EFFECT OF APPLICATION TIMING ON THE EFFICACY OF DRIP-APPLIED SOIL FUMIGANTS

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INTRODUCTION

The scheduled withdrawal of methyl bromide from use as an agricultural fumigant in 2005 has prompted a great deal of research aimed at finding economically acceptable alternatives. Researchers have determined that combination applications of metam sodium and chloropicrin or 1,3-dichloropropene plus chloropicrin (1,3-DC), injected via chisel, provide good control of soilborne fungal pathogens, nematodes, and weeds in vegetables grown under plastic mulch on raised beds. The recent introduction of emulsifiable formulations of 1,3-DC has made application of this material, as well as metam sodium, through drip irrigation to raised, mulched beds feasible.

The purpose of this study was to evaluate the effects of metam sodium and 65% 1,3-dichloropropene plus 35% chloropicrin on the survival *Fusarium* spp., *Pythium* spp., total fungal species, and the root-knot nematode (*Meloidogyne incognita*) when applied in combination via drip tape to raised, plastic-mulched plant beds, and to determine the optimum interval between application and planting for maximum suppression of these organisms.

MATERIALS AND METHODS

An experiment was initiated March and April 2002 at the Blackshank Farm in Tifton, GA on a Fuquay loamy sand (loamy, siliceous, thermic Arenic Plinthic Paleudults). Applications of 1,3-dichloropropene (65% v/v) plus chloropicrin (35% v/v) EC (emulsifiable concentrate) in combination with metam sodium (42% EC) were made at rates of 93 l/ha and 349 l/ha, respectively, to raised beds at intervals simulating 4 weeks, 3 weeks, 2 weeks, and 1 week prior to transplanting of yellow crookneck squash. The materials were applied separately through drip tape for a period of approximately 6 hours (24 hour interval between 1,3-DC and metam sodium) at each application date. Metam sodium (42% EC) and 1,3DC EC were applied separately at 349 l/ha and 84 l/ha, respectively, and methyl bromide (chisel-injected at 224 kg/ha) were included as comparison treatments along with an untreated control.

Treatment effects on the survival of fungi were determined by assaying soil samples, taken for each treatment immediately prior to transplanting of yellow squash (10 April) and assayed on selective media to determine the numbers of colony forming units (CFU) per gram of soil of *Fusarium* spp., *Pythium* spp., and total fungal species. Nematode counts (numbers of juveniles per unit of soil) were determined from soil samples taken at harvest, and squash roots were

evaluated for severity of root galling on a 0-10 scale where 0=no galls and 10=maximum galling. Squash were harvested 2-3 times per week for a total of 11 harvests. Analysis of variance (ANOVA) was performed on the data, and treatment means were separated using Fisher's protected least significant difference test (FLSD).

RESULTS AND DISCUSSION

In general, populations of *Pythium* spp., *Fusarium* spp., and total soil fungi were significantly reduced by applications of 1,3-DC plus metam sodium, 1,3-DC alone, metam sodium alone, and methyl bromide when compared to the untreated control. Performance of drip-applied 1,3-DC EC, alone and in combination with metam sodium, was equal to or superior to chisel-applied methyl bromide No differences in populations of *Pythium* spp., or *Fusarium* spp., were found between application intervals of 1,3-DC plus metam sodium (Table 1). Total populations of fungi did not differ at 4, 3, or 2 weeks after application of 1,3-DC through drip tape. Total fungal populations and populations of *Fusarium* spp. were higher in plots treated with only 1,3-DC EC 4 weeks prior to transplanting than in those treated with the combination of 1,3-DC EC plus metam sodium EC at the same timing.

At harvest, only 1,3-DC EC plus metam sodium EC, applied at 4 weeks prior to transplanting, significantly reduced numbers of *M. incognita* juveniles as compared to the untreated control. Gall indices taken at harvest were lowest in plots treated with 1,3-DC EC plus metam sodium EC, applied at 4, 3, and 1 weeks prior to transplanting of squash, and in plots treated with metam sodium alone at 4 weeks before transplanting. Yields, however, were highest, in comparison with the untreated check, in plots treated with methyl bromide or metam sodium EC (alone at 4 weeks prior to transplanting). The disparity between root gall indices and yield with regard to these treatments may reflect late-season colonization of the root systems in those plots. Yields in plots treated with 1,3-DC EC, alone or in combination with metam sodium EC, did not differ from those in untreated check plots. The poor yields in these treatments may reflect plant injury caused by 1,3-DC rather than damage caused by the root-knot nematode, given that, in general, root-gall indices were lower for these treatments than the untreated check.

In conclusion, the optimal time of exposure to 1,3-DC EC plus metam sodium EC needed to suppress fungal pathogens, when delivered to raised, mulched beds via drip irrigation, appears to be 1 week. Further work is needed to determine the reasons behind yield loss associated with the combination of 1,3-DC EC plus metam sodium EC.

Table 1. Population densities of *Pythium* spp., *Rhizoctonia* spp., and *Fusarium* spp., in soil after drip application of alternatives to methyl bromide at various intervals prior to transplanting of squash.

Treatment[a]	Application rate	Application timing[b]	Fungal populations[c] *Fusarium*		*Pythium*		Total	
1,3-DC EC + Metam sodium 42%	93 l/ha 349 l/ha	4 weeks	16	d	4.8	bc	384	def
1,3-DC EC + Metam sodium 42%	93 l/ha 349 l/ha	3 weeks	16	d	0	c	128	f
1,3-DC EC + Metam sodium 42%	93 l/ha 349 l/ha	2 weeks	32	d	0	c	192	f
1,3-DC EC + Metam sodium 42%	93 l/ha 349 l/ha	1 week	0	d	0	c	528	de
1,3-DC EC	349 l/ha	4 weeks	1696	c	7.2	b	2208	c
Methyl bromide 98%	224 kg/ha	4 weeks	8800	b	0.8	bc	4368	b
Metam sodium 42%	349 l/ha	4 weeks	240	d	0	c	672	d
Untreated check	--	--	24912	a	41	a	26912	a

Means followed by the same letter do not differ significantly as determined by Fisher's protected least significant difference test (P=0.05).

[a]1,3-DC=Emulsifiable concentrate containing 1,3-dichloropropene (65%) plus chloropicrin (35%) and was drip-injected; metam sodium (42% EC) was drip-applied one day after 1,3-DC EC; methyl bromide 98% contained 2% chloropicrin by weight and was chisel-injected.

[b]Interval between application and planting.

[c]Populations of *Fusarium* spp., *Pythium* spp., and total fungi expressed as the number of colony forming units per gram of soil.

Table 2. Population densities of *Meloidogyne incognita*, root gall indices, and yield of yellow squash taken at harvest in plots where alternatives to methyl bromide were drip-applied at various intervals prior to transplanting of squash.

Treatment[a]	Application rate	Application timing[b]	*M. incognita*[c]	Gall index (0-10)[d]	Yield (kg/plot)
1,3-DC EC + Metam sodium 42%	93 l/ha 349 l/ha	4 weeks	19 b	0.6 b	66 c
1,3-DC EC + Metam sodium 42%	93 l/ha 349 l/ha	3 weeks	178 ab	2.6 ab	64 c
1,3-DC EC + Metam sodium 42%	93 l/ha 349 l/ha	2 weeks	102 ab	1.3 b	77 bc
1,3-DC EC + Metam sodium 42%	93 l/ha 349 l/ha	1 week	81 ab	1.8 b	74 bc
1,3-DC EC	349 l/ha	4 weeks	333 ab	4.4 ab	75 bc
Methyl bromide 98%	224 kg/ha	4 weeks	843 ab	3.7 ab	117 a
Metam sodium 42%	349 l/ha	4 weeks	419 ab	2.2 b	105 ab
Untreated check	--	--	954 a	6.1 a	65 c

Means followed by the same letter do not differ significantly as determined by Fisher's protected least significant difference test (P=0.05).

[a]1,3-DC=Emulsifiable concentrate containing 1,3-dichloropropene (65%) plus chloropicrin (35%) and was drip-injected; metam sodium (42% EC) was drip-applied one day after 1,3-DC EC; methyl bromide 98% contained 2% chloropicrin by weight and was chisel-injected.

[b]Interval between application and planting.

[c]Populations of M. incoginita, expressed as numbers of juveniles per unit of soil.

Table 2. Survival of *Fusarium solani*, *Pythium irregulare*, *Rhizoctonia solani*, and yellow nutsedge in soil after treatment with alternatives to methyl bromide at various intervals prior to transplanting of squash.

	Application		Pathogen and weed viability[c]			
Treatment[a]	**rate**	**timing[b]**	***F. solani***	***P. irregulare***	***R. solani* AG4**	**Yellow Nutsedge**
1,3-DC plus Metam sodium 42%	93 l/ha 349 l/ha	4 weeks	48 b	0 b	10 c	0 c
1,3-DC plus Metam sodium 42%	93 l/ha 349 l/ha	3 weeks	20 b	0 b	0 c	0 c
1,3-DC plus Metam sodium 42%	93 l/ha 349 l/ha	2 weeks	64 ab	0 b	52 ab	10 c
1,3-DC plus Metam sodium 42%	93 l/ha 349 l/ha	4 days	64 ab	0 b	86 a	68 b
Metam sodium 42% plus Chloropicrin	349 l/ha 84 l/ha	4 weeks	18 b	0 b	0 c	0 c
Methyl bromide 98%	224 kg/ha	4 weeks	100 a	0 b	20 bc	2 c
Untreated check	--	--	100 a	80 a	74 a	88 a

Means followed by the same letter do not differ significantly as determined by Fisher's protected least significant difference test (P=0.05).

[a]1,3-DC=1,3-dichloropropene (83%) plus chloropicrin (17%); methyl bromide 98% contained 2% chloropicrin by weight.

[b]Interval between application and planting.

[C]Percentage of pathogen-infested oat grains or yellow nutsedge nutlets that were viable after removal from treated soil prior to transplanting of peppers.