FRUIT TEEE PROTECTION PROJECT IN URUGUAY

(March 1995 - February 2000)

PLAN OF EXPERIMENTS FOR FIRST YEAR (1995.3-1996.2)
(A PROPOSAL)

I. Disease control

(1) Fungal diseases on fruit

① Disease occurrence

1) Kind and occurrence of fruit diseases

In commercial orchards of large, middle and small scales of poducers and packing houses in principal citrus area of Northwest regions of Uruguay, survey on the kind of diseases and the degree of their occurrence on fruit. Moreover, collect the information on the disease occurrences on fruit at the past, spray program and their problems for disease control from the technician of orchards and packing houses.

2) Parts of overwinter of scab fungus and its infection period

In this year, experiments are carried out only on the infection period. As it is thought that fruit is susceptible from just after petal fall,study on the infection period bringing to forcus of its termination. The following experiments are designed :

(a) Artificial inoculation to fruits on trees

Select the healthy trees until last season in the field of INIA Salto Grande, spray the effective fungicide (Delan, 1,000-fold) one time of dormant stage (September) and 6 times of growing season (October to December, 2 weeks interval). After fruits grow 1 cm of their diameter, take off the fungicidal deposits on fruit surface, and inoculated artificially at every 7 days by the following method : cover fruits with thin layer of absorbent cotton dipping in macelate solution of mycelia, then cover twigs bearing the several inoculated fruits with polyethylene bag, and remove it next morning. Number of fruits used for inoculation is 30 of 3 twigs until physiological fruit dropping season and 10 of 3 twigs thereafter until mid sommer. Disease occurrence is observed on inoculated fruit and also uninoculated fruits of the same trees at every time of the inoculation.

(b) Relation of size and temperature to susceptibility of fruits

One and 2 months after the petal fall, collect different size of fruits and inoculate by the same method described above, and inculate 15, 20 and 25°C. Fruits are collected by cutting at peduncle or twig with leaves. For every plots, use 5-10 fruits.

② Diagnosis and identification of causal agents

1) Identification of the causal fungus of scab, greasy spot and Phythophthora rot.

Collect diseased leaves or fruits of different symptoms from different species and cultivers. Isolate the causal fungus from the lesions (tissue isolation and single spore isolation). Observe the morphology of isolated fungi under a optical microscope.

③ Control measures

1) Optimal time of fungicidal application to scab

In the first year, select Satsuma trees having the records of much occurrence of scab until last year, the following three experiments are conducted. Each plots of the experiments are consist of 2 trees of 3 repetitions.

(a) Reconfirmation of the effectiveness of dormant spray

Spray Benlate (2,000-fold) or Delan (1,000-fold) at dormant stage and Copper oxychloride (333-fold) at growing season. Experimental plots are as follows :

a) Dormant spray and growing season application
b) Growing season application
c) Dormant spray
d) No spray control

Time of spray is just before germination for dormant spray (September) and thereafter 2~3 times of 1 month intervals for growing season application (October to December).

(b) Survey of the effective fungicides

Other than Benlate, Carbendazol (1,430-fold) and Copper oxychloride which are usually used in Uruguay for scab control, use several kinds of fungicides of which effectiveness are already wellknown. Spray these fungicides at 3 times of 1 month intervals after germination.

(c) Possibility of the application of alarm system for control

Begin to applicate the effective fungicide (Benlate or Delan) just after germination. After first application, record the air temperature and precipitation every days. Experimental plots are as follows :

a) After first application, spray 2 times of 1 month interval
b) After first application, spray every 25 mm of precipitation
c) After first application, spray every 50 mm of precipitation
d) After first application, spray every 100 mm of precipitation
e) No spray control

Grade of disease occurrence are shown both of ratio of diseased fruit and the following disease index.

$$\text{Disease index} = \frac{1 \times n1 + 3 \times n2 + 6 \times n3}{6 \times N} \times 100$$

N:total number of fruits observed. n1, n2 and n3 are number of fruits having mild, middle and severe occurrence of lesions, respectively.

2) Application of alarm system to melanose control

Select adult trees of grapefruit and lemon which suffer severely from melanose in every year

in the fielf of INIA Salto Grande, and begin to applicate the effective fungicide after petal fall. After first application, record the air temperature and precipitation every days. Experimental plots are as follows :

a) After first application, spray 2 times of 1 month interval
b) After first application, spray every 200 mm of precipitation
c) After first application, spray every 300 mm of precipitation
d) After first application, spray every 400 mm of precipitation
e) No spray control

Use Dithane M-45 (800-fold) for application, and calculate the degree of disease occurrence by the same equation as the case of the expriment on scab (1)-③-1).

(2) Virus and virus-like disease

① Study on occurrence and transmission

1) Occurrence and damage of psorosis and other virus-like diseases

In commercial citrus orchards of principal citrus areas at Northwest region of Uruguay (Departments of Salto and Paysandu), survey on the disease occurrence and its severity, tree age, origin of plant, initiation of occurrence and some others on different cultivars.

2) Transmission of psorosis

In several citrus orchards having severe occurrence of psorosis, make a map of the plantation and survey the degree of occurrence on every trees 1 or 2 times per annum. Collect insects in these orchards which are presumed as a vector and identify them.

② Study on mild strain

1) Survey on effective mild strain of citrus tristeza virus

Collect the budwoods from both of vigorous and unvigorous trees of grepefruit. Inoculate them to Mexican lime seedlings, and observe the symptoms appeared on them.

③ Management of virus free mother trees

1) Production of plantlets by micrografting

On the clone of promising cultivars in Uruguay,continue the production of virus free plantlets in vitro by the method of micrografting already carring out.

2) Indexing for main viruses on plantlets obtained

On plantlets of the clone of promising cultivar already obtained by micrografting, continue the biological indexing on psorosis, tristeza and exocortis.

II . INSECT PEST CONTROL

(1) Forecasting technique for major pests

① Identification and classification

1) Collection of thrips and their identification

In citrus orchards the beating will be done tree by tree. Thrips that have fallen down in the board will be collected (board 30 x 45cm cover with a blue marine cotton cloth). The prepared and liquid specimen (liquid alcohol 70%) will be done. The beating will be done in the flowering time, in the petal-fall stage and in the fruit growthing period (September~November).

Dr. Masahisa Miyazaki, from the National Institute of Agroenvironmental Science Ministry of Agriculture, Forestry and Fisheries (MAFF), will be asked to identify the specimen.

2) Collection of mites and their identification

Shoots, leaves and fruits will be collected from trees in the citrus orchards. The liquid specimen (alcohol 70~80% sugar saturation) will be prepared. The recollection time will be before the shooting (July) and in the time of the fruit growth (October~December).

Mr. Fujio Kadono from the Chiba Prefectural Agriculture Experiment Station will be asked to identify the samples.

② Monitoring method

1) Seasonal prevalence of occurrence of thrips with yellow plate sticky trap and survey on rate of fruit infested

The experiment will be done in two places, in Murcott mandarin and Navel orange orchards. In each orchard will be located five yellow traps of 20cm x 20cm per hectare. Once a week or every two weeks, traps will be changed and the survey of the number of individual thrips to identify species will be done. Some of them will be done in liquid specimen. The traps will be placed from the flowering time (September) to next April.

On the other hand, the rate of fruit infested by thrips from October to next February will be investigated. In this case, in each experimental orchard 100 fruits (5 fruits x 4 trees x 5 blocks) will be chosen. The survey will be carried out once a week or every two weeks. Also a study to observe the thrips behavior in winter will be done.

2) Seasonal prevalence of occurrence of California red scale with sex pheromone trap and survey on rate of fruit infested

Experiments will be carried out in a Valencia orange orchard and one or two traps of pheromones per hectare will be placed. The trap will be changed once a week or every two weeks and the survey of the number of male adult individuals traped will be done. The traps will be placed from August to next April.

Besides, a survey of the rate of fruit infested by California red scale will be done from November to April of the next year (every 2 weeks). Other methods will be similar to those used for the thrips.

3) Population desnsities of citrus rust mite with sampling of leaves and fruits, and survey on grade of their damages

Experiments will be carried out in Valencia Orange orchards. One hundred fruits and 100 leaves/hectare will be chosen (every 2 weeks) from October to April. Leaves will be collected

and the number of mite will be observed under binoculars. In the case of the fruits, a study on the number of rust mite on its surface will be done. Two places at randon will be chosen. The observation with hand lens of 10X will be done. A study of overwintering ecology of the mite will take place. The other methods to those used for thrips will be similar.

4) Analysis of already known data of citrus whitefly in Uruguay

In Salto area of Uruguay, have already been done a survey of the number of individuals in yellow traps and in leaves between 1988 and 1994. This data will be analyzed.

(2) Integrated control

① Identification of natural enemies

1) Collection of domestic natural enemies of California red scale and their identification

In citrus orchards, fruits and branches from the places where there is population of California red scale will be collected. This material will be placed in rearing cages. The parasitic wasps emerge from the host will be collected and the prepared specimen and dry specimen will be done. Besides, in the citrus orchards where the California red scale is found, the beating in determined periods will be done. The predacious natural enemies that have fallen in the board will be collected and the dry specimen will be done.

Mr. Kazuo Takagi from the Fruit Tree Research Station, MAFF and Dr. Kazuaki Kamijo from the Hokkaido Prefectural Forest Experiment Station will be asked to identify the parasitic wasps Dr. Hiroyuki Sasaji from the Fukui University will be asked to identify other predacious ladybirds.

2) Collection of domestic natural enemies of mites and their identification

When mites population appears, the beating method will be done to collect natural enemies. Among these specimens, predacious mites will be prepared and sent to Dr. Shozo Ehara, late professor of the Tottori University, for their identification. The identification of predacious ladybirds will be asked to Dr. Hiroyuki Sasaji.

3) Collection of domestic natural enemies of thrips and their identification

In some periods, the beating method will be done in the citrus orchard to detect thrips. The natural enemies that fall down in the board will be collected.

The identification of the parasitic wasps will be asked to Mr. Kazuo Takagi and to Dr. Kazuaki Kamijo. The identification of the predacious thrips will be asked to Mr. Kazuo Takagi while the predacious mites will be identified by Dr. Shozo Ehara.

4) Collection of domestic natural enemies of citrus whitefly and their identification

In the orchards where whitefly appears, leaves will be collected and the survey on the parasitism and predation of natural enemies will be done under binoculars. Besides, the whitefly found on leaves will be put in rearing cages and the parasitic wasps emerged from the host will be collected.

② Integration of selective control measures

1) Selection of selective chemicals for thrips, mites, scale insects and whitefly

Influences of some chemicals on Phytoseiid mite, which is thought to be an efficient predaciuos mite, will be studied. The treatment method consists in applying the chemicals in the usual doses in young trees where the Phytoseiid mite appears and the beating will take place every 2, 20 and 30 days after the applications in each one of the treated trees. The beating in two places of the low part of each tree will be done. There will be a survey of the number of individuals of Phytoseiid mite and other natural enemies that have fallen in the board. Then, a survey of the number of female adult individuals found in the trees will be done. For sampling, 30 leaves of each tree (3 replications) will be done.

III. ORCHARD MANAGEMENT

(1) Improvement for tree management

① Stabilization of fruit setting

1) Fruit thinning on Satsuma

To evaluate the effect of hand and chemical fruit thinning on the number and quality of the fruits in Satsuma trees and their crop stability. Two experiment will be conducted.

(a) It will be conducted in a commercial orchard of 8 year-old Satusma cv. 'Owari' . The trees are grafted on P. trifoliata rootstock. It will be selected homogeneous trees for the experiment (vigor and productivity). It will be used the following treatments:

a) T_0: without growth regulators
b) T_1: Ethychlozate (Figaron) 100 ppm 30 days after full bloom.
c) T_2: Ethychlozate (Figaron) 100 ppm 45 days after full bloom.
d) T_3: Ethychlozate (Figaron) 200 ppm 30 days after full bloom.
e) T_4: Ethychlozate (Figaron) 200 ppm 45 days after full bloom.
f) T_5: NAA 100 ppm 20 days after full bloom.
g) T_6: NAA 100 ppm 30 days after full bloom.
h) T_7: NAA 200 ppm 20 days after full bloom.
i) T_8: NAA 200 ppm 30 days after full bloom.

(b) It will conducted in INIA-SG, with an 8 year-old Satsuma cv. 'owari' mandarin. The trees are grafted on P. trifoliate rootstock. It will be selected homogeneous trees for the expreiment (vigor and productivity) it will be used the following treatments:

a) T_0: withuot manual thinning
b) T_1: Manual thinning, fruit/leaf ratio: 1/15.
c) T_2: Manual thinning, fruit/leaf ratio: 1/25.
d) T_3: Manual thinning, fruit/leaf ratio: 1/30.

2) Promotion of fruit setting of Ellendale by ringing

The effect of ringing on Ellendale upon fruit quality and fruit number will be studied. Two milimeter wide ringing will be performed in the bark until xylem on the trunk of the trees.

Treatments:

a) T_1: Before flowering.
b) T_2: 50% of flowering.
c) T_3: 15 days after petal-fall.
d) T_4: 30 days after petal-fall.
e) T_5: 45 days after petal-fall.
f) T_6: Immediately after June-drop.
g) T_7: No ringing (control).

Three trees per treatment and 3 relications.

Note: T_2 and T_6 treatments will be applied in INIA Salto Grande; where the effects of different ringing intensities will be studied.

Measurements: Two trees from each treatment will be selected, and two - 70cm branches from each tree will be selected to measure on fruit number (after petal-fall, after June-drop and before harvest). The size of 20 tagged fruits will be measured every 15 days. In each marked branches the number and surface area of leaves (by measuring 100 leaves) will be recorded and related to the number of fruits. Canopy volume, total fruit/tree (number and weight) and fruit analysis every 15 days from April will also be registered.

3) Effect of different methods of pruning of Satsuma and Ellendale adult trees

To evaluate the effect of different types of pruning and the pruning time for Uruguay climatic condition on Ellendale and Satsuma. Two experiments will be conducted in order to evaluate the type of pruning and the pruning time.

(a) Type of Pruning in Satsuma. It will be conducted in a 4 year-old plot. It will compare in 40 trees the japanese style of prunning with the type of prunning that is used in that orchard as a control treatment. It will be evaluated productivity, stability, tree vigor, canopy volume, etc.

(b) Type of pruning in Ellendale. It will be conducted in 7 year-old Ellendale commercial orchard grafted on P. trifoliate rootstock. The plot will consist of 27 trees, 9 by treatment. It will be evaluated productivity, stability, tree vigor, canopy volume, etc.

The treatment are the following:

a) T_1: Without pruning
b) T_2: Pruning of 3 branches of 4 to 5 cm diameter
c) T_3: Pruning of 10 branches of 1 to 2 cm diameter

The pruning will be made just before sproud.

4) Tree management on different plant densities of Satsuma

The trial will be carried out on INIA Salto Grande, to study the effect of tree density on yield precocity and fruit quality.

Material to be used: Satsuma Okitsu Wase/P. trifoliata with the following treatments:

a) T_1: 4m between rows x 2m within plants.
b) T_2: 4m between rows x 2.5m within plants.
c) T_3: 4m between rows x 3m within plants.

When plant competition be observed within rows, a half of the trees will be thinned on each

treatment.

Measurements: Tree vigor, canopy volume, phenology, yield and fruit quality.

② Control of physiological disorders on fruit

1) Occurrence of creasing and splitting in orchards

To inquire the possible orchard and climatic conditions which conditioned the creasing and splitting frequency.

It is proposed to survey different orchards with high and low historical creasing and splitting occurrence. In each orchard, it will be collected data from the grower records such as damage of creasing and splitting percentage, fertilization history, etc. and from the field. In the field, it will be evaluated soil fertility, soil water holding capacity, cultivar and roostock used, nutrient foliar concentration, creasing and splitting occurrence on premature and mature fruit and climatic data if it is possible.

2) Control measures on creasing and splitting

To reduce creasing and splitting damage adjusting the nutrient (potassium and phosphorus) and water management in Washington Navel and Ellendale.

The following four experiments are conducted.

(a) It will be used adult trees of Washington Navel orange grafted on P. trifoliata. In two similar orchards with high and low creasing occurrence, it will increase one,two and three times the amount of the potassium in the soil. This will help to inquire if the K is involved in the creasing formation. It will evaluate : available K in the soil, total K in the soil, N, P, K foliar concentration, fruit growth and anatomy and creasing occurrence.

(b) It will be used adult trees of W. Navel grafted on P. trifoliata. The trees will be fertilized with a standard rate of potassium, nitrogen and phosphorus fertilizer. The half of these will be water stressed in order to reduce the potassium assimilation by the roots during the period of fruit peel formation, the other half of the trees will be well watered. It will be evaluated : available K in the soil, soil water depletion, tree water status, fruit growth, creasing occurrence, etc.

(c) It will be used adult W. Navel trees in an orchard of high historical occurrence of creasing. The plot will consist of 30 trees. In 15 of them, it will aplly 30 ppm of Gibberellic Acid (AG3) in December, in the other 15 trees will apply nothing. It will evaluated creasing occurrence in different fruit growth stages.

(d) Eight year-old trees of Ellendale grafted on P. trifoliata rootstock will be subjected to a soil water stress. The stress will be established for 6-10 days in a soil water depletion of 1/3 of water availability. After this the plants will be rewatered. The stress will be established in February or March. It will be evaluated soil water status, plant water status, fruit growth, fruit number, splitting occurrence, etc.

3) Influence of fruit handling and chemical treatment after harvest to improve fruit quiality

To determine the influence of fruit handling from harvest to consumers, leading to a maximus fruit conservation and quality. The following different experiments are conducted.

(a) Evaluation of temperature and RH during different stages of fruit handling after harvest

Fruit temperature and RH will be measured at different moments : ① before degreening, ② during degreening, ③ after degreening (storage room). Two measurements (temperature and RH) will be performed in each packinghouse during the harvesting period.

Repetitions : 3 packinghouses. Evaluations : Rind puffing will be rated as 0,1,2,3 from firm touch (0) to severe (3) by feeling in finger over the fruit.

(b) Injury assessment in citrus harvesting operations

Physical injury detection after harvest will be performed by using the dye 2,3,4-tryphenyl-2H-tetrazolium chloride (TTC). TTC is a water soluble powder which becomes insoluble and turns bright red when it comes in contact with freshly exposed (injured) tissues.

Four to 20 citrus fruit samples will be placed in a 0.5 % TTC, collected : ① after harvest immediately, ② before dumping in the packinghouse line and ③ after run in the packing line.

Repetitions : 3 packinghouses. Evaluations : ① stained spots, ② cuts and scratch marks and ③ bruises.

Injuries will be classified in the following categories : ① sound, ② slight, ③ moderate and ④ severely injured.

(c) Evaluation of corpuscular calcium carbonate to control of rind puffing of Satsuma

Three applications times : ① before fruit coloration, ratio<6, ② when 10-20% of the fruit rind was colored, ratio >= 7,<10 and ③ when 50 % of the rind fruit was colored, ratio>10-12.

Concentrations : Corpuscular calcium carbonate (Clefnon) : 1 and 2 %. Four mature trees/each treatment + control and 3 repetitions.

Evaluations : ① % rind puffing at harvest and 1 month after harvest at 6°C and/or in shelves conditions, ② degree of rind color, 0 = green, 10 = orange, ③ specific gravity of fruit, ④ thickness of the rind, ⑤ moisture content of the rind, ⑥ rind/weight ratio and ⑦ evaluation of possible chemical injuries to the rind.

③ Determination of optimal time for harvest and yield prediction

1) Modeling fruit growth and quality for different cultivars

To evaluate the fruit growth and fruit quality under different environmental and orchard conditions in order to predict fruit size and quality for different cultivars.

It will be conducted in plots of Satsuma, W. Navel, Ellendale and Valencia. Three trees by cultivar will be used. Each sampling will be on five fruits, 4 of them from each cardinal point the other from the top of the canopy. Every 15 days it will evaluate: fruit growth, foliar nutrient content, soluble solid, acidity, ring percent, color, fruit diameter, etc. In addition it will be measured soil fertility, and soil water status. The data from this measures will be processed and correlated with climatic parameters mainly temperature and rainfall.

2) Relationship between phenology and fruit production for yield prediction

To quantify the relationship between the flowering (intensity and duration), fruit set and yield in order to predict the citrus crop for a particular area.

It will be used observation plots in the Experimental Station and commercial orchards of Satsuma, W. Navel, Ellendale and Valencia.

a) It will use the methodology of 50 cm branch length. It will be evaluated: number of new and old leaves, number of new shoots, number and type of flowers, and number and type of fruits. It will study the relationship between the phenological stages and yield.

b) It will design a prediction system of yield based in the flowering intensity. One to five grades will be defined.

c) It will frequently surveyed the fruit diameter, in order to describe the growth curve and a system to predict it. The meansurements will be made every 15 days from june drop to maturity. It will target each 50 fruits form flowers with and without leaves in each tree. It will use three trees by cultivar.

(2) Nutrition and Water Management

① Characterization of fertilizer application

1) Soil phosphorus critical level

To establish the soil P critical value for maturity advance on Valencia.

Three strategies will be used :①the identification of the soil P level on Valencia orchard,② the identification of the lateral and in depth distribution of P soil in orchard and ③ the calibration and test plots to establish the soil P critical value to anticipate maturity.

(a) The main soils of Salto area, Argisoles (sandy loam) and Brunosoles (clay loam), which represent the 49% and 31% of the area will be used for a fertilizer survey on Valencia orchards. Fifty orchards on each type of soil will be used to identify the use of fertilizers (source, rate, time and localizations), the soil fertility level and the P soil level in orchards.

Using the survey result information, two sites (commercial orchard) will be selected with P low level in soil. Four phosphorus treatments will be used with a non limit rate of nitrogen and potassium : ① P_1; with no addition of phosphate fertilizer, ② P_1;half of the average phosphate rate fertilizer of the survey, ③ P_2; average phosphate rate fertilizer of the survey, ④ P_3;two times the average phosphate rate of the survey. A randomized plot design will be used with five repetitions and a size plot of three trees with common guard trees.

Measurement will be taken : ① total and available P soil, ② foliar P from fruiting terminals in the standard sampling period of the area (April~June), ③ total yield in Kg/tree, ④ fruit quality (fruit size and weight, color, rind thickness, total soluble solids, acidity etc), at least four samples before harvest will be taken from 15 fruits/tree, ⑤ creasing evaluation of 50 target oranges, ⑥ if it is possible it will be evaluate weight of root/soil volume, pH, CEC, Mn, Cu and Zn in soil.

(b) At the same time 50 isolate plots (commercial orchard) of two trees without repetition will be fertilized with the recommended NK rate of the area. Half of the total plots will receive no application of phosphate fertilizer and the other half two time the usual N recommended rate. Before and after phospate fertilization soil samples will be taken. It will be evaluated : ① precocity, with a monitoring survey of fruit quality (at least four samples at preharvest time per plot), ② yield estimation using the frame method, ③ creasing similar to the above mentioned. Using the total points information, the P critical value will be established by ① Mitscherlich equation, ② Cate and Nelson technique and ③ Lineal plateaux.

(c) As a mean to study the vertical and lateral distribution of the P soil in orchard, soil

samples at different depth and distance of the trunk will be used. The soil samples will be taken on trees with high and low P soil, at the following depth 0-5, 5-10, 10-15, 15-20, 20-25, 25-30cm and at 30, 60, 90, 120cm from the tree trunk on the row and inter row orientation.

2) Nitrogen and potassium fertilization on Satsuma

To establish the optimal foliar nitrogen and potassium concentration for maximum productivity and fruit quality on Satsuma.

The experiment will be conducted within a commercial citrus grove of Salto area. The soil selected will be the Argisol ocrico of Salto. Young irrigated trees of Satsuma on P. trifoliata will be used with the standard plant density of the area (833 trees/ha). A 2^3 factorial experimental design with five replications and a size plot of three trees with common guard will be used. The rate of Nitrogen will be 175, 250 and 325 kg/ha, and the rate of Potassium 150, 200 and 250 kg K_2O/ha; using urea and potassium chloride as a source. The total rate will be splited in three times during the year 1) 2/4 before flowering stage, 2) 1/4 after November drop (South Hemisphare) and 3) 1/4 after harvest season. Evaluation parameters will be : ① tree growth with measurement of trunk diameter and canopy volume, ② total yield in kg/tree, ③ fruit quality (color, size, rind thickness, total soluble solid, acidity etc) using a sample of 45 fruits/plot, ④ evolution of soil nutrient level with sampling of each plot, ⑤ nutritional level using a foliar sample of the fruiting terminal. Irrigation and pesticide program will be according to the routine commercial grower practice.

② Irrigation Scheduling

1) Characterization of soil and plant water condition

To reach basic data on the soil-water environment and plant water status looking for a better relationship on productivity efficiency on irrigated and non irrigated trees.

Two approches will be used to determine when to irrigate and how much water to apply : ① a monitoring of the soil water status and ② a monitoring of the plant water status. Using the main soils of the area (Argisoles and Brunosoles), laboratory measurements will be taken on the water holding capacity with determination of the field capacity and permanent wilting points; soil bulk density; infiltration rate; hydraulic conductivity and monitoring of the soil moisture by the use of tensiometers and gravimetric methods. Plant water status will be determined using the pressure bomb and infrared termometers. Field determinations will be made on the relationships between leaf water potential for well-watered and water-stressed trees and leaf water potencial on irrigated and non irrigated trees after time for the main soils.

2) Optimal time for water application

To determine the optimal time of water application looking for the stabilization of the productivity and the increase of the fruit quality on Ellendale, Washington Navel and Satsuma.

The experiment will be placed on the field of INIA Salto Grande on a new plantation of Ellendale, Washington Navel and Satsuma grafted on P. trifoliata rootstock. It will be used a density of 408 trees/ha, (3.5 between trees and 7 m in the row). The potential requirement of the different phenological stages will be evaluated using the same soil water depletion level. The different irrigation period will be : ① non irrigated through the year, ② irrigation from harvest through flowering, ③ irrigation from harvest through the end of the stage I of fruit

growth, ④ irrigation from harvest through stage II of fruit growth and ⑤ irrigation all the year. The experimental design will be a split plot in randomized blocks with four repetitions, with a size plot of five trees with common guard trees. It will be evaluated as follows, ① productivity parameters : yield precocity, alternate bearing, total yield in kg/tree, fruit quality (color, size, rind thickness, total soluble solid, acidity, etc.), using a sample of 15 fruits/tree, ② hydric parameters : water use efficiency, available water, soil water depletion etc., ③ physiological parameters: nutrient foliar level, stomatic conductivity, shoot and fruit growth, leaf area index, ④ economical evaluation of the differential irrigation timing application. Water availability will be checked by means of tensiometer placed a two soil depth/plot and recheked by a neutron probe. Standard fertilization program will be followed with recommendation based on annual leaf analysis and pesticide program will be according to the routine practice.

3) Evaluation of different irrigation systems

To determine the characteristics and limitations of the irrigation systems of the citric area and to compare their performance and efficiency.

A survey will be made on the citric irrigation systems of the Salto and Paysandu area. A randomized block on each site will be used to test the efficiency of the system using the standard ASAE (American Society of Agriculture Engineers) recommendation. Two parameters will be defined : ① the system uniformity and ② the emitter variation coefficient of discharge. Two exprimental blocks for 50 trees with 2 replications will be placed in the field of INIA Salto Grande. Washington Navel grafted on P. trifoliata with a density of 408 trees/ha, (3.5 between trees and 7m in the row) will be used to evaluate the four systems : ① drip irrigations, ②drip irrigation with compensate emitters, ③ micro-sprinklers and ④ micro-yet. The irrigation criteria will be based in the soil characteristics. Tensiometer will be used to maintain 85% of the water available. Tree spacing, soil management, fertilizer and pesticide program will follow the standard citric recommendation. Parameter will be taken : yield and fruit irrigation efficiency, root system evolution, soil bulk density, oxygen diffusion rate, wetted area, water infiltration, irrigation duration, water use efficiency and application and maintenance costs.

別添資料 8

5ヵ年活動計画(英文)

FRUIT TREE PROTECTION PROJECT IN URUGUAY

(March 1995 - February 2000)

FIVE YEARS TECHNICAL COOPERATION PROGRAM
(A PROPOSAL)

I. DISEASE CONTROL

(1) Fungal disease on fruit

Background

From the begining of 1990s, the amount of exportation of citrus in Uruguay gradually increase and recently reached to 45 - 50 % of total amount of production. Because of the many factors such as fruit disorders which prevent high quality fruit production, the increasing rate of exportation dose not still come up to the expectation of the counrtry. Some fruits for domestic selling are inferior in quality by damages of diseases, insects and physiological disorders causing a low price of fruits and a difficulty for the good management of producers. Under these situations, an urgent purpose on citriculture at present is the stable production of high quality fruits, and the control of fruit diseases has the greater importance. For this purpose, first of all it is necessary to know the kinds and the grade of damage of fruit diseases exactly in orchards and in post-harvest distributions for marketing.

On the observation in Uruguay until now, the most important fungal disease is citrus scab affecting Satsuma mandarin. The difficulty for its effective control seems to be caused by an indistinctness of ecology of the causal fungus such as the parts of overwintering on host plants and the relationship between fruit developing stage and disease susceptibility in the condition of Uruguay. As some difference of scab symptoms between in Uruguay and in Japan, the differences of species of the causal fungus and its strain or biotype are suggested and also a diagnostic measures concerned with the type of lesions have to be developed. On the other hand, decreasing of the effectiveness of benzimidazole fungicides for scab control by the appearence of resistant strains is suggested in some areas, so that the effective control measures by using alternative fungicides must be immediately established.

Now in Uruguay, postharvest chemical treatment on citrus fruits for prevention of fruit rots is actually done. It may be necessary to diffuse contol measures for posthavest diseases by pre-harvest fungicidal application to the producers on the view point of the safety for human body.

As mentioned above, the fungal disease control will be studied mainly on citrus scab in Satsuma mandarin and also on the diseases that cause stain and rotting on fruits such as melanose, greasy spot and Phytophthora rot.

① Disease occurrence

1. Duration of experiment March 1995 - February 1999 (1st - 4th year)
2. Objectives Study the kinds and the damage of fruit diseases caused by pathogenic fungi on citrus trees in Uruguay, and identify the moment of disease occurrence and the influence of main environmental conditions concerned with them.
3. Experiments
   1) Kind and occurrence of fruit diseases
   2) Parts of overwinter of scab fungus and its infection period
   3) Environmental conditions related with the occurrence of principal friut diseases in Uruguay
4. Results expected
   1) To identify the kinds and degree of damages of principal fruit diseases in Uruguay.
   2) To identify the duration and time of occurrence of scab and to detect the period of time necessary for control on citrus fruits.
   3) Study the influence of environmental factors on the occurrence of scab.

② Diagnosis and identification of causal agents

1. Duration of experiment March 1995 - February 1999 (1st - 4th year)
2. Objectives Because the plural number of the causal fungi are known on scab, greasy spot and Phytophthora rot in the world, identify these fungi found in Uruguay and detect the existence of their strains or biotypes. This step will help the control of these diseases.
3. Experiments
   1) Identification of the causal fungus of scab, greasy spot and Phytophthora rot
   2) Pathogenicity (host range) and lesion type of scab and greasy spot fungus on citrus cultivars
4. Results expected
   1) To identify species and/or biotypes of Elsinoe in Uruguay.
   2) To identify the species of Mycosphaerella in Uruguay as a causal fungus of greasy spot.
   3) To identify the varietal susceptibility of citrus to greasy spot.
   4) To identify the species of Phytophthora on fruit.

③ Control measures

1. Duration of experiment March 1995 - February 2000 (1st - 5th year)
2. Objectives Establish the effective control measures of principal diseases which cause the severe decrease of fruit quality.
3. Experiments
   1) Optimal time of fungicidal application to scab
   2) Study on resistant strain of scab fungus to benzimidazole fungicides
   3) Application of alarm system to melanose control
   4) Confirmation of the effectiveness of preharvest spray on postharvest diseases
4. Results expected
   1) Confirm the effectivity of dormant spay for the control of scab in Satsuma mandarin in the

condition of Uruguay.

2) Adjust the timing and interval of fungicidal application for the effective control of scab in Satsuma mandarin during growing season in the condition of Uruguay.
3) Detect the existence and distribution of the resistant strain of scab fungus to benzimidazole fungicides in citrus orchards in northwest region of Uruguay.
4) Establish the effective control program for scab in areas where the resistant strains of the fungus are known.
5) Establish the effective control program for melanose.
6) Confirm the effeciveness of preharvest spray for the control of postharvest diseases.

(2) Virus and virus-like diseases

Background

In Uruguay, the citrus materials were introduced from Europe, United States and some other countries. In orchards of long standing of Northwest region, the existence of psorosis are known at present. And in some commercial orchards, number of the affected trees increase gradually from year to year. It is difficult to know whether these affected trees were derived from the certified materials or not, however, the natural transmission of psorosis by vectors are assumed in the Province of Entre Rios of Argentina where located in the other side of Uruguay River from Salto, therefore, its vector transmission in Uruguay is undeniable. Moreover, seed transmission of psorosis is also reported in the past, and it is strongly desired to know whether the transmission in seeds of trifoliate orange which is commonly used for a roostock of citrus trees is the actual problem or not in Uruguay condition.

On the other hand, Marchitamiento repentino (sudden wilt) are found on trees of sweet oranges, mandarins and other hybrids in some commercial orchards and its damages are conspicuous. The main symptoms are sudden decline of tree accompanied with small leaves and fruits, and eventual death. The disease was first found at 1956 in Uruguay, and later its graft transmissibility was reported by the group of foreign and Uruguayan researchers, and then its similarity or dissimilarity has been discussed with declinamiento in Argentina, declinio in Brasil, citrus blight in Florida and some others.

Addition to the problems caused by these virus and virus-like diseases, the production of virus free materials is strongly requested from the producers because of the high price of nursery plants from foreign countries. And recently the virus free material production program is going to establish. INIA actually has the important position of this national program, and distribution of virus free materials is thought to be urgent necessity. On the other hand, the most important vector of citrus tristeza virus (CTV), Toxoptera citricidus, is widely distributed in citrus areas of Uruguay, and damages of CTV are known in some cultivars. To escape from the damage of CTV, the utilization of cross protection phenomenon of the mild strain to the severe strain is most effective. For this purpose, it is necessary to survey the effective mild strain of CTV from the fields.

① Study on occurrence and transmission

1. Duration of experiment March 1995 - February 2000 (1st - 5th year)
2. Objectives Survey the kinds and the damages of virus and virus-like diseases which cause tree decline and death in Uruguay citrus and obtain the basis for control.
3. Experiments
   1) Occurrence and damage of psorosis and other virus-like diseases
   2) Transmission of psorosis
4. Results expected
   1) Clarify the relationship between the occurrence of psorosis and some other virus-like diseases and the citrus cultivars in Northwest region of Uruguay.
   2) Clarify the annual development on damages of psorosis in orchards and obtain the information on the existence of its vector.
   3) Clarify the possibility and importance on seed transmission of psorosis agent

② Study on mild strain

1. Duration of experiment March 1995 - February 2000 (1st - 5th year)
2. Objectives To escape the damage caused by the infection of the severe strain in the case of new plantation of virus free materials in fields, it is desirable to use the phenomenon of cross protection of the mild strains of the same virus. For this purpose, survey and collect the effective mild strains having a high cross protection ability.
3. Experiments
   1) Survey on effective mild strain of citrus tristeza virus
   2) Confirmation of cross protection of mild strain of citrus tristeza virus to severe strain
4. Results expected
   1) Clarify the contamination of citrus tristeza virus and its damage on principal citrus cultivars.
   2) Obtain the effective mild strain of citrus tristeza virus from citrus cultivars which show severe damages of the disease.

③ Management of virus free mother tree

1. Duration of experiment March 1995 - February 2000 (1st - 5th year)
2. Objectives Produce the virus free mother trees of the high fruit quality clone of the principal citrus cultivars in Uruguay, reserve them separately from other citrus cultivation areas, and establish the basis for production and distribution program of virus free materials.
3. Experiments
   1) Production of plantlets by micrografting
   2) Indexing for main viruses on plantlets obtained
   3) Separate reservation of virus free mother tree
   4) Indexing for virus free confirmation in foundation and increasing blocks

4. Results expected

1) Obtain the virus free material of the high quality clones of the main citrus cultivars and establish the foundation block.
2) Establish the increasing block for these cultivars and the indexing system for virus free confirmation.

II . INSECT PEST CONTROL

(1) Forecasting technique for major pests

Background

Among the major citrus pests found in Uruguay, we can mention that California red scale, thrips, whitefly and mites are most serious. These pests affect the exterior aspect of the fruit and reduce its quality, causing the decrease of the exported fruit.Therefore, it is desired to develop the techniques to forecast the occurrence of the mayor pests for stabilization of the good quality fruit production and exportation.

Related with this technique we point out the following problems:

a) Regarding to thrips, it is not clear yet which are the most important species that cause damage. Besides, the growers are confused because they do not know if the damage in the fruit is caused by the thrips or by the wind in some cases.

b) It is not exactly well known the timing of control for the main pests.

① Identification and classification

1. Duration of experiment March 1995 - February 1998 (1st - 3rd year)
2. Objectives Among the major pests that take part of the objective of this study, the thrips is in the first place, followed by the mites. These pests will be written some easy handbooks regarding to their identification and classification. About 12 thrips species have been informed, but the main species causing damages are still unknown, so this will be studied. Related to the mites the main objective will be the mites of the Eriophyidae family.
3. Experiments
   1) Collection of thrips and their identification
   2) Collection of mites and their identification
4. Results expected

The main thrips species will be identified and also the mites species of the Eriophyidae family. This information will be published as the identification and classification handbook. This will permit to clarify some aspects of the ecology of these pests.

② Monitoring method

1. Duration of experiment March 1995 - February 1999 (1st - 4th year)
2. Objectives To develop an effective monitoring method to permit to know the major pest densities. This is necessary to forecast the occurrence of thrips, mites, California red scale and

whitefly. On this manner, traps and effective monitoring methods will be studied, and the investigation will be focused on thrips.

3. Experiments

1) Seasonal prevalence of occurrence of thrips with yellow plate sticky trap and survey on rate of fruit infested

2) Seasonal prevalence of occurrence of California red scale with sex phermone trap and survey on rate of fruit infested

3) Population densities of rust mites with sampling of leaves and fruits, and survey on grade of their damages

4) Analysis of already known data of citrus whitefly in Uruguay

4. Results expected

With the developed monitoring method, will be possible to determine accurately the ecology of the major pests and will be increased the precision for forecasting the pests occurrence.

③ Forecasting method of occurrence

1. Duration of experiment March 1996 - February 2000 (2nd - 5th year)

2. Objectives To forecast in a precise way the pests occurrence, to plan rational control steps that permit to avoid damages through an appropriate control period.

3. Experiments

1) Survey on forecasting method of appearance time of thrips

2) Survey on forecasting method of appearance time of California red scale

4. Results expected.

To develop a method that permit the forecasting of the appearance time, in order to determine if it is necessary or not to do the control.

(2) Integrated control

Background

In Uruguay, the frequency of the utilization of pesticides is very low compared with Japan. May be, for this reason there are a few examples of the pest resistance to the pesticides. Besides, it is almost impossible to observe resurgence cases (abnormal reproduction of the pests). In this way, according to that the problem that exists in other countries related with the abuse of pesticides, is insignificant in Uruguay, it is necessary to plan a rational control system to avoid this problem. For this reason, it is desired to develop an effective technique of integrated pest control to stabilize the ecosystem.

To develope this technique it is necessary to face the following problems :

1) Neither the appropriate control time nor the application techinques to the major pests are determined accurately.

2) It is not enough the research in relation with the identification, ecology and evaluation of the effectiveness of the main natural eneaies.

① Identification of natural enemies

1. Duration of experiment March 1995 - February 1998 (1st - 3rd year)
2. Objectives The knowledge about the natural enemies of the California red sale, thrips, mites and whitefly is not enough. It is necessary to confirm through the survey the species name of the domestic natural enemies, in order to publish later the identification and classification handbook.
3. Experiments
   1) Collection of domestic natural enemies of California red scale and their identification
   2) Collection of domestic natural enemies of mites and their identification
   3) Collection of domestic natural enemies of thrips and their identification
   4) Collection of domestic natural enemies of citrus whitefly and their identification
4. Results expected
   Once confirmed the species names of the domestic natural enemies of the major pests, it will be possible to know some aspects of the fauna of natural enemies.

② Integration of selective control measures

1. Duration of experiment March 1995 - February 2000 (1st - 5th year)
2. Objectives To evaluate the characteristics and effectiveness of natural enemies and clarify the effective ways of use. On the other hand, selective chemicals will be searched in order to control thrips, mites, scale insects and whytefly. A test plot for integrated pest management will be installed to try to develop the techniques of use of natural enemies and selective chemicals.
3. Experiments
   1) Survey on characteristic and effectiveness of natural enemies of California red scale and mites
   2) Selection of selective chemicals for thrips, mites, scale insects and whitefly
   3) Survey on major pests, natural enemies and damage in test plot for selective control
4. Results expected
   It will be published a handbook for the development of the techniques of integrated control for the major pests, having as bases, the utilization of natural enemies and selective chemicals.

③ Determination of control threshold

1. Duration of experiment March 1996 - February 2000 (2nd - 5th year)
2. Objetives The fruits damaged by the thrips are culled and this fact produces a decrease in the citrus fruit exportation. Then, to produce good quality fruit it is necessary to establish the convenient threshold level to control thrips in the susceptible varieties.
3. Experiments
   1) Survey on density of thrips and rate of fruit infested
   2) Survey on rate of fruit infested by thrips and grade of their damage
4. Results expected
   Once clarified the threshold to control the thrips, then will be possible the timely control.

III. ORCHARD MANAGEMENT

(1) Improvement for tree management

BACKGROUND

Citrus industry, with an old history specially for sweet oranges, has already been stablish plant management techniques for Uruguay growing conditions. On the other hand, Satsuma mandarin crop is comparatevely new. In the last years, it has been increasing the plantin area and now, it is very important the amount of mandarins produced and exported.

The extensive crop management and large orchards are characteristic of the citrus industry in Uruguay. Also the excellent fruit quality of the citrus produced, in spite of the annual variation in yield and fruit size. Physiologial disorders, among other factors, increase the losses for fresh disorders, among other factors, increase the losses for fresh market production and some years these losses are very important.

Harvesting period and yield prediction will help to plan the production and the merchandise sending to other countries. Also the selection of good producer and well adapted cultivars for different production areas, are the bases for a sustantible production.

Fortunately, regarding to Satsuma mandarin extensive management, it has been introduced pruning and thinning techinques, which will improve the citrus pruduction. In addition, it is expected that japanese techniques will be very usefull in this more extensive crop management condition too.

① Stabilization of fruit setting

1. Duration of experiment March 1995 - February 2000 (1st - 5th year)
2. Objectives To evaluate the effect of different management techniques on the citrus fruiting process and fruit quality improvement in order to correct the alternate bearing in citrus trees. These techniqoes will involve field evaluation of girdling, fruit thinning and pruning.
3. Experiments
   1) Fruit thinning on Satsuma
   2) Promotion of fruit setting on Ellendale by ringing
   3) Effect of different methods of pruning on Satsuma and Ellendale adult trees
   4) Tree management on different planting densities of Satsuma
4. Results expected

   Alternate bearing problen correction through the standardization of management techniques such as pruning, chemical thinning and girdling (ringing); and a orchard handbook edition of fruiting management.

② Control of physiological disorders on fruit

1. Duration of experiment March 1995 - February 1999 (1st - 4th year)
2. Objectives Fruit physiological disorders involve different and mixed factors such as cultivar susceptibility, nutritional disorders, climatic events, etc. Therefore it is a priority to evaluate techniques for fruit physiological disorders reduction, by studying the orchard and

packing situations in which these disorders appear. In this area it was defined creasing and splitting as preharvest physiological disorders and puffing and pitting (a type of chilling injury) as postharvest disorders. Creasing and puffing are the major physiological disorder problems, which produce a great reduction of the marketable fruit.

3. Experiments

1) Occurrence of creasing and splitting in orchards

2) Control measures on creasing and splitting

3) Influence of fruit handling and chemical treatment after harvest to improve fruit quality

4. Results expected

To elucidate the orchard situations in which the fruit physiological disorders appear; creasing, splitting and puffing occurrence including orchard management techniques to reduce the occurrence in pre- and postharvest.

③ Determination of optimal time for harvest and yield prediction

1. Duration of experiment March 1995 - February 1999 (1st - 4th year)

2. Objectives To evaluate the tree and environmental factors that take place in the field and influence the harvest time and yield will help to design a prediction method to be used in planting and marketing time for different areas of the country. The Experimental Station have meteorological and fruit quality data which will compose part of the data base for yield and harvet time prediction, however the proposed survey can include other areas of the country.

3. Experiments

1) Modeling fruit growth and quality for different cultivars

2) Relationship between phenology and fruit production for yield prediction

4. Results expected

To clarify the parameters necessary to predict the optimum harvest time and yield in the most important cultivars : Ellendale, Satsuma, Nova, Washington navel and Valencia.

④ Fast methodology for cultivar evaluation

1. Duration of experiment March 1996 - February 2000 (2st - 5th year)

2. Objectives In this project, it will be transferred the japanese techniques of rapid cultivar evaluation in order to evaluate the already exists citrus collection in Uruguay in different areas of the country.

3. Experiments

1) Field methods for fast cultivar evaluation

2) Biochemical methods in cultivar identification and evaluation

4. Results expected

To improve the techniques of citrus evaluation in Uruguay through fast techniques used in Japan. In this way reducing the number of years used by the traditional evaluation methodology of Uruguay.

(2) Nutrition and water management

Background

Maximum tree growth, development, productivity and fruit quality is achieved when a successful strategy is used in a nutrient and water management program. The main objective is to give the basic understanding of the relationships between soil-plant and nutrient-water conditions to enhance the efficiency of utilization and porductivity of fertilizer and irrigation systems.

① Characterization of fertilizer application

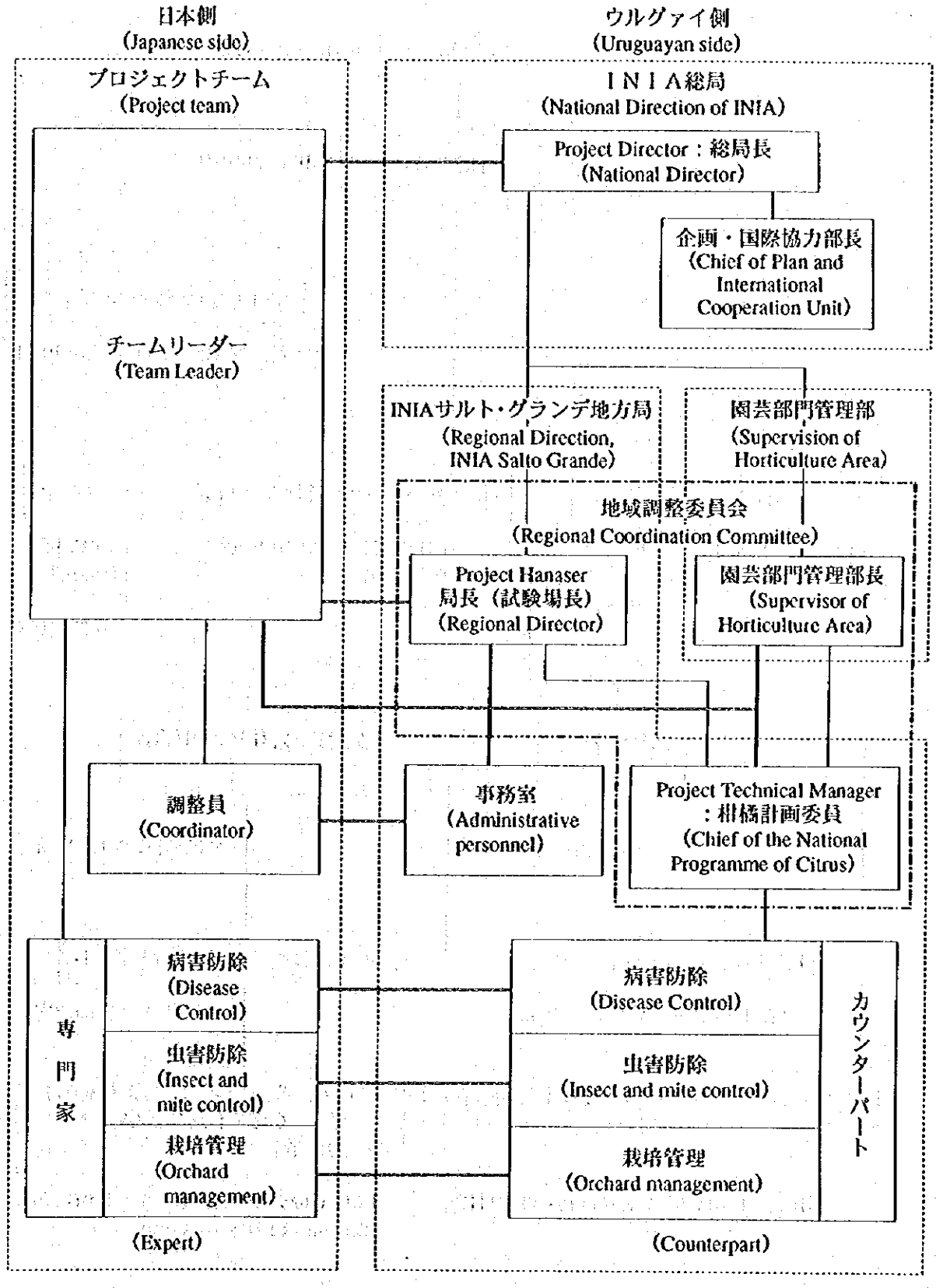
1. Duration of experiment March 1995 - February 2000 (1st - 5th year)
2. Objectives The main goal is to overcome nutritional limitations of the citrus area, using a wide characterizations of the soil-nutrient conditions and fertilizer used. Special emphasis will be given in the nutritional requirement of Satsuma. Concretely, to establish the soil phophorous critical value for maturity advance, and to determine the optimal foliar nitrogen and potassium requirement for maximum productivity and fruit quality.
3. Experiments
   1) Soil phosphorous critical level
   2) Nitrogen and potassium fertilization on Satsuma
4. Results expected
   1) To establish the lower limit of P soil requirement value to enhance fruit maturity in the most important soils of the area.
   2) Technical adjustment on P soil sampling for citrus.
   3) Technical recommendation on rate of global N and K fertilization.
   4) Preliminary N and K foliar level for maximum productivity and fruit quality.

② Irrigation scheduling

1. Duration of experiment March 1995 - February 2000 (1st - 5th year)
2. Objectives · To decide when to irrigate and how much water to apply. It is necessary to obtain measurements of soil water content to determine the water use rates and seasonal total use by trees for a more accurate estimation of the tree productivity and efficiency of water application. Concretely, to reach basic data on the soil-water environment and plant water status looking for a better relationship on productiveity efficiency, to determine the optimal time of water application looking for the stabilization of the productivity and the increase of the fruit quality on Ellendale and Washington navel, to measure the effect of irrigation depletion levels maintained on growth stages on productivity and fruit quality, and to test the field efficiency of different irrigation systems.
3. Experiments
   1) Characterization of soil and plant water contitions
   2) Optimal time for water application
   3) Optimal amount for water application
   4) Evaluation of different irrigation systems
4. Results expected
   1) To obtain the basic data of the soil-plant water condition status.

2) To establish a productivity and economical evaluation of the main effect of the irrigation periods for Ellendale, Washington navel and Satsuma.
3) To show the edaphic and physiological behavior of the three varieties.
4) To give accure criteria on irrigation timing of the production for export.
5) To establish the optimal level of soil water depletion requirement for growth stages.
6) To know the advantages and weaknesses of the different systems available.
7) To obtain parameters of irrigation efficiency able to extrapolation for other type of soils.
8) To orientate growers to a better decision at the inversion moment.

プロジェクト組織図
(Orgnization Chart of the Project)



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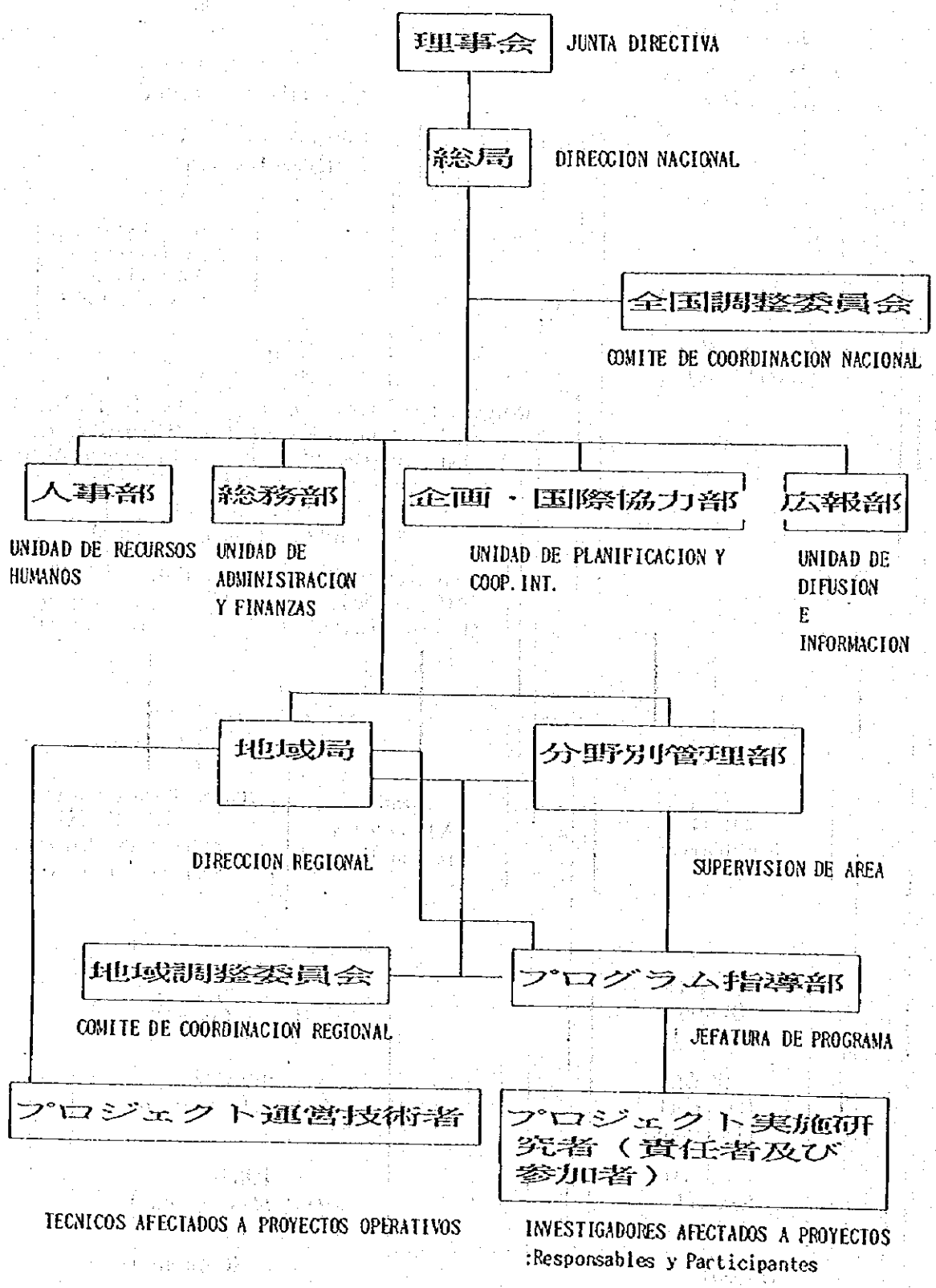
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プロジェクト実施研究者（責任者及び参加者）
INVESTIGADORES AFECTADOS A PROYECTOS
:Responsables y Participantes