FACTORS INFLUENCING VAPAM® EFFICACY ON YELLOW NUTSEDGE TUBERS

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Ontario, OR, 2004

Introduction

Yellow nutsedge is a perennial weed common in irrigated row crop production in the Treasure Valley of Eastern Oregon and Southwestern Idaho. It is particularly problematic in onion production. Onion plants are relatively short in stature with vertical leaves producing an incomplete canopy with limited potential to effectively suppress weeds. The conditions of high light intensity as well as frequent irrigation and high nitrogen fertilization required to maximize onion yield also serve to stimulate yellow nutsedge growth (Keeling et al. 1990). We have demonstrated that without any competition a single yellow nutsedge plant can produce over 18,000 tubers in a single year (Rice et al. 2004). We have also found that heavily infested commercial fields can have as high as 1,800 tubers/ft^2 in the top 10 inches of soil (unpublished data). Producers often apply Vapam® (metham sodium) in the fall prior to planting onions in an attempt to control yellow nutsedge. Control with Vapam is often variable and seems to depend on a number of environmental factors. The objective of this research was to determine the effect of metham rate, duration of exposure, temperature of exposure, and yellow nutsedge tuber condition on metham sodium efficacy.

Materials and Methods

Trials were conducted at the Malheur Experiment Station in the laboratory to determine the influence of metham sodium rate, duration of exposure, temperature during exposure, and tuber conditioning on yellow nutsedge control. Yellow nutsedge tubers were extracted from the soil in November and either stored at a constant 50°F in a small volume of soil or washed and subjected to 38°F for 4 weeks prior to the initiation of the experiment. The conditioning treatment was meant to reduce tuber dormancy. Washing and chilling have been reported as effectively overcoming dormancy (Tumbleson and Kommedahl 1961). All tubers were produced from a single plant the previous summer. Soil (1.76 lb) and 15 tubers were placed in 1-quart jars. The soil was an Owyhee silt loam. The soil was wetted to 14 percent moisture on a weight for weight basis by adding one third of the water to the bottom of the jar, adding half the volume of soil and then the yellow nutsedge tubers, adding another third of water, adding the remaining soil and then the final third of the water. The jars were placed in growth chambers at 41, 55, or 77°F for 24 hr to equilibrate. Vapam was injected into the soil 0.5 inch below the tubers at equivalent field rates of 0, 20, 40, 60, and 80 gal of product per acre based on soil volume. Jars were sealed and placed back in their respective temperatures for 1, 3, or 5 days. After each duration of exposure, the soil was removed from the jars and the tubers were washed from the soil. Extracted tubers were placed in petri-dishes between 2 pieces of filter paper and 5 ml of water was added to each dish. The petri-dishes were sealed and placed in the dark at 77°F. Germinated tubers were recorded at the time of removal and weekly for 6 weeks. Treatments were replicated four times and the trial was repeated once after the initial run. Total percent tuber germination was analyzed by ANOVA. For each combination of exposure temperature, exposure duration, and tuber conditioning, tuber sprouting response to Vapam dose was fitted to the logistic model:

$$y = \frac{D - C}{1 + (x / I_{50})^{b}}$$

Where y = the percent sprouting yellow nutsedge tubers, x = metham sodium rate, C = percent tubers sprouting at high rates, D = percent of tubers sprouting in the non-treated treatment, b = the slope at the I_{50} dose, and I_{50} = the dose providing 50 percent reduction in sprouting tubers (Seefelt et al. 1995).

Results and Discussion

In general, tuber sprouting was affected by metham sodium rate, temperature of exposure, duration of exposure, and yellow nutsedge tuber conditioning. This is in agreement with research by Boydston and Williams (2003), which evaluated fumigant affects on volunteer potatoes. All main effects and interactions were significant (Table 1). The I_{50} dose for metham sodium under various conditions ranged from 21.64 to >80.0 gal/acre and was lower for conditioned tubers compared to nonconditioned tubers across all conditions except for tubers exposed at 77°F for 3 or 5 days (Table 2). Non-conditioned tubers had lower germination in preliminary trials (data not shown), but washing and other conditions during the trial overcame any dormancy as *D* values (maximum germination) were similar among all treatments. Nonconditioned tubers did require more time to germinate than conditioned tubers (data not shown). Nonconditioned tubers were unaffected by metham sodium rate at 1 day exposure at 41°F (Fig. 1). For nonconditioned tubers, increasing exposure temperature, and increasing duration of exposure decreased sprouting. As duration of exposure or temperature of exposure increased, differences among conditioned and nonconditioned tubers decreased. Metham Sodium must be converted to methyl isothiocyanate (MITC) to have activity against yellow nutsedge. At lower temperatures conversion of metham sodium to MITC takes place at a slower rate. In addition to slow conversion of metham to MITC, the reduced response of yellow nutsedge tubers at cooler temperatures could also be attributed to yellow nutsedge tubers being less metabolically active. The similar response of conditioned tubers regardless of duration of exposure at 59 or 77°F and the increased response of nonconditioned tubers to increasing duration of exposure, suggests that at 59 and 77°F metham sodium conversion to MITC is not the limiting factor, but rather uptake by the nonconditioned nutsedge tubers may have been the limiting factor. In contrast, at 41°F, both conditioned and nonconditioned tubers responded to increasing duration of exposure, suggesting that both rate of metham sodium conversion to MITC and uptake by the tubers were having an affect on metham sodium efficacy. I_{50} values were actually lower for conditioned tubers exposed for 5 days at 41°F compared to 59 or 77°F. This result is difficult to explain. It may be that while conversion of metham sodium to MITC is faster at high temperatures, breakdown of MITC is also increased. This research illustrates that fumigant efficacy depends on the dose reaching the target organism. While the rate applied directly influences the dose, environmental or physiological factors may affect what dose the yellow nutsedge receives. Applying metham sodium at a time when yellow nutsedge tubers are more susceptible may increase metham sodium efficacy against yellow nutsedge.

References

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Acknowledgement

Thanks to the Idaho/Eastern Oregon Onion Growers Association for financial support.

Table 1. Significance of ANOVA main effects and interactions for total percent of yellow nutsedge tubers sprouting.

Factor	*P*
Dose	0.00001
Temperature	0.00001
Time	0.00001
Conditioning	0.00001
Dose by temperature	0.00001
Dose by time	0.00001
Temperature by time	0.00001
Conditioning by dose	0.00001
Conditioning by temperature	0.00001
Conditioning by time	0.00001
Dose by temperature by time	0.00001
Dose by temperature by conditioning	0.00001
Temperature by time by conditioning	0.00001
Dose by time by conditioning	0.00001
Dose by temperature by time by conditioning	0.00001

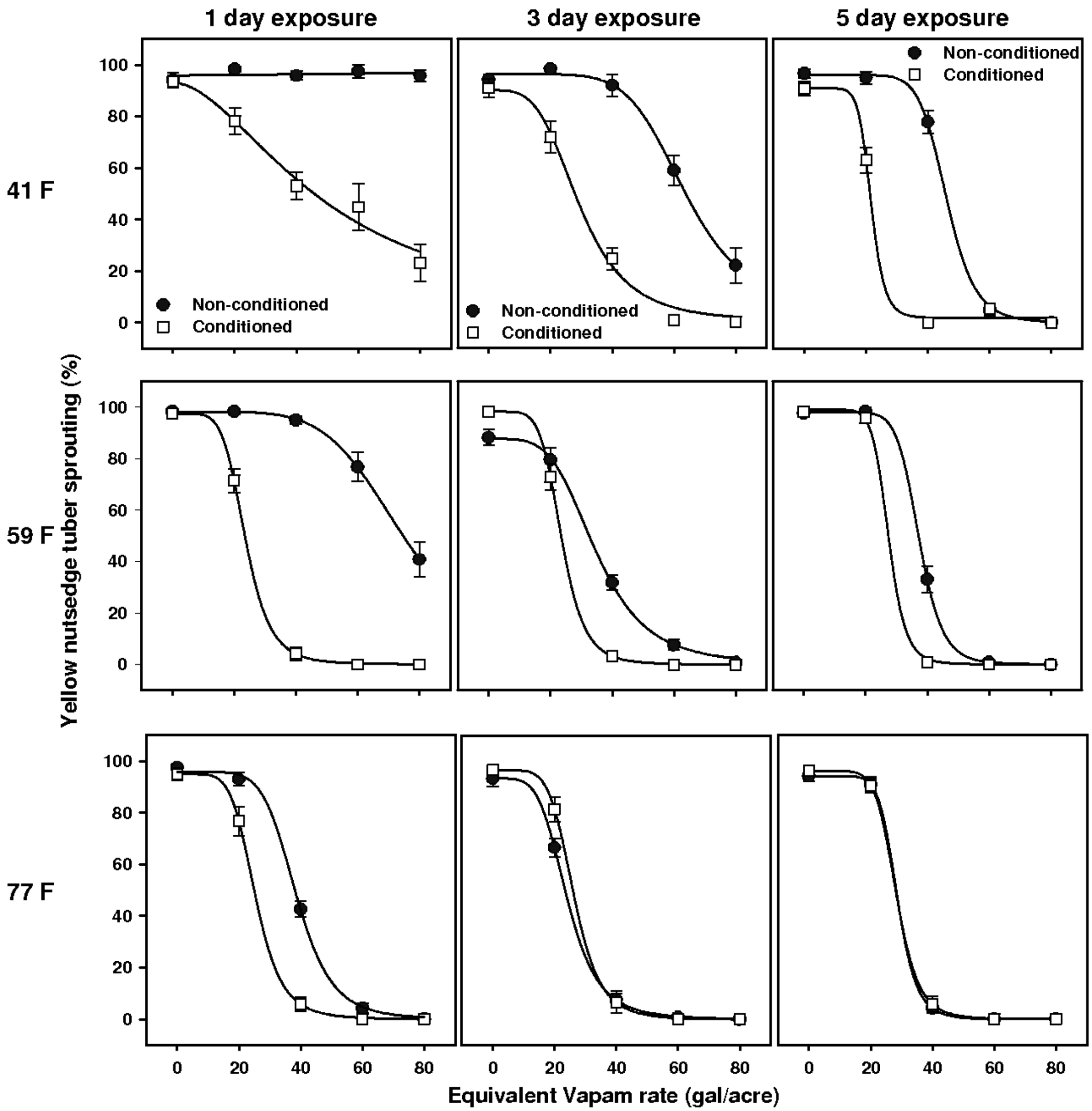

Figure 1. Yellow nutsedge germination in response to Vapam® rate, temperature of exposure, duration of exposure, and conditioning of the yellow nutsedge tubers. Conditioned tubers were washed and chilled at 38°F for 4 weeks prior to trial initiation. Nonconditioned tubers were stored in soil at a constant 50°F. Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 2. Estimated parameters for nonlinear regression analysis of yellow nutsedge sprouting in response to Vapam® rate, exposure temperature, exposure duration, and yellow nutsedge tuber conditioning. Standard errors are in parentheses.*, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Temperature	Time	Tuber condition	*D*	*C*	I_{50}	*b*	R_2
°F	days		-------------------%----------------		gal/acre		
41	1	Nonconditioned	--	--	--	--	0.00
		Conditioned	93.16 (6.23)	0.00 (56.29)	49.57 (36.77)	1.82 (1.15)	0.65
	3	Nonconditioned	96.21 (3.21)	6.34 (26.29)	63.18 (7.10)	6.59 (3.73)	0.84
		Conditioned	89.99 (3.83)	0.00 (4.33)	29.57 (2.09)	3.80 (0.68)	0.92
	5	Nonconditioned	96.02 (1.87)	0.00 (2.96)	46.07 (1.32)	10.00 (1.67)	0.97
		Conditioned	90.84 (2.84)	1.69 (2.04)	21.64 (4.61)	10.00 (26.72)	0.96
59	1	Nonconditioned	98.20 (2.78)	0.00 (126.09)	75.24 (37.21)	5.57 (4.91)	0.80
		Conditioned	97.50 (2.37)	0.00 (1.86)	23.69 (0.95)	5.96 (1.14)	0.98
	3	Nonconditioned	87.78 (2.86)	0.00 (3.67)	34.82 (1.59)	4.28 (0.81)	0.95
		Conditioned	98.33 (2.46)	0.00 (1.88)	23.62 (1.05)	6.38 (1.44)	0.97
	5	Nonconditioned	98.01 (1.88)	0.00 (2.63)	37.36 (2.49)	10.00 (10.28)	0.98
		Conditioned	99.01 (1.04)	0.00 (0.75)	27.48 (0.93)	10.00 (0.99)	1.00
77	1	Nonconditioned	95.86 (1.64)	0.00 (2.65)	38.62 (0.63)	6.72 (1.76)	0.98
		Conditioned	94.99 (2.95)	0.00 (2.31)	25.37 (1.31)	6.02 (1.06)	0.96
	3	Nonconditioned	95.60 (2.86)	0.00 (2.22)	26.24 (1.31)	6.21 (0.94)	0.97
		Conditioned	93.33 (2.41)	0.00 (2.06)	24.15 (0.94)	4.83 (0.70)	0.97
	5	Nonconditioned	96.18 (2.11)	0.00 (1.45)	28.36 (1.26)	7.98 (0.99)	0.98
		Conditioned	94.16 (1.78)	0.00 (1.29)	28.64 (1.48)	9.20 (1.35)	0.99

*Abbreviations: *D*, percent of tubers sprouting in nontreated treatment; *C*, percent of tubers germinating at high metham dose; I_{50}, dose causing a 50 percent reduction in sprouting tubers; *b*, slope at I_{50} dose. For one treatment the I_{50} was higher than the rates evaluated.