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GUMMOSIS CANKER AND ROOT DISEASE PROJECT

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This project was begun in autumn, 1965 with the object of determining the nature of gummosis canker and means for controlling it. The killing of the above ground portions of affected prune trees is thought to be largely due to the bacterium, Pseudomonas syringae. There is evidence, however, that some soil factors predispose stone fruit trees to this disease. In peach this factor appears to be biological in that it is amenable to control by various soil fumigants. It was hypothesized that the same predisposing factor or factors might be involved in the prune disorder, but adequate experimental data to support this hypothesis were not available.

Research on this project involved the establishment of an extensive experimental plot (Harmeson) near Healdsburg in the winter of 1965-66, and more recently (winter of 1968-69) a second plot in the Jim Pettis orchard near Marysville. Additional work has been done in other grower orchards, and in our orchard, greenhouse, and laboratory at Davis. Some of the research has been cooperative with the Departments of Nematology, Pomology, and Soils; with farm advisors in Sonoma, Sutter and Yuba counties; and with several commercial companies.

Harmeson plot.--This plot, involving 1785 trees, was established in an area of Sonoma County where gummosis canker has been serious for many years. Major emphasis in this plot has been on rootstocks and chemical soil treatments. However, several other factors have been included, as follows: time of pruning, method of propagation, minor element nutrition, use of bactericidal sprays and paints, protection of the trees with plastic, and surveys of the populations of nematodes and Pythium spp. in the soil.

The results of some of this research are shown in Tables 1-3. The data in Table 1 indicate that the greatest amount of disease occurred in nursery budded trees pruned in mid-winter. The least amount of canker was found in the fall-pruned trees. Trees that were high budded and those treated with Demosan were intermediate in canker development. These trees, however, were a year younger than the others, and this may explain the difference in canker severity. The disease was slightly less severe in the Trizone-fumigation block than in the nonfumigated site.

Tables 2 and 3 show the results obtained when various fumigants and fungicides were applied to the soil either pre- or postplant, or in combination. Some of the chemicals used are principally nematicidal whereas others are largely fungicidal. None of the soil treatments have had a significant effect on canker severity or tree mortality. The trees on peach rootstock were less severely affected than those on plum rootstock, but since the trees on Nemaguard root were a year younger than the others only those on Lovell rootstock were compared. It is too early to know whether high working on peach rootstocks will provide adequate canker control. There have been no significant differences in tree growth regardless of rootstock or soil treatment.

Table 1. Effect of Certain Treatments on Gummosis Canker Development in French Prune. Harmeson Plot, May, 1969.

Treatment[a]	Mean Canker Severity[b]	% Mortality[c]
Trizone preplant soil fumigation		
Myrobalan 29C rootstock, Cerano[d]	3.2 a[e]	4.0
" " "	2.6 ab	4.0
Marianna 2624 rootstock	2.3 b	4.0
" " " , high budded[e]	1.9 bc	0.0
Myrobalan 29C rootstock, Demosan[f]	1.8 bcd	0.0
" " " , high budded	1.3 cd	0.0
" " " , fall pruned	1.3 cd	0.0
Lovell peach rootstock, fall pruned	1.1 d	0.0
No soil fumigation		
Myrobalan 29C rootstock	3.5 a	8.0
" " " , Cerano	3.4 a	16.0
Marianna 2624 rootstock	3.0 a	4.0
Myrobalan 29C rootstock, Demosan	2.2 b	0.0
" " " , high budded	2.0 b	0.0
Marianna 2624 rootstock, high budded	1.8 bc	0.0
Lovell peach rootstock, fall pruned	1.5 bc	0.0
Myrobalan 29C rootstock, fall pruned	1.2 c	0.0

[a]Unless otherwise indicated the trees were nursery budded and pruned in mid-winter.

[b]Based on a scale from 1 (healthy) to 6 (dead). Means followed by different letters differ significantly (P=.05).

[c]Data taken in November 1969.

[d]Applied as a paint to trunk and scaffold branches.

[e]Budded on scaffold branches 1-1 1/2 years after planting.

[f]Applied annually in autumn in a basin around the trunk; trees in this treatment are one year younger than the other nursery budded trees.

Table 2. Effect of two Plum Rootstocks and Various Soil Treatments on Gummosis Canker Development in French Prune. Harmeson Plot, 1969

	Soil Treatment[a]	Mean Canker Severity[b]		% Mortality	
		Myrobalan 29C	Marianna 2624	Myro 29C	Mar. 2624
A	Trizone preplant	2.6	2.5	8	12
B	" " , Fumazone postplant[c]	1.8	2.1	4	12
C	Fumazone preplant	2.1	2.3	8	8
D	" " and postplant	2.5	2.3	20	4
E	Telone preplant, Fumazone postplant	2.1	2.6	4	0
F	Carbon bisulfide preplant	1.4	1.5	0	0
G	Ethylene dibromide preplant	1.5	1.5	0	4
H	Lanstan postplant	2.7	2.8	16	12
I	Dexon postplant	2.7	2.6	4	8
J	Check	2.8	2.4	12	8

[a]The postplant treatments with Lanstan and Dexon were made annually in autumn in a basin around the trunk.

[b]Based on a scale ranging from 1 (healthy) to 6 (dead).

[c]The postplant treatments with Fumazone were made each fall by injecting the chemical in a 4-ft band on each side of the row.

Table 3. Effect of two Peach Rootstocks and Various Soil Treatments on Gummosis canker Development in French Prune. Harmeson Plot, 1969

	Soil Treatment[a]	Mean Canker Severity[b]		% Mortality	
		Lovell	Nemaguard	Lovell	Nemaguard
A	Trizone preplant	1.4	1.4	4	0
B	" " , Fumazone postplant[c]	1.2	1.0	8	0
C	Fumazone preplant	1.3	1.1	4	0
D	Fumazone preplant and postplant	1.3	1.0	4	0
E	Telone preplant, Fumazone postplant	1.3	1.2	0	0
F	Carbon bisulfide preplant	1.1	1.6	0	4
G	Ethylene dibromide preplant	1.2	1.2	0	0
H	Lanstan postplant	1.2	1.5	0	8
I	Dexon postplant	1.6	1.9	4	4
J	Check	1.3	1.7	8	4

[a]The postplant treatments with Lanstan and Dexon were in a basin around the tree trunk each autumn.

[b]Based on a scale ranging from 1 (healthy) to 6 (dead).

[c]The postplant treatments with Fumazone were made each fall by injecting the chemical in a 4-ft band on each side of the row.

Although high populations of Pythium spp. (root infecting fungi) were found in the Harmeson plot in 1966, especially in the unfumigated soil, extremely low populations were found in 1969 regardless of soil treatment. It is possible that this decrease is due to the annual use of herbicides which may have eliminated much of the food for these fungi.

Periodic sampling of the soil for plant parasitic nematodes has yielded the following data (identifications by Dr. B. F. Lownsbery). Samples taken in May, 1967 yielded small numbers of Xiphenema americanum and Paratylenchus sp., and even fewer numbers of Criconemoides, Meloidogyne, and Pratylenchus. Samples taken in October 1968 showed low populations of C. xenoplax and X. americanum in the untreated soil, no nematodes in the CS_2-treated soil, and only a few C. xenoplax in the Trizone fumigated soil. Samples taken in July, 1969 yielded C. xenoplax and Paratylenchus amblycephalus (?), both in considerably higher numbers than had previously been obtained. The populations of these nematodes in untreated soil varied from zero in some sites to several hundred in other sites. Soil given a preplant treatment of Telone and annual postplant treatments of Fumazone yielded no nematodes, whereas soil fumigated with ethylene dibromide at preplant (no postplant fumigation) showed relatively high counts of both nematode species. Nematode populations did not appear to be correlated with gummosis canker severity.

The use of minor elements as a supplement to the regular nitrogen fertilizer applications has as yet had no effect on either tree growth or canker severity. The quantity of minor elements applied was markedly increased in 1969 to obtain further information on their possible relationship to this canker disorder. Sprays of Bordeaux mixture or Streptomycin in fall, winter (immediately after pruning), and early spring have to date had no significant effect on disease severity. Covering trees with plastic shelters during the winters of 1967-68 and 1968-69 appeared to reduce somewhat the severity of gummosis canker, however, the differences were not statistically significant.

Studies on the relationship of bacteria (Pseudomonas syringae) to gummosis canker were made during 1968 and 1969. Pathogenic bacteria were found in canker tissue throughout the year, but they were most frequently obtained in the spring when cankers were active. Large numbers of viable bacteria were found in exuded gum in the spring, but none were present in September. Evidence was obtained in support of the hypothesis that many old cankers reactivate the following year. A significantly higher incidence of cankers was found on southerly exposures of the trunk than on other exposures. Inoculation tests (in Sonoma County and at Davis), showed that pruning wounds are a potential site of entry for the bacteria and are apparently more susceptible to infection in winter and spring than in fall.

One fact that stood out in the Harmeson plot in 1969 was that gummosis canker was severe in two small areas and relatively light in the remainder of the block. It was not possible to correlate disease severity with tree vigor, as one of the sites with severe canker had trees with rather low vigor whereas the other site had highly vigorous trees. It is planned to examine soil type and soil moisture in this plot to determine if these factors might be related to canker development.

Pettis plot.--This plot was established in 1968-69 in a 40-acre block of French prune trees, mostly on Myrobalan C rootstock, that had been planted in 1966. Heavy losses from a canker and root-rot condition had occurred in portions of this orcahrd in 1967 and 1968, and have continued into 1969. Two of the worst areas were cleared for preplant fumigation and replanting; two other areas were used for postplant fumigation.

Preplant fumigation was as follows:

1. Telone, 100 gpa - deep-shallow injection.
2. Telone, 100 gpa - deep-shallow injection plus Fumazone, 2.5 gpa, 2 years later.
3. Telone, 100 gpa - deep injection.
4. Telone, 100 gpa - shallow injection.
5. Telone - Picfume, 85-15 gpa - deep-shallow injection.
6. MC 33, 300 lbs/A - deep-shallow injection.
7. MC 33, 300 lbs/A - deep-shallow injection plus Fumazone, 2.5 gpa, 2 years later.
8. MC 33, 300 lbs/A - deep injection.
9. Check - ripped 30" deep just ahead of fumigation.
10. Check - not ripped, shallow dry chisels only.

Fumigation done Oct. 23-24, 1968; soil a bit too wet; soil temperature approx. 55°F.; soil ripped to a depth of 30" except for treatment 10. Deep-shallow injection done by straddling row with 2 chisels on 36" centers inserted to a depth of 18-20 inches, and 3 chisels on 36" centers, alternating with the deep chisels, and inserted 6-8". The fumigated swath therefore was approximately 6' wide. The deep fumigation done in the same manner but with the shallow chisels dry. Shallow fumigation done with 6 chisels on 12" centers inserted to a depth of 6-8". In the deep-shallow fumigation 2/3 of fumigant injected deep and 1/3 shallow. Treatments 5-8 were tarped and 1-4 were cultipacked. MC 33 is methyl bromide 67 parts and chloropicrin 33 parts. Each treatment consisted of 5 10-tree-space replicates in a randomized block design. The site to be replanted with French prune/Myro 29c during Jan.-Feb., 1969.

Postplant fumigation was as follows:

Two badly diseased areas of the orchard were selected for postplant fumigation with Fumazone at 2.5 gpa. They consisted of a mixture of the original 3-year-old trees, some year-old replants, and sites where trees were dead or missing. Fumazone was injected to a depth of 6" with 4 chisels on 1' centers on each side of the row--a 4-ft. swath on each side. Injection was immediately followed by cultipacking. In each fumigation plot 5 randomized untreated rows served as checks. These were chiseled with dry fumigation shanks. The fumigation was done October 25-26, 1968.

No results have been obtained as yet from the preplant fumigation test in this orchard. Results, however, were obtained from two postplant fumigation (Fumazone) plots. Canker severity was rated on a scale of 1 (Healthy tree) to 6 (dead tree). In plot B-1, canker severity in Fumazone-treated trees was 2.54 and in the checks 2.88. In plot B-2 canker severity in the Fumazone-treated trees was 2.55 and in the checks 2.94. Although the fumigant may have done some good, the differences were not large enough to be significant.

Pruning tests in this orchard during a two-year period have shown that time of pruning probably does not have a significant effect on gummosis canker in this area. Canker incidence has been high regardless of whether trees were pruned in November, February or March. These results are somewhat at variance with those from the Harmeson plot where pruning trials are being continued.

Soil samples taken in May and September, 1968 from badly diseased and relatively healthy areas of the Pettis orchard failed to show a correlation between Pythium population and canker severity. With regard to nematodes, a May sample showed only low numbers of Criconemoides xenoplax, and September samples showed only a low population of Xiphinema americanum. Similar numbers of the latter nematode were found in the root zone of both diseased and healthy trees. These data suggest that nematodes and Pythium spp. are not important predisposing factors in the development of gummosis canker in this orchard. Preliminary observations suggest that soil type and related soil moisture conditions may be predisposing factors to this disorder.

Rootstocks resistant to bacterial canker and crown gall.--In cooperative work and coordinated with Project No. 3137 of the Department of Pomology, three selections of bitter almond which are resistant to bacterial canker and crown gall are being hybridized with peach selections which are resistant or immune to root knot nematodes. The objectives of this study are to develop a combined resistance to nematodes, bacterial canker, and crown gall in rootstocks with desirable pomological characteristics.

As a result of hand pollinations made in 1968 and 1969, approximately 1500 almond X almond and 100 almond X peach seedlings were screened for crown gall and bacterial canker resistance. The almond parent trees of most value from the standpoint of disease resistance were pollen incompatible with each other. Outcrosses with commercially-grown almond varieties were pollen compatible but only about 1 in 100 of the seedling stocks had resistance like that of the parent bitter almond stock. The almond X peach crosses resulted in seedlings that showed considerable variability within a single cross for disease resistance after at least two series of inoculations with Pseudomonas syringae (bacterial canker) and Agrobacterium tumefaciens (crown gall). Selections having high-high, high-low, low-high, and low-low resistance to crown gall - bacterial canker were found. Forty-four almond X peach hybrids having a range of resistance to bacterial canker and crown gall are being propagated by cuttings for field tests on disease resistance.

Bacterial canker toxin.--A study is being made of the nature and mode of action of the toxin produced by Pseudomonas syringae in relation to the development of bacterial cankers in stone fruit trees. Results indicate that the toxin destroys cells by disrupting membrane permeability and by binding to deoxyribonucleic acid causing an inhibition of the enzyme RNA polymerase. The delicate balance of nutrients and environmental conditions required for the synthesis of this toxin by P. syringae in vitro, strongly suggests that changes in bark nutrients caused by temperature, soil fertilization and fumigation could affect the ability of the bacteria to produce this toxin in vivo. Future work will be mainly concerned with the effect of soil fumigation and temperature on bark nutrients in regard to toxin formation by the bacteria.

It is planned to continue our research on gummosis canker in 1970 in both Sonoma County (Harmeson Plot) and Yuba County (Pettis Plot). Much of the research will follow the lines already established until definitive data are obtained on the effect of the various treatments on this disorder. A new approach will involve a critical examination of soil type and soil moisture as related to disease development. These studies will be made in both the Harmeson and Pettis plots, and possibly in other orchards where gummosis canker is a problem. Further attention will be given to the role of the Pseudomonas bacterium and Cytospora spp. (canker fungi) to disease development. It was observed last summer in the Harmeson plot that Cytospora had invaded gummosis cankers and apparently caused additional killing of trunk and branches. This fungus also is associated with a dieback of bearing trees, but its role in this disorder has never been completely elucidated.

The cooperative rootstock research with the Department of Pomology will be continued as discussed above. Additional work with the toxin produced by Pseudomonas syringae and its relation to canker development in stone fruit trees will be done as time and personnel permit.

Research personnel involved in the gummosis canker study in 1969 included Jack Otta, Paul Backman, Frank Schick, J. E. DeVay, and W. H. English. Research personnel who will participate in this project in 1970 include Paul Bertrand, Frank Schick, J. E. DeVay and W. H. English.

PERSONNEL MAN-DAYS AND DOLLAR EXPENDITURES IN THE PLANT PATHOLOGY PROGRAMS

	A. Root and Root Zone Problems		B. Fruit Quality and Production		C. Problems Related to Mechanization	
	Man Days Worked		Man Days Worked		Man Days Worked	
	7/68-6/69	7/69-12/69	7/68-6/69	7/69-12/69	7/68-6/69	7/69-12/69
PRUNE FUNDS						
Res. Asst.	77	143	62	114	15	29
Lab. Helper	19	28	15	22	4	6
Lab. Asst. I	22		18		4	
Field Supervision & Farm Division	54	25	43	20	10	5
Contract Labor	15		12		3	
Nurseryman	11		8		3	
Departmental Contribution						
Academic - Plant Pathologist	65	32	52	26	13	6
Nonacademic - Lab. Technicians	65	32	52	26	13	6

3. Expenditures

	A		B		C		Totals	
	7/68-6/69	7/69-12/69	7/68-6/69	7/69-12/69	7/68-6/69	7/69-12/69	7/68-6/69	7/69-12/69
Personnel	5,376	4,554	4,301	3,643	1,076	910	10,753	9,107
Operating	2,550	807	2,040	646	510	161	5,100	1,614
Total	$7,926	$5,361	$6,341	$4,289	$1,586	$1,071	$15,853	$10,721

4. Research to be continued (see attached reports)

Personnel and cost estimates - January-June 1970:

Personnel	$2700	$2160	$540	$5400
Operating	1690	1352	338	3380
Total	$4390	$3512	$878	$8780