report by Yokoyama et al. (1977), where a 2.2- to 6-fold increase in rubber content of young plants was shown. This difference could be due, in part, to the age of plants or the timing of application. Plants used in this experiment had more lignified stems than young, greenhouse-grown plants. To date, there is no convincing evidence that DCPTA significantly increases rubber content in field-grown guayule.

Stem cross sections of guayule showed nontreated plants having normal cortex and cambial development, with rubber formation throughout the cortex (Fig. 2A). Cross sections of morphactin-treated guayule stems had irregular cambium development and nonuniform rubber deposition (Fig. 2B). Cortical tissue of a nontreated stem showed uniform rubber deposition surrounding the resin duct (Fig. 2C). Morphactin-treated stems exhibited abnormal cell development surrounding the duct (Fig. 2D). Parenchyma cells differentiated into xylem tissue, which, perhaps,

explains the absence of rubber.

Since rubber production depends on the amount of parenchyma tissue, environmental factors may be useful to increase this ratio. For example, timing of irrigation might be used to induce cambial cell divisions that favor this ratio. Girdling may also be a possibility to increase rubber storage in cortex tissues. However, breeding and selection for a high bark : wood ratio may be the best approach.

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Competition Between Perennial Ryegrass Sod and 'Chardonnay' Wine Grapes for Mineral Nutrients

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Abstract. Competition between perennial ryegrass (*Lolium perenne* L. 'Manhattan II') sod and wine grapes (*Vitis vinifera* L. 'Chardonnay') for mineral nutrients was investigated with three methods of vineyard floor vegetation management (bare floor, mowed, and unmowed sod) and three rates of urea application (0, 137, and 274 kg N/ha). Sod decreased N concentration of grape leaves in both 1986 and 1987; Fe concentration in 1986; and S, Ca, B, and Mn in 1987. Sod also reduced total content of all measured nutrients in grape leaves. Mowing did not alleviate this reduction in leaf nutrient content. A high rate of urea (274 kg N/ha) compensated for N reduction in grape leaves caused by sod competition. Chemical names used: 2-[1-(ethoxyimino) butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one (sethoxydim); N,N-diethyl-2-(1-naphthalenyloxy)propanamide (napropamide).

Sod management is a common orchard practice (Atkinson and White, 1980; Hogue and Neilson, 1987) that reduces soil erosion, increases soil organic matter and water infiltration into the soil, may improve crop nutrient status, limits weed invasion, and improves traffic and working conditions (Butler, 1986; Hogue and Neilson, 1987).

Effective use of sod systems depends on an understanding of competitive interactions, including nutrient interactions, between sod and crop plants (Haynes, 1980; Zimdahl, 1980; Morlat et al., 1984; Skroch and Shribbs, 1986). Competition between sod and tree fruits suggests that N is of primary importance (Hill, 1962; Lord and Vlach, 1973; Haynes, 1980). Reports on other nutrients are rare and often conflicting (Greenham and White, 1968; Bould et al., 1972; Atkinson and White, 1980; Zimdahl, 1980). Possible methods to reduce the nutrient competition include sod suppression 'with chemicals or by mowing, and provision of additional nutrients (Skroch and Shribbs, 1986). In this study, the nutritional and growth changes of

grapes were investigated by differing vineyard floor management and by varying the rate of urea fertilization.

Field experiments were conducted during 1986 and 1987 at Oregon State Univ., Corvallis. The vineyard soil was a Chehalis silty-clay loam. 'Manhattan II' perennial ryegrass was sowed in 1983 and the wine grape cultivar Chardonnay was planted in 1984 at a spacing of 1 × 3.5 m. A randomized complete-block design with two factors and three replications was used. Each replication of each treatment had five vines. Factor one was vineyard floor vegetation management that included interrow sod strip without mowing (unmowed sod), interrow sod strip with mowing (mowed sod), and vineyard floor treated with herbicides (bare floor). The sod between two grape rows in the sod plots was 2.5 m wide. Factor two was urea fertilization at 0, 137, and 274 kg N/ha.

Sethoxydim was sprayed at 0.56 kg a.i./

Fig. 1. Leaf N concentration change of grapes with increasing urea fertilization for three vineyard floor management schemes (1987). Management mean separation by orthogonal contrast tests for each urea rate at $P = 0.05$.

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Table 1. Grape leaf macronutrient concentration as influenced by vineyard floor vegetation management and urea fertilization in 1986 and 1987.

Treatment	Macronutrient concn (g·kg ⁻¹)											
	N		P		K		S		Ca		Mg	
	1986	1987	1986	1987	1986	1987	1986	1987	1986	1987	1986	1987
Vegetation management^a												
Bare floor	24.7 A	22.3	4.6 a	3.5 a	9.4 a	9.9 a	1.8 a	1.9 A	28.0 a	36.8 A	5.8 a	6.8 a
Mowed sod	21.4 B	21.2	5.6 a	4.8 a	9.4 a	9.9 a	1.8 a	1.6 B	28.0 a	32.8 B	5.4 a	6.5 a
Unmowed sod	20.6 B	20.0	5.0 a	4.1 a	9.6 a	8.7 a	1.7 a	1.6 B	26.8 a	32.5 B	5.2 a	6.9 a
Urea fertilization rate (kg N/ha)												
0	20.7	17.3	7.3	7.5	10.3	11.7	2.0	1.9	28.4	35.5	5.4	6.4
137	22.6	22.5	4.0	2.8	8.8	8.2	1.6	1.5	25.7	33.0	5.5	6.7
274	23.4	23.7	3.9	2.2	9.5	8.3	1.7	1.6	27.1	33.7	5.5	7.2
Significance of regression for urea fertilization												
Linear	*	---	**	**	NS	**	*	**	NS	NS	NS	**
Quadratic	NS	---	**	**	*	**	*	*	**	NS	NS	NS
Significance of interaction	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

^aMean separation by contrast tests at $P = 0.05$ (lowercase letters) or 0.01 (uppercase letters).
NS, *, **Nonsignificant or significant at $P = 0.05$ and 0.01 , respectively.

Table 2. Grape leaf micronutrient concentration and vegetative growth as influenced by vineyard floor vegetation management and urea fertilization in 1986 and 1987.

Treatment	Micronutrient concn (mg·kg ⁻¹)										Shoot length (m/plant)		Leaf dry wt (kg/plant)
	Mn		Fe		Cu		B		Zn		1986	1987	1987
	1986	1987	1986	1987	1986	1987	1986	1987	1986	1987			
Vegetation management ²													
Bare floor	73 a	317 a	221 A	311 a	18 a	13 a	32 a	29 a	23 a	23 a	5.0 A	19.3 A	0.44 A
Mowed sod	73 a	286 b	185 B	280 a	15 a	14 a	28 a	25 b	23 a	25 a	3.5 B	12.0 B	0.26 B
Unmowed sod	66 a	252 b	189 B	309 a	13 a	12 a	29 a	25 b	22 a	23 a	3.6 B	11.7 B	0.25 B
Urea fertilization rate (kg N/ha)													
0	73	252	188	313	16	17	34	33	23	30	3.6	10.9	0.20
137	66	282	198	284	14	11	27	22	21	19	4.1	14.7	0.30
274	73	321	209	303	17	10	29	23	23	21	4.4	17.4	0.45
Significance of regression for urea fertilization													
Linear	NS	*	NS	NS	NS	**	*	**	NS	**	NS	*	**
Quadratic	NS	NS	NS	NS	NS	*	NS	**	NS	**	NS	NS	NS
Significance of interaction													
	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

^aMean separation by contrast tests at $P = 0.05$ (lowercase letters) or 0.01 (uppercase letters).
NS, *, **Nonsignificant or significant at $P = 0.05$ and 0.01 , respectively.

ha in Apr. 1986 to remove the perennial ryegrass in the bare-floor plots and in 1-m-wide strips centered along the trellis rows in the sod plots. In May 1986, 0, 100, and 200 g urea per vine were banded 30 cm from vine trunks on both sides of the trellis rows immediately before irrigation. The vineyard was sprinkler irrigated with 100 mm of water monthly from May to Sept. 1986. Grass was mowed three times with a lawn mower (mowed sod) and clipping weight was measured at each mowing. Grapevine shoot length was measured at the end of the growing season. On 18 Aug. 1986, grape leaves with petioles were collected and both were used to determine N, P, K, S, Ca, Mg, Mn, Fe, Cu, B, and Zn concentrations, using a micro-Kjedahl method for N (0.4 g per sample) (Schuman et al., 1973) and an inductively coupled argon plasma spectrometer (Jarrell-Ash Div., Fisher Scientific Co., Waltham, Mass.) for the remaining elements.

In 1987, the following changes were made. Napropamide was sprayed at 4.48 kg a.i./ha on bare areas of all plots. Total urea application rates remained the same as in 1986, but were applied in three equal amounts in

May, June, and July before 130 mm of irrigation each time. Grass was mowed four times (mowed sod). AH grape leaves were picked, dried, and weighed in October.

Data were statistically analyzed using a variance analysis to detect the significance of main effects of floor management and urea fertilization and interactions between floor management and urea fertilization. Vineyard floor management means were separated by orthogonal contrasts (no sod vs. sod and mowed sod vs. unmowed sod), and the effect of urea fertilization was tested with regression analysis.

Results in 1986 suggest that leaf N (Table 1) and Fe (Table 2) concentrations were significantly reduced by sod treatments, regardless of mowing. In 1987, vineyard floor vegetation management and urea fertilization interacted significantly when evaluated by measuring leaf N concentration (Table 1 and Fig. 1). This interaction indicates that a high rate of urea fertilization could compensate for reduction of grape leaf N concentration in plots with sod competition. Leaf N concentration in sod plots was significantly lower than that in bare-floor plots when no urea

was applied; when urea rate was increased to 274 kg N/ha, no significant difference existed between sod and bare-floor plots. When urea was applied at 137 kg N/ha, leaf N concentration of grapes in mowed sod plots was not significantly different from that in bare-floor plots; leaf N of unmowed sod plots was significantly lower than the bare floor, implying mowing could be beneficial by increasing grape leaf N at this rate of urea fertilization. These results show that sod and grapes compete for N when it is limiting, as also has been reported in studies with tree fruit (Hill, 1962; Lord and Vlach, 1973; Haynes, 1980). Leaf S, Ca (Table 1), Mn, and B (Table 2) concentrations were significantly decreased by sod in 1987. Shoot length, leaf dry weight (Table 2), and total content of measured nutrients in leaves (Table 3) were also significantly reduced by sod.

Urea fertilization significantly increased leaf N concentration in both 1986 and 1987, and Mg and Mn concentrations in 1987 (Tables 1 and 2). Urea also increased total content of leaf N, S, Ca, Mg, Mn, Fe, and Zn (Table 3). However, significant decreases in leaf P, K, S, and B concentrations in both

Table 3. Total measured nutrient content in grape leaves and grass dry weight as influenced by vineyard floor vegetation management and urea fertilization in 1987.^a

Treatment	Macronutrient (g/plant)						Micronutrient (mg/plant)					Grass dry wt (kg/plot)
	N	P	K	S	Ca	Mg	Mn	Fe	Cu	B	Zn	
Vegetation management ^b												
Bare floor	10.0 A	1.5 A	4.5 A	0.9 A	16.6 A	3.1 A	151 A	139 A	5.5 A	12.8 A	10.2 A	---
Mowed sod	5.7 B	0.9 B	2.2 B	0.4 B	8.4 B	1.7 B	78 B	72 B	3.1 B	5.9 B	5.7 B	1.9 a
Unmowed sod	5.3 B	0.8 B	2.0 B	0.4 B	7.9 B	1.7 B	66 B	73 B	2.5 B	5.6 B	5.3 B	2.0 a
Urea fertilization rate (kg N/ha)												
0	3.7	1.3	2.3	0.4	7.4	1.3	54	60	3.5	6.7	6.1	1.0
137	6.7	0.8	2.6	0.5	10.1	2.0	91	83	3.3	6.8	5.5	2.3
274	10.7	1.0	3.8	0.8	15.5	3.2	150	141	4.4	10.8	9.6	2.6
Significance of regression for urea fertilization												
Linear	**	NS	NS	*	**	**	**	**	NS	NS	*	**
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
Significance of interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

^aTotal measured nutrient content determined by leaf dry weight × nutrient concentration.

^bMean separation by contrast tests at P = 0.05 (lowercase letters) or 0.01 (uppercase letters).

NS,*,**Nonsignificant or Significant at P = 0.05 and 0.01, respectively.

years, Ca concentration in 1986, and Cu and Zn concentrations in 1987 were observed as urea fertilization increased from 0 to 274 kg N/ha.

Several studies have used leaf nutrient concentration as a measure of sod and crop competition (Greenham and White, 1968; Bould et al., 1972; Atkinson and White, 1980; Morlat et al., 1984). Results of this experiment indicate that sod significantly reduces the total measured nutrient content in grape leaves (Table 3), but has minimal effect on concentrations of some nutrients due to differences in leaf mass associated with treatments (Tables 1 and 2). In 1987, urea fertilization did not affect the total content of leaf P, K, Cu, and B and significantly increased total content of S and Zn (Table 3). However, at the same time, the concentrations of these nutrients were decreased as urea fertilization rate increased (Tables 1 and 2). This relationship could have resulted partially from a growth dilution effect, with higher urea fertilization rates resulting in increased leaf and shoot growth (Table 2) and a consequent decrease in some nutrient concentrations (Haynes, 1980). Leaf mass changes, such as from pruning, could alter nutrient concentrations and cause inconsistent responses of fruit crops to sod management when nutrient concentration is used as

a criterion (Greenham and White, 1968; Bould et al., 1972; Haynes, 1980).

Grass dry weights from mowed and unmowed sod plots were 1.9 and 2.0 kg/plot, respectively, in 1987 (Table 3). Mowing did not significantly decrease total grass dry weight and sod competition with grapevines, as shown by lack of significant differences in grape shoot length, leaf dry weight (Table 2), and nutrient status (Tables 1-3). Grass dry weights increased from 1.0 to 2.6 kg/plot as rates of urea fertilization increased from 0 to 274 kg N/ha in 1987 (Table 3). Sod suppression by mowing and urea fertilization at higher rates appear not to be satisfactory approaches to reducing nutrient competition between sod and grapes.

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