control system, performing the monitor and control function with great speed and without taking time out for lunch, coffee breaks, holidays, etc. The nursery/greenhouse manager is now free to go about his/her duties.

Benefits.

— The computer performs *continuously* the monitor and control functions with speed and accuracy.

— Alarm signalling by the computer can advise the manager when his/her attention is required.

— The computer generates records of its operation for the manager.

— A print-out records events as they occur.

— Greater control of costs of production through precise and timely control; savings are commonly seen in energy (electricity, gas, fuel oil), manpower, water, fertilizers, pesticides, water treatment chemicals, etc.

— Higher quality plant materials and decreased loss of plants due to close control of the greenhouse or nursery environmental conditions.

Typical applications. Computerized control systems for nurseries and greenhouse are commercially available for:

— Mist propagation
— Hydroculture (hydroponics)
— Aeroponics
— Tissue culture/micropropagation
— Drip irrigation for pots and containerized stock
— Drip and conventional irrigation for field-grown stock
— Greenhouse environmental control

APPLICATION OF A MICROCOMPUTER IN A WHOLESALE NURSERY

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At our nursery we need to manage the complex scheduling that comes in hand with our production volume. In order to schedule the propagation of over three million plants, manage labor data of 30 employees, and handle over 100 orders a week, we gradually turned to the computer for assistance. Our first microcomputer was purchased in October, 1982. Shortly thereafter we needed another microcomputer to handle all the work that had been transferred onto the computer.

There are four basic types of programs available to use on a microcomputer: *word processing*, *spreadsheets*, *database management*, and *graphics*. We use the first three types quite extensively.

Word processing programs allow the computer to act as a very sophisticated typewriter. A document written with a word processing program is extremely flexible. The user can type a document on the keyboard, get a permanent copy, easily revise it, and print it out again.

Spreadsheet programs allow the computer to act as an electronic calculator. The user can create and print reports with formulas in different locations on the form so calculations can be performed as other values are entered. S/he can then change the formulas or manipulate different data items and see how they affect the final results. For example, the user may want to make a sheet to calculate the labor costs of planting three different plant cultivars and the amount of time it takes to plant a flat. S/he would set up the general structure of the form and enter formulas for the calculations that need to be performed (see Table 1). Once the form has been set up s/he can enter the data and print it out (see Table 2). Workers' wages may be raised from $4.25 per hour to $5.00 per hour, or a way may be found to plant pyracanthas faster. With this form the user can test to see how each change will affect the labor costs per plant (Table 3 illustrates the affect of the wage change on the cost).

Table 1. Blank form initially set up to calculate weekly labor costs per plant

Labor Rate $

Plants	plants/ flat	hours	number planted	cost/pl cents	hours/ flat
Acer				@	*
Rhododendron				@	*
Pyracantha				@	*
Total		#	#	$	

Note: The formulas represented by each symbol is listed below:

@ $\frac{\text{labor rate} \times \text{hours}}{\text{number planted}}$

* $\frac{\text{hours}}{(\text{number planted})/\text{plants/flat}}$

add the column

$ $\frac{\text{total hours} \times \text{labor rate}}{\text{total number planted}}$

Table 2. Weekly labor costs per plant

Labor rate $4 25

Plants	plants/ flat	hours	number planted	cost/pl (cents)	hours/ flat
Acer	36	30	1800	7 08	0 60
Rhododendron	72	40	5040	3.37	0.57
Pyracantha	36	10	3600	1.18	0.10
Total		80	10,440	3 26	

Table 3. Weekly labor costs per plant

Labor rate $5 00

Plants	plants/ flat	hours	number planted	cost/pl (cents)	hours/ flat
Acer	36	30	1800	8 33	0 60
Rhododendron	72	40	5040	3 97	0 57
Pyracantha	36	10	3600	1.39	0 10
Total		80	10,440	3 83	

Data base programs allow the user to store and manipulate many bits of information. They are similar to filing cabinets full of employee records. Once the records have been filed, information such as addresses, salaries, and annual tax records can be taken and used for reports or calculations. They could also handle payables or receivables. For example, suppose the user entered information about each customer, what they have on order, and what they have ordered in the past. From this information invoices and reports can be printed. The reports can include what and how much each customer has ordered in the past, what a customer has on order, who has a certain plant on order, and a list of the plants to be shipped on Friday.

Graphics programs allow the user to see a pictorial display of data s/he has entered. Often pictorial displays are easier to interpret and it is easier to see trends than with raw data.

At our nursery we have found many uses for each type of program. Below I outline some of the uses we have found for each.

We use a word processing program for any documents which change often but where the basic format and information remain the same. (We cannot do any calculations with our word processor.)

I. Word processing
   A. Letters of recommendation
   B. Business letters
   C. Price list — plant availability
   D. List of the plants we offer

Spreadsheets are also good for documents which have a basic format that doesn't change. Data can be entered on the document and calculations performed with that data.

II. Spreadsheet
    A. Sales summaries
        1. By month
        2. Comparison with previous years
    B. Cost accounting
    C. Inventory valuation
    D. Production records
        1. Yield
        2. Weekly plant counts
        3. Efficiency calculations
        4. Individual plant percentages
    E. Fertilizer calculations

There is a special advantage using the spreadsheet for production records. Our department supervisors enter the data, not the main office. Therefore we have current data and we skip the time delay required for middle management to enter this data.

We use our database management extensively, for any application where we have many records of related information.

III. Database management
    A. Reference index
        1. Search
            a. Genus
            b. Family
            c. Author
            d. Topic
        2. Print cards
    B. Plant scheduling
        1. Print out cards to show when and how many of each plant to propagate
        2. List the amounts of each plant we want to finish throughout the year
        3. Print schedules showing quantities and timing for each plant so that the right stages are ready in the right numbers and at the right time of year
    C. Order and inventory control
        1. Enter and print single or multiple orders
        2. Update inventory

3. Get reports
    a. What did customer 'X' order in March last year
    b. Who has plant 'V' on order for next month
    c. What do we need to ship on Friday
    d. What is the current inventory
    e. What does customer 'X' have on order

D. Printing special forms
    1. Phytosanitary forms
    2. Waybills
    3. Shipping labels

Although we don't have a graphics program we have managed to mimic one with the database management program to print out our shipping labels with block letters.

IV. Graphics
    A. Graphs
        1. Pie
        2. Bar
        3. Line
    B. Shipping labels
    C. Data trends

Everything we have accomplished with our microcomputer can be done by anyone with a background in high school algebra (and a little background in computer theory). However, be aware that it is an incredibly time-consuming process to get these programs running. We have been working on the database programs for over a year and a half!

New software allows different programs to be integrated with one another. Once the data have been entered they can be used by the different programs, and the user doesn't have to reenter for each type of program.

If you decide to buy a microcomputer for your business, you should buy it from a local dealer because you might have problems with the hardware (the actual computer system) or the software (the programs) and need someone nearby to answer your questions. You should first decide, however, what you want to do with a computer, then find the programs that seem most likely to do those tasks, and lastly purchase the "toys," the computer and all of its related parts which can use those programs.

Our nursery had its eleventh birthday this past July. We have grown slowly and steadily and there is one thing we

agree upon; we don't always love our computers, but we could not accomplish what we are doing without them.

PHIL BARKER: I would like to ask Gene Blythe of Monrovia Nursery about the possibility of micropropagation of sequoias. In your production program have you chosen to use cuttings rather than micropropagation?

GENE BLYTHE: Up to this point we have been using exclusively cutting propagation for the sequoia cultivars. We have been experimenting with tissue culture and feel that it will be feasible. We can produce large quantities of plants throughout the year this way, whereas with cutting propagation plants can only be produced at one time per year. Our lab is under construction now and we will be opening it in another month and at that time we will most likely begin *in vitro* propagation of sequoias, at first to supplement the cutting propagation, and later on probably to take over the propagation entirely. We find it a great advantage to stagger the production through the year.

BRUCE BRIGGS: My question has to do with a tree developing a central leader in a hurry and when it does not do this. We notice a trend with Colorado blue spruce or Douglas fir when grown from cuttings that there is a relationship between the quantity of roots and how quickly it develops a central leader. If you can get a mass of roots growing immediately you get a nice central leader. But if you get only one or two roots coming out you have to wait a few years for a mass of roots to develop before you get a central leader. Have you noticed this with sequoia?

GENE BLYTHE: No, we find that even though we may begin with material from lateral branches that we do get production of a strong leader without any problem. With 'Majestic Beauty' it does take a little bit more training than with other cultivars, but we have not run into any problems at all in developing a good central leader.

BRUCE BRIGGS: We inject chlorine into our water system for sanitation and have for many years and we also have, on the other hand, injected fertilizers, such as ammonia sulfate into the water. We can raise chlorine up to 25 parts per million, inject it through the water system, put it in a container that has soil, and take a leachate coming out of the bottom and it will remain pretty near 25 parts per million. Normally it should be zero because of the soil. My question is then does it pick up some of the other parts which are stable?

CONRAD SKIMINA: Yes. In fact, you are making monochloramine, because if you have ammonium nitrate or ammo-

nium sulfate in the liquid fertilizer in your water system, the chlorine will immediately react with the ammonium compounds. It is an almost instantaneous reaction. However, you should have the ammonia in the water first before you inject the chlorine, although that is not particularly important in your situation. It is for the cities with drinking water because they do not want to form tri-halomethanes. They have to have the ammonia in the water first before they inject the chlorine, otherwise the chlorine immediately reacts with the organic compounds and forms tri-halomethanes and then it is too late to eliminate the tri-halomethanes. So they inject the ammonium compound first, or simultaneously with the chlorine, and it is an instantaneous reaction with the ammonia, forming chloramine. You have chloramine in your water system and that is why you have the stability of the disinfection. We have used monochloramine in our water treatment plant since its inception in 1979.

VOICE: Are viruses and fungi controlled by chloramines?

CONRAD SKIMINA: Since cities are very particular about drinking water, they are going to be sure that chloramines have disinfection capabilities for bacteria and fungi. I am sure the fungi are controlled. And I know for a fact, that if you have some nematodes and put monochloramine on them, they stiffen up in 60 seconds. Nematodes are hard to kill with straight chlorine. So we know that we can kill nematodes and bacteria, as well as the fungi. Concerning the viruses, I have no information. Viruses are difficult to control. With quaternary ammonium compounds you control some viruses, but with monochloramine I really don't know.

VOICE: What effect does chloramine have on your skin compared to bleach?

CONRAD SKIMINA: Well, straight bleach would be hard on the skin because it also contains sodium hydroxide. In a diluted state, when making monochloramine, I don't think there will be a problem. I don't think it would be as bad as alcohol for drying out the skin. Of course, you might be using 1000 ppm monochloramine. When you get up to really high concentrations I do not know what the problems might be. However, I sprayed 680 ppm on plant foliage and had no phytotoxicity problems, but did find phytotoxicity with 10 ppm monochloramine dripping on one spot on one leaf continuously for a ten hour period. I did get blanching in that one spot from 10 ppm, but with just occasional exposure I don't think there will be a problem.

BRUCE LANE: I was wondering if you have considered using this chlorine to replace your 10 ppm surface chlorine solution?

CONRAD SKIMINA: Well, we can, but chlorine gas is very cheap. As a prewash water for our cuttings — we inject chlorine gas into a continuously flowing stream of water into a washtub; overflowing so we have a purging of any debris, organic matter or organisms, and a continuous replenishment of a fresh 20 ppm chlorinated solution. A tank of chlorine (150 pounds) is going to last you ages at 20 ppm. It is very cheap. It is a lot less than a penny a gallon. A tank of chlorine provides considerably more chlorine than we can use in a year. I was amazed at how little is used at that concentration.

VOICE: For a large operation you can afford to have gaseous chlorine injected, but for a small operation would you use it?

CONRAD SKIMINA: Well, it's going to cost you more for the demurrage on the tank than it is for the chlorine. The usual charge is $6 a month for demurrage. The chlorine cost is insignificant. If smaller tanks are unavailable, you are going to have to go to a sodium hypochlorite solution. That is more difficult to handle; you need injection equipment and the material is very alkaline. Or, you could go to monochloramine, as a last resort.

VOICE: What is the reliability of sensors in the computer controls?

DAVID MEGEATH: It depends. With soil moisture sensors, you will get arguments from one end of the spectrum to the other as to the reliability of them. A system like this takes maintenance. You cannot just stick a sensor out there and expect it to perform routinely for ten years. You have to monitor them on a maintenance basis. We have worked, for example, with flow meters in our computer systems, we have worked with weather stations and so on and we find that in the operation of system, maybe as often as every three to six months, you want to make sure the sensors are really operating. Now some computer systems have the ability to check on their own for malfunctioning devices. An example might be a water meter. The computer has been given a command to start irrigation somewhere and it knows that the flow meter is supposed to be spinning and giving a contact or some sort of signal, and all of a sudden there's nothing happening. The computer will lock out and say "I am not watering", and there are systems that will feed back and say "unopen valve." There's no clear answer to your question — the reliability of computers varies also.

VOICE: Are there computer programs available, prepackaged so to speak, or is this one of those deals where you have to pay unbelievable amounts of money to have someone come in and program it for you?

DAVID MEGEATH: We have both. I deal with preprogrammed packages. There are systems that you buy off the shelf that are intended for greenhouse environmental control, for hydroculture, or for irrigation. I deal primarily with the irrigation-type systems — automation. Let us consider a standard package from a service point of view of the manufacturer — you get yourself into a lot of trouble the minute you start customizing the system. With what I deal with, it is a standard package, software and hardware, so that our service technicians are able to go from Florida to Arizona to California to Hawaii to Italy and so on, and it's exactly the same package wherever they go. The only thing that is varied is the operator's programming within the limits of that software.

VOICE: Do you find a lot of problems with heat, humidity, and dust you find in the nursery with your computer systems and hardware?

DAVID MEGEATH: That is another reason for going to a device that is built for commercial control. What I deal with is all hermetically sealed units. The keypad of a small controller which is computerized is a membrane keyboard as opposed to having push-buttons, like a little calculator would be. There's a lot of thought that goes on as to what environment it has to work in. We work with mil-spec components so our components are rated at temperatures that are far in excess of the typical greenhouse range. We have systems in Arizona working, for example, on 10,000 acres of drip irrigation on cotton — and it gets hot in Gila Bend. We build in lightning protection, surge protection, etc. When you have fertilizers and acids and all sorts of wild chemicals you are spraying around the nursery, you've got to think about that. So, there are systems that address environmental problems and take care of them.

PHIL BARKER: I suppose it's fair to ask, given the fact that computers are with us and will be, what type of a track record have you built up so far showing improved productivity of crops through the use of some of these computer systems?

DAVID MEGEATH: The question is, "Do we have any track record, any documentation. We say the computer can give you all these benefits — show me, show me." My experience has been primarily with irrigation applications which basically works from containerized nursery growing on out, as I mentioned, to 10,000 acres in agriculture. The computer cannot do it by itself. This is a qualification to the answer. If

you don't have excellent hardware that the computer is operating, whether it be mist propagation or drip irrigation or whatever we are working with, we are looking at the uniformity of the complete system. To get an increase in production is possible only when the computer is hooked to a system that is of a level of technology that allows it to do its job. I have seen an application in nursery containerized growing with uniformity of plant materials that is unequaled, but that is because there is a drip irrigation system, in combination with the computer, automating the application of the water, and the application of fertilizer. The savings are there, the real increase in yield comes from the correct and proper program. You have probably all heard the phrase, "garbage in — garbage out", on computers. Eventually, sooner or later, it comes back to the operator running the computer.

SOIL MIXING FOR SMALL GROWERS

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When the current soil mixing systems were reviewed for the preparation of this report, it became readily apparent that very few changes in soil mixing systems have occurred during the past 25 years. The purpose of a soil mixing system should be to achieve a uniform blend of selected dry chemicals, or chemicals which have been placed in aqueous solution with bulk ingredients. Any system which can do this in a reasonable period of time is acceptable and probably has been used at some time in the industry.

The modified concrete mixer is the most common soil mixing machine in use in the medium sized nurseries and greenhouses. With this piece of equipment a batch type system is developed and when the ingredients are added to each batch accurately, the results are quite uniform. Some growers even steam pasteurize or fumigate their soil in these mixers. One of the major disadvantages is the relatively long mixing and unloading time which results in substantial grinding and pulverizing of the bulk ingredients. This is aggravated when either sand, pumice, or lava rock is one of the bulk ingredients.

The second most common mixing system is the use of a tractor with a bucket to blend the ingredients on a hard sur-