ORIENTATION OF GRAPEVINE ROWS AFFECTS WEED GROWTH

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Introduction

Black nightshade (*Solanum nigrum* L.) is a common vineyard weed. It may be effectively controlled with herbicides, but farmers are increasingly seeking alternatives to chemicals. In fact, many California grape growers wish to develop management practices that are economically and environmentally sustainable (Dlott et al. 2002). Sustainable weed control is likely to require a multifaceted approach that includes the design of weed suppressive cropping systems. Such systems may shade weeds to reduce their fitness, but this concept has been developed for annuals and has not been extended to perennial systems such as vineyards.

Canopies of trellised vines may intercept more sunlight in rows oriented north-south (NS) compared to rows oriented EW, but variables including latitude, time of year, canopy architecture, and cultural practices such as pruning style, can all have pronounced effects on canopy light interception, so experimental comparisons of actual systems are needed. Even so, these contrasting row orientations would be expected to affect the quantity and quality of light available to weeds under the canopy. Shade may decrease fitness of some weeds by reducing their photosynthetic capacity and by causing changes in dry matter partitioning that favor vegetative, rather than reproductive, structures (Begna et al., 2002). Therefore, row orientation might serve as one part of an integrated weed management (IWM) strategy for new vineyards.

The objectives of this study were to test the following.

- Effect of row orientation on light environment in the weed canopy zone (WCZ).
- Effect of light environment on weed photosynthesis.
- Effect of row orientation on weed growth and seed production.

Materials and Methods

In April 2003 and 2004, uniform black nightshade seedlings growing in separate, 8-liter, black polyethylene pots were randomly assigned to row orientation treatments and moved to a vineyard at the Kearney Agricultural Center, Parlier. The vineyard was established in 2000 and featured rows oriented NS and EW in a randomized complete block design with four replicates. ‘Selma Pete’ grapevines were spaced about 2 m within rows and 3.6 m between rows, with guard rows surrounding each experimental row. The length of the vine row was 20 m. The vines were trained to quadrilateral cordons on a Y-shaped open-gable trellis (Figure 1). Similar vine and row spacing, and training and trellis systems, are used commercially for raisin and table grape production in California.

Photosynthetically active radiation (PAR) was measured three times a day (0900, 1200, and 1600 hrs) each week with a ceptometer positioned parallel to the vine row and straddling each pot, about 0.5 m above the vineyard floor in the WCZ. Photosynthetically active radiation was also measured hourly between 06:30 and 19:30 hrs on one day during each experiment. On May 20, 2003, and on June 10, 2004, a single leaf of each nightshade was selected and subjected to photosynthesis measurements under ambient light conditions at about 09:30 and 12:00 hrs using a portable photosynthesis system.

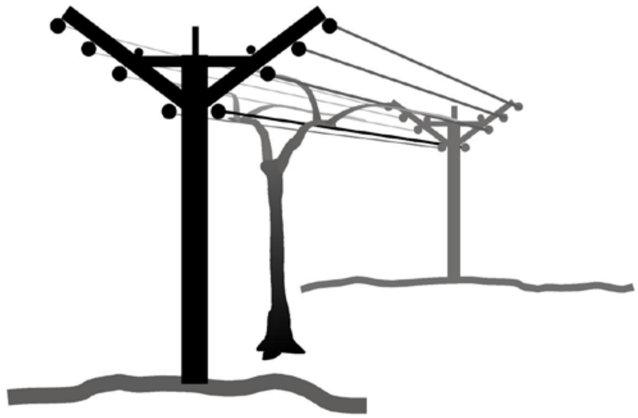

Figure 1. An open-gable trellis system.

Height (stem length from the soil surface in the pot to the shoot apex) of each nightshade was recorded weekly. After about 7 weeks, each plant was harvested and divided into leaves, stems, berries, and roots. Growth media was washed from the roots. Leaf area was measured with a leaf area meter and the total stem lengths of the plants were also measured. The number of berries in each nightshade plant was counted. Leaf, stem, berry, and root dry weights were determined after drying the samples to a constant weight in an oven. Ten berries from each plant were randomly sampled after drying and the seeds contained in each berry were extracted and counted. Leaf area ratio (LAR), leaf weight ratio (LWR), and specific leaf weight (SLW) were calculated as total leaf area/total plant dry weight, total leaf dry weight/total plant dry weight, and total leaf dry weight /total leaf area, respectively.

All data were subjected to analysis of variance. Replication and year by replication interaction were considered random effects. There was a main effect ($P<0.05$) of year on most of the variables measured. However, data were combined for the two years as there was no year by treatment interactions for the variables.

Results and Discussion

Irradiance beneath grapevine canopies in NS rows was bimodal, with peaks occurring at about 09:30 and 16:30 hrs (Figure 2), when the angle of the sun was such that some direct light passed between the canopies of adjacent vinerows. At those times, irradiance at the WCZ in NS rows increased rapidly from about 35 µmol • m-2 • s-1, in both years, to peaks of about 500 µmol • m-2 • s-1, in 2003, and to about 700 µmol • m-2 • s-1, in 2004 (about 30 to 40% of full sun, data not shown). In contrast, the WCZ beneath grapevines in EW rows was characterized by low irradiance throughout the day (Figure 2) due to shade cast from vines within the rows or from vines in the southern guard rows, depending on the time of day. Thus, the WCZ in EW rows received about 80% less light than that in rows oriented NS (based on the difference in the areas under the curves; data not shown). The difference in light levels of each row orientation and time of day resulted in greater photosynthetic rates for the leaves of plants in NS rows compared to those in EW rows, in the morning, but the leaves of plants in both row orientations had similar photosynthetic rates at midday (Table 1).

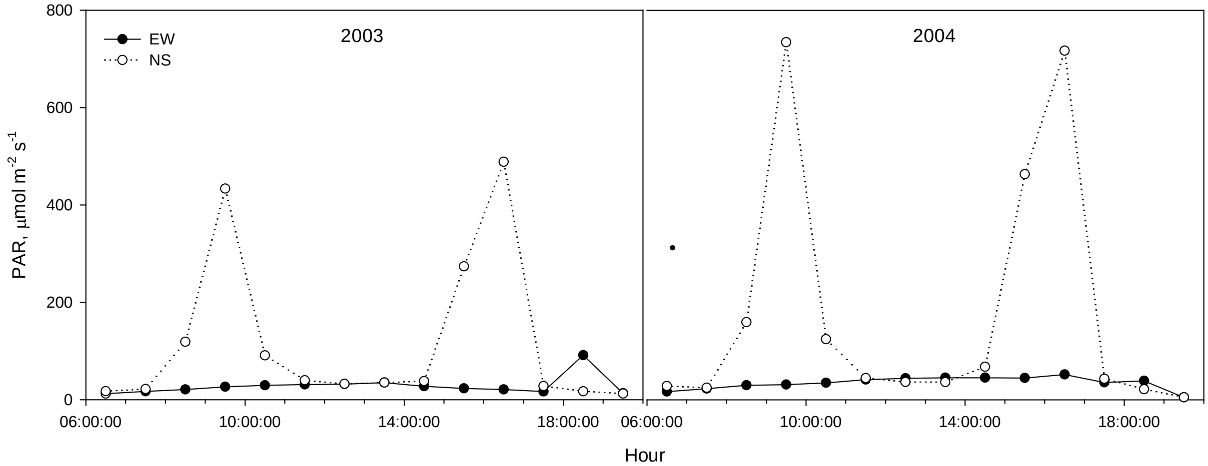

Figure 2. Incident photosynthetically active radiation (PAR) beneath grapevine canopies in rows oriented north-south (NS) or east-west (EW) measured hourly between 06:30 and 19:30 hrs on Julian day 161, 2003, and on Julian day 144, 2004, Parlier, CA.

Table 1. Incident photosynthetically active radiation (PAR) on leaves of potted nightshade plants grown under grapevine canopies oriented East-West (EW) or North-South (NS), and net CO2 assimilation (A) of those leaves. Measurements were made at about 1030 hrs and 1200 hrs on 12 June 2003 or 14 June 2004.

	Time of day							
	1030 hrs				1200 hrs			
	Year		Year		Year		Year	
	2003		2004		2003		2004	
	PAR	A	PAR	A	PAR	A	PAR	A
Row orientation	---------------------------------(µmol • m-2 • s-1)------------------------------------							
EW	24a	1.18	13	0.17	22	0.88	12	1.08
NS	659	9.00	798	6.84	19	0.69	16	0.72
P Valueb	0.007	0.0001	0.04	0.05	0.38	0.37	0.07	0.99

aValues are treatment means, n = 4.

bSignificance level for treatment comparisons within columns

Plants in both EW and NS rows were of similar height at harvest, but row orientation had a marked effect on other plant morphological variables. The total number of leaves per plant was not affected by row orientation, but nightshades growing in the EW rows had bigger and thinner leaves than those in the NS rows as shown by the differences in the total leaf area, 22% greater in EW vs NS, and SLW, 21% lesser in EW vs NS (Table 2). Plants in EW rows also partitioned more resources to leaves at the expense of other organs as evidenced by their greater LAR and LWR compared to NS plants, i.e. 31% and 18% greater, respectively in EW vs NS (Table 2).

Table 2. Average (2003 and 2004) total leaf number, leaf area, stem length, leaf area ratio (LAR), leaf weight ratio (LWR), and specific leaf weight (SLW) of the black nightshade plants as affected by vineyard row orientation.

Row orientation	Total leaves	Total Leaf area	Total Stem length	LAR	LWR	SLW
	No. plant-1	cm2 plant-1	cm plant-1	cm2 kg-1	kg-1 kg-1	g-1 m-2
East-West	178.5	2376.9	307.6	180.9	0.33	1.8
North-South	171.0	1843.4	297.7	124.0	0.27	2.3
P Valuea	.4543	<.0001	.7970	<.0001	.0002	<.0001

aSignificance level for the treatment comparisons within a column.

Specifically, plants in the EW rows partitioned less dry matter to berries and to roots compared to those in the NS rows (Figure 3). Number of berries, average number of seeds per berry, and total seed return per plant was 16%, 7%, and 20% lower respectively, in the nightshades in EW compared to NS rows (data not shown). Such reductions in seed return could have long term implications for plant population dynamics and future weed management. The low root:shoot ratio of nightshades in EW rows may make that these plants more vulnerable to moisture and nutrient stress than those in the NS rows. A smaller root biomass may also facilitate uprooting the weeds by hand or by mechanical cultivation. Further, a higher leaf area and lower root mass might influence the degree of susceptibility of plants to herbicides (Ipor and Price, 1994).

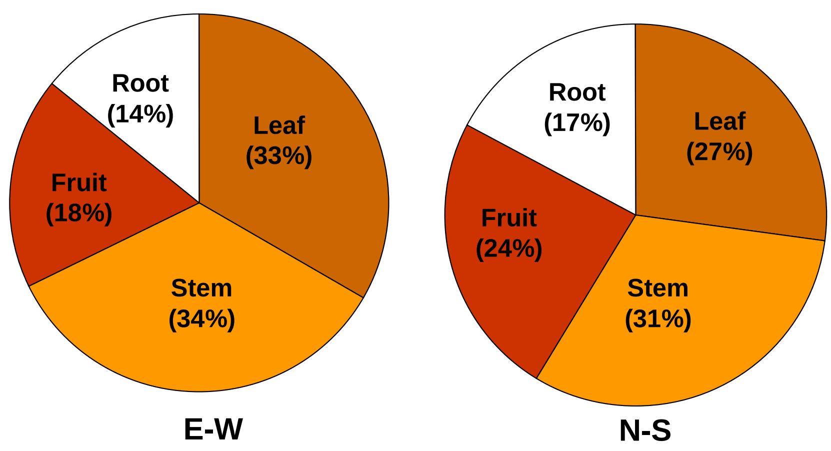

Figure 3. Proportion of dry mass allocated to roots, leaves, stems and fruit of black nightshades grown under 'Selma Pete' grapevines in rows oriented east-west (E-W) or north-south (N-S), Parlier, CA, April to June, 2003 and 2004.

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