Effects of Yellow and Purple Nutsedge Time of Establishment on Their Distance of Influence on Bell Pepper

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SUMMARY. Field trials were conducted to determine the effect of yellow nutsedge (*Cyperus esculentus*) and purple nutsedge (*C. rotundus*) time of establishment on their distance of influence on bell pepper (*Capsicum annuum*). A single seedling of each weed species was transplanted 1, 2, 3, 4, and 5 weeks after transplanting (WAT) bell pepper. Each weed was separately established in the center of plots within double rows of bell peppers. Crop height and yield were determined from bell pepper plants located at 6, 13.4, 24.7, and 36.5 inches away from each weed. Bell pepper height was unaffected by weed species, time of establishment, or the interaction between these factors. Marketable yield data indicate that yellow nutsedge was more aggressive than purple nutsedge interfering with bell pepper. When yellow nutsedge was established at 1 WAT, bell pepper yield reduction was between 57% and 32% for plants at 6 and 13.4 inches away from the weed respectively, which represents a density of ≈ 0.14 plant/ft². One purple nutsedge plant growing since 1 WAT at 6 inches along the row from two bell pepper plants (0.43 plant/ft²) produced a yield reduction of 31%. These results indicate that low nutsedge densities, which are commonly believed to be unimportant, can cause significant bell pepper yield reductions.

Bell pepper is among the leading vegetable crops in the United States. In 2006, this crop produced a gross value of more than \$585 million and was planted in more than 60,000 acres (U.S. Department of Agriculture, 2007). In Florida, bell pepper is second only to tomato (*Lycopersicon esculentum*) in total value, representing \$187 million (U.S. Department of Agriculture, 2007). Yellow nutsedge and purple nutsedge interference in polyethylene-mulched bell pepper can cause significant yield reductions. Gilreath et al. (2005a) found that bell pepper yield losses reached 31% with a nutsedge density of ≈ 0.5 plant/ft² during fruit setting, whereas Motis et al. (2003) indicated that a nutsedge density of ≈ 9 plants/ft² can reduce bell pepper yield by at least 70%.

During the last two decades, nutsedge species have been effectively controlled with methyl bromide (MBR) fumigation before placing

plastic mulch. However, MBr is being phased out because it is an ozone-depleting substance (U.S. Environmental Protection Agency, 1999). Thus, a great deal of research has been conducted to find suitable replacements for MBr in mulched vegetable crops. Currently, the leading MBr alternatives have proved to be effective against most soil-borne diseases and nematodes. Direct preplant in-bed injections of the combination of 1,3-dichloropropene and chloropicrin have shown to reduce *Fusarium* wilt (*Fusarium oxysporum* f.sp. *lycopersici*) incidence and root-knot nematode (*Meloidogyne* spp.), stunt nematode (*Tylenchorhynchus* spp.), ring nematode (*Criconeimoides* spp.), and sting nematode (*Belonolaimus* spp.) populations (Gilreath et al., 2005b; Jones et al., 1995). Other soil fumigants

need excessively high concentrations and rates to control nutsedges. Previous studies have indicated that metam potassium, methyl iodide, propylene oxide, and dimethyl disulfate are effective against soil-borne diseases and nematodes, but do not sufficiently reduce nutsedge incidence at the recommended rates, resulting in low initial densities on the planting beds (Gilreath et al., 2004a, b; López-Aranda et al., 2004; Santos and Gilreath, 2004). All this is further complicated because there are no effective selective postemergence herbicides registered for nutsedge control in Florida bell pepper, whereas preemergence S-metolachlor provides fair control of yellow nutsedge, but poor suppression of purple nutsedge populations (Stall and Gilreath, 2002).

Under practical field situations, low nutsedge densities are considered insignificant, but previous research has stressed the importance of low densities on crops by studying the distance or area of influence of weeds (Motis et al., 2001). The distance of influence methodology is a powerful tool to determine the extent of interference of a single weed plant at changing distances from the crop (Oliver and Buchanan, 1986; Santos et al., 2004). Jordan (1989) explained in detail the biological and statistical concerns of this type of study. This methodology requires somewhat complicated data collection, analysis, and interpretation procedures, to which multivariate analysis of variance (MANOVA) must be applied, instead of the frequently used analysis of variance (Jordan, 1989).

It is well known that the extent of yield reduction, fruit quality, and maturity depend on the length of weed interference (Radosevich, 1987). Direct field observations of the performance of most MBr alternatives in mulched bell pepper show that low-density nutsedge sprouting occurred during the initial weeks after

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
0.3048	ft	m	3.2808
0.0929	ft ²	m ²	10.7639
3.7854	gal	L	0.2642
2.5400	inch(es)	cm	0.3937
1.1209	lb/acre	kg·ha ⁻¹	0.8922
0.0254	mil	mm	39.3701
2.2417	ton/acre	Mg·ha ⁻¹	0.4461

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crop transplanting. However, there are no reports on the effect of nutsedge time of emergence on the distance of influence in bell pepper. This study provides basic information on the biological and economical feasibility for controlling low nutsedge densities, thus allowing researchers and growers to make timely decisions. Therefore, the objective of this study was to determine the distance of influence of yellow nutsedge and purple nutsedge as affected by their time of establishment in polyethylene-mulched bell pepper.

Materials and methods

Two field trials were conducted during consecutive bell pepper seasons in 2002 and 2003 at the Gulf Coast Research and Education Center of the University of Florida in Bradenton, Fla. The soil was classified as Eau Gallie fine sand (Alfisol Haplaquod, sandy, siliceous, hyperthermic) with 1.0% organic matter and a pH of 7.2. Bell pepper planting beds were 28 inches wide at the base, 24 inches wide at the top, 8 inches high, and spaced 5 ft apart on centers. Finished beds were fumigated with MBr plus chloropicrin (67:33 v/v) at a rate of 350 lb/acre to eliminate soil-borne diseases, nematodes, and weeds in the soil. Immediately after fumigation, each bed was fertilized according to local crop production recommendations (Maynard et al., 2003). Simultaneously, planting beds were covered with 1.25-mil-thick black low-density polyethylene mulch. Simultaneous with film covering, drip irrigation tubing (T-Tape Systems International, San Diego) was buried 1 inch deep in the bed center. Irrigation was supplied daily both via drip and sub-surface irrigation to minimize water stress. According to local crop recommendations, additional N and K were supplied to the crop through the drip lines (Maynard et al., 2003). 'Capistrano' pepper seedlings in the four-true leaf stage were manually transplanted 3 weeks after fumigation in double rows, with in-row and between-row distances of 12 inches. Beginning at 1 week before bell pepper transplanting, yellow nutsedge and purple nutsedge tubers (0.5 inch in diameter) from nearby fields were collected and planted in 0.1-gal containers filled with a commercial potting medium. This procedure was

repeated every week for 5 weeks to ensure supplying 1-week-old nutsedge plants with two leaves for the treatments.

Treatments were arranged in a split-plot design with six replications. The nutsedge species formed the main plots, whereas times of weed establishment were distributed in the subplots. Experimental units contained 18 bell pepper plants, with two rows of nine plants each. A single nutsedge seedling of either species was transplanted in the middle of each plot, equidistant from each bell pepper row (6 inches apart) at 1, 2, 3, 4, and 5 weeks after transplanting (WAT). A weed-free control was also established. Undesired volunteer nutsedge plants and other weeds on bed tops were removed by hand immediately after emergence. A weed-free control was also established.

Bell pepper plant height and marketable yield were determined from plants located along the row at 6, 13.4, 24.7, and 36.5 inches away from each weed. Marketable fruits were at least 2.5 inches thick by 4 inches long with no visible blemishes. For each distance, plant height of one plant from the southwest quadrant of each plot was measured at 7 WAT. Bell pepper yield was obtained by harvesting pairs of plants at the same distances from the weed. Marketable bell pepper fruits were harvested six times beginning at 6 WAT. Fresh weights of marketable fruits were analyzed for nutsedge species, time of establishment, and the interaction between both factors ($P = 0.05$) by using the Wilks' lambda statistic calculated by the MANOVA procedure (Jordan, 1989). When significant effects were found, market-

able fruit weights were converted to percentage of the control treatment. Standard errors were used to separate treatment means.

Results and discussion

There was no significant season-by-treatment interaction. Therefore, data from two seasons were combined for analysis. Time of weed establishment had no effect on bell pepper plant height at 7 WAT within each nutsedge species, which indicated that weed interference did not reflect on this variable (data not shown). However, the interaction between nutsedge species and time of establishment affected marketable fruit weight. Thus, each combination will be discussed separately. Time of establishment of yellow nutsedge had an effect on the distance of influence on bell pepper. However, significant bell pepper yield reductions occurred only when the weed was established at 1 and 2 WAT. At 1 WAT, the impact of yellow nutsedge interference on bell pepper marketable yield decreased as distance increased from 6 to 24.7 inches (Table 1). Crop yield reductions reached 57% and 32% when the weed grew at 6 and 13.4 inches from the bell pepper plants respectively. This harmful effect disappeared at 24.7 inches or farther. At 2 WAT, only the yellow nutsedge growing at 6 inches caused 35% bell pepper yield reduction, with no effect at 13.4 inches or farther. In contrast with yellow nutsedge, only purple nutsedge plants established at 1 WAT caused significant bell pepper yield reductions (Table 2). At 6 inches from the weed, the crop fresh fruit weight declined 31%, whereas there was no difference between the

Table 1. Effects of yellow nutsedge distance and time of establishment on bell pepper marketable fresh weight at Bradenton, Fla., in 2002–03.

Weed distance (inches) ^a	Marketable fresh wt, mean $\pm$ SE (ton/acre) ^b				
	1 WAT ^c	2 WAT	3 WAT	4 WAT	5 WAT
6	7.6 $\pm$ 0.8	11.4 $\pm$ 0.9	17.6 $\pm$ 1.3	17.7 $\pm$ 1.3	17.8 $\pm$ 1.3
13.4	12.0 $\pm$ 1.1	18.7 $\pm$ 1.2	17.3 $\pm$ 1.4	17.6 $\pm$ 1.4	17.7 $\pm$ 1.5
24.7	18.3 $\pm$ 1.3	17.2 $\pm$ 1.3	17.5 $\pm$ 1.6	17.5 $\pm$ 1.7	17.5 $\pm$ 1.8
36.5	17.2 $\pm$ 0.9	18.5 $\pm$ 1.3	17.4 $\pm$ 0.9	17.4 $\pm$ 1.8	17.7 $\pm$ 1.9
Weed-free control	17.6 $\pm$ 1.1	17.6 $\pm$ 1.1	17.6 $\pm$ 1.1	17.6 $\pm$ 1.1	17.6 $\pm$ 1.1
Significance ^d	*	*	NS	NS	NS

^a1 inch = 2.54 cm.

^bBell pepper yield obtained during six harvests beginning at 6 weeks after transplanting (WAT); 1 ton/acre = 2.2417 Mg·ha⁻¹.

^cData from two seasons were combined and analyzed with multiple analysis of variance and treatment means separated with SE ($P = 0.05$).

^dNS=Non-significant or significant at $P = 0.05$.

Table 2. Effects of purple nutsedge distance and time of establishment on bell pepper marketable fresh weight at Bradenton, Fla., in 2002–03.

Weed distance (inches) ^a	Marketable fresh wt, mean ± SE (ton/acre) ^b				
	1 WAT	2 WAT	3 WAT	4 WAT	5 WAT
6	12.0 ± 1.4	16.4 ± 1.4	17.3 ± 2.1	17.7 ± 0.9	17.8 ± 1.7
13.4	17.4 ± 1.2	17.8 ± 0.8	17.8 ± 1.9	17.9 ± 1.4	17.6 ± 1.8
24.7	18.1 ± 1.2	17.1 ± 1.2	17.6 ± 1.7	17.1 ± 1.5	17.5 ± 0.9
36.5	16.7 ± 1.4	17.9 ± 1.3	17.5 ± 1.4	17.3 ± 1.4	17.4 ± 1.3
Weed-free control	17.6 ± 1.1	17.6 ± 1.1	17.6 ± 1.1	17.6 ± 1.1	17.6 ± 1.1
Significance ^c	*	*	NS	NS	NS

^a1 inch = 2.54 cm.

^bBell pepper yield obtained during six harvests beginning at 6 weeks after transplanting (WAT); 1 ton/acre = 2.2417 Mg·ha⁻¹.

^cData from two seasons were combined and analyzed with multiple analysis of variance and treatment means separated with SE ($P = 0.05$).

NS,*Nonsignificant or significant at $P = 0.05$.

weed-free control and the yields of bell pepper plants growing at 13.4 inches or more from purple nutsedge.

These results indicate that low nutsedge densities, which are commonly believed to be unimportant, can cause significant bell pepper yield reductions, especially if the weeds emerge early during the growing season. For example, a single yellow nutsedge plant growing 13.4 inches away from bell pepper plants represents an approximate density of 0.14 plant/ft², whereas for purple nutsedge, one weed plant growing between two bell pepper plants in double rows results in a density of about 0.43 plant/ft². In relative terms, these findings showed that yellow nutsedge is more aggressive than purple nutsedge against bell pepper. Santos et al. (1997a) suggested that under greenhouse conditions, yellow nutsedge was a better competitor than purple nutsedge against tomato. This increased competitive ability can be explained in part by the lower light compensation point that yellow nutsedge has with respect to purple nutsedge, allowing the former to endure shading conditions successfully (Santos et al., 1997b). In this case, a single yellow nutsedge plant emerging 2 WAT could still reduce bell pepper fruit weight, whereas at the same time purple nutsedge had no effect on the crop. In practical terms, these findings emphasize the importance of effectively controlling low nutsedge densities through diverse weed control methods—namely, herbicides and soil fumigation with alternatives to MBr—to reduce bell pepper yield losses.

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