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The Effect of Woven Plastic Mulch, Herbicides, Grass Sod, and Nitrogen on 'Foch' Grapes Under Irrigation

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Abstract. **Three soil surface treatments were compared for grape production under irrigation. Plastic mulch was superior to glyphosate and to grass sod in producing yields during the first 2 years of production. By the 3rd year, the glyphosate treatment was equal to the plastic and both were superior to grass sod. Cluster weights and pruning weights were suppressed by grass sod, compared with plastic or herbicide, but were unaffected by nitrogen. Nitrogen fertilizer treatments had no measurable effects on the grapevines and showed no interaction with the soil surface treatments. None of the treatments (soil surface or fertilizer) had any effect on berry soluble solids. The use of plastic mulch is an effective cultural technique, the usefulness of which will depend mostly on cost and environmental comparisons with herbicides.**

Mulching for water conservation, for retention of or insulation against heat, and for weed control is a very old cultural technique. Among the first to report effects of synthetic materials was Emmert (5) who, in 1957, tried black polyethylene with vegetables. Since then, plastics have been investigated on such diverse fruit crops as strawberries (1, 9), pears (7), apples (10), and mulberry (11).

Researchers have tested plastic mulches on grapes (2, 3, 6, 8, 12, 14) and reported improved yields as well as increased vigor of vines. Volosky (14) found increased shoot growth and weights of cane prunings of 'Torontel' vines, which he attributed to complete weed control by plastic. He did not report yields, because the vines were young and nonbearing.

Most of these trials on grapes were conducted under rainfall alone or with only occasional supplemental irrigation. Of interest in the Okanagan Region of the Pacific Northwest is the effect of mulches and ground covers where irrigation is regular and comprises almost the entire source of water. Stevenson (13) reported a competitive effect of cover crop on grape yields under full season-long irrigation.

Solid plastics keep rain and sprinkler water away from roots and prevent evaporation of water that is in the soil at the time the plastic is laid. As long as ground vegetation or weeds are suppressed by plastic or herbicide, water is not lost through their transpiration. Under rain-fed noncontrolled soil water conditions, control of ground vegetation can be vital to grape production. Under irrigation, where soil water is controllable, it may be of lesser importance.

Godden and Hardie (8) reported that, in Australia, weights of prunings and fresh berry clusters of 'Cabernet Sauvignon' vines under trickle irrigation were doubled by the use of plastic sheeting compared to the use of a number of herbicides for weed control. The nonselective herbicide glyphosate is commonly used for removing ground vegetation in tree and vine rows in orchards and vineyards in the United States and Canada, but must be applied carefully to avoid drift to the vines. Daniell and Lane (4) reported that muscadine grapes (*Vitis rotundifolia*) were undamaged as long as basal leaves were not hit by glyphosate spray. Wallinder et al., however, reported severe damage to 'Concord' grapes (*Vitis labrusca*) when glyphosate spray struck low hanging foliage or basal shoots (15).

The objectives of this experiment were to test, under season-long irrigation, the field usefulness of plastic mulching and to compare plastic mulch, herbicide, and grass sod effects on yields, cluster weights, pruning weights, and soluble solids of grapes. The mulch could be an alternative to glyphosate, which can damage grapes and which may be environmentally less desirable than the mulch. Since N fertilization is a normal practice in vineyards in the region, a secondary objective was to establish appropriate levels of N fertilization under mulch, herbicide, and grass sod.

A vineyard of the French hybrid, cv. Foch, was planted in 1979 in a sandy loam soil on a south-southeast facing slope. The vines were own-rooted and trained onto a T-bar system. They were planted 2 m apart in rows 4 m apart.

Trickle irrigation with emitters 1.5 m apart applied water for about 5 hr, 5 days out of every 7, at a rate equivalent to 35 $mm \cdot wk^{-1}$, or about 750 $mm \cdot season^{-1}$. This irrigation was more than 80% of the water supply for the grapes during the 150- to 160-day growing season. Light, infrequent rains, totaling only 140 to 200 mm per growing season, occasionally halted evapotranspiration but seldom would contribute significantly to soil water. The spacing of the emitters allowed for about a 20% overlap of the spreading circles, in the particular soil type, of water moving laterally from the emitters. The result was a band of irrigated soil about 1.5 m wide along the rows.

Comparative treatments were initiated in 1981. However, solid black plastic mulch was put in place in 1980, where it remained until Spring 1982. During the 1980 season, the vines were trained and a complete grass cover crop was established, primarily of crested wheat grass (*Agropyron cristatum*) and Kentucky bluegrass (*Poa pratensis*). Treatments were (on each side of a row): a) a strip of grass sod mowed when 10 to 15 cm high, b) a strip kept clean with glyphosate, and c) a strip of plastic cover. All 3 strips were 1 m wide on each side of each row making each plot 2 m wide. The glyphosate was applied in time to prevent ground vegetation from becoming large and competitive with the grapevines. The remaining 2 m between rows were mowed 2 or 3 times per season as needed. In combinations with soil surface treatments (SST) were 3 levels of N, specifically 25, 50, and 75 $kg \cdot ha^{-1}$ applied in the form of NH_4NO_3. Because of zero responses to N in 1982 and 1983, these rates were doubled in 1984. Together, these made 3 distinct SST × 3 levels of N in a randomized block design. There were 4 vines per plot replicated 4 times. For all treatments, the trickle irrigation system was placed on the ground. The plastic covered the trickle lines in the mulch treatments.

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Table 1. Yields of 'Foch' grapes under grass sod, glyphosate, plastic mulch, and 3 levels of N fertilizer.

Soil surface treatment	Yield (kg·vine^{-1})		
	1982	1983	1984
Grass sod	3.4 a[z]	2.9 a	3.0 a
Glyphosate	6.4 b	8.1 b	7.1 b
Plastic mulch	9.1 c	10.8 c	8.4 b
Nitrogen (kg·ha^{-1})			
25 (50)[x]	6.2[y]	6.7	6.0
50 (100)	5.6	7.2	6.2
75 (150)	7.2	7.8	6.3
SE	0.6	0.6	0.6

[z]Mean separation each year by Neuman–Keul test, 1% level.
[y]No significant differences any year. Soil surface treatments × N interaction not significant any year.
[x]1984 rates of N fertilization are in parentheses.

In 1980 and 1981, the plastic was black, nonporous polyethylene anchored with soil on the outer edges. By Spring 1982, the plastic had weathered and was destroyed by winds. The damaged plastic was removed and a new black, woven, porous material called Propex was then applied, with the same dimensions as before. This material showed little deterioration by the 3rd season. While it blocks all light, it is permeable to air and water. Rather than the full 2-m width of the plots, 1-m-wide strips of the plastic were laid on each side of the grape rows. The divided strips allowed easy access to trickle emitters. The strips were held together in mid-rows by brass paper fasteners thrust through the weave. This procedure also prevented winds from tearing the plastic.

Nitrogen fertilizer was applied by placing the appropriate quantities of NH_4NO_3 in 5 × 5-cm jiffy peat pots, each set directly under an emitter so that irrigation water dissolved and carried the fertilizer into the soil volume irrigated by the emitter. The appropriate quantities were based on the per hectare rate prorated to the area irrigated by each emitter (1.5 × 1.5-m spacing). Use of peat pots is not a practical technique for growers, but in experiments it avoids the costly construction of a separate trickle system for every plot. The N fertilizer was applied once each year at the time of the first irrigation in May.

Table 2. Production and growth characteristics of 'Foch' grapes subjected to grass sod, glyphosate treated strips, and plastic mulch treatments independent of N treatments.

Soil surface treatment	Growth characteristics		
	1982	1983	1984
Cluster weights (g·cluster^{-1})			
Grass sod	93 a[z]	49 a	71 a
Glyphosate	146 b	96 b	110 b
Plastic mulch	146 b	117 b	122 b
SE	6.5	6.2	6.0
Pruning weights (kg·vine^{-1})			
Grass sod	- - -[y]	0.96 a	0.34 a
Glyphosate	- - -	2.13 ab	1.13 b
Plastic mulch	- - -	3.44 b	1.12 b
SE	- - -	0.44	0.06
Soluble solids (%)			
Grass sod	23.2	18.8	22.5
Glyphosate	23.3	18.1	22.9
Plastic mulch	23.8	16.4	22.4
SE	0.32	0.50	0.27

[z]Mean separations each year by Neuman–Keul test, 1% level.
[y]Not measured.

Fruit yields, cluster weights, and soluble solids were measured in 1982, 1983, and 1984 for each plot. Pruning weights were measured in 1983 and 1984. Some berry losses to birds occurred in a few plots in 1984. Therefore, fruit yields in each damaged plot were adjusted upward by a factor derived from the number of empty clusters multiplied by the average weight of undamaged clusters.

The SST did not affect the first fruiting of the young grapevines. All treatments produced a first crop in 1982. Yield of the first crop in 1982 from mulched plots was almost triple the yield of plots with grass sod (Table 1). The glyphosate treatment was intermediate in its effect. In subsequent years, yields from the mulch treatment remained triple or almost triple the grass sod treatment, while, by 1984, yields from the glyphosate treatment about equaled those of the mulch. These data (Table 1) show that, in the early stages of a vineyard, mulch is superior to herbicide and, by the 3rd year, remains at least as effective as herbicide. Grass sod is clearly inferior to the other 2.

The levels of N fertilizer had no differential effects on yields at any time (Table 1). There was no interaction between ground treatments and N, so only the independent means are shown. Because of the absence of N effects in 1982 and 1983 and because growth in the grass plots appeared weak, doubled rates of N were tried in 1984, but again no significant differences were evident. Under specific conditions of this trial we cannot argue that 25 kg·ha^{-1} N was sufficient or that 150 kg·ha^{-1} N was insufficient to produce a response. The N treatments had shown no measurable effects on the major attributes of the grapevines. Three-year average yields under plastic mulch (8.3 kg·vine^{-1}), even at the lowest N treatment, was far superior to yields under grass sod (4.1 kg·vine^{-1}) at the highest N treatment.

Weights of berry clusters were consistently 30% to 50% lower under grass sod than with glyphosate or plastic mulch (Table 2). The latter were not significantly different in any of the 3 years. The reduced weights of clusters could not have been the sole reason for yield reductions, since yields were also lower with glyphosate than with plastic before 1984, while cluster weights were statistically the same. The number of clusters per vine also would contribute to the difference. These differences are not as large as those found by Godden and Hardie (8), but are of similar order. Vigor of the vines as evidenced by weights of prunings (Table 2) was 2 to 3 times less with the grass sod than with either glyphosate or plastic, consistent with the results of Volosky (14). Soluble solids of the berries were not affected by SST (Table 2).

We conclude from these results that woven plastic, laid as a permanent mulch, is a useful and effective culture technique for grapes and is at least as effective as herbicide for the yield and vigor of grapevines. Whether it is as cost-effective as herbicide has to be determined for specific circumstances. We anticipate that the plastic will last a minimum of 5 years. We have made no comparisons with cultivation, but similar cost comparisons would be necessary.

Obviously, grass sod cover in the rows is not an effective production technique; but, under irrigation, grass between the rows is desirable for erosion control and prevention of muddy conditions. Trickle irrigation placed under the mulch has performed well; but, since the weave of the plastic allows water to filter through, there is no reason that the mulch could not be used with sprinkler irrigation, providing some land-shaping in the rows was done prior to planting and placement of the plastic. A slight sloping of the plastic toward the rows would keep water from running off.

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Effect of Nitrogen and Pruning on Primocane Fruiting Red Raspberry 'Amity'

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Abstract. **Nitrogen was applied to red raspberry (*Rubus ideaus* L. cv. Amity) in the spring (March, April, and May) at 67 and 135 kg·ha^{-1}, and 3 pruning treatments were imposed: a) pruning of dormant floricanes at 0 cm (ground level); b) pruning of dormant floricanes at 0 cm plus cutting back primocanes to 40 cm in mid-May; and c) pruning dormant floricanes to 20 cm. Date of flowering, time interval from flowering to fruit maturity, and fruit size were unaffected. High N (135 kg·ha^{-1}) increased yield late in the harvest season, increasing total yield by 14% (8.1 vs. 7.0 MT·ha^{-1}). Pruning back the current season primocanes increased the number of branched canes but reduced yield per cane and did not increase total yield.**

Self-supporting, machine-harvestable, primocane fruiting (PF) red raspberries offer many advantages to growers if production and fruit quality problems are overcome (4). 'Amity', a PF cultivar, has fruit of excellent quality but all fruit does not mature before commencement of inclement fall weather, and its primocanes are not completely self-supporting.

Lockshin and Elfving (6) found that N not only stimulated vegetative growth, but also shortened the time required for flowering to occur in PF 'Heritage'. Brierly (1) found that pruning of mature canes increased the number of laterals in floricane fruiting types. Pruning and N treatments can increase cane diameter (7, 8) and may lead to sturdy, self-supportive canes. Neither height of dormant cane pruning or pruning during the growing season to stimulate branching have been tested as a means of promoting self-supportive canes.

Vegetative and fruiting characteristics may have a relationship to earliness and self-supportiveness. Past studies have shown that growth and fruiting habit have a relationship to yield (2, 3, 5, 7). Two rates of N fertilizer and 3 methods of pruning were evaluated as means of encouraging earlier fruit ripening and causing canes to be more self-supporting.

In Apr. 1982, dormant plants of 'Amity' were planted on a silty loam soil with a row spacing of 3 m and plants 76 cm apart in the row. The plots, 7.6 m long, were arranged in a randomized complete block design with 4 replications. Two rates of N, as NH_4NO_3, were side dressed by hand at 67 and 135 kg N·ha^{-1}. N was split into 3 mid-month applications (Mar., Apr., and May 1983 and 1984) to minimize leaching. Pruning treatments consisted of cutting dormant one-year-old canes to ground level on 14 Mar. 1983 (0 cm); 20 cm above ground level (20 cm); and ground level in March, followed by heading back current season primocanes to 40 cm on 13 May (0 + 40 cm).

Ten random canes from each plot were taken to measure growth and yield characteristics. Earliness of flowering and fruiting were determined by monitoring the uppermost 4 flower buds of each cane for dates at which anthesis, fruit set, and fruit ripening occurred. Buds at the apical end were selected because they are the first to reach anthesis (9).

Fruit weight and number were measured by cane section; top (apical nodes 1–5); middle (nodes 6–10); and bottom (all lower fruiting nodes). These values were used to obtain mean berry weight and number of fruit per cane. Laterals were considered part of the cane from which they originated, unless they had 15 or more nodes. The latter were designated branches and were considered separate from the original cane.

Total plot yield was obtained by hand harvesting all remaining canes and adding this weight to the yield of the selected 10 canes. Fruit were picked from the 10 canes on 13 dates from 8 Aug. until 27 Sept. 1983. Hand harvesting for total yield occurred 14 times —from 28 July to 12 Sept. In 1984, yield was measured on 6 dates by mechanical harvesting only, using a Littau berry harvester (Littau Harvester, Stayton, Ore.). Berry size for each plot was determined by weighing a 50-fruit sample collected from the sorting belt of the harvester.

At the end of the 1983 harvest season, 5 of the 10 canes were taken at random to assess the effects of N level and pruning on plant growth and fruiting habit. The following data were taken: cane diameter 30 cm from base, total leaf area (using an electronic area meter), cane length, number of vegetative and flowering nodes, number of flower and fruiting sites per node, and the percentage of potential fruiting sites that set fruit. Total number of canes and branches per plot also were counted. Canes per plot were counted after the 1984 harvest season, and then 5 random canes were measured for the following: cane diameter, cane length, vegetative nodes, and fruiting nodes.

Total fruit yield was greater at the high N treatments in 1983 (8.1 vs. 7.0 MT·ha^{-1}) but was not significant at the 5% level. The yield in 1984 was measured on only 6 harvest dates and was not adequate for measuring yield differences from N or pruning treatments. Increased N did not result in earlier fruit ripening. Yields per harvest increased with each picking, reaching a high of 2.2 MT·ha·yr^{-1} on the final harvest date. The greater yield late in the season came from berries ripening on the lower nodes. Other workers (3, 5) have also found that number of fruit per node increase basipetally along the cane.

Machine harvesting in 1984 was generally unsuccessful because of fruit resistance to separation from the plant—a genetic trait of 'Amity' with no measurable relationship to treatment. Average yield from 6 harvest dates was 2.6 MT·ha^{-1}. The fruit was mostly overripe and judged marginally acceptable for processing and not acceptable for fresh marketing. Nitrogen did not affect cane diameter or the self-supporting growth habit in either year (data not shown). There was not a significant difference in July leaf N samples between the 2 N treatments (3.67% vs. 3.69%), likely because of the leaching effects of irrigation. The size of the fruit was smaller than the hand-picked fruit of 1983 (2.77 g vs. 3.12 g) (Table 1), probably due to greater transpirational losses on the generally overripe fruit.

Mean berry weight declined with harvest date until about mid-September (data not

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