EFFECTS OF ROW SPACING ON DISEASES, HERBICIDE PERSISTENCE, AND QUALITATIVE CHARACTERISTICS OF PEANUT

A Dissertation

by

BRENT ALAN BESLER

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2004

Major Subject: Agronomy

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Approved as to style and content by:

Scott A. Senseman (Chair of Committee)	Robert G. Lemon (Member)
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ABSTRACT

Effects of Row Spacing on Diseases, Herbicide Persistence, and Qualitative Characteristics of Peanut. (May 2004)

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Field and greenhouse studies were conducted to assess the effects of row-spacing on diseases, weed control, herbicide persistence and plant development in peanut.

Tebuconazole, when averaged across cultivars and row spacing, effectively controlled white mold (57%) and rust (58%). Azoxystrobin also controlled white mold (58%) and controlling rust (44%). Both fungicides reduced leaf spot severity in the conventional and twin rows when compared to untreated plots. Twin rows showed a 10% yield increase compared to the conventional planting.

Both diclosulam and imazapic, when applied to twin rows at the full and reduced rate, provided better yellow nutsedge control than when applied to the conventional row. Twin rows yielded higher than the conventional rows when averaged across herbicides in one year. All full rate herbicide treatments enhanced yield over the untreated check.

Diclosulam and imazapic treated soil sampled 60 DAP adversely affected all four crops. The advantage of planting peanuts in twin rows to reduce diclosulam and imazapic residual concentrations was not apparent.

Georgia Green and Tamrun 96 planted in twin rows at three of the four locations in 1999 and 2000 yielded higher than peanuts planted in conventional rows. Yields were comparable to twin-row spacings that had higher plant densities. Georgia Green and Tamrun 96 planted in conventional rows, in most cases, had higher yields than narrow-rows. Measurements for plant diameter, pod distribution, and main stem length were higher with Tamrun 96 at most row spacings and planting densities compared to the respective Georgia Green planting densities and row spacings. Both cultivars when planted in twin or narrow rows at all planting densities did not enhance maturity when sampled late season. Georgia Green and Tamrun 96 when planted in conventional rows had the most pods/plant compared to the narrow and twin row spacing. No clear evidence was found to suggest that peanuts grown in narrow or twin rows increased white mold disease incidence. Grades for Georgia Green were higher than Tamrun 96 when planted in twin rows at the standard planting density. Tamrun 96 in twin rows at the standard planting density had a higher grade than when planted in conventional rows at the low planting density.

DEDICATION

I dedicate this dissertation to my lovely wife Judy. You have endured the many times I expressed doubt and fear to offer words of encouragement and support. You have truly been there for me to unselfishly and unconditionally give of your love and time. Thank you for the countless times you took care of the children when I had to leave early in the mornings to attend class or work on my research projects. Thanks for understanding the mood swings I had when studying for a test or writing my dissertation. Never once did I hear you complain. I drew strength and comfort from the Christian attitude you displayed during those times and cannot express fully in words the appreciation I feel.

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

CHAPTER I

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is an important crop both nationally and internationally. Peanut ranks as one of the top five crops worldwide for oilseed production (Carley and Fletcher, 1995). Commercial production of peanut usually occurs in tropical or temperate regions of the world. China, India and the United States account for over 70% of the world peanut production (Shokes and Melouk, 1995). Peanut production areas in the United States include the Southeast (Georgia, Alabama, South Carolina and Florida), the VC region (Virginia and North Carolina) and the Southwest (Texas, Oklahoma and New Mexico). Peanut production now exceeds 129,500 ha in Texas (Lemon *et al*., 2001). The past five years have seen peanut production expand in west Texas, including the Rolling Plains and Southern High Plains areas where 85% of Texas peanut production now exists. In Texas, all four peanut market types (runner, spanish, virginia and valencia) are grown with runner (64%) and spanish (22%) being the predominant types (Smith *et al*., 1998).

The peanut plant is unique in that its growth and development differs substantially from other crops. Unlike other leguminous plants, the peanut flowers above ground, but sets fruit beneath the soil surface. A typical peanut plant is sparsely hairy with either an upright or prostrate growth habit. It produces a well-developed taproot with several lateral roots (Boote, 1982).

This dissertation follows the style and format of Peanut Science.

Peanut production in Texas is replete with many challenges. However, from a biotic standpoint weed and disease problems rank near the top. In South Texas, where humidity and rainfall can be high throughout the growing season, peanuts are susceptible to substantial yield losses due to foliar diseases such as early leaf spot (*Cercospora arachidicola* S. Hori), late leaf spot [*Cercosporidium personatum* (Berk. & M. A. Curtis) Deighton] and rust (*Puccinia arachidis*) and soilborne diseases such as white mold (*Sclerotium rolfsii* Sacc.) and Rhizoctonia pod/limb rot (*Rhizoctonia solani* Kuhn). The use of crop rotation and fungicides such as chlorothalonil (2,4,5,6-tetrachloro-1,3 phthalodinitrile), tebuconazole (alpha-[2-(4-chlorophenyl)ethyl]-alpha-(1,1-demethylethyl)-1*H*-1,2,4-triazole-1-ethanol) and azoxystrobin (methyl (*E*)-2-{2-[6-(2-cyanophenoxy)pyrimidin-4-yloxy]phenyl-3-methoxyacrylate) applied at proper timings can effectively control these diseases. Rotation with small grains, corn, sorghum and forage grasses can be effective in reducing inoculum loads in problem fields (Melouk and Backman, 1995).

Weeds compete with peanuts for light, nutrients and moisture thereby reducing yield and quality. Brecke (1995) reported that common cocklebur (*Xanthium strumarium* L.) and fall panicum (*Panicum dichotomiflorum* Mich.) reduced peanut yield by as much as 85%. Broadleaf signalgrass [*Brachiaria platyphlla* (Griseb.) Nash] and sicklepod [*Senna obtusifolia* (L.) Irwin and Barneby] reduced yields up to 70%. Wilcut *et al*. (1995) reported that yield reductions due to weed escapes cost producers $49 and $149/ha. Due to the prostrate growth habit of most peanut cultivars, early season weed control is essential to maintain a healthy and productive plant. Weeds can also reduce yields by interfering with digging and harvesting operations. Weeds such as yellow nutsedge (*Cyperus esculentus* L.) and morningglory spp. (*Ipomoea spp.)* become intertwined with peanut causing pod loss at digging. Also, at harvest, weed seed are combined with the peanut and can be transported to other fields.

Weed control methods in peanut include cultural, mechanical and chemical control. Crop rotation is one cultural method that growers have adopted to suppress weeds. Crop rotation allows growers to control weeds in other crops that otherwise would be hard to control in peanuts (Linker and Coble, 1990). Glaze (1987) observed that in a stale seedbed weed control program, shallow tillage effectively reduced yellow nutsedge. However, from a practical standpoint, the growth habit and fruiting pattern of the peanut plant mid- to late-season inhibits the use of cultivation (Brecke and Colvin, 1991).

To effectively control problem weeds most growers in Texas typically apply a preplant incorporated (PPI) herbicide such as pendimethalin (*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine), ethalfluralin (*N*-ethyl-*N*-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzenamine) or trifluralin (2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)benzenamine) and/or a preemergence (PRE) herbicides such as diclosulam (*N*-(2,6-dichlorophenyl)-5-ethoxy-7-fluorol[1,2,4]triazolo-[1,5-c]pyrimidine-2-sulfonamide), metolachlor (2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide), dimethenamid (2-chloro-*N*-[(1-methyl-2-methoxy)ethyl]-*N*-(2,4-dimethyl-thien-3-yl)-acetamide) and imazathepyr (2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid), depending on the weed spectrum. A postemergence application (POST) of various herbicides such imazapic {(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5methyl-3-pyridinecarboxylic acid}, clethodim [(*E*,*E*)-(±)-2-[[(3-chloro-2-propenyl)oxy]imino]propyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one], acifluorfen (5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid) and bentazon (3-(1-methylethyl)-(1*H*)-2,1,3-benzothiadiazin-4(3*H*)-one 2,2-dioxide) may be needed to further manage problem weeds.

Literature Review

Peanut planted in a narrow- or twin-row spacing is a management practice that has some advantages both in terms of increased yields and weed suppression. Buchanan and Hauser (1980) found that as rows were narrowed from 80 to 40 cm yields increased 10-30%, with further 20 to 40% increase as rows were narrowed to 20 cm. Kirby and Kitbamroong (1986) found that yield was highest when runner and spanish-type cultivars were planted in a narrow-row spacing compared to conventional row spacing. In a 10-yr study, Chin Choy *et al.* (1982) reported that spanish peanut, when planted in a narrow-row spacing yielded more than peanut grown using conventional row spacing. Other studies have found that a bunch type peanut, when planted in 46-cm rows produced yields 16% higher than when planted in 91-cm rows. In the same study, no differences occurred when runner peanut were planted in a narrow row pattern (Norden and Limpscomb, 1974). Studies conducted by Baldwin *et al.* (1998) and McGriff *et al.* (1999) consistently found yield increases with four runner peanut cultivars when planted in a twin-row spacing at a constant seeding rate. Furthermore, tomato spotted wilt virus was reduced 7 to 37% when peanut were planted in a twin-row spacing. Jaafar and Gardner (1988) concluded that at a constant plant population, both a narrow- and a twin-row spacing increased ground cover, leaf area indices, canopy light interception, crop growth rate and subsequent pod yield when compared to conventional row spacing.

Soil and foliar borne diseases in peanut can reduce yield and quality. Environmental factors such as high humidity and rainfall coupled with warm temperatures provide conditions conducive to disease development. Under severe leaf spot conditions, Jacobi and Backman (1991) reported that yield losses in Georgia and Florida exceeded 1100 kg/ha. Yield losses can exceed 70% when no preventative fungicides are applied and a susceptible cultivar is planted (Nutter and Shokes, 1995).

Rust can also reduce peanut yields, especially in areas that are prone to tropical weather influences including high humidity and wet conditions. The early onset of rust can reduce yields 40% as was reported in Africa (Nutter and Shokes, 1995). Early season control of leaf spot and rust is critical because both diseases reduce the rate of photosynthesis in the plant thus reducing the plants ability to develop adequately (Boote *et al*., 1980).

Soilborne diseases can also drastically reduce yields if not properly controlled. White mold (*Sclerotium rolfsii* Sacc.) is a disease that thrives in warm, moist conditions and attacks stems and pods, eventually killing the plant. Backman and Brenneman (1997) reported yield losses from white mold to be as high as 80%. Even when fungicides are applied, yield losses can reach 7 to 10% under extreme wet conditions (Melouk and Backman, 1995).

Control of these diseases can be obtained through crop rotation, tolerant or resistant cultivars and appropriately timed fungicide applications. Leaf spot and white mold inoculum was reduced when fields with high disease incidence were rotated in both a short (1-yr) and long term (2- to 4-yr) rotation (Kucharek, 1975; Flowers, 1976). It is suggested that a 1-yr rotation with corn or grain sorghum can effectively reduce white mold disease inoculum (Melouk and Backman, 1995). Where crop rotation is not an option, deep burial of crop residue using a moldboard plow is suggested to reduce both white mold and leaf spot inoculum (Porter *et al*., 1982; Lemon *et al*., 2001).

The use of tolerant or resistant cultivars can reduce the amount of fungicides needed throughout the growing season to control foliar and soilborne diseases while maintaining acceptable yields. Tamrun 96 in a 3-yr study under heavy white mold disease pressure showed lower white mold disease incidence and higher pod yields compared to other commercial cultivars (Besler *et al*., 1997). Moderate resistance to late leaf spot and white mold was reported with the cultivar Southern Runner but due to growth development and quality concerns, it was not widely accepted by growers (Gorbet *et al*., 1982; Brenneman *et al*., 1991). Therefore, other issues must be considered including disease tolerance or resistance when selecting a peanut cultivar.

Soil and foliar disease development in a narrow- and twin-row planting pattern are not widely documented. The quicker development of a peanut canopy provides an early season microclimate conducive for disease development. As in-row plant populations were increased, late leaf spot severity also increased (Farrell *et al*., 1967). Contradictory information has been reported with white mold incidence. Harrison (1970) concluded that planting peanuts in twin-row spacing had no impact on white mold disease development. In contrast, Sconyers *et al*., (2002) found that white mold was higher when peanuts were planted in twin rows compared to conventional rows. They also reported that white mold was higher in a 10-cm twin-row spacing compared to twin rows spaced 30 cm apart.

The use of fungicides can be an effective method to controlling foliar and soilborne diseases. Tebuconazole, a fungicide widely used by growers, provides good control of early and late leaf spot, white mold, and rust. Brenneman *et al*. (1991) found that white mold disease incidence was reduced by as much as 70% when tebuconazole was applied throughout the growing season, resulting in a yield and grade increase. In Texas, tebuconazole reduced white mold and increased yields 46% or more (Besler *et al*., 1996). Grichar (1995) reported that tebuconazole reduced white mold significantly over the untreated check and increased yields as high as 46%. Additional studies conducted in Alabama and Oklahoma documented the effectiveness of tebuconazole for controlling white mold (Hagan *et al*., 1991; Damicone and Jackson, 1994; Bowen *et al*., 1997). Tebuconazole when used alternately with chlorothalonil provides good leaf spot control (Brenneman *et al.* 1991). Jaks *et al*. (1998) found that when tebuconazole was applied on a 14-, 21- and 28-d schedule, leaf spot severity was reduced compared to the untreated check.

Azoxystrobin, a fungicide recently registered for control of various foliar and soilborne diseases, gives peanut producers additional disease management options. Grichar *et al*. (2000) found that azoxystrobin applied twice, provided control of white mold and leaf spot comparable to four applications of tebuconazole. Azoxystrobin was also comparable to chlorothalonil for leaf spot control.

Weed infestation in peanut fields can significantly reduce yield and quality. Therefore, it is essential that growers utilize management practices that effectively control problematic weeds. In Texas, weeds such as yellow and purple nutsedge (*Cyperus rotundus* L.), Texas panicum (*Panicum texanum* Buckl.), pigweed (*Amaranthus* spp.), and morning-glory species are highly competitive with peanut and if not controlled early season can reduce yields (Dotray *et al*., 2001). In a competition study, Buchanan *et al.* (1976) found that sicklepod reduced yields by 61%. Yellow nutsedge, listed as the second most troublesome weed in Texas, can reduce yields by as much as 87% (Keeley, 1987; Dowler, 1998).

Imazapic, an imidazolinone herbicide, provides good to excellent control of various broadleaf and grass weeds. Grichar and Nester (1997) reported that imazapic controlled purple nutsedge $\geq$ 94%. Similar results were reported by Dotray and Keeling (1997). They concluded that imazapic provided better yellow and purple nutsedge control than imazethapyr, a similar imidazolinone herbicide. Imazapic also controls other troublesome weeds such as common ragweed (*Ambrosia artemisiifolia* L.), eclipta (*Eclipta alba* L.), Florida beggarweed [*Desmodium tortuosum* (S W.) D C.], and sicklepod that imazethypr does not effectively control (Wilcut *et al*., 1994b). An important advantage that imazapic provides is its control of grass weeds such as Texas panicum, broadleaf signalgrass, southern crabgrass [*Digitaria ciliaris* (Retz.) Koel] and rhizome johnsongrass [*Sorghum halepense* (L.) Pers.] (Wilcut *et al*., 1993). The season-long broad spectrum weed control that imazapic offers may allow growers to eliminate applications of other POST herbicides such as the aryloxyphenoxy propionoate and diphenylether herbicides.

Diclosulam is a triazolopyrimidine sulfonanilde herbicide released in 2000 for use in peanut. Diclosulam is applied PPI or PRE and controls many troublesome weeds such as morning-glory species, common ragweed, Florida beggarweed, pigweed spp., common lambsquarter (*Chenopodium album* L.), bristly starbur (*Acanthospermum hispidum* DC.), prickly sida (*Sida spinosa* L.) and yellow nutsedge (Braxton *et al*., 1997; Richburg *et al*., 1997; Sheppard *et al*., 1997). A study conducted in Texas found that diclosulam controlled Palmer amaranth and devil's claw [*Proboscidea louisianica* (Mill.) Thellung] at least 83% (Dotray *et al*., 1999). Grichar *et al*. (1999) reported that diclosulam applied PPI in combination with ethalfluralin controlled devil's claw 91% and Texas panicum, morningglory species, Palmer amaranth, and golden crownbeard [*Verbesina enceliodes* (Cav.) Benth. & Hook. f. ex. Gray] at least 95%. Brecke *et al*. (2002) suggested that diclosulam could serve as an alternative weed control option to imazapic or used as a supplement. They concluded that diclosulam may provide an economic advantage in fields where sicklepod was not a problem.

Minimal peanut injury has been observed with imazapic and diclosulam. Dotray *et al*. (2001) observed that imazapic applied at the labeled rate to 10 peanut cultivars caused minimal injury and did not reduce yields. Bailey *et al*. (2000) reported negligible diclosulam injury on eight virginia-type cultivars when applied at 36 g/ha and no reductions in yield. Brecke *et al*. (2002) also found that imazapic and diclosulam at the 2X rates did not adversely affect five runner cultivars.

The use of twin- or narrow-row spacings have resulted in the suppression of troublesome weeds. More rapid canopy closure allows the peanut plant to compete more favorably with weeds, thereby, reducing the weeds ability to compete for moisture and nutrients. Hauser and Buchanan (1981) found that sicklepod fresh weights were reduced by as much as 53% in peanut planted in twin or narrow rows. In another study, grass infestations were reduced when peanuts were planted in twin rows in two out of three yrs. However, they concluded that reduced herbicide use did not provide acceptable control (Wehtje *et al*., 1984). Colvin *et al*. (1985) reported that a twin-row pattern of 18 cm provided more effective weed control than a conventional spacing of 91 cm due to a faster canopy development.

Both imazapic and diclosulam have crop rotation restrictions for various crops and should be used with caution. Imazapic has an 18-mo crop rotation for cotton (*Gossypium hirsutum* L.) and 9-mo restriction for corn (*Zea mays* L.) (Wilcut *et al*., 1993; Richburg *et al*., 1994). Diclosulam has a crop rotation interval of 10-mo for cotton, 18-mo restriction for corn, grain sorghum (*Sorghum bicolor* L.), rice (*Oryza sativa* L.), and tobacco (*Nicotiana tabacum* L.) (Anonymous, 2000). Grichar *et al*. (2002) reported reduced cotton lint yields when imazapic was applied at rates as low as 9 g/ha. York and Wilcut (1995) also found that imazapic at 35 g/ha reduced yields by

34%. However, Matocha *et al*. (2003) concluded that cotton, sorghum, corn, IR corn and soybean incurred no injury when imazapic was applied at rates as high as 210 g/ha. Gerngross (2002) found in field bioassay studies, that conventional corn fresh shoot weights had lower weights when diclosulam was applied at a rate of 81 g/ha.

The twin- and narrow-row spacing systems were investigated to a limited extent in the Southwest in the 1970's using spanish market types no longer grown today. Presently, it is important to evaluate the potential of twin-row spacings using modern, runner market type cultivars. In addition, it would be of benefit to determine disease and weed response in twin-row spacings employing reduced rate pesticides. Also, due to crop rotation restrictions associated with newer peanut herbicides such as imazapic and diclosulam, it would be important to determine if reduced rates with peanuts planted in twin rows would provide acceptable weed control and reduce the crop rotation restriction intervals.

CHAPTER II

ROW SPACING, PEANUT CULTIVAR AND FUNGICIDE EFFECTS ON FOLIAR AND SOILBORNE DISEASES

Introduction

Foliar and soilborne diseases can severely impact yield and quality of peanut. Backman and Crawford (1984) found that yield losses from leaf spot ranged from 10 to 15%, but exceeded 50% when conditions were conducive to disease development. Early leaf spot has caused yield reductions of 50 to 70% where fungicides were not used (Shokes and Culbreath, 1997). Yield reductions in Georgia and Florida, were reported to exceed 1100 kg/ha when leaf spot was severe (Jacobi and Backman, 1991). Grichar *et al*. (2000) made the observation that leaf spot is prevalent in South Texas due to high humidity and longevity of leaf moisture. Under ideal environmental conditions, disease symptoms occur within 10 to 14 d after inoculation and progress throughout the growing season. The pathogen thrives when temperatures are between 24 to 28 C and humidity exceeds 90% for several days (Smith and Littrell, 1980).

Control of leaf spot includes the use of fungicides and cultural practices. In South Texas, growers have historically relied on the use of chlorothalonil for control of leaf spot. The initial application of chlorothalonil begins 30 to 40 d after planting and is subsequently applied on a 10- to 14-d schedule, for 7 to 8 applications per yr. Unfortunately, chlorothalonil has no activity on soilborne pathogens and other fungicides are required. Fungicide applications begin 45 to 60 DAP to control both foliar and soilborne diseases with 2 to 5 applications throughout the growing season depending on weather conditions. In these cases, only one or two applications of product containing chlorothalonil may be used. A 2- to 3-yr crop rotation has proven to suppress leaf spot (Nutter and Shokes, 1995); however, growers in south Texas find this practice difficult to employ due to land and financial constraints.

Similar to leaf spot, rust caused by *Puccinia arachidis* Speg. can be devastating to peanut. Subrahmanyan *et al*. (1989) found pod yield reduction as high as 50 to 60% under severe rust pressure. Rust develops faster than leaf spot and may cause peanuts to mature 2 to 3 wks early, resulting in smaller seed, and pod loss at digging (Nutter and Shokes, 1995). Rust is prevalent in South Texas when tropical storms result in inoculum arriving from the Caribbean or central America. Control of rust can be achieved through the use of chlorothalonil, but a spray schedule of every 7 to 10 d may be needed. Rust does not survive winter in the continental U. S. and crop rotation does not reduce rust infestations (Van Arsdel and Harrison, 1972).

White mold caused by *Sclerotium rolfsii* Sacc. is a soilborne disease that south Texas growers must contend with every growing season. White mold is greatly influenced by moisture (Boyle, 1961). Therefore, in irrigated and fields with limited rotations, white mold can occur with greater incidence. Yield reductions of up to 10% have been reported as a result of white mold in the southeast and up to 5% in southwest peanut regions (Melouk and Backman, 1995). Smith and Lee (1986) reported that white mold damage cost growers in Texas and Oklahoma approximately $15 million annually. Because this disease can significantly reduce peanut yields, growers include fungicide and cultural control measures into their management scheme.

New fungicides developed during the past 5 to 10 yr have given growers more options in controlling leaf spot, rust and white mold. Studies have reported the effectiveness of tebuconazole and azoxystrobin in controlling these pathogens. In Georgia, tebuconazole was found to control white mold when applied multiple times as a foliar spray (Brenneman *et al*., 1991). Hagan *et al.* (1991) concluded that tebuconazole reduced white mold and enhanced yields compared to the untreated check. Besler *et al*. (2001) found that several peanut cultivars had less white mold when tebuconazole was applied as few as two times. Also, when applied on a 14, 21, and 28-d schedule, tebuconazole reduced leaf spot severity and increased yield compared with an untreated check. Jaks *et al*. (1998) reported significant rust control with tebuconazole when used in an advisory schedule program.

Azoxystrobin, a naturally occurring fungicide, provides control of leaf spot and white mold similar to tebuconazole (Grichar *et al*., 2000). Lunsford *et al*. (1998) found that azoxystrobin reduced leaf spot defoliation when applied at the rate of 0.17 kg/ha and was comparable to chlorothalonil.

Little research documents the effects of twin-row planting configurations on the development of foliar and soilborne diseases in conjunction with fungicide use. The hypothesis is that a twin-row configuration will provide a more rapid canopy closure, thereby, creating a favorable microclimate for foliar and soilborne diseases. Consequently, growers in south Texas have been slow to adopt this planting scheme. Harrison (1970) found no apparent differences in soilborne disease development with a twin- and narrow-row spacing when compared to the conventional row spacing.

However, Sconyers *et al*., (2002) concluded that white mold disease severity was greater in 10 cm twin rows than a conventional single row pattern. They also found that white mold was greater along rows in the 10 cm twin-row spacing than in a 30-cm twin-row or conventional row spacing.

The objective of this study was to evaluate the response of four runner cultivars planted in a conventional and twin-row planting configuration and determine the incidence of soil and foliar borne diseases when sprayed with azoxystrobin and tebuconazole.

Material and Methods

Field studies were conducted in 2001 near Pearsall, TX and 2002 at the Texas Agricultural Experiment Station near Yoakum, TX. The soil at the Pearsall location was a Duval very fine sand (fine-loamy, mixed, hyperthermic Aridic Haplustalfs) with less than 1% organic matter. The Yoakum test site was a Straber loamy sand (fine mixed thermic Aquic Palenstalfs) with less than 1% organic matter. The test site in Pearsall was in a 2-yr crop rotation while the Yoakum site was in continuous peanut for more than 5 yr and had a known history of both foliar and soilborne disease pressure. The runner cultivars ‘AT 1-1’, ‘Flavor Runner 458’, ‘Georgia Green’ and ‘Tamrun 96’ were planted on 30 May in 2002 and 3 Jun in 2002. Seed of each cultivar was planted with a Monosem precision vacuum planter (Monosem ATI, Inc., Lenoxa KS 66219) at the rate of 20 seed/linear m (215,186 plants/ha) on a 91 cm row spacing for the conventional planting configuration. For the twin-row spacing, 10 seed/linear m (215,186 plants/ha) were planted and spaced 18 cm apart on a 91-cm bed. The experimental design was a split-plot arrangement with three replications. Whole plots consisted of fungicide treatments and sub-plots consisted of row spacing configuration and cultivars. Plot size was 2 rows by 7.6 m long.

Azoxystrobin at 0.34 kg/ha was applied 62 and 90 d after planting (DAP) in 2001 and 59 and 87 DAP in 2002. Tebuconazole at 0.23 kg/ha was applied 62, 76, 90 and 105 DAP in 2001 and 59, 73, 87 and 102 DAP in 2002. Fungicides were applied with a CO_2-pressurized backpack sprayer with D3-13 hollow-cone nozzles delivering 187 L/ha. Chlorothalonil was not applied to the test area during the growing season. Only rust developed in 2001 at the Pearsall location and was evaluated using the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) scale 1-9 (1 = no disease, 9 = plants severely affected, and 50 to 100% of the leaves are withering) (Subrahmanyan *et al*., 1982). Only one observation was recorded on Oct 9, 2001. Similarly, leaf spot developed only in 2002 at the Yoakum test site and was evaluated using the Florida scale 1-10 (1 = no leaf spot and 10 = plants completely defoliated and killed by leaf spot) was used to assess leaf spot severity (Chiteka *et al*., 1988). Leaf spot was rated multiple times throughout the growing season. Due to late-season leaf spot severity, only the final rating is reported. White mold developed both years at each location. White mold was assessed immediately after inversion on Oct 19, 2001. In 2002, due to high leaf spot severity, white mold was assessed above ground on Oct 1. A disease locus was defined as $\leq$ 30 cm of consecutive white mold damage of plants in a plot row (Rodriquez-

Kabana *et al*., 1975). Identification of white mold was determined by dead or wilted branches with visible mycelial growth and the presence of sclerotia.

Peanut were dug Oct 19, 2001 and Oct 15, 2002. Peanuts were field dried 5 to 7 d and then harvested using a tractor-pulled thresher. Plot weights were taken after all foreign matter was removed. Analysis of variance was performed on white mold disease incidence and peanut yield to test the effect of year, row spacing, fungicide treatments and all possible interactions. All main effects and possible interactions were analyzed for rust and leaf spot each year. Mean separation was then calculated using Fisher's protected LSD test (P=0.05).

Results and Discussion

Data for white mold incidence and pod yield were combined over years due to lack of year by fungicide treatment interaction (Table 1). A significant cultivar and fungicide treatment main effect occurred for white mold while a significant cultivar, fungicide and row spacing main effect occurred for yield. In 2001, a significant fungicide and cultivar main effect resulted for rust. A significant fungicide, cultivar and fungicide treatment by row spacing effect also occurred for leaf spot.

White Mold. Treatments with both azoxystrobin (53%) and tebuconazole (57%), when averaged across row spacing and cultivar, reduced white mold incidence compared to the untreated check (Table 2). This is consistent with previous work indicating that both fungicides reduced white mold (Besler *et al*., 1996; Grichar *et al.,* 2000). Tamrun 96 had at least 44% lower white mold disease incidence than all other cultivars when

Table 1. Source of variation and associated statistical significance for white mold, rust, leaf spot and yield.

		Pr>F (0.05)			
Source	df	White mold	Rust 2001	Leaf spot 2002	Yield
Year	1	NS	-	-	0.0001
Rep	2	NS	NS	0.0039	0.0001
RS[a]	1	NS	NS	NS	0.0002
Cult[b]	3	0.0001	0.0001	0.0012	0.0001
Trt[c]	3	0.0001	0.0001	0.0001	0.0001
Cult x RS	3	NS	NS	NS	NS
Cult x Trt	6	NS	NS	NS	NS
Trt x RS	2	NS	NS	0.0184	NS
Year x Trt	2	NS	-	-	NS
Year x RS	1	NS	-	-	NS
Means square error		30.61	0.25	0.12	265247
CV		43.34	11.82	9.25	14.29

[a]Row spacings (RS) included conventional (2 rows spaced 91 cm apart) and twin-row (18 cm apart on a 91-cm bed).

[b]Cultivars (Cult) include AT 1-1, Flavor runner 458, Georgia Green, and Tamrun 96.

[c]Treatments (Trt) included an untreated check, azoxystrobin at 0.34 kg/ha, and tebuconazole at 0.23 kg/ha.

Table 2. Effects of fungicides on white mold, rust and yield 2001-2002 when averaged across cultivar and row spacing.

		Disease rating		
		White mold[a]	Rust[b]	
Treatment	Rate	2001-2002	2001	Yield
	kg/ha			kg/ha
No Spray	-	9.9	7.8	3041
Azoxystrobin	0.34	4.7	4.4	4502
Tebuconazole	0.23	4.3	3.3	4570
LSD[c] (P=0.05)		1.1	0.3	208

[a]Hits/7.6 m where a disease locus was defined as ≤ 30 cm of consecutive white mold damage of plants in a plot row.

[b]ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) scale where 1 = no disease and 9 = plants severely affected, 50 to 100% leaves withering.

[c]LSD, least significant difference. Differences between means that are greater than the LSD within a column are significantly different.

averaged across fungicide treatments and row spacing (Table 3). In a 3-yr study Besler *et al*. (1997) concluded that Tamrun 96 was fairly tolerant to white mold when compared to other cultivars. AT 1-1 had the highest white mold disease incidence with Flavor Runner 458 and Georgia Green showing intermediate levels of disease.

Rust. Rust severity was high in the untreated plots having a mean level of 7.8 on the ICRISAT scale (Table 2). Rust severity developed late season possibly due to weather patterns that developed and originated from the Gulf of Mexico. Azoxystrobin and tebuconazole reduced rust 44 and 58%, respectively, when compared to the untreated check (Table 2). Tebuconazole was significantly better in controlling rust than azoxystrobin. The improved control could be attributed to the late-season application of tebuconazole. Most cultivars resulted in consistent rust pressure when averaged across fungicide treatments and row spacing. Flavor Runner 458 was lower in rust than AT 1-1 and Tamrun 96 but not Georgia Green (Table 2).

Leaf spot. Early leaf spot was the predominant disease. Leaf spot severity was extremely high in 2002 with a late-season mean rating of 9.3 (Florida Scale) in the untreated. This resulted in some plants being completely defoliated. Although azoxystrobin and tebuconazole reduced leaf spot when compared to the untreated check, leaf spot was still considered high (Table 4). Heavy rainfall mid- to late-season coupled with high temperatures and humidity caused severe leaf spot pressure, which ultimately overwhelmed both the untreated and plots that received a fungicide application. A treatment x row spacing interaction revealed an increase in leaf spot severity with the untreated plots when cultivars were planted in a twin-row configuration (Table 4).

Table 3. White mold, rust and yield effects on various runner peanut cultivars when averaged across fungicide treatments and row spacing 2001-2002.

	Disease rating		
	White mold[a]	Rust[b]	
Cultivar	2001-2002	2001	Yield
			kg/ha
AT1-1	7.8	5.5	3595
Flavor Runner 458	7.2	4.9	3639
Georgia Green	6.6	5.0	4258
Tamrun 96	3.7	5.3	4657
LSD[c] (P=0.05)	1.3	0.3	240

[a]A disease locus was defined as $\leq$ 30 cm of consecutive white mold damage of plants in a plot row.

[b]ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) scale where 1 = no disease and 9 = plants severely affected, 50 to 100% leaves withering.

[c]LSD, least significant difference. Differences between means that are greater than the LSD within a column are significantly different.

Table 4. Treatment by row-spacing interaction on early leaf spot control at Yoakum in 2002 when averaged across cultivars.

		Early leaf spot [a]	
Treatment	Rate	Conventional	Twin-row
	kg/ha		
No spray	-	9.0	9.5
Azoxystrobin	0.34	7.9	7.7
Tebuconazole	0.23	6.6	6.4
LSD[b] (P=0.05)		0.4	

[a]Florida scale where 1 = no leaf spot and 10 = plants completely defoliated and killed by leaf spot.

[b]LSD, least significant difference. Differences between means that are greater than the LSD within and between columns are significantly different.

zoxystrobin and tebuconazole lowered leaf spot severity in both row spacing configurations when compared to the untreated plots. Tebuconazole lowered leaf spot severity compared to azoxystrobin in both the conventional and twin-row configuration.

Yield. When averaged across row spacing and cultivar, azoxystrobin and tebuconazole increased yield when compared to the untreated plots (Table 2). No differences in yield occurred between plots that were sprayed with azoxystrobin and tebuconazole. Tamrun 96 had a higher yield than all other cultivars when averaged across fungicide treatments and row spacings (Table 3). Georgia Green was higher in yield than AT 1-1 and Flavor Runner 458. Moderate white mold disease incidence both years, with high rust and leaf spot severity in 2001 and 2002, respectively, contributed to lower yields with cultivars AT 1-1 and Flavor Runner 458. Also, in 2002 due to excessive late-season rainfall, these two cultivars were not inverted at the optimum digging time which may have also resulted in lower peanut yields. Row spacing effects on yield revealed that the twin-row spacing was higher (10%) in yield then the conventional row spacing (Figure 1). Baldwin *et al*. (1998) found that, when averaged across four runner cultivars and locations in Georgia, twin rows resulted in yield increases of 381 kg/ha. Another study conducted in Georgia in 1997 and 1998 found a 716 kg/ha and 375 kg/ha increase in yield, respectively, in twin rows compared to a conventional row spacing (McGriff *et al*., 1999).

This study revealed that azoxystrobin and tebuconazole effectively controlled both white mold, rust but was not as effective for control of early leaf spot. Azoxystrobin and tebuconazole were applied on 2 and 4 times respectively, throughout the growing

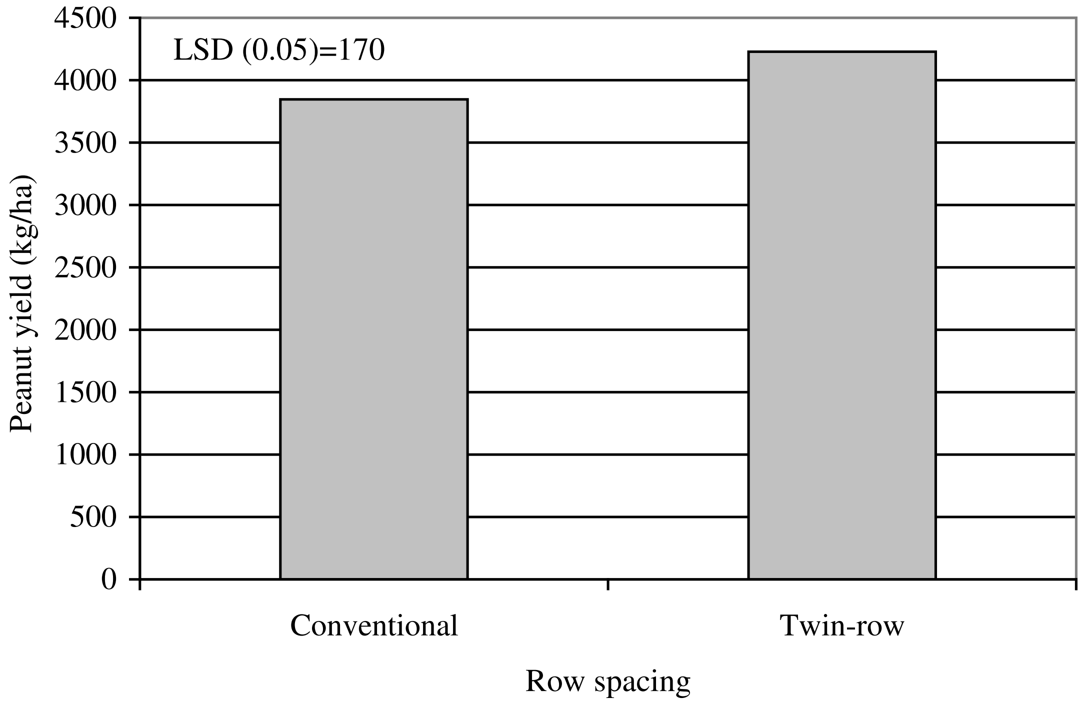

Figure 1. Effects of row spacing on peanut yield when averaged across varieties and fungicides 2001-2002.

season and because leaf spot severity was high, additional fungicide applications were required. This study also revealed that Tamrun 96 was lower in white mold and higher in yield than AT 1-1, Flavor Runner 458 and Georgia Green. Therefore, growers who have fields with a history of white mold could possibly benefit by planting this cultivar. Over a two-yr period, peanuts planted in a twin-row spacing yielded higher than peanuts planted in conventional rows when averaged across cultivar and fungicides. Based on these findings, an advantage to planting twin rows to increase yield may exist. Additionally, an identical planting density with the twin-row spacing compared to the conventional row spacing would eliminate additional cost in seed.

CHAPTER III

YELLOW NUTSEDGE CONTROL WITH IMAZAPIC AND DICLOSULAM AS AFFECTED BY PEANUT ROW SPACING

Introduction

Adequate weed control in peanut is important to maintain yield and quality. Because peanut plants generally grow prostrate to the ground and are slow to cover row middles, weed competition can be enhanced (Walker *et al*., 1989). This is particularly harmful because weeds compete with the peanut plant for nutrients, water, and sunlight.

Yellow nutsedge is a weed that can compete with a peanut crop causing reduced yields and quality if not adequately controlled (Holm *et al*., 1977; Wilcut *et al*., 1994c; Young *et al*., 1982). Dowler (1998) listed yellow nutsedge as the second most troublesome weed in Texas peanut. Keeley (1987) reported that yellow nutsedge reduced agronomic crop yield up to 87%. Yellow nutsedge control is very difficult because of its prolific tuber development. A study conducted by Tumbleson and Kommedahl (1961) showed that one yellow nutsedge tuber produced 1900 plants and 7000 tubers and covered an area of 2 m in diameter in only one year.

Grichar *et al*. (1992) attributed the increase of yellow nutsedge in Texas to the use of dinitroaniline herbicides. These compounds control most grasses and small-seeded broadleaf weeds but do not control yellow nutsedge. If not controlled, the prolific reproduction of yellow nutsedge will enable tubers to spread by contaminated equipment or seed . Even under intensive fallow weed management, yellow nutsedge population densities and tubers increased exponentially (Johnson and Mullinix, 1997).

High yellow nutsedge densities also deplete nutrients necessary for healthy peanut plant development (Volz, 1977). Digging and harvesting efficiency of peanut can be affected in fields with high densities of yellow nutsedge. Davidson *et al*. (1982) concluded that nutsedge tubers were difficult to separate from peanut and reduced peanut quality and profit.

Several studies have documented the importance of integrating management practices such as chemical, mechanical and cultural control tactics for yellow nutsedge control (Beste *et al*., 1992; Grichar *et al*., 1992; Johnson and Mullinix, 1997). Glaze (1987) concluded that shallow tillage of yellow nutsedge in fallow fields can be effective as part of a stale seedbed weed control program. Although mechanical practices such as cultivation may slow the development of yellow nutsedge, chemical control is often needed especially in areas with high densities. However, the growth habit of the peanut and fruiting pattern inhibit the use of cultivation mid- to late-season (Brecke and Colvin, 1991; Wilcut *et al*., 1994b, 1995).

Early work revealed that vernolate (*S*-propyl dipropylcarbamothioate) provided good control of yellow nutsedge but had little residual activity (Wilkinson, 1988). Bentazon also provided effective control of yellow nutsedge temporarily weed control is limited because of poor translocation (Wilcut, 1994c). Imazethapyr applied preemergence (PRE) controls yellow nutsedge inconsistently (Wilcut, 1991 Grichar *et al*., 1992). Pereira *et al*. (1987) contributes the lack of control of yellow nutsedge to marginal herbicide translocation to sites of action, temporary inhibition of tuber sprouting, and inconsistent control when applied at different growth stages under various environmental conditions.

In the past 3 to 5 years, peanut herbicides have been developed that provide excellent control of yellow nutsedge and several broadleaf and grass weeds. The herbicides imazapic and diclosulam are in the imidazolinone and triazolopyrimidine sulfonamilide families, respectively. Grichar and Nester (1997) found that imazapic at 0.05 and 0.07 kg/ha gave 88% yellow nutsedge control early season but was inconsistent late in the season. Wilcut *et al*. (1992) reported that imazapic controlled yellow nutsedge greater than 90% at rates as low as 0.04 kg/ha. Dotray and Keeling (1997) and Grichar and Sestak (2000) also reported that imazapic provided good control of yellow nutsedge. Diclosulam, when applied preplant incorporated (PPI) or PRE, controls several weeds including common cocklebur, morningglory species, pigweed species, Florida beggarweed and yellow nutsedge (Braxton *et al*., 1997; Langston et al., 1997; Richburg et al., 1997; Sheppard et al., 1997). Diclosulam provided at least 89% control of yellow nutsedge but was less consistent when applied postemergence (POST) at rates ranging from 0.02 to 0.06 kg ai/ha (Grichar *et al*., 1999).

The use of narrow-row peanut planting could also lend to the suppression of yellow nutsedge. Crops such as corn and cotton that develop a more rapid canopy closure tend to compete more favorably with yellow nutsedge (Stoller *et al*., 1979; Thullen and Keeley, 1980). The hypothesis in using narrow-row spacing in peanut is to develop a more rapid canopy closure that would diminish weed competition enabling reduced herbicide inputs to be effective. Hauser and Buchanan (1981) concluded that under varying levels of weed control, twin rows increased yield 12 to 15% compared to conventional row spacing. Wehtje *et al*. (1984) reported reduced grass competition when peanut were planted in twin rows verses conventional spacing. Colvin *et al*. (1985) found that a twin-row spacing of 18 cm provided more effective weed control than a conventional spacing of 91 cm. They concluded that yield increases were greatest when weed competition was minimized by using an intense herbicide program. Cardina *et al*. (1987) reported that herbicide inputs in peanut could be reduced with narrow-row spacing if weed populations were low. However, in cases where weed pressure was high, increased herbicide inputs were needed.

The objective of this study was to (1) evaluate yellow nutsedge control when imazapic (POST) and diclosulam (PRE) were applied at ½X and 1X rates, (2) assess the response of weed control from herbicide systems when peanut were planted in a conventional and twin-row planting configuration, and (3) compare yield from the conventional and twin-row configuration.

Material and Methods

Field experiments were conducted near Pleasanton, TX in 2000, and at the Texas Agricultural Experiment Station near Yoakum in 2001 and 2002. The experimental design was a randomized complete block with at least three replications. Treatments consisted of a factorial arrangement of herbicide treatments (4) and row spacings (2). Herbicides used in the study included diclosulam applied PRE at rates of 13 g/ha (½X and 27 g/ha (1X) and imazapic applied POST approximately 30 days after planting

(DAP) at 36 g/ha (½X) and 71 g/ha (1 X). A nonionic surfactant (Kinetic[1]) was added to imazapic at a 0.25% v/v rate. The row patterns consisted of conventional (two rows spaced by 91 cm apart) and twin row (18 cm apart on a 91-cm bed). Plot size at each location was 7.6 m long.

The soil at Pleasanton was a Nueces loamy fine sand (loamy, mixed, hyperthermic Aquic Arinic Palenstalfs) with less then 1% organic matter and pH of 7.2. The soil at Yoakum was a Straber loamy sand (fine, mixed, thermic Aquic Paleustalfs) with a pH of 6.8 to 7.0. The cultivar 'Georgia Green' was planted Jun 6, 2000 at Pleasanton and Jun 6, 2001 and Jun 19, 2002 at Yoakum. The seeding rate was 20 seed/linear m (215,186 plants/ha) for the conventional spacing and 10 seed/linear m for the twin-row spacing (215,186 plants/ha).

Either ethalfluralin at 0.84 kg ai/ha or pendimethalin at 1.12 kg ai/ha was applied each year to the test sites to control annual grasses and small-seeded broadleaf weeds. Herbicides were applied using a CO_2 backpack sprayer with a two-row hand-held boom calibrated to deliver 187 L/ha at 207 kPa. Yellow nutsedge weed control was assessed throughout the growing season each year with the exception of Pleasanton where yellow nutsedge stand was poor and could not be effectively evaluated. Because the impact from herbicide treatments were best reflected late in the year, only late-season those yellow nutsedge control ratings are presented. Yellow nutsedge control was based on a

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[1] Kinetic (a nonionic wetter/spreader/penetrant adjuvant containing a 99% blend of polyalkyleneoxide-modified polydimethylsiloxane and polyoxypropylene-olyoxyethylene block copolymers), Helena Chemical Co., 5100 Poplar Avenue, Memphis, TN 38137.

percent scale of 0 to 100 where 0% = no control and 100% = complete death of yellow nutsedge.

Yields were obtained by digging each plot and allowed to field dry 5 to 7 d. Plots in 2000 at Pleasanton were harvested on Nov 2. In 2001 and 2002 at Yoakum, plots were harvested on Oct 30 and Nov 14, respectively. All plots were harvested using a tractor-pulled combine with a sacking attachment. Plot weights were recorded after all foreign materials were removed. Weed evaluations and yield were subject to analysis of variance and means separated using Fisher's Protected LSD (P = 0.05). Arcsine square root transformation was conducted on weed ratings to ensure normal data distribution. However, data were not affected so non-transformed data are presented.

Results and Discussion

A significant year by herbicide treatment interaction occurred for yellow nutsedge control and yield so results are presented separately for each year (Table 5). Results for each year reflect main effects and treatment by row spacing interactions. Yellow nutsedge density was heavy (>20 plants m^2) at Yoakum both years. Due to high weed density, no distinguishable reduction in weed density occurred with the untreated twin-row spacing.

Pleasanton 2000. Yield was obtained to assess production differences between conventional and twin-row configurations. Analysis of variance revealed no differences among main effects (row spacing and herbicide treatment) or row spacing by herbicide

Table 5. Source of variation and associated statistical significance for yellow nutsedge control and yield.

		Pr>F (0.05)	
Source	df	Yellow nutsedge control	Yield
Year	1	0.0001	0.0001
Rep	3	NS	NS
RS[a]	1	NS	0.0001
Trt[b]	4	0.0001	0.0195
Trt x RS	2	0.0132	NS
Year x Trt	2	0.0001	0.0021
Year x RS	1	NS	NS
Means square error		87.25	390901
CV		12.60	15.97

[a]Row Spacings (RS) included conventional (two rows spaced 91 cm apart) and twin-row (18 cm apart on a 91 cm bed).
[b]Treatments (Trt) included an untreated check, diclosulam at 13 and 27 g/ha, and imazapic at 36 and 71 g/ha.

treatment interaction for yield. No increase in yield occurred with the twin-row spacing compared to the conventional row spacing when averaged across herbicide treatments. Also, no yield increases resulted with herbicide treatments compared to the untreated check when averaged across row patterns.

Yoakum 2001 and 2002. The 105 and 118 DAP rating revealed a row spacing by herbicide treatment interaction in 2001. At both ratings, imazapic and diclosulam at the 1X rate applied to the twin-row spacing provided at least 90% yellow nutsedge control (Table 6). No differences occurred when the 1X rate of imazapic was applied to the twin-row and conventional spacing when rated 105 DAP. When rated 118 DAP, imazapic at the 1X rate applied to the twin-row spacing maintained excellent control and was better than the 1X rate of imazapic applied to the conventional row spacing. Yellow nutsedge control at both ratings was improved with the 1X rate of diclosulam applied to the twin-row spacing compared to its respective conventional row spacing. Regardless of row spacing, the 1X rate of both imazapic and diclosulam provided better yellow nutsedge control than their respective ½X rate. Imazapic and diclosulam at the ½X rate applied to the twin-row spacing provided better yellow nutsedge control compared to the same treatments applied to the conventional row spacing. Unacceptable yellow nutsedge control (< 75%) resulted when diclosulam and imazapic at the ½X rate were applied to the conventional row spacing rated 118 DAP. Wilcut *et al*. (1997) concluded that diclosulam (PPI or PRE) controlled yellow nutsedge approximately 80%. Imazapic typically provides good control of yellow nutsedge and has longer residual activity (Dotray and Keeling, 1997; Grichar and Nester, 1997). Grichar *et al*. (1999) reported

Table 6. Response of row spacing, herbicide treatments and herbicide rate on visual control ratings of yellow nutsedge at Yoakum, TX in 2001 and 2002.

			2001		2002
	Row		------------Days after planting------------		
Treatments[a]	spacing[b]	Rate	105	118	120
		g ai/ha		%	
Check	CONV	-	0	0	0
	TR	-	0	0	0
Diclosulam	CONV	13	68	60	41
	TR	13	84	82	61
	CONV	27	82	79	58
	TR	27	90	90	69
Imazapic	CONV	36	75	71	44
	TR	36	84	86	43
	CONV	71	93	87	79
	TR	71	98	96	80
LSD[c] (0.05)			7	5	9

[a]Diclosulam was applied PRE with rates 13 g ai/ha = (½X) and 27 g/ha = (1X); imazapic was applied POST approximately 30 DAP with rates 36 g ai/ha=(½X) and 71g/ha = (1X).

[b]Conventional row-spacing (two rows spaced 91 cm apart); twin-row spacing (18 cm apart on a 91-cm bed).

[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

that diclosulam when applied POST at rates ranging from 2 to 30 g/ha provided good control of yellow nutsedge at one location and unacceptable control at another.

Row spacing and herbicide treatment main effects significantly affected yield. The twin-row spacing yielded higher than the conventional spacing when averaged across herbicide treatments (Figure 2). Imazapic and diclosulam at both the ½X and 1X rate yielded higher than the untreated check, but no differences were detected among herbicide treatments (Table 6).

In 2002, herbicide treatment main effect differences occurred at the 107 DAP rating while a herbicide treatment by row spacing interaction was observed at the 120 DAP rating. When rated 107 DAP, imazapic at the 1X rate controlled less than 75% yellow nutsedge averaged across row spacings (Figure 3). Both imazapic and diclosulam at the 1X rate provided better yellow nutsedge compared to the ½X rate. Yellow nutsedge control was less than 60% when imazapic and diclosulam were applied at the ½X rate. Extremely heavy rainfall mid-season (27 cm) may have contributed to the breakdown of both imazapic and diclosulam. Matocha *et al*. (2003) concluded that increased soil moisture leads to increased imazapic dissipation.

Imazapic at the 1X rate, evaluated 120 DAP, provided 80% yellow nutsedge control when applied to the twin-row spacing but was not different than imazapic at the 1X rate applied to the conventional row spacing (Table 6). Also at the 1X rate, imazapic applied to the twin-row and conventional row spacings controlled yellow nutsedge better than diclosulam applied at the 1X rate in both row spacings. Although not acceptable, improved yellow nutsedge control resulted when diclosulam at the ½X

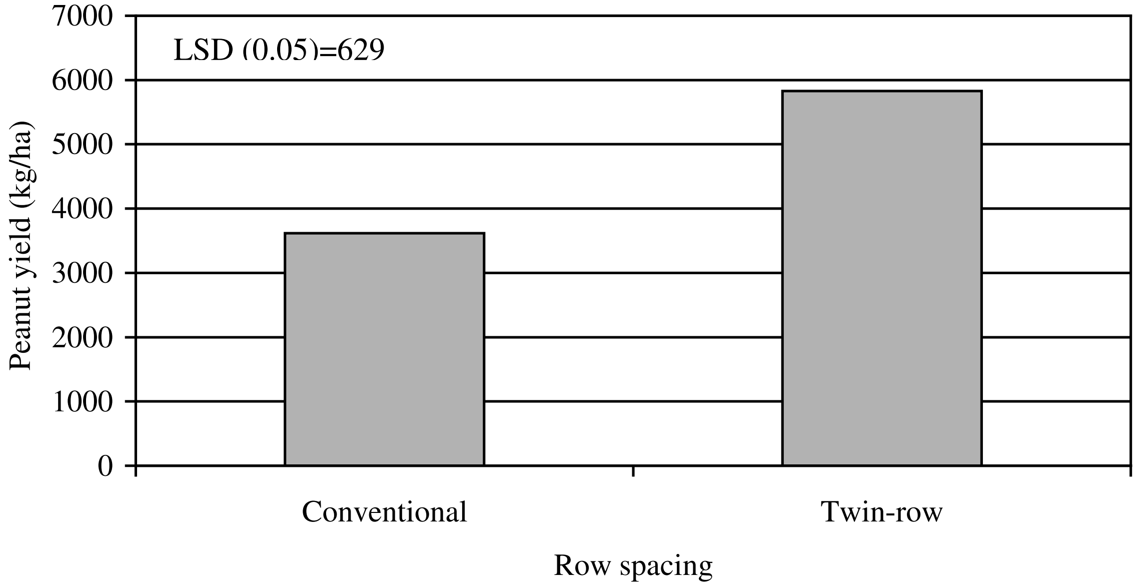

Figure 2. Row spacing effects on peanut yield when averaged across herbicide treatments in Yoakum, 2001.

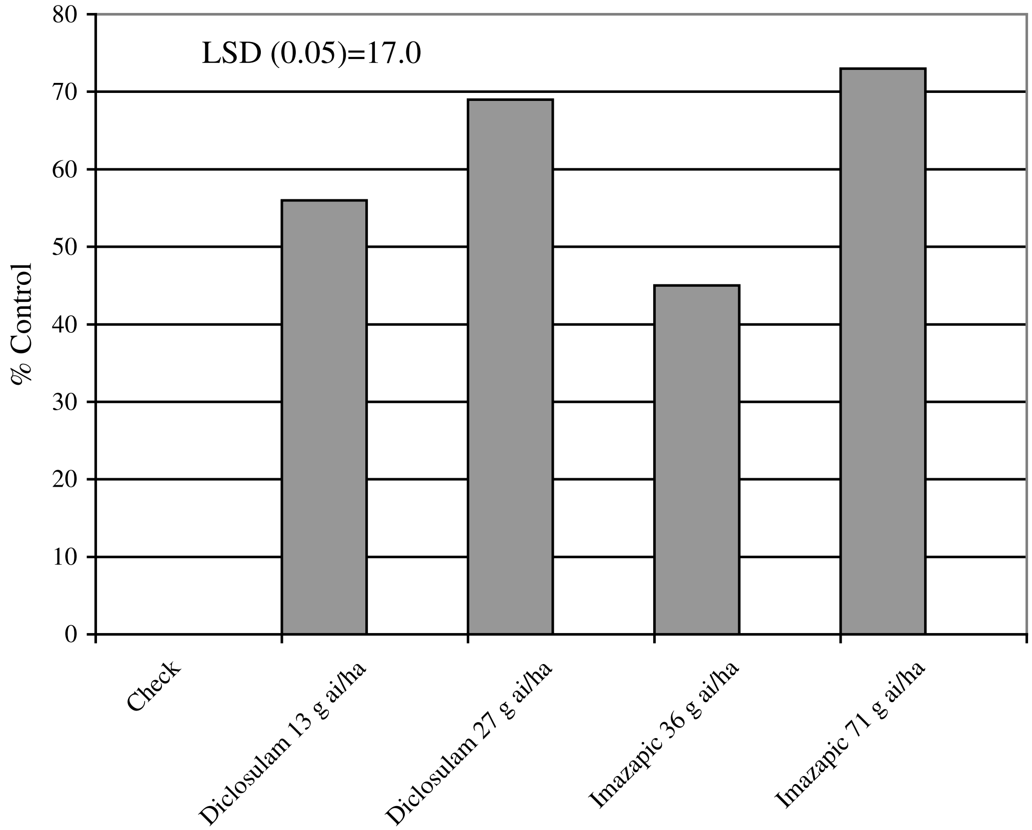

Figure 3. Yellow nutsedge control when rated 107 DAP from herbicide treatments averaged across row spacings. Diclosulam was applied PRE with rates 13 g ai/ha = (½X) and 27 ai/ha = (1X); imazapic was applied POST approximately 30 DAP with rates 36 g ai/ha=(½X) and 71g ai/ha = (1X).

and 1X rate were applied to the twin-row spacing compared to their respective conventional row spacing. Also, due to excessive rainfall and lack of adequate weed control late season, yields were lower than 2001 (Table 7). All herbicide treatments provided greater yields than the untreated check with the exception of imazapic at the ½X rate (Table 7). Although all treatments provided relatively poor weed control (< 85%), the ½X imazapic treatments was particularly weak on yellow nutsedge.

This study revealed that to fully maximize yellow nutsedge control, the full rate of either imazapic or diclosulam should be applied to peanuts planted in a conventional and twin-row spacing. However, this may not necessarily translate into higher yields. Reduced rates of imazapic and diclosulam in 2001 and the reduced rate of diclosulam in 2002 had yields comparable to full rates of both herbicides. The use of twin rows showed a yield increase in 2001 compared to conventional row spacing but not in the other years. Therefore, the advantages of planting peanuts in twin rows combined with an effective herbicide program may not be associated with higher peanut yields. In a growing season where excessive rainfall occurs, an additional herbicide application may be required to obtain acceptable yellow nutsedge control.

Table 7. Response of herbicide treatments for peanut yield averaged across row spacings at Yoakum, TX in 2001 and 2002.

		Yield	
Treatments[a]	Rate	2001	2002
	g ai/ha	kg/ha	
Check	-	3894	2209
Diclosulam	13	5083	3296
	27	4995	3950
Imazapic	36	4773	2582
	71	4869	3229
LSD[b] (0.05)		657	677

[a]Diclosulam was applied PRE with rates 13 g ai/ha = (½X) and 27 g/ha = (1X); imazapic was applied POST approximately 30 DAP with rates 36 g ai/ha = (½X) and 71g/ha = (1X).

[b]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

CHAPTER IV

ROTATIONAL CROP RESPONSE TO SOIL TREATED WITH IMAZAPIC AND DICLOSULAM IN CONVENTIONAL AND TWIN-ROW SPACING

Introduction

Peanut growers rely primarily on herbicides to control troublesome weeds. Weed infestations in peanut when not properly managed can cause severe yield losses. Therefore, an intense weed management program is generally required. Weeds such as common cocklebur and fall panicum caused yield losses in excess of 85% and broadleaf signalgrass and sicklepod up to 70% yield loss (Brecke, 1995). Wilcut *et al*. (1995) reported that yield reductions in peanut due to weed escapes could cost producers between $49 and $124/ha.

New peanut herbicides have been developed in the past several years that provide excellent control of broadleaf and grass weeds. Two of these herbicides include imazapic and diclosulam. Both of these herbicides inhibit the production of the acetolactate synthase (ALS) enzymes responsible for mediating the production of amino acids valine, leucine and isoleucine in plants (Devine *et al*., 1993; Hatzios, 1991). Imazapic, an imidazolinone herbicide, has provided excellent control of sicklepod, small flower morningglory, yellow nutsedge and Florida beggarweed (Richburg *et al*., 1996; Grichar and Nester, 1997) when applied early post (EPOST). Diclosulam (triazolopyrimidine sulfonamilide), a new herbicide cleared by the Environmental Protection Agency for use in peanut in 2000 provides excellent control of Palmer amaranth, bristly starbur, golden crownbeard, yellow nutsedge, prickly sida, morningglory, and devil's claw when applied preemergence or preplant incorporated (PPI) (Sheppard *et al*., 1997; Wilcut *et al*., 1997; Dotray *et al*., 1999; Grichar *et al*., 1999). Also, both herbicides provide residual weed control that other soil and foliar peanut herbicides may not provide. Dissipation of imazapic and diclosulam occur through microbial degradation under ideal environmental conditions including temperature, moisture content and pH (Zabik *et al*., 2001; Goetz *et al*., 1990). Murdock and Witt (1999) found that the amount of tillage affected diclosulam persistence and, therefore, they concluded that the amount of diclosulam decreased as tillage decreased.

No substantial injury to peanut at some locations has been reported with imazapic or diclosulam. Dotray *et al*. (2001) reported initial injury with imazapic at the labeled rate on various peanut market types but found no yield reductions. Diclosulam caused minimal peanut injury to virginia-type cultivars when applied at 36 g/ha but yield reductions were not evident (Bailey *et al*., 2000).

However, crop rotation restrictions for crops such as corn (*Zea mays* L.), cotton, and grain sorghum (*Sorghum bicolor* L.) could minimize the use of these compounds. Imazapic has an 18-mo crop rotation restriction for cotton and 9-mo restriction for corn (Wilcut *et al*., 1993; Richburg *et al*., 1994). Diclosulam has a crop rotation interval of 10-mo for cotton and an 18-mo restriction for corn and grain sorghum (Anonymous, 2000). Therefore, Texas growers who rotate peanuts with cotton, corn, grain sorghum or various vegetables often express concern about imazapic and diclosulam carryover. Gerngross (2002) found that fresh and dry biomass weights from cotton and grain sorghum were not significantly different than the untreated check in a field bioassay where soil concentrations ranged from 18 to 81 g ai/ha. However, a 3X rate of diclosulam reduced grain sorghum plant height at one location. Imazapic at rates as low as 9 g ai/ha (⅛X rate) caused reduced cotton lint yields. In addition, cotton injury was observed 12 and 18 wks after planting (WAT) (Grichar *et al*., 2002). In North Carolina, York and Wilcut (1995) found that cotton yields were reduced 34% when imazapic was applied at 35 g/ha. Matocha *et al*. (2003) found that carryover injury did not occur with rotational crops (cotton, sorghum, corn, imidazolinone resistant (IR) corn and soybean) when imazapic was applied at rates ranging from 70 to 210 g/ha. Greenhouse bioassay results indicated no difference in biomass weights for grain sorghum and cotton from soils that were sampled 3 mo after treatment.

No research in Texas has been conducted that studied the residual effects of imazapic and diclosulam on rotational crops when peanuts where planted in a twin-row spacing. The hypothesis is that quicker plant development will occur in a twin-row system followed by increased herbicide uptake and metabolism by peanut plants, thereby, decreasing the residual concentration of imazapic and diclosulam for potential carryover. Therefore, the objective of this study was to evaluate the response of cotton, corn, grain sorghum and watermelon to soil treated with a 1X rate of imazapic and diclosulam on conventional and twin-row spacings in the greenhouse.

Material and Methods

Greenhouse bioassay studies from three separate locations were conducted at the Texas Agricultural Experiment Station near Yoakum, TX in 2002. Soil samples consisting of the 1X rate of imazapic (71 g ai/ha) and diclosulam (27 g/ha) applied to conventional (spaced 91 cm apart) and twin-row spacings of peanut (spaced 25 cm on 91-cm rows) were collected from field test plots at Pleasanton in 2000 (Location 1) and Yoakum in 2001 (Location 2) and 2002 (Location 3). Soil samples were collected 60 DAP when peanut vegetation slows and reproductive growth (pegging) occurs and at peanut harvest. Soil samples from untreated check plots were also collected at each location. Soil at Pleasanton (Location 1) was a Nueces loamy fine sand (loamy, mixed, hyperthermic Aquic Arinic Palenstalfs) with < 1% organic matter (OM) and pH of 7.2. At Yoakum (Location 2 and 3), the soil was a Straber loamy sand (fine, mixed, thermic Aquic Paleustalfs) with < 1% OM and pH of 7.2 and Tremona (clayey, mixed thermic Aquic Arenic Paleustalfs) loamy fine sand with < 1% OM and pH of 7.4 respectively.

Ten random samples approximately 7.6 cm deep were collected from each plot using a hand-held soil probe. Soil samples were then placed in Ziploc® freezer bags and frozen until time to conduct greenhouse experiments. Soil samples were placed in 6.4 cm^{-2} pots. Corn, cotton, grain sorghum and watermelon were chosen for bioassay because growers in Texas use these crops predominantly in rotation with peanuts (Grichar et al., 1999). Four seed of corn (RX 897), cotton (DP 20 B), grain sorghum (DK 554-00) and watermelon (Charleston Grey) were planted 2.5 cm deep and watered to field capacity. Additional water was added as needed throughout the experimental period. Pots were arranged in a factorial design with three replications. Plants were allowed to grow for 2 wks at which time shoot heights, fresh shoot and root weights were obtained. Plant heights were determined by measuring from the base of the soil line to the furthest point of plant. Shoot weights were obtained by cutting the plant at the base of the plant and weighing immediately. Roots were washed free of soil and blotted dry prior to weighing. Because it was difficult to separate root systems, the entire root mass of all four plants was included in the weights. Shoots and roots were subsequently placed in paper sacks and allowed to air dry in the greenhouse for a period of 7 d upon which dry shoot and root weights were measured. Analysis of variance (P = 0.05) was performed on all parameters and significant differences determined using Fisher's least significant difference (LSD).

Results and Discussion

Corn plant response. Only main treatment effects for corn plant response are presented due to no location by treatment interactions both 60 DAP and at harvest (Table 8). Diclosulam and imazapic treated soils when sampled 60 DAP reduced plant height and fresh and dry shoot weights compared to the untreated check (Table 9). No difference in fresh root weight or dry root weight resulted with either herbicide.

Corn plant height and dry shoot weight were also reduced in soils treated with imazapic and diclosulam and sampled at peanut harvest (Table 10). No differences in fresh and dry root weight resulted with either herbicide from soil sampled at harvest.

Cotton plant response. A significant treatment main effect occurred for plant height and fresh root weight and dry root weight (Table 11). Plant height and fresh and dry root weight from soil sampled 60 DAP was reduced with diclosulam (Table 12). Imazapic did not have an adverse impact on these parameters.

Table 8. Source of variation and associated statistical significance for corn plant response to diclosulam and imazapic.

		Pr>F (0.05)									
		Plant height		Fresh plant weight		Fresh root weight		Dry plant weight		Dry root weight	
Source	df	60[a]	Harvest[b]	60	Harvest	60	Harvest	60	Harvest	60	Harvest
Loc[c]	2	0.0004	0.0001	0.0001	NS	0.0018	0.0001	0.0141	0.0029	0.0001	0.0001
Rep	2	0.0004	NS	NS	NS	NS	NS	NS	NS	NS	NS
Trt[d]	2	0.0001	0.0018	0.0001	0.0001	NS	NS	0.0001	NS	NS	0.0026
Loc x Trt	4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
RS[e]	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Loc x RS	2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Means square error		1090	1518	139593	139593	373704	621970	1107	1047	12700	22739
CV		8.17	9.27	13.72	15.01	14.17	19.66	13.45	15.00	16.02	22.48

[a]Soil sampled 60 days after planting.
[b]Soil sampled at harvest.
[c]Soil sampled from three locations.
[d]Soils treatments included an untreated check, imazapic at 71g/ha and diclosulam at 37 g/ha.
[e]Row Spacings included conventional (two rows spaced 91 cm apart) and twin-row (18 cm apart on a 91-cm bed).

Table 9. Corn plant response to soil treated with imazapic and diclosulam sampled 60 DAP.

Treatment	Rate	Plant height	Fresh shoot weight	Fresh root weight	Dry shoot weight	Dry root weight
	g ai/ha	mm	mg			
Check	-	438	3161	4289	293	694
Imazapic	71	387	2522	4300	231	679
Diclosulam	36	388	2483	4356	217	737
LSD[a] (0.05)		23	254	NS	23	NS

[a]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 10. Corn plant response to soil treated with imazapic and diclosulam sampled at harvest.

Treatment	Rate	Plant height	Fresh shoot weight	Fresh root weight	Dry shoot weight	Dry root weight
	g ai/ha	mm	mg			
Check	-	448	2861	3810	248	588
Imazapic	71	397	2283	4233	195	718
Diclosulam	36	417	2322	3989	204	707
LSD[a] (0.05)		27	254	NS	22	NS

[a]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 11. Source of variation and associated statistical significance for cotton plant response to diclosulam and imazapic.

		Pr>F (0.05)									
		Plant height		Fresh plant weight		Fresh root weight		Dry plant weight		Dry root weight	
Source	df	60[a]	Harvest[b]	60	Harvest	60	Harvest	60	Harvest	60	Harvest
Loc[c]	2	0.0014	0.0001	NS	NS	0.0051	0.0001	0.0001	0.0433	0.0011	0.0232
Rep	2	0.0004	NS	NS	NS	NS	NS	0.0041	NS	NS	NS
Trt[d]	2	0.0074	NS	0.0005	NS	0.0019	NS	0.0001	NS	0.0069	NS
Loc x Trt	4	NS	NS	0.0055	0.0001	NS	0.0001	0.0011	0.0001	NS	0.0001
RS[e]	1	NS	NS	NS	NS	NS	NS	0.0001	NS	NS	NS
Loc x RS	2	NS	NS	0.040	0.0041	NS	0.0039	0.0002	0.0002	NS	0.0165
Means square error		1402	737	147946	70566	82077	62125	475	587	87	1886
CV		25.54	19.11	17.69	12.78	24.56	20.56	9.69	10.86	33.33	36.53

[a]Soil sampled 60 days after planting.
[b]Soil sampled at harvest.
[c]Soil sampled from three locations.
[d]Soils treatments included an untreated check, imazapic at 71g/ha and diclosulam at 37 g/ha.
[e]Row Spacings included conventional (two rows spaced 91 cm apart) and twin-row (18 cm apart on a 91-cm bed).

Table 12. Cotton plant response to soil treated with imazapic and diclosulam sampled 60 DAP.

Treatment	Rate	Plant height	Fresh root weight	Dry root weight
	g ai/ha	mm	mg	
Check	-	160	1307	97
Imazapic	71	158	1171	106
Diclosulam	36	122	1021	81
LSD[a] (0.05)		26	195	21

[a]LSD, least significant difference. Differences between means that are greater than than the LSD within columns are significantly different.

Analysis of variance revealed a location by treatment by row spacing interaction for fresh and dry shoot weight from soil sampled 60 DAP and at harvest and fresh root weight from soil sampled at harvest (Table 11). Imazapic and diclosulam treated soil from Location 1 sampled 60 DAP reduced fresh shoot weight compared to the untreated check for both row spacings (Table 13). Soil collected from Location 2, resulted in no reductions in fresh shoot weight with either herbicide for both row spacings from the untreated check. This location from which these samples were collected received over 50 cm of combined irrigation and rainfall throughout the season, which most likely attributed to the degradation of these compounds. Soil treated with diclosulam applied in the twin-row spacing was the only treatment to reduce fresh shoot weight from soil collected from Location 3.

Cotton dry shoot weight was reduced by diclosulam treated soil collected 60 DAP in two of three locations (Table 14). Diclosulam treated soil at Location 1 lowered dry shoot weight in both row spacings compared to the untreated check. At Location 2, diclosulam treated soil in the twin-row spacing lowered dry shoot weight.

Imazapic and diclosulam treated soil collected at harvest from the conventional row spacing lowered fresh shoot weight at Location 1 (Table 15). Whereas, only diclosulam treated soil from the twin-row spacing reduced fresh root weight compared to the untreated check only at Location 3 (Table 16).

Both herbicide treated soils reduced dry shoot weight in the conventional row spacing at Location 3 when sampled at harvest (Table 17). Also, at Location 3, imazapic treated soil in the twin-row spacing reduced dry shoot weight compared to the untreated.

Table 13. Cotton plant response (fresh shoot weight) to soil treated with imazapic and diclosulam collected from conventional (Conv)[a] or twin-row (TR)[b] spacings 60 DAP.

		Location 1[c]		Location 2[d]		Location 3[e]	
Treatment	Rate	Conv	TR	Conv	TR	Conv	TR
	g ai/ha	mg					
Check	-	2870	2470	2187	2633	2640	2370
Imazapic	71	2330	2070	2727	2378	1970	2060
Diclosulam	36	1600	1700	2160	2110	2337	1277
LSD[f] (0.05)		220		606		810	

[a]Conv=Conventional row pattern, spaced 91 cm apart.
[b]TR=twin rows spaced 25 cm apart on 91-cm rows.
[c]Location 1= Pleasanton in Atascosa County in 2000.
[d]Location 2= Yoakum site 1 at the Texas Agricultural Experiment Station (TAES) in 2001.
[e]Location 3= Yoakum site 2 at the TAES in 2002.
[f]LSD, least significant difference. Mean differences within each test greater than the LSD are significantly different.

Table 14. Cotton plant response (dry shoot weight) to soil treated with imazapic and diclosulam collected from conventional (Conv)[a] or twin-row (TR)[b] spacings 60 DAP.

		Location 1[c]		Location 2[d]		Location 3[e]	
Treatment	Rate	Conv	TR	Conv	TR	Conv	TR
	g ai/ha	mg					
Check	-	243	230	257	257	237	223
Imazapic	71	257	210	327	249	193	197
Diclosulam	36	190	190	213	219	227	124
LSD[f] (0.05)		24		60		51	

[a]Conv=Conventional row pattern, spaced 91 cm apart.
[b]TR=twin rows spaced 25 cm apart on 91-cm rows.
[c]Location 1= Pleasanton in Atascosa County in 2000.
[d]Location 2= Yoakum site 1 at the Texas Agricultural Experiment Station (TAES) 2001.
[e]Location 3= Yoakum site 2 at the TAES in 2002.
[f]LSD, least significant difference. Mean differences within each test greater than the LSD are significantly different.

Table 15. Cotton plant response (fresh shoot weight) to soil treated with imazapic and diclosulam collected from conventional (Conv)[a] or twin-row (TR)[b] spacings at harvest.

		Location 1[c]		Location 2[d]		Location 3[e]	
Treatment	Rate	Conv	TR	Conv	TR	Conv	TR
	g ai/ha	mg					
Check	-	2430	1970	1597	1970	2673	2400
Imazapic	71	1800	2000	2340	2170	1783	1927
Diclosulam	36	2030	1770	2127	2504	1850	2000
LSD[f] (0.05)		270		725		NS	

[a]Conv=Conventional row pattern, spaced 91 cm apart.
[b]TR=twin rows spaced 25 cm apart on 91-cm rows.
[c]Location 1= Pleasanton in Atascosa County in 2000.
[d]Location 2= Yoakum site 1 at the Texas Agricultural Experiment Station (TAES) in 2001.
[e]Location 3= Yoakum site 2 at the TAES in 2002.
[f]LSD, least significant difference. Mean differences within each test greater than the LSD are significantly different.

Table 16. Cotton plant response (fresh root weight) to soil treated with imazapic and diclosulam collected from conventional (Conv)[a] or twin-row (TR)[b] spacings at harvest.

		Location 1[c]		Location 2[d]		Location 3[e]	
Treatment	Rate	Conv	TR	Conv	TR	Conv	TR
	g ai/ha	mg					
Check	-	1330	1230	2187	2633	2640	2370
Imazapic	71	1170	1200	2727	2378	1970	2060
Diclosulam	36	1200	1200	2160	2110	2337	1277
LSD[f] (0.05)		NS		606		810	

[a]Conv=Conventional row pattern, spaced 91 cm apart.
[b]TR=twin rows spaced 25 cm apart on 91-cm rows.
[c]Location 1= Pleasanton in Atascosa County in 2000.
[d]Location 2= Yoakum site 1 at the Texas Agricultural Experiment Station (TAES) in 2001.
[e]Location 3= Yoakum site 2 at the TAES in 2002.
[f]LSD, least significant difference. Mean differences within each test greater than the LSD are significantly different.

Table 17. Cotton plant response (dry shoot weight) to soil treated with imazapic and diclosulam collected from conventional (Conv)[a] or twin-row (TR)[b] spacings at harvest.

		Location 1[c]		Location 2[d]		Location 3[e]	
Treatment	Rate	Conv	TR	Conv	TR	Conv	TR
	g ai/ha	mg					
Check	-	250	203	160	223	260	233
Imazapic	71	237	217	267	233	197	177
Diclosulam	36	257	187	227	286	190	200
LSD[f] (0.05)		30		37		43	

[a]Conv=Conventional row pattern, spaced 91 cm apart.
[b]TR=twin rows spaced 25 cm on 91-cm rows.
[c]Location 1= Pleasanton in Atascosa County in 2000.
[d]Location 2= Yoakum site 1 at the Texas Agricultural Experiment Station (TAES) in 2001.
[e]Location 3= Yoakum site 2 at the TAES in 2002.
[f]LSD, least significant difference. Mean differences within each test greater than the LSD are significantly different.

Sorghum plant response. There were no significant treatment by location interactions with sorghum plant response (Table 18). Plant height was reduced for sorghum grown in soil treated with both imazapic and diclosulam sampled 60 DAP (Table 19). This reduction in height resulted in a lower fresh shoot weight with diclosulam but not with imazapic. Microbial degradation may have reduced imazapic concentration and contributed to this result.

Fresh root weight and dry shoot weight were lower only with plants grown in soil treated with imazapic collected at harvest compared to the untreated check (Table 20). Dry shoot and root weights were also lower than the untreated check with diclosulam treated soil sampled at harvest. No differences occurred with fresh shoot weights with either herbicide (data not shown).

Watermelon plant response. Location x treatment effects did not occur so only main treatment effects are presented (Table 21). Watermelon shoot and root weights, and dry shoot and root weights were lower when plants were grown in soil treated with imazapic or diclosulam with sampled 60 DAP (Table 22). When soil was sampled at harvest, no significant reductions in plant height, fresh shoot and root weights and dry root weights resulted with either herbicide when compared to the untreated check (Table 23). Both imazapic and diclosulam lowered dry shoot weight compared to the untreated check.

Diclosulam and imazapic treated soil sampled 60 DAP adversely affected all four crops. In most cases, reduced plant height, fresh shoot and root weights and dry shoot and root weights were reduced compared to plants grown in untreated soil.

Table 18. Source of variation and associated statistical significance for grain sorghum plant response to diclosulam and imazapic.

		Pr>F (0.05)									
		Plant height		Fresh plant weight		Fresh root weight		Dry plant weight		Dry root weight	
Source	df	60[a]	Harvest[b]	60	Harvest	60	Harvest	60	Harvest	60	Harvest
Loc[c]	2	0.0013	0.0009	0.0001	0.0019	0.0001	0.0001	NS	0.0001	NS	NS
Rep	2	0.0039	NS	NS	NS	0.0433	NS	0.0041	NS	NS	NS
Trt[d]	2	0.0074	NS	0.0005	NS	0.0019	0.0001	0.0245	0.0037	NS	0.0026
Loc x Trt	4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
RS[e]	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Loc x RS	2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Means square error		1874	2763	21349	42913	62515	67255	7677	4923	3729	3670
CV		15.19	18.77	25.65	33.24	33.12	32.05	51.71	82.91	74.70	34.19

[a]Soil sampled 60 days after planting.
[b]Soil sampled at harvest.
[c]Soil sampled from three locations.
[d]Soils treatments included an untreated check, imazapic at 71g/ha and diclosulam at 37 g/ha.
[e]Row Spacings included conventional (two rows spaced 91 cm apart) and twin-row (18 cm apart on a 91-cm bed).

Table 19. Grain sorghum plant response to soil treated with imazapic and diclosulam sampled 60 DAP.

Treatment	Rate	Plant height	Fresh shoot weight
	g ai/ha	mm	mg
Check	-	313	626
Imazapic	71	274	566
Diclosulam	36	268	517
LSD[a] (0.05)		30	100

[a]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 20. Grain sorghum plant response to soil treated with imazapic and diclosulam sampled at harvest.

Treatment	Rate	Fresh root weight	Dry shoot weight	Dry root weight
	g ai/ha		mg	
Check	-	898	121	206
Imazapic	71	714	63	156
Diclosulam	36	814	70	171
LSD[a] (0.05)		177	48	41

[a]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 21. Source of variation and associated statistical significance for watermelon plant response to diclosulam and imazapic.

		Pr>F (0.05)									
		Plant height		Fresh plant weight		Fresh root weight		Dry plant weight		Dry root weight	
Source	df	60[a]	Harvest[b]	60	Harvest	60	Harvest	60	Harvest	60	Harvest
Loc[c]	2	0.0001	0.0001	NS	NS	NS	0.0001	0.0001	0.0001	0.0001	0.0001
Rep	2	NS	NS	NS	NS	0.0433	0.0149	NS	NS	NS	0.0013
Trt[d]	2	NS	NS	0.0015	NS	0.0026	0.0053	0.0002	0.0001	NS	NS
Loc x Trt	4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
RS[e]	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Loc x RS	2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Means square error		954	539	210667	407704	112562	284795	1771	3261	14894	17433
CV		20.52	15.67	15.17	20.34	29.58	30.97	19.90	24.38	79.40	64.93

[a]Soil sampled 60 days after planting.
[b]Soil sampled at harvest.
[c]Soil sampled from three locations.
[d]Soils treatments included an untreated check, imazapic at 71g/ha and diclosulam at 37 g/ha.
[e]Row Spacings included conventional (two rows spaced 91 cm apart) and twin-row (18 cm apart on a 91-cm bed).

Table 22. Watermelon plant response to soil treated with imazapic and diclosulam sampled 60 DAP.

Treatment	Rate	Fresh shoot weight	Fresh root weight	Dry shoot weight	Dry root weight
	g ai/ha	mg			
Check	-	3372	1319	248	204
Imazapic	71	2922	1047	183	138
Diclosulam	36	2783	1036	204	118
LSD[a] (0.05)		312	228	29	83

[a]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 23. Watermelon plant response to soil treated with imazapic and diclosulam sampled at harvest.

Treatment	Rate	Plant weight	Fresh shoot height	Fresh root weight	Dry shoot weight	Dry root weight
	g ai/ha	mm	mg			
Check	-	156	3328	1714	296	161
Imazapic	71	144	3172	1744	201	210
Diclosulam	36	144	2917	1711	206	239
LSD[a] (0.05)		NS	NS	NS	39	NS

[a]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Nevertheless, cotton plants at Yoakum in 2001 sampled 60 DAP and at harvest were not affected by either herbicides. Watermelon plant response was not affected with both diclosulam and imazapic when planted in soil sampled at harvest. This may indicate that watermelon is less sensitive to herbicide residual concentrations.

In this study, the advantage of planting peanuts in a twin-row spacing to reduce diclosulam and imazapic residual concentrations was not apparent. Consequently, growers should be cautious when planting these crops following peanut fields treated with these herbicides.

CHAPTER V

EFFECTS OF ROW SPACING ON PEANUT PLANT DEVELOPMENT, MATURITY, GRADE AND YIELD

Introduction

The advantages of planting peanut (*Arachis hypogaea* L.) in a narrow- or twin-row spacing have been documented in studies largely conducted in the southeast peanut growing region. In Georgia, Buchanan and Hauser (1980) reported higher yields (42 to 52%) as rows were narrowed from 80 to 40 to 20 cm. They also reported a 15% increase in yield when the runner cultivar 'Florunner' was planted in a narrow-row spacing (46 cm) compared to a conventional, 91-cm row spacing (Hauser and Buchanan, 1981). Bunch type cultivars (a clustering growth appearance) were reported to have 16% higher yields with a narrow row spacing compared to a conventional row spacing (Norden and Lipscomb, 1974). They also found that yields from runner cultivars were also higher in the narrow-row spacings but were not significantly higher than the conventional row spacings.

In a three-yr study conducted by Duke and Alexander (1964), yields from large seeded virginia bunch types were higher in the 30- and 46-cm row spacings compared to the standard row widths 2 out of 3 years. Furthermore, they found no differences in yield among the narrow-row spacings. In Virginia, Mozingo and Coffelt (1984) found that VA 81B, a bunch-type cultivar, responded with higher yields when planted as twin rows with seeding rates similar to the conventional row spacing. Jaaffar and Gardner (1988) found that narrow and twin-row spacings had greater ground cover, leaf area indices, canopy light interception, crop growth rates and ultimately higher pod yields when compared to a conventional row spacing. Similarly, Stewart *et al*. (1997) found that greater light interception and leaf area occurred by decreasing row spacing. Baldwin *et al.* (1998) in Georgia reported a significant increase in yield of 381 kg/ha and total sound mature kernel (TSMK) with the twin-row spacing over the conventional row pattern when averaged across four runner cultivars and locations. Similar yield and grade increases were reported by McGriff *et al*. (1999). Seeding rates in these studies were approximately the same for both the conventional and twin-row spacing. These studies also consistently found that the tomato spotted wilt virus (TSWV) was reduced 6.5 to 37% when peanuts were planted in twin rows.

Other research involving narrow-row spacing has shown that yields increased with little effect on market quality of the peanut (Cox and Reid, 1965; Norden and Lipscomb, 1974). In North Carolina, a two-yr study that encompassed various seeding rates and row spacings, showed no differences in peanut yield with virginia market types when planted in narrow rows of 45 cm or twin rows with 23-cm spacings when compared to conventional row spacing (Jordan *et al*., 2001). However, it was concluded that these studies were relatively free from pests with adequate irrigation. In Alabama, Mixon (1969) found no advantage to planting runner-type cultivars in a narrow- or twin-row spacing. However, he suggested the use of twin- or narrow-rows for suppressing weeds and diseases.

Relatively little research in the Southwest peanut growing region is available on planting peanuts in a narrow- and twin-row spacing to a wider row spacing of spanish peanuts grown in the semi-arid Southwest. Harrison (1967) found that spanish peanut cultivars planted in south Texas yielded higher when planted in conventional single rows compared with the same cultivars planted in twin rows at various seeding rates for both row spacings.

Also, no research in Texas has addressed the relationship of yield to peanut architecture such as plant diameter, main stem length, pods/plant, and maturity. A study conducted by Mozingo and Steele (1989) found that main stems were taller and cotylendonary lateral branches were longer with close intrarow spacing. They also concluded that pods per plant decreased as plant density increased. However, they did not evaluate plant growth in a narrow- or twin-row spacing. Cahaner and Ashri (1974) found that when plant density increased with virginia-type cultivars, pod and cotylendonary branch length were not affected.

Presently, it is important to evaluate the potential of narrow and twin rows in Texas using recently released runner peanut cultivars and how these systems influence growth habit, pod development and subsequent yield.

Material and Methods

Field studies were conducted in 1999 at the Texas Agricultural Experiment Station near Yoakum, TX and in a grower's field near Pearsall, TX. In 2000, field studies were conducted in grower fields located near Pleasanton and Pearsall, TX. Soil at the Yoakum, Atascosa and Pearsall test sites were Straber loamy sand (fine, mixed, thermic Aquic Paleustalfs) with a pH 6.8 to 7.0; Nueces loamy fine sand (loamy, mixed, hyperthermic Aquic Arinic Palenstalfs) with less then 1% organic matter and pH 7.2; and Duval loamy fine sand (fine-loamy, mixed, hyperthermic Aridic Haplustalfs) with less than 1% organic matter and pH 6.8 to 7.2, respectively. The runner cultivars 'Georgia Green' and 'Tamrun 96' were selected due to their phenotypic differences. Georgia Green has a smaller, compact canopy, whereas, Tamrun 96 has a large and robust canopy. The test design both years consisted of a randomized complete block with four replications. Plot length in 1999 at the Yoakum location was 12 m and 10.7 m at the Pearsall location. In 2000, plot length at Pleasanton was 18.3 m and 30 m at Pearsall. Three row spacings were used in this study. The conventional row spacing was 91 cm whereas, the twin rows were spaced approximately 25 cm apart on 91-cm beds. The narrow-rows were spaced 38 cm apart.

The desired planting densities are defined in Table 24. Seed for each cultivar was planted using a Monosem vacuum planter (Monosem AT1, Inc., Lenoxa, KS 66219). Cultivars were planted on flat beds to ensure a more efficient planting with the twin- and narrow-row patterns. In 1999, peanuts were planted on Jun 2 and Jun 7 at Pearsall and Yoakum locations, respectively. In 2000, plots were planted on May 31 at Pearsall and Jun 6 at Pleasanton. All cultural practices followed the recommendations outlined by the Texas Cooperative Extension Service (Lemon *et al*., 2001).

Table 24. Desired planting densities for peanut cultivars Georgia Green and Tamrun 96

Row Spacing	Desired planting density
	Plants/m
Conventional	7 to 9 (ultra low)
	10 to 12 (low)
	13 to 15 (standard)[a]
Narrow-row	7 to 9 (ultra low)
	10 to 12 (low)
	13 to 15 (standard)
Twin-row	13 to 15 (ultra low)
	20 to 24 (low)
	26 to 30 (standard)

[a]Considered typical planting density used by growers for each row spacing.

Plant emergence was determined approximately 2 to 3 wks after planting at each test location both. Plant diameter, main stem height, and pod distribution were measured at both locations in 1999 and at Pearsall in 2000 shortly after inversion. Main stem height was measured from the crown of the plant to the terminal. Plant diameter was measured across the length of the longest lateral branch. Pod distribution was measured as the farthest harvestable pod on the longest lateral branch from the main stem. Pods/plant data were collected from five arbitrary plants/plot at Pearsall and Yoakum in 1999, whereas maturity and white mold caused by *Sclerotium rolfsii* data were collected in 2000 at Pearsall and Pleasanton. White mold disease loci was defined as $\leq$ 30 cm of consecutive damage in a row (Rodriquez-Kabana *et al*., 1975).

Maturity samples were collected 120 and 130 DAP from all plots at both locations to determine if narrow and twin-row spacings promoted earlier maturity compared to the conventional row spacing. One hundred fully developed pods were arbitrarily selected from each plot and the hull scrape method used to determine maturity (Sanders, 1995). Pods were placed in the following maturity classes white, yellow 1, yellow 2, orange, brown and black. Pods that displayed orange, brown and black were combined and percent maturity calculated. Plots in 1999 were inverted on Nov 3 at Yoakum and Oct 11 at Pearsall. In 2000, peanuts were inverted on Oct 19 at Pearsall and Oct 27 at Pleasanton. Plots were field dried approximately 4 to 12 d depending on weather conditions and harvested using a two-row tractor-pulled combine with sacking attachment. Grades were determined by taking 200 g of pods from each plot and applying the grading procedures outlined by the Federal State Inspection Service

(USDA, 2002). Analysis of variance was performed on all parameters and significant differences determined using Fisher's Protected Least Significant Differences (P=0.05).

Results and Discussion

Analysis of variance for plant emergence and yield revealed a significant treatment by year and treatment by location interaction (Table 25). Therefore, emergence and yield data are presented separately for each location and year. There was not a treatment by year or treatment by location interaction for plant diameter, pod distribution, main stem length and grade allowing data to be pooled over years and locations (Tables 25 and 26). In 1999, there was not a significant treatment by location interaction for pods/plant. There was not a significant treatment by location interaction in 2000 for both maturity samplings. A significant treatment by location interaction for white mold resulted in 2000 (Table 27). Treatments included cultivar, row spacing and planting densities. Based on the planting densities, comparisons were made between the conventional and twin-row spacing across planting densities and conventional and narrow-row at each planting density.

Comparison of conventional and twin-row spacings

Plant emergence. Increased plant emergence at Yoakum in 1999 occurred with the twin-row spacing for Georgia Green and Tamrun 96 at the standard planting density (Table 28). At Pearsall in 1999, Georgia Green also had the highest plant emergence at the standard twin-row planting density. Plant emergence with Tamrun 96 at the standard twin-row planting density was not different than the low planting density.

Table 25. Sources of variation and associated statistical significance levels for peanut emergence, yield and grade for 1999 and 2000.

		Pr>F (0.05)		
Source	df	Emergence	Yield	%TSMK[a]
Year	1	0.0025	0.0001	0.0001
Rep	3	NS	0.0001	NS
Trt[b]	11	0.0001	0.0024	0.0004
Loc	2	NS	0.0001	NS
Year x Trt	11	0.0001	0.0230	NS
Trt x Loc	17	0.0012	0.0141	NS
Mean square error		0.42	240415.09	6.31
CV		15.75	12.82	3.39

[a]TSMK=total sound mature kernels.
[b]Treatments consisted of cultivar, row spacing and planting density.

Table 26. Sources of variation and associated statistical significance levels for peanut plant development for 1999 and 2000.

		Pr>F (0.05)		
Source	df	PLTDIA[a]	PODIST[b]	MSLGTH[c]
Year	1	0.0001	0.0001	0.0001
Rep	3	0.0056	NS	0.0005
Trt[d]	11	0.0001	0.0001	0.0004
Loc	1	0.0001	0.0001	NS
Year x Trt	11	NS	NS	NS
Trt x Loc	17	NS	NS	NS
Mean square error		13.30	7.57	2.59
CV		10.23	18.90	14.37

[a]Plant diameter.
[b]Pod distribution.
[c]main stem length.
[d]Treatments consisted of cultivar, row spacing and planting density.

Table 27. Sources of variation and associated statistical significance levels for pod/plant, maturity and white mold.

		Pr>F (0.05)			
		1999	2000		
Source	df	Pods/plant	Maturity 1[a]	Maturity 2[a]	White Mold
Loc[b]	1	NS	0.0001	0.0001	0.0004
Rep	2	NS	NS	NS	0.0200
Trt[c]	17	0.0002	0.0001	NS	NS
Trt x Loc	17	NS	NS	NS	0.0001
Mean square error		96.39	160.23	23.33	144.09
CV		36.04	26.60	32.97	17.78

[a]Based on hull scrape method where only orange, brown and black pod were considered mature.
[b]Locations included test sites near Yoakum, Pleasanton and Pearsall.
[c]Treatments consisted of cultivar, row spacing, and planting density.

Table 28. Effects of cultivar, planting density and row spacing for plant emergence and yield in 1999 and 2000.

			Plant emergence				Yield			
			1999		2000		1999		2000	
Cultivar	Row spacing	Planting density[a]	Yoakum	Pearsall	Pearsall	Pleasanton	Yoakum	Pearsall	Pearsall	Pleasanton
			plant/m				kg/ha			
Georgia Green	C	ultra low	-	-	6.6	5.9	-	-	5676	3798
		low	11.8	10.5	9.5	6.6	2418	4514	5963	4239
		standard	13.1	11.5	10.8	10.8	2340	3704	5545	3707
Georgia Green	TR	ultra low	-	-	10.2	11.5	-	-	6355	4227
		low	14.1	12.8	19.7	18.7	2696	5659	6251	4408
		standard	26.6	25.3	16.4	14.8	3097	5595	5702	3549
Tamrun 96	C	ultra low	-	-	6.9	4.3	-	-	6434	3278
		low	9.5	11.2	12.5	10.5	2204	5142	6905	3459
		standard	9.2	11.2	13.1	18.0	2763	5092	6068	3052
Tamrun 96	TR	ultra low	-	-	19.4	10.5	-	-	6866	3413
		low	17.0	21.3	20.3	22.3	2968	6104	6539	3210
		standard	22.3	20.7	21.0	13.8	2879	5960	6408	2962
LSD[b] (P=0.05)			5.4	2.7	3.8	3.5	583	477	434	760

[a]Ultra low = 7 to 9 plants/m for conventional and 13 to 15 plants/m for twin rows; low = 10 to 12 plants/m for conventional and 20 to 24 plants/m for twin rows; standard = 13 to 15 plants/m for conventional and 26 to 30 plants/m for twin rows.

[b]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

At Pleasanton in 2000, an increase in plant emergence with Georgia Green and Tamrun 96 was apparent at the twin-row, low planting density compared to the Georgia Green twin-row standard planting density (Table 28). However, at both locations in 1999 and 2000, plant emergence at the standard twin-row planting density was below the targeted planting density by as much as 38 %. This could have been attributed to poor seed germination with both cultivars and/or inter-row plant competition.

Yield. At Yoakum in 1999, Georgia Green, when planted in a twin-row spacing at the standard planting density showed a yield increase over Georgia Green planted in a conventional row spacing at the low and standard planting density. However, it was not different than the Tamrun 96 twin rows at the low and standard planting density (Table 28). Tamrun 96 in a twin-row spacing at the low and standard planting density was higher than the conventional planted Tamrun 96 at the low planting density.

The twin-row planting of Tamrun 96 at the low planting density at Pearsall in 1999 was higher in yield than all planting densities and row spacings except Tamrun 96 twin rows at the standard planting density and Georgia Green twin rows at the low planting density (Table 28).

At Pearsall in 2000, the low and ultra-low planting density of Tamrun 96 in a conventional and twin-row spacing respectively, resulted in a higher yield than all Georgia Green planting densities and row spacings and was higher than Tamrun 96 in a conventional and twin-row spacing when planted at a standard planting density (Table 28).

The twin-row spacing of Georgia Green, at a low planting density at Pleasanton in 2000, was higher in yield than all Tamrun 96 row spacings and planting densities. However, no differences in yield were found when compared to Georgia Green at all planting densities in a conventional row spacing (Table 28).

***Pant development*.** Plant diameter, pod distribution and main stem length for Tamrun 96 planted in a conventional spacing at the low planting density was higher than Georgia Green planted in a conventional and twin-row spacing at both the standard and low planting densities (Table 29). In addition, Tamrun 96 planted in a conventional row spacing at the low planting density had a plant diameter larger than Tamrun 96 planted in a twin-row spacing at the standard planting density; a higher pod distribution than Tamrun 96 planted in twin rows at the low and standard planting density; and a larger main stem length than Tamrun 96 planted in twin rows at the low and standard planting density (Table 29).

***Grade*.** Georgia Green planted in a conventional row spacing at the standard planting density had a higher grade compared to Tamrun 96 planted in a conventional and twin-row spacing at the low and standard planting density (Table 30). No differences in grade resulted among row spacing and planting densities with Georgia Green.

***Maturity*.** At the first sampling, Georgia Green when planted in a conventional row spacing at the standard planting density matured faster than Georgia Green planted in twin rows at all planting densities and Tamrun 96 at both row spacings and planting densities. However, at the second maturity sampling, no differences among row spacings and planting densities resulted with either cultivar (Table 31). In previous

Table 29. Effects of cultivar, planting density and row spacing for plant diameter, pod distribution and main stem length across three locations in 1999 and 2000.

Cultivar	Row spacing	Planting density[a]	Plant diameter[b]	Pod distribution[c]	Main stem length[d]
				cm	
Georgia Green	C	low	84.0	35.1	26.4
		standard	84.0	34.3	24.6
Georgia Green	TR	low	79.0	31.2	24.1
		standard	79.0	26.4	24.1
Tamrun 96	C	low	105.0	50.0	36.5
		standard	104.1	47.5	33.0
Tamrun 96	TR	low	99.1	39.1	32.0
		standard	96.5	38.0	32.0
LSD[e] (P=0.05)			7.4	6.6	3.6

[a]Low = 10 to 12 plants/m for conventional and 20 to 24 plants/m for twin rows; standard = 13 to 15 plants/m for conventional and 26 to 30 plants/m for twin rows.

[b]Plant diameter was measured across the longest lateral branch.

[c]Pod distribution was measured as the farthest harvestable pod on the longest lateral branch from the mainstem.

[d]Main stem height was measured from the base of the plant to the terminal.

[e]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 30. Effects of cultivar, planting density and row spacing on grade across four locations in 1999 and 2000.

Cultivar	Row spacing	Planting density[a]	%TSMK[b]
Georgia Green	C	low	75
		standard	76
Georgia Green	TR	low	75
		standard	75
Tamrun 96	C	low	72
		standard	74
Tamrun 96	TR	low	73
		standard	74
LSD[c] (P=0.05)			2

[a]Low = 10 to 12 plants/m for conventional and 20 to 24 plants/m for twin rows; standard = 13 to 15 plants/m for conventional and 26 to 30 plants/m for twin rows.

[b]Total sound mature kernels.

[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 31. Effects of peanut cultivar, planting density and row spacing for maturity across two locations in 1999 and 2000.

Cultivar	Row spacing	Planting density[a]	Maturity 1[b]	Maturity 2[b]
			%	
Georgia Green	C	ultra low	57	67
		low	58	74
		standard	67	74
Georgia Green	TR	ultra low	50	72
		low	49	64
		standard	54	68
Tamrun 96	C	ultra low	45	64
		low	43	69
		standard	45	69
Tamrun 96	TR	ultra low	36	65
		low	44	68
		standard	41	59
LSD[c] (P=0.05)			13	NS

[a]Ultra low = 7 to 9 plants/m for conventional and 14 to 18 plants/m for twin rows; low = 10 to 12 plants/m for conventional and 20 to 24 plants/m for twin rows; standard = 13 to 15 plants/m for conventional and 26 to 30 plants/m for twin rows.

[b]Maturity at 120 and 130 DAP based on hull scrape method.

[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

research, it was observed that Georgia Green and Tamrun 96 had similar pod maturity at harvest (Besler et al. 2001). Furthermore, Cahaner and Ashri (1974) reported that maturity was not enhanced when pod density increased.

Pods/plant. The conventionally spaced Tamrun 96 at the low planting density had the most pods/plant than Georgia Green planted in a conventional and twin-row spacing at both the low and standard planting density (Table 32). Sternitzke *et al*. (2000) determined that as total plant emergence and population decreased, pod mass per plant increased. Georgia Green planted in a twin-row spacing at the standard planting density had the lowest pods/plant. Mozingo and Steele (1989) concluded that as seed spacing decreased pods/plant were significantly decreased.

White Mold. Disease results are presented for each location. Assessment of white mold disease incidence at Pearsall revealed that disease severity was higher with Georgia Green compared to Tamrun 96 at all row spacings and planting densities (Table 33). White mold was not significantly higher in the twin-row spacing with Georgia Green compared to the conventional row spacings. The twin-row spacing of Tamrun 96 at the low and standard planting densities had more white mold when compared to the conventionally planted Tamrun 96 at the ultra-low planting density. At Pleasanton, white mold was higher with Tamrun 96 for all row spacings and planting densities than Georgia Green. Both Tamrun 96 and Georgia Green have been reported to have moderate resistance to white mold (Besler *et al.,* 1997; Branch and Brenneman, 1993). Therefore, the inconsistency in white mold disease incidence for both cultivars at both locations could have been due to the lack of uniform natural disease inoculum.

Table 32. Effects of cultivar, planting density and row spacing for pods/plant across two locations in 1999.

Cultivar	Row spacing	Planting density[a]	Pods/plant[b]
Georgia Green	C	low	28
		standard	30
Georgia Green	TR	low	25
		standard	18
Tamrun 96	C	low	41
		standard	35
Tamrun 96	TR	low	27
		standard	25
LSD[c] (P=0.05)			11

[a]Low = 10 to 12 plants/m for conventional and 20 to 24 plants/m for twin rows; standard = 13 to 15 plants/m for conventional and 26 to 30 plants/m for twin rows.

[b]Pod counts were taken from five randomly selected plants per plot.

[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 33. Effects of cultivar, planting density and row spacing on white mold development at two locations in 2000.

Cultivar	Row spacing	Planting density[a]	White mold[b]	
			Pearsall	Pleasanton
			loci/60m	loci/37m
Georgia Green	C	ultra low	21	10
		low	20	9
		standard	19	6
Georgia Green	TR	ultra low	25	13
		low	20	11
		standard	18	10
Tamrun 96	C	ultra low	9	17
		low	10	20
		standard	11	15
Tamrun 96	TR	ultra low	14	18
		low	16	16
		standard	16	11
LSD (P=0.05)[c]			9	11

[a]Ultra low = 7 to 9 plants/m for conventional and 14 to 18 plants/m for twin rows; low = 10 to 12 plants/m for conventional and 20 to 24 plants/m for twin rows; standard = 13 to 15 plants/m for conventional and 26 to 30 plants/m for twin rows.

[b]A disease loci was defined as $\leq$ 30 cm of consecutive damage in a row.

[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Comparison of conventional and narrow row spacings

Plant emergence. Comparison of the conventional and narrow-row spacing resulted in differences in plant emergence at the standard planting density in three of four locations in 1999 and 2000 (Table 34). Georgia Green narrow-row plant emergence at Yoakum in 1999 was higher than the Tamrun 96 conventional and narrow-row spacing. At Pearsall in 2000, Tamrun 96 planted in a narrow-row spacing was higher in plant emergence than Tamrun 96 conventional and Georgia Green conventional and narrow-row spacing whereas, Tamrun 96 conventional plant emergence was higher than Tamrun 96 narrow-row and Georgia Green conventional and narrow-row spacing at Pleasanton in 2000.

Low planting density differences in plant emergence occurred in three of four locations in 1999 and 2000 (Table 35). Georgia Green plant emergence in a conventional row spacing in 1999 at Yoakum was higher than Tamrun 96 in a narrow-row spacing. At Pearsall in 2000, Tamrun 96 in a conventional spacing had a higher plant emergence than when planted in a narrow-row spacing. Georgia Green in a narrow-row spacing at Pleasanton in 2000 had the highest plant emergence compared to the Georgia Green and Tamrun 96 conventional and Tamrun 96 narrow-row planting.

The ultra-low planting density resulted in an increase plant emergence for Tamrun 96 in the narrow row spacing at Pearsall (Table 36). At Pleasanton, both Georgia Green and Tamrun 96 in the narrow-row spacing had a higher plant emergence than Georgia Green and Tamrun 96 in a conventional row spacing.

Yield. Differences in yield for conventional and narrow-row spacings at the standard planting density resulted in 2 of 4 locations in 1999 and 2000 (Table 34). At Pearsall

Table 34. Comparison of conventional (C) and narrow-row (NR) spacings for plant emergence and yield at a standard[a] planting density in 1999 and 2000.

		Plant emergence				Yield			
		1999		2000		1999		2000	
Cultivar	Row spacing	Yoakum	Pearsall	Pearsall	Pleasanton	Yoakum	Pearsall	Pearsall	Pleasanton
		plant/m				kg/ha			
Georgia Green	C	13.1	11.5	10.8	10.8	2340	3704	5545	3707
	NR	13.8	13.5	11.2	10.5	2698	4994	5532	4001
Tamrun 96	C	9.2	11.2	13.1	18.0	2763	5092	6068	3052
	NR	8.2	11.5	16.4	14.8	2506	5456	5571	3572
LSD[b] (0.05)		1.9	NS	2.2	3.4	NS	1046	NS	787

[a]Standard = 13 to 15 plants/m.

[b]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 35. Comparison of conventional (C) and narrow-row (NR) spacings for plant emergence and yield at a low[a] planting density in 1999 and 2000.

		Plant emergence				Yield			
		1999		2000		1999		2000	
Cultivar	Row spacing	Yoakum	Pearsall	Pearsall	Pleasanton	Yoakum	Pearsall	Pearsall	Pleasanton
		plant/m				kg/ha			
Georgia Green	C	11.8	10.5	9.5	6.6	2418	4514	5963	4239
	NR	10.2	10.8	9.5	12.8	2333	5367	5702	3707
Tamrun 96	C	9.5	11.2	12.5	10.5	2204	5142	6905	3459
	NR	7.9	10.9	8.9	8.9	3103	5656	5702	3165
LSD[b] (0.05)		2.6	NS	2.1	1.4	509	389	852	894

[a]Low = 10 to 12 plants/m.

[b]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 36. Comparison of conventional (C) and narrow-row (NR) spacings for plant emergence and yield at an ultra-low[a] planting density in 1999 and 2000.

		Plant emergence		Yield	
Cultivar	Row spacing	Pearsall	Pleasanton	Pearsall	Pleasanton
		plant/m		kg/ha	
Georgia Green	C	6.6	5.9	5676	3798
	NR	5.9	9.2	5856	3796
Tamrun 96	C	6.9	4.3	6434	3278
	NR	8.9	9.5	5649	3098
LSD[b] (0.05)		1.5	3.1	454	605

[a]Ultra low = 7 to 9 plants/m.

[b]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

in 1999, Tamrun 96 in a narrow-row spacing was only higher in yield than Georgia Green planted in a conventional row spacing. At Pleasanton in 2000, Georgia Green in a narrow-row spacing was only higher in yield than the conventionally planted Tamrun 96. At Yoakum in 1999, Tamrun 96 in a narrow-row spacing at a low planting density was higher in yield than Tamrun 96 and Georgia Green planted in a conventional row spacing and Georgia Green planted in a narrow-row spacing (Table 35). Similar yield results occurred at Pearsall in 1999. At Pearsall in 2000, Tamrun 96 in a conventional row spacing at a low planting density had a higher yield than the narrow-row spacing of Tamrun 96 and Georgia Green and conventional row spacing of Georgia Green. The conventionally planted Georgia Green at Pleasanton in 2000, was only higher in yield than the narrow-row planting of Tamrun 96.

At Pearsall in 2000, Tamrun 96 in a conventional row spacing at the ultra-low planting density was higher in yield than Tamrun 96 and Georgia Green in a narrow-row spacing and Georgia Green in a conventional row spacing (Table 36). The conventional row spacing of Georgia Green at Pleasanton in 2000 had a yield only higher than the narrow-row spacing of Tamrun 96.

Plant development. A comparison among conventional and narrow-row spacings with Georgia Green and Tamrun 96 at a standard planting density revealed that Tamrun 96 in both row spacings had a larger plant diameter, pod distribution and main stem length than Georgia Green regardless of row spacing (Table 37). No differences with Tamrun 96 were found between the two row spacings. Similar results occurred at the low planting density. However, at the low planting density, Tamrun 96 planted in narrow-

Table 37. Comparison of conventional (C) and narrow-row (NR) spacings for plant development at a standard[a] planting density across three locations in 1999 and 2000.

Cultivar	Row spacing	Plant diameter[b]	Pod distribution[c]	Main stem length[d]
		cm		
Georgia Green	C	84.0	35.1	26.4
	NR	84.0	34.3	24.6
Tamrun 96	C	104.1	47.5	33.0
	NR	100.6	41.0	32.3
LSD[e] (0.05)		9.7	6.6	3.6

[a]Standard = 13 to 15 plants/m.
[b]Plant diameter was measured across the longest lateral branch.
[c]Pod distribution was measured as the farthest harvestable pod on the longest lateral branch from the mainstem.
[d]Main stem height was measured from the base of the plant to the terminal.
[e]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

rows had a lower pod distribution and main stem length than the conventionally planted Tamrun 96 (Table 38).

***Grade*.** Conventional and narrow-row spacings at the standard planting density resulted in no differences in grade with both cultivars (Table 39). Although, at the low planting density, Georgia Green both in the conventional and narrow-row spacing had a higher grade than the conventional and narrow-row spacing of Tamrun 96 (Table 40).

***Maturity*.** Georgia Green at the first maturity sampling, planted in a conventional row spacing at a standard planting density matured faster than Tamrun 96 at both the conventional and narrow-row spacing but was not different than Georgia Green planted in a narrow-row spacing (Table 41). This was also the case at the low planting density (Table 42). Tamrun 96 planted in narrow rows at an ultra-low planting density matured slower than Georgia Green when planted in narrow rows or conventional rows (Table 43). However, at the second sampling, Tamrun 96 was not different than Georgia Green at both row spacings and planting densities.

***Pods/plant*.** The conventional planting of Georgia Green and Tamrun 96 at the standard planting density had more pods/plant than Georgia Green planted in a narrow-row spacing (Table 44). Both the conventional and narrow-row spacings of Tamrun 96 at the low planting density had more pods/plant than Georgia Green planted in a narrow-row spacing (Table 45).

***White mold*.** At Pearsall, Tamrun 96 in a conventional and narrow-row spacing was lower in white mold than Georgia Green planted in a conventional and narrow-row spacing at the standard planting density (Table 46). At Pleasanton, white mold was

Table 38. Comparison of conventional (C) and narrow-row (NR) spacings for plant development at a low[a] planting density across three locations in 1999 and 2000.

Cultivar	Row spacing	Plant diameter[b]	Pod distribution[c]	Main stem length[d]
		cm		
Georgia Green	C	84.0	35.1	26.4
	NR	81.5	29.0	24.9
Tamrun 96	C	105.0	50.0	36.5
	NR	99.1	41.4	32.3
LSD[e] (0.05)		7.1	5.3	3.8

[a]Low = 10 to 12 plants/m.
[b]Plant diameter was measured across the longest lateral branch.
[c]Pod distribution was measured as the farthest harvestable pod on the longest lateral branch from the mainstem.
[d]Main stem height was measured from the base of the plant to the terminal.
[e]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 39. Comparison of conventional (C) and narrow-row (NR) spacings for grade at a standard[a] planting density across four locations in 1999 and 2000.

Cultivar	Row spacing	%TSMK[b]
Georgia Green	C	76
	NR	75
Tamrun 96	C	74
	NR	73
LSD[c] (0.05)		NS

[a]Standard = 13 to 15 plants/m.

[b]Total sound mature kernels.

[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 40. Comparison of conventional (C) and narrow-row (NR) spacings for grade at a low[a] planting density across four locations in 1999 and 2000.

Cultivar	Row spacing	%TSMK[b]
Georgia Green	C	75
	NR	76
Tamrun 96	C	72
	NR	73
LSD[c] (0.05)		2

[a]Low = 10 to 12 plants/m.
[b]Total sound mature kernels.
[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 41. Comparison of conventional (C) and narrow-row (NR) spacings for maturity at a standard[a] planting density across two locations in 2000.

Cultivar	Row spacing	Maturity 1[b]	Maturity 2[b]
		%	
Georgia Green	C	67	74
	NR	53	70
Tamrun 96	C	45	69
	NR	34	69
LSD[c] (0.05)		14	NS

[a]Standard = 13 to 15 plants/m.
[b]Maturity at 120 and 130 DAP based on hull scrape method.
[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 42. Comparison of conventional (C) and narrow-row (NR) spacings for maturity at a low[a] planting density across two locations in 2000.

Cultivar	Row spacing	Maturity 1[b]	Maturity 2[b]
		%	
Georgia Green	C	58	74
	NR	53	68
Tamrun 96	C	43	69
	NR	30	58
LSD[c] (0.05)		13	NS

[a]Low = 10 to 12 plants/m.

[b]Maturity at 120 and 130 DAP based on hull scrape method.

[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 43. Comparison of conventional and narrow-row spacings for maturity at an ultra-low[a] planting density across two locations in 2000.

Cultivar	Row spacing	Maturity 1[b]	Maturity 2[b]
		—— % ——	
Georgia Green	C	57	67
	NR	59	68
Tamrun 96	C	45	64
	NR	41	69
LSD[c] (0.05)		13	NS

[a]Ultra low = 7 to 9 plants/m.
[b]Maturity at 120 and 130 DAP based on hull scrape method.
[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 44. Comparison of conventional (C) and narrow-row (NR) spacings for pods/plant at a standard[a] planting density across two locations in 1999.

Cultivar	Row spacing	Pods/plant[b]
Georgia Green	C	30
	NR	17
Tamrun 96	C	35
	NR	28
LSD[c] (0.05)		13

[a]Standard = 13 to 15 plants/m.

[b]Pod counts were taken from five randomly selected plants per plot.

[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 45. Comparison of conventional (C) and narrow-row (NR) spacings for pods/plant at a low[a] planting density across two locations in 1999.

Cultivar	Row spacing	Pods/plant[b]
Georgia Green	C	28
	NR	22
Tamrun 96	C	41
	NR	31
LSD[c] (0.05)		11

[a]Low = 10 to12 plants/m.
[b]Pod counts were taken from five randomly selected plants per plot.
[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 46. Comparison of conventional (C) and narrow-row (NR) spacings for white mold development at a standard[a] planting density at two locations in 2000.

Cultivar	Row spacing	White mold[b] Pearsall	White mold[b] Pleasanton
		loci/60m	loci/37m
Georgia Green	C	19	6
	NR	18	9
Tamrun 96	C	11	15
	NR	10	13
LSD[c] (0.05)		8	8

[a]Standard = 13 to 15 plants/m.

[b]A disease loci was defined as $\leq$ 30 cm of consecutive damage in a row.

[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

higher with Tamrun 96 when planted in a conventional row spacing than Georgia Green planted in a conventional row spacing.

At Pearsall, Georgia Green in a conventional and narrow-row spacing had higher white mold than Tamrun 96 planted in a conventional row spacing at the low planting density. Georgia Green both in a conventional and narrow-row spacing at Pleasanton had white mold higher than Georgia Green planted in a conventional and narrow-row spacing (Table 47). At the ultra-low planting density, Tamrun 96 in a conventional planting had lower white mold than Tamrun 96 and Georgia Green narrow-rows and Georgia Green conventional rows. At Pleasanton, white mold incidence did not appear to affect both cultivars with either the conventional or narrow-row spacing (Table 48).

Plant development revealed phenotypic differences between Georgia Green and Tamrun 96 both in a twin- and narrow-row spacing. This is not surprising considering that Tamrun 96 has a bunch growth plant habit and Georgia Green has more of a prostrate type growth. However, at the standard planting density, Tamrun 96 in a twin-row spacing had a lower plant diameter, pod distribution and main stem length compared to conventionally planted Tamrun 96. This may indicate that Tamrun 96 plant architecture is more sensitive to a denser plant population. This response was not as evident in a narrow-row spacing when compared to the conventional row spacing at all planting densities.

Twin- and narrow-rows did not enhance late-season maturity nor were there many differences in pods/plant for both Georgia Green and Tamrun 96. At the standard planting density, both Georgia Green and Tamrun 96 in a twin-row spacing, had fewer

Table 47. Comparison of conventional (C) and narrow-row (NR) spacings for white mold development at a low[a] planting density at two locations in 2000.

Cultivar	Row spacing	White mold[b]	
		Pearsall	Pleasanton
		loci/60m	loci/37m
Georgia Green	C	20	9
	NR	22	8
Tamrun 96	C	10	20
	NR	15	16
LSD[c] (0.05)		9	4

[a]Low = 10 to 12 plants/m.
[b]A disease loci was defined as $\leq$ 30 cm of consecutive damage in a row.
[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

Table 48. Comparison of conventional (C) and narrow-row (NR) spacings for white mold development at an ultra-low[a] planting density at two locations in 2000.

Cultivar	Row spacing	White mold[b]	
		Pearsall	Pleasanton
		loci/60m	loci/37m
Georgia Green	C	21	10
	NR	16	9
Tamrun 96	C	9	17
	NR	16	22
LSD[c] (0.05)		5	NS

[a]Ultra low = 7 to 9 plants/m.
[b]A disease loci was defined as $\leq$ 30 cm of consecutive damage in a row.
[c]LSD, least significant difference. Differences between means that are greater than the LSD within columns are significantly different.

pods/plant than the conventional low density planting which agrees with Sternitzke *et al.* (2000) who found that pod mass increased as total plant emergence decreased.

In three of four locations in 1999 and 2000, yield increases resulted when Georgia Green and Tamrun 96 were planted in a twin-row spacing compared to the conventional row spacing. The twin-row low planting density had yields not different and in some cases, higher than the standard planting density. Hence, growers may benefit from a lower planting density and still experience acceptable yields. When considering twin-row planting, growers will need to determine if this increase in yield would offset the cost of equipment required to plant this configuration. No clear yield advantages were evident when peanuts were planted in narrow-rows at a standard or ultra-low planting density. However, growers could benefit by planting peanuts in narrow-rows at a low planting density.

CHAPTER VI

SUMMARY AND CONCLUSIONS

In the fungicide row spacing study results indicated that the twin-row planting configuration did not have a negative impact on white mold and rust disease development when compared to the conventional row spacing. Both azoxystrobin and tebuconazole reduced white mold, rust and leaf spot when compared to the untreated check. However, it is obvious that severe leaf spot requires additional fungicide applications, preferably a chlorothalonil product. Results also indicate that similar leaf spot control with azoxystrobin and tebuconazole occurred in both the conventional and twin-row planting configuration. The use of tebuconazole provided better control of leaf spot over azoxystrobin when planted in a conventional and twin-row configuration. The late-season application of tebuconazole enhanced leaf spot control over azoxystrobin due to prolonged protection. Increased yields using the twin-row planting configuration and adequate foliar and soilborne disease control may be evidence that growers in south Texas need to adopt this practice. An identical seeding rate in the twin-row configuration compared to the conventional row spacing also eliminates additional cost in seed.

Results from the herbicide row spacing study indicated that yellow nutsedge control can be obtained with ½X and 1X rates of imazapic and diclosulam under ideal growing conditions. However, better yellow nutsedge control was obtained when imazapic and diclosulam were applied at the 1X rate. A row spacing by herbicide treatment interaction, which occurred in 2001, revealed that a twin-row pattern suppressed yellow nutsedge to acceptable levels (> 80%) when the ½X rate of imazapic and diclosulam was applied. Excessive weed pressure and rainfall, which was the case in 2002, revealed that a full rate of diclosulam or imazapic was needed to suppress yellow nutsedge regardless of row spacing. This agrees with Cardina *et al*. (1987) who suggested that increased herbicide inputs in a narrow-row pattern may be needed under high weed density.

Finally, this study revealed that to fully maximize yellow nutsedge control, the full rate of either imazapic or diclosulam should be applied to peanuts planted in a twin-row spacing. However, this may not necessarily translate into higher yields. Reduced rates of imazapic and diclosulam in 2001 and the reduced rate of diclosulam in 2002 had yields comparable to full rates of both herbicides.

Results revealed that corn planted in soil treated with imazapic and diclosulam sampled 60 DAP and at harvest had reduced fresh and dry shoot weights. This indicates that both of these herbicides were at concentrations high enough to adversely affect corn. Also, fresh root weights, dry shoot and dry root weights of sorghum were significantly reduced from soil treated primarily with diclosulam when sampled at harvest. This indicates that corn and sorghum maybe more sensitive to these herbicides. No clear advantages were apparent by using a twin-row spacing to reduce imazapic and diclosulam residual concentrations. Corn, sorghum and watermelon plant response was consistent when imazapic and diclosulam were applied to either row pattern resulting in only significant main treatment effects. Row spacing effects for cotton varied from location to location. In most cases, plant response to soil sampled from the twin-row spacing was consistent with that of the conventional row spacing. Futhermore, in most cases, soil treated with imazapic and diclosulam when collected at harvest did not have an adverse effect on cotton with either row spacing.

Effects of row spacing on peanut plant development, maturity, grade and yield revealed that the use of twin-row spacing may improve yields when compared to conventionally spaced peanuts. Both Georgia Green and Tamrun 96 in most cases had higher yields when planted in a twin-row spacing compared to their respective conventional row spacing in three out of four locations in 1999 and 2000.

As expected, based on phenotypic differences, Tamrun 96 had a higher plant diameter, pod distribution, and main stem length than Georgia Green at most row spacings and planting densities. Pod distribution for both cultivars was lower in the narrow and twin-row spacing compared to the conventional row spacing. This indicates that harvestable pod development occurred closer to the crown of the peanut plant. At the standard planting density, the twin-row spacing caused lower plant diameter and pod distribution for Tamrun 96 compared to the conventional row spacing. This effect was not evident with Georgia Green, which has a more prostrate growth habit. The use of narrow or twin-row spacing did not enhance maturity despite a more compact pod set. Pods/plant for both cultivars were reduced in a narrow and twin-row spacing compared to the conventional row spacing at the standard planting density. This agrees with Mozingo and Steele (1989) who found that pods/plant decreased as plant density increased.

Although grade (%TSMK) was improved when Tamrun 96 was planted in a twin-row spacing at the standard planting density, it was only higher than Tamrun 96 planted in a conventional row spacing at the low planting density. Grades were consistent across Georgia Green planting densities and row spacings.

Although white mold was inconsistent at both locations, disease development was not different with each cultivar for both the narrow and twin-row spacing compared to the conventional row spacing. Therefore, based on the results of this study, growers need not be concerned with increased disease development with these two cultivars when planted in a narrow or twin-row spacing. However, it should be noted that this study was conducted at multiple locations within only one year and disease development may vary with other peanut cultivars.

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