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Allyl Isothiocyanate as a Methyl Bromide Alternative for Weed Management in Polyethylene-Mulched Tomato

Sanjeev K. Bangarwa, Jason K. Norsworthy, and Edward E. Gbur*

Methyl bromide has been widely used for weed control in polyethylene-mulched tomato production. With the phaseout of methyl bromide in the United States, an effective alternative is needed. Field experiments were conducted in 2007 and 2009 to determine if allyl isothiocyanate (ITC) would provide substantive weed control in tomato along with crop tolerance under low-density polyethylene (LDPE) and virtually impermeable film (VIF) mulch. Treatment factors included two mulch types (LDPE and VIF) and six rates of allyl ITC (0, 15, 75, 150, 750, 1,500 kg ha^{-1}). A standard treatment of methyl bromide : chloropicrin (67 : 33%) at 390 kg ha^{-1} under LDPE mulch was also established. Allyl ITC was broadcast applied and incorporated in soil before forming raised beds and laying plastic mulch. Tomatoes were transplanted 3 wk after applying allyl ITC or methyl bromide treatments. Tomato injury was ≤ 8% in all treatments at 2 wk after transplanting (WATP). Allyl ITC at 913 (± 191) kg ha^{-1} was required to control yellow nutsedge, Palmer amaranth, and large crabgrass equivalent to methyl bromide at 6 WATP and maintain marketable tomato yield equivalent to methyl bromide treatment. VIF mulch was not effective in increasing weed control or improving the marketable yield of tomato over LDPE mulch. This research demonstrates that allyl ITC under an LDPE mulch can have a practical application for weed control in polyethylene-mulched tomato in the absence of methyl bromide.

Nomenclature: Allyl isothiocyanate; methyl bromide; large crabgrass, *Digitaria sanguinalis* (L) Scop. DIGSA; Palmer amaranth, *Amaranthus palmeri* S. Wats. AMAPA; yellow nutsedge, *Cyperus esculentus* L. CYPES; tomato, *Lycopersicon esculentum* Mill. 'Amelia'.

Key words: Alternative weed control, plastic mulch, soil fumigation.

El methyl bromide ha sido extensamente usado para el control de malezas en la producción de tomate con cobertura de polietileno. Con la eliminación progresiva de methyl bromide en los Estados Unidos, se necesita una alternativa efectiva. Experimentos de campo se realizaron en 2007 y 2009 para determinar si allyl isothiocyanate (ITC) podría proporcionar un control sustancial de malezas en tomate, permitiendo la tolerancia del cultivo bajo una cobertura de polietileno de baja densidad (LDPE) y una cobertura de película virtualmente impermeable (VIF). Los factores de los tratamientos incluyeron dos tipos de cobertura (LDPE y VIF) y seis dosis de allyl ITC (0, 15, 75, 150, 750, 1500 kg ha^{-1}). También se estableció un tratamiento estándar de methyl bromide: chloropicrin (67: 33%) a 390 kg ha^{-1} bajo cobertura LDPE. Allyl ITC fue aplicado al voleo e incorporado al suelo antes de formar camas elevadas y colocar la cubertura plástica. Los tomates se trasplantaron 3 semanas después de aplicar los tratamientos de allyl ITC o methyl bromide. El daño al tomate fue ≤8% en todos los tratamientos 2 semanas después del trasplante (WATP). Allyl ITC a 913 (±191) kg ha^{-1} fue requerido para el control de *Cyperus esculentus*, *Amaranthus palmeri* y *Digitaria sanguinalis*, a niveles equivalentes a methyl bromide a las 6 WATP, y también para mantener el rendimiento comercial del tomate, equivalente al tratamiento con methyl bromide. La cobertura VIF no fue efectiva en aumentar el control de malezas o en incrementar el rendimiento comercial del tomate por encima de los niveles obtenidos con el uso de una cobertura LDPE. Esta investigación demuestra que allyl ITC bajo una cobertura LDPE puede tener una aplicación práctica para el control de malezas en la producción de tomate con cobertura de polietileno en ausencia de methyl bromide.

Tomato is an important fresh-market vegetable crop in the United States, with an annual market value of $2.3 billion in 2010 (USDA 2011). Weeds are the major pests in vegetable crops, reducing yield and interfering with harvesting. Weed management in plasticulture vegetable production has relied heavily on a preplant soil fumigant, methyl bromide (Duniway 2002). Methyl bromide is an effective and broad-spectrum pesticide applied in combination with chloropicrin under plastic mulch to fumigate the entire bed. However, because of its ozone-depleting potential, methyl bromide is banned in the United States (USEPA 2008). Although methyl bromide is currently available for vegetable producers under the Critical Use Exemption (USEPA 2008), this limited stock will phase out eventually. Thus, an effective alternative strategy is urgently needed by tomato and other vegetable producers.

One potential alternative strategy is to use isothiocyanates (ITCs) as soil fumigants. ITCs are volatile compounds with biocidal properties and are naturally produced by plants belonging to the Brassicaceae family through enzymatic hydrolysis of secondary metabolites, glucosinolates (Brown and Morra 1995; Fenwick et al. 1983; Rosa et al. 1997). ITCs belong to a family of compounds with a basic structure of R—N=C=S, with variable side chain (aliphatic, aromatic, or indolyl). Aliphatic ITCs are more volatile than aromatic ITCs (Sarwar et al. 1998), and high volatilization may improve ITC movement throughout treated soil and thereby can enhance pesticide activity. In the present study, an aliphatic ITC (allyl ITC) was

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* Former Graduate Assistant and Associate Professor, Department of Crop, Soil, and Environmental Sciences, University of Arkansas, 1366 West Altheimer Drive, Fayetteville, AR 72704; Professor of Statistics and Interim Laboratory Director, Agricultural Statistics Laboratory, University of Arkansas, 101 Agricultural Annex Building, Fayetteville, AR 72701. Corresponding author's E-mail: jnorswor@uark.edu