Proc. Fla. State Hort. Soc. 114:268-271. 2001.

A PEER REVIEWED PAPER

YELLOW NUTSEDGE INTERFERENCE EFFECTS ON FRUIT WEIGHT OF POLYETHYLENE-MULCHED BELL PEPPER

T. N. MOTIS AND S. J. LOCASCIO
University of Florida
Horticultural Sciences Department
Gainesville, FL 32611

J. P. GILREATH
University of Florida
Gulf Coast Research and Education Center
Bradenton, FL 34203

Additional index words. *Cyperus esculentus*, *Capsicum annuum*, competition.

Abstract. **A study was conducted at Gainesville, Fla. during the spring and fall of 1999 and 2000 to determine the effect of yellow nutsedge (*Cyperus esculentus* L.) interference on bell pepper (*Capsicum annuum* L.). Yellow nutsedge tubers were planted 5 or 10 cm apart in a circle, with a radius of 0 (no nutsedge), 7.6, 15.2, 22.9, or 30.5 cm, around a pepper plant. Bell pepper transplants and nutsedge tubers were planted at the same time in drip-irrigated, polyethylene-mulched beds with 61 cm bed tops. Nutsedge interference reduced pepper fruit yield to a greater extent with tubers spaced 5 than 10 cm within circles. Initial nutsedge tuber circle radius, year, and season interacted in their effects on large, marketable, and total pepper fruit weight loss. In spring seasons, total yield losses increased quadratically from as low as 46% to over 68% with an increase in tuber circle radius from 7.6 to 30.5 cm. In fall 1999, total yield was reduced 89% with tuber circle radii of 7.6 to 22.9 cm and 65% with a tuber circle radius of 30.5 cm. In fall 2000, yield reductions were at least 74% and similar with all circle radii. All circle radii used, with tubers spaced 5 and 10 cm within circles, resulted in substantial pepper yield loss in all seasons. Pepper plants were intolerant of nutsedge planted 30.5 cm from the plant for which total yield loss was 65% or greater.**

Bell pepper (*Capsicum annuum* L.) is a major Florida vegetable crop with over 7,400 ha planted annually between 1984 and 1999 (Witzig and Pugh, 2000). In 1998, the total value of bell peppers produced in the state, $243,000,000, ranked second to that of tomato. Most of the bell peppers produced in Florida are field-grown on raised beds covered with polyethylene mulch. Nutsedge (*Cyperus* spp.) rhizome tips arising from underground tubers easily penetrate polyethylene mulch and become established in planting beds.

Once established, nutsedge has the capacity to significantly reduce crop yields. For instance, season-long interference of purple nutsedge (*Cyperus rotundus* L.) reduced greenhouse-grown bell pepper fruit yield by 73% (Morales et al., 1998) and 32% (Morales et al., 1997). Yield of field-grown okra [*Abelmoschus esculentus* (L.) Moench.] and tomato (*Lycopersicon esculentum* Mill.) was reduced 62% and 53%, respectively, by season-long interference of purple nutsedge. (William and Warren, 1975). Yellow nutsedge (*Cyperus esculentus* L.) interference reduced watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nak.] fruit yields by up to 94% (Buker, 1999).

Methyl bromide fumigant effectively controls nutsedge but is being phased out of production (U.S. Environmental Protection Agency, 1993). Furthermore, there are no herbicides labeled for pepper that provide acceptable nutsedge control. Therefore, nutsedge control in bell pepper fields is expected to be a major concern.

Weeds compete with crops for resources such as light and nutrients. Competition is a function of distance between crop and weed plants. Torner and Gonzales-Andujar (1993) found that the presence of one black nightshade (*Solanum nigrum* L.) plant 10, 80, or 110 cm from a pepper plant reduced yield by 59%, 26%, or 9%, respectively. Similarly, Perry and Currey (1985) reported 14% less soybean plant dry weight with sicklepod (*Cassia obtusifolia* L.) grown 25 than 50 cm from soybean [*Glycine max* (L.) Merrill] plants.

The distance between bell pepper and yellow nutsedge plants at which pepper yield is reduced has not been defined. This information is needed to design strategies for managing nutsedge infestations without the use of methyl bromide. This study, therefore, was conducted to determine the effect on pepper yield of yellow nutsedge tubers planted at varying distances from pepper.

Materials and Methods

Experiments were conducted during spring and fall on a Kanapaha fine sand (loamy siliceous, hyperthermic, Grossarenic Paleaquult) in 1999 and on an Arredondo fine sand (loamy, siliceous, hyperthermic, Grossarenic Paleudult) in 2000 at the Horticultural Research Unit of the University of Florida in Gainesville, Fla. Treatments were arranged as a 2 × 5 factorial replicated five times with two spacings (5 and 10 cm) of yellow nutsedge tubers planted in five circle radii from a pepper plant of 0 (no nutsedge), 7.6, 15.2, 22.9, or 30.5 cm (30.5 cm was the maximum available circle size on the 61 cm bed tops). A circle with a radius of 7.6, 15.2, 22.9, or 30.5 cm received 9, 19, 28, or 38 tubers, respectively, with tubers spaced 5 cm apart. With tubers spaced 10 cm apart, a circle with the same radii received 4, 9, 14, or 19 tubers.

Beds were formed on 1.2-m centers, fumigated with 392 $kg \cdot ha^{-1}$ of 75:25 methyl bromide:chloropicrin injected 20 cm deep with two shanks, and covered with polyethylene mulch (black in spring; white in fall). Planting holes for pepper were punched in single rows per plot at an in-row spacing of 46 cm. Holes for nutsedge tubers were punched via a board with dowels 7.6 cm long spaced 5 cm apart to form the four circles. Nutsedge planting holes were punched around six pepper planting holes per 6.4-m-long plot. Holes were punched 1 to 2 weeks after fumigation, but in fall 1999 they were punched 5 weeks after fumigation.

Bell pepper ('X3R Camelot') seedling and nutsedge tuber planting began on the day holes were punched. Pepper

This research was supported by the Florida Agricultural Experiment Station, and approved for publication as Journal Series No. R-08187.

Table 1. Main effects of year, season, yellow nutsedge tuber spacing, and planted tuber circle radius from pepper on loss of large, marketable, and total pepper fruit weights relative to yield obtained with peppers grown weed-free.

Treatment	Pepper fruit yield loss (%)		
	Large	Marketable	Total
Year (Y)			
1999	74.2	71.8	76.3
2000	72.1	74.1	75.3
Significance	NS	NS	NS
Season (S)			
Spring	63.0	63.7	68.9
Fall	84.6	83.1	83.5
Significance	***	***	***
Tuber spacing (TS; cm)			
5	79.1	78.1	80.8
10	67.4	67.6	70.9
Significance	***	***	***
Radius (RAD; cm)			
7.6	62.5	63.4	67.2
15.2	78.7	77.2	80.0
22.9	80.9	81.2	82.6
30.5	70.8	69.7	73.5
Significance	Q***	Q***	Q***
Y × S × RAD	***	***	***

NS, ***Main effects and interactions were nonsignificant or significant at $P \leq 0.001$ respectively, according to F tests from analysis of variance. Effects of nutsedge circle radius were quadratic (Q) according to orthogonal polynomial contrasts.

transplanting/nutsedge tuber planting dates for spring 1999, fall 1999, spring 2000, and fall 2000, respectively, were 24 Mar./24-25 Mar., 2 Sept./30 Aug., 23 Mar./22 Mar., and 16 Aug./16-17 Aug.. For the 5 cm tuber spacing, each nutsedge planting hole, or for the 10 cm tuber spacing, every other hole, received one nutsedge tuber ['Chufa' tubers, a cultivated variety (*sativus*) of native yellow nutsedge (de Vries, 1991), were used]. Nutsedge seedlings from planted tubers were allowed to proliferate throughout the season.

Drip irrigation was used to supply water as needed to prevent moisture stress to plants. During each season, plants received 224 N:37 P:186 K $kg \cdot ha^{-1}$. All P and 40% of N and K were preplant-incorporated before mulch application. The remainder of N and K was fertigated in 10 equal weekly applications each season. Pesticides were applied as needed to control insects and diseases.

Pepper fruit were harvested twice each season except for fall 1999 when peppers were harvested once due to an insufficient quantity of fruit for a second harvest. Weights were recorded for US Fancy, No. 1, and No. 2 fruit according to U.S. Dept. of Agriculture standards. Immature and blossom-end-rotted fruit weights were also recorded.

Total-season pepper fruit yield data were converted to percent yield loss relative to yields obtained with pepper

Table 2. Daily minimum and maximum temperature and rainfall averaged within time periods corresponding to physiological pepper growth stages during each season.

Time (days)	Avg. temp. (°C) Min	Avg. temp. (°C) Max	Rainfall (cm)	Time (days)	Avg. temp. (°C) Min	Avg. temp. (°C) Max	Rainfall (cm)
	Spring 1999				Fall 1999		
1-21	13	31	0.0	1-21	19	32	10.4
22-40[z]	12	27	1.6	22-40[z]	20	30	11.5
41-70[y]	17	31	10.1	41-60[y]	13	27	1.7
71-93[x]	20	31	11.0	61-81[x]	9	25	3.6
Total			22.8	Total			27.3
	Spring 2000				Fall 2000		
1-21	10	25	6.8	1-21	21	31	19.8
22-40[z]	11	26	1.8	22-41[z]	21	29	13.2
43-68[y]	18	32	1.8	42-63[y]	14	26	1.6
69-94[x]	19	32	21.8	64-91[x]	13	26	0.4
Total			32.3	Total			34.9

[z]First plant height measurement during the four seasons at late pepper flowering/early fruit set was on day 40, 40, 40, and 41 of seasons, respectively.
[y]Second plant height measurement during the four seasons at pepper fruit development was on day 70, 60, 68, and 63 of seasons, respectively.
[x]Final pepper fruit harvest during the four seasons was on day 93, 81, 94, and 91 of seasons, respectively.

grown weed-free. Data were subjected to analysis of variance using SAS (SAS, 2000). Significant effects were obtained with F-tests. Yield loss responses to tuber circle radius were characterized via orthogonal polynomials or a best-fit nonlinear equation, and respective coefficients of determination (r^2) were determined with regression analysis.

Results and Discussion

Large, marketable, and total pepper fruit yield losses during spring and fall seasons of 1999 and 2000 were less variable than yield losses for individual fruit grades. Discussion, therefore, is focused on large, marketable, and total fruit weight loss. Fruit weight losses due to nutsedge interference were similar in 1999 and 2000 (Table 1), but were greater in fall than spring pepper plantings.

The greater yield loss in fall than spring may be attributed, in part, to temperature effects (Table 2). Minimum temperatures in the fall were 6 to11°C higher than those in the spring seasons during the first 40 d of the growing season. These higher temperatures accounted for greater early-season nutsedge growth and vigor in fall than spring plantings. At 6 weeks after pepper transplanting (WAT), nutsedge leaf blades were 65 and 38 cm tall (data not shown) in fall and spring seasons, respectively. Cooler temperatures in spring than fall, therefore, reduced nutsedge vigor and allowed bell pepper to more effectively compete with nutsedge in spring than fall seasons.

Over time, daylength increased in the spring and decreased in the fall seasons. Greater yield losses in fall than spring seasons may also be attributed to the decline in daylength with time during fall seasons. This was supported by dry weight data (not shown) for pepper and nutsedge plants sampled after final pepper fruit harvest. Dry weight of pepper plants grown weed-free and of nutsedge shoots were less in fall than spring seasons. Pepper yield losses, however, were still high in fall seasons. Therefore, in fall seasons, the effect of high early-season temperature and subsequent nutsedge vigor influenced pepper yield loss to a greater extent than the decline in daylength.

Tubers planted 5 cm apart in the circles resulted in greater pepper yield reductions than those planted 10 cm apart (Table 1). This result was expected as more tubers were planted per circle with tubers spaced 5 than 10 cm apart.

The effects of initial tuber circle radius from pepper on loss of pepper fruit weight interacted with those of year and season but not tuber spacing within the circle (Fig. 1). During spring 1999, large and marketable yield reductions were less with tubers planted in a circle 7.6 than 15.2 to 30.5 cm from pepper. In contrast, during fall 1999, large and marketable yield reductions were less with tubers planted 30.5 than 7.6 to 22.9 cm from pepper.

Differences in these seasonal yield loss responses to tuber circle radius were likely due to nutsedge growth habit and temperature factors. As nutsedge leaf blades expanded, they fell across the tops of the pepper plants. The extent of nutsedge leaf coverage of pepper, however, depended on the proximity (circle size) of nutsedge plants to a pepper plant. When grown in a circle close to a pepper plant, nutsedge grew in clump fashion with most leaves falling away from the pepper leaf canopy. With increased distance between nutsedge and a pepper plant, nutsedge leaf coverage of pepper increased. Therefore, light availability to pepper plants appeared greater with nutsedge grown close than further away from pepper. This explained less yield loss in spring 1999 with nutsedge tubers

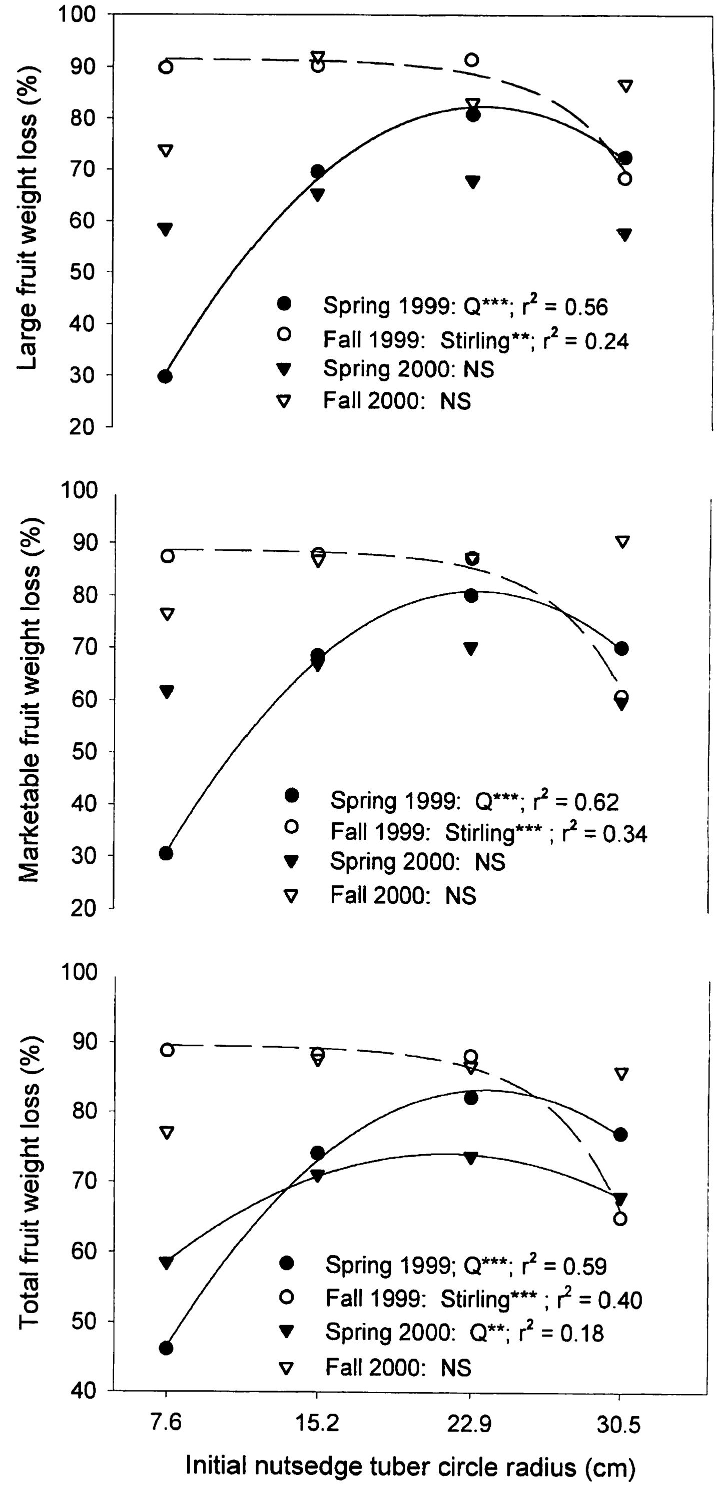

Figure 1. Effects of year, season, and initial yellow nutsedge tuber circle radius on loss of large, marketable, and total pepper fruit weight relative to yield obtained with no nutsedge. NS, Q, **, *** Effects were nonsignificant or quadratic at $P \leq 0.01$ or 0.001, respectively, according to orthogonal polynomial contrasts. Although fall 1999 trends were quadratic at $P \leq 0.01$, an exponential growth equation (Stirling model; $y = y_0 - a \times e^{bX} - 1)/b$) was more appropriate than a quadratic model due to lack of curvature between distances of 7.6 and 22.9 cm. Coefficient of determination (r^2) values were obtained by regressing data points within means (shown) against lines obtained with quadratic or exponential growth equations.

planted 7.6 than 15.2 to 30.5 cm from pepper. In fall 1999, high temperatures (Table 2) enhanced early-season nutsedge growth and increased interference with pepper. Nutsedge leaf heights, in circles with radii of 7.6 cm, were 19 cm taller in fall than spring 1999 at 6 WAT (data not shown). Therefore, nutsedge grown close to pepper competed more strongly with pepper in fall than spring seasons, and this accounted for high losses of large and marketable pepper yield during fall 1999 with tubers planted 7.6 to 22.9 cm from pepper.

During both 1999 seasons, large and marketable pepper fruit weight reductions declined slightly with an increase in tuber circle radius from 22.9 to 30.5 cm (Fig. 1). Although the correlation of yield loss data to the model in fall 1999 was poor, combined spring and fall 1999 data suggested that nutsedge interference with pepper declined with an increase in tuber circle radius from 22.9 to 30.5 cm. Even at the maximum distance from pepper plants of 30.5 cm for planted tubers, nutsedge interference reduced pepper yield by over 60%.

Large and marketable fruit weight losses during spring and fall 2000 were not differentially influenced by nutsedge circle radius. Nutsedge interference reduced pepper yield by over 58% with all tuber circle radii in both seasons.

Response of total pepper fruit weight loss to nutsedge circle radius was similar to that observed for large and marketable fruit in all seasons except spring 2000. Total fruit weight loss response to tuber circle radius in spring 2000, though poorly correlated with the model, resembled that in spring 1999. During both spring seasons, total yield losses were maximized with tubers planted 22.9 cm from pepper; however, maximum yield losses were lower in spring 2000 than spring 1999. Nutsedge plants at 6 WAT were 8 cm shorter in spring 2000 than spring 1999, possibly due to effects of a frost on the 19th day of the spring 2000 season. Reduced nutsedge vigor in spring 2000 allowed pepper plants to more effectively compete with nutsedge.

Shading of pepper by nutsedge was an important factor influencing the competitiveness of nutsedge plants against pepper. Similarly, Pike et al. (1990) reported a high correlation of soybean yield losses to leaf area of weeds (*Datura stramonium* L. and *Xanthium strumarium* L.) directly above the crop canopy.

With all tuber circle radii evaluated, from 7.6 to 30.5 cm, yellow nutsedge interference substantially reduced pepper yield. Therefore, with the number of tubers planted, a distance of tubers from a pepper plant needed for satisfactory pepper production is greater than 30.5 cm. With this treatment, nutsedge interference reduced total fruit weight by at least 65% with 19 tubers planted 30.5 cm from the pepper plants (fewest per m^2 used in the study).

Literature Cited

Buker, R. S. III 1999. Interference of yellow nutsedge with watermelon. MS Thesis, University of Florida, Gainesville.

de Vries, F. T. 1991. Chufa (*Cyperus esculentus*, Cyperaceae): A weedy cultivar or a cultivated weed?. Econ. Bot. 45:27-37.

Morales-Payan, J. P., B. M. Santos, W. M. Stall, and T. A. Bewick. 1997. Effects of purple nutsedge (*Cyperus rotundus*) on tomato (*Lycopersicon esculentum*) and bell pepper (*Capsicum annuum*) vegetative growth and fruit yield. Weed Technol. 11:672-676.

Morales-Payan, J. P., B. M. Santos, W. M. Stall, and T. A. Bewick. 1998. Interference of purple nutsedge (*Cyperus rotundus*) population densities on bell pepper (*Capsicum annuum*) yield as influenced by nitrogen. Weed Technol. 12:230-234.

Perry, K. M. and W. L. Currey. 1985. Sphere of influence of sicklepod (*Cassia obtusifolia*) in conventionally grown Florida soybeans. Proc. Southern Weed Science Soc., 38th Annu. Meeting. 1985, 456.

Pike, D. R., E. W. Stoller, and L. M. Wax. 1990. Modeling soybean growth and canopy apportionment in weed-soybean (*Glycine max*) competition. Weed Sci. 38:522-527.

SAS Institute. 2000. Proprietary software release 8.1. SAS Inst., Cary, N.C.

Torner, C. and J. L. Gonzalez-Andujar. 1993. 'Area of influence' of 'black nightshade' (*Solanum nigrum* L.) in transplanted peppers (*Capsicum annuum* L.), p. 295-298. In: Proc. 1993 Congr. of the Spanish Weed Sci. Soc., Lugo, Spain, 1-3 Dec. 1993.

U.S. Environmental Protection Agency. 1993. 40 CFR Part 82, Protection of stratospheric ozone: Final rule making. Federal Register, 10 Dec. 1993, 58(236):65018-65062.

William, R. D. and G. F. Warren. 1975. Competition between purple nutsedge and vegetables. Weed Sci. 23:317-323.

Witzig, J. D. and N. L. Pugh. 2000. Florida Agricultural Statistics. Vegetable Summary. Fla. Dept. Agr. Consum. Serv. Tallahassee.