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Cultural control of yellow nutsedge (*Cyperus esculentus*) in transplanted cantaloupe (*Cucumis melo*) by varying application timing and type of thin-film mulches

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Abstract

Irrigated field trials were conducted in Tifton, GA, at the Coastal Plain Experiment Station to determine the effectiveness of thin-film mulch application times and mulching materials in suppressing yellow nutsedge in transplanted cantaloupe production. Thin-film mulches were applied to freshly tilled seedbeds the day of transplanting, 1, 2, and 3 weeks prior to transplanting. Mulching materials were clear, black, and white on black low-density polyethylene (LDPE), along with a non-covered (bareground) control. Yellow nutsedge emergence in transplanted cantaloupe was suppressed by the combined effects of a physical barrier provided by thin-film mulches and competitive size differential provided by using cantaloupe transplants. All of the thin-film mulches applied to freshly prepared seedbeds either the day of transplanting or 1 week before transplanting effectively suppressed yellow nutsedge in transplanted cantaloupe production, without the need for fumigants or herbicides. Yellow nutsedge suppression in bareground seedbeds freshly prepared within 1 week of transplanting was nearly as effective as suppression from thin-film mulches. Seedbed preparation and applying thin-film mulch 2 or 3 weeks before transplanting did not effectively suppress yellow nutsedge and cantaloupe yields were reduced. In systems where soil fumigation and herbicide use are not possible, yellow nutsedge can be effectively suppressed and crop yields protected by applying thin-film mulches immediately prior to transplanting cantaloupe.
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Keywords: Cultural weed control; Organic weed control; Yellow nutsedge

1. Introduction

Perennial nutsedges (*Cyperus* spp.) are among the most common and troublesome weeds of cucurbit crops in the southeastern US (Webster, 2002). Yellow nutsedge (*Cyperus esculentus* L.) and purple nutsedge (*Cyperus rotundus* L.) comprise the complex, with yellow nutsedge the more common species in the region. Both species reduce yield of cucurbit crops and are costly to control. In conventional production systems, perennial nutsedge management systems are built around preplant fumigation with methyl bromide (where uses are still permissible), metham-sodium (methylcarbamodithioic acid), chloropicrin, and/or 1,3-D (1,3-dichloropropene) (Gilreath and Santos, 2004; Johnson and Mullinix, 2002; Locascio et al., 1997). Halosulfuron {3-chloro-5-[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl] amino]sulfonyl]-1-methyl-1*H*-pyrazole-4-carboxylic acid]} is a selective herbicide that controls perennial nutsedges in certain vegetable crops, including cucurbits (Johnson and Mullinix 2002, 2005). However, marginal cucurbit crop tolerance (Webster et al., 2003) and persistence to future plantings of sensitive crops hinders its widespread adaptation.

An integrated system of fumigants and halosulfuron is costly and requires specialized equipment to apply the fumigants. A system using these inputs is often relegated to intensive cropping systems that feature elevated seedbeds 1.8 m wide, drip irrigation, and black thin-film low-density polyethylene (LDPE) mulch. Systems of this type use

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sequential plantings of short-season crops on the same covered seedbeds. While this system is an attractive means to amortize cost of LDPE mulch and drip irrigation across several crops, perennial nutsedges puncture opaque thin-film mulch, greatly reducing the integrity of the seedbed cover.

Many cantaloupe and watermelon growers in the southeastern US use a different production system. These growers use hybrid transplants on narrow (40 cm wide) thin-film mulch-covered seedbeds, overhead irrigation, and use the seedbeds for only one crop in the growing season (Johnson and Mullinix, 2002, 2007). In these cases, maintaining the long-term integrity of the thin-film mulch is not as important as in the multi-crop system. The major objective of weed control in this modified system is to simply prevent watermelon and cantaloupe yield loss from weed competition, with little concern in maintaining the integrity of the thin-film mulch.

Despite the losses that perennial nutsedges cause in vegetable crop production, perennial nutsedges tend to be among the least competitive weeds. Both yellow and purple nutsedges were found to be susceptible to shading from crops and other weeds (Keely and Thullen, 1978; William, 1976). Santos et al. (1997) also showed the sensitivity of perennial nutsedges to shading from other plants, with purple nutsedge being more sensitive to low light intensity than yellow nutsedge. Cucurbits are aggressive crops that offer the potential to be effective competitors with shade-sensitive perennial nutsedges. Furthermore, transplanting cucurbits creates an artificial size differential that beneficially alters the competitive relationship between crops and weeds (Bond and Grundy, 2001; Mohler, 1996). It is plausible that the combined benefits of aggressive cucurbit crop growth and use of transplants would greatly benefit the integrated management of perennial nutsedges.

Thin-film mulches effectively suppress weed emergence, including perennial nutsedges (Majek and Neary, 1991; Webster, 2005). In Georgia, opaque thin-film mulches reduced the number of yellow nutsedge shoots by 96% and tuber production by 49% compared to bareground (Webster, 2005). While thin-film mulches are generally suppressive, enough perennial nutsedges penetrate the mulch and ruin the mulch integrity. Insufficient light penetrates opaque thin-film mulch to stimulate the perennial nutsedge leaf sheath to unfold and the unfolded leaf sheath eventually punctures the opaque thin-film mulch. Clear thin-film mulch is more effective than opaque mulches in suppressing perennial nutsedge emergence. Light-penetrating clear mulch stimulates the leaf sheath of perennial nutsedges to unfold while under the mulch and the plant is no longer able to puncture the clear mulch. Eventually, this leads to weed mortality and reduces perennial nutsedge tuber production (Chase et al., 1998; Patterson, 1998).

In the absence of soil fumigation and the resulting soil-aeration period between fumigation and transplanting, the aggressive growth habit of transplanted cucurbits could be capitalized to suppress emergence of perennial nutsedges through the thin-film mulch. We propose that a system by which thin-film mulch is applied to a weed-free seedbed and immediately transplanting an aggressive cucurbit crop would adequately suppress perennial nutsedges for maximum cucurbit yield. These principles have been broadly discussed as critical components of a weed management system that does not use herbicides or fumigants, particularly organic crop production (Anonymous, 1991; Bond and Grundy, 2001; Hatcher and Melander, 2003).

2. Materials and methods

Irrigated field trials were conducted from 2004 to 2006 at the Coastal Plain Experiment Station Ponder Farm near Tifton, GA. The soil was a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults), composed of 88% sand, 6% silt, and 6% clay, with 0.2% organic matter and pH of 6.4. These sites represent commercial cantaloupe production in the southeastern US and had heavy natural infestation of yellow nutsedge ($\leqslant 75$ plants/m^2).

The experimental design was a split-plot with treatments replicated four times. Main plots were four thin-film mulch application times; 3 week pre-transplant, 2 week pre-transplant, 1 week pre-transplant, and day of transplanting. Sub-plots were types of thin-film mulching material: clear LDPE, black LDPE, white on black LDPE, and non-mulched (bareground) control. All thin-film mulching materials were 0.025 mm thick and 61 cm wide. At the time of laying thin-film mulching materials, the appropriate seedbeds including bareground controls were freshly tilled with a power tiller that prepared a swath 1.8 m wide to a depth of 7.6 cm. Thin-film mulching materials were applied using a mulch layer (Pro-Junior Series® mulch layer, Buckeye Tractor Company, OH, USA), with the finished seedbed 40 cm wide. Once thin-film mulches were applied, plots within that time of mulching remained non-disturbed until transplanting.

Three weeks before transplanting, 'Vienna' cantaloupe (Seminis Inc., CA, USA) were seeded in greenhouse trays (Beaver Plastics Ltd., Alberta, Canada). Each tray contained 128 cells and each cell was 3.8 cm by 3.8 cm in dimension. Seedlings were established using a transplanter (Kennco Manufacturing, Inc., FL, USA) that simultaneously cut holes in the thin-film mulch and transplanted seedlings in one row centered on the finished seedbed. Cantaloupe were transplanted into the field on 20 May 2004, 19 May 2005, and 24 April 2006. Plots were 1.8 m wide and 6.1 m long, with cantaloupe seedlings spaced 56 cm apart. Plots were sprinkler irrigated as needed based on crop and meteorological conditions. Ethalfluralin (0.6 kg ai/ha) plus glyphosate (1.1 kg ai/ha) were applied to the entire experiment after transplanting for maintenance weed control in the row middles using a hooded sprayer that treated a band 71 cm wide. Excluding weed control, cultural practices and pest management decisions for transplanted cantaloupe were based on

recommendations from the Georgia Cooperative Extension Service (Boyhan et al., 1999).

Visual estimations of yellow nutsedge control and numbers of emerged yellow nutsedge shoots in the entire finished seedbed were recorded 3 weeks after transplanting. Visual ratings were based on a scale of 0–100, where 0 = no weed control and 100 = complete weed control. Yields were measured by harvesting mature fruits from the entire plot at 4-day intervals, depending on the continued presence of marketable fruits.

Data were analyzed using a mixed-model analysis. Degrees of freedom were partitioned to test singularly and in combination the effects of time laying thin-film mulch and type of mulching material on yellow nutsedge control and cantaloupe yield. Means were separated using Fisher's protected LSD ($P \leqslant 0.05$).

3. Results

Data analysis showed non-significant year by treatment interactions for all parameters evaluated. Therefore, all data were pooled across years.

3.1. Yellow nutsedge control

Yellow nutsedge was effectively suppressed in the cantaloupe seedbed without the use of fumigants or herbicides by preparing seedbeds and applying thin-film mulch either 1 week prior to transplanting or on the same day of transplanting (Table 1). During this time interval of thin-film mulch application, suppression of yellow nutsedge emergence did not differ among the choice of mulching materials. Furthermore, when seedbeds were prepared within 1 week prior to transplanting, yellow nutsedge emergence in bareground seedbeds did not differ from the seedbeds covered with clear, black, or white/black LDPE films.

Yellow nutsedge was not as effectively suppressed when black or white/black thin-film mulch was applied 2 and 3 weeks prior to transplanting and yellow nutsedge readily punctured both mulching materials. However, clear mulch effectively suppressed emergence of yellow nutsedge when applied 2 weeks prior to transplanting. Yellow nutsedge emerged under clear mulch, but was unable to penetrate the mulch. Furthermore, upward pressure from yellow nutsedge trapped under the clear mulch was not sufficient to displace the mulch. Bareground seedbeds prepared 2 or 3 weeks prior to transplanting were heavily infested with yellow nutsedge.

3.2. Cantaloupe yield

Cantaloupe fruit number was not affected by times of applying thin-film mulch (Table 2). Similarly, the average size of harvested cantaloupe fruits was not affected by the

Table 2
Effects of the time of mulching on transplanted cantaloupe yield; 2004–2006[a]

Time of mulching	Total cantaloupe yield (no./ha)	Average fruit size (kg/fruit)
Day of transplanting	15,640	3.40
1 week prior	14,100	3.33
2 weeks prior	13,940	3.25
3 weeks prior	14,080	3.39
LSD (0.05)	ns	ns

[a]All data pooled across types of mulching material.

Table 1
Interactive effects of time of mulching and mulching material on yellow nutsedge control in cantaloupe evaluated 3 week after transplanting; 2004–2006

Time of mulching	Mulching material	Yellow nutsedge control in seedbed (%)	Emerged yellow nutsedge in seedbed (no./m^2)
Day of transplanting	Bareground	85	7.4
	Clear LDPE	92	1.4
	Black LDPE	92	1.9
	White/black LDPE	89	2.6
1 week prior	Bareground	83	4.9
	Clear LDPE	87	3.6
	Black LDPE	90	1.8
	White/black LDPE	86	4.2
2 weeks prior	Bareground	66	16.4
	Clear LDPE	88	3.8
	Black LDPE	83	9.1
	White/black LDPE	80	8.0
3 weeks prior	Bareground	55	11.8
	Clear LDPE	81	6.4
	Black LDPE	79	4.2
	White/black LDPE	75	6.4
LSD (0.05)		11	5.3

time of mulching. However, cantaloupe fruit number was reduced when transplanted on bareground seedbeds, compared to any of the thin-film mulches evaluated (Table 3), with no difference in cantaloupe yield when transplanted on black, clear, or white/black LDPE-covered seedbeds. Average cantaloupe fruit size was smaller on bareground seedbeds, compared to any of the thin-film mulches evaluated.

Cantaloupe yield (kg/ha) was affected by the interactive effects of time of mulch application and mulching material (Table 4). Cantaloupe yields (kg/ha) were reduced when transplanted on bareground seedbeds when seedbeds were prepared from 1 to 3 weeks before transplanting. In contrast, cantaloupe yields (kg/ha) were not affected when bareground seedbeds were prepared the day of transplanting. Cantaloupe yields (kg/ha) did not differ among the thin-film mulches, regardless of the time of mulch application.

Table 3
Effects of thin-film mulching materials on transplanted cantaloupe yield; 2004–2006[a]

Type of thin-film mulch	Total cantaloupe yield (no./ha)	Average fruit size (kg/fruit)
Bareground	11,020	3.12
Clear LDPE	15,150	3.40
Black LDPE	16,330	3.38
White/black LDPE	15,260	3.47
LSD (0.05)	3210	0.20

[a]All data pooled across times of mulch application.

Table 4
Interactive effects of time of mulching and mulching material on total cantaloupe yield; 2004–2006

Time of mulching	Mulching material	Total cantaloupe yield (kg/ha)
Day of transplanting	Bareground	43,510
	Clear LDPE	57,380
	Black LDPE	56,750
	White/black LDPE	47,010
1 week prior	Bareground	33,030
	Clear LDPE	48,250
	Black LDPE	52,670
	White/black LDPE	54,480
2 weeks prior	Bareground	30,520
	Clear LDPE	47,660
	Black LDPE	52,290
	White/black LDPE	51,810
3 weeks prior	Bareground	26,080
	Clear LDPE	47,030
	Black LDPE	52,620
	White/black LDPE	53,370
LSD (0.05)		23,920

4. Discussion

4.1. Yellow nutsedge control

Perennial nutsedges tend to puncture and emerge through thin-film mulches, yet these materials partially suppress weed emergence and reduce tuber production (Majek and Neary, 1991; Webster, 2005). Our results indicate that black, clear, and white/black thin-film mulch suppresses emergence of yellow nutsedge compared to bareground seedbeds (Table 1). When these mulches were applied to freshly tilled, weed-free seedbeds within 1 week of transplanting cantaloupe, few yellow nutsedge plants were able to puncture and emerge through the thin-film mulch. This is likely due to the physical barrier that the thin-film mulches provide and the shading provided by the rapidly growing transplants. When the black or white/black thin-film mulches were applied to seedbeds 2 or 3 weeks prior to transplanting, yellow nutsedge had time to penetrate the thin-film mulch. In contrast, clear thin-film mulch suppresses yellow nutsedge at all times of mulch application since yellow nutsedge cannot readily penetrate clear mulch due to the unfolded leaf sheath (Chase et al., 1998).

4.2. Cantaloupe yield

Despite the differences in yellow nutsedge suppression due to time and type of mulching, the presence of yellow nutsedge does not necessarily reduce cantaloupe yield. Yellow nutsedge in seedbeds covered with any of the thin-film mulches did not reduce cantaloupe yield (Tables 3 and 4). Cantaloupe yield (kg/ha) was reduced in plots when bareground seedbeds were established from 1 to 3 weeks before transplanting, compared to no yield reduction when bareground seedbeds were prepared the day of transplanting (Table 4). This suggests that on bareground seedbeds, yellow nutsedge needs to be present at least 1 week prior to transplanting cantaloupe before it can reduce yield. Otherwise, cantaloupe effectively competes with yellow nutsedge when promptly transplanted to freshly tilled weed-free seedbeds.

Interestingly, the only cantaloupe yield parameter that was consistently affected by the interactive effects of time of mulching and mulching material was yield expressed as kg/ha (Table 4). The number of marketable cantaloupe fruits was affected only by the type of seedbed mulching material (Table 3), not time of mulching (Table 2). While beyond the scope of this study, these data suggest that yellow nutsedge is not overly competitive with transplanted cantaloupe in this production system. The number of marketable cantaloupe fruits produced in the presence of yellow nutsedge was not consistently affected by yellow nutsedge control. Rather, the fruits tended to be smaller and yield measured as kg/ha reflects that effect. Additional studies are needed to accurately quantify the competitive effects of yellow nutsedge on transplanted cantaloupe.

5. Conclusion

Managing yellow nutsedge is one of the major inputs in transplanted cantaloupe production. In production systems that feature seedbeds used for only a single crop and the integrity of the thin-film mulch is not overly important, this system of cultural weed control offers potential without having to use fumigants or herbicides. Simply compressing the crop production events such that seedbed preparation, thin-film mulch application, and transplanting are in rapid sequence will alter the competitive relationship between cucurbit crops and perennial nutsedges, and potential for yield losses will be minimized. This practice is consistent with the integrated principles of weed management in organic cropping systems and can be easily adapted for use in those systems.

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References

Anonymous, 1991. Mechanical Weed Control: Keys to Getting Yields while Reducing or Eliminating the Use of Herbicides. Land Stewardship Project. Lewiston, MN, 8pp.

Bond, W., Grundy, A.C., 2001. Non-chemical weed management inorganic farming systems. Weed Res. 41, 383–405.

Boyhan, G.E., Kelley, W.T., Granberry, D.M., 1999. Cantaloupe and specialty melons. Univ. GA Coop. Ext. Ser. Bull. 1179.

Chase, C.A., Sinclair, T.R., Shilling, D.G., Gilreath, J.P., Locascio, S.J., 1998. Light effects on rhizome morphogenesis in nutsedges (*Cyperus* spp.): implications for control by soil solarization. Weed Sci. 46, 575–580.

Gilreath, J.P., Santos, B.M., 2004. Efficacy of methyl bromide alternatives on purple nutsedge (*Cyperus rotundus*) control in tomato and pepper. Weed Technol. 18, 341–345.

Hatcher, P.E., Melander, B., 2003. Combining physical, cultural, and biological methods: prospects for integrated non-chemical weed management strategies. Weed Res. 43, 393–403.

Johnson III, W.C., Mullinix Jr., B.G., 2002. Weed management in watermelon (*Citrullus lanatus*) and cantaloupe (*Cucumis melo*) transplanted on polyethylene covered seedbeds. Weed Technol. 15, 387–395.

Johnson III, W.C., Mullinix Jr., B.G., 2005. Effect of herbicide application method on weed management and crop injury in transplanted cantaloupe production. Weed Technol. 19, 108–112.

Johnson III, W.C., Mullinix Jr., B.G., 2007. Yellow nutsedge (*Cyperus esculentus*) control with metham-sodium in transplanted cantaloupe (*Cucumis melo*). Crop Prot. 26, 867–871.

Keely, P.E., Thullen, R.J., 1978. Light requirements of yellow nutsedge (*Cyperus esculentus*) and light interception by crops. Weed Sci. 26, 10–16.

Locascio, S.J., Gilreath, J.P., Dickson, D.W., Kucharek, T.A., Jones, J.P., Noling, J.W., 1997. Fumigant alternatives to methyl bromide for polyethylene-mulched tomato. HortScience 32, 1208–1211.

Majek, B.A., Neary, P.E., 1991. Selective wavelength transmitting mulch for yellow nutsedge control. Proceedings of Brighton Crop Protection Conference, vol. 1, pp. 263–268.

Mohler, C.L., 1996. Ecological basis for the cultural control of annual weeds. J. Prod. Agric. 9, 468–474.

Patterson, D.T., 1998. Suppression of purple nutsedge (*Cyperus rotundus*) with polyethylene film mulch. Weed Technol. 12, 275–280.

Santos, B.M., Morales-Payan, J.P., Stall, W.M., Bewick, T.A., Shilling, D.G., 1997. Effects of shading on the growth of nutsedges (*Cyperus* spp.). Weed Sci. 45, 670–673.

Webster, T.M., 2002. Weed survey—southern states: vegetable, fruit, and nut crops subsection. Proc. South Weed Sci. Soc. 55, 237–258.

Webster, T.M., 2005. Mulch type affects growth and tuber production of yellow nutsedge (*Cyperus esculentus*) and purple nutsedge (*Cyperus rotundus*). Weed Sci. 53, 834–838.

Webster, T.M., Culpepper, A.S., Johnson III, W.C., 2003. Response of squash and cucumber cultivars to halosulfuron. Weed Technol. 17, 173–176.

William, R.D., 1976. Purple nutsedge—tropical scourge. HortScience 11, 357–364.