Weed Problems of Citrus in Belize

International Plant Protection Center

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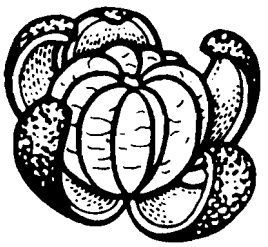

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Contents

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Summary

AID received a request from the leaders of the citrus industry in Belize for assistance in identifying more effective and economical weed control methods in their citrus groves.

In response to this request the author spent the week of April 5-9, 1982, in Belize. Two days were devoted to assessing specific weed problems and talking to growers.

The report contains a general description of the citrus industry in Belize as well as comments on the weed problems.

The request for assistance specifically mentioned climbing vines and mistletoes as serious problems. The search for chemical or biological control measures for these problems will be time consuming and will offer only limited chances of quick success.

The author suggests that a higher priority should be assigned to promoting and refining chemical control of terrestrial weeds. Widespread adoption of the already proven herbicide package will result in a marked increase in yields and profits. This, in turn, will provide an economic climate more conducive to improved cultural practices including manual control of vines and mistletoes.

Conditional support is given to a request from the citrus industry of Belize for foreign assistance to rebuild a solid research organization.

After the new research officer is established within the Citrus Growers Association, the International Plant Protection Center at Oregon State University, through the AID/OSU linkage, should be able to assist with problems related to weed control. Areas where IPPC might be of assistance are:

1. Providing weed control literature.
2. Consulting by mail about specific problems.
3. Short term visits to Belize to advise on weed problems, equipment, herbicides, or research methods.
4. Long term research and training on weed science in Belize if additional funding becomes available.

Recommendations

Foreword to recommendations

At the time of my visit to Belize reorganization within the Citrus Growers Association had created considerable confusion and specifically left the research group nearly non-existent.

Some of the following recommendations are presented in anticipation that every effort will be made by the industry to build and fund a research team worthy of the name and the industry.

I further recognize that it will be nearly impossible to find within the country a person with training and experience to provide the leadership needed to conduct a research program and support the planned extension effort.

Consequently, philosophically I would support a request from the citrus industry of Belize for foreign assistance in the formation of a new research unit. Specifically, I support a foreign agriculturist, well trained in research methods, spending an extended period in Belize to work with the newly identified research officer.

My support is given with the understanding that the industry has assigned top priority to recruiting someone to work full-time at extending improved production practices in the industry. However, I must emphasize that an extension effort, especially a young one, has the best chance to succeed when supported by an active research program.

I was alarmed to hear that consideration is being given to consolidating various commodity research programs into a central program within the Ministry of Agriculture. While this system has proven effective at the state level in the United States and is conceptually sound, it has a poor record in developing countries. Even the best people soon become unproductive in these all too often bureaucratic, political, and underfunded organizations.

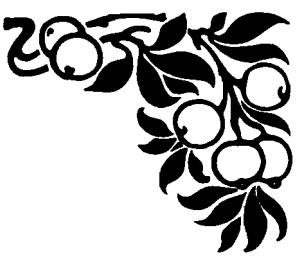
Throughout the report I make the assumption that adoption of an economical and effective weed control program resulting in increased yields will improve farmers' income. This, of course, only occurs if prices paid to growers do not drop.

The impact on the Belizean national economy due to increased herbicides importation has not been addressed in this report, nor has the impact of widespread herbicide use in the citrus industry on welfare of laborers traditionally employed to perform manual weeding.

Since over 300 of the 350 growers hold plantings of marginal size I can appreciate their reluctance to try new weed control methods. Their aversion to taking on added risks has been developed over many years. If they consider their current hand-cutting method of weed control as having no cost, then the use of herbicides is certainly an added expense and risk, albeit a small one. Without solid yield data, it is difficult to show growers why they should change.

In general, the economic health of the industry is good. This might be a time for many of the growers with small holdings to consider expansion. Growers, by increasing their holdings to an economically viable size, might find herbicides a more attractive option to the traditional hand weeding methods.

What surprised and puzzled me is the nearly unanimous refusal of the large growers to adopt what seems to me to be effective and economically sound technology. I would like to assume that with the current bright economic picture in the industry, the trickle of interest I observed will develop into widespread adoption of herbicides by larger growers. Eventual adoption by small growers is then much more likely.



Observations and recommendations

Observations	Recommendations
1. Under current management practices losses due to weeds must be very high, but I did not see any research data.	1. Start, as soon as possible, some simple, long term studies to determine effect of weeds on citrus yields.
2. Although weed growth is slower during the dry season, harmful effects due to moisture stress on citrus trees may be more severe than in the rainy season.	2. Initiate research to compare dry season weed control and rainy season control with good control all year.
3. Economically sound controls are available now for most of the weed problems, but either are ignored or performed incorrectly.	3. The Citrus Growers Association should initiate an agressive extension-demonstrative program to encourage grower adoption of herbicide program. The importance of correct and timely use of herbicides must be emphasized.
4. Even when philosphically convinced, growers may be slow to adopt herbicides due to cost of sprayers and poor understanding of principles involved.	4. If the Citrus Growers Association decides that quick and widespread adoption of herbicidal weed control is in the best interests of the industry they could offer an application service if the growers are willing to fund it.
5. Vines and parasitic weeds are difficult and expensive to control when first cleaning up a grove, but the method is effective.	5. Encourage the manual pruning of mistletoe and vines, but emphasize importance of follow-up control through use of special crews or a bounty system for harvest crews.
6. In only two days of looking at citrus trees, I came to the almost inescapable conclusion that strong, healthy trees are much more able to resist invasion by the mistletoes and epiphytes. The healthy trees were those growing in well drained areas and receiving adequate fertilizer and <u>good weed control</u>.	6. The majority of the growers are very capable <u>now</u> of adopting improved cultural practices which would improve the health and productivity of their groves and put the industry on more solid footing. New infestations of parasitic and epiphytic weeds should be greatly reduced as a result.

Observations	Recommendations
7. Some of the control methods now available for weeds on the orchard floors, as well as mistletoe, are not completely satisfactory and/or new problems will occur with time. This is the normal situation with weeds regardless of crop or country.	7. Initiate a sound, well funded research program to develop better solutions and methods. For example: a) screen new herbicides and combinations of herbicides; b) search for better application methods; c) test surfactants and other additives; d) refine time of application and herbicide rates; e) identify new weeds; f) conduct studies on biology of key weeds.
8. Blank spots in groves produce no fruit, yet when new trees are planted weed control is often ignored. Young trees are very sensitive to weed competition. Time from planting to production can be two or three times the normal five years if weeds are not controlled.	8. Make a concentrated effort to advise growers of the importance of keeping area around young trees weed-free.
9. Eventual increase in herbicide use can result in problems due to misuse such as: a) poor weed control; b) tree injury; c) health problems to applicators.	9. As part of new extension effort, develop publications and instruction programs on safe and correct use of herbicides.
10. Larger growers are primarily interested in the Citrus Growers Association as a bargaining and political arm while small growers badly need technical and mechanical services. Since the few larger growers pay the greatest share of support to the CGA, a natural conflict occurs as to the extent of services offered by the CGA.	10. While this is somewhat beyond the weed control problem I was asked to address, some of my earlier suggestions can be implemented only if there are well organized and adequately funded research and service groups within the industry.

Narrative Report

Citrus industry in Belize

Citrus ranks second to sugarcane on the list of economically important crops in Belize. The estimated value of the sugarcane crop in 1980 was US $49 million while citrus was about 8 million. A report by the American Consulate in Belize indicates that there are good prospects for the industry and strong demands from traditional customers such as Trinidad and Tobago. Since over 85% of the total production is processed into juices and concentrates, the most serious obstacle to expansion seems to be insufficient processing capacity.

All of the commercial citrus is located on the floor and foot-hills of the Stann Creek Valley and just inland from the central coast town of Dangriga. The total citrus area is little more than 25 miles across at any point. There are approximately 8,700 acres now planted to citrus. Of this, 5,760 acres or 66% is oranges and 2,940 acres or 34% is grapefruit. The acreage is divided among 350 growers, but there is a great variation in size of holdings. Fourteen growers, or 4%, control 66% of the acreage. One hundred and sixty growers have five acres or less. Ninety three have from 6 to 10 acres and 55 growers have between 11 and 20 acres. Most of these 308 growers require outside employment to meet their family's income needs.

Belize Citrus Growers Association

The citrus (Processing and Production) Ordinance of 1967 established the Citrus Growers Association with the following objectives:

a) promote growing of citrus, delivery to processors, and extension and welfare of the industry;
b) assist in settling terms and contracts for growers, processors, and labor;
c) buy, sell, and deal in fertilizer, equipment, and materials;
d) invest and deal with money of the association;
e) obtain and/or extend financial aid for members.

All of the growers are members of the Citrus Growers Association which is financed by an assessment of no more than 5-1/3 Belize cents per box of fruit delivered to the processors. The Association is governed by a Board made up of nine growers. There is also a Research Committee composed of growers, employees of the Association, staff of the Ministry of Agriculture, and miscellaneous "specialists" associated with the industry. A Citrus Control Board is responsible for negotiating with the processors for fruit prices and in regard to disputes that might rise. A Harvest Committee regulates the flow of fruit to the processors. There are about 12 paid staff of the Citrus Growers Association including a General Manager and a Research Officer. The research effort, including some long term, unfinished and unreported studies, was coming to a halt at the time of my visit due to the announced resignation of the Research Officer.

Most of the other staff of the Association are clerical, or equipment operators who conduct the fertilizer application service and mowing of weeds between tree rows.

Citrus Production

The citrus growing area has a hot and humid climate. Annual rainfall exceeds 100 inches (254 cm). The rainy season extends from May to February. Standing water reduces tree vigor and occasionally kills trees in scattered areas throughout the valley. Even during the rainy season there is ample sunlight which means conditions are ideal for weed growth. Moisture stress can occur in the citrus groves during the dry season. Hurricanes have occasionally caused heavy damage to the citrus crop, but generally cause little damage to the trees themselves.

Various planting patterns can be found in the valley, but the most common for both oranges and grapefruit is 20 feet (6 meters) between trees in both directions. This arrangement results in 100 trees per acre.

While close spacing resulting in dense shade is a valid approach to reducing weed growth, it needs careful research in the case of citrus. There is evidence that reduced air movement can lead to increased disease problems in the trees.

Citrus yields vary considerably; overall average falls below 200 boxes per acre (90 lbs/box (40.8 kg) of oranges, 80lbs/box (36.2 kg) of grapefruit). World average is 300 boxes while growers in the U.S. harvest between 400 and 600 boxes per acre.

Several serious biological problems face the citrus industry in Belize. I will list them in no particular order.

Foot rot (Phytophthora spp). This fungul disease is common in the citrus groves but the extent of tree or yield losses it causes remains unknown. It is known that the disease is introduced into the tree through wounds in the bark. In the process of cutting weeds around the trees with a machete and removing the vines growing up the trunk many wounds are inflicted on the tree trunks.

This soil-borne disease is carried to the tree when rain hitting bare soil splashes water and soil onto the tree trunk. This must be remembered and the disease should be closely monitored as increased use of herbicides result in weed-free soil under the trees.

Premature fruit drop. This is a fungul disease resulting in fruit drop very soon after pollination. The seriousness is largely dependent on weather, or probably more accurately on the air humidity around the trees. Fungicide trials have not been successful due to the low level of disease in the research area. It is possible that weed growth on the ground or in the trees could, through transpiration or by reducing air flow, lead to an increase in this disease.

Citrus nutrition. Most growers in the valley are now using commercial fertilizer. However, a large portion of it feeds weeds. Rates, time of application, and ratios of nitrogen, phosphorus, and potassium still need to be refined. Even more important is the need for lime applications. Levels of soil pH between 4.5 and 5.5 are common in the citrus groves. Phosphorus and, to a lesser extent, nitrogen and potassium are not readily available to the plants in highly acidic soils. Most growers need to start on a 5-year program of lime applications.

Replanting. Trees that die or are in poor condition are often not replaced. When they are replanted the young trees rarely receive the extra care they need.

Mexican fruit-fly (Anastrepha ludens). This potentially serious pest is presently under fairly good control as the result of a regular spray program. Growers are advised to use a mixture of the insecticide malathion and PB7 bait on a 14 day cycle. Only a small portion of every other tree in the row is treated. For a fee the Association will spray for those growers who cannot.

Weeds. As in any humid tropical environment the weed population in the citrus groves is diverse and agressive. The traditional practice in the valley is to allow weeds to become established throughout the grove. Periodic slashing with a machete is used to temporarily control weeds under the trees. A tractor drawn rotary mower cutting a 6 to 8 foot swath is generally used to set back vegetation between rows. The Citrus Growers Association will provide the mowing service to small growers for a fee. Large growers have their own equipment. The slashing and mowing operations are conducted two to four times per year depending on the judgement of the owners or managers.

Following is a list of weeds commonly found in the citrus groves. The list was prepared by Research Officer Reynold Gabourel. Mr. Gabourel has received assistance in identifying some of the weeds from Dr. John Hammerton of CARDI (Caribbean Agricultural Research and Development Institute), Mr. Bryon Adams, a British tree crop specialist, and the Weed Research Organization of England.

● SOME WEED SPECIES IN CITRUS IN BELIZE ●

* Grasses

Paspalum conjugatum
Paspalum paniculatum
Paspalum virgatum
Panicum maximum
Panicum muticum
Eleusine indica
Imperata brasiliensis
Sporobolus jaceqemonti
Setaria geniculata
Digitaria ciliaris
Cynodon dactylon
Cenchrus echinatus
Andropogon bicornis

* Sedges

Cyperus odoratus
Cyperus rotundus
Cyperus ferex

* Parasitic weeds (Mistletoes)

Struthanthus orbicularis
Struthanthus cassythoides

* Broadleaves

Ipomoea congesta
Mimosa invisa
Solanum torvum
Wedelia trilobata
Colocasia spp.
Amaranthus spp.
Revenia spp.
Petiveria spp.
Commelina spp.

* Vines

Syngonium podophyllum (Araceae family)
Cissus rhombifolia (Vitaceae family)

* Epiphytes

various orchids

Special weed problems

In addition to the "normal" weeds of the groves there are a few species that present special control problems.

Mistletoes. Seeds of these plants are commonly spread by birds, but mistletoe easily moves from tree to tree when branches of adjoining trees meet. Wherever they start in the tree they quickly make their way to the top and can form a dense canopy. In addition to severely reducing sunlight penetration to the trees the thick mat interferes with fruit harvest and reduces air flow through the trees.

Mistletoe is in the family Loranthaceae. Struthanthus orbicularis has been a problem in citrus for many years. It has larger leaves and hence forms a more dense canopy than S. cassythoides. However, the S. cassythoides is more difficult to control by the traditional hand pruning method because it forms a large haustorium wherever its branches come in contact with the citrus branches.

A severe hurricane in 1978 removed much of the S. orbicularis from the trees and it has been slow to reinfest. It is not at all uncommon however.

The common control method used by most growers is to wait until the problem is severe and then physically remove all of the vines and much of the tree. This severe pruning sets fruit production back for

about three years. Some of the growers I talked with said they are able to keep the mistletoe from infesting or reinfesting their groves by paying a "bounty" to members of the harvest crew for every mistletoe plant they bring in. A manager of one of the large farms said this system would not work for them because of the rapid turnover of workers. Small mistletoe plants are not easy to see when still hidden by tree leaves and people need some practice to become good at it.

Herbicidal control presents a special problem in that mistletoe is always growing on the tree, never on the ground (other species will and do grow in soil). If an effective herbicide could be identified it could be sprayed on the thick mats of mistletoe with very little contacting the citrus leaves. This would not be an ideal solution since the mistletoe would have to be allowed to grow unitl it was dense enough to intercept most of the herbicide and thus protect the tree. It would be much better to find a selective foliage applied herbicide, or perhaps one that could be injected into the tree to enter the mistletoe where it attaches to the tree.

During our discussions, Mr. Gabourel said that, in his tests, glyphosate had not been effective on the mistletoes. Paraquat gave good control if the foliage was thoroughly wet. Application with a mist blower did not give good results. Comment!! Inhalation of paraquat mist can cause cumulative damage to the lungs. In severe cases death will result. Paraquat should never be applied with a mist blower or a high pressure hand-gun.

None of the herbicides (including paraquat) currently recommended for use on citrus are intended to be applied to the foliage of the trees, nor is it likely that any ever will be recommended for this use. The potential sales simply do not warrant the expense and risk to the chemical companies.

It is my opinion that individual growers can afford now to initiate a program to remove existing infestations of mistletoe and to keep it out through good management and constant surveillance. The options are a known 2 to 3 year set-back in production following pruning, or doing nothing in hopes that a more satisfactory solution can be found.

During discussions with citrus specialists in Florida I was told that mistletoe, while found in Florida, is not a problem in citrus. It was speculated that frequent application of copper for disease control prevents mistletoe from becoming established. Most of the copper is applied in a form of copper sulfate. Research to determine the effect of copper on existing mistletoe is certainly warranted. However, the use of copper sulfate as a preventive measure should be approached with caution to avoid upsetting a natural balance now keeping disease problems at a relatively low level.

Biological control of mistletoe

The relatively pessimistic outlook for herbicidal control and the unusual growth habit of the mistletoe should make it a good candidate for biological control research. Whether or not there is economic justification is another question. Unless the problem is widespread in other countries, it is doubtful the expense would be warranted. At any rate, the search for a biological control agent is a long term program and control would be years away at best.

Weedy vines

Cissus rhombifolia is called "re-rooting vine" because it is able to grow adventitious roots from any part of the stem, even after the stem has been cut off. I saw this new growth at least 15 feet long high above where the parent stem had been cut off.

Syngonium podophyllum is another vine with the same characteristic. It seems to be increasingly common in groves where improved weed control is removing competition to new seedlings.

Both plants are commonly used as house plants in the United States. They are able to grow well in shaded areas. Once either of these vines become established there are only two control methods now available to the growers. The first is complete removal of the vines by hand. Anytime workers go in to remove the mistletoe they also remove all the vines.

This is obviously time consuming, expensive, and sets the trees back about three years. Also, when the machete is used to cut the vines from the tree trunk, the wounds offer an entry route for the "foot rot" disease of citrus trees.

The second method involves the use of the herbicide 2,4-D or a mixture of 2,4-D and 2,4,5-T. The system was proven effective by the research group of the Citrus Growers Association. Four to six inches of the thin bark of the lower stem is cut away. With a small paint brush a 5% solution of the herbicide mixture is painted on the cut surface. Some of the growers who have tried the method report poor results. They probably are using a stronger mixture of the herbicide which would tend to kill part of the stem too fast and before it could be moved completely through the stem. Growers also need to be reminded of the importance of removing enough of the bark to assure adequate uptake.

One grower was reported to have rid his grove of the vines with very careful applications of picloram (Tordon) to the lower leaves. Comment: While picloram is a very potent broadleaf herbicide it is sometimes discharged from the roots of treated plants and is then available for uptake by the roots of sensitive crops. Unexplained symptoms such as small deformed leaves may appear months later.

The key to successfully controlling these weeds, based on currently available information, seems to be in the follow-up after the initial control. While both weeds are resistant to most herbicides used in citrus repeated applications of 2,4-D, applied before the plants start to climb the trees, will give acceptable control. This problem is certainly worthy of additional research to look for better herbicides or other control methods.

Epiphytes

The most common epiphytes in citrus trees are various orchids. They are most prevalent in the upper end of the valley where rainfall is higher. There is no evidence that these plants directly harm the trees, although severe infestations will shade parts of the tree and interfere with normal limb development and air circulation. It is probably much more serious

that the orchids attract ants, sometimes in such numbers that harvesters will bypass a tree. No control other than physical removal is known. The epiphytes are probably a sign of orchard neglect. If the grower wants to remove them he can.

Orchard floor weed control

There is little doubt that improved weed control offers the greatest single increase in citrus yield in Belize. Even when performed on a regular schedule (which simply is not done in the valley) ring weeding with a machete cannot eliminate serious weed competition. Research in Trinidad showed that even when weeds were cut at 2 to 3 month intervals yield losses up to 50% occurred. In 2 days of looking at citrus groves, I did not see one example of satisfactory control where the machete was the only method used under the trees. My comments here will be limited to that area under the trees.

Research by the Citrus Growers Association has produced a herbicide program which offers effective, safe, and economical control of those weeds most seriously reducing citrus yields.

The program is based on the use of a tank mix of paraquat and diuron applied 3 times per year and followed as needed by spot treatments with 2,4-D to control certain broadleaf weeds and glyphosate (Roundup) to control some of the hard-to-kill grasses.

Control program recommended by the Citrus Growers Association

First year

June Paraquat • 2 pints (.5 pound active ingredient per acre)
plus
Karmex (diuron) 3 pounds of the 80% active product per acre

Followed by spot treatment with 2,4-D ester @ .75 pounds a.e. per acre on broadleaf weeds.

Followed by spot treatment with a 1% solution of Roundup on grass weeds.

September Same as above with spot treatments as needed.

January Same as above with spot treatments as needed.

The success of this approach depends on how carefully the total program is followed. The spot treatments are essential to control weeds not controlled by the paraquat and Karmex and to prevent a buildup of resistant species. For instance, the vine Syngonium podophyllum can be controlled when very young with repeated applications of 2,4-D. Once it starts up into the tree only hand removal can be used.

Experience has shown that when herbicides are used correctly the first year rates can be reduced subsequently to one pint of paraquat and 2 pounds of Karmex. The spot treatments may be reduced to one per year of each of the 2,4-D and the Roundup, but each grower should be alert for weeds not controlled. The few growers in the valley who have used the program correctly have had excellent results.

Additional herbicides

There are some relatively new herbicides now registered for use in citrus in the United States and not yet tested in Belize. All of these should be tested to determine their performance under the prevailing high rainfall conditions. Those I suggest as most promising are napropamide (Devrinol) and oryzalin (Surflan). Two others not registered yet but worthy of testing now are oxyfluorfen (Goal) and Fluazifop-butyl (Fusilade).

Weeds between rows

It is assumed throughout this discussion that farmers will continue to use a tractor drawn mower to control weeds between the rows; however, this current method is not necessarily the best.

Research with a "rope wick applicator" may show that tall weeds can be eliminated in favor of shorter, less competitive weeds. An advantage to this method would be the need for smaller tractors using less fuel and causing less soil disturbance during periods of high rainfall.

I must emphasize that any changes in management of orchard floor vegetation must be done with caution and supported by good research. Under these conditions of high rainfall and high temperatures at least a partial ground cover is essential to replenish the soil organic matter and prevent erosion. Earlier comments in this report referred to the "foot rot" disease being transmitted to trees through soil particles splashed onto the trunks. Consideration might be given to using a different kind of mower between the rows and blowing the cut weeds under the trees. This layer of mulch might discourage weed growth as well as reduce soil splashing on to the trees.

Living mulch

Weeds are serving as a living mulch in the citrus groves of Belize. Erosion is slowed, impact of vehicle reduced, and organic matter returned to the soil. The problem, of course, is that weeds reduce crop yields.

Eventually, the research team may wish to explore the possibility of planting a grass or legume species to provide the mulch benefits now derived from weeds. A thick, low-growing sod, once established, can reduce weed infestation while protecting the soil. Only research can determine the best species and whether it should be planted under the trees or just between trees. The impact of this rather drastic change in orchard flora on insect and disease problems must also be considered.

Equipment

The CP-3 and CP-15 knapsack sprayers produced by Cooper Pegler in England are available in Belize at costs of U.S. $145 and U.S. $117 respectively. These are high quality sprayers and would be a good investment by large or small farmers. When equipped with a wide-angle nozzle, they can be used to quickly and accurately apply herbicides under the trees or for spot treatments. It is recognized that carrying a sprayer full of water on one's back under tropical conditions can be uncomfortable, but certainly no more than cutting weeds with a machete.

One large grower is now using a tractor-mounted sprayer with a special side mounted boom to spray under the trees. I was told the sprayer was purchased in Florida. This is certainly the fastest and most accurate method of spraying when the initial cost can be justified. For spot treatments the sprayer can be equipped with two hoses and hand spray wands. A tractor may be at a disadvantage to the knapsack sprayer when heavy rains make the soil too soft.

I do not recommend the hand-held spinning disk sprayer for this situation in spite of the obvious advantage of using much less water and as a result being much easier to carry. Because the spray emits a circular pattern and because it is very difficult to see the spray application accuracy is hard to control.

Future research efforts could include testing of a "rope wick applicator" for controlling weeds between rows. A simple 6 to 10 foot wide rope wick "boom" could be mounted on bicycle wheels and easily pushed through the groves. Only the tall, more agressive weeds would be treated with the Roundup herbicide leaving a low growing sod to protect the soil. If effective, this method would probably be less expensive than mowing because very little herbicide is used.