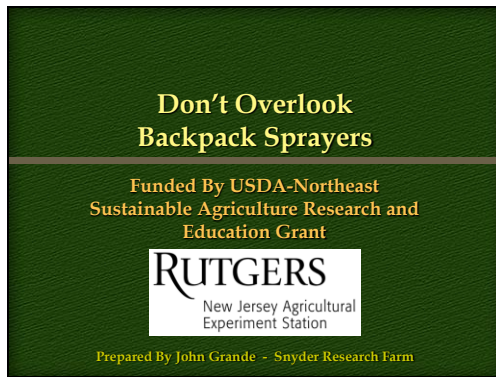


Slide 1



Introduction to the topic of backpack sprayer's – this presentation will cover several aspects of backpack sprayer's including: 1] functionality in small-scale agriculture. 2] the “disconnect” between the manufactures of backpack sprayer's, spray nozzles and accessories, liquid spray product suppliers. 3] basic sprayer calibration

Please note: not all backpack sprayer's are represented in the following presentation

Slide 2



Small-scale farmers should consider backpack sprayers for many reasons. Two major reasons are cost and the ability to intelligently alter application practices as variables present themselves in the field.

For example: missing plants, variable pest population, different row spacings.

Slide 3



Aerial view of Main complex at New Jersey Agricultural Experiment Station-- Snyder Research and Extension Farm where sprayer evaluations took place.

Slide 4

### Backpack Sprayer Features:

- Simple design
- Easy to fill & clean
- Inexpensive: buy a bunch
- Sprayer connected to brain

Backpack sprayers offer some advantages over larger tractor mounted sprayers

Slide 5

### Well Suited For:

- Less than 40 GPA applications
- Odd shaped areas: triangles, etc.
- Impediments: trees, fences, steep slopes
- Directed spraying
- Small areas: less than 1 acre
- On-going small area applications
- Spot treatments

Some spray application criteria or backpack sprayers offer the greatest benefits

Slide 6

### On Farm Evaluation



Much of the information presented is based upon small-scale agricultural evaluations by personnel with extensive small-scale farming experience.

Slide 7



Video clip demonstrates modern lightweight gasoline powered backpack sprayer providing reliable performance. Note: these types of sprayers are most appropriate for higher pressure application 30 to 100 psi

Slide 8



A video clip of a well-designed hand-operated backpack sprayer: notice operator pumping at a comfortable rate due to efficient, high capacity internally mounted piston pump with appropriate nozzle, sized for sprayer as well as pest control products requirements.

Slide 9



An overview of the various backpack sprayers obtained representing various sprayer technologies and design characteristics: Main categories represented include; hand powered diaphragm and piston pumps, gasoline powered hydraulic and air assisted, and rechargeable electric powered motors.



Slide 10



Backpack sprayer's filled with spray solution weigh 30 to 40 pounds. A comfortable and convenient carrying system is important to ensure operator comfort, reducing fatigue which enhances application practices.

Slide 11



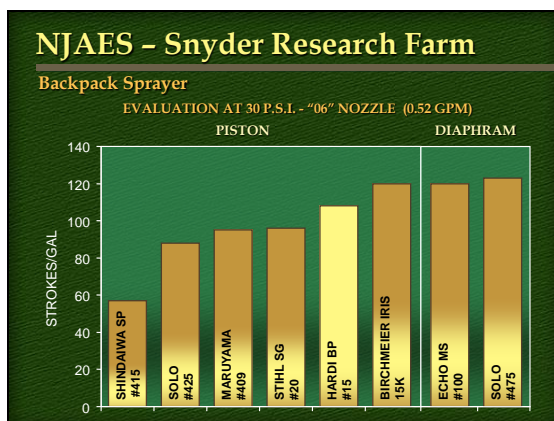
This slide is a series of four slides depicting ; 1] 2 nearly identical sprayers which substantial price differences, 2] 2 Solo sprayers - piston pump on the left , diaphragm pump on the right, 3] sprayers with a large internally mounted piston pumps. 4] sprayers with large externally mounted piston pumps

Slide 12



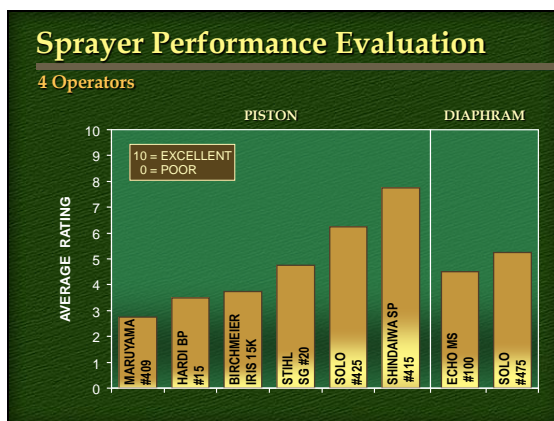
Sprayers representing less popular design characteristics – top left – modern lightweight gasoline powered assisted and hydraulic sprayers. Top right – electric motor/diaphragm pump sprayer powered by rechargeable battery [includes three preset pressure settings]. Bottom center – gasoline powered light weight sprayer with suction hose for supply tank and 50 foot discharge line with handgun for specialized applications.

Slide 13



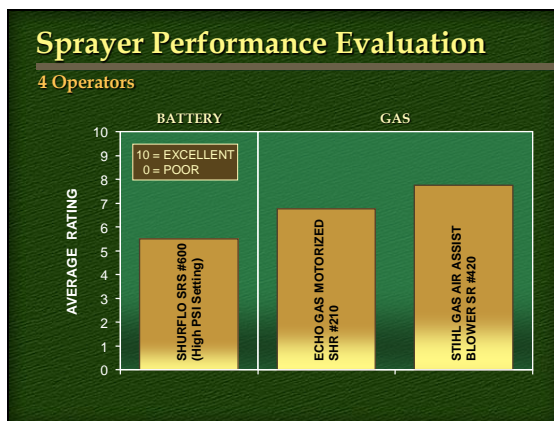
Evaluation data of hand-operated backpack sprayers representing piston and diaphragm pumps. The number of pump strokes per gallon of spray was determined for each sprayer utilizing a 30 psi pressure regulator and a nozzle producing 0.52 gallons per minute at 30 psi. The nozzle and operating pressure were selected to maximize pumping requirements. Sprayers were modified with a “Spraying Systems- TeeJet ” handle assembly as shown in slide 20

Slide 14



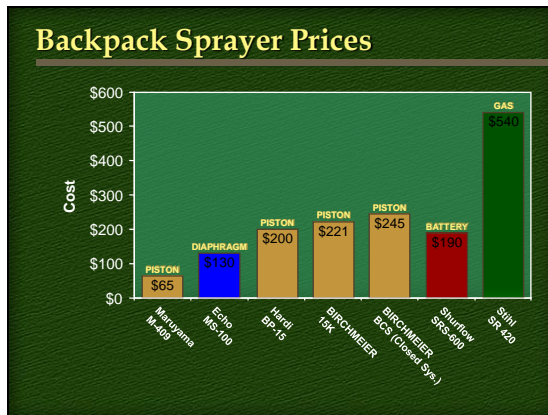
Data as the average from 4 experienced operators evaluating a selection of sprayers “in field” representing small-scale farming requirements. The operators were instructed to provide a single **evaluation number from 0 to 10 with zero being the poorest and 10 being the best**. They considered primarily application efficiency but also considered comfort , filling and clean out. Sprayers were modified with a “Spraying Systems- TeeJet “ handle assembly and CF pressure regulating valve.

Slide 15



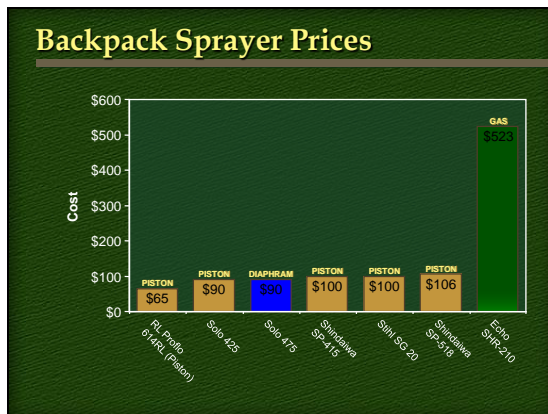
Data as the average from 4 experienced operators evaluating a selection of **motorized** sprayers “in field” representing small-scale farming. Operators were instructed to provide a **single evaluation number from 0 to 10 with zero being the poorest and 10 being the best**. They considered primarily application efficiency but also comfort ,filling and clean out. Sprayers included factory original spray handles due to the unique characteristics of each sprayer.

Slide 16



Sprayer pricing based upon retail cost—motorized sprayer generally two to three times more expensive than hand powered sprayers.

Slide 17



Sprayer pricing based upon retail cost – battery powered sprayers generally twice as expensive as hand powered sprayers with gas engine powered sprayers three to five times the cost of hand powered.

Slide 18



The “disconnect” refers to - need to combine sprayer with a wide selection of application components such as nozzles, strainers, pressure regulators, multi-nozzle assemblies etc. addressing application requirements of the multitude of liquid products small-scale farmers apply such as; compost teas, clay suspensions, emulsions etc.



Slide 19



Two sprayers represent, on **right** a **factory original sprayer** - on **left** a **sprayer adapted to Spraying Systems** – **TeeJet spray handle** components including a CF pressure regulating valve, quick change nozzle body, strainer, rubber gasket, turbo flood jet nozzle, and snap lock nozzle cap.

Slide 20



Retrofitting Spraying Systems – TeeJet spray handle assembly requires a few common tools and a few minutes – approximately \$100 in parts for conversion. The conversion allows the farmer access to all the compatible quick change nozzle bodies, nozzles, screens etc. from the manufacturer.

Slide 21



Conversion parts required for a Spraying Systems – TeeJet assembly –swivel barb is recommended preventing operator fatigue from spray hose twisting– a non-locking trigger valve is recommended to prevent accidental application from the trigger valve failing to shut off due to locking mechanism – either hose clamp works but the crimp clamp works better preventing leaks and not catching clothing.

Slide 22



Various spray handles displayed below the original factory handle of a Solo sprayer provide insight into the flexibility attained converting sprayers to a Spraying Systems – TeeJet handle assembly – various length extensions addressing operator and crop height variations are available. Curved, straight, swivel nozzle bodies, as well as plastic components allow for flexibility in application criteria.

Slide 23



The critical working end of any sprayer is the nozzle body assembly including, most importantly the nozzle itself – the parts are labeled above – please note the strainer can either be a check valve equipped strainer or a plain strainer without an anti-drip check valve. In this case the pressure regulating CF valve acts to prevent dripping when trigger valve is shut off. The lower photograph indicates the need to utilize the same nozzle cap for all nozzle designs –the following slide will more clearly address the nozzle cap issue.

Slide 24



Point out that there are many different styles of nozzle caps which are specifically designed for various nozzles but they are related to multi-nozzle boom sprayers. For backpack sprayers utilizing a single nozzle the Round nozzle cap should always be used. The reason is that it allows the nozzle to be freely rotated to align the nozzle based on operators requirements. The other nozzle caps prevent the rotation of the nozzle.





Spraying Systems – TeeJet manufacturers a wide array of nozzles addressing a multitude of various application requirements. Top left – a turbo floodjet nozzle producing a wide angle of spray generally large droplets. Works well for directed spraying and drift control. It will also spray from 3 feet to 5 feet wide depending upon height. Top right – air induction nozzle relatively new design which is starting to become popular producing spray droplets of uniform size and reducing drift. Lower left – an example of FlatFan nozzles which are very popular. The two nozzles are identical with the exception that the nozzle on the left provides an 80° angle of spray while the nozzle on the right provides 110° angle of spray. The angle of spray determines the distance the nozzle needs to be maintained in relationship to the target. The 110° nozzle can be held closer to the target to achieve the same width of spray. Lower right –twin jet FlatFan nozzle. Twin orifices dramatically change the droplet characterization compared to a single orifice nozzle. Smaller droplets will be produced while spray volume will be identical to a single orifice nozzle producing the same flow rate.



Nozzle selection for large high-volume sprayers takes into account type of material utilized for the orifice. This is not a major consideration for low volume backpack sprayers since they wear characteristics of the nozzle generally are not critical. Please note however that all plastic nozzles are very prone to damage significantly affecting sprayer performance from inadvertent dropping of the spray handle. If choices are available nozzles that have hard material are recommended.

Slide 27



Describe difference between strainers and strainer check valves. Strainers do not prevent dripping when handle valve is off while strainer check valves incorporate a spring and ball to prevent dripping. Note strainer check valves also can reduce nozzle output and sprayer calibrations need to be adjusted when used. Strainers come in different designs but most importantly they must be matched to the size of the orifice in nozzle. The basic rule is that the strainer openings must be slightly smaller than the nozzle orifice to prevent clogging. Strainers are generally listed in 25 to 100 sieve size.

Slide 28



In order to address a multitude of spray application issues including crop geometry etc. the ability to readily and simply incorporate various custom nozzle configurations is beneficial to the farmer. Such items as swivel nozzle bodies as indicated in the lower right photograph can address many different application issues. Other components such as drop nozzles etc. are available from Spraying Systems – TeeJet.

Slide 29



Liquid agricultural products come in many different formulations from emulsifiable concentrates noted above to powders compost teas etc.. Strainer and nozzle selection need to address the consistency of the sprayed material to prevent nozzle clogging coupled with accurate application.

Slide 30



Surround WP [Wettable Powder] is utilized at high concentrations in water carrier potentially clogging nozzles. Inappropriate nozzle and strainer combinations as noted on green strainer[100 mesh] left is clogged making application problematic. Red strainer [50 mesh] in middle is working properly but still showing signs of potential clogging. The white strainer [25 mesh] shows no signs of clogging. Nozzle orifice size must be slightly larger than the mesh size.

Slide 31



Spot treating weeds, insects and diseases usually results in significant applicator over application error. It is not uncommon to have 3-5 times the recommended product rates applied with backpack sprayer spot treating. Device above is a MeterJet spot treatment applicator manufactured by TeeJet Corporation. It has an adjustable chamber allowing calibration for spot treatment. Significant cost savings can be achieved with accurate spot treating as well as accurately following label directions for the product. Each pull of the trigger dispenses a predetermined amount on a predetermined area.

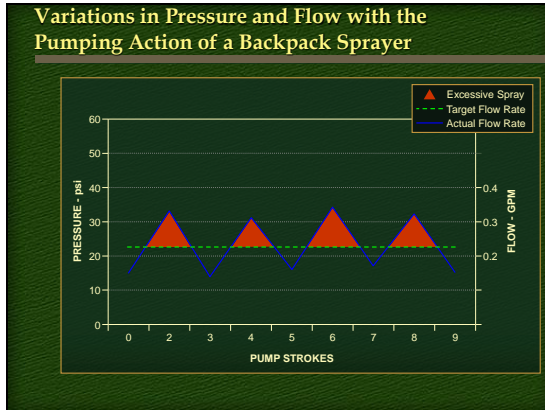
Slide 32



“Calibration Tips” - farmers are busy. Simple, quick calibration, reasonably accurate, is one method. Gravel or paved areas provide visualization of calibration such as nozzles spray swath measurements. **“Area” calibration** requires three inputs – constant speed, constant spray swath width, and constant nozzle flow rate. Other types of calibration include spraying a **percent solution** on leaf surfaces, [thoroughly wet, glistening, lightly misted, etc.]



Slide 33



Hand pump sprayer's fluctuate in pressure with up-and-down pump strokes as noted in this slide causing uneven flow rate and poor calibration. Adding a pressure regulator ensures constant flow rate an important calibration criteria. The following slide discusses pressure regulators.

Slide 34



Backpack sprayer pressure regulators vary in design and complexity; regulators on left available from some backpack sprayer manufacturers require changing color coded springs to change pressure settings. The regulators on the right are color-coded in preset pressures ;15 psi - 43 psi [CF Valve]. Most pressure regulators prevent operator from exceeding preset high limit pressure but allow spraying below preset pressure. The CF Valve prevents nozzle flow above or below set pressure increasing accuracy.

Slide 35

### Calibrating Formula

#### Sprayer Calibration Worksheet

*(fill-in the calibrated numbers)*

$$GPA = \frac{5,940 \times GPM (0.25)}{MPH (2.0) \times Width (30'')} = \frac{1485}{60} = 24.75/A$$

GPM - Gallons Per Minute  
GPA - Gallons Per Acre  
MPH - Miles Per Hour  
Width - 1 Nozzle Inches

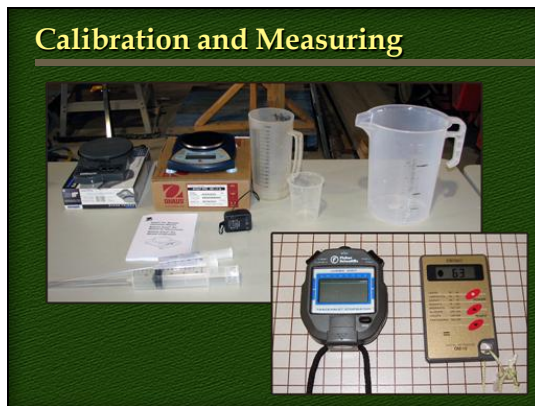
**Gallons per Acre** is a common calibration measurement for applying agricultural products. Formula represents a simple calibration method requiring **three** measurements. 1] flow of nozzle in **gallons per minute**, 2] constant speed in **miles per hour** and 3] **constant spray width**. The operator of backpack sprayers should calculate speed in the field not in a driveway, a pressure regulator is helpful to calibrate gallons per minute and holding a constant nozzle position maintains a constant spray width.

Slide 36



This slide shows the three steps of a simple calibration method [**Fill- Spray – Measure**]. First determine the spray Width of nozzle, add a known amount of water to the sprayer, flag a known area at the proper nozzle spacing, then spray area, then measure how much spray solution was utilized for the known area. For example measure a 1000 ft.<sup>2</sup> and determine ounces of spray material required. It's important to walk at a constant speed and maintain nozzle height to provide the appropriate coverage.

Slide 37



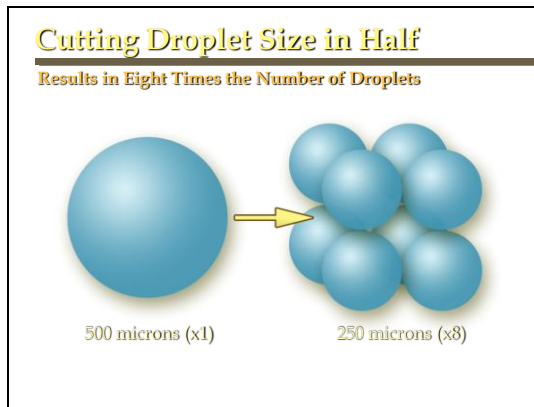
Some useful tools for calibrating sprayers – a good quality postage scale for measuring dry products, various measuring cups from a few ounces to 1 gallon. For measuring small quantities of liquids necessary for backpack sprayers plastic syringes with plastic extension tubes are inexpensive and useful. A stopwatch or a watch with a secondhand is adequate for measuring nozzle output as well as walking speeds. Metronome in lower right is handy for learning different walking speeds but not required after experience. Walking speeds for calibration with backpack sprayers max out at about 3 mph.

Slide 38



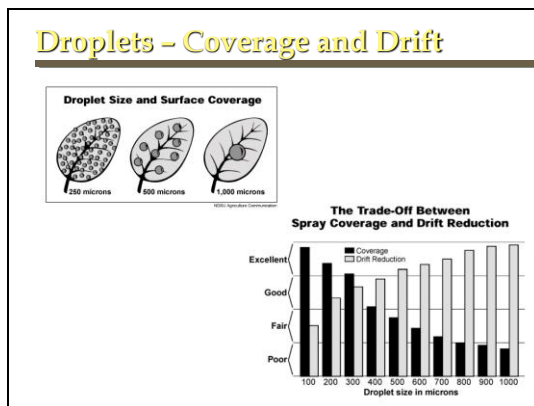
Backpack sprayers were evaluated by a team of four experienced small-scale farmers on crops of different canopy shapes.

Slide 39



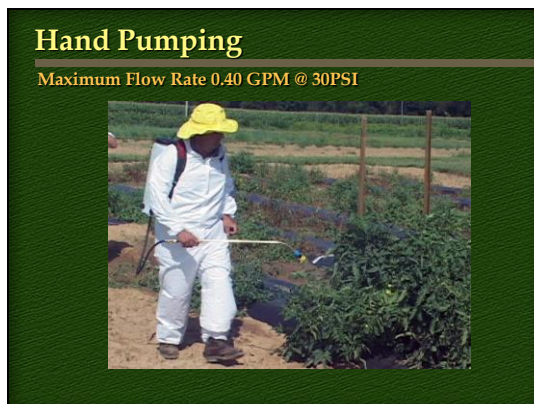
A basic spraying principle - changes in droplet size dramatically increase or decrease leaf coverage with the same quantity of water. Since backpack sprayers have limited capacity this is an important concept especially with products requiring good leaf coverage. However smaller droplets drift more.

Slide 40



Top schematic indicates leaf coverage by droplet size comparisons referred to in the previous slide. The lower schematic provides a practical comparison of spray coverage compared to drift. Where white bar and gold bar are nearly the same height is approximately 300 microns. It's drift is not a consideration as with benign products, thorough leaf coverage with finer droplets is preferred for backpack sprayers of limited capacity.

Slide 41



This video clip demonstrates hand pumping requirements for specified nozzle and pressure selections [0.40 gpm @ 30psi] that will result in operator fatigue after a short time. With small areas, for instance less than one quarter acre, operator fatigue may not be an issue. Hand pumping capacity is completely utilized with this combination of sprayer, nozzle, and pressure.



Slide 42



This video clip is compared to the previous video clip. In this demonstration a significantly smaller diameter nozzle orifice [0.25 GPM @ 30 psi] is utilized with the same sprayer. Notice the operator is pumping very infrequently to maintain pressure and appropriate nozzle flow. Operator can maintain accurate spraying for long periods of time without undue fatigue with the proper matching of spray application equipment.

Slide 43

**Shindaiwa 415 - Operator Evaluation**  
Maximum Flow Rate with Extended Operation

- 15 PSI – 0.36 GPM
- 20 PSI – 0.36 GPM
- 30 PSI – 0.25 GPM
- 43 PSI - < 0.2 GPM

This pressure flow rate table was developed having several small-scale farmers with backpack spraying experience evaluate a large, hand operated internal piston pump backpack sprayer at four preset pressures. Nozzles of different flow rates were evaluated under field conditions determining maximum nozzle flow rate, at the noted pressures, where spraying could be accomplished without undue operator fatigue. For backpack sprayers with smaller less efficient pumps and leveraging systems operator fatigue would occur.

Slide 44

**Operator Evaluation**  
Maximum Flow Rate with Extended Operation

Sprayer	Yellow CF Valve 14.5 PSI	Red CF Valve 20 PSI	Blue CF Valve 29.5 PSI	Green CF Valve 43 PSI
	Flow Rate GPM	Flow Rate GPM	Flow Rate GPM	Flow Rate GPM
Shindaiwa Model 415	0.36	0.36	0.25	< 0.20
Solo Diaphragm Model 475	0.30	0.22	< 0.25	< 0.20
Solo Piston Model 425	0.30	0.29	< 0.25	< 0.20

We tested 3 sprayers for “extended use” > than 1 hour. Chart provides maximum flow rate at 4 pressures with acceptable operator fatigue.

Slide 45

### What's My Coverage



White kaolin Clay was added to water to evaluate leaf coverage with a hand-operated backpack sprayer equipped to provide fine spray droplets in squash having dense leaf canopy. If thorough leaf coverage is required including the undersides of leaves hand operated backpack sprayers will require significant effort. Air assisted backpack sprayers may be more appropriate for these situations.

Slide 46

### Know Your Sprayer and Product Performance



A modern lightweight motorized sprayer is capable of delivering spray pressures in excess of 100 psi. If agricultural spray products require very fine misting droplets and the crop has large amounts of leaf area a motorized sprayer either hydraulic or air assisted may be a better choice than hand operated backpack sprayers.

Slide 47

### Product Coverage Requirements



Is important for the farmer to understand the mode of action and spray requirements of each product. In this case the backpack sprayer operator was moving at a pace through the field did not allowing for complete coverage of the tomato fruit and leaves. The applicator must take into account and understand the application requirements of the product and calibrate accordingly.



Slide 48

### What's The Problem Here?



Modern manufacturing techniques have allowed for improvements in air assisted backpack sprayers. Air flows 400 ft.<sup>3</sup> per minute at over 125 MPH provide horizontal and vertical coverage of over 20 feet with finally atomized spray droplets. This airflow allows for leaf movement providing better coverage of the plant interior and leaf undersides. However, as the operator raises in the spray tube the video shows a lack of spray droplets near the top of the trees. This is a result of the **LACK** of flow of liquid from the tank into the spray tube as it is raised.

Slide 49

### Solving The Problem!



The problem is solved by spraying fruit trees that are lower in height. In this case the flow of solution into the application tube is not interrupted because the operator did not have to raise the tube as vertical to treat the shorter trees.

Slide 50

### Achieving Thorough Coverage [If Needed] -- Get My Drift!



Tomatoes being treated with an air assisted backpack sprayer achieving thorough coverage. **The trade-off**; under these spraying conditions adjacent crops generally within 20 or 30 feet even with calm conditions may be inadvertently treated. If spray drift onto adjacent crops is unacceptable the farmer must compromise utilizing larger spray droplets less prone to drift that do not provide the same level of leaf coverage increasing water carrier and time required to achieve adequate results.



Slide 51



The application of plant protection products requires common sense regardless of the products being utilized. The appropriate protective equipment for the operator is mandatory and as the video indicates the operator was spraying with people harvesting crops in the same field

Slide 52



Slide 53

