Smooth Amaranth Interference with Watermelon and Muskmelon Production

Ernest R. Terry, Jr.¹, William M. Stall², Donn G. Shilling³,
Thomas A. Bewick⁴, and Steven R. Kostewicz⁴
University of Florida, Gainesville, FL 32611

Additional index words. *Amaranthus hybridus*, competition, critical period of weed control, *Cucumis melo* var. *reticulatus*, *Citrullus lunatus*

Abstract. Studies were conducted to determine the critical period of smooth amaranth interference in watermelon (*Citrullus lunatus* L.) and muskmelon (*Cucumis melo* L. var. *reticulatus*). Best-fit linear or exponential regression models were used to predict the maximum period of competition and the minimum weed-free period for 10% yield loss. The maximum period of competition and minimum weed-free period was 0.50 and 2.97 weeks after watermelon emergence, respectively, and 1.0 and 3.9 weeks after muskmelon emergence, respectively. The critical periods of smooth amaranth interference for the crops were between those intervals. In both crops, late emerging smooth amaranth had little effect on total yield. Smooth amaranth introduced at crop emergence reduced total yield. The effect of competition on yield components, i.e., fruit number per hectare and fruit mass, varied by crop. Muskmelon fruit count was more sensitive to smooth amaranth competition than was watermelon fruit count. Conversely, mass per fruit of muskmelon was less sensitive to this competition than was mass per fruit of watermelon.

Florida is the largest producer of watermelons in the United States, with about one-third of the U.S. crop, yielding ≈ 26 t·ha⁻¹ (Freie and Pugh, 1995). Elmstrom and Maynard (1991) estimated that 809 ha of muskmelon were grown in Florida. Production of muskmelon is minor in Florida, but continues to increase, mostly for local consumption (Elmstrom and Maynard, 1991).

Watermelon yield losses due to weeds in the Southeast region (Alabama, Georgia, Florida, and South Carolina) are estimated to be 15% annually (Chandler et al., 1984). At current market value, that annual loss is equivalent to about \$22.5 million (Freie and Pugh, 1995). Estimated annual yield losses in muskmelon are 13% (Chandler et al., 1984). At current market value, that annual loss is equivalent to \$300,000 (Elmstrom and Maynard, 1991).

Mechanical weed control in cucurbits is difficult due to the vining growth habit (Gilreath and Everett, 1983; Glaze, 1975). The wide spacings between rows and slow initial crop growth complicate control measures. Early season weed control is critical for profitable production (Stall, 1992). Mechanical cultivation

is possible early in the season, but must be shallow to prevent injury to crop roots. At 4 to 5 weeks after emergence, the vines begin to run and this precludes mechanical cultivation. Chemical weed control is also an option. The number of herbicides labeled for cucurbits is limited and many of those have a narrow range of crop tolerance. Misuse or mistakes in calibration or application may cause crop injury (Stall, 1992). Most of the herbicides labeled for use in cucurbits are applied before planting or weed emergence. Postemergent herbicides are applied primarily as directed or shielded sprays (Stall, 1992).

In a Canadian study of pickling cucumber (*Cucumis sativus* L.), the critical period of interference with crop growth was between 12 and 36 d after crop emergence (Friesen, 1978). A Spanish study estimated the period of interference in cucumber to be from 20 to 40 d after planting (Acuna and Gamboa, 1985). Mallet and Ashley (1988) determined that the critical period of interference in summer squash (*Cucurbita pepo* L.) was between 4 and 6 weeks after crop emergence. The critical period of interference in 'Galia' muskmelon was also between 4 and 6 weeks after crop emergence (Nerson, 1989). Yield and fruit quality were decreased by longer periods of interference (Nerson, 1989). Nerson et al. (1988) also reported the critical period of weed interference to be 6 to 9 weeks after emergence. These variations demonstrated that the period of interference varied with crop, weed species, and environmental conditions and must be determined for each crop and single weed species present (Friesen, 1978; Mallet and Ashley, 1988; Rushing et al., 1985).

The objectives of this study were to determine the critical period of smooth amaranth

interference in watermelon and muskmelon production and the effects of the smooth amaranth interference on the fruit yield components, number per hectare and mass per melon, and their relationship to the critical period.

Materials and Methods

The experiments were conducted in Spring and Summer 1991 and 1992 at the Horticultural Research Unit, Univ. of Florida, Gainesville, on a Pomona fine sand soil (sandy, siliceous, hyperthermic Ultic Haplaquod; pH 6.4 to 6.8; 1.8% organic matter).

The soil was bedded 3 weeks before planting at 3.65 m center to center for watermelon and 1.85 m center to center for muskmelon. At bedding, the soil was fumigated with 98% methyl bromide and 2% chloropicrin mixture (252 kg·ha⁻¹) to control weeds in the row. Polyethylene mulch applied during fumigation was removed 1 week before planting. Fertilization was done according to soil test recommendation for watermelon and muskmelon (Hochmuth, 1988, 1990). Supplemental overhead irrigation was applied, as needed, to keep soil moisture continuously above water stress levels, as determined with tensiometers (Irrometer Co., Riverside, Calif.) placed 30 and 60 cm in the soil.

'Crimson Sweet' watermelon and 'Primo' muskmelon were seeded 1 m apart on 24 Apr. 1991 and 8 Apr. 1992. Plots were 7 m long and consisted of five plants each. 'Charleston Gray' watermelon and honey dew (*Cucumis melo* L. var. *inodorous* 'XPH 5403 Hybrid') were planted at the end of each watermelon and muskmelon plot, respectively, to serve as guard plants between plots. Watermelon fruit were harvested from 9 to 10 weeks after crop emergence in 1991 and 11 to 12 weeks after crop emergence in 1992. Muskmelon fruit were harvested at 9 to 11 weeks after crop emergence, at three-fourths to full slip. The number and mass of fruit at each harvest were recorded.

Smooth amaranth plants were established by seeding in expanded polystyrene trays (Speedling Co., Sun City, Fla.) with 2.96-cm³ cells 4 weeks before the various treatment dates. Seedlings were thinned to one plant per cell starting 1 week after emergence and were fertilized with a soluble fertilizer as needed from week 1 to 4. Seedlings were removed from trays on the specific treatment dates and planted six plants/m in the row between the watermelon and muskmelon plants. The amaranth plants had about four true leaves and were ≈ 6 cm tall.

Paraquat (0.5 kg·ha⁻¹) was applied in the crop rows as a shielded spray to control nut-sedge (*Cyperus esculentus* L. and *Cyperus rotundus* L.) early in the season. Weeds in the crop row other than the transplanted smooth amaranth were removed weekly by hand. Weeds between the rows were controlled with shallow cultivation until lay-by. Maintenance insect and disease control practices were carried out according to Florida Cooperative Extension Service recommendations (Johnson, 1991a, 1991b; Simone, 1991a, 1991b).

Received for Publication 10 June 1996. Accepted for publication 7 Jan. 1997. Florida Agricultural Experiment Station Journal Series No. R-04931. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

¹Former Graduate Assistant, Horticultural Sciences Dept.

²Professor, Horticultural Sciences Dept.; to whom reprint requests should be addressed.

³Professor, Agronomy Dept.

⁴Associate Professor, Horticultural Sciences Dept.

Table 1. Regression models used to predict critical period of interference of smooth amaranth in muskmelon and watermelon.

Crop	Yield parameter	Competitive interval	Model	R ²
Muskmelon	Total mass	Weeks initially weedy	$y = 98 - 8.4x$	0.97
	Fruit count		$y = 101.1 - 7.9x$	0.98
	Mass per fruit		$y = 100.3 - 2.9x$	0.87
	Total mass	Weeks weed free	$y = 104.2(1 - 0.9e^{-0.48x})$	0.998
	Fruit count		$y = 102.9(1 - 0.8e^{-0.46x})$	0.999
	Mass per fruit		$y = 100.0(1 - 0.3e^{-1.88x})$	0.999
Watermelon	Total mass	Weeks initially weedy	$y = 93.3 - 6.5x$	0.87
	Fruit count		$y = 95.6 - 4.9x$	0.84
	Mass per fruit		$y = 100.3 - 3.7x$	0.95
	Total mass	Weeks weed free	$y = 98.5(1 - 0.7e^{-0.70x})$	0.998
	Fruit count		$y = 95.5(1 - 0.5e^{-1.66x})$	0.998
	Mass per fruit		$y = 102.7(1 - 0.4e^{-0.81x})$	0.999

The minimum weed-free periods were determined by maintaining the crops free of smooth amaranth for various periods. In 1991, plots were maintained weed free for 0, 3, 5, and 7 weeks for watermelon and for 0, 3, and 5 weeks after crop emergence for muskmelon. In 1992, both crops were maintained weed free for 0, 1, 3, 5, and 7 weeks after crop emergence. Treatments were initiated at crop emergence, which was 8 d after planting in 1991 and 9 d thereafter in 1992.

The maximum period of competition was determined by planting smooth amaranth at crop emergence and allowing competition to occur in both crops for 0, 3, 5, 7, and 9 weeks in 1991. In 1992, competition was allowed to occur in both crops for 0, 1, 3, 5, and 7 weeks after crop emergence. Smooth amaranth transplanted at crop emergence was harvested at the end of the appropriate interval of competition.

The experiment design was a randomized complete block with five replications. Data were subjected to analysis of variance to determine treatment effects and interactions. Because there were no year $\times$ treatment interactions ($P > 0.05$), data for both years were combined. The original data were transformed to percentage of weed-free controls and means were used to establish the relationship between yield and duration of interference. Models were selected based on R^2 values and residual plot analysis. Models used for prediction of critical period are given in Table 1. The critical period of weed interference was determined as the time interval between the minimum weed-free period and the maximum period of competition.

Results and Discussion

Watermelon. Watermelon yield of the weed-free control in these studies averaged 39.2 t ha⁻¹. Average commercial yield in 1995 for the Florida crop was 28 t ha⁻¹ (Freie and Pugh, 1995). This difference indicated that the conditions of these studies were equal to or better than those experienced in commercial fields. Therefore, results from these studies could be directly applied to determine yield loss due to weed competition in commercially grown watermelon.

Watermelon had to be maintained weed free for 3.0 weeks to prevent yield losses >10% (Fig. 1A). Preemergence herbicide programs are available that are effective for 3

weeks. Cultivation during this period is also possible. By setting the tolerable losses at 20% of the weed-free control, the minimum weed-free period was 1.9 weeks after emergence (Fig. 1A). Interference by smooth amaranth was significant early in the growing season, as 20% of yield was lost even if smooth amaranth interfered for <2 weeks.

If smooth amaranth competed initially with watermelon for 0.5 week, then yield loss was 10%. Postemergence weed control options in watermelon are limited. In addition, effective control is further exacerbated by the short tolerable period of competition. For a yield loss of $\leq 20\%$, postemergence control of smooth amaranth was needed by week 2 (Fig. 1A). The linear yield decrease suggests that amaranth established at emergence had a constant intensity of interference throughout the season.

The critical period of interference of smooth amaranth in watermelon with an arbitrary 10% yield loss was between 0.5 and 2.9 weeks after watermelon emergence (Fig. 1A). To sustain 90% of normal yield, no interference by smooth amaranth is tolerated during this interval. By increasing the arbitrary permissible loss to 20%, the critical period of interference was 1.9 to 3.0 weeks after emergence (Fig. 1A). If 20% yield loss is tolerable, it may be possible to conduct a single weed control operation during this period. Practically, this means that preemergence control measures must be effective through this period; if not, a corrective program must be implemented.

Muskmelon. The yield of muskmelon in the weed-free control was 43.8 t ha⁻¹. Average muskmelon yields in Florida were 45.4 t ha⁻¹ (Maynard and Elmstrom, 1991). Our muskmelon yields were similar to the state average, which indicated that the conditions in these studies were similar to those experienced in commercial fields.

The minimum weed-free period in muskmelon resulting in 10% yield loss was 3.9 weeks after crop emergence (Fig. 2A). A preemergence herbicide, or other control measure, would have to control smooth amaranth for at least this period of time. After that interval, effects of emerging smooth amaranth were negligible. Allowing for 20% yield reduction in muskmelon by smooth amaranth, the minimum weed-free period was 2.8 weeks. As for watermelon, early-season smooth amaranth interference was critical.

Smooth amaranth that competed with musk-

melon for 1 week after emergence caused a 10% yield reduction (Fig. 2A). To prevent yield reduction of up to 10%, postemergence weed control should be implemented no later than 1 week after emergence. Smooth amaranth that competed with muskmelon for 2.1 weeks caused 20% yield loss (Fig. 2A). The smooth amaranth that emerged with the muskmelon caused a linear reduction in yield just as was observed for watermelon.

The critical period of interference of smooth amaranth in muskmelon with an arbitrary yield loss of 10% was between 1 and 3.9 weeks after crop emergence (Fig. 2A). To maintain yields of at least 90% of the weed-free control, muskmelon must be maintained free of smooth amaranth during this critical period. When the tolerable level of loss was increased to 20%, the critical period of interference was 2.8 to 2.1 weeks after emergence (Fig. 2A). Preemergence control measures should last at least 2.8 weeks or postemergence control measures should be implemented by 2.1 weeks. This result further emphasizes that muskmelon is sensitive to early season competition from smooth amaranth.

Longer critical periods of interference (4 to 6 weeks) for muskmelons have been previously reported (Nelson et al., 1988). There are several possible explanations for the differences in results. Because different weed species were studied, and because each weed has unique competitive characteristics, interference varied. The two studies were conducted in differing ecosystems; therefore, interference may have changed. Environmental and edaphic conditions, management inputs, and genetic differences could have all contributed to changes in crop and weed interactions. Means comparisons were used in the cited research, whereas we used regression analysis. However, statistical differences alone are probably not the cause of the differences between these studies. In all probability, these differences were real and support the argument that if information on critical periods is going to be useful, data need to be obtained locally using accepted management practices.

In the critical period study conducted by Nelson (1988), yield of muskmelon maintained weed free for 4 weeks after emergence was 18% lower than when kept weed free for the entire season. When muskmelon was infested for 3 weeks after emergence, marketable yield was reduced 31% when compared to season-long weed-free control. These re-

Fig. 1. Effect of duration of competition (■) from smooth amaranth and weed-free period (○) on watermelon (A) total yield, (B) number of fruit per plant, and (C) mass per fruit, expressed as a percentage of the weed-free control. Bars indicate the critical period of weed control for either a 10% or 20% reduction in marketable yield.

sults are similar to our muskmelon total mass yield percentages. Nerson (1988) reported the critical period of interference in muskmelon as occurring from 4 to 6 weeks after emergence by using least significant differ-

Fig. 2. Effect of duration of competition (■) from smooth amaranth and weed-free period (○) on muskmelon (A) total yield, (B) number of fruit per plant, and (C) mass per fruit, expressed as a percentage of the weed-free control. Bars indicate the critical period of weed control for either a 10% or 20% reduction in marketable yield.

ence tests. In our studies, regression analysis allowed for an accurate estimate of the critical period. Growers could use these estimates to decide on a level of loss that they are willing to incur.

Literature Cited

- Acuna, B.M. and C.J. Gamboa. 1985. Determination of the initial competition period between cucumber (*Cucumis sativus* L.) and weeds. *Agronomia-Costavencence* 9(2):213-218. (Abstr.)
- Chandler, J.M., A.S. Hamel, and A.G. Thomas. 1984. Crop losses due to weeds in Canada and the United States. *Weed Sci. Soc. Amer.*, Champaign, Ill.
- Elmstrom, G.W. and D.N. Maynard. 1991. Muskmelon and specialty melons adapted to Florida. Proc. 1991 IFAS Inst. for Watermelons and Other Cucurbits. SSVEC-3. Fla. Coop. Ext. Serv., IFAS, Univ. of Florida, p. 3-15.
- Freie, R.L. and N.L. Pugh. 1995. Vegetable summary 1993-94. Florida agricultural statistics. Florida Dept. of Agr., Orlando.
- Friesen, G.H. 1978. Weed interference in pickling cucumbers (*Cucumis sativus*). *Weed Sci.* 26:626-628.
- Gilreath, J.P. and P.H. Everett. 1983. Weed control in watermelon grown in South Florida. Proc. Southern Weed Sci. Soc. 36:159-163.
- Glaze, N.C. 1975. Weed control in cucumber and watermelon. *J. Amer. Soc. Hort. Sci.* 100:207-209.
- Hochmuth, G. 1990. Watermelon production guide for Florida. Fla. Coop. Ext. Serv., IFAS, Univ. of Florida. SSVEC-51.
- Hochmuth, G.J. 1988. Muskmelon production guide for Florida. Fla. Coop. Ext. Serv., IFAS, Univ. of Florida. Circ. 122C.
- Johnson, F. 1991a. Insect control in watermelon. Fla. Coop. Ext. Serv., IFAS, Univ. of Florida. Fact sheet ENY-446.
- Johnson, F. 1991b. Insect control in cantaloupe. Fla. Coop. Ext. Serv., IFAS, Univ. of Florida. Fact sheet ENY-423.
- Mallet, S.J. and R.A. Ashley. 1988. Determination of summer squash's tolerance to weed interference: A critical period study. Proc. Northeast Weed Sci. Soc. 42:204-208.
- Maynard, D.N. and G.W. Elmstrom. 1991. Vine crop varieties of Florida. Proc. of the 1991 IFAS Institute for Watermelon and Other Cucurbits. SSVEC-3. Fla. Coop. Ext. Serv., IFAS, Univ. of Florida. p. 118-125.
- Nerson, H. 1989. Weed competition in muskmelon and its effects on yield and quality. *Crop Protection* 8:439-443.
- Nerson, H., M. Edelstein, and T. Bar-Shiro. 1988. The critical period of weed control in Galia muskmelon. *Hassede* 68:1314-1318.
- Simone, G. 1991a. Disease control in watermelon (*Citrullus vulgaris*). Fla. Coop. Ext. Serv., IFAS, Univ. of Florida. Fact sheet PP-118.
- Simone, G. 1991b. Disease control in cantaloupe (*Cucumis melo*). Fla. Coop. Ext. Serv., IFAS, Univ. of Florida. Fact sheet PP-100.
- Stall, W.M. 1992. Weed control in cucurbit crops (muskmelon, cucumber, squash and watermelon). Fla. Coop. Ext. Serv., IFAS, Univ. of Florida. HS-190.