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IMPROVING PRODUCTION OF FRUIT FOR EXPORT

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CONTENTS

	Page
CLIMATIC FACTORS	2
Winter Cold	2
Growing Season Temperatures	4
Distribution of Rainfall	6
VARIETY ADAPTATION	8
UPGRADING NURSERY STOCK	10
NUTRITION OF FRUIT TREES	10
TRAINING AND PRUNING	13
FRUIT THINNING	15
POST HARVEST STUDIES	17
Peach Rot Control	17
Post-Harvest Treatment of Apple	20
SUGGESTIONS IN GENERAL	24
Fruit Wastage	24
Pollination Facilities	24
Land Use at Las Brujas	25
Fruit Tree Cankers	25
A Demonstration Orchard	26
Hydraircooling	26
Fruit Research Personnel	26
ACKNOWLEDGEMENTS	28
Useful References and Literature Cited	29

The problems of agricultural production in Uruguay are well documented (2, 3, 8, 13, 14, 18, 20, 25)[1/]. In earlier reports (18, 20) I too have presented such philosophies and it seems superfluous to use them again extensively in preparing another report. Peterson (25 b.) recently appraised the productivity of the Agricultural and Marketing project of the U.S. Agency for International Development. He cited the early history (1966-72) of the project and cited a decision made in 1972 as radically changing AID's approach to helping solve Uruguay's agricultural problems. Supporting the GOU's objective of increasing productivity and exportation of non-traditional crops, the Agency signed that year the Agreement La-722 with a Consortium of universities (The Pennsylvania State University, The Michigan State University and the Texas A & M University) with the aim of upgrading the research capabilities in fruit and vegetable production, thereby stimulating an industry-wide ability to produce and market internationally.

Uruguay's export market in deciduous fruits is primarily Brazil (15, 22, 23, 24). The merchandising advantages of Uruguay's nearness to that market currently are shared with no other country. It is believed, however, as has been stated (24), that for some crops such as apples and pears, the amount available for export from Argentina is a more important determinant of the level of exportation from Uruguay than is its own level of production. An example is the less-than-100 ton exportation of apples from 1968 through 1972 (15, 24) to the over-1000 ton record exportation in 1973 (24). Unless the international price is abnormal as caused by crop failure in Argentina in 1973, the high cost of production in Uruguay, including the high cost of packaging for export, prevents its fruit from consistently entering the Brazilian market in quantity (18, 24).

Several factors contribute to the high costs of production in Uruguay. Fletcher and Merrill (14) describe the protection the government gives producers through various subsidies but primarily through preventing imports of fresh deciduous fruits. "This and taxes imposed on imported pesticides and equipment have permitted 'carelessness' in the control of costs of production and of sales quality to develop." (18)

1/ The numbers within parenthesis refer to literature citations listed elsewhere in this report.

I believe that the primary determinant of production costs in Uruguay and the current low competitiveness of its fresh fruits in foreign markets is productivity: per plant, per hectare and per operator. In 1970 for example the productivity of Pennsylvania, U.S.A., orchards was calculated to be twice the level per hectare found in Uruguay (18). The higher the productivity, the lower the cost of production and marketing and the more competitive is the product. Working within the scope of my responsibilities, as defined for the pomologist assignee in the AID-PSU contract (3), I have consistently encouraged those research investigations that attack the cost of production of a fruit crop or improve its attractiveness on foreign markets.

In this termination presentation I will describe several production situations and procedures that influence cost of production and market attractiveness and will discuss the attempts of station personnel and Consortium pomologists to investigate the modification of such procedures.

CLIMATIC FACTORS

A. Winter Cold.

The most significant climatic effect on productivity of fruit trees in Uruguay results from its relatively mild winter.

The commercial orchards near Montevideo are located at the northern edge of areas generally considered suitable for production of deciduous fruits. The varieties grown in the area and their management must be governed by the trees' response to low amounts of winter cold, at least until breeding programs produce commercial cultivars that bloom and set good crops with few hours of effective cold.

The number of hours of winter cold at 7.2°C. required to stimulate uniform spring growth and bloom of deciduous fruit plants is considered quite specific in many parts of the world, in spite of recent recognition (11, 12) that temperatures near the level cited also are effective. According to the calculations of Hatch (17) and Bowen (7) and their counterparts, several peach varieties that grow and fruit more-or-less well in Uruguay would grow spasmodically or die when grown in southern U.S.A.
The variety Red Haven, for example, although not matching in Uruguay its world reputation of heavy annual productivity, often bears very profitably. It is said to require 900 hours of effective cold, whereas in Uruguay in the years 1968-75 there were never more than 700 hours registered (7) and in several years the hours were below 500. Bowen (7) estimated that even the most ideally adapted varieties Rey Del Monte and Melil'a, both of local origin, would require around 800 hours of cold by U.S. standards.

Both workers, while on assignment in Uruguay, sought means of explaining the response of various cultivars to the growing conditions of the country. Hatch proposed the use of chilling degree days calculated as the number of days:

$$\left[18^{o}C. - \frac{\text{max.temp.} - \text{min.temp.}}{2}\right]$$ for the period May through August.

He believed this measurement which included both daily maximum and minimum temperatures in its calculation would explain the situation in Uruguay and recommended it be tested in the years following.

Bowen (7) suggested the use of a reference temperature other than 7.2°C. (as has been done the last few years at Las Brujas) or better still to use the method of Erez and Lavee (11) which permits measurement of the accumulated differential effectiveness of all temperatures between 18°C. and -27°C.

Hatch and his counterpart, Ing. Formento, applied the chemicals which had been found to be effective in breaking peach-tree rest particularly in Israel (12). Little benefit resulted from the treatment the first year or upon Formento's repeat of the trials in 1974. The lack of favorable response to the trials in 1973 and observations of peach tree growth in the country led Hatch to believe that factors other than lack of chilling were causes of low productivity in Uruguay.

Bowen, from observations made during the summer of 1975-76 and from correlated studies of winter temperatures and yield records, suggested that tree vigor as influenced by pruning, thinning and nutrition may have a marked effect on tree response to winter cold or perhaps was more important than cold in influencing annual yields of some peach cultivars. Hatch in 1973 recommended and Bowen in 1976 complimented the more extensive test of varieties now being conducted by Ing. Borsani.

For only a few years have observations been made at or near Las Brujas on the results of application of spray oil to apple or pear trees before bloom. The hastening of bloom and the possible earlier harvest of fruit to result in an export period ahead of the Rio Negro Valley of Argentina is worthy of continued study. In the 1976 data exists the possibility that the earliest blooming flowers of Delicious produce fruits of the most desirable shape, see next section.

B. Growing Season Temperatures.

Compared to the more famous South American apple producing areas in Argentina and Chile, Uruguay has one tremendous climatic advantage. Fruit specialists at Las Brujas can remember no season when frost near blossoming time has reduced Uruguayan production of apples. This advantage is not without its faults. The Delicious, the chief variety of both Argentina and Uruguay and probably the world, is pictured mentally as an elongated conic fruit, distinctly crowned with 5 lobes at the calyx end. In localities where temperatures are cool and frost possible during blossoming and immediately following, the Delicious apple assumes the shape mankind has attributed to it. Most Delicious harvested in Uruguay are not of such shape but are round or oblate without prominent lobes and to the Brazilian consumer, more accustomed to shaped Delicious of Argentina, are not recognized as Delicious.

Experiments with the objective of modifying the shape of Delicious apples have been conducted in four of the past 5 years. The treatments have consisted of applications of a mixture of growth substances applied at full bloom and shortly afterwards. The formulated mixture (Amdal 3001) of Gibberellin A_4A_7 and the cytokinin benzyladenine was furnished by a U.S. company -Abbot Laboratories.

The results of the experiments in brief:

1971-72

The fruits from treated trees had larger length/diameter ratios than fruits from check trees; when data derived from a statistical model, proportioning L/D with lobe development were compared, several spray treatments yielded fruit shape statistically superior to untreated fruits; the treatments had no significant effect on fruit set and yield of trees.

1973-74

The only spray treatments applied permitted an evaluation of the effect of 2 applications of the mixture of growth substance applied near blossoming. Untreated fruits necessarily were obtained from trees outside the orchard of spray treatment.

Fruits of sprayed trees had a significantly greater L/D ratio and yielded greater values for the statistical model utilized in 1971-72.

Weight and volume per fruit were determined on fruits from sprayed and unsprayed trees following separation of the fruit into 5 sizes by diameter. Within each diameter classification fruits from sprayed trees were heavier and of greater volume than were fruits of untreated trees.

A series of measurements from the base of an apple to the point of its widest diameter and from the calyx to the same point revealed that the elongation of affected apples occurred only in the latter section.

1974-75

The experiments were conducted on the same farm as the year before but in different trees than previously used. Three replicates were on young trees and three were on rather old, low-vigor trees. Treatment and application methods were similar to those used previously.

In the records accumulated there was no statistically significant influence of treatment on fruit set or yields, although values for all the spray treatments were numerically inferior to those of the unsprayed trees. The fruit L/D ratios of all treatments except the one where two applications of 50 ppm were applied, were significantly greater than on those from unsprayed trees. The ratios of the treated fruits were around 0.86 whereas this measurement on a few Washington State Delicious purchased in the U.S. was 1.02 and on selected groups of fruits from a local orchard -where shape normally is extraordinarily good- the ratios averaged 0.97 (wood from some trees of this orchard are being vegetatively propagated at Las Brujas to determine if this superior shape is a genetic factor and therefore can be made available to all growers).

Williams (26) has stated that ratios of 1.0 or more are most desirable. Ratios below 0.9 have been considered unacceptable (19).

1975-76

In each experiment until now it always has been possible to find within any treatment fruits with L/D ratios varying widely. In two years the flower buds not open at time of spraying were removed from selected branches. Fruits remaining on these branches generally had higher L/D ratios than the tree averages. In order to determine the influence of bud development at time of treatment, modifications were made in the timing of the applications, and at each application for each tree of three of the replications, buds at full bloom, past full bloom and not yet in bloom were tagged.

Luckily there was enough set within each classification to permit some interpretation of results. Subject to a more detailed evaluation with the completion of harvest and the total analysis of results, I suspect that trees receiving three applications (at weekly intervals) will yield a higher percentage of well formed fruits than trees receiving fewer applications; that flower buds already past bloom were affected by applications but that those not yet open were not affected.

There are now sufficient data and experience available at the Las Brujas Station that recommendations regarding the commercial use of the gibberell-cytokinin mixture can be made as soon as it becomes generally available.

If more research time is available for this program I suggest that trials with the two components used separately would be of value. The gibberell is said to stimulate fruit elongation; the cytokinin stimulates the production of the lobes. It is possible that gibberell used alone would be more effective than in a mixture. The lobes formed in our trials usually have been abnormal in appearance and size. It is possible that concentration and time of application would affect the stimulation exerted by the cytokinin.

C. Distribution of Rainfall.

Fletcher and Merrill (14) reported the summer climate of Uruguay to be humid, with an average rainfall enough to grow most crops, although droughts of various durations are not uncommon during the growing season. Much of the fruit production around Montevideo is on soils somewhat heavy and shallow (by U.S. standards) with poor internal drainage (9 b.). The poor drainage no doubt limits depth and spread of roots which in turn limits the amount of moisture available to trees during the periods of drought. The commonly employed clean cultivation of orchards springs from a recognition of the need to conserve moisture against the drought periods, thereby insuring the trees' ability to carry heavy crops, and to maintain productivity and vigor. However, it is probable that the deep plowing, used to remove the weeds and to move the soil to and from the trees as drainage and conservation conditions dictate, counter-balances the conservation of clean cultivation by reducing still further the soil areas exploitable by tree roots.

I have found tree mortality and unhealthy trees to be unusually high in some orchards in Uruguay. Missing and weak trees decrease productivity. Although the direct cause of tree weakness may be attributed to sunscald, canker diseases or something else, I believe the trees fail to resist or outgrow these adversities mainly because of loss of vigor from limited rooting.

In my opinion the general lack of beneficial soil management practices that would improve drainage, improve the conservation of soil moisture and prevent erosion is among the most important of the factors retarding productivity in Uruguay. There are several wellknown soil-management systems which have these characteristics but which are not practiced in Uruguay.

Sod cover with chemical weed control in the rows. Sod is allowed to grow vigorously in the row middles when moisture is plentifull and is closely mowed when deficient. Chemical weed control in the rows eliminates practically all weed control.

Sod plus mulch. Row middles are managed as above. Organic mulch, thick enough to prevent weed growth, is spread from near the tree trunk to just beyond the periphery of the tree. In my several experiments with orchard soil management, this system generally has promoted the best growth and yields on soils a little too light, a little too heavy or a little too shallow. Drainage can be improved, especially for size-controlled trees by moving soil, prior to planting, to the tree rows so as to make the rows higher than the middles.

The economics of irrigation, especially drip irrigation, and subsurface tiling for drainage should be investigated.

An extensive, short-term experiment with seedling plants was designed in 1973 to determine the factors most responsible for early mortality and slow growth of newly set apple trees. The planting plan isolated the factors of soil drainage conditions, good planting and management methods versus careless handling methods and planting immediately after the digging of the nursery stock versus 30 days of delay. The drainage conditions were: a) moving and ridging of top soil so that the trees had abnormally great depth of well-drained top soil in which to grow; b) planting in areas from which the top soil had been removed; c) planting over a gravel-filled drainage ditch 2 feet below planting depth --to stimulate excess drainage; and d) planting in soil of normal depth for the area. The well managed trees were not root-pruned at planting, were watered after planting and were mulched with organic material to such depth as to prevent the growth of most types of weeds; the trees poorly managed had 2/3 of the roots removed at planting and received no watering or mulching; a third group received identical treatment except that only 1/3 of the roots were pruned. The sub, sub plots of the experiment permitted comparison of immediate versus delayed planting.

In the first year of growth of the experimental plants, the mulched trees, that is, those of carefully planted and managed treatment were outstandingly superior to those of any other isolatable treatment. The advantage of size and vigor of this treatment continued through 1975 when the closeness of the planting tree-to-tree was considered to have ended treatment separations and the experiment was terminated.

At least one of the larger growers in Uruguay, after observing this experiment, has commenced a mulching trial of his own. Hopefully the practice will spread. Las Brujas personnel, Talice and Canale, have commenced a larger trial comparison of mulched versus non mulched trees where moisture and nutrient availability and soil temperatures will be recorded. These trials will be beneficial but larger scale demonstrational trials are urged in order to obtain a quick appraisal-adoption of the practice.

VARIETY ADAPTATION

In the earlier discussions of the problems of rest periods and fruit shape variety adaptation was of frequent mention. New varieties of peaches are needed to extend the duration of the export market; is there a Delicious sport that has both the red color and the shape to compete with the Rio Negro Delicious? Although varieties originating from breeding programs in neighboring countries, in Europe and in other parts of the world are under test at Las Brujas, most of those imported for test within the past few years have been from the United States. Through response to AID and Consortium requests, some 35 varieties of stone fruits, over 40 varieties of apple and pear and 25 varieties of grapes have been imported since 1970 for propagation at Las Brujas. Included in these varieties are ones originating in Japan, Israel and Australia. Principal centers of supply and the assignee originating the request have been: peaches and other stone fruits -- the national virus-free repository at Pullman, Washington (Boyle, Hitz), The Texas A & M University (Bowen), Rutgers University (Hitz); apples -- Michigan State University (Carlson), Rutgers University (Hitz), Pennsylvania State University (Hitz); grapes -- The University of California, Davis (Hitz).

Among all the varieties under test, which in the 1975 propagation included also 14 from France and 43 from South Africa, may there be some that in Uruguay are characterized by good tree vitality and by high yields of exportable quality. A well-adapted variety is cheaper to grow than one only partially adapted to a climate and market.

Dr. Carlson, a short-term Consortium assignee, is a recognized international authority on the commercial utilization of size-control stocks. In his termination report (9 b.) he describes the use of dwarf rootstocks, i.e. roots which keep the mature tree at less-than-standard size. Such trees of apple and pear, are planted at greater density than standard trees. Their smaller size necessitates less powerful spray equipment and less expensive (and more efficient) harvest and pruning equipment. Such trees, when properly trained, have few shady areas per plant and when planted at the correct density have more leaves (and leaves more efficient in the synthesis of organic materials) and consequently more yield per hectare than standard trees. These higher yields can lower the costs of production to produce a more competitive product on international markets. It is unfortunate that an increasing percentage of the production of the Rio Negro Valley is coming from dwarf trees. (21)

Although I recognize well the need for Las Brujas to test the response of various dwarfing rootstocks and interstems (there are some 10-12 of recognized value in commercial use) with the varieties grown in Uruguay under Uruguayan conditions, I doubt that its production for the international market can await the proven 'best' stock-scion combination. I recommend that station personnel make an intelligent guess of the most suitable combinations and that they and their planting distances be recommended for trial plantings; else the productivity and cost-of-production advantages of the Rio Negro Valley will continue to widen over Uruguay's cost.

The specialists at Las Brujas have the responsibility of maintaining their contacts with the assignees cited earlier so that there are available to Las Brujas those new scion and rootstock varieties which are most likely to be adaptable to Uruguayan cultivation.

UPGRADING NURSERY STOCK

In 1972 I remarked (20) of the need to improve the quality of the nursery stock that is available to growers. Carlson expanded the basic premise (9 b.) and in a special report (9) prepared with Ing. Borsani, described how a certification program might work in Uruguay. In their opening paragraph the authors emphasize the role of healthy nursery trees toward affecting productivity in that "poorly propagated trees can cause problems for the fruit grower in the forms of tree losses, lack of uniformity and weak, non-productive trees."

The producers need a reliable source of true-to-name and healthy trees whether they be from a government or station-controlled nursery or through a government or nursery-financed inspection and certification program. Now, when the Las Brujas extensive testing of rootstock and scion varieties soon should be yielding recommended introductions new to both producers and nurserymen would seem a logical time to upgrade the quality of the nursery stock available for purchase.

NUTRITION OF FRUIT TREES

An important determinant of fruit tree productivity is the supply of soil nutrients available for the life processes of the tree. The key element of productivity in Uruguay as in other parts of the world is nitrogen. Trees growing under cultures supplying insufficiencies of this element show reduced fruit bearing areas and small crops of undersized fruits undesirable for export.

Among the elements considered essential for successful fruit culture, potassium is very important. The element is in ample supply in the soils surrounding Montevideo, and no doubt can or should be omitted from most fertilizer programs in Uruguay. Phosphorus is of low availability in local soils and, were not fruit trees such excellent foragers for this element, would need consideration in the fertilization program for these plants. Only a few experiments world-wide have revealed a response of fruit trees to applications of phosphorus fertilizers and these on soils totally unlike those of Uruguay.

In 1971 I helped locate and design experiments for the fertilization of apple and peaches. These probably were the first fruit tree experiments ever employed in Uruguay with a design permitting statistical analysis and interpretation of the results. Both the experiments had the primary objective of determining the level of nitrogen which would stimulate tree

productivity. In each experiment 3 or 4 levels of nitrogen applications in the form of urea were checked against a zero level treatment and one of a complete fertilizer (15% nitrogen, 15% phosphorus and 15% potassium) at a rate to supply nitrogen equivalent to one of the levels of N--plus phosphorus, plus potash.

The experiment with peaches was located in an orchard showing symptoms of nutritive shortages. Although leaf color and growth responses were evident even the first year of treatment the trial had to be abandoned after the 1972 harvest because tree mortality had confounded the statistical analyses and interpretations seriously.

Another experiment was designed in 1973 on a very uniform block of peach trees. By 1974-75 the experiment was providing evidence of the influence of both tree pruning and tree nutrition on growth and yield. In the short crop of that year the experimental trees, which were pruned much less severely than other trees in the orchard had at least twice the productivity as the classically pruned, non-experimental trees. Also the trees were responding to the nitrogen fertilization: in growth (weight of prunings), tree productivity and in nitrogen content in leaves. A more complete separation of treatment responses can be expected as more years and data accumulate.

Through the harvest season of 1975 the fertilizers applied in the apple tree experiment were stimulating no response, in trunk growth, fruit yield and size, and foliar analyses (N,P and K only). Adding potash and phosphorus to the fertilizer was of no benefit.

It is recommended that this experiment be abandoned. If after 5 years of treatment, there is no significance in response of fertilized over non-fertilized trees, it is evident that the trees, if not at their upper limits of productivity and growth for the conditions under which they grow, have factors other than their supply of nitrogen, phosphorus and potash influencing vigor and fruiting. These factors are unknown at present but are not believed to be of a nutritional nature since no visual symptoms of deficiency have been recognized. The variability among trees has increased and some have been lost perhaps due to unequal drainage as indicated by water frequently standing in some row middles. Roots damaged by the cultivation procedures have been observed yet compaction from traveling over the wet soil with tractors and sprayers is possible.

I believe that fertilization can and will have an influence upon the productivity of apple trees, especially upon the vigor and precocity of young trees. I, therefore, recommend that a new fertilizer trial should be commenced in an orchard of uniform young or newly set trees where soil depth, excess moisture and cultural methods are not likely soon to become factors limiting responses among treatments.

Treatments should be basically a measurement of the influence of nitrogen level not unlike the old experiment. In none of the experimental data accumulated thus far has there been any evidence of benefit of adding phosphorus and potash to the orchard fertilizer, which must be applied at a rate which provides the proper supply of nitrogen. Three times as much 15-15-15 as urea must be applied to supply an equivalent amount of nitrogen. Rarely is urea 3 times as expensive as 15-15-15.

I doubt that any benefit of a complete mix will be shown in the continuation of comparisons of complete versus nitrogen-only fertilizers in the orchards surrounding Montevideo. I, therefore, advise station personnel to recommend even more strongly the use of nitrogen only programs in fruit orchards. This is a relatively safe declaration since the specialists already own a great deal of data supporting the recommendations; and monitoring of experimental and grower orchards through a foliar-analysis laboratory will soon be possible in Uruguay. Such monitoring should forewarn of any difficulties developing from the utilization of this cheaper fertilizer material (per gram of nitrogen).

Minor element supply (i.e. elements other than nitrogen, potash and phosphorus) is apt to be deficient or poorly balanced with other elements in soils of the nature and pH of those surrounding Montevideo. Although I found evidence of boron deficiency (or perhaps manganese excess) as early as 1967, I did not encounter additional serious deficiencies until Dr. N.F. Childers pointed out boron deficiency during his visit to Uruguay in early 1975. Subsequently it was found to be a serious problem in several orchards and an experiment testing control method was initiated the spring of 1975 by Ing. R. Menendez. In his experiments, Menendez -who received a M.S. at Washington State University with the support of AID- is combining spray applications of boron and calcium. The latter element could be expected to enhance fruit finish and possibly protect fruit from the physiological disorder "bitter pit".

Visual symptoms of deficiencies of other elements have been identified or observed. The chlorosis of iron deficiency has been seen in the spring; magnessium deficiency could be expected, stimulated by the high levels of soil potash common to Uruguay. Apple measles, unlikely to have been caused by an excess of soil manganese under the pH conditions of Uruguay was observed in 1967 and could have resulted from a manganese-boron imbalance.

Positive confirmation of visual symptoms need await in Uruguay the installation of a foliar-analysis laboratory. For fruit trees soil analyses rarely reflect their nutritional status for the simple reason that it is practically impossible to obtain soil samples representative of the foraging areas of the roots. Most soil analyses do not correlate well with foliar analyses or with the nutritional status of the trees.

Fortunately, through support provided by AID, Uruguay is expected to have complete foliar-analysis facilities for research and for a recommendation service to growers by late 1976. It is recommended that these facilities and their specialists be utilized fully by research personnel at Las Brujas and that no attempt be made to duplicate any equipment or function of these facilities. There is so much to be done by so few people with so little financial support that the specialists and the Ministry can ill afford to duplicate any facility or function at Las Brujas or Salto that can be done elsewhere.

TRAINING AND PRUNING

An American fruit specialist traveling through the fruit areas of Uruguay always is attracted to the tree forms resulting from the traditional methods of training and pruning free-standing trees. In the U.S. a cone-shaped, central leader type tree is desired because this form exposes the greatest proportion of leaves to the sun; the typical tree of Uruguay has the shape of a baseless goblet. In the U.S. most pruning is through thinning cuts to a lateral, or by the complete removal of laterals; in Uruguay heading back cuts are common to leave trees formally level across their tops and across the orchard. Strong tree structure is sought in the U.S. by spacing wide-angled scaffold limbs vertically around the trunk; in the traditional open-vase tree of Uruguay several scaffolds originate at one point on the trunk and often are narrowly angled to the trunk and one another.

The basic objectives of training and pruning are:

to obtain structurally strong trees capable of supporting heavy crops over a long life span;

to obtain a large bearing surface per tree;

to obtain profitable production early;

to maintain trees at a size of greatest economic return; and

to maintain a balance between fruiting and growth.

The Consortium specialists assigned to Uruguay believe that most of these characteristics are found in the cone or central-leader tree or in some slight modification from it. Certainly the severe pruning of young trees as traditionally practiced in Uruguay must delay bearing, it must dwarf the trees and the goblet shape the trees assume permits the shading of many leaves. But spring

foliage develops earlier and more completely on "cut-back" limbs than on growths not shortened. (Perhaps the cutting back excites dormancy-inclined branches into growth). Perhaps the dwarfing resulting from severe pruning keeps tree tops more in balance with a root system limited in area by deep cultivation and a shallow, poorly aerated soil. Certainly heavy pruning reduces the fruit thinning that might otherwise be necessary or reduces the amount of nitrogen that need be applied, although in trying for this objective, the profits of a crop can be lost.

I doubt that the severe pruning traditional to Uruguay is the most productive. I doubt too that the vase type of tree is structurally strong enough to withstand the heavier cropping that could result from utilization of well-adapted varieties and improved cultural practices. Clear is the need of experimentation to prove the effect of tree form and severity of pruning on the productivity of fruit trees for the growing conditions of Uruguay. The controversy regarding the training and pruning to recommend will be greatly confounded by general adoption of tree dwarfing, spur-type varieties and high density plantings. These factors, as well as the general nutritional status and the soil management employed, need consideration in planning experiments in training and pruning.

In 1971 two training-pruning experiments -one on young apples, one on young peaches- were initiated. Within a short time it became necessary to abandon the apple study because of excessive tree mortality. The experimental trees were entirely of replants within a commercial block, and as such, failed to receive the care expected of new plants; also each replant may have been a replant because of the adversities the first plant had not survived at the site.

Records of trunk diameter and yields have been collected on the experimental planting of peaches each year since the experiment started. Through the harvest records of 1976, the data reveal a tree response much as would be expected in Pennsylvania. The unpruned or slightly pruned trees are larger and more productive than those trees heavily pruned, i.e. trees of the traditional vase pruning and trees severely pruned in order to maintain a particular form of tree (the Michigan side branch). Trees of the most severe pruning yielded larger fruits but smaller tonage than the lightly pruned trees. In the 1976 yield data it is noteworthy that trees trained to the "Street" system averaged the largest yields but the smallest fruits.

A program of year-to-year photography in this block has yielded a set of slides of excellent value for teaching and demonstration.

The same year that the apple experiment was terminated, I and my counterparts, not possessing enough trees and space to set up a new experiment of approved statistical design, made planting at Las Brujas where different tree trainings could be demonstrated and photographed year-by-year. Because of a lack of suitable replication in type, rootstock and tree age at planting, the growth and yields of these Delicious trees are not suitable experimental parameters. The photos and the trees themselves should continue to be good teaching and demonstration aids.

I recommend that a training block of minimum experimental size be designed for apple trees and planted as soon as possible. The differential pruning experiment with peaches should be continued but the experiment station should attempt to insure that the trees receive proper fertilizing and thinning each year -- even to the extent of underwriting the costs of these operations if necessary. It is recommended also that the scaffold selections be accomplished this year on the trees of the Street system and that the removal of unwanted scaffolds commence with the plan that it will take 3-4 years to bring the trees to the form desired.

I further recommend that the fruit specialists continue and expand their research with training and pruning. As stated previously the many innovations in tree culture (dwarf stocks, spur types, growth retardants, tree density) and their probable influence upon productivity and cost of production all demand attention from the standpoint of training and pruning.

FRUIT THINNING

The first chemical thinning experiments for the Delicious apple were designed for the growing season of 1974-75. The expected response of the variety to several thinning chemicals was considered before the growth substance naphthaleneacetic acid (NAA) was finally chosen. Of the comparative advantages and disadvantages arising from the use of this chemical, its ability to induce "come-back" blossoming in addition to its thinning action, was considered most important in regulating crop size and production costs year-to-year in Uruguay.

Because I feared over thinning on trees generally less vigorous than those of Pennsylvania, rather low concentrations of the growth substance were recommended. Because the bloom period extends over many days in Uruguay and because differential thinning action is reported for different dates of treatment (24), single applications of the material were made at 15, 20 and 25 days after full bloom.

Because in none of the treatments was fruit or crop size differing significantly at harvest from the no-application treatment, it was decided that the concentrations applied were too low. Helpful to future testing was the revelation that fruit set on selected branches on either the north or south side of the tree did not differ from set on the other side.

Experiments in chemical thinning were continued for the 1975-76 season, but at this writing the results are not available.

Many experiment stations in the U.S. recommend the insecticide Sevin in preference to NAA for thinning Delicious. As soon as possible the thinning experiments should include studies of Sevin in comparison with NAA, especially in their stimulation of "come-back" bloom, a most important aspect of fruit thinning. The other two recognized chemical thinners would seem unlikely to succeed in Uruguay: DNOC (dinitro) because it is erratic in humid areas; naphthylacetamide (NAD) because it causes too many dwarf Delicious to hang on the trees.

Peaches and plums respond well to the thinning of heavy crops with increased fruit size of improved quality and competitiveness. Bowen (7) suggests overcropping may be an important determinant of irregular annual cropping in well-adapted peach variety Rey del Monte. Chemical thinning of peaches has not been adopted in most parts of the world. This means that mechanical thinning is generally employed. Thinning by hand, if enough careful laborers can be found to cover the orchard in time, is no doubt the most reliable means of mechanical thinning. But this is several times more expensive and slower than other means of thinning mechanically. Tree shakers and systems of knocking off fruits with a pole (pole thinning) are faster, and cheaper than hand thinning; they are reasonably effective and, therefore, are widely utilized, often in combination with hand thinning, in the U.S.

Because I think it is no easier to get Uruguayan growers to hand thin than it is Pennsylvania growers, I urge that the Station re-evaluate hand with pole thinning, especially in relation to effectiveness and cost. Pole thinning is much easier to sell than is hand thinning.

In discussions of thinning with growers it is important to recommend that the thinning of early varieties start early, even at blossoming, and that the completeness of thinning be determined not by the number of fruits on the ground but by the number remaining on the trees. No more than 600-700 fruits should be carried by most peach trees -even those not severely cut back each year.

Plums are mostly still hand thinned in the U.S. The rule-of-thumb there is to thin the fruits to 2 inches apart, starting immediately after the pollination (June) drop.

In view of the conclusions by Bowen (7) regarding the importance of thinning Rey del Monte toward regulating annual productivity and because of the recognized influence of chemical thinning on saleability and annual productivity of apples, the studies with thinning must continue if the objectives of exportability are to be met.

POST HARVEST STUDIES

The determinants of exportability of any fruit crop are numerous. Of equal importance to its availability for export i.e. its production and productivity, is the ability ofthe product to survive the transport of its export and to arrive at the market place attractively priced. To attain this status the fruit must be well grown at the lowest possible cost per export unit, but not necessarily at lowest cost per acre. The cost of preparation for transport and market must be low. There is relatively small return to the entire fruit industry from flying one or two-layer containers of fancy , cell-packed fruit to distant markets. The costs are high and the demand is limited. But there is value to all producers and to the country if large quantities of quality fruit can be moved cheaply in low priced (returnable?) containers to neighboring countries.

It has been the objectives of the investigations in post harvest to provide the means by which Uruguayan fruit can survive the rigors of transport and storage to arrive in quantity at export markets at an attractive price and attractive in appearance.

Stone fruits and apples will be discussed separately.

Peach Rot Control

The peach is second only to citrus crops in its export importance and potential (2, 10, 13, 15, 22). Problems of exporting Uruguayan peaches, even the attractive, firm-fleshed Rey del Monte, have been reported, but seldom mentioned as a factor of exportability is rot susceptibility. Yet the well recognized perishibility of peaches and other stone fruits results not so much from over-ripeness as from an increasing liability to rots as softening develops. It is the rots caused by Monilinia (*Monilinia fructicola*) and Rhizopus (*Rhizopus stolonifer*) that limit the marketability and sales life of peaches.

Cold retards the growth of these fungi and refrigeration sometimes may be recommended to control the diseases. But cold does not kill the organisms and they may grow rampant when the fruit is returned to ambient temperatures. "The best interests of the peach industry are not served when refrigeration is mainly depended upon to hold rot in check." (16)

However, it was because the precooling and refrigerated transport facilities were and are not adequate to protect significant quantities of export peaches from rotting and ripening that these experiments were started. If rot could be held to around 10 percent or less without refrigeration for ten days the export market for Uruguayan peaches could be greatly increased.

The first experiments to improve the post harvest protection against rots were conducted in 1970. There were additional studies in the harvests which followed. The highlights to the experiments can be noted.

We, my fellow workers at Las Brujas and I, were among the first researchers to recognize the relatively high specificity of the fungicides Botran[1/] against Rhizopus and of Benlate[1/] against Monilinia; among the first researchers to mix solutions of the two together to use as a post harvest dip; and Las Brujas probably was the first experiment station in the world to recommend the use of baths of the fungicidal mixture for post harvest control of these two diseases. This was in 1971.

Most generally the work over the succeeding years has been with the variety Rey del Monte because of its attractive export quality. All studies were designed to permit statistical interpretation of results involving the isolatable factors: concentration of each product in a single-dip treatment; duration of the bath treatments, temperature of the baths, effectiveness of pre-harvest treatments, influence of cold storage and package types; effectiveness of the baths in preventing contact spread of the diseases and the interaction effects of several of the factors listed.

These experiments will not be discussed in great detail but several overall conclusions can be presented.

1/ Trademark names. Benlate (benomyl) is methyl 1-(butylcarbamoyl) -2-benzimidazole carbamate.
Botran (DCNA is 2,6-Dichloro-4-nitroaniline.

1. The specificity of each fungicide has been very pronounced. No beneficial effect of Benlate in controlling Rhizopus has been observed, but it is very effective against Monilinia, even in very dilute concentrations. Botran, sometimes called Dicloran, is far more effective in controlling Rhizopus than Monilinia, although it is sometimes used to control the latter.

2. Increasing the temperature of the bath increases the effectiveness of each chemical to such an extent that heat can substitute, at least in part, for the fungicides. Baths of higher than 50°C. temperature and longer than 2 minutes in duration have not been tried. The fungicidal baths have been relatively ineffective when used at precooling temperatures.

3. The effectiveness of the treatments of the fungicidal dip increases with duration of treatment. At ambient temperatures there probably is no increased value resulting from durations greater than ten minutes.

4. Both Monilinia and Rhizopus characteristically spread peach-to-peach by mycilia "nesting". The fungicidal bath is very effective in retarding mycilia growth or preventing mycilium entrance to uninfected fruits. This is of inestimable value in maintaining quality of peaches bulk-packed for export.

5. The bath treatment is outstandingly effective in controlling the rots of cold-stored peaches. It prevents the infection and rapid development of rots upon removal of the fruit from cold storage. The cold itself, if of sufficient duration, kills the larvae of several insects that spread the disease.

6. Pre-harvest application of the two fungicides offers no benefit to the post-harvest control of Rhizopus. It is doubted that a pre-harvest application can protect export fruits against the Monilinia and Rhizopus infections that they may incur during harvesting, packing and transport. A post-harvest bath treatment offers the best protection.

The described experimentation has been of great value to growers and exporters of peaches. During the just-past harvest season CALFORU -member cooperatives UFRUCA and JUMECAL are reported to have exported around 1,200 tons of peaches and plums, mostly to Brazil. Most of the peaches were shipped to processors in bulk packages (about 20 kilos each). All peaches exported were subjected to a post-harvest, Botran-Benlate bath treatment. Officials at UFRUCA reported that not a single complaint of rotten fruit was received, even from the processors purchasing their peaches in bulk packages. This is something new for the exporters of Uruguay and they can visualize a decided increase in Brazilian demand for fresh peaches.

I recommend that exporters be helped to modernize their dipping facilities. Most of the export fruit -treated this year were hand dipped in the fungicidal solutions for indefinite durations, most only momentarily it is reported. Immersion tanks, with facilities for heating the dip solution, could be constructed for which the fruits would need two or more minutes to traverse. I fear that momentary dipping in unheated solutions may not protect peaches in a season of severe infection.

Station personnel, if these post-harvest operations are continued, need investigate the effectiveness and economics of utilizing baths below 50°C. The 50°C. baths have been used in the investigations for the purpose of obtaining treatment effectiveness at reduced cost for fungicides. This temperature at a two-minute duration is believed to be near the point of damaging the skin of Rey del Monte (and has damaged Melilla). A 45°C. bath, if nearly as effective as 50°C., would provide a greater safety margin against skin damage and would require less heating. The costs of fuel and the safety and effectiveness of any fungicidal concentration will change at each modification of the bath temperature.

Post-Harvest Treatment of Apple

I believe that the Uruguayan producers of today will reap their greatest reward from their proximity to the large market that is Brazil by immediately shipping their apple harvests to that Market. The higher the cost of transport proportional to the total cost of the product, the greater is proximity-to-market advantage that Uruguayan growers have over those of Argentina's Rio Negro Valley. The more cost a Uruguayan grower has in his export product (costs arising from expensive containers, cold storage, etc.) the less is his transport cost proportional to his total costs, thus allowing the cheaper production costs of the Valley to negate the advantage of his proximity to the markets of Brazil.

This system of export marketing would mean that a large part of Uruguay's apple exportation would be in orchard-run fruit. It remains to be tested whether this would be more profitable to the individual grower than selling primarily to the domestic market.

The post-harvest studies with apples then have as much the objective of improving the quality of apples available on the domestic market over a long storage and sales season as of improving the exportability of the commodity at any time during its storage life.

The most severe post-harvest rots of pome fruits are caused by the fungi Penicillium expansum and Botrytis cinerea. Penicillium is the more common and considered the most damaging fruit rot of pome fruits; Botrytis is the fastest growing fruit rot under cold storage conditions.

Control of post-harvest rots is one phase of the post-harvest studies my counterparts and I have conducted at Las Brujas. Equal attention is given to the physiological disorder -scald, bitter pit, internal breakdown- that appear in apples of long-term storage.

The factors isolatable one or more times over the past 3 years from designs permitting statistical interpretation of results have been: fruit maturity; storage period; concentration of the fungicide Benlate[1/] and of the scald inhibitor diphenylamine[2/] mixed in a post-harvest, one dip treatment; temperature of the dip-treatment mixture; duration of the dip treatment; and the interaction effect of these, one with others.

Some of the general conclusions and beliefs can be presented without detailing specific experiments.

Penicillium generally has been easier to control than Botrytis.

There is increased control of the two diseases with increased concentration of Benlate in the bath.

Increasing the temperature of the Benlate bath up to 50°C. has so improved the effectiveness of the bath treatment that 1/4 the Benlate concentration in a 50°C bath is as effective as 800 ppm in an ambient temperature bath.

In 1974 it was found that dipping apples one day following an artificial inoculation with Penicillium provided good control of the rot. Dipping one day prior to the inoculation also was reasonably effective. But dipping more than 24 hours before or after inoculation did not yield satisfactory control. The test solution was not strong enough or warm enough (see above) to provide control of Botrytis growth even when the apples were dipped the same day they were inoculated. The effectiveness of the bath was reduced still further in inoculations made 24 hours before or after the dipping.

These data reveal that the post harvest dip can be expected to retard rot development in lesions occuring during the packing house operations, but cannot be expected to yield material control of rots initiated much before or after the bath treatment.

1/ A trade-mark name. The active agent in Benlate (benomyl) is methyl 1(butylcarbamoyl)2-benzimidazole carbamate.

2/ Commonly called DPA or DFA.

There was little effective control of either organism if the fungicide was prevented from directly contacting the inoculation. No systemic effect of the fungicide was evident.

Increasing the concentration of DPA in the treatment bath sometimes has shown interference with the action of Benlate, i.e. any concentration of Benlate may be less effective in rot control in baths containing high concentrations of DPA. The concentrations of Benlate used did not appear to have interfered with the scald-control action of DPA.

The isolates date of harvest, concentration of DPA in the dip solution and temperature of the solution have shown importance and significance as determinants of scald development. The response to these factors signifies that the greatest care for scald control must be exercised on fruits of the earliest harvests; and that product costs can be reduced by heating the treatment solution.

Delicious apples dipped in the 50°C. solutions in 1974 developed significantly less bitter pit than fruits treated at 36°C. or at ambient temperature. This effect was most marked at the highest concentration (2000 ppm) of DPA employed. An isolate of this experiment was date of harvest with significantly less bitter pit being recognized the first harvest than for others. The fact that bitter-pit development in storage usually is more serious on the samples harvested earliest would indicate that we were not measuring true bitter pit or that there was masking of the spots of pit.

In the experiment the apples of the earliest harvest when dipped in a bath of 800 ppm Benlate and 2000 ppm of DPA showed a visible residue that often was the site of skin burning during cold storage. The residue and burning were most evident on fruits dipped at 50°C. Apples damaged as described were susceptible to internal and mealy breakdown, disorders associated with over-ripeness. It is possible that the burning and the ripeness breakdowns masked the spots of pit.

The Station at Las Brujas periodically has warned growers and packers about storage rots and scald and has issued control recommendations based on our experimental results.

A disorder causing considerable deterioration of appearance in Granny Smith apples and which frequently has been incorrectly identified as storage scald is sunburn. Granny is a green apple. Any yellowing, especially that developing on one cheek only is apt to be sunburn rather than over-color (blush). This sunburn often becomes quite dark brown or black during storage and the fruit

becomes unattractive. In 1975 we commenced a photographic study of the sun damage to the Granny Smith fruit. The cheeks of some apples which had little yellow at the time of harvest developed quite large brown areas during the ambient storage following the removal of the apples from cold storage. It is recommended that the study of this disorder be continued. The response of the sunned areas to DPA treatment should be investigated. Too, I have wondered if interference with normal gas exchange -as might happen if a piece of plastic film lay tightly against a fruit for the duration of the cold storage period- might cause skin discoloration.

Other factors that could influence the appearance of the disorder would be fruit exposure during the growing season, date of harvest (fruit maturity) and duration of the cold and post storage period.

The investigational results with pome fruits cannot be so neatly packaged as with peaches. Fields that need study are:

a) Role of post harvest calcium treatments and of bath temperatures on bitter pit development and on the condition of cold stored apples.

b) How to prepare (ripen) Williams and other pears for export and domestic markets. Now that a range of storage and ripening temperatures is available with the new "walk-in" and its neighboring air-conditioned laboratory at Las Brujas, a pear-ripening procedure seems possible to develop.

c) The relation between fruit maturity of Delicious and concentration and temperature of the post harvest dip treatment with the occurrence of residue burn (see earlier section) is not yet well determined.

d) Indices of apple and pear maturity, i.e. determination of the proper harvest date for best storage life and market quality need continued study.

SUGGESTIONS IN GENERAL

This section of my report, perhaps viewed by some as being critical, is intended only to be constructive for the industry of Uruguay and its program at Las Brujas.

Fruit Wastage

I have always been appalled at the carelessness with which fruit is handled in Uruguay. At Las Brujas and on the farms there is little understanding of the extent of damage from rough handling of the individual fruits and their containers.

During harvest fruit is often dropped or tossed into a picking container sitting on the ground; soft-sided picking containers are allowed to bump against ladder rungs, and are roughly emptied into the orchard lugs; ground or drop apples are added to those hand picked. In loading onto the wagons the lugs are tossed and dropped so much that the apples bounce, sometimes to outside the containers. Orchard roads are rough, the wagons without springs, so that the fruit is rattled and bounced during the entire trip to the packing house. Often the mechanical sizers are primitive and there is insufficient protection against drops, squeezes and sharp corners.

The punishment continues through loading into storage, during transport to market and in the sales channels.

I suggest that a survey be planned to discover the extent fruits are damaged and wasted during the harvest and marketing processes. Perhaps a thousand fruits could be selected at random at several different stations: at the tree; from the orchard lugs, at the beginning and completion of packing, at the storage, etc. After selection the fruit should stand at ambient temperature long enough for bruises and cuts to discolor; then the fruit is peeled and the injuries are classified as to type and severity. Employees involved in the various operations should not know the nature of the survey.

Pollination Facilities

Although I am generally surprised, upon being in apple orchards at time of bloom, at the number of bees working the trees, I fear that in most orchards the pollination facilities are inadequate. Inadequate in that there are insufficient numbers of bees or that pollination blossoms are so far away, so few in number or so different in stage of development that they are carrying relatively little pollinating pollen to the blossoms being pollinated. Too, if bees must travel long distances from their hives, more time is spent in flight, they may be diverted to other flowering plants and there is little activity during bad weather.

I believe the fruit and entomology specialists could cooperate in setting up demonstrations or experiments illustrating the importance of arranging proper pollination facilities each spring. A procedure for this is to place a few strong hives at points widely separated in an apple orchard, but each hive near the pollinating variety. At harvest the yields at various distances from the sites of the hives can be estimated or measured.

The hives should be strong -at least 2-2½ kilos of bees per hive. Maintain the friendship of the beekeeper by avoiding the use of insecticides when the bees are in the orchard, and remove the bees immediately upon completion of the pollination season. Kill or mow flowering plants that compete with apple trees for the attention of the bees.

Land Use at Las Brujas

It is my opinion that there is at Las Brujas an excess of land planted to fruit trees that are relatively unproductive of experimental data capable of being analyzed and interpreted statistically. Although with my primary interest in post-harvest investigations I favor and recommend a production always allowing these investigations, I realize that all trees whether valuable experimentally or not need equal attention for pest control, nutrition, management and harvesting. I recommend that the plantings at Las Brujas be carefully evaluated and those that are just "standing" be removed or otherwise be made available for high priority fruit research.

Fruit Tree Cankers

Fruit-tree pathologists assigned to the Consortium program in Uruguay have been shown various cankers on apple and peach trees. The most recent of these assignees, Dr. Sam Alexander and his counterparts, identified Black Rot *Physalospora obtusa* as being common on apple and they found twig canker *Fusicoccum amygdali* which I was misnaming Brown Rot to be common on peach, especially on Red Haven. Both diseases are present in the orchards at Las Brujas as well as in commercial plantings.

I urge that the pruning crew at Las Brujas be trained to recognize these diseases and every tree with canker at Las Brujas or in experimental plots be map-located so that it is easily found for tree surgery or for testing of other control procedures whichever is appropriate. Lack of control confounds experimental data.

A Demonstration Orchard

Early in 1971 I found (18) the production skills of growers of Uruguay to be below those of growers of other countries. In that report I suggested a method of improving grower skills. Frequently discussed at that time and later among my counterparts and associates was the possibility of teaching through setting up a model planting. The IATA Loan (6 b.) now under preparation by AID and MAP at one time included the provision of a demonstrational model tree fruits.

I strongly recommend that such a demonstration be conducted. If possible it should include wherever possible comparisons of 2 or 3 of the systems believed best: in training and pruning, rootstocks, planting density, soil management system, etc. Considerable technical help might be needed in the planning and early management of such a demonstrational planting.

Hydraircooling

The most recent innovation in preparing peaches for market in the U.S. is hydraircooling. Low-temperature, high-humidity air is blown at high velocity over the fruit being chilled. The method of cooling conserves the protective fungicide that might be lost from dipped peaches hydrocooled (i.e. cooled with cold water) and yet is faster than cooling in cold storage. Fruits that are dipped in solutions heated to improve the efficacy of rot or scald control treatments may need special, fast cooling to retard ripening. It is recommended that cooling velocity studies be undertaken with the new cooling facilities at Las Brujas or from structural modifications (wind tunnels for example) fabricated from them.

Fruit Research Personnel

In my opinion the fruit staff at Las Brujas, individual by individual, is extremely talented and productive, especially in consideration of its size and the facilities at the station. Whether the staff can be increased in order to speed the improved competitiveness of fruits in foreign markets is an administrative or political decision.

Although the potentiality of earning foreign exchange from the increasing exportation of fruits and fruit products I consider very promising and worthy of increased support from governmental and international agencies, I realize that the administrators who must make the important decisions of support may not agree with me. I remind them that throughout the world the return per unit of land from fruit plantings is among the highest for any agricultural production. Fruits, of basic food and health attributes generally

remain in high demand in all important countries. It would seem important that Uruguay with its relatively small land area utilize all the land it has suitable for high value, intensive agriculture. Fruits are such a crop.

If the various research projects and grower services that are needed to make the country a center of fruit production and that production an important source of foreign exchange, expansion of personnel and programs even greater than described in this report are necessary.

The maintenance of research at or near the present level depends primarily on the ability of the CIAAB administrators to keep intact the present fruit staff at Las Brujas and provide facilities for them to do research. This too is an administrative decision. There is great risk of loss of investment and progression if the fruit research program is allowed to deteriorate.

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