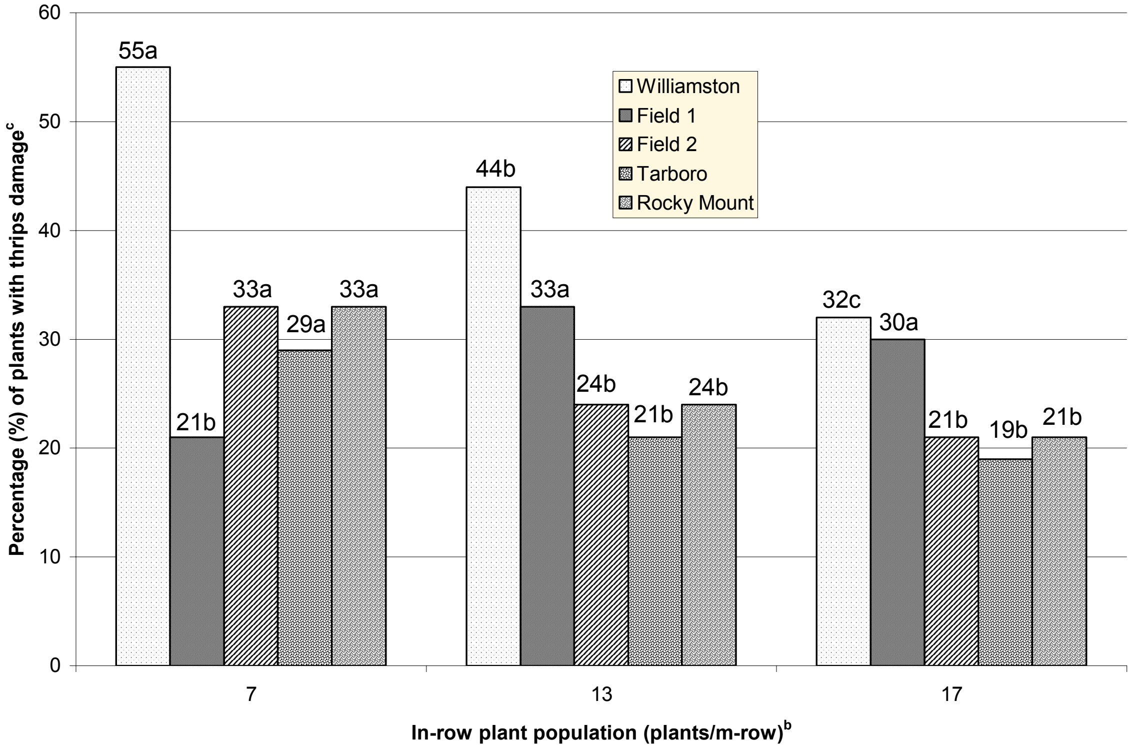

Figure 1. Interaction of location and plant population on thrips damage[a].

[a]Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p<0.05$. Data are pooled over cultivars. Locations "Field 1" and "Field 2" are located at the Peanut Belt Research Station near Lewiston-Woodville, NC.

[b]Plant populations of 7 and 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

[c]Thrips damage recorded 33 days after planting.

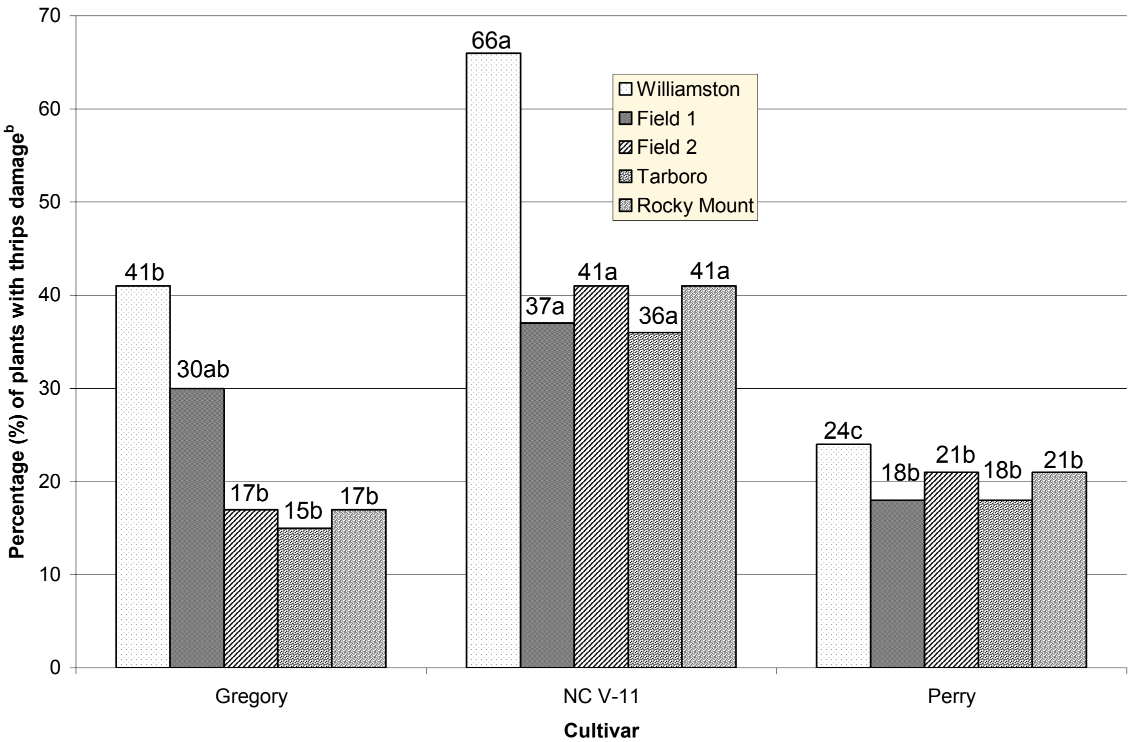

Figure 2. Interaction of location and cultivar on thrips damage[a].

[a]Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD test at p<0.05. Data are pooled over plant populations. Locations "Field 1" and "Field 2" are located at the Peanut Belt Research Station near Lewiston-Woodville, NC.

[b]Thrips damage recorded 33 days after planting.

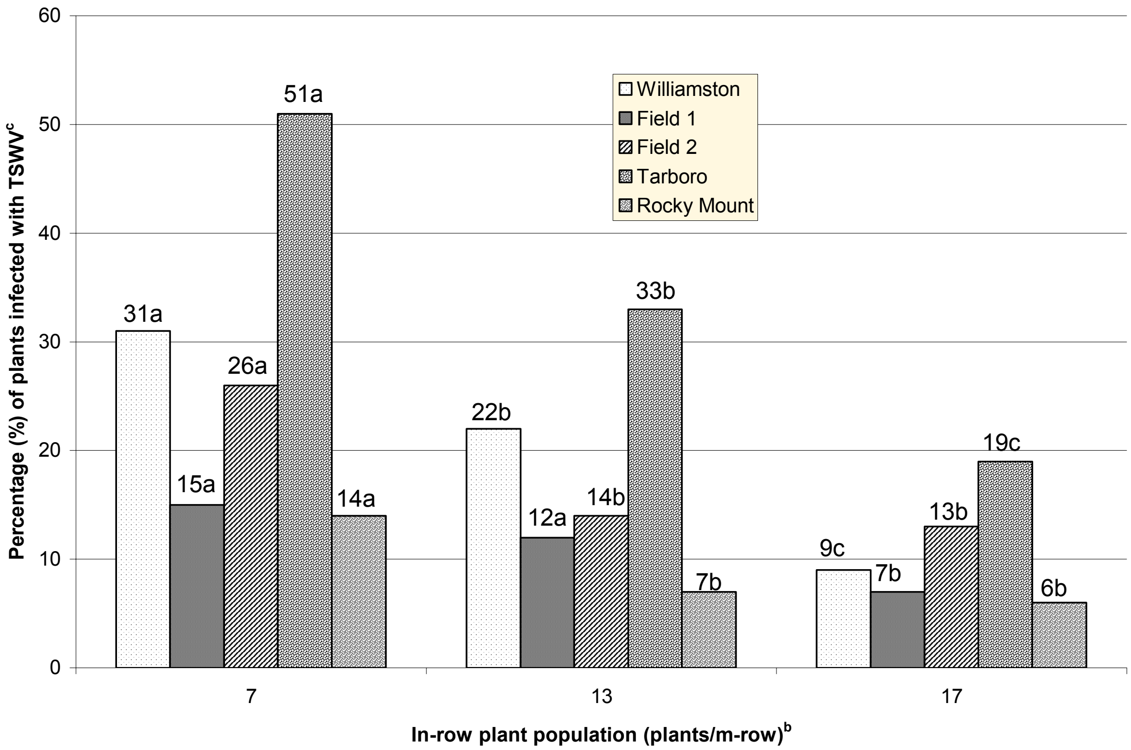

Figure 3. Interaction of location and plant population on tomato spotted wilt virus (TSWV) incidence[a].

[a]Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p<0.05$. Data are pooled over cultivars. Locations "Field 1" and "Field 2" are located at the Peanut Belt Research Station near Lewiston-Woodville, NC.

[b]Plant populations of 7 and 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

[c]TSWV incidence from late May through late September as the percentage of total plants at harvest exhibiting TSWV symptoms at some point throughout the growing season.

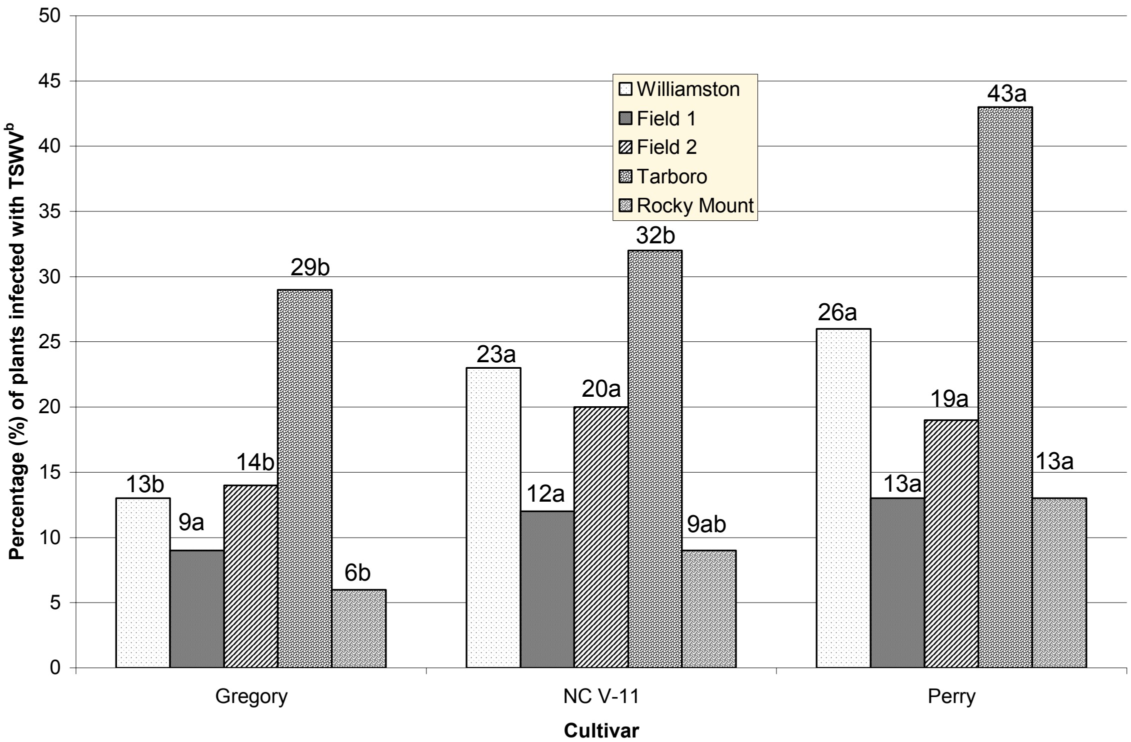

Figure 4. Interaction of location and cultivar on tomato spotted wilt virus (TSWV) incidence[a].

[a]Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p<0.05$. Data are pooled over plant populations. Locations "Field 1" and "Field 2" are located at the Peanut Belt Research Station near Lewiston-Woodville, NC.

[b]Cumulative TSWV incidence from late May through late September as the percentage of total plants at harvest exhibiting TSWV symptoms at some point throughout the growing season.

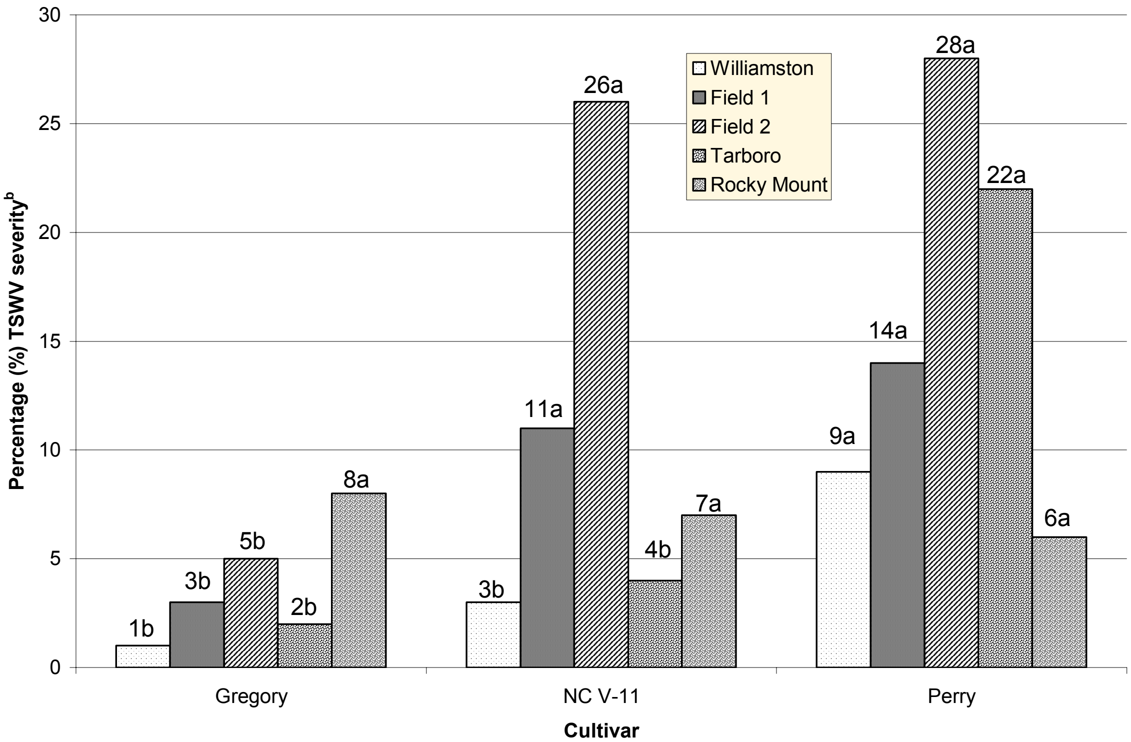

Figure 5. Interaction of location and cultivar on tomato spotted wilt virus (TSWV) severity[a].

[a]Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p<0.05$. Data are pooled over plant populations. Locations "Field 1" and "Field 2" are located at the Peanut Belt Research Station near Lewiston-Woodville, NC.

[b]Severity of TSWV measure in late September using a scale of 0 to 100%, where 0 = no symptoms of TSWV and 100 = the entire peanut canopy expressing symptoms of TSWV.

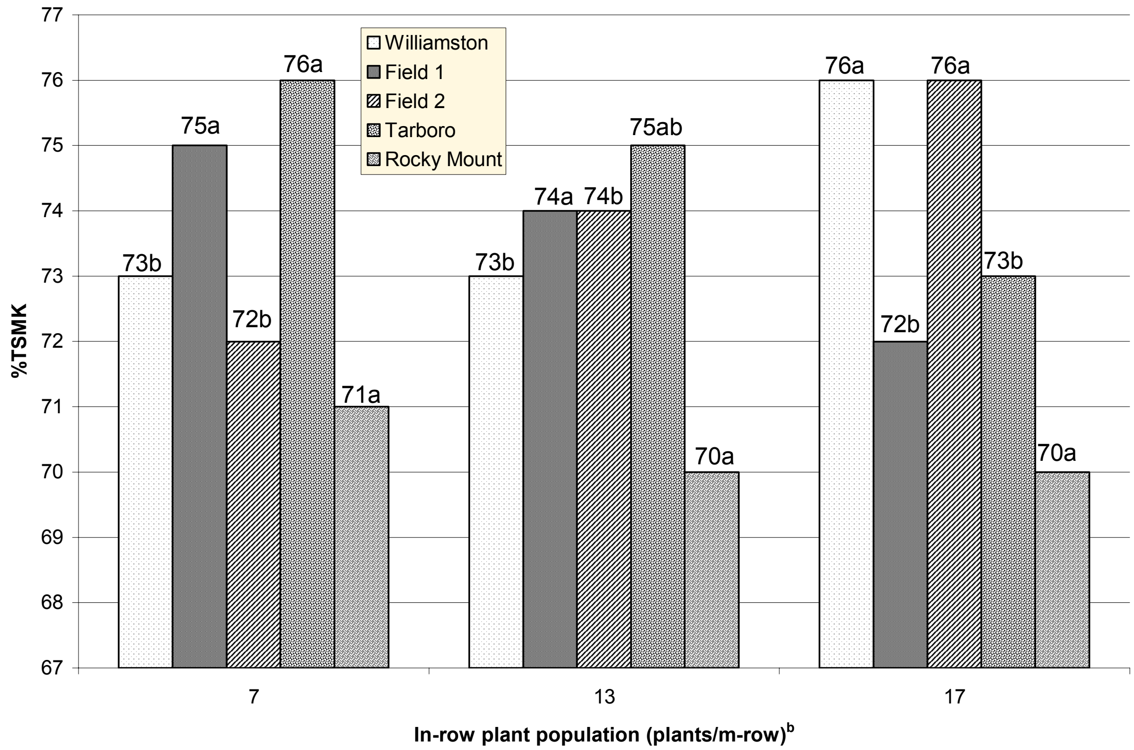

Figure 6. Interaction of location and plant population on the percentage of total sound mature kernels (%TSMK)[a].

[a]Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD test at p<0.05. Data are pooled over plant populations. Locations "Field 1" and "Field 2" are located at the Peanut Belt Research Station near Lewiston-Woodville, NC.

[b]Plant populations of 7 and 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

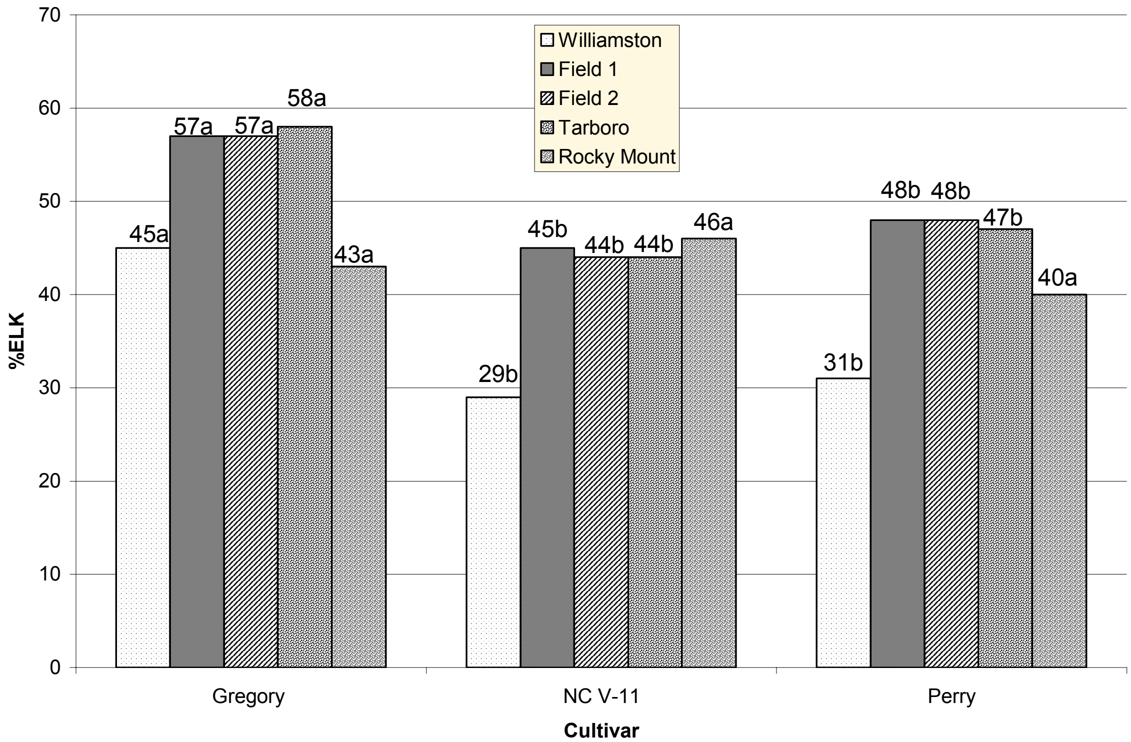

Figure 7. Interaction of location by cultivar on the percentage of extra large kernels (%ELK)[a],

[a]Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p<0.05$. Data are pooled over plant populations. Locations "Field 1" and "Field 2" are located at the Peanut Belt Research Station near Lewiston-Woodville, NC.

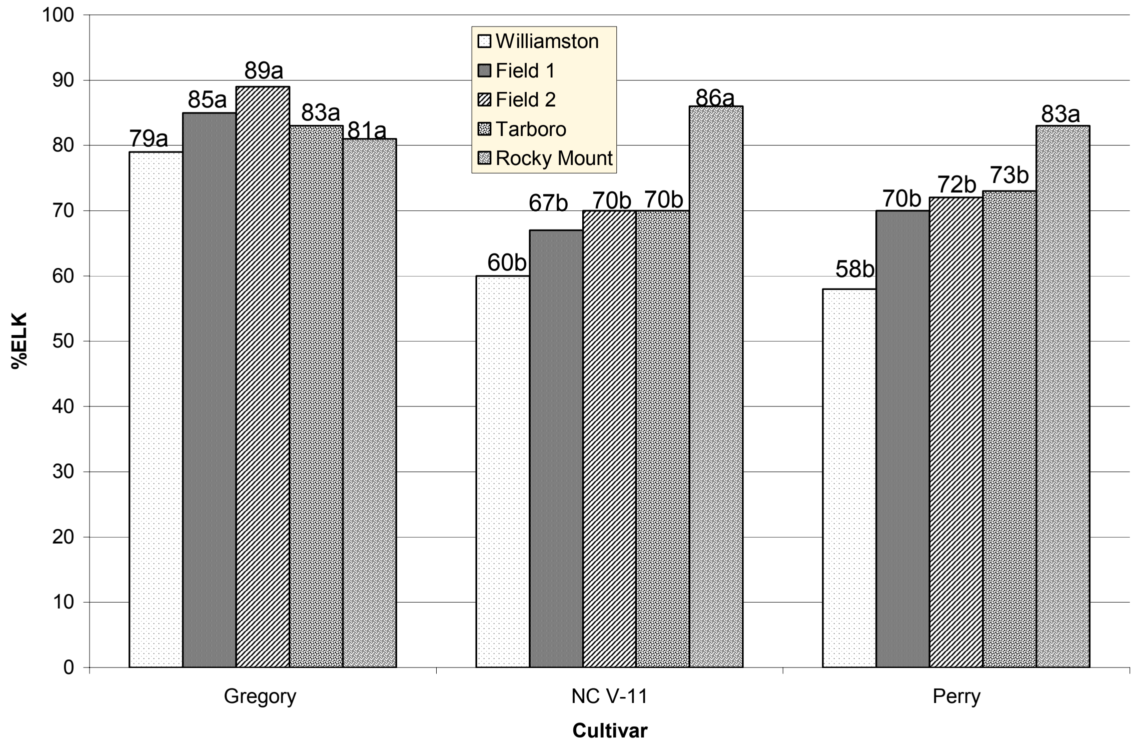

Figure 8. Interaction of location by cultivar on the percentage of fancy pods (%FP)[a].

[a]Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p<0.05$. Data are pooled over plant populations. Locations "Field 1" and "Field 2" are located at the Peanut Belt Research Station near Lewiston-Woodville, NC.

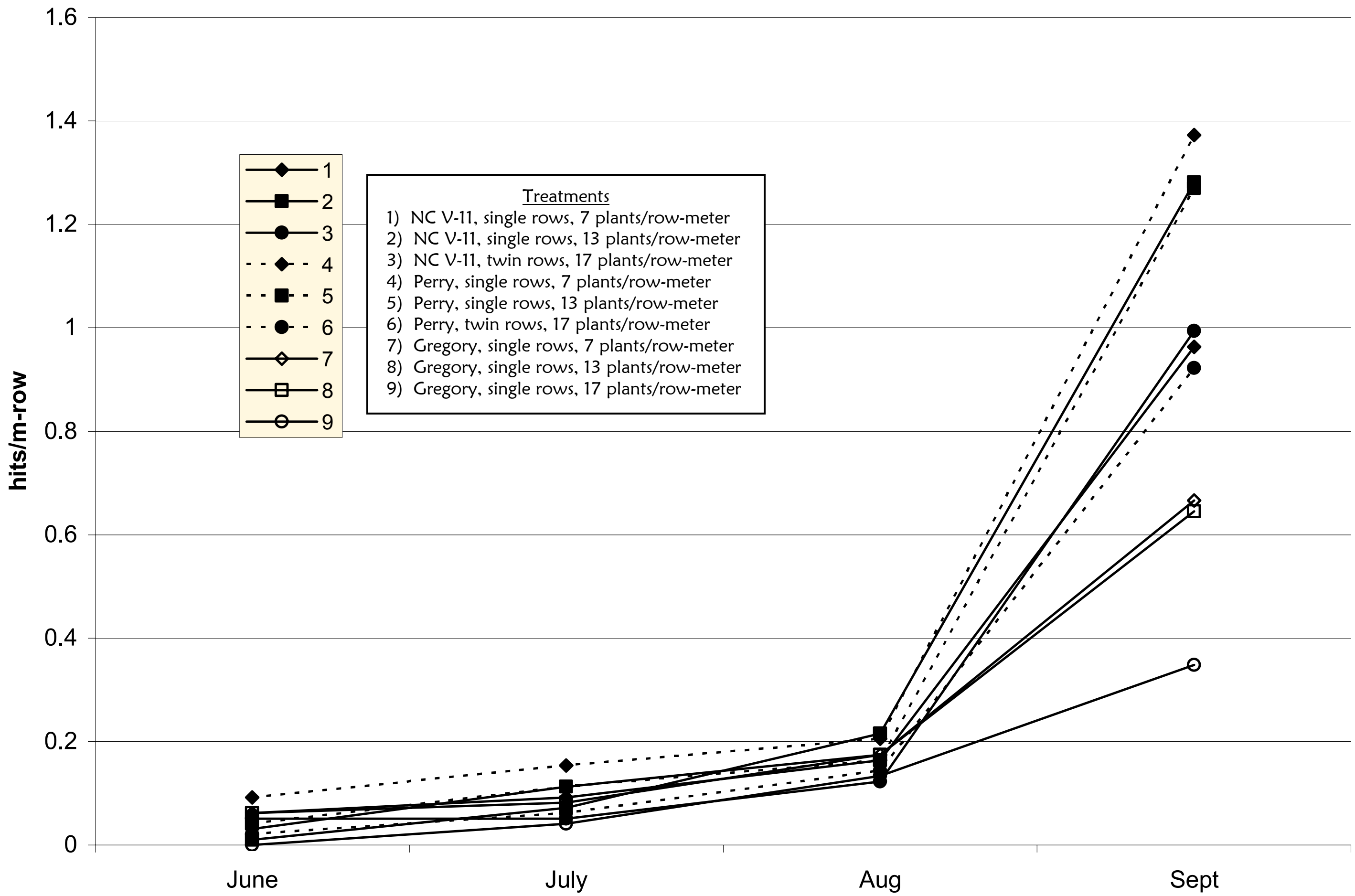

Figure 9. Cumulative TSWV at Williamston, NC 2001

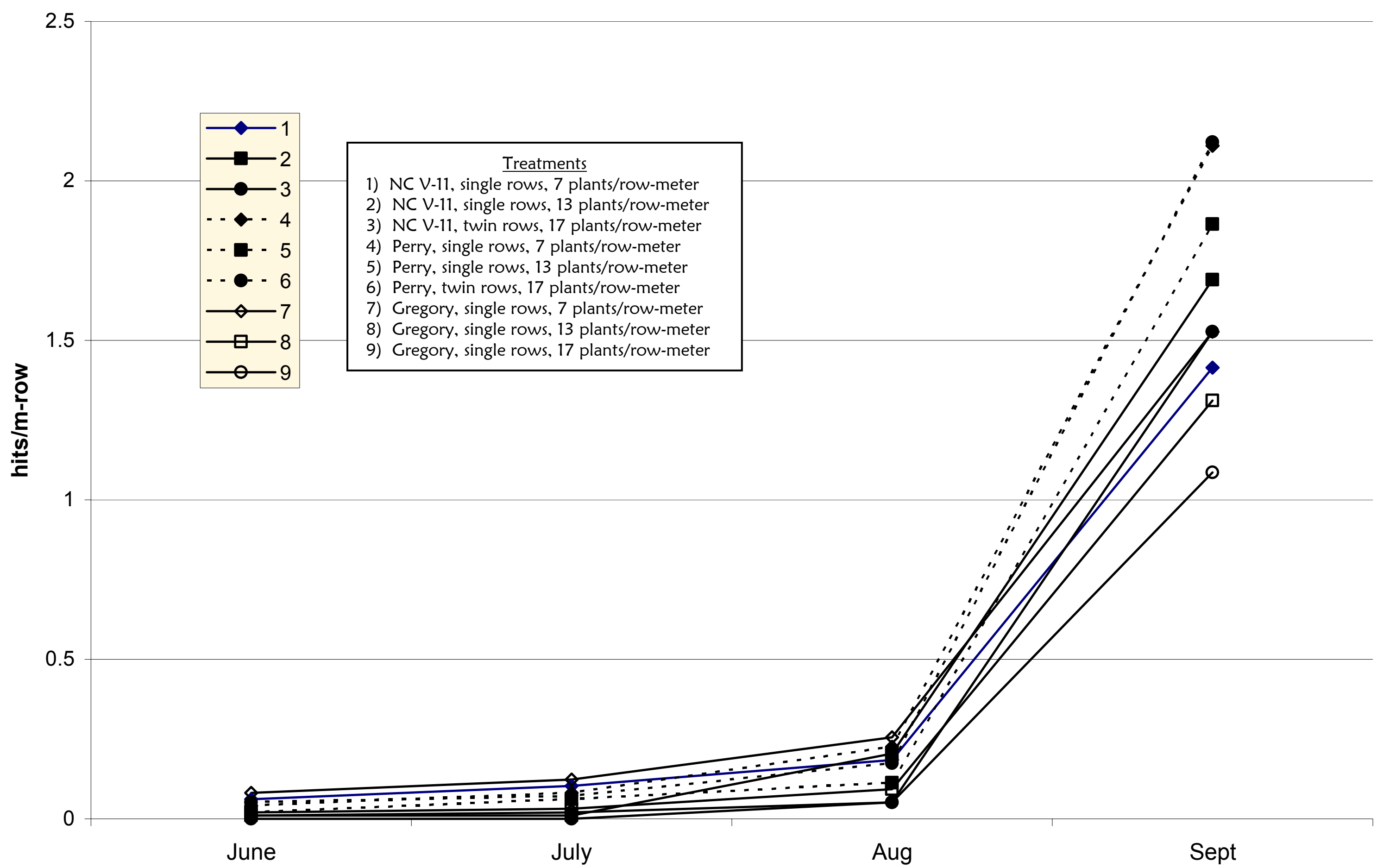

Figure 10. Cumulative TSWV at Tarboro, NC 2001

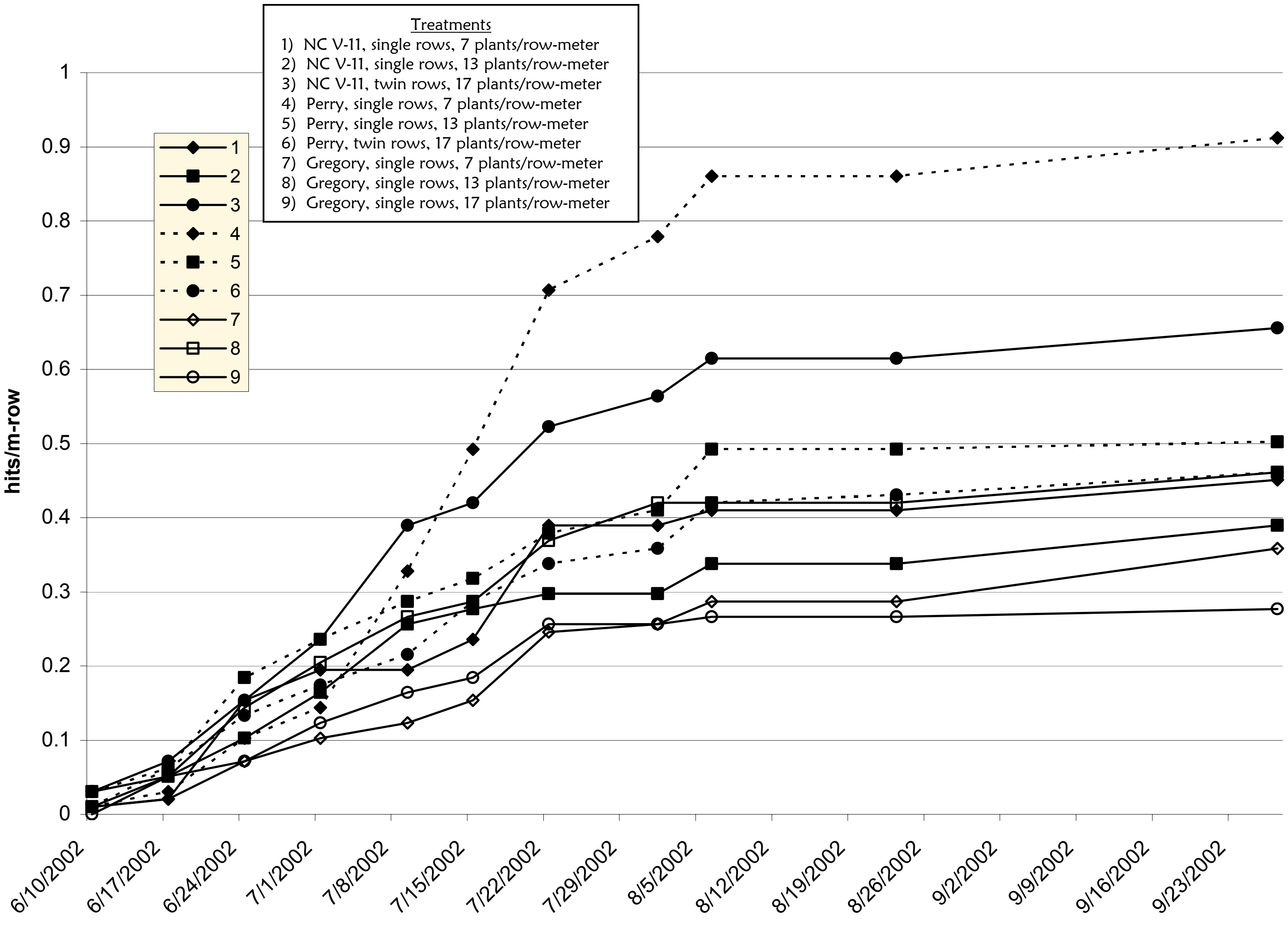

Figure 11. Cumulative TSWV at Rocky Mount, NC 2002

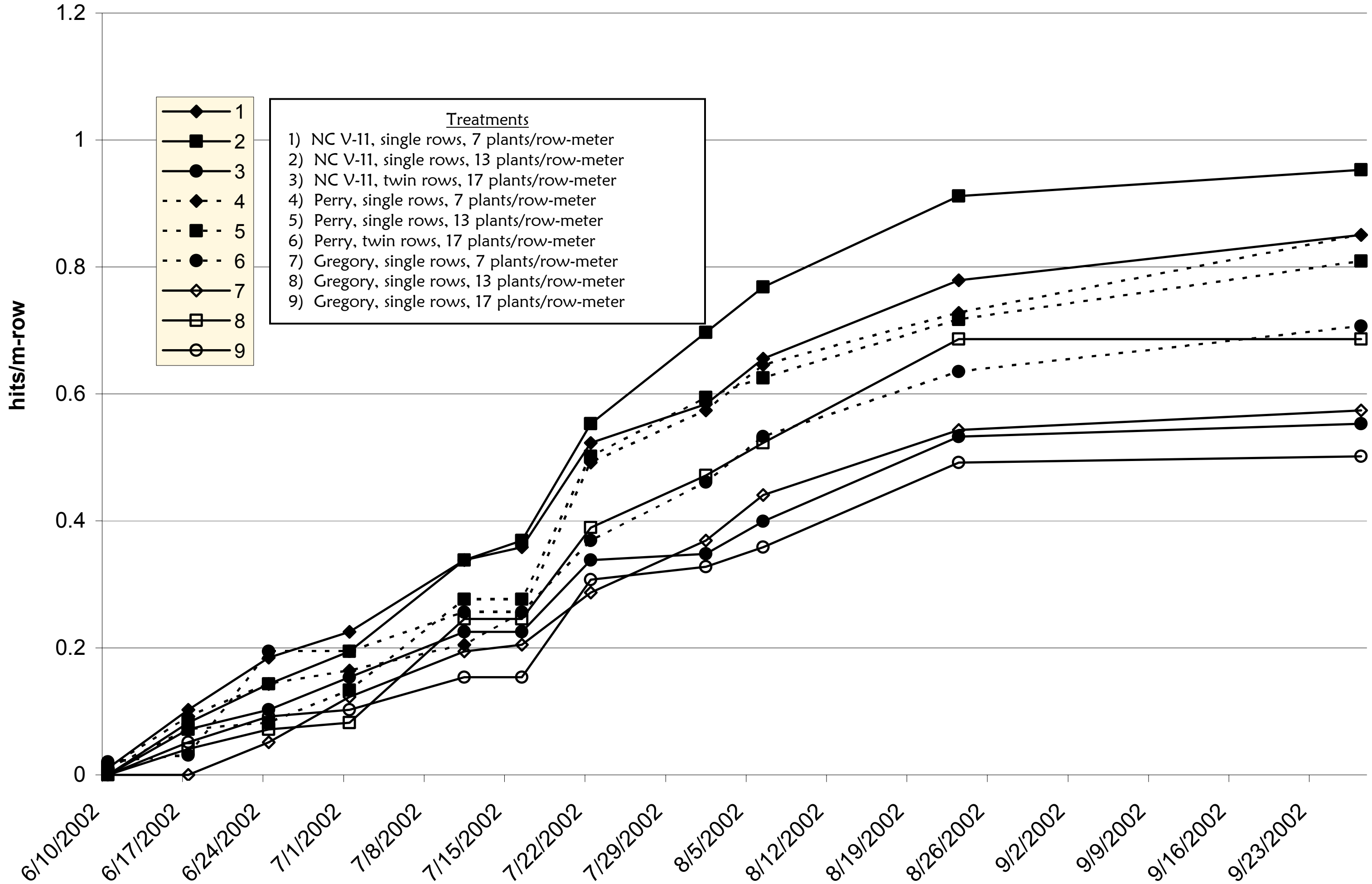

Figure 12. Cumulative TSWV at Field 1 at Lewiston-Woodville, NC 2002

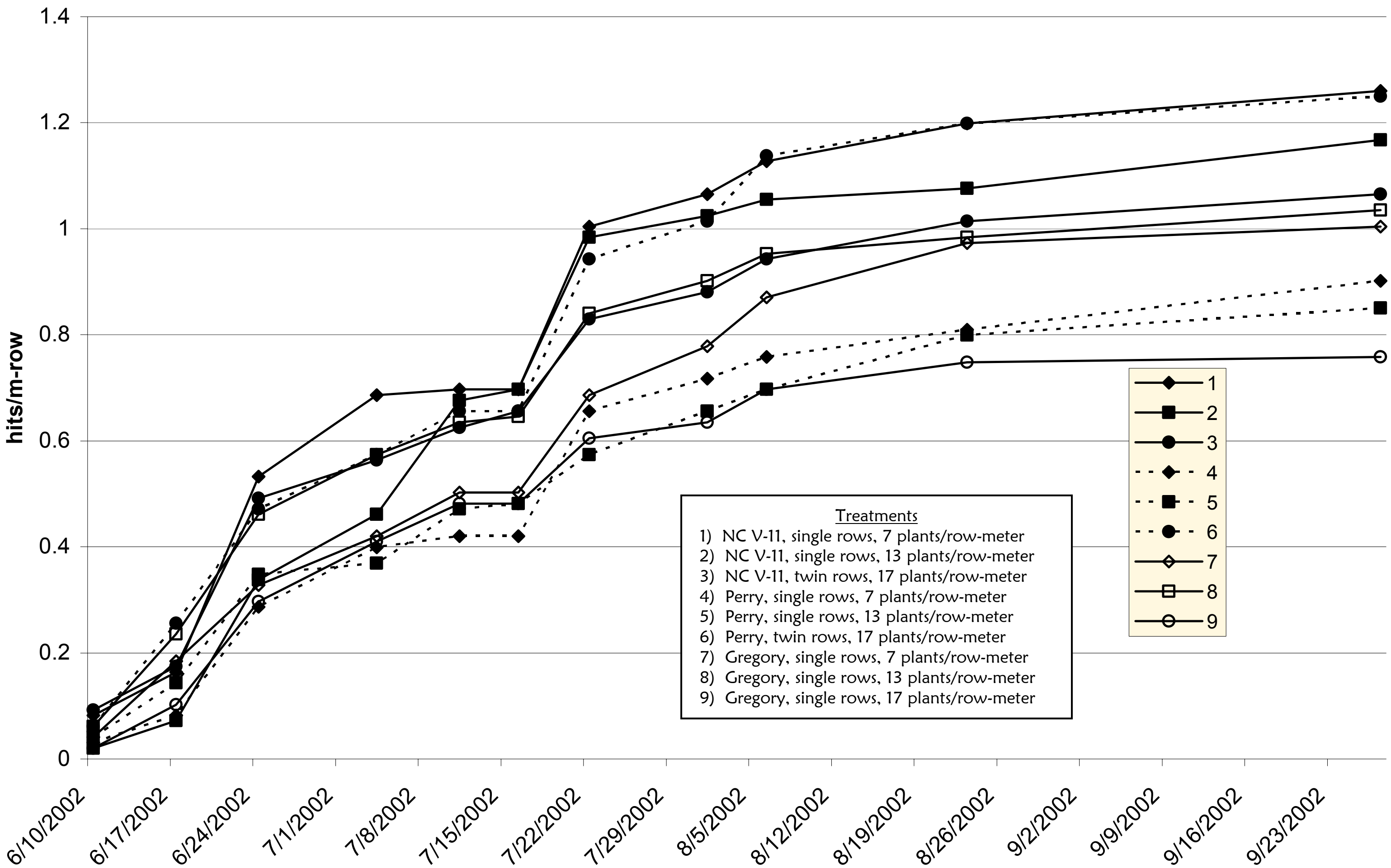

Figure 13. Cumulative TSWV at Field 2 at Lewiston-Woodville, NC 2002

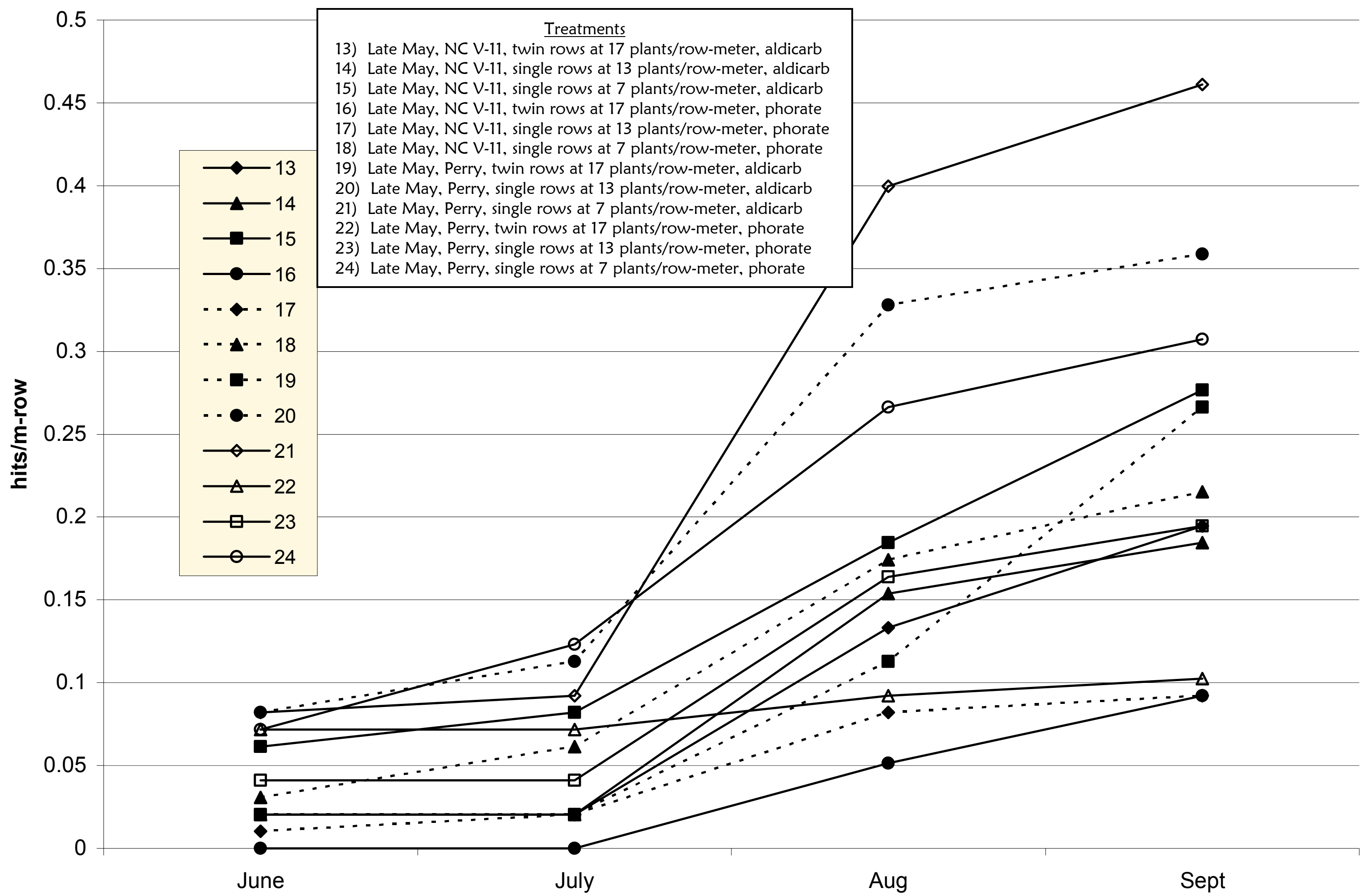

Figure 14. Cumulative TSWV at Lewiston-Woodville, NC 2001

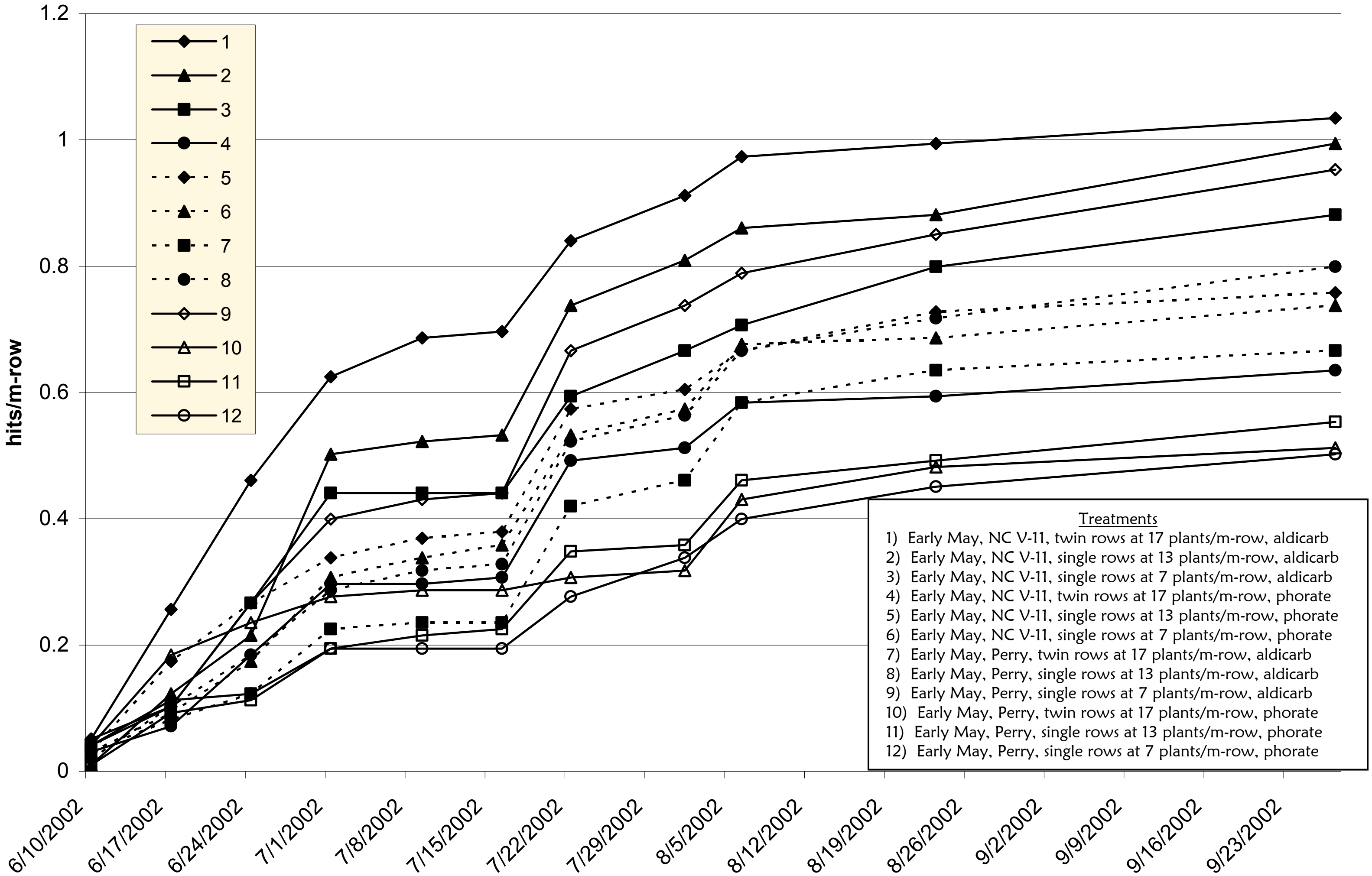

Figure 15. Cumulative TSWV at Lewiston-Woodville, NC 2002

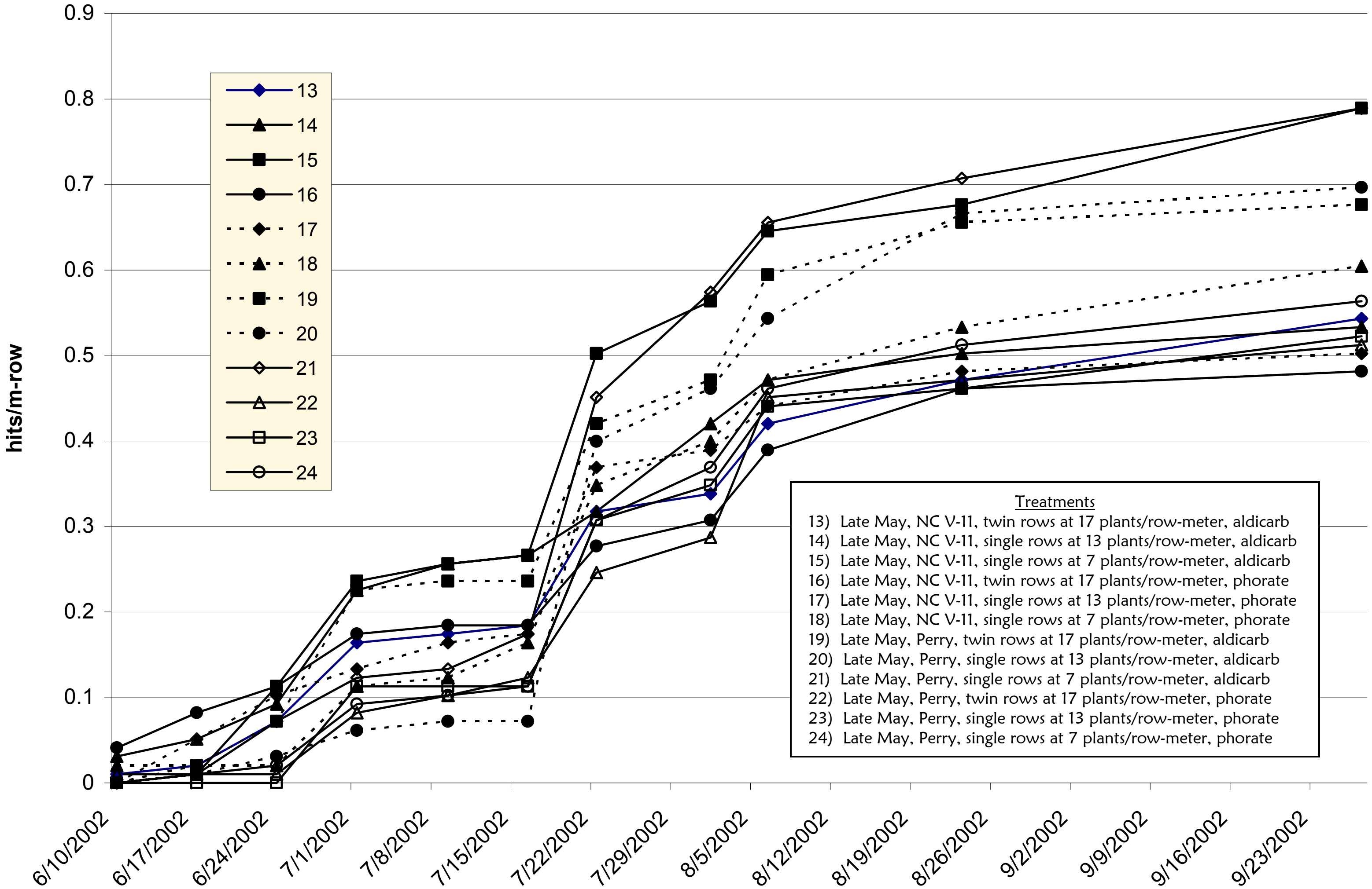

Figure 16. Cumulative TSWV at Lewiston-Woodville, NC 2002

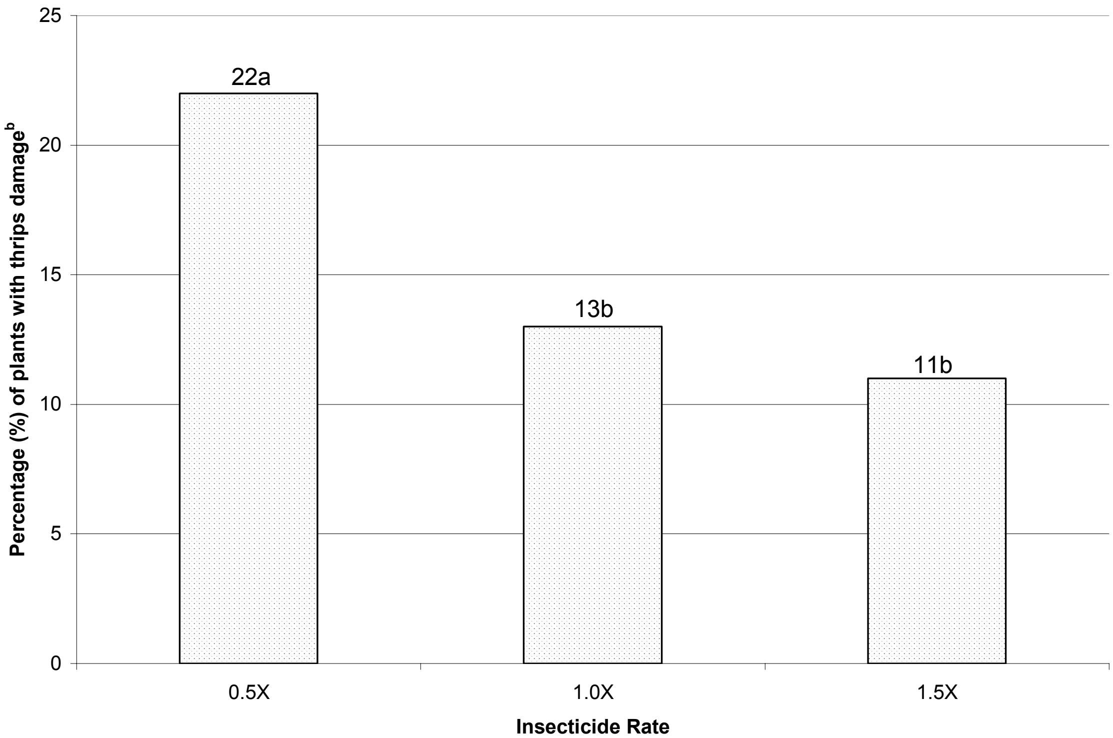

Figure 17. Main effect of insecticide rate on thrips damage[a].

[a]Means for thrips damage followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over insecticides and locations.

[b]Thrips damage recorded 20 days after planting.

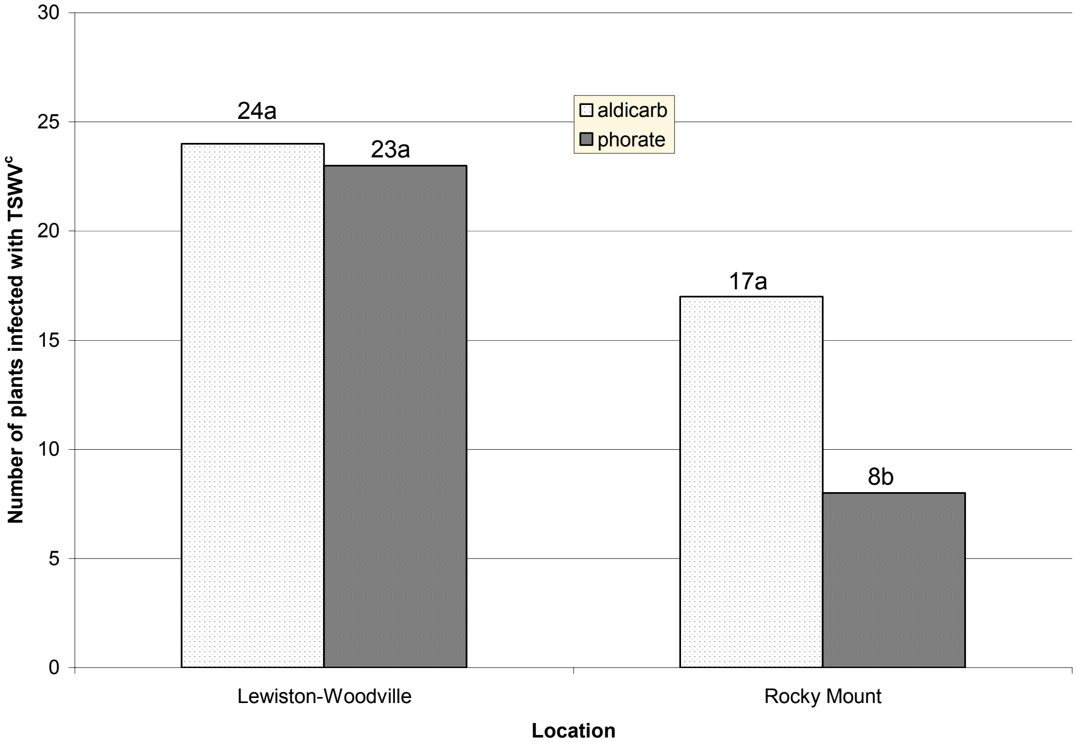

Figure 18. Interaction of location and insecticide on the number of plants infected with tomato spotted wilt virus (TSWV)[a, b].

[a]Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD test at p≤0.05. Data are pooled over insecticides rates.

[b]Cumulative TSWV incidence from late May through late September as the total number plants at harvest exhibiting TSWV symptoms at some point throughout the growing season.

[c]Thrips damage recorded 20 days after planting.

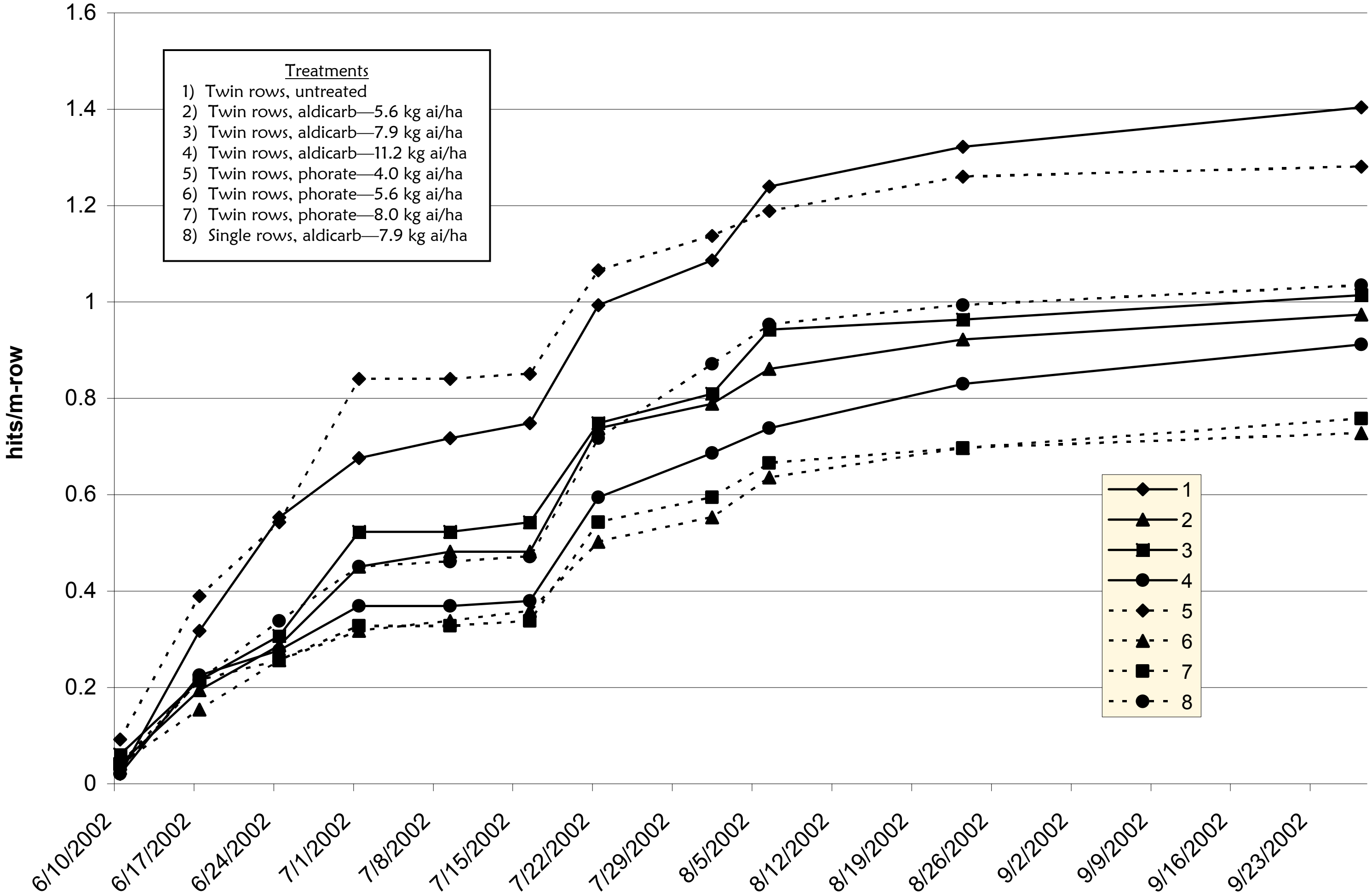

Figure 19. Cumulative TSWV Lewiston-Woodville, NC 2002

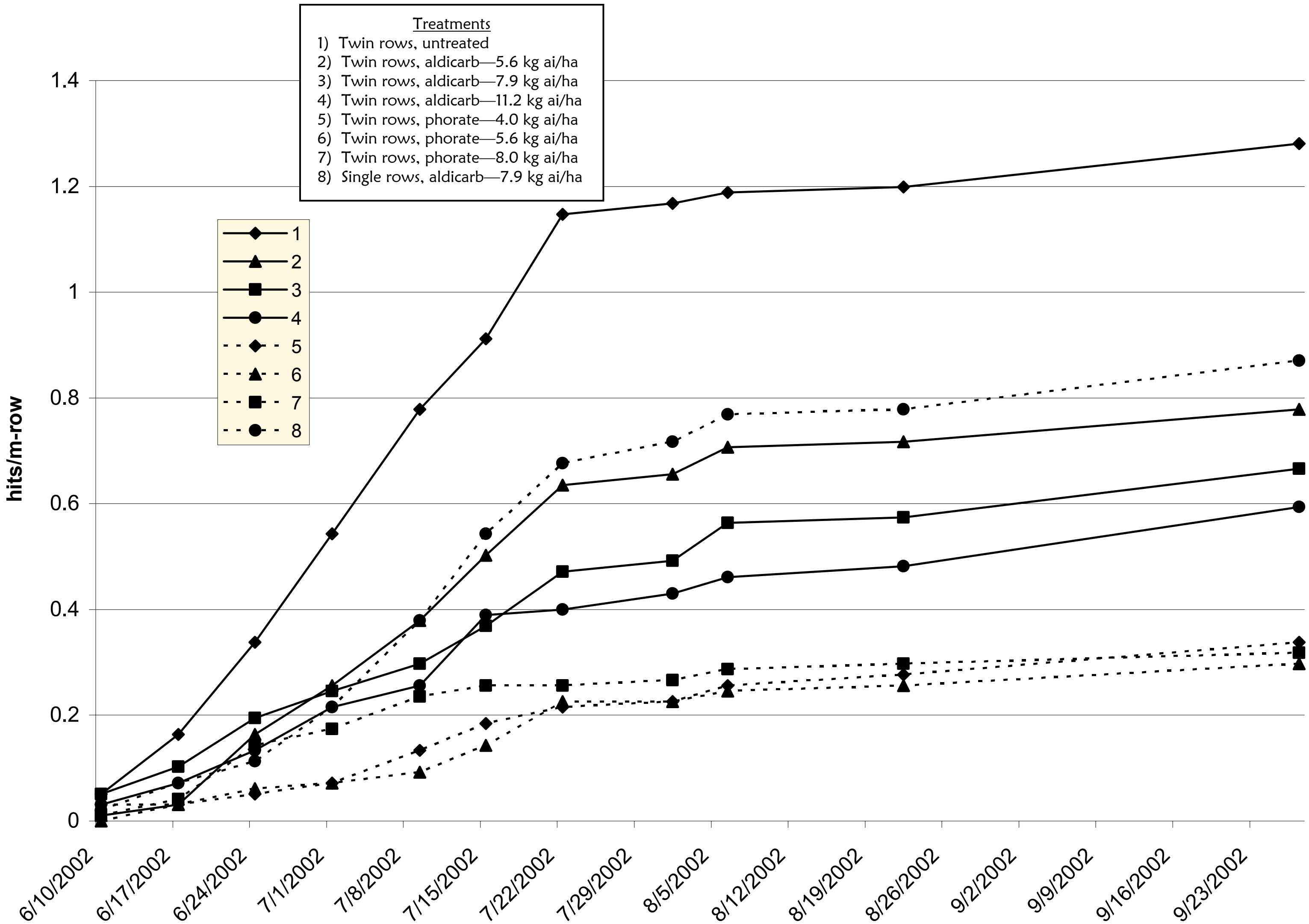

Figure 20. Cumulative TSWV at Field 1 at Rocky Mount, NC 2002

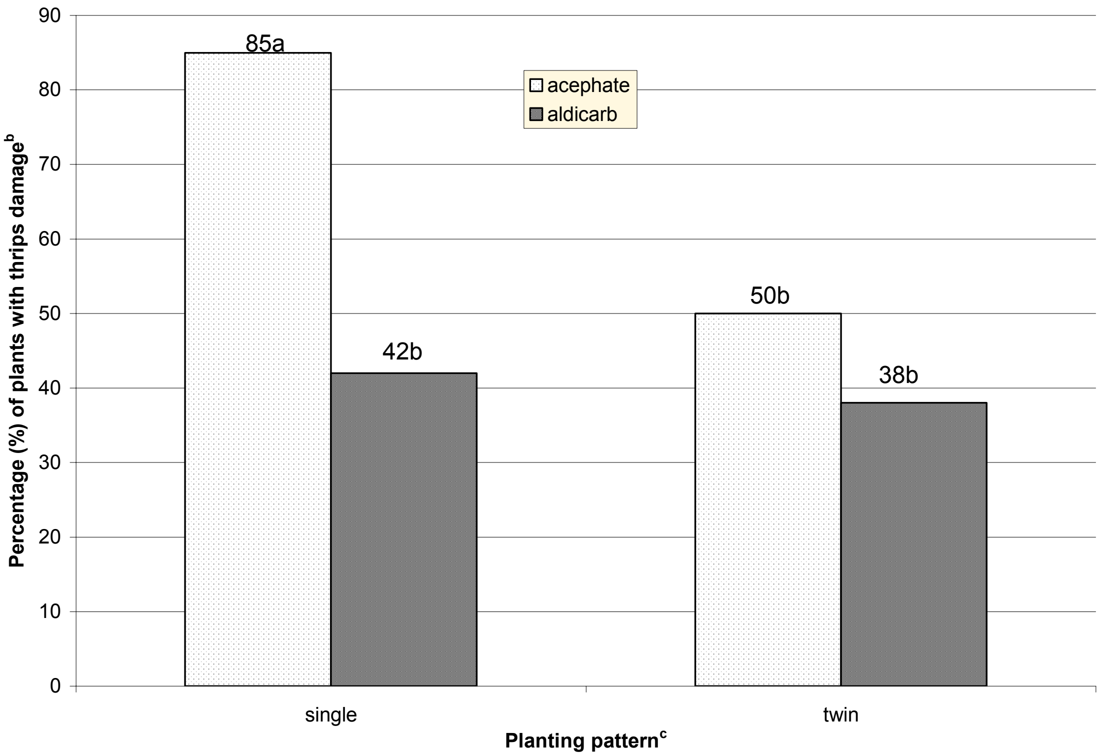

Figure 21. Interaction of insecticide and planting pattern on thrips damage[a].

[a]Means for thrips damage followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over insecticides rates. These results were from Goldsboro, NC.

[b]Thrips damage recorded 20 days after planting.

[c]Plant populations of 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

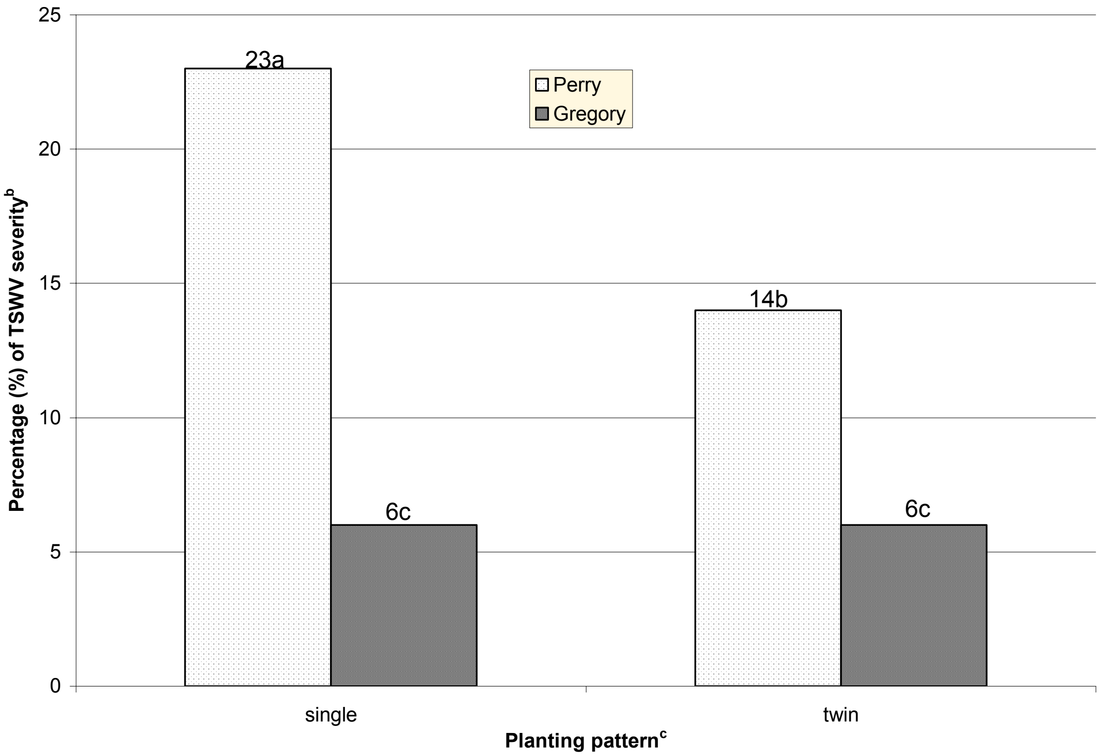

Figure 22. Interaction of cultivar and planting pattern on tomato spotted wilt virus (TSWV) severity[a].

[a]Means for TSWV severity followed by the same letter are not significantly different according to Fisher's Protected LSD test at $p \leq 0.05$. Data are pooled over tillage and insecticide.

[b]Severity of TSWV measure in late September using a scale of 0 to 100%, where 0 = no symptoms of TSWV and 100 = the entire peanut canopy expressing symptoms of TSWV.

[c]Plant populations of 13 plants/m-row were established in singe row planting patterns spaced 91 cm apart. Plant populations of 17 plants/m-row were established in the twin row planting pattern.

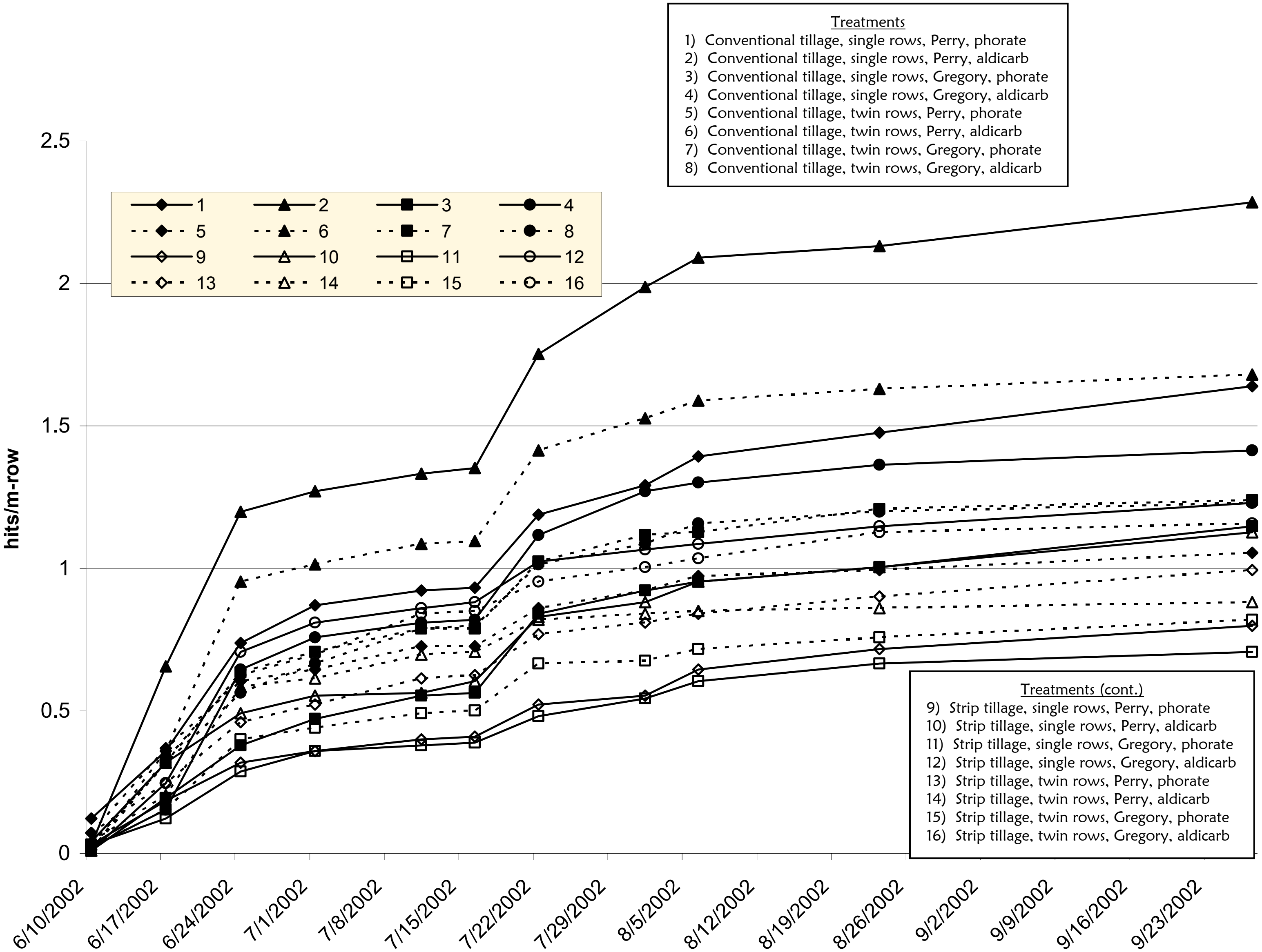

Figure 23. Cumulative TSWV at Field 1 at Lewiston-Woodville, NC 2002

Summary

Results from these experiments demonstrated a consistent trend for increased foliage damage from thrips as the plant population decreased. Less thrips damage from thrips feeding was noted for the cultivars Gregory and Perry than for the cultivar NC V-11. Higher rates of thrips damage were present when insecticides were used at low rates instead of normal or high rates. Acephate used as a foliar insecticide to control thrips feeding damage led to peanut with significantly higher damage for peanut when compared to aldicarb applied in-furrow. The twin row planting pattern, which also had a higher total plant population, was damaged less by thrips than peanut in single row planting patterns with lower plant populations. Brown et al. (1996) reported similar findings with runner marker-type cultivars.

Consistent with the results for thrips-induced damage, the percentage of plants infected with TSWV and severity of TSWV increased as plant population decreased. The cultivar Gregory had the lowest incidence of TSWV symptoms expressed, while the cultivar NC V-11 was intermediate between Gregory and the most susceptible cultivar Perry. Although less incidence of TSWV infection was noted in general when planting was delayed, Perry was more responsive to planting date than NC V-11.

Higher levels of TSWV were noted when aldicarb was applied in-furrow compared with in-furrow applications of phorate. TSWV severity ratings were consistent with higher severity when peanut is treated with aldicarb. When the 0.5X rate of insecticide was used, the severity of TSWV was higher when compared with insecticides used at the 1.0X or 1.5X rate. The percentage of plants infected with TSWV increased for peanut treated with acephate at the 0.5 rate as compared to the 1.0X rate of acephate, and compared to the 0.5 X and 1.0X rates of aldicarb in-furrow. Twin row planting patterns often resulted in lower levels of TSWV when compared to single rows. Strip-tillage had reduced incidence of TSWV compared with conventional-tillage.

In some cases, Perry had higher levels of virus, but still had higher yields than NC V-11 with lower levels of virus. In most cases yield reflected visual estimates of TSWV. Yield decreased with decreasing plants/meter-row, regardless of cultivar. As thrips damage increased, yield decreased in most cases. Peanut treated with in-furrow aldicarb had higher yields than peanut treated with acephate as a method of thrips control. Peanut seeded in the twin row planting pattern with higher plant populations often expressed fewer symptoms of TSWV than the single row planting pattern with lower plant populations. Gregory had consistently the highest %ELK and %FP across treatments and location whereas no definitive trend in market grade characteristics were noted among treatments.

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