ROTATIONAL CROP RESPONSE FOLLOWING STAPLE USE IN ARIZONA COTTON

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Abstract

Crop rotation is an important agronomic and economic influence in irrigated agriculture of the desert southwest. Rotation of crops can help reduce weed competition, plant disease and insect pest pressure. Rotation can also improve soil tilth and fertility. In Arizona, cotton acreage is often rotated with small grains, corn, sorghum, alfalfa, melons and vegetables if economic conditions are favorable.

In 1994-1996, a large scale, long-term rotational crop study was conducted in Central Arizona. The purpose of the study was to evaluate the response of 17 rotational crops, under different rotational regimes (rotation interval areas), following Staple Herbicide (pyrithiobac sodium) use in upland cotton (*Gossypium hirsutum* L.)

To create a worst case scenario, single EPOT (early post over-the-top) applications of Staple were broadcast applied in 1-3 leaf stage cotton, at 1.0, 2.0 and 4.0 oz ai/ac. All treatments included 1% v/v COC (crop oil concentrate). Soil was classified as sandy clay loam with 1.1% organic matter and a pH of 8.0. Following cotton harvest, all tillage and seedbed preparation was conducted in a way that would not significantly move soil. No deep plowing or landplaning were utilized, only discing. Rotational crops were planted perpendicular to previously treated cotton, and evaluated from emergence to harvest.

Wheat, alfalfa, carrots and green leaf lettuce planted the first fall after cotton, 5 MAT (months after treatment), exhibited good tolerance to Staple up to 4.0 oz ai/ac. Head lettuce and bok choy demonstrated good tolerance up to 2.0 oz ai/ac. Broccoli, cauliflower, napa cabbage and barley showed acceptable tolerance up to 1.0 oz ai/ac. Onions displayed unacceptable tolerance at all rates tested (5 MAT).

Corn, sorghum, cantaloupe and watermelon exhibited good tolerance to Staple up to 4.0 oz ai/ac when planted the following spring (10 MAT). No significant difference was observed when ground was left fallow after cotton versus having a cover crop (wheat) grown after cotton.

Twelve vegetable crops planted into Staple treated soil the second fall after cotton (16 MAT), and following a full season cereal double crop, showed no adverse effects up to 4.0 oz ai/ac. Crops included head lettuce, green leaf lettuce, red leaf lettuce, romaine leaf lettuce, spinach, red cabbage, bok choy, napa cabbage, broccoli, cauliflower, carrots and onions.

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Introduction

Controlling weeds in cotton has many benefits and selective herbicides have played a vital role in this effort for more than 40 years. Selective herbicides are generally considered for use based on either preemergence or postemergence weed control. The decision to use a herbicide can depend on: cost effectiveness opposite hand hoeing, weed species that are either present or expected in a field, the size or stage of weeds, cotton tolerance, need for residual weed control, or potential for crop injury in subsequent crops. Many standard cotton herbicides are used for preemergence control of weeds. Some herbicides (i.e. prometryn, diuron and fluometuron) are used for post-directed weed control as well, by adding non-ionic surfactants. The use of these herbicides have been a chronic concern for growers in regards to cotton tolerance and/or potential rotational crop injury.

Seven factors affect the persistence of a herbicide in soil: microbial degradation, chemical degradation, photo-degradation, adsorption on soil colloids, leaching, volatility and removal by higher plants.

Rotational crop response to herbicide soil residue can vary depending on several other contributing factors: herbicide rate of application, method of application, number of applications, duration of time between application and planting, soil characteristics, sunlight, temperatures, rainfall, irrigation, tillage operations and natural crop tolerance.

In 1996, Staple Herbicide was introduced for early postemergence weed control in Arizona cotton. This introduction provided cotton growers with a new and improved tool for controlling broadleaf weeds such as annual morningglories (*Ipomoea* spp.), pigweeds (*Amaranthus* spp.) and groundcherry (*Physalis* spp.) with over-the-top or post-directed applications. Growers found that selective, early season weed control could be achieved in commonly grown upland varieties, without having to switch to genetically modified varieties to ensure crop safety.

Preemergence activity can be an advantage in cotton weed control. It can also be a disadvantage if herbicide residues significantly affect the growth and development of subsequent crops. With well documented preemergence activity of Staple on certain weed species in cotton, it is important to know if Staple can affect rotational crops.

Since 1990, numerous crop rotation studies have been conducted in Arizona to better understand Staple, and have focused on:

1) What rotational crops are sensitive to Staple?

2) What rates are rotational crops sensitive?

3) What intervals can rotational crops be safely planted?

4) How will multiple year use affect rotational crops?

5) What options are available to reduce or eliminate potential rotational crop injury (i.e. banded applications, post-tillage operations, double cropping, green manure/cover crops)?

Materials and Methods

In spring 1994, a large scale, long term study was designed and implemented to evaluate response of 17 rotational crops, under different rotational regimes (rotation interval areas), following Staple use in cotton.

To conduct the experiment, several key components were necessary in selecting an appropriate test site:

1) Irrigation capability from two different directions
rotational crops would be planted perpendicular to cotton

2) Relatively large area (10 acres)
four different rotational crop areas (2.5 acres/regime) would follow cotton, to simulate grower options and practices

3) Rotational crops managed independently of each other
crops would require different seedbed preparation, fertility, irrigation, cultivation, weed control, insect control, planting and harvesting equipment.

4) Relatively light soils
lighter soils are common to Arizona cotton growing areas and tend to exhibit greater crop injury from herbicide residue

The study was designed to demonstrate significant crop injury and/or tolerance of rotational crops. To create a worst case scenario, four procedures were critical for the experiment:

1) Broadcast applications
applied in small cotton for maximum soil exposure

2) Label and overlabel treatment rates
single application at 1x, 2x and 4x rates

3) No significant soil movement after cotton
No deep plowing or landplaning allowed, only discing.

4) Multiple rotational crop regimes
short and long term planting intervals with and without a cereal double crop or green manure/cover crop.

The test site selected was in Central Arizona, and located at the University of Arizona Maricopa Agricultural Center (UA MAC). The experimental station is approximately 30 miles south of Phoenix and is well suited for this type of experiment. The eastside of Field #3 was used, due to the location of head irrigation ditches on the east and south sides of the field. Ten acres planted with oats was first disced down, deep plowed, then laser leveled essentially flat for controlled irrigation purposes. Prowl 3.3E (pendimethalin) was broadcast applied at 0.75 lb ai/ac and preplant incorporated into soil to control weeds in the cotton crop. Rows were then listed east and west for upland cotton to be planted. Soil texture was classified as sandy clay loam, with 1.1% organic matter, a pH of 8.0 and 22.1 CEC.

Approximately 10 acres of short staple cotton, variety DPL 5415, was planted in an east/west direction on May 1, 1994. Row width was 40 inches. Cotton plots were 16 rows wide (53.33 feet) by 640 feet long. Two fallow rows separated each cotton plot. Cotton was furrow irrigated from a head irrigation ditch on the eastside.

Single applications of Staple 85SP Herbicide were broadcast applied EPOT (early post over-the-top) in 1-3 leaf stage cotton, on June 6, 1994. Treatment rates were 1.0, 2.0 and 4.0 oz ai/ac. All treatments included 1% v/v COC (crop oil concentrate). A tractor-pulled sprayer treated four cotton rows per pass, and made four passes in each 16 row cotton plot. Two randomized and replicated cotton plots were used for each Staple treatment rate and untreated check. The spray boom was configured with TeeJet XR 8004VS nozzles spaced 20 inches apart. Spray volume was 22 GPA and spray pressure was 30 PSI.

Cotton was furrow irrigated (every-row) throughout the summer months. A total of six irrigations were used following the Staple EPOT applications. Irrigations were made on June 9, June 21, July 7, July 22, August 9 and August 24, 1994. An estimated half-acre foot of water was used per irrigation. Generally, this is equivalent to six inches of rainfall per irrigation. An estimated total of three-acre foot of water was used to irrigate the upland cotton in this study (approximately 36 inches of rainfall equivalent).

Cotton was fertilized and sprayed for insect pests per standard grower practice. Cotton was defoliated with broadcast applications of Dropp 50WP (thiazuron) plus Def 6E (tribufos) at 0.1 + 1.125 lb ai/ac on September 15, 1994.

Cotton was machine picked on October 12, 1994. Cotton plots (16 rows x 640 feet) were picked separately one time, dumped into individual cotton trailers and weighed for seed cotton yields.

Following cotton harvest, post-tillage operations included: shredding cotton stalks, pulling-out stalks, discing down cotton rows, deep ripping diagonally, discing crossways and listing new rows north and south (perpendicular to the cotton rows). Cereal crops were planted to rows without additional seedbed preparation, while alfalfa rows were disced flat prior to planting, and vegetable rows were mulched and shaped prior to planting. All tillage and seedbed preparation was conducted in a way that would not significantly move soil, in order to maintain the integrity of the treated and non-treated areas.

Rotational crops, in their respective regimes, were dry planted in a north/south direction, perpendicular to previously treated cotton. Crops were planted in either four-row wide blocks or as individual rows (planted replicates), depending on the crop. Two fallow rows separated each four-row wide block. There were two planted replicates of each crop within a regime. With treatments replicated twice in cotton, and crops replicated twice in each rotational regime, there would be four replicate crop treatments to evaluate. All rotational crops were furrow irrigated from a head irrigation ditch on the southside. Rotational crops were treated for insect pests and grass weeds on an as needed basis.

The first rotational regime (Regime #1), was the western most regime. Fall 1994 rotational crops were dry planted on November 8 and 9, 1994, approximately 5 MAT (months after treatment). The first germinating irrigation for these crops was on November 10, 1994.

Fall 1994 rotational crops included head lettuce, variety Van Max (2 rows/rep); green leaf lettuce, variety Royal Green (1 row/rep); red leaf lettuce, variety Prizehead (1 row/rep); broccoli, variety Marathon (2 rows/rep); cauliflower, variety Ravella (1 row/rep); cauliflower, variety Candid Charm (1 row/rep); bulb onions, variety Henry's Special (1 row/rep); and alfalfa, variety CUF 101 (4 rows/rep). All fall vegetable crops were planted with two seedlines per row. Alfalfa was drill planted solid to flat rows. All crops were dry planted in a north/south direction and irrigated from a southside irrigation ditch.

The second rotational regime (Regime #2), located to the east of Regime #1, was left as fallow-beds throughout the fall and winter months, and planted with spring 1995 rotational crops on April 14, 1995 (10 MAT).

Spring 1995 rotational crops included silage corn, variety Germains 3114 (4 rows/rep); grain sorghum, variety Oro Amigo (4 rows/rep); cantaloupe, variety Valley Gold (2 rows/rep); and watermelon, variety Emperor (2 rows/rep); All spring crops were drilled planted with one seedline per row. Corn and sorghum were planted in four-row planted replicates. Cantaloupe and watermelon, were skip-row planted in their four-row planted replicates, to allow these crops to spread properly without overcrowding. All melon rows were treated with Prefar 4E (bensulide) at 3.0 lb ai/ac prior to mulching and shaping beds.

The third rotational regime (Regime #3), located immediately east of Regime #2, was planted with wheat, variety Kronos, as a green manure/cover crop (5.5 MAT), on November 21, 1994. Wheat was drill planted solid in a north/south direction on dry raised beds and irrigated-up. Wheat received irrigations during the winter months along with rainfall. Wheat was disced-down prior to heading so that the same 1995 rotational crops planted in Regime #2 could be planted in Regime #3 on April 14, 1995 (10 MAT). Melon rows were treated with Prefar 4E at 3.0 lb ai/ac prior to mulching and shaping beds.

The two spring 1995 rotational regimes mentioned above (Regime #2 and #3) would be compared to each other to see if having an irrigated cover crop such as wheat, grown immediately after cotton, can help breakdown Staple residue, versus leaving a field fallow prior to planting spring crops.

The fourth and final regime (Regime #4), located immediately east of Regime #3, was planted with barley, variety Mucho (5.5 MAT), on November 21, 1994. Barley was drill planted solid in a north/south direction on dry raised beds and irrigated-up. The barley received irrigations during the winter and spring months as well as rainfall. Barley was grown to maturity and harvested on May 16, 1995. Following barley harvest, stubble was disced down in this regime and remained fallow the rest of the summer. In the fall, rows were again listed in a north/south direction, then mulched and shaped before planting twelve fall 1995 vegetable crops on October 19, 1995 (16 MAT).

Fall 1995 vegetable crops planted were head lettuce, variety Van Max (1 row/rep); green leaf lettuce, variety Royal Green (1 row/rep), red leaf lettuce, variety Prizehead (1 row/rep), romaine leaf lettuce, variety Clemente (1 row/rep); spinach, variety Bolero (1 row/rep); red cabbage, variety Sombrero (1 row/rep); napa cabbage, variety China Express (1 row/rep); bok choy, variety Joi Choi (1 row/rep); broccoli, variety Marathon (2 rows/rep); cauliflower, variety Ravella (2 rows/rep); carrots, variety Navajo (2 rows/rep); and bulb onions, variety Henry's Special (2 rows/rep). All fall vegetables were planted with two seedlines per row. Volunteer barley was treated postemergence with Poast 1.5E (sethoxydim) at 0.375 lb ai/ac + 1% v/v COC on November 15 and November 30, 1995 in all fall vegetable crops.

Stand counts were taken after emergence for all rotational crops. Fall vegetables, corn, sorghum and melon crops were counted as # plants/10 foot row, from two rows or seedlines (sub-plots) per plot. Alfalfa and barley seedlings were counted as # plants/square foot, from three random locations per plot.

Plant height or width measurements were made as crops developed and grew. Ten plants per plot (5 plants/sub-plot) were measured from fall vegetables, alfalfa, silage corn, sorghum and melons. Visual crop response evaluations were taken in barley.

Barley yields were taken at maturity by harvesting two sub-plots (10 feet wide x 52 feet long) with a small plot combine and weighing the grain.

Alfalfa fresh weight yields were determined by sicklebar mowing a five foot wide strip through the middle of all alfalfa plots. Fresh cut alfalfa was then gathered from a 5 foot wide x 10 foot long area within each plot and weighed.

Fall vegetables, silage corn and sorghum fresh weight yields were found by randomly cutting ten plants per plot (5 plants/sub-plot) at the soil surface and weighing them.

Carrot and onion fresh weight yields were determined by randomly digging-up ten entire plants per plot and weighing them.

Fruit numbers and fresh weight yields were taken for melon crops by collecting, counting and weighing all fruit in a designated sample area (13.33 feet wide x 10 feet long) within each plot.

Grain sorghum head weights were taken by randomly cutting and weighing ten heads per plot (5 heads/sub-plot).

Results and Discussion

Cotton yields taken from Staple treatments were not significantly different from the untreated check. The untreated check averaged 2986 lbs/acre seed cotton, while Staple treatments averaged 2833, 2865, and 2877 lbs/acre seed cotton at the 1.0, 2.0 and 4.0 oz ai/ac, respectively.

Regime #1 - Cotton fb Fall 1994 Crops (5 MAT)

Stand counts of 10 fall rotational crops, planted 5 MAT, were not significantly effected by Staple when evaluated on December 20, 1994 and January 9, 1995.

Chinese cabbage. Bok choy exhibited acceptable tolerance at the 1.0 and 2.0 oz ai/ac rates, but less than acceptable tolerance at 4.0 oz ai/ac. Fresh weight yields taken on March 1, 1995 were 93%, 94% and 80% of check, with ascending rates of Staple.

Napa cabbage showed acceptable tolerance at the 1.0 oz ai/ac rate, but less than acceptable tolerance at 2.0 and 4.0 oz ai/ac. Fresh weight yields taken on March 1, 1995 were 103%, 85% and 70% of check, with ascending rates of Staple.

Leaf and head lettuce. Green leaf lettuce showed good tolerance to Staple up to 4.0 oz ai/ac. Fresh weight yields taken on March 13, 1995 were greater than 99.5% of check in all Staple treatments.

Red leaf lettuce exhibited fresh weight yields of 73%, 56% and 54% of check, with ascending rates of Staple. It should be noted however, that only reps I and III had a crop to harvest. In reps II and IV we had to use older seed (1993) when planting, and it did not germinate in either Staple treatments or untreated checks.

Head lettuce, harvested on April 3, 1995, showed good tolerance to Staple at 1.0 and 2.0 oz ai/ac (99% of check), but less than acceptable tolerance at 4.0 oz ai/ac (77% of check).

Broccoli and cauliflower. Broccoli exhibited an early season rate response (stunting) to Staple when evaluated on January 11, 1995. Plant height measurements, averaged 92%, 77% and 50% of check, at 1.0, 2.0 and 4.0 oz ai/ac, respectively. As the season progressed, broccoli appeared to recover well. Fresh weight yields taken on April 3, 1995, were 106%, 100% and 119% of check, with ascending rates of Staple.

Cauliflower (cv. Ravella) showed an early season rate response (stunting) to Staple when evaluated on January 11, 1995. Plant height measurements were 94%, 67% and 66% of check with ascending rates of Staple. At harvest, on April 3, 1995, fresh weight yields were 97%, 85% and 85% of check, respectively.

Cauliflower (cv. Candid Charm) showed similar early season response and fresh weight yield results. Plant height measurements averaged 99%, 78% and 75% of check, with ascending rates of Staple. Fresh weight yields were 106%, 76% and 81% of check, respectively.

Carrots and onions. Carrots demonstrated acceptable tolerance to Staple at all rates tested. Fresh weight yields taken on April 3, 1995 were 94%, 92% and 93% of check, at 1.0, 2.0 and 4.0 oz ai/ac, respectively.

Onions showed unacceptable crop injury (stunting and fresh weight yield reduction) at all rates tested. Plant height measurements, taken on January 11, 1995, averaged 94%, 75% and 87% of check at 1.0, 2.0 and 4.0 oz ai/ac, respectively. Fresh weight yields taken on April 3, 1995 were 72%, 68% and 62% of check, with ascending rates of Staple.

Alfalfa. Alfalfa exhibited some early season crop response (stunting) to Staple when evaluated on January 11, 1995, but only at the two highest rates tested. Plant height measurements, averaged 99%, 76% and 90% of check, at the 1.0, 2.0 and 4.0 oz ai/ac rates. Alfalfa fresh weight yields taken on April 3, 1995, were 102%, 114% and 92% of check, at ascending rates of Staple.

Regime #2 - Cotton fb Fallow fb Spring 1995 Crops (10 MAT)

After cotton harvest, this regime was listed with north/south rows and remained fallow through the fall/winter months. Rows were mulched and shaped prior to planting spring 1995 crops on April 14, 1995 (10 MAT).

Stand counts of four spring rotational crops, planted 10 MAT, were not adversely effected by Staple up to 4.0 oz ai/ac, when evaluated on May 22, 1995.

Cantaloupe, watermelon, silage corn and grain sorghum planted in the spring of 1995 (10 MAT) showed no significant injury up to 4.0 oz ai/ac.

Regime #3 - Cotton fb Wheat (cover crop) fb Spring 1995 Crops (10 MAT)

Wheat, planted the first fall (5.5 MAT), as a green manure/cover crop exhibited acceptable early season tolerance to Staple up to 4.0 oz ai/ac. The wheat was disced down prior to heading, in order to list rows and prepare seedbeds for the spring 1995 rotational crops planted on April 14, 1995 (10 MAT).

Stand counts of four spring rotational crops, planted 10 MAT, were not adversely effected by Staple up to 4.0 oz ai/ac, when evaluated on May 22, 1995.

Cantaloupe, watermelon, silage corn and grain sorghum planted in the spring of 1995 (10 MAT), showed no significant injury up to 4.0 oz ai/ac. The wheat cover crop, planted the first fall after cotton, and disced under prior to heading, did not appear to help or hinder the tolerance of spring planted crops to Staple.

Regime #4 - Cotton fb Barley (full season) fb Fall 1995 Crops (16 MAT)

Barley, planted the first fall (5.5 MAT), exhibited a rate response to Staple in the early tillering stage. Subjective visual crop injury evaluations taken on January 14, 1995 showed significant chlorosis and stunting of barley, particularly at the two highest rates tested versus the untreated check. Stunting averaged 13%, 23% and 38% of the check at rates of 1.0, 2.0 and 4.0 oz ai/ac, respectively. Crop injury ratings six weeks later, exhibited less stunting then before with averages of 3%, 13% and 18% of the check, with ascending Staple rates. Barley grain yields were taken on May 16, 1995. Even though significant stunting was observed early season at the two highest rates, grain yields averaged 88%, 91% and 101% of check, with ascending rates of Staple.

Following barley harvest, stubble was disced down in this regime and remained fallow the rest of the summer. In the fall, rows were again listed in a north/south direction, then mulched and shaped prior to planting twelve fall 1995 vegetable crops on October 19, 1995 (16 MAT).

Twelve vegetable crops planted into Staple treated soil the second fall (16 MAT), and following a full season cereal double crop after cotton, displayed no significant crop injury up to 4.0 oz ai/ac. Crops included head lettuce, green leaf lettuce, red leaf lettuce, romaine leaf lettuce, spinach, red cabbage, bok choy, napa cabbage, broccoli, cauliflower, carrots and onions.

Conclusions

Based on the results from this study, several rotational crop options exist for growers following the use of Staple in Arizona cotton:

* Wheat, alfalfa, carrots and green leaf lettuce, planted the first fall after cotton (5 MAT), exhibited good tolerance to Staple up to 4.0 oz ai/ac.

* Head lettuce and bok choy, planted the first fall after cotton (5 MAT), demonstrated good tolerance up to 2.0 oz ai/ac.

* Barley, broccoli, cauliflower and napa cabbage, planted the first fall after cotton (5 MAT), showed acceptable tolerance up to 1.0 oz ai/ac.

* Onions were least tolerant to Staple at all rates tested (5 MAT).

* Corn, sorghum, cantaloupe and watermelon, planted the first spring after cotton (10 MAT), displayed good tolerance to Staple up to 4.0 oz ai/ac.

* Twelve fall vegetables planted into Staple treated soil the second fall after cotton (16 MAT), and following a full season cereal double crop, showed no adverse effects up to 4.0 oz ai/ac. Crops included head lettuce, green leaf lettuce, red leaf lettuce, romaine leaf lettuce, spinach, red cabbage, bok choy, napa cabbage, broccoli, cauliflower, carrots and onions.

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