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Effect of Various Soil Fumigant, Mulch Type, and Herbicide Treatments on Pepper Plant Stand and Control of Nutsedge and Nematodes[1]

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Materials and Methods

Plots were established in the spring of 2004 on a Lakeland fine sand at the North Florida Research and Education Center – Suwannee Valley near Live Oak, Florida. The soil was prepared by rototilling to a depth of eight inches. Beds were formed on 5-ft centers oriented north and south and were fertilized with 600 lbs/A of 13-1.7-10.8 (N-P-K) as they were formed. The remaining fertilizer was applied weekly via drip irrigation resulting in a total nitrogen rate of 180 lbs/A. Plots were arranged in a split – split plot design with four replications. Main plots were soil fumigants, subplots mulch types, and the sub-subplots herbicide treatments.

Soil fumigation treatments are described in Table 1. All herbicides, mulches, and fumigants were applied on 2 Mar 2004. As mulch was applied to the beds, the herbicide treatment was applied to the tops of the pressed beds by using a spray boom attached to the back of the press pan. The herbicide spray was applied to the soil just ahead of the back mulch roller. The herbicide treatments were either "herbicide" or "no herbicide". The herbicide treatment was clomazone (Command) 1.0 lb ai/A plus metalochlor (Dual Magnum) 0.95 lbs ai/A + napropamide (Devrinol) 2.0 lbs ai/A.

Mulch treatments were either black virtually impermeable mulch (VIF) (Hytibarrier, Klerk's, Richburg, SC) or black high density polyethylene (HDPE) (Sonoco, Hartsville, SC). All plots had drip irrigation tape, Roberts RoDrip (San Marcos, CA) 24 gal per hour per 100 ft of tape, applied to the bed as the mulch treatments were applied.

'Brigadier' pepper transplants were planted on 2 Apr 2004 in two rows per bed with 12 inches between plants in each row. Each plot was 30 ft long. Standard insecticide and fungicide sprays were applied weekly during the entire growing season.

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Beginning one day after the fumigant treatment (1 DAT), soil gas traces of 1,3-D were recorded in all plots. Concentrations of 1,3-D were determined by sampling the air in the soil four inches deep in the bed center using a gas sample tub (Gas Tech, Kanagawa, Japan) sensitive to 1,3-D. Gas samples were taken on 1, 6, 10, 15, 20, 24, 27, 29, and 32 DAT (0 DAT = 2 Mar 2004).

Purple nutsedge counts were taken in each plot on 20 and 71 DAT. Counts were made on 5-ft subplots and final data are presented on a basis of number per 100 linear ft of bed top.

A number of dead pepper plants per plot were recorded on 28 May 2004. Plant samples of dead or dying plants were taken and sent to the University of Florida, Plant Diagnostic Lab for diagnosis.

Mature green pepper fruits were harvested on 8 and 15 June 2004. All fruits were graded using USDA grade standards for bell pepper with fancy, US No. 1, US No. 2, and cull categories. Fruit yield weights of each grade were recorded.

Soil samples for nematode assay were taken from each plot on 24 June 2004. Samples were assayed for root-knot nematode (*Meloidogyne* spp.), and four other species, and reported as number per 100 cm^3 soil.

All data were analyzed by analysis of variance and mean separation was by Duncan's Multiple Range Test.

Results and Discussion

The interaction of herbicide treatments and mulch treatment was not significant. The interactions of fumigant and mulch for most variables were significant so the data was re-analyzed by mulch type.

A significant interaction was found between fumigant and mulch treatments for 1,3-D gas levels found in the soil air (Table 2). The highest levels of 1,3-D were found in the bed center in the "C-35 Prebed" treatment on 1 DAT for both mulch types. Gas levels were found at higher levels under the VIF mulch than the HDPE mulch. "C-35 Yetter" and "C-35 Prebed" fumigation treatments resulted in the longest period of detection of 1,3-D under VIF mulch, lasting until 29 DAT. 1,3-D was not detected on 10 DAT for any fumigation treatment under HDPE mulch. 1,3-D was not detected 32 DAT for any treatment. As expected, no 1,3-D was detected for the methyl bromide and untreated control on any date with either plastic mulch.

Fumigation treatment significantly affected sedge populations on both collection dates (Table 3). Highest sedge populations on 22 March and 11 May were found in the "Untreated" check and "Telone II-Yetter" treatments under the HDPE mulch. Under the VIF mulch treatments, the highest sedge populations were found in the "Untreated" check and all other fumigation treatments were not significantly different from each other. The VIF mulch reduced nutsedge populations for "C-35 Prebed", "C-35 Yetter", and "Telone II-Yetter" populations in comparison to HDPE. Herbicide treatment had no effect on nutsedge populations on either date (Table 3).

Pepper Plant Stand – The number of dead plants in each plot was converted to a percentage of the total in each plot and is presented in Table 4. The plant disease diagnosis by the University of Florida Plant Disease Clinic was determined to be Pythium root rot. The number of dead plants was higher in the VIF mulch plots, except in the untreated check under VIF. Very few dead plants were found in any fumigation treatment under HDPE mulch. The early season plant stand in all plots was excellent. The problem resulting in dead plants did not begin to exhibit itself until early May and was exhibited only in certain VIF plots. The exact cause of this problem is not clear; however, this impacted all yield parameters in this study. Two possible factors in the cause of increased plant death due to Pythium may have been (1) the higher soil temperatures generally found under VIF mulch, or (2) the potential role of chloropicrin being maintained at high levels under VIF. The untreated check in the VIF plots had very few dead plants. It is possible the higher levels of nutsedge in these plots acted to cool the soil somewhat by providing holes to vent the heat. The soil temperature was not tracked across all plots in the experiment.

The pepper yield data is not presented here due to the confounding effect due to dead plants.

Soil samples at the end of the season were analyzed for five species of nematodes and the data is presented in Table 5. No significant difference due to fumigation was found in four of the five species due, in part, to the very low populations found overall. Those four species were stubby root (*Trichodorus*), ring (*Mesocriconema*), sting (*Belonolaimus*), and sheath (*Hemicycliophora*). The primary nematode pest in the region is root-knot nematode (*Meliodogyne* sp.). Root-knot nematode was found to be significantly affected by fumigation treatment. The untreated check had very high populations of root-knot nematode. All other fumigation treatments essentially eliminated root-knot nematode populations to zero under both mulch types.

Table 1. Soil fumigant treatments and descriptions.

Treatment	**Description**
Untreated	No soil fumigant applied.
Prebed	Telone C-35® (61.1% 1,3-dichloropropene plus 34.7% chloropicrin) Dow AgroSciences LLC, Indianapolis IN, applied at a rate of 35 gal per treated acre in prebed with fumigation chisels 8 inches deep with Kennco superbedder followed with the mulch application equipment.
C-35 Yetter	Telone C-35 (61.1% 1,3-dichloropropene plus 34.7% chloropicrin) Dow AgroSciences LLC, applied at a rate of 35 gal per treated acre in the prebed using a Yetter fumigation rig (Mirusso Fumigation, Boynton Beach FL) via three chisels per bed, 12 inches apart and 14 inches deep. The Telone C-35 Yetter treatment was followed by an application of chloropicrin (100%) 150 lbs per treated acre applied in the prebed using the Kennco superbedder followed with mulch application equipment.
Methyl Bromide	Methyl bromide (67%) plus chloropicrin (33%) Hendrix and Dail, Tifton GA, was applied to the prebed with the mulch application equipment. Methyl bromide rate was 400 lbs per treated acre.
Telone II-Yetter	Telone II® (98% 1,3-dichloropropene plus 2% chloropicrin) Dow AgroSciences LLC, applied at a rate of 12 gal per treated acre in the prebed using a Yetter fumigation rig (Mirusso Fumigation, Boynton Beach, FL) via three chisels per bed, 12 inches apart and 14 inches deep. The Telone II Yetter treatment was followed by an application of chloropicrin (100%) at 150 lbs per treated acre in the prebed using the Kennco superbedder followed with the mulch application.

Table 2. Soil air 1,3-D traces found in samples taken in bed centers.

Mulch Type	Fumigation Treatment	1,3-D gas trace levels in bed center (ppm)								
		3 Mar	**8 Mar**	**12 Mar**	**17 Mar**	**22 Mar**	**26 Mar**	**29 Mar**	**31 Mar**	**2 Apr**
HDPE	C-35 Prebed	338 a	10 bc	0	0	0	0	0	0	0
HDPE	C-35 Yetter	250 b	40 a	0	0	0	0	0	0	0
HDPE	Methyl Bromide	0 c	0 c	0	0	0	0	0	0	0
HDPE	Telone II Yetter	238 b	18 b	0	0	0	0	0	0	0
HDPE	Untreated	0 c	0 c	0	0	0	0	0	0	0
		**	**	**	**	**	**	**	*	NS
VIF	C-35 Prebed	788 a	188 a	75 a	49 a	48 a	23 a	9 a	9 ab	0
VIF	C-35 Yetter	388 b	190 a	55 ab	39 a	48 a	23 a	8 a	14 a	0
VIF	Methyl Bromide	0 c	0 c	0 c	0 c	0 c	0 b	0 b	0 b	0
VIF	Telone II Yetter	350 b	144 b	46 b	20 b	23 b	0 b	0 b	0 b	0
VIF	Untreated	0 c	0 c	0 c	0 c	0 c	0 b	0 b	0 b	0
		**	**	**	**	**	**	**	*	NS

[z] Interaction is significant and mean separation within mulch types by Duncan's Multiple Range Test at the 5% level. Means in the same column (for each mulch type separately) followed by different letters are significantly different ($p \leq .05$).

Table 3. Effect of soil fumigation, mulch, and herbicide treatments on total purple nutsedge (*Cyperus rotundus*) populations on two sampling dates.

Mulch Type	Fumigation Treatment	Purple nutsedge populations (No./100 linear feet of bed)	
		22 Mar	11 May
HDPE	C-35 Prebed	123 b	605 b
HDPE	C-35 Yetter	195 b	445 b
HDPE	Methyl Bromide	33 b	185 b
HDPE	Telone II Yetter	823 a	1675 a
HDPE	Untreated	1153 a	1850 a
		**	**
VIF	C-35 Prebed	0 b	105 b
VIF	C-35 Yetter	0 b	53 b
VIF	Methyl Bromide	0 b	0 b
VIF	Telone II Yetter	280 a	1263 b
VIF	Untreated	2253 a	3255 a
		**	**
Herbicide		401	830
No Herbicide		529	1074
		NS	NS

[z] The interaction between treatments was not significant; therefore, main effects are presented. Within source of variation, means in the same column followed by a different letter are significantly different by Duncan's Multiple Range Test at the 5% level.

Table 4. Effect of soil fumigation and mulch treatments on late season (28 May 2004) pepper plant stand.

Mulch Type	Fumigation Treatment	Dead Plants (%)
HDPE	C-35 Prebed	12
HDPE	C-35 Yetter	1
HDPE	Methyl Bromide	3
HDPE	Telone II Yetter	1
HDPE	Untreated	0
		NS
VIF	C-35 Prebed	43 a[z]
VIF	C-35 Yetter	25 ab
VIF	Methyl Bromide	30 ab
VIF	Telone II Yetter	11bc
VIF	Untreated	1 c
		**

[z] Means in the same column (for each treatment separately) followed by a different letter are significantly different by Duncan's Multiple Range Test at the 5% level.

Table 5. Effect of soil fumigation and mulch treatment on the populations of five nematode species.

Mulch Type	Fumigation Treatment	Nematode Counts on 24 June 2004 (No/100 cm3)				
		Root-Knott	Stubby	Ring	Sting	Sheath
HDPE	C-35 Prebed	0 b	3	0	0	0
HDPE	C-35 Yetter	0 b	4	0	0	0
HDPE	Methyl Bromide	1 b	19	1	0	0
HDPE	Telone II Yetter	3 b	15	2	0	4
HDPE	Untreated	1369 a	7	6	0	0
		**	NS	NS	NS	NS
VIF	C-35 Prebed	0 b	2	2	0	0
VIF	C-35 Yetter	0 b	1	0	0	0
VIF	Methyl Bromide	0 b	1	2	0	0
VIF	Telone II Yetter	0 b	12	0	0	0
VIF	Untreated	801 a	4	7	0	0
		**	NS	NS	NS	NS

[z] Means in the same column (for each treatment separately) followed by a different letter are significantly different by Duncan's Multiple Range Test at the 5% level.