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Workshop Proceedings

CROP PRODUCTION using COVER CROPS and SODS as LIVING MULCHES

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Oregon State University - 1982

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CROP PRODUCTION using COVER CROPS and SODS as LIVING MULCHES

Material presented and developed
during a workshop held April 21-22, 1982,
at Oregon State University, Corvallis, Oregon,
sponsored by a Coordinating Committee from
the Departments of Horticulture, Entomology,
and Crop Science, and the
International Plant Protection Center,
all at Oregon State University.
Edited by J. C. Miller, Assistant Professor of Entomology
and S. M. Bell, Graduate Research Assistant

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Foreword

PURPOSE

Evidence from areas around the world, including tropical regions and temperate North America, demonstrates that improved crop production, along with soil and water conservation, can be obtained by interplanting legumes or grasses within the cropping system.

Based on current research and the interest exhibited by colleagues in the United States and Canada, the Coordinating Committee decided to organize a workshop for research, extension and soil conservation personnel. The objectives of the workshop were as follows:

1) To share knowledge, experiences, ideas and enthusiasm on cover crops and sods as living mulches for annual and perennial cropping systems;
2) To discuss some future program needs such as: spring trials, multidisciplinary projects and the possibility of a Western Regional Research Project to evaluate crop production with living mulches.

WORKSHOP

The event was held at the Oregon State University Foundation Center April 21 and 22, 1982. The format consisted of short presentations on current research which were followed by discussions.

PROCEEDINGS

The open exchange of ideas which took place at this workshop was taped and transcribed for this publication. We have been careful to preserve the informality and individual style of each presentation. The discussion held after each presentation is provided to supply a transfer of additional information.

JCM

SMB

Acknowledgements

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Coordinating Committee:

S.M. Bell, Department of Horticulture
R. Bonanno, Department of Horticulture
L.C. Burrill, International Plant Protection Center & Department of Crop Science
R. Madar, Departments of Entomology and Crop Science
J.C. Miller, Department of Entomology
R.D. William, Department of Horticulture

Summary

The members of the Coordinating Committee believe that as representatives of the University, they should address the problems, concerns and interests of Oregon's citizens. Identifying specific concerns and initiating programs to resolve problems should be achieved in conjunction with an advancement of scientific inquiry. Ideally, projects or programs should be founded on a multidisciplinary basis and reflect a cooperative stance toward other public institutions and agencies.

The Workshop was organized and conducted with this approach in mind. It succeeded in bringing together, for two days, participants from six States and British Columbia, who together represented a variety of interests.

Eleven invited speakers represented research results and ideas on annual and perennial crops. Discussions on crop-living mulch production considerations included topics on: competition [Topics 1, 2, 8, 9, 11], water stress [Topic 8], soil structure and erosion [Topics 1, 10], alteration of the microclimate [Topics 5, 11], insects [Topics 4, 8, 9, 11], pathogens [Topic 11], rodents [Topic 3], and weeds [Topics 6, 11].

One direct result of this workshop was the initiation and establishment of research plots involving living mulches in filbert, apple, pear, peach, cherry, Christmas tree, grape, raspberry and assorted annual cropping systems. An evaluation of these plots will be conducted by growers and University staff members representing a number of disciplines.

A second outcome was the identification of a need to develop an experimental design which could be incorporated into commercial production. These experiments would extend present ideas into knowledge by addressing the effect of living mulches on microclimate, moisture, fertility, tilth, rodents, insects, nematodes and plant pathogens, along with crop quality and yield. From a researcher's viewpoint, plot size, experiment length, and whether or not a plot should be intensely managed for insects and rodents are issues which need to be addressed.

The Coordinating Committee believes that a great potential exists for establishing an effective program that can:

- improve crop production
- develop answers to current questions on living mulches
- generate new questions relating to using living mulch in crop production
- eventually attract increased funding from both the public and private sectors in order to continue enlarging multidisciplinary activities in this area

Participants from seven regions represented a cross-section of disciplines (Table 1).

Table 1

Workshop Participant Demography

	Region							
A. Affiliation	California	Idaho	New York	Ohio	Oregon	Washington	British Columbia	TOTAL
Extension Service	-	-	-	-	7	-	-	7
Univ. research/teaching	1	1	1	1	18	1	-	23
USDA/Ag. Canada	-	-	-	-	6	1	1	8
State Dept. of Agriculture	-	-	-	-	2	-	-	2
Soil Conservation Service	-	-	-	-	10	-	-	10
Students	-	-	-	-	8	-	-	8
							TOTAL	58
B. Special Interests								
Christmas trees (Forestry)	-	-	-	-	3	-	-	3
Crops/Agronomy	-	1	-	-	5	-	-	6
Economics	-	-	-	-	1	-	-	1
Engineering	-	-	-	-	1	-	-	1
Entomology	-	-	-	-	3	-	-	3
Horticulture	1	-	1	1	17	4	1	25
Soils	-	-	-	-	4	-	-	4
Wildlife	-	-	-	-	1	-	-	1
							TOTAL	44

Topic 1

OBSERVATIONS ON THE USES AND EFFECTS OF COVER CROPS IN AGRICULTURE

Bob Sweet

Cornell University, Ithaca, NY

Considerable interest has been given to wind and water caused soil erosion. We are interested in those factors, but we have two additional problems to consider. One is soil structure which is a serious problem for many reasons. I will talk about that as I go through my presentation. The other problem is leaching. How many of you are familiar with the material called Temik? It is an effective pesticide, but is now appearing in underground water supplies in our intensive agricultural regions. One of the most productive agricultural counties east of the Mississippi has most of its ground water partially contaminated. This means that you can measure the amount of Temik in the ground water. Whether that is damaging or not, I don't know, but many wells are being equipped with filters to take the Temik out. Cover crops or living mulches can help reduce the problems of leaching and soil structure.

We have three main thrusts to our work in New York. The first is choosing a mulch crop. This we are spending a lot of time on because we have fallen into a rut as to what we think are good cover crops. We are trying to get away from the idea that it is just a cover crop. We want something that is present for a longer period of time than what we think of with typical cover crops. Secondly, we are trying to go a step further with our no-till work. We avoid following the practice of killing all the plants off with a total vegetation killer at the beginning of the season.

The third area of our research is the management of the new crops. Obviously, the choice of mulch crop and the management depends on what kind of crop you plant with it. If it happens to be tree fruits or cabbage, the choice of mulch and how you manage it, is going to be extremely different.

I would like to emphasize our situation. Many farmers find themselves under economic pressures that cause them to do some things that are detrimental to the soil. Many of these agricultural people have been forced to either specialize in crops or specialize in animals. That raises problems. They tend to over extend their planting and harvesting schedules. Fields are often worked when they are too wet. They want to increase their yields. They get a bigger piece of equipment and then they have to have more land. The only trouble is, nobody increased the length of the working day and nobody is able to provide more dry working days during the season. Just because a grower now is operating 1,000 or 2,000 acres of vegetables, when he previously operated 250 acres, doesn't mean that he has five times as much time in which to do it in. He still has the same amount of time. The way you get around wet soil problems is to put more floatation treads on your tractor, or get a tractor with a bigger engine and you plow through it. If one tractor doesn't do it, you put on two. Soils are getting worked wetter and wetter these days.

To set the stage a little more, I should remind you that I am speaking from the context of the Midwestern United States and the Northeast. I am not an expert in other areas, so when I make a statement, remember that I am speaking in that context. In the Midwest, where I grew up, it was very common to have a few animals, along with crops of corn, oats, wheat, and hay. But now, acreage is often planted in only corn and soybeans. That is the trend and it is the same with all the vegetables in the Northeast. With this planting scheme we are getting much more leaching and much more erosion. We have lost the organic matter and even though commercial fertilizer is being used, the soil is not producing up to its full potential. Rain and irrigation cause the soil to run off. When we are irrigating fields they seem fairly level, but at the end of the rows, out near the highway or by the ditches, there is water standing that didn't go into the soil.

Let's talk about replacing organic matter, because in most cases, if we had good soil organic matter we would reduce leaching along with wind and

water erosion. If we could get organic matter into the soil quickly, we would be helping ourselves a lot. There are two choices. You can haul the organic matter into the fields or you can grow it. The economics of hauling it in isn't all that great. It is easier to grow it. If you put about a third of your crop land in sod for two or three years out of ten, that would keep it in very nice condition. Another way to improve your soil is to put in fall cover crops. We are short on sunshine and have low temperatures in the Northeast. That is a bad combination for any cover crop that you are trying to grow. We finally came around to thinking about living mulches and the advantages they offer. Most people when they are ready to plant, will plow under everything that is green or kill it with Roundup or paraquat. We say, "let's not do that. instead, let the material continue to capture the sunshine". If we use this system, we don't have to set the land aside in order to grow mulch crops. Another nice thing about this system is that it is almost perfect for weed control. Generally, the first plant that occupies the land is going to dominate it for the next several months or maybe for the next year, depending on the crop. Weed control is enhanced with this system and leaching and erosion are reduced.

I have listed some disadvantages derived from growing cover crops, but almost all of those disadvantages come from our not being smart enough. It was about 10 years ago that I tried to regulate weeds and then finally admitted that I wasn't smart enough. I started on this living mulch system with the intention of managing the weeds. The only trouble was every time I managed about five weed species, I kept adding a sixth to it and that was the crop. I decided that if I got it down to two species, it would work better. I planted something that deliberately took the place of a weed and then by managing it, along with the cash crop, I had a lot more success.

When the new class of grass regulator herbicides came along, we were interested in looking at them. With a slight change in dosages, we could cause stunting, yellowing, or death of the grass. In other words, we now have some regulator tools.

We started a nursery of living mulch candidates for primary evaluation. We had about 50 legumes and 50 grasses. It is from these types of plots that we selected out mulches and tried them to see how they were going to work. Some of them had weed problems. Some are susceptible to insects or viruses.

We don't need these problems in the cash crop field. When we evaluate them, we harvest the tops to get a measure of the top growth. We also sample the soil and get the root measurements because we think about 90% of the benefits derived, like increased soil structure, reduce leaching and reduce erosion, are coming from the root structure of the plant rather than from the top portion.

The top portion of the plant is important where insect control is concerned. In general, we have had excellent reduction in cabbage insect problems in the presence of a living mulch. It didn't seem to make much difference whether it was a legume or a grass and that made us suspicious. Maybe we were seeing a color difference phenomenon which discouraged the insects from moving in. At the same time entomologists were telling me that the mulches were a haven for predators of various types. We had practically no aphids in our vegetable crops.

Regulating the mulch is important. When living mulch dry matter increases, there is reduced crop yield (Figures 1 and 2). That is another way of saying that the mulch can be too competitive without regulation. In the first year that you establish the mulch, crop yields should not be effected. In three or four years you are going to have a better soil structure. The better the soil structure, the better the crop is likely to yield in spite of adverse weather situations.

Red clover is a favorite mulch with most of our farmers. It grows perhaps knee high and is rather loose or open growing. It makes a lot of nitrogen, but by being loose and open, it lets the weeds through.

Alfalfa is a miserable rascal to try to manage as a mulch crop. You have to be desperate before you try to work with alfalfa. We get good corn crops and good management of other legumes with 3/4 pound of atrazine. If we choose the right legumes, we do not let the weeds through.

When we experimented with planting dates, we found that we seriously damaged the corn yields when we planted our mulch extra early. We did much better when we put the crop and the mulch in simultaneously. If we had regulated our early mulch planting, we might have gotten by with it. When we planted the mulch later than the crop, we could seed it in by broadcasting or

Figure 1.

1981 SWEET CORN/LIVING MULCH STUDY

Correlation of Marketable Ear Weight
and Living Mulch Dry Matter

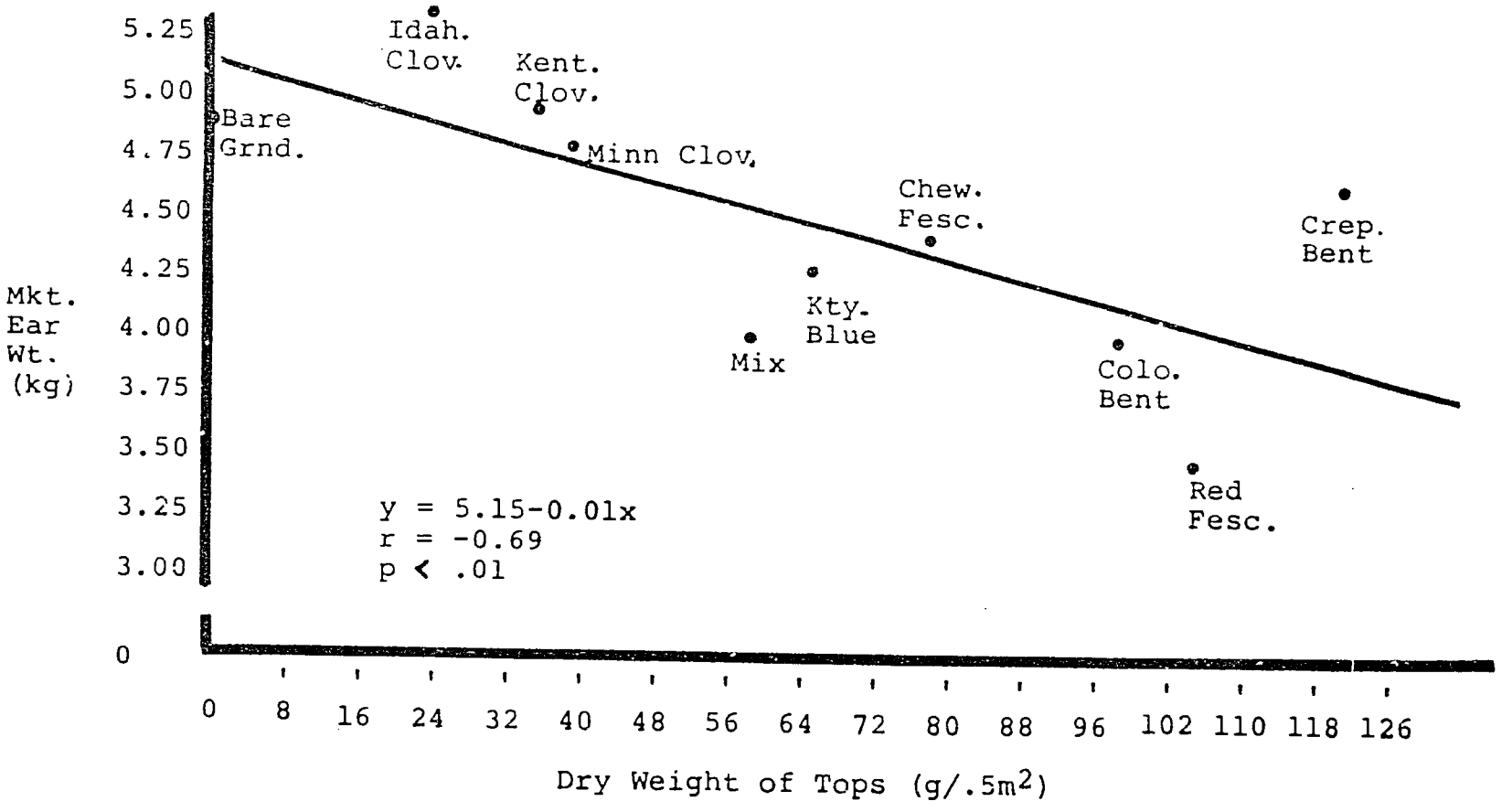
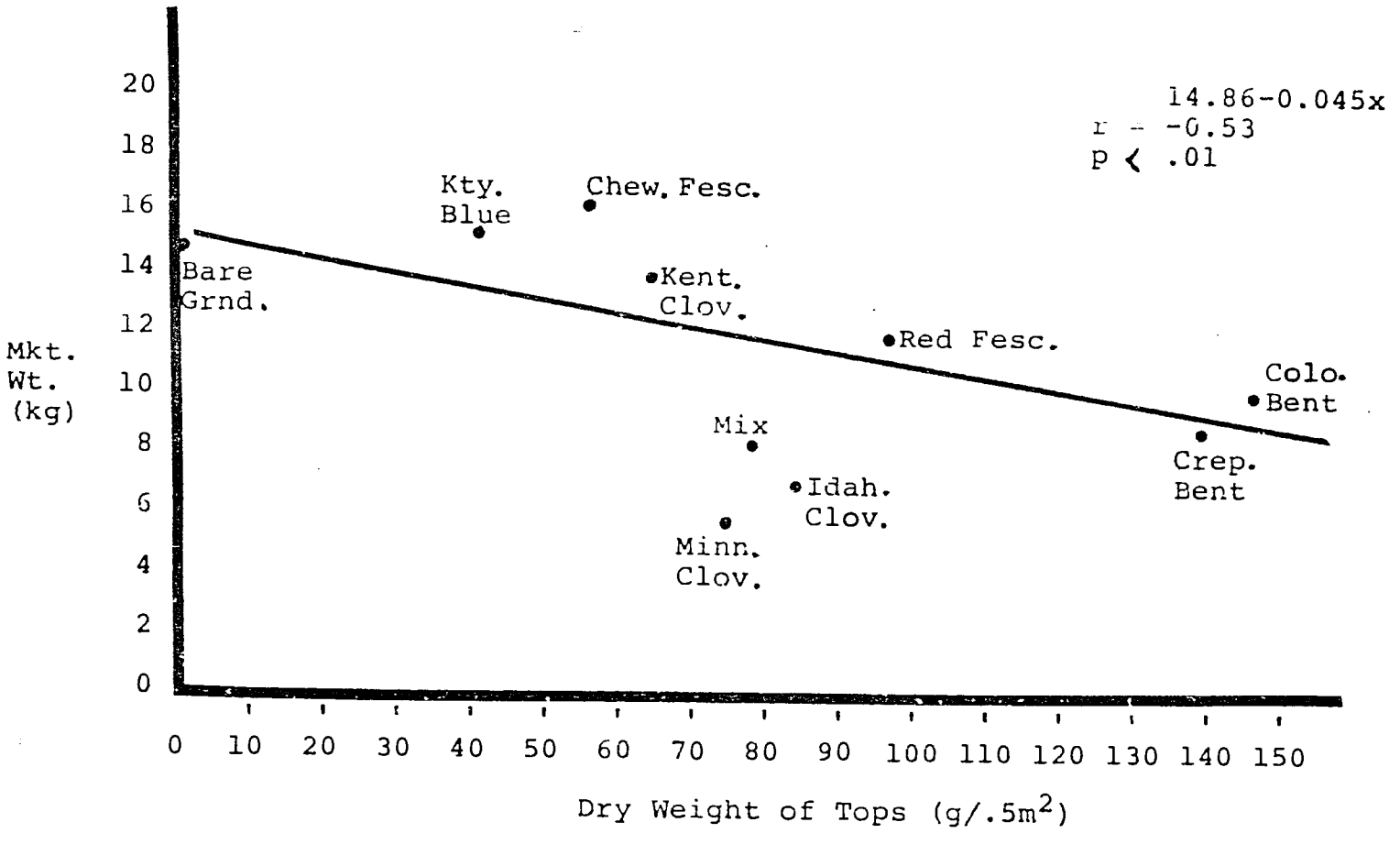


Figure 2.

1981 MAIN CABBAGE/LIVING MULCH STUDY

Correlation of Marketable Head Weight
and Living Mulch Dry Matter



we could put it in strips in the middle of the rows. Our corn was not hurt by the practice, nor were the yields.

The earlier the clovers or alfalfas are put in, the better the job they do on controlling weeds. White clover and ladino clover gave us satisfactory weed control. The red clover was barely satisfactory if planted early and it was less than satisfactory, as was alfalfa, if planted later.

We find that atrazine does some nice management for us. The plots looked as though they are getting extra nitrogen when treated with atrazine. This is what some of the data indicates as well. The white and ladino clover give a pretty good nitrogen level compared to other covers. No nitrogen came from the untreated or unmanaged established legumes. This is typical of what has been reported in the past. Often you have to plow, disk or kill most legume sods before you pick up the nitrogen benefit. What we are pleased with is atrazine is causing nitrogen to be given off by the legume crop without killing it. When we rotovated or plowed under an established white clover sod, we got better yields in terms of dry weight. If you mow alfalfa it does not recover, but white clover will. Many of us know that already, but some of us have to reinvent the wheel. Weeds come in quickly if you mow alfalfa, it opens it up and the weeds take over. Glyphosate and atrazine can be used to knock down the total growth. White clover comes back after both of these treatments, but alfalfa does not. It doesn't matter whether you mow it or put on a low rate of glyphosate or atrazine, white clover is able to keep a dense cover, and we think that is very important.

On the degree of suppression, we found that by applying chemical controls to the mulch on the 21st of May, we were able to get a quick reduction in top growth. It wasn't until fall that they came back to full growth. The kind of growth that the annual cash crop will make should be just the reverse of that. So, what we have done is to open the door for our annual crop. We don't get mulch growth during the time that our annual crop is supposed to be making its major growth. This is exceedingly important when you are thinking in terms of management. You have to look at your crop to see when you need the growth in that crop, and then you have to regulate the mulch accordingly. Either you start with a species that regulates itself naturally through photoperiod, temperature, moisture or some factor like that, or you have to

supply a management technique so that the mulch does not compete for resources when they are needed by the crop.

We are lucky to have atrazine to work with, we haven't found anything better. Foliar applications give us the regulation we need. When we put atrazine on white clover we get almost a complete cessation of nitrogen formation. It looks like the nitrogen that is available, or could be available, is sluffed off into the soil and it becomes available for the crop root that happens to be adjacent to it. There will be one or two weeks where there is very little new nitrogen fixation, but it soon picks up again and we have a N rate that looks as though it is about three times that of the untreated plots. At the end of the season, with this harsh treatment in the spring, it looks to us like our total nitrogen for the growing season is only slightly lower than if we hadn't done the treatment. By doing this treatment we gave a shot of nitrogen to the crop, and with most of our vegetables, we want the extra nitrogen there to get it started.

DISCUSSION

Ogg: Were your cover crops replanted each year or were they maintained from year to year?

Sweet: We have both systems. Sometimes the living mulch is established as early as possible the first year, and then we plant into it the next year.

William: I wonder if the clover is sluffing the nitrogen off during the crop production cycle after the two-week period or is nitrogen being fixed by the clover and not available to the crop?

Sweet: Atrazine treated or not? When its atrazine treated, it sluffs it off.

William: How about after the two-week period?

Sweet: I think from that period on we are not getting any nitrogen. By using parallel plots, where you put on certain amounts of nitrogen and then check and see which plots correlate most closely with your legume plots, we find that we are in a range of 50 pounds of nitrogen per acre with the atrazine treatment.

There are some other aspects of living mulches which are beneficial. We have some rodent problems, but we are working very closely with Professor Mike Richmond at Cornell, who says that the choice of mulch species is very important in determining what will be there in the way of rodents. He has a quick test that he does. He has some special pens where the rodents are given free choice of different plant species. With this test he can get a rough estimate as to whether they will prefer a certain plant species or not. He knows that if the rodents eat certain plants willingly, then you are almost certain to be in trouble when those species are planted in the field. Yet the reverse is not necessarily true, they might avoid one until they get really hungry, then they might eat it and thrive. He is forced to work mainly with our small plots, but we are going to try and get some larger plots this year. Moles are really hard to kill in the Hudson Valley fruit district, but Mike has been able to work out which of the legumes and grasses will not support them. He is now working with a pomologist to get a tree fruit management point of view. He has several legumes and several grasses that will not support those small rodents that chew on the bark and roots of trees. The nitrogen relationships in tree roots is exceedingly important, so fruit growers are pretty skiddish about establishing a living mulch, but none the less, we will get there someday. Living mulches could be a simple way of handling the mouse and mole problems in crops.

Ogg: In the orchard work are they utilizing total cover or strips or both?

Sweet: We are using both systems. The present practice is to keep a clean culture underneath the trees. This leaves you open to problems, like herbicide damage. If you get heavy rains or a bad winter, there are a lot of things that can go wrong with that kind of management system. From my point of view, and from Mike Richmond's point of view, there is no reason that you would have to have that bare strip heavily laced with chemicals.

McEvoy: Have you called in Richard Root to look at your plots? His work is in insect colonization on collards. I am particularly interested in your observation that there were very few insect problems with your cabbages and I was wondering what it might be. I would suspect that the cabbage worm would be finding those plants, since they are quite adept

at colonizing plants in mixed stands. Since colonization is not disrupted, I would ask is survivorship low because of the influence of beneficial insects or is it poor nutrition of the plants grown in mixed crops?

Sweet: We are not far enough along to say for sure. I am not working directly with Dick Root. Anthony Shelton at the Geneva station is the one who is probably going to take the lead role on that, he is specializing in insects on Cruciferae. We haven't been at this long enough to really come up with any conclusions. So far we have reduced our insect problems. These are small plots, and in small plot work I am always a little skiddish to know what is really going on. We happened to have a farm that is blessed with enormous numbers of cabbage flea beetles, and one thing that surprised me is the results from some of those plots; the cabbage under clean culture was riddled with flea beetles, but this was not the case in the living mulch plots. Now, what happened to them? Perhaps they were there and something else ate them or they preferred the open culture. I don't know.

McEvoy: Your latter point might have something to do with it. The phenomenon of associational resistance and mixed plantings frustrates flea beetle colonization; that is well documented. So with the flea beetles, I am not surprised to hear your results.

Sweet: I have been telling you about the positive aspects of living mulch, yet there is one very scary thing I learned. A plant pathologist, Professor Zitter, is finding that some of these clovers are excellent hosts for some viruses, particularly with the Cucurbit species. That is the kind of thing that we want to avoid if we can. I don't think you can take anything for granted as to what is going to be a good association or a bad association. We have to check it out.

Hogue: What about nematode populations in some of these cover crops?

Sweet: We have not checked that yet, we are just gradually getting this project put together. Rosemary Loria at our Long Island station will be working on the nematodes. She will be starting that work this year. I am exceedingly pleased with the group that we have working together. The reason I am pleased is that we don't have any money, and when you can get people working on a project for which you don't have money, they are definitely interested. I would rather get it started this way. Of

course, if anybody offers us money, we'll take it. In our own department alone we have three professors actively interested in the project and three or four graduate students, along with others that are associated with us. You won't find much written up on it, no experiment station reports or anything like that. I believe a lot of good is going to come from it though. The traditional ecologist and the production agriculturalist are going to get together, at least on the Cornell campus, before too much longer. We have been in two different worlds thus far. We are at the point now that we both need each other and I think we are going to get somewhere with this. I think there is going to be some sort of agricultural ecology.

Another thing that pleases me is that much of the push has been coming from the graduate students. They say to me, "Why haven't you been doing this all your life?" I say, "Well, it takes some of us longer to learn than others." Then they say, "it seems like such a natural thing to try and put a system together." I say, "Yes, that is natural in a way, but it doesn't just happen. You have to have some specifics before you can put things together in a system. You have to be able to take it apart to understand it, and then you have to put it back together again into a constructive system".

Booster: Have you monitored the influence of these living mulches on soil temperatures?

Sweet: Yes, we've monitored temperature and moisture. Temperatures tend to be more even, it's not as hot and not as cold when a living mulch is present. We thought that soil moisture would be a very critical factor, but so far it hasn't been. It could be that we just haven't had the right combinations, like a lack of rainfall or irrigation. During our growing season we get some rain and, on the average, we get enough rain. We are likely to get our rains as heavy downpours in the summer and it looks like these mulch plots are catching more of it, and it is going into the soil. We are not losing as much water during these heavy showers. We tend to get deeper crop rooting underneath these mulches. This combination of better water penetration and a very distinct and different rooting pattern looks as though it may balance out. We did a little bit of irrigation work last year. We put on traditional light amounts of water (about 3/4 inch to 1 inch) and where we irrigated those

mulches, we lowered the yield of the cash crop. The mulches grew beautifully, but we didn't put on enough water to get it down to the crop roots. So in a dry spell, without irrigation, we didn't get hurt by having the mulch, but with irrigation, we stimulated the mulch and lowered the crop yield. That could happen with rain too. It surprised us. I am not an expert on apple tree roots, but I am working with Warren Stiles on some of these problems with mulches. He is finding some of the same moisture responses that we are showing. A few of the mulch species that are shallow and densely rooted, are causing the same response from apple trees as they do on our vegetables. I didn't think they would respond the same at all. It surprises me that we are getting similar correlations in bluegrass sods. Stiles says that bluegrass is one of the best plants to grow under apple trees. He thinks it is due to the fact that in our climate, if we get a hot dry period, bluegrass goes dormant and doesn't draw on the soil and water resources. You start out with less moisture in those areas, but since the tree roots tend to be a little deeper underneath bluegrass than they are in open culture, the trees are less vulnerable.

Doerge: Do you have a feel for the seasonal distribution of nitrogen release from a clover mulch under the various treatments of spraying, mowing or untreated? Does it all come at once or does it spread out in terms of utilization by the cash crop?

Sweet: I'm glad that you phrased that, "do I have a feel for it", the answer is, partially. It looks to us as though with clover you won't get much nitrogen during the crop year unless you zap the clover with atrazine. Possibly you would with frequent mowings, but atrazine is the treatment that really shows up. Now, if we rototill the clover or plow it, then bingo, you'll get plenty of N, but we are trying to have our cake and eat it too. I am sure that there are going to be a lot of sophisticated techniques developed as a means of regulating the clover. There is still a lot of work to do on this, but we are working on the wrong class of compounds to do it with. Nate Hartwig has been trying to work with crown vetch in Pennsylvania. Actually it was his work that really stimulated us to go further with legumes. He kept saying, "I can't do it, it doesn't work," but I kept saying, "let's give it a different twist, it has so much potential, let's work on it." Then in the summer

of 1981, he did some triazine regulation of his crown vetch and he said, "For the first time, I have been able to grow corn with crown vetch and get some beautiful yields, and still keep my crown vetch." Prior to that he was using hormones primarily and Roundup for his regulators. I don't think it is just chance that the triazines are showing us that there is a class of materials for regulating legumes that has some promise.

Raese: Over the long stretch would you anticipate different requirements of fertilizer for the legume mulch system compared to bare ground management of the cash crop?

Sweet: Absolutely. I anticipate that in a given field with this kind of system, inputs of chemical fertilizer are probably going to be cut in half once the system gets going. In Pennsylvania we are working closely with Dick Harwood of Rodale Press. He is the director of their research. You don't see much about Dick's work, you read mostly testimonials. These things are very hard to document and so most of us involved in agriculture are inclined to ridicule them and say that it is a bunch of nonsense. Well, Bob Rodale said a few years ago, "We have gone as far as we can with testimonials, we have to get data and furthermore we don't have any credibility in the land grant institutions. We have to have credibility in the land grant institutions." So he brought in Dick Harwood. Rodale is now financing two assistantships in the Vegetable Crops Department. They are using a little different twist than what we are doing. They are spreading the corn rows out a little bit and putting in bigger strips of legumes. They have some interesting systems going. There is one farm adjacent to Rodale that is privately held. It is very intriguing. They apply no commercial fertilizer at all and use no herbicides. They are running about 500 acres, mostly in corn, soybeans and hay, along with some beef cattle. The farm is producing corn for about 75¢ a bushel in terms of cash outlay, while competing farms are spending $2 a bushel. Their yields are running about average for the state of Pennsylvania. The farm is on very steep ground, but has no erosion problem at all. They are making it work. I am telling you this because I have had my eyes opened. We don't have all the answers in traditional agriculture. We have a lot to learn. Dick Harwood is trying to study the system in some

detail and he has put out some large scale, long-range plots. If you ever get East, you ought to make arrangements to see those plots. He has some that the state of Pennsylvania is calling the shots for on soil management. In terms of fertilizers, liming, and pesticides he follows official Penn State recommendations, but he has others that he is putting into his own living mulch system. One of the big difficulties is that the first two or three years he tries to get into this system, the crops do very poorly. As soon as you cut off the chemicals, especially chemical fertilizer, yields drop way down. This looks as though it is a nitrogen relationship to me and we think we are close together on this one. There is something about the turnover of the organic matter. When you are putting on plenty of chemical fertilizer the organic matter is not turning over the way we would expect it to. It turns over differently under a mulch system. It is amazing that when you cut out the use of fertilizer for one year, on fields that have been getting 100 or more pounds of every nutrient for the past 30 years, all possible deficiencies show up. Yet, if you keep with it and work a little organic matter in, without using any chemicals, in about three years the yields are back up and away you go. You don't need to put it on anymore. With most of the research that our department and other departments have done, we usually quit testing too soon. We run a short-term test and say, "without chemical fertilizer, particularly nitrogen, you go broke." Well, you do, if you only have resources for one year.

Hobart: In your plots did you find atrazine by itself, without the mulch, to have any stimulation on nitrogen in corn?

Sweet: No, we did not. Somebody else may want to comment on atrazine stimulation or apparent stimulation of nitrogen. We sometimes think we see it, I don't have any good evidence as to how many pounds equivalent we are getting. All the corn had atrazine, but some of it had an extra 3/4 pounds over the legume. We put on a half pound over every row just for annual weed control, unless it was to be untreated. I think the direct atrazine effect by itself was eliminated. We had the right number of plots in there to rule that out.

Davenport: I am still not clear on when you put the mulch in compared to when you put the crop in.

Sweet: Establishment can be almost anytime during the year when you are able to get it done. We have accomplished it in many different ways. We've used a system of mini cultivators and cultipackers. You can put the mulch in anytime you can still get through the rows. We have established legumes anywhere from early May to October. Then the next year you are into a sod situation. Establishment is one set of problems that depends on the weather and the species. For us the easiest sods to establish are the large seeded grasses. Some of the fine seeded clovers are hard to establish. The fine seeded turf grasses are very hard to establish. Use your imagination, use your crop and use your weather, you have all kinds of flexibility there.

Davenport: But you are actually putting it in a year before the crop?

Sweet: No, we grow the crop at the same time. Our premise is, we are going to get a cash crop every year. We have to do that to keep the sheriff from taking our machinery away that we bought on credit. What we are trying to do is to keep a living cover on the ground as long as we can. We have some plots that have been in three years.

Davenport: Do you do anything with the cover after you have taken the crop off?

Sweet: No, we stand back and hope that it grows beautifully. We are trying to do everything we can to help improve the soil structure. We are trying to get a species to give us as much root growth as possible.

Young: What do you do to control the weeds when you plant the cover crop late, like in August or October?

Sweet: It depends on the crop we are in. Obviously if it is corn, it is an atrazine program plus something else. If it is vegetables, it is likely to be a low rate of Treflan plus something else. With most of our vegetables, and with closely spaced crops, the critical time is the first three to four weeks, after that the crop closes in. After the crop closes in, new weed growth is not a problem. So, we are able to go with low chemical doses early and, depending on the crop, establish the mulch crop. At that time of the year, following establishment, we have very few weeds bothering us. When we tried to establish a mulch crop in July, the lack of moisture with fine seeded grasses or legumes, gave us problems.

Young: My second question was regarding this organic farm you mentioned. You say that they used no commercial fertilizers at all. Does that also include lime and rock phosphate?

Sweet: I think he occasionally did lime. I don't believe he is buying any rock phosphate though, but I don't know that specifically. Remember, he has a beef cattle operation that works in with this and he does buy some cattle feed to supplement the corn, soybeans and legumes that he grows. But in the end, all that goes back on his land.

Young: Do you know anything about his soil test results, in particular on the phosphates?

Sweet: Yes, they are in very good shape. They are up where they should be and they seem to stay there. I am sure that Dick Harwood and some of the other people would know because they are using the Penn State soil test as a basis for fertilizing their plots on that farm. The farmer has been with this program of minimized buying of nutrients for 10 or 15 years.

Topic 2

THE POTENTIAL OF TURFGRASSES AS LIVING MULCHES IN CROPPING SYSTEMS

Tom Cook

Oregon State University, Corvallis, OR

My purpose in presenting the following information is to extrapolate what we know about grass performance as turf to how grasses might perform when used as a living mulch under cropping conditions. Keep in mind that my experience and expertise is limited largely to conditions in the Willamette Valley, so most of my remarks will be oriented with this region in mind.

While there are plenty of interesting plant materials that might be of value as mulches, turfgrasses are particularly appealing because they are readily available commercially. In fact, all but one of the grasses I will discuss today are available from various sources throughout the seed trade industry.

The primary question is whether or not these available grasses are suitable for the various crops that they might be used in. I can't answer that question, but I can discuss the characteristics of each grass and let you decide for yourself if there is a future for grass in your cropping system.

Perennial ryegrass

Ryegrass would be my first choice for weed suppression in most crop situations. Perennial ryegrass is extremely fast to germinate and establish, and as a result, it is very competitive during the early stages when weeds are also trying to establish. In side by side comparisons, young ryegrass will always have fewer weeds in it than all other turfgrasses.

Another advantage is that perennial ryegrass is a bunchgrass, which means it won't encroach into crop rows once you establish the border with chemicals or cultivation. Other grasses present constant problems in this regard.

Perennial ryegrass grown as a turf has the highest fertility requirement of all turfgrasses. Without regular fertilizer applications it will quit growing and eventually thin out. On the other hand, ryegrass responds well to fertilizer applications and will regain vigor and density quickly. I view these characteristics as advantages in crop situations, since growers can stimulate or retard growth as needed simply by manipulating nitrogen fertility levels.

Wear tolerance is very good. If worn bare, however, its recuperative ability is poor, since there are no rhizomes or stolons to fill in bare areas. Under most situations, ryegrass has tolerated wheel traffic quite well and has allowed turf managers to grow grass in areas where nothing would grow before.

Most textbooks will rate ryegrass's drought tolerance as poor, but my observations indicate it tolerates drought as well as or better than most other grasses. Once injured from drought, ryegrass recovers very rapidly when water becomes available. Its bad reputation seems to come from its poor performance in areas with hot, humid summers. In those areas it often fails because of disease or prolonged drought, which we don't have to contend with here.

Cold tolerance is poor, so ryegrass may be injured in climates with severe winters. Cold has never caused any problems in the Willamette Valley or coastal areas. In cold portions of interior Oregon, ryegrass may thin out over a period of several years.

One final point to consider regarding perennial ryegrass, is that there are two types available. Common types such as 'Linn', 'Norlea', and 'Pelo' are fast, rank growing grasses which have poor density under turf conditions. I don't feel these would be acceptable for most circumstances. The improved turf types listed in Table 1 have much better density, tillering, etc. and are the ones you will probably find most useful.

Table 1.

Some available improved perennial ryegrasses

Acclaim	Citation	Futura*	Pennfine
Barry	Dasher	Loretta	Prelude
Bella	Derby	Manhattan	Premier
Birdia	Diplomat	Omega	Regal
Blazer	Elka	Palmer	Yorktown
CBS*	Fiesta	Pennant	Yorktown II

*commercial blends of perennial ryegrass

Tall fescue

This grass rates very close to perennial ryegrass in most performance characteristics. Tall fescue germinates and establishes relatively fast providing temperatures are fairly warm. Once temperatures drop in late September and October, germination slows and the grass establishes very slowly. It is not as competitive as perennial ryegrass initially, unless seeded at rates of 7 lbs seed/1000 sq. feet or higher. Persistence under low fertility is better than perennial ryegrass, but it must be fertilized enough to maintain density. Wear tolerance to wheel traffic is quite good, but once injured, recuperative potential is poor. Drought tolerance is superior to all other cool season turfgrasses. Tall fescue can remain green and growing without irrigation during most Willamette Valley summers. Cold tolerance is only fair, but practically speaking, it is not likely to be of significance.

As with perennial ryegrass, it is important to distinguish among tall fescue varieties. Old varieties such as Ky. 31,' Fawn,' and 'Alta' are rank growing forage grasses. They get large and require frequent mowing to keep them under control. Newer varieties have been selected for turf characteristics; they are denser, finer textured and somewhat lower growing, providing they are mowed. If allowed to grow wild, these improved types get just as rank as the old varieties. Neither produce significant rhizomes, so both types behave like bunchgrasses. Which is best for you depends on your situation. Some of the newer tall fescues are listed in Table 2.

Table 2.

Some improved tall fescues

Clemfine	Houndog	Olympic
Falcon	Mustang	Rebel

Red fescue

There are three types of fine fescue used commonly for turf. Historically, red fescue has been most widely planted. Red fescue is a rhizomatous grass which germinates relatively fast, yet it is somewhat slow to establish. During establishment it does not tolerate wear very well. It is not very competitive during establishment, but once it is mature, it competes fairly well. Fertility requirements are lower than most other grasses. Density will improve if at least some fertilizer is applied annually. Wear tolerance is fair, but traffic during wet times of the year will cause severe loss due to Helminthosporium blights. It would not be a good choice in orchards where winter activity is high (e.g., pruning, spraying, etc.). Drought tolerance is fair to good, but it ranks well below tall fescue. Cold tolerance with red fescue is not a problem in Oregon.

There are relatively few improved red fescues available. Fortunately, the common types and older varieties perform reasonably well. One newer variety that looks promising is 'Ensylva'.

Hard fescue

Of the various fine fescues, hard fescue has more potential than any of the others, but it has one major weakness -- establishment. Hard fescue is probably the most difficult grass to establish of those we currently use. Once established, it forms a dense, fine textured turf that is very competitive. It definitely has a low fertility requirement and it has been ranked almost as good as perennial ryegrass in wear tolerance trials. Its

drought tolerance ranks second only to tall fescue. Little is known about cold tolerance at this time.

Because of its establishment problems, hard fescue will only be used in mixtures with fast starting grasses, such as perennial ryegrass. In mixtures it would probably come on very slowly and eventually dominate under drought and low fertility conditions. Improved cultivars are just starting to come onto the market. Some available varieties include 'Scaldis', 'Tournament', 'Waldina', 'Reliant', and 'Biljart'.

Chewings fescue

Chewings fescue is a third widely used fine fescue. It is popular for turf because it is dense and aggressive, even though it is a bunchgrass. It germinates fast, but is only moderate in establishing. Its fertility requirements and wear tolerance are similar to red fescue. It has the poorest drought tolerance of all the fine fescues. Once injured from drought, it is very slow to recover. Its cold tolerance is similar to other fine fescues.

My experience tells me that chewings fescue has the least potential of the fine fescues as a mulch in crop situations. It may be of use in mixtures, but I doubt in general, if it will prove very useful. In choosing a variety, you can just about take your pick from the many common and improved types.

Colonial bentgrass

Ecologically, bentgrasses are better adapted to the valley climate than any of the other turfgrasses. Practically speaking, they probably have limited value as mulches in most crop situations. Colonial bentgrass would be the only bentgrass I would even consider. Compared to other grasses, it germinates fast, but establishes slowly and does not tolerate wear at all during establishment. Its juvenile period is so long, that it pretty much has to over winter once, before it is able to tolerate much wear and tear. It is moderately aggressive once it is established and most varieties will produce stolons and/or rhizomes. Its fertility requirement is lower than most grasses and it tolerates acid soils quite well. Its wear tolerance is very poor. Along with this, I've noticed that while perennial ryegrass and tall fescue tend to firm up the soil once they are established, bentgrass

never does. Once bentgrass turf gets wet, the soil is almost as mushy as bare soil. Drought tolerance is poor, though survival (via dormancy) is quite good. Its cold tolerance is good. Available varieties include: 'Highland', 'Astoria', 'Exeter', and 'Bardot'.

Kentucky bluegrass

Kentucky bluegrass is the most widely used turfgrass in northern regions. Unfortunately, it does not do terribly well in our climate and in my opinion, has little to offer. Germination and establishment rates are slow. Once established it is vigorous and evasive (via rhizomes). It can last for several years if fertilized regularly. Eventually it thins out and is replaced by weedy species. Its fertility requirement is high and under low fertility rust is a serious problem. Wear tolerance is good and recuperative ability is good. Drought tolerance is fair, while cold tolerance is quite good. It may have value in mixtures for recuperative reasons. There are many varieties available.

Annual bluegrass

Regardless of what you start with, annual bluegrass is probably what you will end up with. Unfortunately, you can't readily obtain seed, so you can't plant this grass intentionally. Annual bluegrass is a genetically variable plant that ranges from distinct annual to perennial types. Its habit ranges from bunch to stoloniferous. It germinates at an average rate, but establishes very quickly. Fertility requirements are moderate, yet it can invade at either high or low fertility levels. Wear tolerance is reason ably good. It has no drought tolerance. After seeding in the spring, it simply dies when drought comes in the summer. When fall rains come, it germinates again and establishes by early winter. Its invasion rate in existing turfs is slow initially, but eventually it increases almost geometrically. Its cold tolerance in the valley, is fairly good. I have no idea where you can get seed commercially.

Summary

If someone asked me, "What should I plant between my trees?" I would probably say, "Start with perennial ryegrass, tall fescue, hard fescue, or a

mixture containing perennial ryegrass and hard fescue." More complex mixtures might also work, but I can't predict how well. Tall fescue will generally perform best if planted by itself.

DISCUSSION

Brown: You know, I almost want to turn around your drought tolerance statements for the purposes which I am thinking about--the grass with poor tolerance might be more desirable, because otherwise it will compete for moisture with the crop.

Cook: That would be a consideration, but I relate this to turf and in turf green is of the essence.

Brown: If the grass dies from drought, but like annual bluegrass, comes back for the next season and that is acceptable to the grower, would you change your recommendations?

Cook: If you want a grass that will go dormant--so that it was green in the winter, yet didn't give you any problems in the summer and then came back in the fall--then go with annual bluegrass. Annual bluegrass will germinate in the fall, give you a lush, beautiful turf all winter long and then it will seed and die in the summer. What you would probably end up with under a cycle like that, where you want a grass to go dormant, would be a mixture of annual bluegrass and wild bentgrasses. If you had some of the fine fescues in there, I think what would happen is perhaps red fescue or hard fescue would persist. I don't think chewings fescue would persist under that regime. Tall fescue would not be the ticket at all. Ryegrass still would be a good way to establish a stand, if you started with a low seeding rate, for example: 2 lbs/1000 sq. feet or 80 pounds per acre. With a rate of 1 lb/1000 sq. feet, you are going to have clumps everywhere.

Brown: If you eliminate the annual bluegrass, what would be your next choice of a grass that will not compete for moisture with the crop, but has the ability to maintain a stand?

Cook: I think I would go with ryegrass.

Jordan: I am from California and we have had some experience with ryegrass. On the coastal areas where it is cool and moist, we can hold the ryegrass during the summer fairly well, but in the desert areas where it

is hot, we cannot. It doesn't compete very well. It gets to be about four to six inches high, depending on the variety, and then it just sits there. If you miss a watering it starts going out on you and we have a hard time maintaining the stands.

Cook: You have described perfect eastern Oregon and eastern Washington situations. Ryegrass would not be good under those conditions. My perspective is from the Willamette Valley and Puget Sound areas. Ryegrass is definitely the grass for this side of the Cascades. When you move it to the eastern side, you have a whole new set of rules.

William: Tom, could you list the native bentgrasses and put some information in the same columns for the native bentgrasses as you have for the other grasses?

Cook: I really couldn't do that; there are a lot of native species.

Ogg: How would you categorize the grasses as to stem height and rooting depth?

Cook: When you say stem height, I assume you don't want to mow?

Ogg: In terms of orchard management, the less mowing, the better.

Cook: Starting with rooting depth, tall fescue by far has the deepest root system. Next it would probably be a toss up between hard fescue and perennial rye. Next you would go to red fescue and after that it's hard to say. There would be a distinct difference between tall fescue, perennial ryegrass and hard fescue on down to red fescue.

William: One grass variety that I saw at the Portland Trade Show was a tall fescue called 'Houndog'. The International Seed Company in Salem has developed this; I believe it is a patented variety. The seed stalk gets pretty tall, but the turf part of it only gets about four or five inches high. It has been developed as turf for football fields in Kentucky and Tennessee. I would guess that if the football players can play on this type of turf, it might traffic pretty well in some of our horticulture cropping systems. It's a very coarse grass, so they like to mix about 30% fine fescue with it in order to give the turf a finer texture. It requries only a few mowings. It is one that we would like to test.

Sweet: I was wondering if you had any observations on shade tolerance. In some situations, it seems you would want grasses that don't tolerate shade too well. They should die down a little bit when the crop is really going, and then revive when the crop has matured.

Cook: That is a good point. Historically, a shade tolerant grass would be red fescue, but here in the Willamette Valley where shade is associated with wet soil, it doesn't persist very well. Some of the perennial ryegrasses do quite well under shady conditions (e.g., 'Belle', 'Diplomat', 'Yorktown II', 'Prelude', 'Omega'). Bluegrass has very poor shade tolerance. Colonial bentgrass would struggle, but survive. Chewings fescue would probably not be as good as red fescue. There is not much I can tell you about hard fescue. Tall fescue has pretty good shade tolerance from the standpoint of maintaining turf. I would suspect that most of the ryegrasses would suffer during the shady part of the year. They wouldn't be overly competitive and would recover very nicely once the crop is harvested or the leaves drop.

Sweet: That has been our experience with perennial ryegrass too, but we don't have enough history on the others.

Cook: I think tall fescue would work in your location (New York). If it didn't freeze out, it would do well throughout the summer. As you go south into the transitional zone, it is a very good shade grass. Red fescue probably would go dormant on you and hard fescue too.

Sweet: In our work we would prefer, when the cash crop is doing well, that the mulch crop be quiet.

Cook: In an annual cropping system, that is a good idea.

Fox: How does your wear factor relate to wheel tractor packs? Specifically, where they run the wheels of the tractors?

Cook: This wear rating here, would be a combination of modest compacting forces and a lot of abrasion as opposed to tractors. To answer your question, I would have to go back to my observations made earlier. Ryegrass and tall fescue tend to firm up the soil and give you a very rigid structure for a good part of the year, which means they should support wheel traffic very well. I have also observed that when it gets really muddy, ryegrass will let mud ooze up around it. The same thing would be true for tall fescue, but you would be able to maintain a firmer surface than with any of the other grasses.

Fox: Are the root systems of these grasses able to at least stand up enough to the strain of compaction from equipment?

Cook: If they are allowed to establish first, they can. For ryegrass, if you establish it in the fall, by the following late spring you are in

good shape. If you get in a hurry, then it won't tolerate it. You would end up having to deal with some ruts. Ryegrass will grow where virtually no other grass will grow, even in very compacted soil.

Lombard: Is there any difference in flood tolerance for some of these grasses?

Cook: Yes, ryegrass would persist under wet conditions, but it wouldn't look great. Bentgrass does quite well under wet conditions. The fine fescues would not be of any value. Tall fescue grows in drainage ditches, so I can't say much more than that. Poa annua might be the ticket.

Brown: I am going to open the topic of Poa annua. I would like to explore that variety, because under certain management systems, like in orchards and caneberry fields, you develop a beautiful stand of annual bluegrass. It seems like an ideal kind of ground cover, because it goes dormant so early. Everytime I have talked about this with anybody, I have been really discouraged. First, because the seed isn't readily available and second, because it is such a noxious weed for so many people. Can you expand on this? Are there any possibilities for Poa annua as a ground cover?

Cook: I think so. When I began, I said that if you started with a little annual bluegrass you would end up with alot. We are in the heart of annual bluegrass country and if you can't grow annual bluegrass here, then you are totally incompetent. I don't feel that bluegrass is terrible. I think it can be used as a tool. What is difficult however, is getting it started. You cannot buy reliable sources of Poa annua. The last time I got some, it was supposed to be 95% Poa annua, but was 60% Poa trivialis. If somebody was interested and would care to develop a reliable source of annual bluegrass, that would be great. I think there is great hope for it, but how can I make a recommendation? If you want a grass that won't persist for a long period of time, I would use annual bluegrass and possibly chewings fescue. Under drought stress, it won't persist, but it will establish quickly. I wouldn't use ryegrass in that case. Poa annua does not compete very well with ryegrass at any stage. If you are talking about several years, you are talking transition.

Lagerstedt: What happens under non-irrigated and non-tilled orchards? It seems that if you start out with Poa annua, you wind up with some deep-rooted perennials. In some orchards we don't want to till, we want to maintain a stable floor.

Cook: In the orchard situation where you have a dense canopy throughout the year, you would have another matter to deal with. Everybody here is thinking, "What will work in my situation?"

Brown: The situations where I have seen the annual bluegrass develop so well, have been under cultivation. The cultivation is done fairly late and it knocks out everything else but the annual bluegrass, which has already gone to seed. Tremendous stands of annual bluegrass develop. I was wondering if there aren't ways of using chemicals to manipulate it. One could wait until it went dormant and then spray it with Roundup or some other material that would knock out the late grasses. Of course, you would have to control the broadleaf weeds with something else.

Cook: I think you could do that, but time it for late spring. You really wouldn't have to wait for it to die. All you would have to do is to wait for the bluegrass to get a seed crop on it and then spray everything while there is adequate moisture to kill some of the broadleaf weeds as well. Following that up by giving the area a light tilling in the early fall, prior to the fall rains. This would kill any other broadleaves that were there or at least set them back. When the rains come, you will end up with lots of Poa annua.

Raese: I presume you use Embark as a growth retardant. I wonder if that is one of the better ones for controlling grass height?

Cook: I found it to be an excellent tool. For my class, I like to maintain pure stands, because I teach my students what the various grasses look like. I found that Embark will slow down ryegrass, but it won't stop it. I haven't had disease problems like red thread, though I thought I would. Embark is very rough on Poa annua, but it won't kill it. I usually spray in the spring, about the time that the Poa annua is already starting to flower. I stop it cold in its tracks. It turns bright yellow and looks bad, but grows out of it and flowers. I have never had reduced percentages of Poa annua, but I have given the competitive edge to ryegrass. I usually come back in the summer and kill it with something else. Embark injures tall fescue a little more.

It is also very rough on Kentucky bluegrass. It stops it too effectively and then rust comes in, along with other grasses. If you go to a sod farm where you have bluegrass, with a little bit of fine fescue in it, spraying it with Embark two years in a row will give you 90% fine fescue. This works with chewings or anything else, because you just stop the bluegrass cold. Of the growth regulators that we have tried on turf, Embark is the best, and the rates are low. One other thing I like about Embark is that it has a rather short activity period--four to six weeks--after that the grass recovers and looks like it was fertilized. I think it has tremendous promise. It does not do much to most broadleaf weeds, so you will have to practice broadleaf control. It is registered for use in turf, but I don't know if it is registered in other situations. I know they use it along roadsides in turf.

Raese: Is there much of it used?

Cook: No, but people are catching on. It could save people some time and money.

Raese: Orchardgrass wasn't mentioned and I don't know whether people like it or not. I suppose the main problem with it is that it grows too tall and it's hard to get rid of. How about quackgrass? Would it interfere with the establishment of some of these other grasses?

Cook: I really can't tell you. I know that we have tried to use it for turf, but it won't develop any density. Under our conditions here, it does not remain competitive against turf. Of course, our culture would be more intensive than it would be in the orchard. I suspect that you might have some problem getting it started. Orchardgrass is a pretty persistent weed; we don't consider it a turf variety.

Peterson: I wonder if you have used any annual fescue or annual bromes. What effects do these have on farming and soil structure?

Cook: I haven't had any experience with them at all.

William: Does anyone else have any experience with those?

Anon.: I can make a comment on the annual bromes. They are hard to control. I can't get very excited about introducing something that we can't control.

Appleby: I have more of a bias against bromes that Tom does against annual blue for that reason.

Bell: Tom, do you have any information on undesirable allelopathic effects obtained with some of these grasses when they are used with crops?

Cook: Just about anybody you want to talk to has found that there appears to be a lot of allelopathy between ryegrass and other plants. The literature I am most familiar with would be literature on competition between trees and turf. The work that was done in Florida indicated that trees were allelopathic to germinating turf and that established turf was allelopathic to young trees. It seems to be a standoff. I am sure it exists, but I think rooting vigor, foliar growth rate and temperature effects on growth are more important.

Sweet: I'd agree, in general if allelopathy occurs, it is likely to be relatively specific with one species against another species. Photoperiod, moisture and nitrogen are more universal tools to work with than allelopathy.

Cook: There has been a lot of interest in perennial ryegrass for showing allelopathy during the germination phase. I have observed that when I plant grass initially (in the first six months), I have far fewer weeds in ryegrass. And certain weeds don't seem to occur at all during this establishment phase. I would like to attribute that to competition and the rate of growth, but it may be possible, that in fact, allelopathy is involved.

Topic 3

POTENTIAL RODENT PROBLEMS IN A LIVING MULCH SYSTEM

David S. deCalesta

Oregon State University, Corvallis, OR

Living mulch systems have the potential of encouraging rodent damage to some agricultural crops. Such a cultural practice will provide additional food and shelter for rodents.

Major pests include the pocket gopher and the meadow mouse or vole. Both eat above ground parts of hay and grain crops, as well as grasses and weeds. Both girdle the trunks of orchard trees. Pocket gophers also eat the roots of trees. In some instances, damage to harvest machinery and reduction in crop quality result from the mounds pushed up by gophers and moles.

IDENTIFY THE PEST

As with any control program, the first step is to properly identify the pest. Damage by pocket gophers, meadow mice, and moles may be quite similar, but control methods for each are different. Proper identification is a prerequisite to achieving adequate control. Because moles and gophers are mound builders, misidentification of the two is common. Pocket gophers extend lateral or side tunnels to the surface from deeper main tunnels. They push out the excess soil in flattened or fan-shaped mounds. These may range from 12 to 24 inches in diameter with a height of six or more inches. The surface opening through which the soil was initially pushed is plugged, leaving a noticeable dent at one end of the pile. The entire lateral may be backfilled with soil to the main tunnel.

Mole mounds are the result of repeated eruptions from below. They simply continue to grow or enlarge until the mole has disposed of the excess soil and moved on. Mole mounds are higher than gopher mounds and look more like miniature volcanoes. No hole on the side of the mound is evident, but if you place your finger in the middle of the mound and push it down in a

circular fashion, you will discover the mole's hole is in the middle rather than on the edge of the mound.

The pattern of mounds helps to distinguish gopher work from mole activity. The gopher mounds tend to be clumped in tight groups, whereas the mole's tend to be spaced in a line as single mounds.

The handiwork of meadow mice may be separated from that of pocket gophers by the presence of small tunnel systems. These systems emerge above ground and continue on the surface under an overhanging shelter of grasses. Meadow mice have no mounds at the entrances of their burrows. The entrances are about the size of a fifty-cent piece.

The tooth marks of mice or voles are quite small, leaving a fuzzy appearance on the bark of damaged trees. Pocket gophers, on the other hand, will girdle trees, but more often tend to chew off roots and rootlets. Mice will often use pocket gopher burrow systems, but usually they will make their own excavations. When pocket gopher burrows and mounds are riddled with small holes, one can assume that they harbor mice as well as pocket gophers.

CONTROLLING THE DAMAGE

Pocket Gophers

When damage is restricted to a small area, usually less than five acres, trapping often is the quickest and surest method for eliminating pocket gophers. The large valley pocket gopher, which has a hole about three inches across, may be trapped using the cinch trap. The smaller pocket gophers, of which there are several species, have a hole about 1½ inches in diameter, about the size of a golf ball. These smaller gophers may be trapped using the Victor or Macabee trap. It is important that the proper trap be used for the different sized pocket gophers.

When the damaged areas are larger than five acres, poison baiting is the most effective method of control. This may be accomplished by hand using a probe, but in cases where damaged areas exceed 20 acres, a tractor-mounted machine called a burrow builder is used to bait areas rapidly.

Gas cartridges, exhaust from automobiles, and poison gas such as methyl bromide have been used in the past with varying degrees of success, but none is as effective as trapping and poison baiting. When using gas the soil must

be wet and have a composition that is high in clay, otherwise poison gases have a tendency to seep through the soil and escape. Pocket gophers have the ability to detect the presence of these gases quickly and they will seal them off from their main tunnel systems.

Habitat manipulation has been used in some circumstances to control pocket gophers. Vegetation which the gophers used for food is removed by herbicides. This seems to be counter to the purpose of a living mulch system. Unless vegetation can be removed for significant periods of time, especially during the winter, there can be little application for habitat manipulations. Studies on vegetation manipulation in southwestern Oregon indicate that the removal of grasses and weeds by herbicides results in a 50% reduction in wildlife damage to crops.

Meadow Mice

Generally, hand-baiting with zinc phosphide-treated wheat, is the method of choice for reducing meadow mouse populations. Newer anticoagulant baits, with attractants, are also part of the arsenal use against meadow mice. The most effective control results when baits are thinly scattered down the burrow entrances and in the narrow surface runways of the mice. Baits may be broadcast, but results are not as good as those obtained by individually hand-baiting burrows. Habitat manipulation also works very well with meadow mice, since they tend to leave areas where vegetation above ground has been removed by mowing, flailing or herbicides. Again, if the cover can be removed, especially during winter months, there may be some chance of habitat manipulation.

Moles

The most effective method for controlling mole damage is to use the out-of-sight trap. Generally speaking, one mole will make many mounds and usually inhabit an area of one to two acres. Trapping the newest or freshest system of mounds will easily result in the removal of the mole.

Poison baits have been reported as an effective control for the coast mole in the Tillamook area, but usually baits are not effective because moles are insectivorous.

DISCUSSION

Rackman: There seems to be more of a rodent problem where you have grass, particularly grass up around the base of trees. Is it a matter of protection or do they like a varied diet? You also mentioned that where there wasn't any grass, you could still have a gopher problem, why is that?

deCalesta: Gophers can travel fairly long distances in their tunnel systems and so they can invade areas quite rapidly. When you poison or trap out one pocket gopher, others will use the old burrow system to reinvade the field. You can have situations where there isn't much vegetation, but if it is within a few hundred feet of the edge of a field, there is the potential for renewed damage by gophers. We like to stress to people who are trying to control pocket gopners, to go outside the field if at all possible. The control doesn't stop at the edge of the field. It is a problem to try and eliminate that population which will migrate onto the fields, because they can go above ground, as well as underground. It is good to have a buffer zone when possible, 100 to 200 yards outside of a field. Often you have neighbors who don't practice any kind of controls, then you won't have an opportunity to have a buffer zone. Meadow mice especially need dense vegetation for cover. If they are damaging growing trees, eliminate the cover around the base of the tree and you will cut down the amount of damage they do.

Lagerstedt: We found last year when we had the 108° temperature, that the mouse problem was really magnified due to the lack of moisture. Not only were filbert trees girdled, but weeds actually were eaten. Mice were just seeking moisture. I want to mention that we tried this Phostoxin gas on the moles without very much success. The soil was very sandy where we used it. It should have had good penetration, because it's heavier than air.

deCalesta: Well, they're still working on that one.

William: Up in The Dalles area, if we eliminated a lot of our vegetation, the vertebrate pests would then start chewing on the cherry trees. Right now they seem to leave the orchards alone. Can you elaborate on that?

deCalesta: Which kinds of pests are we talking about?

William: The small ones, like the gophers and moles.

deCalesta: If you eliminated vegetation where?

William: In the cherry orchards. We feel that they would eat the cherry roots rather than leave the area if we removed the vegetation. We are talking about several hundred acres.

deCalesta: I would think that would be true. Before they would leave because of a lack of food, they would damage the root systems fairly extensively. So, if you remove all of the vegetation, but you don't have a program to remove the pocket gophers at the same time, then I would expect that you would get some serious damage.

Pumphrey: Speaking from experience, I'd say that if you had a population of gophers and you didn't allow them their food source, all you would do is immediately increase the pressure on your trees. The gophers that are doing all the digging are the males and the young gophers. Basically, the mature female rarely comes out of the burrow. She does little digging and she is a lot harder to control.

deCalesta: Another comment that I'd like to make relating to mouse damage is this; there are a number of chemicals which may be sprayed directly on the grass to poison their food source. The mice eat the grass and die. That is another potential source of control which may also work for pocket gophers.

Ogg: If we go to a grass strip in between tree rows in orchards, and we want a clean area under the trees, how large an area does this have to be to reduce the rodent problem? It sounds like many of these species can travel far enough that it really wouldn't make that much difference.

deCalesta: I don't think it would make that much difference with pocket gophers and with mice. I have seen a one meter area cleaned of vegetation and damage still occurred. As long as there is a fairly wide cover adjacent to the tree, where they have protection from predators, you will not have a complete reduction of damage.

Anon.: We had some plots this year where we planted Malling 26. The check plots were heavily grassed in with foxtail and other weeds; we had a very high population of mice there. They girdled all the trees in the check plots. Adjacent to the weedy checks, we had a weed free check. Trees which were 1 meter, or ½ meter apart were girdled, but beyond that distance of 1 meter there wasn't any damage. The edge of the plots had

the most damage, while the center of the plots were spared. It looked like they would travel about one meter from the heavily grassed plots, but no further.

Bell: If you prevent the grasses from lodging by keeping them mowed, would you decrease the chances of mouse damage?

deCalesta: Yes, you will. There was a study done in North Carolina with apple orchards which indicated that vegetation kept short would really reduce the habitat that the mouse needs. Mice prefer vegetation about one foot high to protect them from predators. If the vegetation is quite low, they will not use the area as much. It won't keep them out totally, but it will keep the population down and significantly reduce the damage.

Ogg: Are there certain times of the year when the rodents become a greater problem?

deCalesta: It depends on the crop of course, but it seems like during the winter the activity of the pocket gopher is reduced, though mice will remain quite active. That is the time when succulent plants are missing, so you tend to have a lot of animal damage in the winter. We also have a squirrel problem, though most people are not aware of it. In orchards close to the Willamette River, we have fox squirrels that have been introduced. They cause quite a bit of damage, particularly in the winter when there isn't much food. They will strip the bark off the base of mature trees.

Robinson: I was wondering what the most effective time for baiting is. What time of year would give the best control?

deCalesta: The best time is before the animal breeds.

Robinson: How often and when do they do that?

deCalesta: Pocket gophers are breeding in the early spring, April and March through May. Sometimes they will breed again in the summer, if there is a lot of food available. Mice will breed year-around, but usually they have a low period in the winter. If you can get them before they breed or when food sources are low, the baits will be more attractive.

Bell: If you rated food versus cover, which would be the most important for rodents?

deCalesta: I would say for mice, cover would be more important. The pocket gopher lives underground, so for them, it is going to be food. It depends on the pest.

Bell: Could you talk some about rabbit damage in Christmas tree plantations?

deCalesta: Most of the grasses that grow in Christmas tree plantations, particularly with high crop density, are going to provide enough cover for rabbits. I think you could expect a rabbit problem from time to time if you are in an area that is bordered by brush and other vegetation. Rabbits can travel fairly large distances, about ¼ mile or less is their home range. The Christmas tree situation usually is fairly susceptible to rabbit and mouse damage. Baits are best for controlling rabbit damage. Some people have found that if you wrap aluminum foil, six to eight inches up on the tree trunk (starting at ground level), it seems to reduce mouse damage. Baits have only a questionable success with mice. You can avoid the problem by protecting the tree; that seems to be the most effective method.

Bell: Have you heard anything about providing alternate browse for deer and other pests so that they won't feed on Christmas or filbert trees?

deCalesta: Yes. Researchers haven't done as much with horticulture or commercial crops as they have with Douglas-fir seedlings. They have used combinations of orchardgrass and ryegrasses with white clover. They find that when these crops are planted with Douglas-fir seedlings the deer no longer prefer the Douglas-fir seedlings; they eat the other plants. However, the deer only take those alternate plants in the winter time, during the rest of the year they are eating other things. So what happens is you get rank growth of the grass which was intended for the deer and this is accompanied by a population explosion of mice. You have one problem substituting for another. What was eventually done in those situations was to keep the grass down in the summer and fall by grazing it with sheep. You can defer damage by deer, if you use the proper type of alternate crop. You just have to be very careful that you don't create another problem with mice. A buffer crop along the edge of a plantation or interplanted among the trees seems to work.

Green: I'd like to ask a question about the rabbits. We have legal control for mice and other rodents. They may not always be that effective, but at least we have them. Is there anything like that for rabbits?

deCalesta: There is a strychnine bait that is available and legal for rabbits. It seems to work. The problem with rabbit bait is protecting it so that other animals don't eat it. Generally, what you do is to build a little bait station, like a small house, where the rabbit can go in and get the bait, but other larger animals can not.

Topic 4

VEGETATION MANAGEMENT IN PEACH ORCHARDS

Alex Ogg

U.S.D.A., Prosser, WA

I got into orchard cover crop research as a result of an integrated pest management pilot test, which had been initiated by the USDA in Yakima, Washington to control green peach aphid. Green peach aphids overwinter in the peach orchards. Populations increase in the spring and then the aphids fly off to other crops. They spread leaf roll virus in potatoes and have an impact on peaches as well. My involvement as a weed scientist consisted in helping with the vegetation management, specifically with the broadleaf weeds that grew on the orchard floor. The entomologists did surveys and found that dandelions, mustards, field bindweed and lambsquarters were excellent hosts for the green peach aphid. If the weeds were present on the orchard floor during a critical period of time, then a population of aphids could develop very rapidly. If the weeds were eliminated, however, that would cause a weak point in the lifecycle of the aphid and their populations could not increase as rapidly.

We began to look at grass cover crops as an alternate method of eliminating undesirable broadleaves in the orchards. Our initial thoughts were to use herbicides to maintain a clean strip a few meters wide under the trees, while seeding grass to eliminate undesirable vegetation in between the rows. The orchards we worked with had sandy and silt loam soils. They were all sprinkler irrigated, so we were able to do spring seedings. We seeded the grasses with a Vicon spreader, because we were able to adjust the seeding width. We tine-harrowed and followed with a packer, and then irrigated. With this method we were able to get good stands of grass.

In a typical orchard situation, where just a natural vegetation was allowed to grow, we had a relatively high popluation of dandelions early in the spring. Later, the field bindweed emerged and became dense. Normally

these areas would be tilled with a disk and then left untilled thereafter. It is during this period, every spring in May, that the aphids fall from the trees and get on the weed foliage. In June and July aphids migrate to the potato fields.

Red fescue is one of the grasses that we have been working with. Where the grass starts, the field bindweed growth is greatly suppressed. We are not sure whether this was competition or whether there was some allelopathy involved with the suppression. Another grass we looked at was 'Derby' ryegrass. It probably grows too tall for use as a vegetative cover in orchards, however, it is very competitive with the undesirable weeds. The suppression level with 'Derby' ryegrass on field bindweed was close to 90% and that was without any herbicide treatment. A new ryegrass that we are working with which we think has tremendous potential for orchards is 'Elka'. It is roughly four to six inches tall and very competitive. It essentially eliminated the dandelions and the field bindweed. I strongly believe that with 'Elka' we are dealing with allelopathy. The grass is producing a natural toxin that is suppressing the growth of the perennial weeds.

We are now in our third year of observations with the ryegrasses in the Yakima Valley. In 1979, the first year we planted, we had a severe winter, but the grasses survived. I don't feel that we have had a good test yet on winter hardinesa. Our winter minimum temperatures are traditionally between 0° and -10°F.

We were very interested in how these grasses would stand up to orchard traffic. Last year after apple harvest, we examined the grasses for durability. In the area of the wheel tracks, 'Ensylva', a creeping red fescue, stood up quite well to the vehicle traffic. But, when we compared the 'Elka' ryegrass to it, we found that the ryegrass did even better than the red fescue.

I think that we have some grass species which are very competitive with weeds. Perhaps we can use them to manage undesirable vegetation in the orchards. Some important questions still need to be answered, particularly those concerning the effect of the grasses on tree growth. We need to come up with this information before we start making recommendations to orchard growers. In our area we have spring frosts which are quite critical. If we put a grass cover crop in, as opposed to bare soil, there is an indication

that we are going to decrease the temperature in the orchard. It may be only by a few degrees, but if we are talking about the difference between 22° and 24°, we are talking about the difference between minimal damage and severe damage to the fruiting buds.

DISCUSSION

Bell: Did you notice an increase in the rodent damage with the sod cover in your orchards?

Ogg: We didn't have a large rodent population in this particular orchard to begin with and we did not see any increase in rodent damage.

Willett: I have heard that there may be an optimum width for herbicide strips to provide maximum radiation retention. Have you read anything about this?

Ogg: I haven't seen anything in terms of published information. However, I have corresponded with a few people on this. The general consensus was that if the grass-free strip is six to ten feet wide, there is not that much of a reduction in heat retention.

Lombard: I would like to comment on Mike Willett's question. I've looked at temperatures on sodded plots at the experiment station in Medford. We didn't see any lowering of night temperatures where we had a bare strip equal in size to the sod strip, particularly when the sod was closely mowed.

Bell: In your slides it looked as though you didn't mow the grass, did you?

Ogg: They had not been mowed at the time we took most of the pictures. We did mow about four times. The reason we mowed was because annual weedy grasses grew in the seedings and caused severe competition. The only thing we did do to them was to mow, and for awhile I had very serious doubts as to whether we would be able to establish the desired grasses. The comments that Tom made earlier about rapid germination and rapid establishment of ryegrass were correct. Yet, it looked like a very weak seeding compared to green foxtail. But it competed very well and by the end of the year it had gained control.

Jordan: Some years ago there was a freeze in Texas and the amount of damage to the citrus trees was in proportion to the height and amount of vegetation around the trees. The higher the vegetation was in the

orchard, the greater the freeze. They were getting a 6° difference in temperatures within their orchards. We commonly come up with a 2° to 4° difference with low-growing vegetation, but as it gets taller the temperature difference becomes greater.

Ogg: We have done some measurements in the orchard, but do not have a good system yet. We measured temperatures in areas less than an acre and perhaps we should use larger-sized plots. By just measuring the difference in temperature from the orchard floor to a height of four meters, we observed a 15° temperature difference. There is a lot of temperature stratification in there and a lot of opportunity for variability.

Fox: Was this with or without grass coverage?

Ogg: That particular measurement was without grass coverage. Another point I want to make, relates to fertility in the grasses. When we fertilized in the winter, the red fescues and the ryegrasses grew better; they were dark green and lush during that time when frost could have been a problem. When we didn't fertilize the grass was yellow or brown. The management of fertilizer could help in regulating the amount of growth you have during the critical frost period.

William: How did the 'Elka' perennial ryegrass affect the bindweed? Did it also suppress it about as much as the 'Derby'?

Ogg: Yes, both ryegrasses essentially competed very vigorously with the bindweed. Whether this will continue to persist for several years, is a question that we can not answer.

Miller: Did you gather any data on aphid densities?

Ogg: That was the entomologist's part of the project. We identified the weed species on which the aphids were found. Dandelions had the highest percentage of aphids carrying leaf roll virus, but field bindweed and common lambsquarters had the highest numbers of aphids.

Miller: Why should the peach grower plant grasses to reduce aphid numbers for the potato grower?

Ogg: Good question. That has been one of the problems of selling the program. If we can't show benefits to the peach grower, he isn't going to be very sympathetic about spending a lot of money on cover crops to save the potato growers. I think that the benefits, in addition to the suppression of the green peach aphid, will be in improved orchard travel

during the wet spring months. We know that we get improved water infiltration and reduced erosion with a cover crop.

Miller: Has George Tamaki noticed any changes in other arthropod populations? Like mites or some of the worms?

Ogg: He hasn't made any comments to me about them. One of the interesting observations that we made was with bees. When there were dandelions in the orchard, about half of the bees which should have been pollinating the trees, were working the dandelions. If we eliminate dandelions, then we are not drawing the bees down to them.

Lombard: The same thing holds true with mustards. We see quite a difference in cultivated orchards as compared to sodded orchards. The weeds attract the bees.

Willett: I think it is really important to talk to growers about switching management techniques. Could you outline some of those management techniques? You mentioned fertilizer management and weed control, but are there some other ones that you think would be important?

Ogg: We suggest to the growers that they apply an extra 50 pounds of nitrogen per acre for the sod cover crop. They need to allow that, otherwise they are going to get reduced tree growth. The timing of the fertilizer application is very important. We don't like to see our growers applying fertilizer after the first of June; they get too much vegetative growth and a lack of winter hardiness in the trees. In some cases we have to allow for some extra irrigation for the grasses, but that depends on the soil type.

Anon.: You say to apply 50 extra pounds of nitrogen, how much nitrogen would your base be?

Ogg: I was afraid that you were going to ask me that. I think we are talking about 100 to 120 pounds of N per acre, but don't quote me on that.

Raese: What about seeding 'Elka' ryegrass after the orchard trees are three or four years old to control the bindweed? Also, would 'Elka' ryegrass be shade tolerant?

Ogg: That is one point that I forgot to mention. We are dealing with fairly young orchards, three to four years old, so there is a lot of open area and a lot of sunlight. As the trees get older and they fill in, we may find that the ryegrasses may not work up as well. The fescues we have

used in older orchards are standing up well. We do not have a good comparison on ryegrass yet. We have to be careful so that we do not interfere with tree growth, especially with the ryegrasses.

Tingey: In orchards and in vineyards there is some question whether or not compaction is the cause of reduction in growth and production. I am wondering if there are any studies that indicate that a grass cover might alleviate some of the compaction that takes place. What about root growth and water infiltration with the sods?

Ogg: We haven't specifically looked at that, but other researchers have and they have found great differences in the amount of soil compaction. Much less compaction was evident where they had the cover crop planted. They found significant increases in water infiltration too. Their study was all under surface irrigation. They were working in established orchards, but I don't recall whether they measured yield response with those trees or not.

Raese: In your slides, I noticed that the 'Elka' ryegrass appeared to be a much darker green than the 'Ensylva'. Is this typical?

Ogg: In the spring it was a very dark green. Although it is a short growing sod, it does respond to nitrogen; in fact, all the ryegrasses respond very rapidly to nitrogen. That may be an indication that they are good scavengers for nitrogen. When we want to get nitrogen out of the soil in the latter part of the season, the ryegrasses acting as scavangers would be beneficial. That should be part of a management study.

Weber: Last weekend a vineyard owner reported to me that his vineyard is half clean cultivation and half green cover crop. The temperature difference was from 5° to 6°.

Ogg: That is a major concern of mine.

William: What percent cover did he have in the vineyard, to give us some idea of the actual cover he has in relation to the strips?

Weber: As near as he could tell, about 65%.

Anon.: You mentioned needing an extra 50 pounds of nitrogen, would there be any legumes that could be satisfactory to use with grasses such as trefoil or white clover?

Ogg: There is a possibility that white clover would work. You would have to manage that nitrogen balance pretty carefully though or you might shift it to favor one or the other.

Miller: You just traded off your objective of controlling green peach aphids when you mentioned clover.

Jordon: If you add nitrogen you give the grass the advantage. Quite often we find that with legumes, they don't produce enough nitrogen for themselves along with the grass and the trees. We have to add nitrogen and as soon as we start doing that we shift to grasses.

Ogg: That is typical with any pasture management. In a mixed pasture it is very easy to shift one way or another depending on the nitrogen management.

Lombard: I would like to comment about the shade tolerance of some of these grasses we are concerned with. If you run your rows east and west you will get a lot more sunlight on the row middles. In north and south rows, they are going to be shaded most of the day.

Ogg: I am sure that would have a definite effect on the grass.

deCalesta: With field mice you will find that there is less of their damage in orchards that have turf, if that turf is mowed quite close, particularly around the trees themselves. Anytime you get a lot of vegetation, grasses or weeds, growing up around the base of the trees, then you get field mice damage. If you can keep the vegetation down, you can keep mouse problems down also.

Ogg: Is there an optimum distance to keep the grass away from the tree trunk?

deCalesta: I haven't really seen any figures, but I have seen people try and protect conifers, like Christmas trees, by killing the vegetation in a one-meter radius around the tree. But still they had damage. I would say it would be greater than one meter, maybe two or three meters.

Sweet: According to Professor Richmond, your best control is to get a species of grass or legume that doesn't attract rodents in the first place. That is one way to keep the population down. A lot of the fescues will not support rodents the way ryegrasses will.

Topic 5

USE OF SODS IN ORCHARD MANAGEMENT

Gene Hogue

Agriculture Canada, Summerland, British Columbia

In the Okanagan Valley our soils are quite coarse and shallow. They have a low cation exchange capacity and are low in organic matter content. One of the problems that has been developing in the last 15 or 20 years is acidification of the soils. The native pH of the soils in the Okanagan Valley was around 7.5 to 8.0, but now we are finding orchards that have a pH of around 4.0. We have even seen some soils with a pH less than 4.0. This acidification seems to have developed very recently and it seems to have coincided with the widespread installation of solid set irrigation systems. When we shifted over from rill to solid set irrigation, there was quite an increase in the amount of water applied to these soils. Since they were low cation exchange soils, this accelerated leaching. The acidification seems to coincide with the use of herbicides, the herbicide strip and a system of grassed-alleys.

In our trial we wanted to see what the relationship might be between a sod covered orchard floor and various other management techniques. The other concern that we had were cold winters, as there have been reports of a relationship between clean cultivation and injury to trunks or roots of trees. We wanted to see just how great the soil temperature differences were under the various management systems. We set up a system to monitor soil temperatures as well as a system to monitor the mobility of cations.

One of our treatments was a grass cover, another treatment involved keeping the soil bare year-round with nonresidual chemicals like paraquat and glyphosate. A third treatment involved frequent tillage to keep most of the vegetation controlled (about three to four very shallow tillings per season). The fourth treatment was the one that simulated the practice that we now have in the Okanagan Valley of B.C. -- a herbicide strip is maintained in the tree row during the spring and the weeds are allowed to grow elsewhere till the end of the season. We applied paraquat twice. This controlled weeds until

mid to late July. The final treatment we put in a year later because we couldn't find the material; it was a woven black plastic mulch. There has been considerable interest in this last treatment because our soil is very coarse and in new plantings the residual herbicides have been causing some toxicity problems. The growers have been looking for something that they might be able to use in the first few years of establishment. We found a very strong plastic that is used as a mulch by citrus growers in Florida. It is woven so that irrigation water can penetrate through the plastic.

One of our main interests in this study was to look at the mobility of nitrogen and the cations in the soil. For this purpose we installed suction lysimeters and after each irrigation we took a water sample at a 20 cm depth and a 1 meter depth. Some of the first year results are summarized in Table 1. We also installed microloggers that recorded temperatures at depths of 20 cm and 1 meter. We consider those depths to coincide with the top and bottom of the root system of the trees. We were particularly interested in the pH changes. We looked at changes in organic matter and soil density. Growth of the trees, yield, fruit quality and other factors were also observed.

Table 1.

Cation content of soil water at two depths under two surface management systems.

cation	depth	cation	
		grass sod	clean surface
	(cm)	(ppm)	
CA	20	39.6	36.1
	100	43.2	48.8
Mg	20	7.8	7.7
	100	5.1	8.2
K	20	5.2	4.8
	100	2.6	3.6

Under grass at the 100 cm depth, we were obtaining a little more calcium than at the 20 cm depth. More calcium was found at the 100 cm depth under

the clean surface than with the sod-covered treatments. This was true for other cations as well. Magnesium mobility increased when the sod cover was removed.

To automate temperature measurements, a CR 21 micrologger (Campbell Scientific) was installed. It took temperatures three times per minute, integrated them, and gave us a daily low, a daily high and a daily average under the plots on a year-round basis (Fig. 1). With the clean soil surface the temperature fluctuationed the most during the warmest month of the year. At one time there was as much as a 4°C difference in the soil temperatures at 20 cm between the clean and grassed plots. In the winter, during the coldest month, we found that the soil temperature under the mulch was the warmest, probably not significantly different, but certainly the temperatures under the clean surface were colder.

DISCUSSION

Sweet: On your temperatures, particularly in the winter time, was that an average of the two depths?

Hogue: No, that was at 20 cm. At 100 cm the differences are not quite as pronounced.

Davenport: How long does the woven black plastic last?

Hogue: We hope that it will last for three years. It has been on the plots for one year now and there is no indication of it disintegrating yet. The manufacturers believe that it can probably last for three years. If it does we think that perhaps it can be economical, at least for a strip, but probably not for a ten-foot width like we had on our plots.

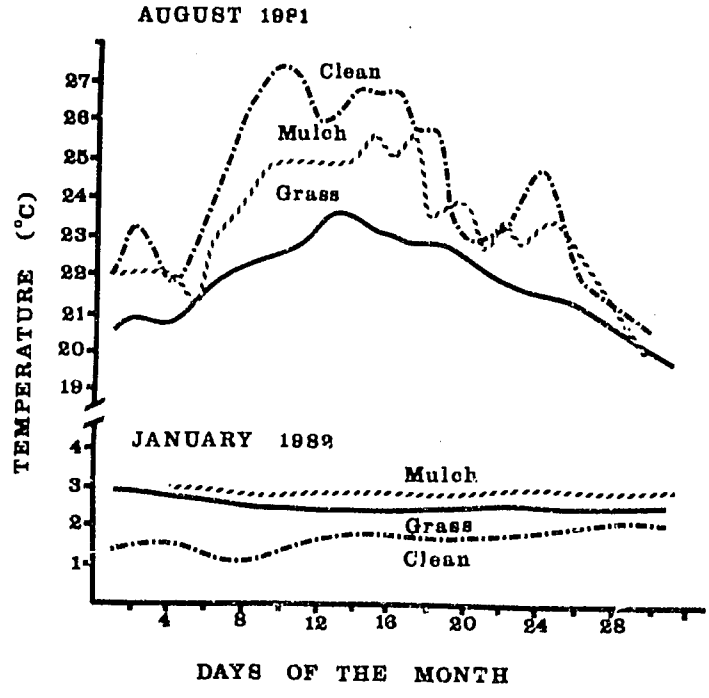
Lagerstedt: The cation data that you showed, was this for the first year?

Hogue: Yes it was. We are presently analyzing the data for the second year. It confirms some other work that Dr. Stevenson, our station irrigation specialist, has been generating. He had another lysimeter study where he showed that the calcium in the soil under the clean cultivation moved through the profile and out into the drainage waters. This occurred much more readily under clean cultivated soil than under a sod cover. It looks like the leaching of the soil calcium may be a part of the problem in the acidification of our coarse soils.

Vomocil: What kind of fertilizer program are you using?

Figure 1.

Soil Temperature Comparisons.



Sampling depth: 20 cm

Clean soil: no cover

Mulch: woven black plastic

Grass: sod

Hogue: Strictly nitrogen. The recommendations we are using vary from 50 to 100 kilograms per hectare, depending on the vigor, age and variety of the trees. In this case we were using 80 kilograms per hectare per year.

Anon.: Has this nitrogen utilization been going on enough to possibly be involved in the acidification that you are noticing?

Hogue: Yes, and presently growers are using ammonium nitrate, but they are shifting over to urea as their source of nitrogen. The main source of N use to be ammonium sulphate and that of course was more acidifying than either one of these two new sources of nitrogen.

Ogg: Have you made any attempt to monitor the nitrogen levels in the leaves of the trees to see if it has been translocated?

Hogue: Yes, we are looking at the total picture including the nitrogen and all the cations in the leaves. We are also looking at the turnover of cations in the cover crops. We think that there is a recycling of cations with the sod which would prevent or slow down their movement through the profile. So far, in the foliage of trees from various plots, there seems to be an indication that those trees under clean cultivation, as you might suspect, are higher in leaf nitrogen than the ones that are in the grass sod plots.

Sweet: I would like to make a comment on this matter of the sod preventing nitrogen loss. On Long Island we had two problems, one was nitrogen getting into the water table and the other was Temik in the water supply. Both of those are fairly serious problems. One of the worst sources of nitrogen pollution we found was from well-managed turf. When turf starts out it will absorb a lot of nitrogen, but after that it doesn't, though they keep pouring it on at high rates to keep it green all the time.

Topic 6

COVER VEGETATION IN FILBERTS AND CHRISTMAS TREES

Harry Lagerstedt

Oregon State University, Corvallis, OR

Each of us have a different approach to the idea of living mulches. I would like to echo a comment made earlier, that much of our thinking is geared to our specific crop. We have certain restraints which allow us to do some things, but not others with living mulches. If you switch to apples or pears you can do a number of practices that you can't do in filberts.

Filbert growers in Oregon have been using the living mulch idea, but it has evolved into a system called non-tillage orchard management. Non-tillage orchard management means two things: chemical weed control in the tree row and mechanical weed control in the aisle. Oregon growers have used this system for about 14 years. The filbert growers went down to California where they saw this system being used in almonds and walnuts. They brought the idea back with them. It became tremendously popular and within two years all the major filbert growers were practicing non-tillage. Today, 14 years later, I would say that 98% of our growers are using non-tillage orchard management. The beauty of non-tillage orchard management is that it leaves the orchard in harvest-ready condition 365 days a year. The native vegetation ultimately shifts to broadleaved, deep-rooted perennial plants, which seem to prevent a great deal of soil compaction. The aisle vegetation provides for good percolation of moisture through the soil. We usually do not have any problem with puddling or compaction. The aisle vegetation also provides a firm, stable surface for all orchard vehicle traffic.

In filberts we harvest the nuts from the orchard floor. The aisle vegetation is managed by a flail mower and not by a rotary mower. So, when I look at living mulch, I only want half of that mulch, the lower half -- the root system. When you say living mulch to me, you are indicating a large number of little green pumps that are depleting the soil moisture. I want to

eliminate them and that is what the flail does; it moves along very close to the orchard floor, right at the crown level of most plants. We go through the orchard four to six times a year with the flail to beat off that green competition. We must have a type of vegetation that is extremely tolerant to such a practice. Native vegetation or anything that will exist under those conditions, is what we allow to be there.

When young filbert orchards are being established, tillage is used for weed control for the first three years. A few growers have started orchards directly under non-tillage management, but that is not the usual practice. In either case the objective is to eliminate vegetation in the tree row, because we know that it represents competition for moisture, and filbert orchards are not irrigated. In the first few years we use a dead mulch, if you will, of sawdust. We find that we can get as much growth on a young tree with a sawdust mulch as we can with irrigation in the first year. Another limitation on orchard establishment, is that there is only one herbicide registered for first-year plantings and that is Devrinol. From the second year on we can use simazine; it is the herbicide most commonly used in the tree row. For post-emergence we have both paraquat and Roundup. In a tilled orchard we normally have a crop of annual bluegrass each year. This annual bluegrass is easily controlled with simazine. When simazine is continually applied in the tree row, we find that there are a few weeds which become resistant to this herbicide. One of these resistant species is a plant that you would normally recognize only as a very small, prostrate growing weed -- filaree. Without competition from other weeds it can become extremely vigorous and sometimes climb right up the tree! We have the same kind of problem with knotweed, miner's lettuce and morningglory. They make it through the simazine treatment and when you remove all of the competition, they become extremely vigorous.

I understand that many people in the audience are interested in what happens to the soil organisms following herbicide applications. We find that we continue to get earthworm castings in the first, second and third year after we go into non-tillage orchard management. Because earthworms live in organic matter, the only place you find them is in the living mulch in the aisles. It appears that simazine per se doesn't hurt the earthworms. But

since they will only live where there is organic matter in the soil, once the organic matter is depleted, they're gone.

Many of our growers interplant a cash crop in the young filbert orchards to obtain some return from the aisle space. Intercropping can be successful with good management that does not permit the intercrop to compete with the young trees. Winter wheat is commonly intercropped during the first and sometimes the second year, when the young orchard is getting established. This really represents another type of vegetation management.

We can harvest filbert nuts from a grass ground cover much easier than from a broadleaf ground cover. The tines of the sweeper will go through the grass very easily and pick the nuts out, but they get tangled in any kind of a cross weave or broadleaf plant. Clovers and subclovers are very difficult to harvest from.

We did run a test with different kinds of subclovers for aisle vegetation. We have essentially only one subclover here in the Northwest. It is called 'Mount Barker' and it was designed for forage. It gets about two feet tall. In Australia they have developed a whole series of very low growing, early maturing subclovers with unusual names like: 'Dinninup', 'Yarloop', 'Geraldton' and 'Dwalganup'. These subclovers are very interesting because they mature and go to seed in June. The seed is such that it stabs itself down into the ground and germinates in the Fall. Of course, they are legumes and they will nodulate and provide some nitrogen. Since we don't irrigate filberts, we thought that they would be ideal for our particular type of system. They matured early, were gone by summer and would come back in the fall. We were doing fine until the 1972 freeze hit us and essentially wiped out our stand of young seedlings. That was the time when we had 12° below zero here. I found that these subclovers were wearing out under our conditions, gradually the native vegetation was coming back in. I did not pursue it any further, but maybe the subclovers may fit someone else's situation.

In using the flail mower the idea is not to rototill the soil, nor to leave the cover very high. The flail should be set so that you are working right at the soil level or as close to it as you can. There is another important piece of equipment used by filbert growers called an orchard

leveler. It has a series of blades that cut off high spots and deposit the soil in low spots when its drawn through the orchard. It's used prior to harvest. This also tends to scalp the weeds off right at the crown level. It is very important to get that orchard as flat and smooth as possible for harvest. When orchards were cultivated the soil remained soft. If a deer went through the orchard each hoof print left a depression that could contain four nuts. The sweeper would run right over those depressions and not pick the nuts up. This is why non-tillage orchard management is so desirable; it provides a firm surface from which we can harvest. The first filbert nuts drop around the first of September, so you have to do everything you are going to do in the orchard prior to that time. During the last week of August the flail goes through for the last time and the vegetation is cut right down to the ground so that by the 15th of October, when they harvest, there will not be much vegetation.

In an effort to aid the grower, we have experimented with one pound of Embark prior to the last flailing. Embark suppressed the vegetation, broadleaf as well as grass, very well, but it is not registered for use in filbert orchards. When Embark was used in place of flailing, during the growing season, it would only take the place of one flailing. That didn't make any sense economically because you had to go through the orchard to apply the Embark and on top of that you had to add the cost of the product. Late in the growing season, in September, the temperatures have cooled down a little bit and the vigor of the plants is less. Embark was a little more useful then, because we didn't get that rapid regrowth when the first rains came. In the mature filbert orchard we are not at all concerned with living mulches, because the full canopy completely shades the orchard floor and eliminates vegetation.

While filberts are my vocation, my advocation is Christmas trees. What I have done is simply to take non-tillage orchard management from filberts and try it in Christmas trees, with a few minor modifications.

The bane of the Christmas tree grower is grass. Often Christmas trees are planted in old pastures and it takes many years for the little Christmas tree seedling to get up above that grass. The majority of Christmas tree growers find that it is very inexpensive and efficient to fly over their plantations to apply either atrazine or Velpar to get total vegetation management.

My personal Christmas tree farm happens to be on hilly ground. For the first few years I had very little in the way of equipment, so I had to fly on herbicides and I was getting quite a bit of erosion. I could not contend with having all my soil run down to the neighbor's.

Normally, Christmas trees are spaced either 5 or 5½ feet apart, but I chose a little wider spacing -- six feet -- so that I could use a small tractor in between the rows. The first year I clean cultivated with a spring-tooth harrow and constructed a small two-nozzle boom to spray simazine in the tree row. In the fall I planted grass, which is unheard of in Christmas tree plantings. I talked with many agronomists and got their advice, and after hearing Tom's talk this afternoon, apparently I wasn't ill advised. My choice happened to be a tall fescue, which is second on the preferred list. I chose 'Fawn' fescue; it was developed here at Oregon State. It is a grass that maintains a high vigor and is very green throughout most of the season. The one thing that I did find very difficult as a weekend farmer was getting out and mowing early enough. Frequent spring rains keep things pretty wet and sometimes it is late April before you have a good day to mow. Preferably, one should have two or three dry days before mowing. The longer one is delayed, the taller the grass gets. The main mowing time is usually during April and May. After June the grass tends to go dormant due to the lack of moisture and mowing becomes a lot easier. I found seeding a two-foot wide strip with a regular lawn fertilizer applicator worked beautifully. The grass stablized the soil. I am extremely happy with this system even if it does have a negative side. I do have rodent problems, which are very difficult for me to control as a weekend farmer. The meadow vole invades the grassy aisles and gophers are also present. Their burrows on hillsides create serious erosion channels.

When one wants to completely remove the vegetation in the aisle or slow it down, a rope-wick applicator and Roundup do a nice job. It does not necessarily kill tall fescue, but it makes it sick enough so that it does not compete quite so well. Some Christmas tree growers do plant grass or let the weeds grow in the seventh and eighth year in order to slow down the growth of the tree to finish it off. But they have a difficult time of maintaining that cover and keeping it in bounds. They must keep it from becoming too

strong a competitor, because they have no mechanical way of getting inbetween mature trees which are closely-spaced within the row.

This is only a very brief introduction to non-tillage Christmas tree management, but I think that you can see that the same basic system of management can be used in both filbert orchards and Christmas tree plantations.

DISCUSSION

Jordan: I was in Australia and the problem with the subclovers wearing out is evident. That is one of the reasons that they are getting away from using them. "Wearing out" means that they are being displaced by the grasses or deep-rooted perennial weeds. They are not wearing out physically, they just don't compete very well.

Brown: During the winter of 1972 the cold weather came with a snow cover; how did that knock out your subclover?

Lagerstedt: The snow cover was thin, so it didn't really act like a big insulating blanket. We found that on the trees themselves the greatest injury and the coldest temperature was right at the surface of the snow. There was radiation from the soil as well.

Brown: Was it the cold temperature that killed the subclover?

Lagerstedt: Well, only fools are positive, but I am reasonably certain that in this case it was low temperature. All of our different varieties of subclover went out that year.

Bell: Do subclovers attract or repel rodents?

Sweet: I don't know anything about subclovers, but crownvetch is a legume that does not support small rodents in the northeast.

Tingey: Harry, how long have you had your Christmas trees in? Were you able to detect any reduction in growth with your cover crop, in contrast to growers who do not use one? We are having difficulty getting any Christmas tree grower to use a cover crop. There has to be some good reason for them to resist this, especially when the erosion problem is so clearly evident.

Lagerstedt: The reason they don't use it is a matter of convenience. When you use a cover crop you have to get in there and maintain it. You have to mow it and then you also have to design special equipment to spray

out your tree rows. I don't think they want to do this. Generally, it is a lot cheaper to go and fly on herbicides. That is the easy way and it's the way they are going to take.

Sweet: Have you seen any reduction in growth rate?

Lagerstedt: I think I am getting some injury from the meadow vole, but since I don't have any clean cultivated control rows, I can't really answer your question. I am getting my trees off the land in approximately the same amount of time as the other growers. So essentially, there is not a great reduction.

William: There is a grower up in the Skagit River Valley who planted creeping red fescue in the field before planting his Christmas trees. He stripped out the tree rows and planted Douglas-fir. He maintains the tree row with herbicides and mows the rest of the creeping red fescue. In the last couple of years they had bad floods in the Skagit River Valley. He had debris up into the trees at about waist height. He says that if it wasn't for the creeping red fescue, he would have lost much of his plantation to flood erosion. The fellow has a small tractor that is equipped with skirts, he can come in and mow without damaging the trees. It is a very nice system.

Brown: A Marion County grower maintains a subclover in his Christmas tree plantation. He mows it and it works beautifully. He produces exceptionally high quality Noble fir Christmas trees. One disadvantage is that the grass does come into the subclover. He hasn't tried to use Kerb yet to kill the grasses. Another disadvantage is that the gophers just drive him up the wall. He fights them constantly. Those are two disadvantages, but other than that it is a beautiful situation.

William: When one mows a field one ends up with a lot of prostrate broadleaf weeds, particularly false dandelion, common dandelion and prostrate knotweed.

Green: How often does the grower mow his field?

Brown: Not very often, he tends to let it get up pretty high before he mows it. It may be mowed three times during the season. I think it would do better if it were mowed more often.

Lagerstedt: As long as we have this wet weather in April, May and early June the grass will continue to grow, and in my case, the tall fescue is very vigorous. I will mow three times during the spring, then only one more

mowing will usually take care of the balance of the season. I may have to mow one more time again in October or early November following the early fall rains, which cause some growth prior to dormancy.

Green: How many hours per acre does it take to do that kind of mowing?

Lagerstedt: It probably takes me an hour or 1¼ hours per acre.

Burrill: I wonder if there isn't some potential here for the weed wiper, or a version of that, to manage this vegetation in place of mowing. Just with the natural selection process, we might shift our population over to lower growing vegetation and thus reduce the need for mowing.

Lagerstedt: 'Elka' ryegrass, that was shown here yesterday, was very interesting to me. That is a perennial ryegrass that is short growing. The way that it filled in, it looked just like a natural cover.

Rackham: I was wondering why more of the shorter grasses, like the perennial ryegrass 'Manhattan' or the chewings and red fescue, are not used. They tend to go dormant in the summer when you don't want the competition and you don't have such a mowing problem as with the tall fescue.

Lagerstedt: If you have something that goes dormant during the summer, be it subclover or grass, you will find that your deep-rooted perennials will move in. This is the nice thing that I find with the tall fescue; it is a very vigorous cover. It stays green all summer long and it stays in place -- it is a bunch grass. It doesn't spread too rapidly. My aisle vegetation is not changing drastically. Where I have weed problems is in the tree row, but the aisle vegetation is being maintained with tall fescue.

Jordan: I found a grower Larry, who uses a weed wiper in his Christmas tree plantation. He can do a lot of weeding with it as long as he doesn't touch the tree. If he touches the tree, he kills that particular branch. He swears by it.

Sweet: Has there been any work in Christmas trees with the newer family of selective grass materials?

Lagerstedt: We have used them a lot in vegetables. There is always an exception, but with most of these grass killers, the broadleaf crops are not hurt. We can use them over 20 or 25 vegetables and not injure the vegetables. We can go all the way from light control down to kill, just by varying the dosage. I think that if we really work at choosing

species and then use some of the newer selectives, we could really lick a lot of our problems.

Brown: This is one thing that I have been wanting to try, but haven't had a chance to. In many of our orchard crops we can use 2,4-D and we know that we can use it safely early in the spring when a lot of the broadleaf weeds are present. For many crops we have Kerb, which is a very good grass killer, but it won't knock out subclover. With these tools available, why doesn't someone knock out those broadleaf weeds in the orchard with 2,4-D?

Lagerstedt: In the case of orchard crops, 2,4-D is not registered for many of them. There is just a little bit of interest coming back at the present time, to get them registered. Some companies have not been willing to take the risk. In about 1972 or 1973, 2,4-D was registered for apples and pears, but the labels were rescinded by certain companies due to damage suits that were filed by growers.

William: We still have apples and pears registered on three 2,4-D product labels.

Jordan: Sometimes 2,4-D will cause damage to the base of the tree. Some trees are sensitive to 2,4-D, that is why you are finding the registration lifted.

Lagerstedt: I think a lot of the stone fruits are quite sensitive.

Fox: I wonder if anyone here has had experience with crown vetch as a cover crop in the Northwest or in California. I tested it several years ago and I didn't think it was all that great.

Sweet: Do you know what the problems were that you had?

Fox: It was very wet at some of the sites and I don't believe that crown vetch can withstand the excess moisture. I think you need better drainage than what we had. Certain clovers and birdsfoot trefoil can stand wetter sites.

Sweet: There has been an interest in establishing crown vetch on our heavy clay loam sites. It is a little slow to establish, but it can be done. Heavy soils in themselves are not bad.

Hogue: We managed to establish a pretty good stand of white dutch clover in an orchard last year by using Kerb and a specific brand of 2,4-D on dandelions. Our soil is very coarse and if you spray 2,4-D you will get tree damage almost certainly. Dandelions were the only weeds that came

in. We had as other treatments, grass plots and clean cultivation. The experiment had to be discontinued because we used Glean to establish the grass stand and Glean caused a lot of damage to our trees. So, Glean looks like it is very mobile in the soil and it is very toxic to the trees.

Green: Are you finding 2,4-D damage occurring through the soil, directly to the roots?

Hogue: In that particular area we had the trial on a fairly coarse soil and the 2,4-D was sprayed on the soil. We irrigated following the application. In our area, we have to irrigate. Usually injuries show up in June with the new growth. The 2,4-D leaches down into the root zone and injuries show up in the new growth later in the season.

William: Dave McAuliffe is a graduate student working with Arnold Appleby and he is our source of information on annual bluegrass availability. Arnold, do you have any information on that?

Appleby: Yes, a source of seed was found at a grass seed company south of Corvallis. Apparently it can be bought in large quantities and has 98% purity.

William: Arnold, your people have said that annual bluegrass is very competitive in wheat. Would you elaborate on that?

Appleby: We simply don't know why, but this little shallow-rooted plant, that is not much more than a few inches tall, can easily cause a 20 or 30 bushel reduction per acre in wheat yields. If you look at moisture and light, they don't seem to be the answer as far as competition is concerned. Possibly it may be taking up the sprayed fertilizer. But we were wondering whether it might be allelopathy.

William: When you look at that little plant, it looks very noncompetitive and it doesn't seem like it would interfere with the crop. Perhaps we need to be more careful with our horticulture crops. We simply cannot assume that a problem will or will not exist just because of size.

Lagerstedt: Annual bluegrass germinates quite well under cool temperatures. Were you getting any competition in the fall with the wheat?

Appleby: I don't know when the competition occurs, Harry, but the annual bluegrass does come in the fall and by spring it is uncontrollable. As the season progresses into the summer, it is obvious that the wheat

isn't doing nearly as well. But there are not a lot of visible differences in the winter as far as the wheat is concerned.

Jordan: Even though annual bluegrass isn't as well adapted to our area (California), it has the same effect on wheat down there.

Topic 7

THE POTENTIAL VALUE OF LIVING MULCHES IN YOUNG FRUIT TREE ORCHARDS

J. Thomas Raese

U.S.D.A. Wenatchee, WA

I would like to discuss how we can influence fruit tree performance in orchards by managing the weeds or cover crops in tree rows. The question that I would like to pose to this group is this -- how might we better manage our cover crops, whether they be grasses or legumes, to obtain quality fruit and control of the tree growth?

Is it feasible to have cover crops in the tree rows? In one experiment we had, one row of pear trees were treated with no supplemental nitrogen fertilizer and no herbicides for weed control. It had about 100% weed cover, primarily dandelions. The other row of pear trees had the weeds controlled with a combination of the two herbicides, amitrole and simazine. Amitrole is no longer registered for use in bearing tree orchards, but at the time we did get excellent weed control with it. Quite an increase in tree growth, along with good leaf color was attained with that particular treatment of herbicides and no supplemental nitrogen. When only simazine was applied in the spring, we saw no control of dandelions, but there was some effect on tree vigor. Tables 1 through 4 illustrate the five different herbicide treatments used and their interaction with the three levels of supplemental nitrogen applied in the spring. The nitrogen was ammonium nitrate applied at the rates of 0, 227, and 454 grams of actual nitrogen per tree.

The first two herbicide treatments, no herbicide and simazine alone, had practically no weed control (Table 1). The paraquat and the amitrole plus simazine treatments, both with no supplemental nitrogen, were nearly equal in their weed controlling abilities. The paraquat plus simazine treatment was an acceptable level of weed control. Weed control became less effective as we increased the application of supplemental nitrogen. In late August we collected data on the percentage of leaf nitrogen (Table 2). All of the

results presented were from 1973, which was the second year for this experiment. The treatment of no nitrogen and no weed control was very detrimental to the trees. Even though not much weed control was achieved with simazine alone, a significant amount of leaf nitrogen was observed with that treatment. There were significantly higher levels of leaf nitrogen in leaves taken from trees treated with amitrole plus simazine, as compared to the paraquat only treatment, yet the weed control was similar in those two treatments.

Table 1.

Effect of herbicides and supplemental N on weed control in a 'd'Anjou' pear orchard, rated Sept. 26, 1973.

	supplemental N per tree			
herbicide	0g	227g	454g	mean
	('% bare ground)			
none	0.9a	0.6a	0.4a	0.6r
simazine	5.4a	3.3a	2.8a	3.8r
paraquat	70.5d	32.9b	21.3b	41.6s
amitrole + simazine	83.6d	78.4d	73.8d	78.6t
paraquat + simazine	56.3c	32.9d	23.6b	37.6s
mean	43.3n	29.6m	24.4m	

[z] Mean separation with herbicide x N, herbicides, and N levels by Duncan's multiple range test, 5% level.

Levels of leaf nitrogen from trees treated with amitrole plus simazine, with no supplemental nitrogen, were greater than any other leaf nitrogen levels taken (even when the treatments included 227 grams of supplemental nitrogen). The effect of herbicides and nitrogen on shoot growth is presented in Table 3. The results are similar to those seen with the leaf nitrogen. The amitrole plus simazine treated trees, without nitrogen, had as much shoot growth as trees treated with the other herbicides and 227 grams of nitrogen. Although supplemental nitrogen applications overcame the lack of weed control in the no herbicide plot, there was still an increase in the

efficiency of nitrogen utilization with the amitrole plus simazine treatment, even when there was no nitrogen added.

Table 2.

Effect of herbicides and supplemental N on leaf N of 'd'Anjou' pear leaves, 1973.

herbicide	supplemental N per tree 0g	227g	454g	mean
	(leaf N - % dry wt)			
none	1.14a	2.17c	2.45def	1.92r
simazine	1.79b	2.24cd	2.36cf	2.13s
paraquat	1.76b	2.25cde	2.42cf	2.14s
amitrole + simazine	2.52efg	2.57fg	2.75g	2.61u
paraquat + simazine	2.16c	2.36cf	2.54fg	2.35t
mean	1.87m	2.32n	2.50o	

[z] Mean separation within herbicide x N, herbicides, and N levels by Duncan's multiple range test, 5% level.

Table 3.

Effect of herbicides and supplemental N on shoot growth of 'd'Anjou' pear trees, 1973.

herbicide	supplemental N per tree 0g	227g	454g	mean
	(growth in cm)			
none	12.7a	46.6cd	51.9de	39.5r
simazine	24.3ab	51.5de	52.7de	42.8rs
paraquat	34.4bc	52.9de	52.3de	46.5rs
amitrole + simazine	57.0de	59.8de	65.0e	60.6t
paraquat + simazine	32.4bc	53.3de	61.9de	49.2s
mean	32.1m	52.8n	58.2n	

[z] Mean separation within herbicide x N, herbicides, and N levels by Duncan's multiple range test, 5% level.

The yield data in Table 4 exhibits different trends. Since the trees were only 6 years old, some juvenile related problems might be evident. Pear trees are just beginning to come into production at 6 to 8 years of age. Even when there was severe weed competition, fruit set increased in the no herbicide plots as supplemental nitrogen was increased. Trees which didn't receive nitrogen and had no weed control appeared weak, yet trees treated with amitrole plus simazine, even though they were not given any nitrogen, were vigorous. Trees treated with paraquat alone and simazine alone showed intermediate vigor.

Table 4.

Effect of herbicides and supplemental N on yield (no. fruit/ tree) of 'd'Anjou' pear trees, 1973.

	supplemental N per tree			
herbicide	0g	227g	454g	mean
	(no. of fruit/tree)			
none	17a	102def	133f	84s
simazine	18a	117ef	121ef	85s
paraquat	75bcd	91cde	115ef	93s
amitrole + simazine	85cde	60bc	110def	85s
paraquat + simazine	48ab	60bc	55bc	54r
mean	49m	86n	107o	

[z] Mean separation within herbicide x N, herbicides, and N levels by Duncan's multiple range test, 5% level.

We also did some work on fruit quality and it was there that we noticed an interesting development with fruit density. We determined high density fruit to be those that sank in water, as opposed to low density fruit which floated. Fruit from trees treated with simazine were more apt to float and have a higher rate of scald than fruit from trees not treated with simazine (Table 5). In addition, fruits from the simazine treated trees which had no supplemental nitrogen, were more likely to retain their green skin color

longer, and have lower soluble solids. Knowing the influence that nitrogen, herbicides and weed control have on fruit tree performance, one must wonder if we can obtain a favorable performance with fruit trees using a living mulch in the orchard?

Table 5.

Fruit circumference, density, color, soluble solids, flavor, and scald ratings of 'Anjou' pears after seven months of storage as influenced by weed control, herbicides, and no supplemental nitrogen, 1973.

herbicide	weed control	fruit size	fruit density[x]	fruit color[y]	soluble solids	flavor rating[z]	scald
	%	(cm)	%	(1-4)	(%)	(1-6)	(%)
none	0.9	18.0	85.0	1.75	15.8	4.0	8.1
simazine	5.4	19.5	37.5	1.00	14.0	3.5	20.4
paraquat	70.5	20.7	50.0	1.31	14.5	2.5	3.0
amitrole + simazine	83.6	20.5	2.5	1.04	13.2	2.5	27.5
paraquat + simazine	56.3	20.7	22.5	1.15	13.9	2.8	9.4

[x] Fruit density = percent fruit that sank in the wash (H20) tank.

[y] Fruit color rating where 1 = green; 4 = yellow skin color.

[z] Fruit flavor rating where 1 = objectionable; 6 = excellent.

DISCUSSION

Brown: What do you attribute that simazine effect to?

Raese: I think it must be more than just weed control in this case. You may recall that there was some work done at Michigan State where certain triazine and triazole herbicides were associated with increased tree vigor and nitrogen uptake. This is the type of response that we believe we obtained in this particular orchard. I tried to repeat this effect in older orchards, of simazine, but to a more limited extent and without amitrole. There might have been more of a nitrogen reserve built up in these orchards, which may explain why I didn't get the same effect. Perhaps our initial results were unique because the land that the orchard was on had been in dryland wheat for a long time. The low

nitrogen levels obtained from that type of farming, along with the elevation and the lower temperatures, may have had something to do with it. In some earlier work, simazine increased the efficiency of nitrate utilization when low levels of nitrogen and low temperatures were evident.

Topic 8

MANAGEMENT OF COVER VEGETATION IN CITRUS ORCHARDS

Lowell Jordan

University of California, Riverside, CA

At one time I believed I knew a lot about growing orchards and what kind of weed coverage or vegetation was desirable there. I was asked to write a chapter to a minimum tillage monograph for the Weed Science Society of America. Our local library had information, but it was all on subtropical crops like citrus, avocados and a few others. I knew I had to go elsewhere for additional information. I went to the Midwestern states of Iowa, Illinois and other surrounding ones and spent three weeks in their libraries. What I found was that I didn't know very much about orchard management in cold climates. I had gotten very provincial. I thought that what applied in southern California would apply for the rest of the world, but it didn't. So many of the statements that we make about orchard management, as far as ground cover is concerned, are dependent upon the crop being grown. I wrote an article with Dr. Lamar Anderson from Utah for a regional project. In the article I made the statement that both cover crops and vegetation in orchards were undesirable, because they decreased the temperature, which could increase freeze damage during a local freeze. Anderson looked at that statement and he immediately challenged it. He said, "You know we need vegetation in the orchard at certain times to reduce the temperature so that we can get better fruit quality." Lower temperatures can either be a benefit or a deficit in an orchard, depending on what trees are growing and when the vegetation is there.

With regard to nitrogen in an orchard, we find that weeds compete with trees for nutrients and probably mostly for nitrogen. We would immediately say that that is a disadvantage. But is it always? The answer is no. In the production of some crops, such as grapefruit, it is desirable to have a relatively high nitrogen content early in the spring, but as the fruit develops during the summer, it is desirable to have low quantities of

nitrogen in the soil. Therefore, it is advantageous to have a scavenger plant for nitrogen in the field, like bermudagrass. It takes the nitrogen out of the soil at about the right time to produce the best quality of grapefruit. I am sure that this happens with other crops. Currently, I am conducting research to determine the best management techniques for ground vegetation in citrus orchards. About six years ago there was a drought in southern California which meant insufficient moisture for tree growth. I set up a series of trials with the idea of determining the effect of weeds and competitive vegetation on tree growth. I continued the trials for six years, trying to determine what kind of measurements could be readily made in orchards for determining the effect of competitive vegetation on tree growth, fruit yield and fruit quality.

The research was designed to determine the effects of various types of irrigation and vegetation management on citrus growth. The orchard (Valencia) was about eleven years old when the plots were established. Bermudagrass was planted to serve as a uniform turf in some plots, while about 30 different types of other grasses and broadleaf weeds were left to grow in other plots. Two types of irrigation systems were used, furrow and sprinkler. Weed control or vegetation management aspects were looked at using three treatments: 1) No weed control, except a fall and spring mowing to remove excessive growth; 2) Control of the annuals and the bermudagrass, to suppress about 50% of their growth, using five applications of paraquat on the annuals and seven applications of paraquat on the bermudagrass; and 3) Complete control of weeds with simazine as a soil residual and paraquat as needed.

Soil moisture was measured at three depths at different locations in the field, to determine the effect of weeds on soil moisture. Moisture levels were determined with a neutron moisture probe at 28, 46, and 92 cm. Moisture reduction near the soil surface was noticed with annual weeds under sprinkler irrigation, when there was no weed control. A slight reduction, but not significant, was noticed with partial weed control. Soil moisture differences were not as great at lower depths, but even at 92 cm there were differences. With the mowed treatment of bermudagrass under sprinkler irrigation, there was a similar pattern noticed -- a substantial reduction in moisture, particularly near the soil surface.

Tree physiology was studied by monitoring the leaf water potential, chlorophyll content, leaf nitrogen and the amount of photosynthesis occurring in the leaves. As expected, a tree without competition was healthier than one under heavy competition or interference from a bermudagrass sod. Physiologically, it occurs with predawn leaf water potential. The amount of water stress in the trees was dependent upon the amount of competition from either the annuals or bermudagrass. An increase in competition caused an increase in water stress in the trees. Chlorophyll content was lower with heavy competition from annuals, as was the photosynthetic efficiency of the leaves. There was a reduction in the leaf water potential (an increase in the water tension) in the trees competing with bermudagrass. A much lower leaf chlorophyll content was observed when bermudagrass was the cover vegetation. The leaf nitrogen content and photosynthetic efficiency also decreased with bermudagrass.

Tree growth was measured by the total volume of vegetation -- leaf area on each tree, trunk circumference, number of new shoots formed in the fall and the length of the new shoots. As expected, a tree with little or no competition was larger and had more area than a tree with heavy competition. The volume of those trees grown under sprinkler irrigation was greater when complete weed control was practiced. Tree trunk circumference increased as weed control increased. This increase was also seen in the leaf area, the number of new shoots that formed in the fall and the length of those shoots. The largest vegetation effect on the tree growth was from bermudagrass as a mowed sod. The bermudagrass cover substantially decreased tree volume, trunk circumference, leaf area, number of new shoots and length of the shoots that were formed.

Fruit yield and fruit quality were measured by determining fruit diameter, percentage of soluble solids and acids, and solid:acid ratio. Trees which were not under stress bore more fruit than trees which were under high stress from competition with either the annual weeds or bermudagrass. The effect of vegetation cover was readily apparent on the individual fruits from a tree. Fruit from trees growing with heavy bermudagrass cover were larger and sweeter. But there was about five times as much fruit on an unstressed tree, as on a tree stressed with bermudagrass.

Under furrow irrigation, as annual weed interference increased, there was a reduction in the amount of fruit per tree. Fruit size increased as ground cover increased. Changes in juice content, soluble solids and acids were also noticed with increased cover, but there was no change evident in the solid:acid ratio. Overall, there was greater interference and reduction in fruit yield with bermudagrass than with annual weeds. A substantial reduction in yield, from 67 to 15 kilograms per tree, was observed in plots with mowed bermudagrass. Also evident was a large change in fruit size and an increase in the percent of solids and acids.

The vegetation complex in the orchard was monitored. A shift in vegetation occurred -- plants that were susceptible to the herbicides were replaced by plants that were resistant to the herbicides. For example, there was a shift from annuals to perennials because only a few annuals could tolerate the simazine and periodic paraquat treatments. As paraquat treatments were used to subdue the annual vegetation, dallisgrass became established and at the end of the trials there were solid stands of it. The furrow irrigation plots saw a shift to johnsongrass. Glyphosate was used to prevent vegetation shifts that were undesirable.

DISCUSSION

Miller: Do you have any observations on red scale?

Jordan: There have been a number of observations on red scale in California and much disagreement on it and on how orchard vegetation will affect it. In some cases there are claims that vegetation helps control red scale, and in other cases there isn't any control.

Miller: The trees in your slides all looked very similar even though some were infested by red scale.

Jordan: There were a number of entomologists and nematologists studying the orchards. The entomologists didn't give us a report indicating an increase in red scale with vegetation like bermudagrass.

Burrill: Do you have foot rot in California?

Jordan: Not to the extent that they have it in other areas of the world. We want vegetation in orchards to prevent different types of diseases that are predominant in soils which are free of all vegetation. Apparently,

the foot rot is made worse if the soil is bare and splashes up on to the trunk of the trees. It is introduced more easily that way.

Bell: What is more desirable in the market place, the smaller fruit or the larger ones?

Jordan: Intermediate-sized fruit are preferred; the larger fruit are too big. The smaller fruit, in the last couple of years, have been too small. Another problem with the large fruit, is that there simply isn't enough of it, and besides, the consumer doesn't want too large a fruit either.

Bell: These fruits are for the market and not for juice?

Jordan: Yes, these are fresh market fruits. Florida provides most of the juice fruits.

Young: Do you find any problems with continued use of Roundup, or other chemicals on the trees?

Jordan: We haven't so far. I am rather cautious about that subject, because citrus trees grow with their lower leaves next to the ground. A number of the growers are going through the groves with broadcast sprayers, and they spray right across the bottom of the trees with Roundup. It looks hazardous to me, but they haven't had any trouble yet. Fortunately, most citrus and avocados that I work with are somewhat tolerant to Roundup. With our deciduous trees, we find that the symptoms which develop when a branch is sprayed, are quite often on the tip of the branch, and not throughout the tree. If we spray over the whole tree, then we start getting red discoloration on the margins of the leaves. If we treat the area too often, dieback on the tips of the branches occurs, which then results in multiple bud-break later.

Ogg: Atkinson and White had some interesting statements on having clean strips under the tree rows and how that effects the growth of tree roots, soil structure and compaction.

Jordan: During some of our trials, we trenched along the trees to determine where some of the roots were. We wanted to see if they were up near the surface or if they were down in the soil profile. We found that without cultivation, but with the use of herbicides, we had more roots up near the surface of the soil.

Ogg: In a recent paper, researchers found that with long-term use of herbicides in the tree rows, to maintain weed-free conditions, they were

getting increased soil compaction, even though there wasn't any vehicle travel. They also noticed a reduction in organic matter and were beginning to see, after many years, some undesirable trends developing with this type of culture.

Jordan: This matter of soil compaction and deterioration with continued use of herbicides, is a variable thing from soil to soil and from area to area. In our soils we can't maintain organic matter; all we can do is let the mulch build up on the surface until it is gone. In some soils that have a tendency to lt over, splashing water plugs up the pores with silt so that the soil surface becomes compacted. This is particularly hazardous in areas of Australia where they continue to use herbicides. The soil has become impervious at the surface. We have similar soils in California. They will plug up with repeated and continuous use of herbicides, but we also have other soils which do not. Sometimes herbicide use increases water penetration, because the plow soil is broken down and not rebuilt by tillage equipment.

Bell: Is it desirable to have roots near the soil surface in dry areas? I would think you'd want just the opposite.

Jordan: Some tree roots just naturally stay closer to the soil surface than others. Citrus is a surface feeding tree, other trees have roots deeper in the profile. We have to provide for some of our subtropical species, an area near the soil surface for the roots to occupy. As I understand, with some crops you don't need that surface area free, because the trees will penetrate deeper into the soil.

Bell: Does irrigation encourage tree roots to stay near the surface?

Jordan: Yes, irrigation does, but the innate nature of the tree has alot to do with it too. There is information in the literature concerning the competitive ability of different trees to deep-rooted legumes and shallow plants. There are some people that say deep-rooted legumes will compete more with the deep-rooted trees than shallow- or fibrous-rooted plants will. Those plants will compete more with shallow-rooted trees.

Young: Are there any cover crops available or being looked at, that have a spreading habit which would create a cover under the trees, without taking all of the moisture and nutrients?

Jordan: Yes. I have looked at plants like spotted spurge. It is not a practical cover crop, because I can't find enough seed. But when I

establish it in an orchard, it really does well. We can keep the area free from weeds by simply applying simazine. In sloping orchards there is a substantial decrease in erosion, because the spurge stabilizes the soil. Spurge causes no apparent competition with the trees, and, as far as insects are concerned, it is essentially sterile. We had few insects in the spurge as compared to other cover crops.

Topic 9

COVER CROP MANAGEMENT FOR WASHINGTON VINEYARDS

M. Ahmedullah

Washington State University, Prosser, WA

Growing winegrapes in Washington is a challenge because of the severe winters. Although winegrape production in New York and Washington may be similar, it is quite different from growing grapes in Oregon and California.

Two types of grapes are grown in Washington: Vitis labrusca, which are hardy and have been grown here for a very long time, and winegrapes, Vitis vinifera, which are comparatively new for Washington. There are eleven varieties of winegrapes and they all differ in their hardiness.

Both Concords and winegrapes are grown under all four systems of irrigation: furrow, overhead sprinkler, center pivot or circle, and drip. There are about 2,300 acres of winegrapes grown under the center pivot system. Cover crops can be grown under this system of irrigation. Cover crop management is related to the type of irrigation system present in a vineyard. It is obviously very difficult to establish cover crops with furrow irrigation.

Grapes are grown under clean cultivation, under permanent cover in some vineyards, or under an annual cover crop such as a combination of spring grain and vetch. The Concord grape processors recommend that the growers plant a cover crop in the later part of the growing season. Because the Concords are juice grapes, processors do not want any dirt on the grapes when they are harvested.

Growing winegrapes in Washington has a calculated risk. In order to minimize the risk, the grapes have to be grown with a cover crop. The cover crop stressed the vines in the later part of the growing season. This stress is for nitrogen as well as for water. Hopefully the cover crop will compete with the grapevines, starting in the middle of August. If you stress the grapevines, then you need to give a post-harvest irrigation. This is very

important. I will not present any experimental data today, but I have some observations and slides relating to this subject.

Dr. Walter Clore, my predecessor, did some work on cover crops, mostly with Concords. Many of the growers are following his recommendations. Spring cereals are planted in combination with vetch. The spring grains die because of the cold, but the vetch survives. Surviving plants are plowed under the following year. The idea is to plow the vetch so that it can provide nitrogen, while the spring cereal provides desireable levels of competition for the grapevines. The vetch will provide about 60 to 80 pounds of nitrogen. Out of that amount, 40 to 50 pounds will be available next year.

Dr. Clore tried alfalfa and spring grains as a cover crop. Alfalfa, generally speaking, is not recommended as a cover crop for grapes. It gives too much competition and it also harbors gophers. But it is recommended that before you start a vineyard, you grow a crop of alfalfa and thereby make use of the nitrogen which alfalfa will fix. In this way, you can grow grapes without any additional supply of nitrogen for several years. Any crop following alfalfa always benefits from it.

There are definite differences in the root systems of Concord and winegrapes. The Concord has a comparatively shallow root system, but the roots of the winegrape, Vitis vinifera, grow at a 45° angle and tend to be deeper rooted. We learned about this in the 1978-79 winter freeze; we lost about 1,000 acres of Concords and several hundred acres of winegrapes in Washington. We dug up the roots and found that many of the shallow roots of the grapes were damaged. We did a survey to find if there was any correlation between the growth of the cover crops and winter damage to the vines. There was no correlation. The shallow-rooted vineyards, which might have been started with greenhouse-grown plants, died during the freeze. Greenhouse-grown plants tend to be shallow-rooted. Those vineyards that had been started from the hardwood cuttings survived. There was no correlation, at least in this survey, between the cover cropping factor and the winter damage.

We encourage a moderate or low of fruit tonnage so that there are good carbohydrate reserves in the permanent parts of the mature vine. A late frost will kill many of the green shoots. Consequently, there will be fewer

good canes for next year's crop. We often get some damage from the cold winters (-10°F to -12°F).

Encouraging some kind of ground cover, whether natural vegetation or not, and permanent or temporary, is absolutely essential for growing grapes in Washington. Red fescue is commonly grown in many winegrape vineyards as a permanent cover crop. Red fescue is comparatively easy to establish. It is hardy, at least under normal winter conditions, and it can suppress the weed population fairly well. It is not grown in the Concord vineyards. Red fescue can be properly managed by mowing. Several mowings are required for red fescue in order to keep it well maintained.

Many people encourage weeds to grow and leave natural vegetation, which they plow in later. This is not a desirable practice, because first, you do not get a uniform, heavy stand of weeds; and second, it is very easy for the noxious weeds to get established. If you want to have a temporary cover, it is much better to plant a cover crop and then plow it in.

Another critical item related to cover crops, is the time they are planted and plowed in. Unlike California, Washington has cutworms. Often, during the time of year when natural vegetation should be present, if the weeds or the cover crop are plowed in, you suddenly get a serious infestation of cutworms. This is why it is important, when cutworms are present, that the cover crop not be incorporated.

In the case of the young vineyard, both with Concords and wine grapes, it is very important to give some competition to the young vines, especially in the later part of the growing season, or the canes will not mature. Immature canes are more susceptable to winter kill, as well as damage from the late fall frosts.

Generally speaking, grapes under our conditions do not respond to added phosphorus. Phosphorus can be applied to the cover crop and thereby be beneficial to the vines.

It should be remembered that grapes are extremely sensitive to 2,4-D. In fact, we have a big 2,4-D problem because of aerial drift. Thus, weeds must be controlled with other herbicides or reduced through the use of cover crops. In the vine rows, weeds are typically controlled with herbicides, but a four to five foot strip of cover crop reduces the weeds between the rows.

In summary, several legumes and non-legumes are grown as cover crops in vineyards. The main purpose for growing cover crops in Washington vineyards is to cause competition for the late season nitrogen and water, in order to improve the vine maturity. In areas subject to wind and water erosion, a cover crop will help prevent soil erosion. A combination of vetch and spring grain (wheat, oat, or barley), seeded in mid-July, is recommended as a temporary cover crop. Creeping red fescue is the most common perennial used.

DISCUSSION

Willett: You said that in winegrapes they usually plant their cover crops about the middle of August, in order to start stressing the vines.

Ahmedullah: The stress has to be by the middle of August, so the cover crops have to be planted earlier. You want to stress the grapevine just before harvest. You do not want vegetative growth to continue as they go into maturity.

Willett: Are you trying to stop growth approximately when the grapes start to color?

Ahmedullah: Exactly. You are forcing those canes to mature because normally they have a tendency to continue vegetative growth. The late-fall frost would kill such growth.

Willett: We have a couple of vineyards in our area around Medford. Some growers say they have to cultivate in order to get some frost protection advantage. They found that if they cultivated sloppily and left some vegetation between the rows, they didn't have a problem with cutworms. But, if they went through and did a real good job of cultivating and worked everything into the soil, the cutworms moved to the grapevines.

Ahemdullah: Cutworms normally are under the soil or under the bark. If you plow the cover crop, which is in the middle of the row, that will affect the cutworm population more than the few weeds that you leave. It is important that some other food is available for the cutworms, especially in the middle of the rows. We have found that by plowing under the cover crop and all of the weeds, the cutworm population substantially increased.

Willett: Was it just the physical movement of the soil, or the elimination of the weeds that increased the population?

Ahmedullah: It is not the physical movement of the soil. It is the removal of a crop of weeds or cover crop which forces cutworms to eat on grapevines, since there is no other vegetation around.

Brown: Is stressing the grapevine in August all that positive? Are you getting some negative effects on yield or quality?

Ahmedullah: The negative effect on quality, in terms of sugar and acid, is less important when compared to survival. If we do not stress the vines, we will not be able to grow grapes. We recommend that you force a small crop rather than a larger crop, because the small crop will be of better quality. A better optimum sugar-to-acid ratio will be achieved with a small crop when compared to an over-cropped situation. In going back to the 1978-79 winter, when we learned most of our lessons, those vineyards which were cropped at the four to five ton level had very little damage compared to those which were cropped at the eight to ten ton level.

Brown: We have late growth too, and if we can stop that terminal growth, then we feel that it is a benefit, although we don't worry about the winter damage as much as you do. If stopping that terminal growth didn't allow more of the plant food to go into the yield, rather than to extend shoot growth, which would be more positive?

Ahmedullah: The carbohydrates do not start moving back into the permanent parts of the vine until it starts approaching dormancy. Some of the work done at Davis has shown that as long as the grapevine keeps growing, and new shoots keep producing, there will be a flow of carbohydrates from the vegetative parts of the vine into the sinks. Only after the growth stops or slows down and the plant approaches dormancy, will there be a backward movement into the roots.

Weber: You spoke of stress, can you give me a measure to look for on water stress or other stresses?

Ahmedullah: The stress is measured by the maturity of the canes.

Topic 10

CROP MANAGEMENT AND WIND EROSION

Vance Pumphrey

Oregon State University, Pendleton, OR

What I have to present is quite different in environmental impact and objective than what has been presented here so far. What I speak of not only applies to Oregon, but also to Washington and central Idaho as well. The problems in the three states are very similar, as are the objectives in trying to overcome them. The sandy lands that have come under cultivation in north central Oregon have been worked for only the past ten years. This land was arid and sandy; it couldn't produce 10¢ an acre prior to its development. Develop costs averaged $1,000 plus per acre. If potatoes were put in, the gross income per acre came out to be $1,000 to $2,000 annually. This was good news for the Chamber of Commerce and the bank. But what are we doing to the land as a resource and how permanent is this development? How permanent the development will be depends on the severity of the wind erosion problem and on economics. It was well known, prior to the establishment of these larger developments, that there was going to be a wind erosion problem. The old Umatilla irrigation project was plagued, since the day it was initiated, with wind erosion. On the sands, water distribution by gravity flow was also a problem. Using center pivot irrigation solved the water distribution problem. But the wind erosion problem was yet to be solved.

The highway sign that warns of blowing dust, is a complete disgrace to agriculture and makes for bad public relations for those who work in research, like myself. It's also bad public relations for the Soil Conservation Service and the Extension Service, as well as for the grower. These signs have been put up just in the last ten years, not only in Oregon, but in Washington and Idaho too.

Several practices are suggested to lessen wind erosion -- cover crops, tree wind breaks and cloddy or rough soil surface conditions. Of the proposed solutions, there was only one that seemed to be within the ballpark

for our sandy, pivot irrigated land, and that was to have some kind of a cover on the soil surface 365 days a year.

What can be done to keep that land covered up continuously? When you look for wind erosion solutions, you turn to the National Wind Erosion Lab at Manhattan, Kansas. The National Lab suggests that having something standing up vertically will give you more wind erosion control than the same material laying horizontal on the ground. Plants standing vertically make a turbulence that reduces the wind velocity on the ground.

What kind of wind velocities are we talking about? Well, once the soil surface gets eroded and scarred, a 15 mile an hour wind will start the soil moving. A 15 mile an hour wind will start sand particles to rolling, which will cause a scouring effect on anything they hit. A weather forecast two weeks in advance that could predict wind velocities would be very helpful. At present, the Weather Bureau forecasts wind conditions only for the next 24 hours. It is difficult, I appreciate that problem, but it would be good if we could have a much longer forecast. Since you don't know what it is going to be like for the next two weeks, you should not risk exposing the soil to potential wind erosion.

Utilizing crop residues and cover crops for erosion control is not easy or simple in modern agriculture. The ideal would be a crop with no expense and instant results. Some desirable features of a cover crop are: an inexpensive seed source, easy and cheap to plant, minimal or no water requirement, minimal or no fertilizer requirement, no pest management, no weed control, no diseases and no interference to the primary crop.

A large number of plant species have been tested for their value as cover crops. We prefer a legume. Its ability to fix nitrogen is very helpful. We have looked at vetch, both hairy and common. The plants are very weak in the fall and winter and so have no possibilities as wind erosion control materials. A cereal like wheat or rye is a possibility. Oats at one time was recommended, but most oats are not winter hardy and provide little surface residue after the main crop is planted. Winter hardy cereals can be easily controlled in the spring by herbicides.

The late harvesting of potatoes is a contributor to wind erosion. The processor wants the potatoes to stay in the field for as long as possible,

until he's ready for them. For this reason growers will extend harvest into late fall and early winter. Heat at this time of year is not sufficient to grow enough vegetation to protect the soil from the wind. Some of our problems are not going to be solved agronomically or mechanically. Cooperation from processors will be needed.

Potatoes are the dominant crop on these developed lands. Most of them are planted into a seedbed which has no plant residue on the surface. The time between when we make this bare seedbed and when the potato plant has grown big enough to provide cover is a crucial period. A potato in warm weather will emerge in about three weeks after it is planted, in cool weather it will take five weeks. Then it will be another three or four weeks until the potato plant gets big enough to provide some cover. That means from seven to nine weeks the land is exposed to possible wind erosion.

What can be done to provide some ground cover until the potato plant is big enough? Oregon State University had a researcher by the name of Chuck Ullery. He had seen cover crops and minimum-till work in Ohio before he came to Oregon. He started working on the problem in 1972; a couple of years later similar work was started in Washington and in Idaho. The main objective was to maintain residue from a winter cereal on the soil surface during potato planting and emergence. Wheat has proved to be, by far, the best cover crop. The wheat can readily be controlled in the spring with an herbicide. Dalapon kills slowly, so in about six weeks or so the wheat is dead and the potatoes have come up. If the wheat is large and a more rapid kill is desired, paraquat or Roundup will do an excellent job.

There are other aspects that have to be considered when managing the cover crop. One consideration is insects, especially wireworm. Dr. Toba, who works in entomology with the USDA in Washington, has worked extensively with wireworm control. The best he can recommend is that we use some kind of an incorporated insecticide. With incorporation, you are destroying the cover crop or the surface residue. It conflicts with the direction you want to go on wind erosion control. Another area of conflict is broadcasting and incorporating of preplant fertilizers. Incorporation of preplant fertilizer destroys the cover crop. The fertilizer instead can be side-dressed during planting. One of the problems you run into in trying to get away from pre-plant fertilizing is that you have some fertilizer representative in the

area with half a million dollars invested in broadcast fertilizer equipment. Why should he want to accept an attitude or idea that will put him out of business? Wind erosion control is a big problem; it goes beyond just talking to the grower.

Some of the growers say they need to subsoil. Subsoiling is usually the first field operation. After subsoiling the soil is firmed or packed. The two operations are somewhat counter productive to each other. A considerable amount of diesel fuel is consumed in subsoiling and packing the soil.

Precision subsoiling is possible. It refers to subsoiling only where each row will be planted. Insecticide and fertilizer can be incorporated with a mini-rotovator (15 to 18 inches wide) where each row of potatoes is to be planted. The cover crop and crop residue are left undisturbed between rows as an aid in reducing wind erosion. An herbicide for controlling the cover crop can be applied before subsoiling or after potato planting.

Oregon, Washington and Idaho are suggesting cover crops, residue management, and minimum-tillage for controlling wind erosion over the winter and during potato emergence. Noble sweeps can be used to till an alfalfa field and keep the crowns of the alfalfa plant on the soil surface. Straw from the wheat crop can be partially disked into the soil soon after harvest. The practice of burning the straw is wasteful.

In other parts of the country there is a definite trend to adopt minimum and no-till corn planting. Besides reducing production costs, the practice is very beneficial in reducing erosion. With minimum-till corn, the rolling coulter, ahead of the disk openers, is the main thing that makes the difference between success and failure in planting through plant residues and cover crops.

About 1,000 to 1,200 acres of watermelon are grown annually in the Hermiston area. Growers have been successfully controlling wind erosion there for many years. In the fall a hardy winter cereal is planted in strips, which are at a right angle to the prevailing winds. The cereal strips are spaced far enough apart to provide room for one row of melons. After the melon vines are large enough to minimize wind erosion, the cereal is killed but left on the soil surface. The melon growers have been utilizing minimum-till wind erosion control very effectively.

A very progressive farmer in that area wanted to raise asparagus on the sand. He asked for a contract. After talking with the processor for awhile and hearing all of the reasons why he couldn't grow asparagus on the sand, he said, "I didn't come all the way over here to hear why I couldn't grow asparagus, I came over here to get a contract." So they gave him a contract and he proved to them that he could raise asparagus on the sand without a lot of wind erosion problems and a lot of sand in the asparagus. What did he do? In the winter and spring he allows weeds, mainly downy bromegrass to grow between the rows. The weeds provide sufficient barriers for wind protection. Weeds within the row are controlled with an herbicide. This is an example of a grower utilizing weeds to his advantage. I feel, as far as we in research are concerned, there are times when we should be more forward and more dynamic and less textbook-bound in our thinking.

There are disadvantages to minimum-till systems. Usually the minimum-till system requires a long-range plan. The wheat producer should start thinking about minimum-till for the following year at the time the wheat is being combined. What do they do with their straw? Do they just pile the straw and chaff in big rows and allow it become a problem to them, or do they scatter it? If they leave it in big rows it can be a problem to them mechanically and then it's no wonder they take a match to it.

In summary, as far as precision subsoiling is concerned, the producer might have to pay a couple of dollars extra an hour to get a tractor driver that can do precision subsoiling. As for broadcasting fertilizing, you are not going to maintain a cover crop or crop residue on the soil surface if you do anything that has to be incorporated. Another obstacle as to why growers are not accepting minimum-till practices is because of their equipment. A 150 hp tractor will do all the minimum-till work needed, thus, the already purchased 300 hp tractor becomes a problem. The owner wants to use it to full-till the soil, that's why he bought it.

DISCUSSION

William: Vance has presented an interesting look at the wind erosion problem. Perhaps Dean Booster, Harry Mack and Jim Vomccil might comment

on their project and particularly on the wet soil conditions that we have here early in the spring. It is a completely different situation than that found in the Hermiston area.

Vomocil: Our project will deal with reducing tillage in vegetable crop production, mainly beans and corn. We are trying to look at ways to reduce the amount of energy required for the tillage operation. The treatment that we will be looking at this season will be rather limited. The field has wheat growing in it now as the cover crop. We will be looking at no-till, strip-till and conventional tillage. One of our concerns has been in processing vegetable crops. The harvest date is controlled by the planting date, and if you are going to plant early, then the soil has to be warm enough to allow your crop to get started. We are interested in the influence of these practices on soil temperature. We may have wind problems too, but we don't know about those yet.

William: Jim, did you want to add anything on the wet soil conditions that we have in the winter and during our spring plantings?

Vomocil: In view of the comments that Vance made about subsoiling, I'd like to comment on that practice and possibly to assess its value here in the Willamette Valley. Many of the vegetable growers use a rotation of cereals and row crops. The practice of subsoiling has been increasing with the advent of the 300-horsepowered tractors. Subsoiling is done to a depth of 18 to 20 inches with the tractors pulling five standards. Behind the subsoiling standards is a roller filled with water to a weight of 30,000 to 40,000 pounds. The soil is packed or mashed back down to approximately the same elevation it was before. Sometimes there is a change in elevation of about one inch. Out of 18 inches you might change the volume by 5 or 10%. We're not sure what good this practice is doing, but it will be very interesting to try and find out because those monster tractors are using about 17 gallons of diesel fuel per hour. Trying to appraise this practice is difficult. One of its claimed benefits is that the breaking up of the compacted layer or hard layer will improve spring drainage. Getting rid of excess water during that time of the year enhances the growth of the vegetable crop planted. Therefore, the effect is beneficial and worthwhile in spite of the very high cost. I imagine that this works in some situations.

If you try to reappraise this practice by having little narrow strips where subsoiling is omitted, in order to compare it against an area where subsoiling has been done, you still have the possibility that the water table is moving short distances and dropping into the slots. It takes very large plots along with plenty of measurements, to overcome the amount of natural variability found in most fields. It is preliminary work that we are involved in right now. I know there have been a few articles on compaction that show some very high densities developing quickly on sandy soils. When you are talking about bulk densities of 1.6 or 1.7 there is probably a mechanical impedance of the root system, as well as irrigation and drainage problems. You can circumvent this problem if you have good control of the fertility and the water. If you can irrigate frequently, then you won't need a crop with deep roots. But that makes it expensive and risky, because if you miss an irrigation you might be in big trouble.

Pumphrey: The USDA at the Columbia Plateau Agricultural Research Service in Pendleton is importing a machine from the National Machinery Lab in Alabama. The machine has a couple of prongs for subsoiling that can be expanded to any width. The general idea is that they are going to subsoil, have a couple little wheels behind the subsoiler to firm the soil for a seedbed, and then have some kind of a planter trailing behind that which plants over the subsoiled area. The machine has a lot of merit because you're getting your subsoiling done and you're not spending all that energy (that Jim talked about) to get it firmed up again. Also, you'll be saving trips across the field because you have your seed right there to plant where you just did your subsoiling. What we are hoping is that we can get our growers to accept minimum-tillage, as far as potato production is concerned. It is similar to what Dr. Sweet said, "You have to put all of these parts together and hope that the package is accepted." I think as far as research, Extension and the Soil Conservation Service are concerned, we are missing a part somewhere. We are just not getting the potato producer to accept minimum-tillage.

Lagerstedt: Vance, in all your slides I didn't see a single tree; whatever happened to windbreaks?

Pumphrey: You are talking to a guy that has done quite a bit of work on that. When you are a commercial aerial applicator and have a contract for 5,000 acres to vine kill potatoes, you are not going to be very happy about that tree row that is just 20 yards beyond the end of the field or in the field. In fact, sometimes there are complaints about the trees growing around the farmsteads which are being sprayed. If you look at the wheat country out there, you may wonder why some of those farmsteads do not have trees. Aerial applied sprays may have accidentally gotten on the trees. Also, the trees are often blown full of Russian thistle and when somebody gets a little careless with a match, well, it's hard on the trees.

Vomocil: I talked to many of the commercial operations out there about the possibility of windbreaks and they chuckled a little. They know that in order for such a practice to be compatible with the pivot circles, tall windbreaks of any kind would have to be half mile apart. If you are thinking in terms of really protecting that whole stretch of country, your windbreak would have to be about 300 feet tall in order to protect an area spreading out to a half mile. Even a much shorter windbreak though, with that kind of spacing, would have some significant effect, particularly if you recognize that the erosive energy of the wind is proportional to the cube of the velocity. Reducing the wind velocity down to 90% of what it was before, is a 10% reduction. The erosion potential is .9 times .9 times .9 or it is 70% as much as it was before, so, just a little influence on wind speed becomes pretty important. I think there is some hope that maybe, even at a half mile spacing, the wind breaks would do some good. I have also tried to get the growers to consider the prospect of mixed cropping. If you have potato rows planted north and south, you could come in every 50 or 60 feet and put in two or three rows of corn. When you have these very late dug potatoes, that Vance was talking about, you could leave the corn rows stand there. They would be dead and you couldn't harvest them, but at least you would have something standing there on a 50 or 60 foot interval. These are some of the ideas that we've been thinking over and talking to growers about, but so far, they've not really been terribly convinced that erosion is such a big problem. Many of them watch themselves lose four or five inches of soil, but they figure they are

working on 40 or 50 feet of sand. That kind of an attitude is one of the big problems.

Miller: Vance, in the asparagus field, did the farmer lose much acreage and producible land by interplanting, or were those standard width rows?

Pumphrey: I think those were standard width rows. He does an excellent job in getting enough yield and he is a highly competitive producer, both in quality and quantity.

Sweet: We have some areas of muck soil that have been in intensive vegetable production for the past 50 years. Wind erosion is much more of a problem there than it is on mineral soil because the muck soil is so light. Some of the areas traditionally never had windbreaks, while a few of them had small row hedges which were very close together and others had larger trees that were a fair distance apart. The wind use to swoop over the top of those tall trees and when it touched down the field got a scouring. You could see where it would come down and take those crops right out. Yet the trees were the first to go and now, the small hedges are going. They are trying all kinds of crop management and special plantings. Currently, the trend is to plant spring barley, about a tractor wheel-width apart, right when you sow the crop. The spring barley comes up fast and using the grass regulators that we have, plus some ingenious rototillers, the barley is eliminated after the primary crop has become established. It is sort of a deliberately planted windbreak of a temporary nature. I have a question on the small rotovators. What is the forward speed that those operate at efficiently?

Pumphrey: About three miles an hour the slow speed that they work at is one of the reasons why they are not being accepted. Rotovators are quite power intensive and slow. And these days, if it isn't doing five miles an hour or six (the trend of course is even faster) it is not accepted.

Appleby: In your slides it looked to me like the rototiller took up 2/3 of the space. Did it need to be that wide?

Pumphrey: Basically, the rotovator was rotovating 17 inches with a sluff on each side. You were correct in your observation, it does take up about that much space. It takes about 15 inches to handle the planting.

Appleby: Couldn't you combine that with the planting operation to get around that precision driving?

Pumphrey: Yes you can, if you want to do a smaller area per hour. If you plan on planting about 100 acres a day, you don't want to do anything that is going to slow down the planting. The more operations you put together, the slower is the single phase. As an example, if you are banding fertilizer at planting time you have to stop and fill up with fertilizer. When you are putting on a half ton or 1,500 pounds of fertilizer per acre it really slows you down. One of the reasons so much fertilizer is broadcast and incorporated is to prevent having the fertilizer application slow the planting process down. There seems to be numerous reasons why minimum-till potato planting is not acceptable and only a few reasons why it is possible.

Fox: In Sidney, Montana, they have worked for many years with small dry grass strips as a method of soil conservation. We have been trying the same thing for many years in conservational field trials in Idaho and Oregon, but we just haven't had much success. We finally did get some to work around Aberdeen, Idaho, in a few of those real sandy areas up where they grow potatoes. I know they work if they are put in properly. In Montana, in the dry wheatland areas, some of the farmers use them. Their main complaint was that you have to be very careful with them. Another complaint was that the hired hands wouldn't take care of them and there is a problem with weeds.

William: This is a reccurring problem, in terms of trying to sell minimum-tillage and conservation practices to our growers. It is hard trying to convince some of our people that these are important concerns. I felt that with respect to Christmas trees and grapes, if we could find a sod that competes with weeds and doesn't require a lot of mowing, it might improve the soil, along with water penetration, nutrient retention and some of those other factors that we talked about. If we get enough of those positive aspects added together, then it ought to be pretty simple to offset some of the problems. What we are really dealing with here, at least in Christmas trees, is that it is a lot easier to call in the aerial sprayer and get the job done quick. I think that with some of these other crops there may be a few selling points that we could utilize.

Green: Within Christmas trees, I have heard that the reasons for calling in the aerial sprayer was because it is easier and cheaper. But I think

the most important reason that aerial spraying is done, is because a better Christmas tree is produced. It works better than any alternative that people have used in the past. It is not only easy and cheap, but it is basically the reason that we are able to grow our trees to the kind of quality that we have here. If we are going to propose something else, we have to find ways to look at the quality problem that it may or may not cause and offset that argument as well.

William: That is a good point, Dan. As we look at these questions and consider the different kinds of crops, the interest represented by this group should make us realize what we need to consider as a starting point. Perhaps we should consider these questions. What kind of sods, cover crops or legumes do we want to put into our crops to begin testing and what kind of research techniques or methodologies do we want to look at? For example in grapes, Porter Lombard and Ralph Garren have both indicated that they want to take a look at grape vigor with a cover crop. Jim Vomocil and Jerry Kling have indicated that they have taken an interest in the soil aspects. The temperature relationship is an extremely important point. We would like to take a look at weed suppression with cover crops. The Soil Conservation people are interested in erosion. By putting all of these things together and getting enough people cooperating at the same time we might come up with answers and selling points that the growers will consider and utilize.

Ogg: Regardless of what crop management system you are going to propose to growers, if you can't show an economic benefit or demonstrate that it will solve a legitimate problem, like wind erosion, they won't accept it. If you can propose a program that will solve a problem for them, then they will accept it. If you can demonstrate an economic benefit, they will be more apt to accept it, but if you are just going to change their practice, you are going to have an uphill battle.

Brown: Unfortunately, the economic benefit has to be immediate. You can show them the long-term benefit and that often doesn't cut it. It has to be, it seems, a very short-term benefit, almost within the same year.

Sweet: We have to be careful. When growers don't jump into our wonderful programs perhaps they know something we don't. Sometimes their reasoning is short-term, but the grower says, "I don't worry about the long-term, I have to pay my bills tomorrow." I don't want to get

discouraged though, since there are going to be some people that gradually will take up the system. I'll quote Dick Harwood, who is interested in promoting these systems, he says, "I think the way to go is to get the grower to take a small field at a time and develop the program, rather than taking one full-swoop to change his whole operation over. You'll have a chance of bringing him along and if it doesn't work as well as you wanted it to, he didn't take a real nipping."

Weber: You mentioned that it had to be economical. In the pear orchards down around Medford there is a bad compaction problem going on. It is very serious. We need a cover crop in the orchards. But when I ask growers why they don't put a permanent cover crop in I get a long list of excuses as to why it can't be used. It varies from disease in the cover infecting the trees to "I can't furrow irrigate with a permanent cover crop," or "I can't work my prunings into the ground." The thing that we need to do is to develop our own long list. I did run across one grower who provided me with a few starters for my list; he said that by having a permanent cover crop he had reduced the costs of maintenance by 15%. That is quite a reduction that is easily quantified and it is a short-term benefit. He also mentioned that if there was a rain during the harvest period he was the first one back in the orchard because of his cover crop. He may be the first one back in for almost two days and that means a lot. He's getting his fruit into the packing shed faster. Maybe we should gather up these positive aspects on cover crops and share them.

William: Probably we should share the negative things too. The growers, if they have the facts before them, will accept and reject a lot of different alternatives. They will be able to make some good decisions and go in directions that will benefit their production system.

Fox: I noticed that in almost every place I ever worked, some of these problems don't ever get answered. Generally, we find that farmers have demonstration plots all over the place. If you circulate around you will find them. I think often the farmers are way ahead of us. Some of them have a real love for the land. They aren't really wanting to destroy it; they want to keep it productive. They are interested in economics, there is no question about that. They have to make a living. I think we do underestimate them sometimes and I think if we listened to

them we would find out that they want to listen too. We need to communicate. There are people who are willing to try anything if it looks better. It doesn't necessarily have to make them more money. I spent about three years in Turkey and the same thing is true. Those farmers will try something if it looks like it will improve their situation.

Ogg: I would like to ask Harry and any other people in Christmas trees a question. Pictures that I've seen of Christmas trees show everything planted in straight rows up and down the hills. I was wondering, hasn't anybody gone to contour planting of Christmas trees?

Lagerstedt: It has been thought of, but it has been discarded just as quickly.

Green: Mostly the plantings are not done on ground that is very steep. We try to discourage people from planting on ground that is so steep that contour planting would be a real important part of it. The erosion you get is often times in places where water concentrates or on particularly fluffy soils where there has been a lot of rototilling. Sometimes people have disregarded our advice and planted on steep slopes.

Vomocil: With regard to Christmas tree planting on contours, a few years ago we tried it a little bit with machine planting. When we were going across the slope we couldn't keep it going straight at all, the machine just drifted down. We decided that the only way we could cross-slope plant by machine would be to have a tool bar-mounted unit, not a separate unit. But even then the driver might have some problems with keeping the rows straight and properly spaced. This gets to be quite an important factor, particularly with the ground spray equipment for weed control.

Anon.: Jim, the 4-wheel drives now help that a lot. Where you have front wheel traction, you don't get so much slippage.

Vomocil: Yes, but I think you still need a mounted planter right on the tool bar, rather than a separate trailing planter.

Topic 11

THE DESIGN OF RESEARCH AND TOPICS ON COVER CROP USES

Robert J. Madar

Oregon State University, Corvallis, OR

What I have been trying to do for the last day and a half is to conceptualize in my mind what types of soil-plant-animal relationships we should be looking at and the kinds of interactions that we might consider. For example, people in Ireland have been doing work with cabbage intercropped with clovers. The reason they are doing this is to try and find a way to control the cabbage root maggot in crucifer crops. They grow cabbage on peat soils which have a very high cation exchange capacity. Soil applied pesticides don't work as a control. Some people who are working with clover as interplants look at predator numbers within the clover because it provides a habitat for ground-dwelling predators. They found that within a crop, when you had clovers interplanted, numbers of ground-dwelling predators were high. But at the same time the number of eggs laid by the root maggot fly was less than normal. From an entomological standpoint, we should be concerned about the possible interactions between cover crops and insects. Other considerations that have been discussed these past two days, are the maintenance of soil fertility, soil structure, erosion control, plant pathogens, rodent control and nemotodes. Everyone that comes into a research effort, especially one with a multiple approach like this, has their own set of biases or ways of doing things, like in methods of sampling, methods of analyzing data, plot sizes and experimental designs. What I would like to do now is develop an idea on how to resolve these differences of approach, so that everybody who comes into such an effort can get the maximum amount of information out of it.

The first questions that came to mind were what is the real problem and how does one conceptualize it? Why do we want to attempt a multi-disciplinary approach? What do we hope to get out of it? We have talked about various subjects. Bob Sweet talked about the benefit of weed control; others talked

about using a living mulch for erosion control. We looked at dryland systems, irrigated land, row crops, and tree crops. In each case there was a different reason for wanting to use a sod cover or a living mulch. How universal is it? For example, with a row crop the reasons you would attempt to use a cover crop might be different than the reasons for using one with a perennial crop. What are the important parameters we should examine?

DISCUSSION

Jordan: When you mentioned the insects that really reminded me of our research. The most diverse collections of arthropods that we had was in birdsfoot trefoil. If you are looking for a haven for parasites and predators, birdsfoot trefoil is where to look. We are really talking about both integrated pest management and integrated crop management in this program. It is much broader than weed control, pest management, or crop management. It is an integration of all aspects.

Sweet: I agree with that. I think we have to break out of certain basic systems based only on a particular crop. Of course it will be modified by the region, but we have to achieve a system as near as we can to a complete systems approach.

Madar: It seems to me that a mathematically-oriented systems approach may not produce a productive model, but it may organize the knowledge that researchers generate and make it available to others. What cropping systems would you suggest?

Sweet: Well, certainly you have some major crops that are almost unique. A few of the trees and fruit crops would be in a group by themselves. They might even be pulled out as speciality items. Perhaps the annual row crops should be grouped, maybe according to families. If we are going to make this into a cooperative effort we must realize that economic considerations are important. We need to show something of benefit to the grower in order to increase the chances of having our system used.

Madar: If you divide it up into different crops and you have people involved from different disciplines, the first thing that would come up would be how are you going to set up your treatments? What should be the plot size? Maybe the entomologist or plant pathologists have an optimum plot

size or treatment design that they generally tend to use that a weed scientist might not.

Jordan: It kind of depends on the objectives. I have had two acre plots that were too small for some insects, so we are now talking about getting into five and ten acre plots. When we get into a plot that size our replications become minimal. The number of replications we need depends on the variability and production. The uniformity of the stand will depend on the size of the plot.

Sweet: I don't see how we are going to tackle this. Some of us will have to focus on the cropping, while others need to provide some input. I hope they'll say, "I've gathered some data that fits your situation, maybe you can utilize it in your system," so we'll have information to aid the efforts of the cropping system as a whole. Somebody has to be looking after the crop, whether you want to call him a crop production specialist or somebody who has just pulled together pieces of information from a lot of different disciplines and tried to make it work.

Green: Erosion under Christmas trees is one of the areas that I would be interested in looking at. Long-term organic matter and how that affects the nutrition of the trees is an important consideration.

Madar: One of the first things you should identify are your major reasons for doing the work. The crop will dictate how you set up the experiment. We talked about the fact that some citrus trees have shallow root systems. This might dictate the kind of experiment that you would design. If we start with the soil scientist's viewpoint, what would be an optimum-sized plot? A 20 acre plot was mentioned earlier and that seems to be a pretty good size.

Vomocil: I was talking about a specific sort of situation; we were attempting to appraise the effect of these no-till systems on water relations. Certainly, it would depend on which of these systems one is managing. I came to the conclusion that with annual row crops and the problem of early spring drainage, our 15 to 20-foot strips were too narrow. I really couldn't say that what happened in those strips would happen in a full-sized field operation.

Madar: From the soil scientist's point of view then, there may not be any set standard on plot size?

Mack: You might pick out a system like annual row crops and identify your major objective. Perhaps you know you could use cover crops to reduce tillage, that then becomes the major objective and within that framework you consider insect control and pathological problems. You can get 15 variables going at the same time. In the preliminary exploration you will learn a few things and you will make some mistakes. Next, you might look at just two or three treatments and perhaps find that the cover crop is creating a problem with insects that you didn't have with conventional tillage. Then you will have to follow up on that. It seems to me that you are going to have to define your objectives and be fairly precise, yet be open at the same time. You may find some areas that will have to be modified later on.

Jordan: I'd like to comment on that statement and follow it up a bit. You are right, when we stress a tree with complications or interference, then a whole series of things start happening -- diseases in the trees, nematodes in the soil, insects get worse -- you can't just pull out one thing and say, this or that is what happened. It is like pulling a string of beads, when you move one everything else moves too.

Mack: The easiest way to go about it may be to look at nutrition or irrigation. I appreciate this idea of looking at a whole system to get a more integrated approach, yet most of us have avoided it because it does get more complicated. We do have to involve more people, but if we agreed to try this approach we would probably get down the road sooner.

Hogue: Both yesterday and today the allelopathic affect of some of these cover crops came up. Shouldn't that be a place to start? Shouldn't we start screening some of these cover crops with the particular crops we are interested in to see if there is any kind of inhibition? It would disqualify a cover crop immediately if there was any allelopathic affect, like reduction in yield or vigor and so on.

Bell: Ray, didn't you mention that there was quite a bit of allelopathic work going on in Michigan?

William: My response is to get Al Putnam all excited about that and send him whatever we want tested and let him write the research papers on it while we just glean the results.

Ogg: We may want to consider the current varieties of annual vegetable crops. They may have been bred and developed under vastly different

conditions than those which we are proposing to grow them under. Maybe some of the initial work should be done in evaluating the varieties of annual crops that we are going to be raising.

Sweet: One of the things that I have been able to do is to con a vegetable variety specialist in adding to his list of chores the evaluation of potential mulch species. This fits into a variety evaluation. But there are a couple of things that I want information on which he can't give me. We don't have an easy way to measure how much root dry weight a given mulch crop is producing. We need a quick test to give us some ballpark figures. Digging, washing, taking measurements and putting them in an oven and so forth is pretty time consuming. I am interested in the amount of roots that either a given treatment or a given cover adds per month or per year. I'd like to see a quantitative quick test developed for it. You need to make hundreds of these observations each year. We also need a quick way of measuring changes in soil structure. When we are evaluating these cover crops, at least from an agronomic standpoint, we should know these things. We have been lucky in our work, there have been entomologists involved and even a wildlife specialist, Mike Richmond, who were making observations on what the rodent and insect populations were doing. Also, the pathologists have been screening, particularly the legumes, to see what viruses we may be bringing in. They are all able to utilize our small plots, but we need to get even more mileage out of them.

Jordan: As far as allelopathy is concerned, sometimes it is very difficult to tell the difference between allelopathy and interference. There is a discussion going on now in the literature between two groups of people in different laboratories on whether bermudagrass is allelopathic or whether it is competing or causing interference. Both sides of this discussion have their information pretty well in order. Maybe both are somewhat right.

Madar: I would like to pose a hypothetical research problem and then get your input on various aspects of the problem as a basis for discussion. I will be working for Larry Burrill at the International Plant Protection Center (IPPC) and it looks like we will be looking at interplanting in sweet corn. We are going to be using at least one or two species of legumes as the cover crop. We will be trying to look at

as many different parameters in the situation as we can. Since we have soil scientists, entomologists and weed scientists present here, it would be interesting to hear from each group on what they feel would be an optimum plot size.

Miller: I would think that the insects would require a large sized plot due to their ability to disperse. I would prefer to work in a plot at least the size of this room (30m x 30m), but then of course, a plot the size of an acre would be even better.

Madar: How about from a weed scientist's viewpoint? Dr. Appleby, what would you consider to be an optimum plot size for this kind of endeavor?

Appleby: For a long-term study with perennials, something like 20 x 20 is absolutely minimum. A 30 x 30 plot is fine, but I don't see much need to go beyond that.

Madar: With larger sized plots do you reach a point of diminishing returns?

Appleby: No, because you can select your own analysis spot. The problem with getting too big is that it becomes hard to find a large uniform area of perennial weeds. The bigger the plot size, the fewer plots you can have for a given patch of weeds.

Madar: How about from a soil scientist's standpoint?

Vomocil: I would guess that probably from the point of view of both soil moisture and fertility, four rows that measured 12 to 15 feet wide and 50 feet long would be adequate, providing that it was adequately replicated. If you are in the middle of a nice big block of land with reasonably uniform soils, three or four reps would be sufficient. If you are in a transitional zone between valley soils and hill soils, which happen to be mixed together in a spot or two, you will get a lot of variation in soils in a very short distance.

Kretchman: If you expect your treatments to give you very large effects on plant growth, as reflected in height, I should say six rows would be minimum to get away from the extreme border effects you would have in sweet corn.

Madar: From an entomologist's standpoint, what would be the minimum duration of a test like this to obtain some meaningful data?

Miller: If you are talking about corn, I would think a year would be okay because of the annual nature of the pests. Now, with other crops you

might be talking about soil insects as well and you may not see any effects for two, three, or four years.

Burrill: I wonder if we could turn the question around to emphasize the dilemma that many of us might have here in initiating this kind of research. It looks like right now we are faced with a $500 an acre land rental fee for this research that he is going to do, okay, we can handle that. Now let's say that he chooses a minimum plot size of 20 x 40 feet. We have these two legumes he mentioned and five replications in one crop of maize. Two of the variables we will be looking at are weeds and insects. Since we are paying the bill we are in the driver's seat, but what could you people get out of that research without any further modifications, or what modifications could we make that would be of minor expense, space and effort to us in order to get much better data out of it?

Anon.: I would certainly like to see you involve some observations on moisture status and irrigation. Keep good records on the irrigation. We might be able to get a little better grasp on the significance of competition for water, even under an irrigated regime. I wish there was a good quick test that would really give us some information on changes in soil organic matter or changes in soil structure, but these changes are extremely slow. If you are going to pick up any changes in the soil's physical condition you need a minimum of five or six years. I think it would take at least that amount of time just to be able to judge the effect of this crop mixing. How is it going to do in a wet year as compared to a dry year? Average years never occur. If you get lucky in that five or six year increment, you will have a very wet year or a very dry one, then you can get some valuable information from that year.

Miller: I would think the same thing might prove true for insects as well, in terms of average years, climatic variables and changes in insect populations.

Sweet: I would like to modify the approach a little bit. If we don't give some priorities to the kinds of things that we really want to accomplish in the next five years, we may end up with not really having this designed right. I think each discipline must identify the important things they want out of it. It would be just short of a miracle if you

could come up with one plot size that is efficient for every discipline. Sometimes you may not need to have them combined, sometimes you will. If you could list the things that you really want to get at the end of five years, then I think you will make some progress.

Miller: In response to your question on limited size and money, Larry, I would tend to reduce my replicates and make my treatments larger.

Lagerstedt: In a filbert orchard, which is nonirrigated, I'd say that your plots would be of relatively little value. I always try to cut through and do the simplest thing if I can, and if I had ten different grasses to grow and evaluate under my orchard conditions, that is exactly what I would do. I would plant those ten grasses and I wouldn't expect all of them to survive or do as well. Ultimately, I would filter down to two or three of these grasses that look good under my conditions. What is going to live under the harsh conditions that I subject it to? That is my first objective and my first evaluation. Those grasses that make it, I would use in all my aisles, and after that I would begin working into these other phases with other people.

SCS Rep: I should mention a little bit on soil conservation, from a service standpoint. We are not a research organization. You all know that we do have a plant testing program and in that program we can test plants for specific purposes. We do have one other mechanism that we use to transfer knowledge to farmers -- conservation field trials. Conservation field trials have to be set up for specific purposes and we usually try to either confirm or demonstrate the benefits of some technology or some plant that we feel will work. We could get involved in something you're talking about, but our concern would mainly be what would survive and look good. All the research that you could impose on this one objective we would be happy to know about, because all of that works into the quality of the crop, the production of the crop and all of those factors that the farmer is interested in. He is interested in something that is going to survive, as well as all of the cultural management required to establish and maintain the cover crop. We could easily call that a conservation practice on steep slopes. We can set up field trials and test through the system, but it has to go through and be approved by the state conservationist. We don't get into replications, because we usually try to do it on a large field size or a

management unit size. We check the soil out and make sure that we have uniformity.

William: We were talking about gathering together a list of perhaps a dozen or so cover crop varieties to test around the tristate area of the Pacific Northwest with the Soil Conservation people, some of our extension agents and researchers at the university. Different individuals from various disciplines should be able to make observations on the plots with their sweep nets and pit traps, or by measuring the length of the grapevines or whatever it takes to get an idea on what is occurring. Bob is interested in trying to put this kind of a program together with a little fine tuning for his Ph.D. work. Jim Vomocil has indicated soil parameters as an area to consider, I'd like to add temperature to that, particularly the early season spring temperatures that occur when we are trying to plant crops. I agree with what Dean Booster was saying earlier about the importance of planting and harvesting dates and cover crop interactions.

Jordan: I would like to suggest that we consider the problems we are trying to solve. There are two types, one involves those answers which you can get immediately or on a year by year basis, the other involves answers that you will get from cumulative effects. The first year your cover crop won't have too much effect. Two or three years down the road you may start to see the effects on the trees or on the crop plants. Effects on the trees may even show up in the fifth year, while the soil cumulative effects may take even a longer period of time. It won't just happen in a year's time. There are some aspects, like insects, that vary from year to year. But with tree crops, it's the later years will give information that is really critical.

Madar: So you would have a short-term objective and a long-term objective? What are some of these short-term objectives? The immediate effects of the cover crop on annual weeds and the insect interactions may be two short-term considerations. Does anyone else have any ideas on short-term objectives that can be looked at in the first year? Crop yield might be another short-term study.

Sweet: One of the early things to consider is what species are going to be best for different situations. We'll have to have a lot of people looking at quite a few different cover crop species. There should be a

whole host of considerations for evaluating those species. One group might say, "Wow! This is pretty bad because it does so and so," while another group might say, "Gee, that is exactly what I have been looking for." Having a list of observations to consider when making evaluations would be helpful, so that later the information could be passed around. Observations on dormancy is one example. Observations on rodents would also be helpful.

Madar: Your objectives would really effect the types of observations you plan to take, along with when and how the observations would be made. I am wondering if there will be any potential conflicts between various disciplines and various workers on how they take their observations. Will one method cause an impact on another person's methods or observations in the same plot? For insects, pitfall traps, sweep net sampling and whole plant samples are nice ways to get a good handle on what the insect populations are doing. What kind of impact would those sampling methods cause to a plant pathologist or a weed scientist? If you go out there and start pulling things up, maybe you will open up the habitat for weedy plants.

Sweet: We haven't had any problem getting multiple use out of our plots when we are in the early stages of evaluation. The problem comes, especially with some pests, in being able to predict how they will react if given a larger plot. So, there are some gaps, but at least if they are found in a small plot, you know it is favorable for them and that's half of the answer.

Appleby: Just to sort of reiterate what has been alluded to already, it seems to me that your objectives of short-term versus long-term methodology, plot size and all these things depend very heavily on what type of crop you are talking about. If you are talking about a long-term perennial crop like apples, that is quite different from cauliflower or corn or any of the other crops in between. What are you thinking about?

Madar: I will be working with sweet corn and either one or two types of legumes here in the Willamette Valley.

Appleby: For your particular system, some things could be carried on for five years, but your plot size would be smaller than with a tree crop. You still have the problem of the mobile insects.

Madar: Yes, mobile insects are the ones that we are going to have to watch. Another problem is that you get a lot of edge effects with insects. If you have a lot of edge relative to not very much center area, then you may get inaccurate results.

William: That might not be true though. Miguel Altieri had a corn plot down in Florida, and his concern was in trying to measure the spider or earwig population as it affected the consumption of the fall armyworm eggs that he put out on the corn leaves. He had plots that were about as small as I would recommend as a horticulturist for nutrition studies or weed competition. For the specific aspect that he was interested in, it seemed that the plot size that he had was quite adequate.

Sweet: In some of our cabbage work with flea beetles and aphids, our plots were six feet wide and 15 feet long. Because of the change from clean culture to grasses and legumes, a tremendous variation was noticed with those two insects between plots. What we are all saying in different ways is that a certain plot size will allow you to pick up certain information, while there will be other things you can't pick up. The plot size should serve the main objectives.

Lagerstedt: I would like to raise a question that might generate a little discussion and that is the question of controls. My philosophy is that the control should be a plot that is managed to the best of our ability, using our best practice. I don't believe that a totally unweeded plot is a control, although it is a type of control, I still don't buy it. I also don't feel that if I plant grasses, I should plant them right up to the base of the tree trunk, because that isn't what anyone else would do. We know about the competition that exists. In my case, the control would just be a natural vegetation, but I would manage it with herbicides. I would also manage the trees with the insecticides and the fungicide that I need and so on. And then over that, I would superimpose these ground covers. This touches on what you were saying, Bob. If you, as an entomologist, come in and the drift from my insecticides affects the data that you are trying to take in those plots, then we have a conflict. Yet, that is the way I would manage it, because those trees are going to be there for 40 years, unless I pull them out, and if I neglect them totally in any one year, that has an affect all the way down the line. It is true that as the twig is bent, so grows the tree.

If I harm the tree when it is young, it will always be a weakling throughout its life, so I must manage these trees to the best of my ability.

Madar: That particular constraint wouldn't operate in an annual crop.

Sweet: That does operate, but just for a shorter period of time. Some of the information we want about these ground cover species you can't get in the presence of the crop. You want to know what influence this system has either directly or indirectly on the various insects. If you have a spray program you can't find anything out, but without a spray program you will learn something. So at that stage of the game we don't attempt to put a crop in there. We get into the crop in a different set of tests. Certainly, conventional production practice has to be one of your treatments, but how many other treatments you have, is something we are struggling with right now. The entomologists and Mike Richmond, who works with rodents, want to go to acre-sized plots and they want to grow cabbage. We didn't have it solved when I left. They were talking about hand-weeding, and when it came to providing weed control, I said, we couldn't afford it.

Fisher: I had a couple of questions. I am curious to know why you are using sweet corn and what do you envision will be the result? What do you think you are going to find out with this system?

Madar: Talking with Larry, it was suggested that sweet corn would be the best crop, but that is subject to modification. My first objective would be to find out what would be a viable living mulch crop for the Willamette Valley. After that, there is a long list of things I would like to know. For example, what happens to organic matter in the soil. I'd like to involve plant pathologists that are interested in mycorrhizae. What are the effects that a living mulch will have on soil and fungal interactions? There are some people working over in the ornamental plants lab who are talking about certain kinds of bacteria within the rhizosphere which have a beneficial effect on plants; I'd like to know what effect organic matter has on those bacteria. I'd also like to know what effects mulches have on pest insects and weeds. My second objective would concern weed management. What is the effect of living mulch systems on weed populations in the field? Do they control weeds or not? How will they work on annual versus perennial weeds?

William: How many graduate students are involved in working on your plots, Bob? Obviously, one man can't do it all, but I would suspect that a whole army could get a lot of information very quickly.

Sweet: We are only paying three, but a lot of observations are taken from our plots. There are probably six or eight graduate students taking data out of the plots. Some of the students involved are from ecology, others are from entomology, then of course, we have some of our own students involved. We had a planning session about a month ago and half the students in the room I didn't recognize. There were 16 students in the room plus four faculty members.

Anon.: It seems to me that the entomologists may be a limiting factor, because they need large plot sizes to work with. Maybe initially we should work with small plot sizes and look at compatability and survivability of the different living mulches in several cropping systems. That would be something concrete that you could work with and only have a couple of treatments. Eventually you could bring in the other people working on soils, insects or rodents. If you have a plot out there and insects or rodents are in there, you would know that they like it, but if they aren't in there, you can't say anything about it. Maybe we need more of a screening test to make some initial observations. To do all the soil parameters and all the insect parameters, you will need to narrow down the numbers of treatments and increase the size of the plots. That probably won't happen in the first year.

Appleby: I want to say something in defense of unweeded plots for us weed people. The only reason we have unweeded plots is because often the weed population is different every year and we are not sure of what the potential weed population might be in that particular year. If all your treatments are different herbicides or cultural practices you won't know how well you are doing, unless you have an idea of what the potential might have been that year had you done nothing.

Burrill: I would like to follow up on some terminology that I heard used here in an earlier exchange. You mentioned "your best practice", Harry, and Bob mentioned a "conventional practice". There might be no difference or quite a large difference, and that would be important if you were going out to sell the practice to a grower someplace. If you

give it your best shot, that may be substantially better than the traditional methods used in that region, but you may not be able to show any noticeable improvements over the old technology. Your new technology may be better or equal to what we call "farmer's practice" and yet they would be two different things. Consider cultivation, the best practice may be a four, the farmer's practice may be a two and both are entirely different ball games, biologically and economically.

Lagerstedt: I understand that, but I don't want to be out selling a practice just because it is only a little bit better, I want it to be a whole lot better before I push it.

Burrill: Yield-wise it may be a little better, but then you have all these other benefits that we have been promoting here for the last two days.

Lagerstedt: I think we are going to find lots of advantages and disadvantages to all the different practices that we impose on the system. Who knows, we may find something that will change our cultural practices as a result of locating one of these new methods.

Sweet: As for the various pests, actually, we got into this system because of weed competition work. I would say if there is anything that has been consistently beneficial with living mulches, it is that we have been able to reduce cultivations and herbicide use. By getting some kind of cover in there we have been able to reduce perennials and annuals. I don't know of a single case where we have been worse off. We may have had to change our herbicide program some, but with the change came different materials and lower rates. So, from a weed control standpoint, this practice has been a 99.9 plus percent. But we are concentrating on other aspects too. If we increase the slug population and they migrate to the cash crop, that isn't very beneficial.

William: One of the topics that Bob Sweet brought up in his presentation yesterday was that of suppression. As he suppresses the legume, in this case clover, with atrazine he is able to pick up a release of nitrogen. Are we going to be concerned about that or are we going to rely on the data that they generate at Cornell and hope that it is applicable out here? It is a question that we should consider.

Burrill: Let's go back to one of my original questions. If we were fairly easy to get along with and we came around to various departments, let's

start with the Soils Department, and say we put out a plot size that would just about fit your needs and ours, is your department going to have a graduate student or two to take some observations out there, or do we have to do it all?

Soils Dept. Rep.: I don't think I could commit anything right now. We are real short-handed and already committed, but if we were given a year or two in advance, I imagine something could be arranged. This is something we are very interested in, but to just say, let's start tomorrow, I don't see where we would find the manpower.

Burrill: How about in six months? You have just been notified. Botany? Entomology? I know you will be ready, you are always ready.

Miller: I think the university should encourage interdisciplinary research by supporting projects like this with special grant opportunities. It is a unique situation and a unique opportunity, it occurs in other places and should occur here.

Soils Dept. Rep.: The key problem is getting these things organized a year or so in advance, so that if the Soils Department is looking for a new graduate student, they can suggest this as a possible topic to work on. Providing Bob is going to be working on this topic for the next couple of years and he has narrowed it down in the first year, then you can contact departments and get things rolling for the second summer. I don't think there is any way you can get cooperation to the extent that you want in the first year.

Madar: By this time most of the graduate students are pretty well sewed up. They can't just hop off and work on something else. One of the critical areas that may be a problem right now is support for graduate students. I think that that may be a real problem for a multidisciplinary approach right now.

Miller: Larry, is it necessary to have thesis-oriented students? Couldn't you get honors students for summer work? In this particular situation most of it will be in the summer.

Burrill: At this stage we should explore every possible avenue. This is the planning stage of this program, for the next few months, until about October, and then it's time to go to work. We will have to have some pretty firm plans by then. Bob has three years to go and from his standpoint we have to get some things done. I would like to think the

program could be longer tenured than that. I guess one of my major concerns in the planning stage is efficiency and my natural love of breaking down these barriers that exist on campus. I'd like to get as much out of the work and the money as possible. As you all know, there are going to be many factors affecting what data he gathers. We are going to need help in order for us to do a complete research program. He is going to need a lot of observations outside of his area of expertise and interest. It would be a shame to waste the information that is there.

Bell: What do the extension agents feel will be some of the problems they might encounter with the growers they will be working with in initiating some of these experiments?

Brown: We are going to be real limited. We are going to have to have plots that are convenient to farmers and that is probably going to be the number one criteria. I think this means working with relatively few plant materials and fairly large-sized plots so that the grower can handle them with his conventional equipment.

William: You made a good point, Ken. I see the variety trial that we are talking about with the agents and soil conservation people as being pretty straight forward and simple. We can make some comparisons on a lot of different crops in a lot of different locations. But, what we are talking about here is really a researchable problem and I see no reason at this point to take any of it to the grower yet, we simply don't have anything to extend.

Anon.: On this combination that you are thinking of growing, corn in legumes, how about pursuing that through a rotation? What will you do after you harvest the corn? What will you do with the corn stalks? Will the legumes stay through the winter and will you plant another row crop the following season?

Anon.: What would be the possibilities, with alfalfa between the corn rows, of making a cutting the following season to use as forage before you plant your row crop?

Fox: Seventeen years ago, when I was working in the northeastern states, I saw a tall fescue sprayed down with paraquat and no-till corn planted in those fields. The tall fescue would come back up in the fall and be a

real good cover crop throughout the winter. That practice doesn't always work quite as well as you would like though.

William: I have reviewed a couple of papers on grasses being used in Kentucky. They found that such a suppression practice was somewhat stimulatory to the corn, but they didn't follow it up and find out why. I don't know whether it is the opposite of allelopathy or what. They were trying to say that it was beneficial for corn production. Timothy was tested and it looked fairly good, but not quite as good as bromegrass. Tall fescue was a little too competitive. There is a lot of research from Kentucky and Tennessee that has been done on corn and soybeans for the past 15 to 20 years. It is something that we ought to pay a bit of attention to.

Penman: I've had experience in New Zealand, with white clover in wheat rotation. The wheat was sown over the top of the white clover. You harvest the wheat and later get a white clover crop. So you get two years cropping off of one cultivation. This may be something you might want to look at, the practice of harvesting some other crop after you have taken your first crop off.

Madar: We might be constrained by the fact that this research will be designed for developing countries in the tropics. The design of it would have to fit with the kinds of practices that you would run into in a developing country.

Burrill: I would prefer to worry about coming up with a system that would be adoptable here. If we work under our conditions and then come up with a system that is usable there, all the better. That is what I call a spin-off and it would be a feather in our cap. The training that comes out of this effort is my major concern. If we also develop technology that, at least in principle, is transferable to a developing country, that is great. I don't think we have many constraints to worry about though. At this point I would like to think that we have no constraints.

Lagerstedt: Larry, I wonder if you have sought the assistance of the work department and the vegetable crops farm, they grow a lot of corn out there. It would seem to me that you might seek out a potential horticulture graduate student to help you. The Hort. Department has interests in plant spacing, competition, weed control, etc. I think it

would be a natural for a hort. graduate student who is majoring in vegetables.

Burrill: I would like to have one to three students from developing countries working with us. I will be sitting down with as many people as I can get interested in living mulch systems to continue this type of discussion and see just what they are willing to contribute in the way of knowledge and student help or whatever. I think it is wide open right now, that is why I enjoy it so much.

Booster: What is your judgement criteria going to be for determining whether you are successful or not, is it yield, product quality, forage production, or what?

Madar: It depends on what we are working with. In the case of sweet corn, I imagine it would be yield or weed suppression. It would be nice to be able to put it into an economic framework. How much does it save the growers in terms of herbicide, pesticide or fertilizer applications? Yield quality and quantity might then balance all of those different factors out.

Sweet: I'd like to add one other idea for your consideration. We are concerned about the long-term economic productivity of our soils and I really feel we owe it to the world to see if we can't come up with a system that pretty much guarantees long-term good economic productivity. We are subject to criticism on many aspects of our agriculture; it hasn't stood the test of time. The way we get our yields is by pouring our money into inputs that are costly. I feel somewhere we have to be addressing long-term stability in our agricultural systems.

Brown: I think I can back that up with an example. This is one of the things that is happening in Christmas trees. Somebody earlier mentioned how effective Christmas trees have been in this area. They have been effective for one rotation or maybe two, but on the second rotation and particularly on the third rotation we are running into some of the darnedest problems that you could imagine. We think it is associated with how we grow this crop of trees, using all that bare ground. It is a real puzzle, but it really is a relatively short-term example of the thing that you are talking about. We have to look at hundreds of years, not just ten years.

William: The component that Ken is talking about is an important one. Testing a few of these grasses out in the Christmas tree plantations will give us some variety trials worth looking at. We have the possibility of initiating a Western Regional Research Committee to come up with at least the university aspects of these living mulches. Lowell Jordan mentioned that he and Lamar Anderson were going to put a program together for perennial crops, which would include tree fruits, caneberries and perhaps grapes. Such a program might have spin-offs which could apply to other crops. We would like to know basically what kinds of needs you people have in terms of this sort of a subject. What should we be thinking about doing in the future as we start into this research?

Jim, your question on rotation was a good one. Bill Mansour and I were driving up to Salem awhile back. I got Bill so excited talking about living mulches that he almost drove off the road. Bill was talking about using an electronic guidance system on tractors. Some tractors can now be equipped with one of these electronic systems and you can pinpoint your location in the field. An interesting system of rotation could be devised whereby you rototill out a foot-wide strip within the living mulch and plant your crop. Next year you come back and move that strip over one foot. So, rather than having crop rotation on a field by field basis, you could be rotating it within the field by manipulating rows from year to year. You simply move the row over every year until you complete the field. If you are on a four-foot row spacing, you would be back to the original spot after four years in the field. That is what Vance was talking about when he mentioned precision planting. If we use our imaginations a little bit there are lots of possibilities in this practice that we can be thinking about for the future. Maybe we can meet like this again in a year or two. Any comments?

Anon.: The advantage to forming a regional committee at first strikes me as crazy, because of all the different objectives that each of us have. But there has been a very good exchange of ideas going on here for the past two days. Hopefully there is some national-type of funding to make it a little bit more legitimate.

William: It is my understanding that the experiment station gets a certain amount of money. From this there is a little bit of money set aside for an individual from each university to participate in a regional project. Lowell is talking about having a national program, so that we could have the Midwest, the East and other areas involved in exchanging ideas and information across the entire country. The regional types of projects seem to be fairly effective. OSU wouldn't be picking up any extra money. This brings up the question I think we were raising with you, Archie, what about you people participating? I think one of the key reasons for interacting in a regional program is that the OSU representative could then come back to campus and report the exchange of information that took place at the regional meeting each year.

Fisher: I realize that time is short for you on your project, Bob. What I would like to do is throw out a question to the audience that might encourage ideas on what we should consider in order to obtain some maximum spin-offs. June Madrid, from the Philippines, might have some ideas to share. June, would you have some ideas on what we could look at? In your country, if you were looking for a cover crop for a particular situation, like with a short-term crop, what would you consider?

Madrid: We would look at this in a different way, especially in developing countries, growing two crops at the same time where one crop gives a return and one is just simply killed off, isn't a luxury that we can have. If we can grow two crops that we can use at the same time, we will do it. The question that you have to ask in a screening process is which two plants can grow side-by-side to benefit each other and the farmer at the same time.

William: Other comments or questions about the conference?

Sweet: A graduate student working with me has developed a very inexpensive and accurate relative humidity sensor. We are very pleased with it. You can put it up in any location. It costs less than $5 per sensor and is wired up to a recorder. They are cheap and practically indestructable, unless you run over them with a tractor. For the first time we are getting some decent relative humidity measurements within crop canopies while the crops are developing. We are particularly

interested in white mold on beans and late blight in potatoes. Humidity also effects certain types of insects.

William: We will extend that bit of information to our pathologist friends here on campus, they are working on white and grey molds. If there are no further comments or questions we will call this meeting to a close and we will see you out in the field with some of our cover crops and evaluation sheets.

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Participants

name	address
M. Ahmedullah	Irrig. Agri. Res. & Ext. Ctr., WSU, Prosser, WA 99350
Susan Aldrich	555 SW Jefferson, Corvallis, OR 97330
Arnold Appleby	Dept. of Crop Sci., OSU, Corvallis, OR 97331
Amir Badiei	USDA-ARS, 3320 Orchard Str., OSU, Corvallis, OR 97331
Miriam Bailey	Soil Cons. Serv., OSU, Corvallis, OR 97331
Gail Barth	Coop. Ext. Serv., 2400 T Str., Vancouver, WA 98661
Susan Bell	Dept. of Hort., OSU, Corvallis, OR 97331
Rich Bonanno	Dept. of Hort., OSU, Corvallis, OR 97331
Dean E. Booster	Agr. Eng. Dept., OSU, Corvallis, OR 97331
Ken Brown	Marion Co. Ext. Ser., Salem, OR 97301
Larry Burrill	IPPC, OSU, Corvallis, OR 97331
Selma Chipenda	Dept. of Crop Sci., OSU, Corvallis, OR 97331
Tom Cook	Dept. of Hort., OSU, Corvallis, OR 97331
Garvin Crabtree	Dept. of Hort., OSU, Corvallis, OR 97331
Katherine Davenport	33935 Hwy. 99E, Tangent, OR 97389
Anne Davis	USDA-Soil Sci. Dept., OSU, Corvallis, OR 97331
Dave DeCalesta	Dept. of Fisheries & Wildlife, OSU, Corvallis, OR 97331
Tom Doerge	Dept. of Soil Sci., OSU, Corvallis, OR 9733
Herb Fisher	IPPC, OSU, Corvallis, OR 97331
S.H. Fuchs	511 NW Broadway, Portland, OR 97209
Ralph Garren	Dept. of Hort., OSU, Corvallis, OR 97331
Dan Green	256 Warner-Milne Road, Oregon City, OR 97045
Jack Gurton	Soil and Water Cons. Dist., Medford, OR 97501
Bob Hawkes	OSDA, 635 Capitol NE, Salem, OR 97310
Delbert Hemphill	15210 NF Miley Rd., Aurora, OR 97002
E.J. Hogue	Agric. Canada Res. Sta., Summerland, B.C., VOH 1Z0, Canada
David Humphrey	OSDA, 635 Capitol NE, Salem, OR 97310

Lowell Jordan	Bot. & Plant Sci., Univ. of Calif., Riversdale, CA 92502
Jan Krabbe	USDA-ARS, 3320 Orchard St., OSU, Corvallis, OR 97331
Dale Kretchman	Dept. of Hort., OSU, Corvallis, OR 97331
Harry Lagerstedt	USDA-Dept. of Hort., OSU, Corvallis, OR 97331
Scott Lambert	3420 NE Granger Ave., Corvallis, OR 97330
Orvid Lee	USDA-ARS, Crop Sci. Dept., OSU, Corvallis, OR 97331
Porter Lombard	Dept. of Hort., OSU, Corvallis, OR 97331
Harry Mack	Dept. of Hort., OSU, Corvallis, OR 97331
Bob Madar	Entomology/Crop Sci., OSU, Corvallis, OR 97331
Modesto Madrid	Dept. of Hort., OSU, Corvallis, OR 97331
Carol Maggard	Dept. of Hort., OSU, Corvallis, OR 97331
Peter B. McEvoy	Entomology, OSU, Corvallis, OR 97331
Jeff Miller	Entomology, OSU, Corvallis, OR 97331
Stan Miller	IPPC, OSU, Corvallis, OR 97331
Alex Ogg Jr.	USDA-ARS, Prosser, WA 99350
Jack O. Peterson	3420 NE Granger Ave., Corvallis, OR 97330
Bill Proebsting	Dept. of Hort., OSU, Corvallis, OR 97330
Vance Pumphrey	OSU, P.O. Box 370, Pendleton, OR 97801
Bob Rackman	2720 NW Polk St., Corvallis, OR 97330
Tom Raese	USDA Tree Fruit Res. Lab., 1104 N Western Ave., Wenatchee, WA 98801
Craig Riggert	Washington Co. Ext. Serv., Hillsboro, OR 97123
Bradford A. Robinson	505 NW 12th, Corvallis, OR 97330
Craig Selhoff	Univ. of Idaho, Parma, ID
Jack Stang	Dept. of Hort., OSU, Corvallis, OR 97331
Karen Strohmeyer	Box 430, Philomath, OR 97370
Bob Sweet	Veg. Crops Dept., Cornell Univ., Ithaca, NY 14850
Marsel Tingey	Soil Cons. Serv., Portland, OR
James A. Vomocil	Dept. of Soil Sci., OSU, Corvallis, OR 97331
Richard Wagoner	Soil Cons. Serv., 1120 S. Baker, McMinnville, OR 97128
Ed Weber	Soil Cons. Serv., 1133-S Room #18, Medford, OR 97501
Ray William	Dept. of Hort., OSU, Corvallis, OR 97330
J.L. Young	Soil Sci. Dept., OSU, Corvallis, OR 97331

Other interested persons

Lamar Anderson	Dept. of Hort., Utah State Univ., Logan UT
Joe Braun	Vancouver Exp. Sta., Vancouver, WA 98660
Ron Cameron	Pathology, OSU, Corvallis, OR 97331
Clyde Elmore	Botany Dept., Univ. of Calif., Davis, CA
Larry Hiller	Dept. of Hort., Washington State Univ., Pullman, WA 99163
Bob Logan	Douglas Co. Ext. Serv., Roseburg, OR 97470
Jim Trappe	Forest Research Lab, Corvallis, OR 97331