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P R O E X A G
NON-TRADITIONAL AGRICULTURAL EXPORT SUPPORT PROJECT

TECHNICAL ASSISTANCE FOR MELON FERTILIZATION AND IRRIGATION

Assignment Number: ST/90-25

PREPARED BY:

Mr. Hunter Johnson, Jr.

THROUGH

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(Contract AID No. 596-0108-C-00-6060-00)

UNDER THE AUSPICES OF:

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(Project No. 596-0108-3-60011)
United States Agency for Interantional Development (USAID)
Regional Office for Central American Programs (ROCAP)
Guatemala City, Guatemala

October, 1990

PREFACE

The goals of this assignment are to assist melon grower/exporters in Honduras and Costa Rica in the improvement and development of fertilization and irrigation practices which will enable them to produce high quality exportable muskmelons. Work will be conducted as visits and interviews with individual growers or grower groups in collaboration with FPX in Honduras and CINDE/DIVAGRO in Costa Rica.

Research to accomplish the goals will include evaluation of current fertilization and irrigation practices, soil conditions, the review of available soil analyses, planting and subsequent management practices, and yield and fruit quality problems encountered. Recommendations will be provided based upon the findings including required elements, rates and timing of applications, and material formulations. Recommendations will be made on the use of soil and plant tissue analyses for planning and evaluating fertilizer programs. Irrigation practices will be reviewed and recommendations will be provided for efficient management of water applications.

Assistance with itinerary and grower meetings will be provided by Dr. Dale Krigsvold of PROEXAG and local representatives of FPX in Honduras: Mario Argeñal, Juan Manuel Moya, and Medardo Galindo, and with CINDE/DIVAGRO in Costa Rica: Claudio Zumbado and Dr, Luis Gonzales.

EXECUTIVE SUMMARY

Melon production in Honduras and Costa Rica is similar in many ways: the crops, the soils, the grower practices, and the fruit quality problems. Fertilizer and irrigation practices may or may not play an important role in export melon quality but recommendations have been made which should improve practices as well as help resolve questionable practices which exist in both countries. The latter includes the application of potassium (K) even though levels appear to be adequate in the soil, the application of calcium (Ca) when soil levels and Ca ratios with magnesium (Mg) is normal, and the use of foliar sprays for minor elements when soil applications should provide more economical long term benefits. An objective evaluation of nitrogen (N) management practices is needed to identify any possible effects on quality. Research on the local level has been recommended to resolve these questions, but this will require the cooperation of local scientists and growers, and probably some special financial support.

Soil analysis is widely used for planning fertilizer programs (although the interpretation in some cases are not consistent with that which would be made by scientists in California), but plant analysis is not in general use. Plant analysis has been recommended as a means of evaluating the fertilizer programs' effectiveness in meeting the nutritional needs of the plants.

Suggestions have been made for the conservation of irrigation water through the use of the crop demand system, as utilized by California growers, which would be based on locally available evapotranspiration data.

There is little evidence of specific effects of fertilizer or irrigation practices on Brix levels or net expression in the southwest U.S. but careful investigation in Central America may prove otherwise. Theories are advanced regarding a possible adverse climatic effect (night temperature) on melon Brix level, and also on a possible effect of high water table on net expression during early season plant development. Evidence of any effect of fertilizer or irrigation practices on fruit softness at maturity is lacking.

An arrangement for short term consultancy by a U.S. post harvest specialist is recommended to provide expertise in the critical evaluation of experimental treatments and current grower practices on fruit quality.

It is recommended that meetings be arranged during my next visit (which is suggested for mid-January 1991) with local scientists, laboratories, and other appropriate institutions in order to gain a better understanding of local soil technology and melon research results which bear on project goals, as well as to enlist their aid and cooperation.

REGIONAL CONCLUSIONS

The purpose of the September 1990 visit to Honduras and Costa Rica was to evaluate fertilization and irrigation practices and to provide recommendations leading to improved yield and fruit quality. The visit provided an opportunity to interview a wide cross section of growers and to obtain details on their current practices and problems. Based upon these discussions and the information obtained recommendations have been made which will be helpful in developing improved programs. Several of these will require research to resolve the efficacy of certain practices for which there is no supporting evidence. The recommendations for both countries are very similar because soils, climate, and crops are similar, and similar practices appear to have developed following recommendations from a central source. These have been useful in helping the melon industry develop but it will be important to carefully evaluate current practices for their validity and then make adjustments based upon objective research results.

There is reason to believe that the Central American climate may have an important effect on fruit quality which may not be overcome solely through adjustments in fertilizer or irrigation practices. The climate tends to promote lush growth and accelerated fruit maturity. Cantaloupe fruits mature in 25 - 28 days compared to 38 - 42 days in the southwest U.S. The shortened maturity period may be a response to high night temperatures causing a higher night period respiration rate which may prevent accumulation of sucrose at the level which is genetically possible. There is support for this theory in a 1970 California research report and more recently in a 1988 report from the Netherlands. If the theory is correct, procedures to delay fruit maturity may be needed, or the selection of varieties with significantly higher genetic potential for sucrose levels.

Research in California and reports in the literature tend to indicate that net expression in cantaloupe is related to root activity. Soil texture and high soil moisture can affect root activity. Pathological disorders are also known to affect net expression. These factors need to be investigated in Central America.

The critical evaluation of fruit quality as affected by current field practices, as well as from experimental treatments in the recommended research work, should involve persons with specialized training and expertise in this field of work. Qualified local expertise may be available in Honduras and Costa Rica who are able to cooperate, but if not it is recommended that short term consultancy be considered for a post harvest specialist from California.

The original plan for a return visit to evaluate the reults of recommendations was to be in mid to late November. From discussions with grower groups in both countries it seems clear that a visit at that time would precede the normal harvest season. It is therefore suggested that the next visit be delayed until mid January 1991.

In order to become better acquainted with local expertise in agricultural research and their research facilities, with analytical laboratories, and scientific knowledge bearing on melon production it is requested that time be allocated to appropriate meetings during my next visit.

SECTION 1. HONDURAS

A. Introduction and Background. Melon production in Honduras is centered in the region around Choluteca. Cantaloupes are the crop of principal interest, but some honey dews and watermelons are grown. Varieties of cantaloupe grown for export are 'Mission' (Asgrow) and 'Hymark' (Petoseeds). Export period is December through April from plantings in October through February. Some very early plantings by small growers are established late August or early September. Irrigation on most farms is by the furrow method, but there is some drip irrigation. Early plantings are frequently grown without irrigation, depending upon soil moisture from the wet season. Plastic bed mulch is rarely used. During the visit (September 18-21) it was not possible to observe field operations because the visit timing preceded most of the normal planting period.

Most growers utilize soil analyses as a guide to planning fertilizer programs. Analysis, interpretation, and recommendations are frequently made A&L Soil Laboratory in Pompano Beach, FL, but some growers use laboratories in Honduras.

Melons are packed in relatively modern packing sheds and cooled by either hydrocooling or forced air cooling. The shipping period to U.S. markets is 11 to 12 days.

Fruit quality problems expressed by most growers were similar: less than desirable Brix on cantaloupes, imperfect netting on cantaloupes, and frequent mention of soft fruit at maturity on both cantaloupes and honey dews.

B. Laboratory Soil and Plant Analysis.

1) Observations and analysis. All growers seem to use soil analyses as a guide for planning fertilizer programs. Analyses were made available for review during grower visits and copies were to be mailed to me as soon as they could be prepared. In general, soils are moderately acid (pH 6.0-6.8), with organic matter in the range of 1.5-2.5%, low in phosphorus (P), high in potassium (K), and with adequate levels of calcium (Ca) and magnesium (Mg). Of the minor elements, zinc (Zn) was interpreted as being low in one area (although adequate by standards in California), and on another farm Zn, copper (Cu), and boron (B), were shown to be very low. Manganese (Mn) and iron (Fe) were adequate.

Of the six growers visited one uses plant tissue analysis to evaluate his fertilizer program. Interpretation was provided by the laboratory but neither analytical methods nor standards for sufficiency were available.

2) Recommendations: Soil analyses are useful in establishing the nutritional status of soils and for planning fertilizer applications. This is good practice and should be used with some regularity for all blocks of ground in order to be aware of differences in the status of mineral nutrients. Annual analysis for each block may not be necessary unless a special problem exists, but analysis should be frequent enough to assess any important changes which occur.

Growers should consider using plant analysis as a means of evaluating the success of their fertilizer programs. Lab results are rarely useful for adjusting management of the current crop because of the rapid growth rate of melon plants and the turn-around time required for analysis and reporting. They are of great value, however, in making adjustments for following plantings. Standards for levels of sufficiency and deficiency for melon crops have been developed by University of California scientists based upon controlled field experiments. These are in published form along with the analytical procedures and are available to local laboratories.

C. Fertilizer Programs.

1) Observations and analysis: All programs included applications at the time of planting followed by additional applications during plant development. Typically, 18-46-0 ammonium phosphate is applied at planting in amounts ranging from 125 to 200 lbs/acre, in bands to the side and below seed position. This application supplies all of the phosphorus and part of the nitrogen. Some growers also apply potassium as KCl at planting. Post emergent nitrogen, generally as urea, and more KCl are applied either at specific time intervals (such as 10, 15, or 20 days) or in reference to flowering stages. Rates of nitrogen are in the range of 100-150 lbs/acre. Total K applied during the crop ranges from 100-200 lbs. K20/acre. Minor elements are applied as foliar sprays 4 to 6 times during crop development. Minors are sometimes applied to supply Zn, Fe, Cu, B, and Mn together from a material labeled 'Metalasato'.

Some questionable practices are used: including N, P, and K along with minor elements in foliar sprays during fruit development; a lab recommendation for late side dressed K as a means of assuring firm fruit for shipment; the application of Ca for a similar purpose. An interesting practice used by one grower is the application of KCl through the drip system to salinize the soil solution as a means of controlling lush plant growth.

On furrow irrigated plantings growers described various methods for the placement of side dress fertilizer, generally several inches to the side of the plant row and a few inches into the soil on the bed shoulder. This needs to be observed in more detail after plantings are established. Some growers apply fertilizer on top of the bed around the plant in a groove cut by a machete.

2) Recommendations. Nitrogen is being applied in an adequate range to satisfy plant requirements. About 25% of the total amount should be applied at planting with the balance in two side dress applications, one at early flowering and the other at early fruit set. Urea is a good source of N but is acid forming so soil acidity should be monitored with continued use of this material. Ammonium nitrate has a more neutral reaction and probably a better choice unless there is a significant cost advantage to urea. Calcium nitrate is alkaline reacting and usually a more expensive source of N. Potassium nitrate is a more expensive source of N but can be justified if the potassium proves to be beneficial.

The side dress placemnet of N materials is important to it's efficient use. N placement should be such that it is adjacent to the active root zone without injury to the roots during placement and in a location where irrigation water can move it into the root zone. Bed surface application of fertilizers is not an efficient procedure and will not be available to plants during the dry season. This practice should be discouraged.

The application of all of the phosphorus at planting time as a band, or bands, a few inches to the side and below the seed line is the correct procedure. Ammonium phosphate 18-46-0 is a good source of P. Other choices are 11-48-0 and treble super phosphate. The rates in use should supply adequate P.

The levels of K shown on the soil analyses are adequate to high by California standards. Recommendations by local laboratories, however, are to apply additional K. There appear to be two bases for this: 1) that the clay minerals in these soils is such that a large part of applied K is fixed and unavailable therefore requiring more K applications during plant development, or 2) an unfounded opinion fostered by market receivers regarding the value of extra K in assuring firm fruit arrival. The visit itinerary did not allow time to discuss K fixation phenomena in these soils with local soil scientists. If K fixation is a reality then lab recommendations seem

valid. Some local research has been conducted which shows response to K addition although no data was provided regarding original soil K levels at the site, and there was no evaluation of fruits to support the idea that added K resulted in firmer fruit. It is recommended that other research be conducted comparing K rates and timing, with appropriate controls, including quality analysis at harvest and following a simulated shipment period. Such an experiment will require the close cooperation of qualified research scientists and controlled storage facilities. 'Agromont', at San Lorenzo, has agreed to cooperate in this type of research, but some special funding may be necessary in order to support this research.

It has been well established that minor element deficiencies are most economically corrected by soil applications of the elements prior to planting. When deficiencies occur during growth foliar sprays are the proper method of treating the disorder for the current crop, but followed by a soil application for long term correction. It is also widely known that continued application of minor elements which are adequately supplied in the soil can sometimes lead to toxicities. The margin of safety between deficiency and excess is narrow. For this reason it is recommended that only those elements which are known to be deficient be applied.

Field experiments should be conducted to compare one-time soil applications of elements known to be deficient with foliar applications of the same elements by the methods currently in use. Plant tissue sampling should be included to determine minor element levels for all treatments. Data collection should consider all aspects of yield and fruit quality. Research management should be the responsibility of properly qualified personnel.

D. Irrigation

1) Observations: Furrow irrigation is the predominant practice used. One grower uses drip irrigation as a general practice but had tested furrow irrigation on selected plantings. Furrow irrigation practice varies from every two days on sandy soils to every eight days on heavier soils. A significant amount of acreage is grown entirely on residual soil moisture from wet season rains.

2) Recommendations : The method of determining need and frequency of irrigation seems to be based on plant appearance or past experience. If climatological data, including evapotranspiration, is available in the Choluteca area growers may be able to develop a system based upon crop demand, as used in California. The application of water based upon crop needs conserves water and avoids leaching of soluble nutrients.

E. Varieties

1): Observations: All growers are currently using either 'Mission' or 'HyMark' or both. These hybrids were originally developed for the southwestern U.S. but are fairly well adapted to Central America. Some growers have tested other varieties but have found none which are an improvement in Brix or netting over those currently in use.

2) Recommendations: There should be on-going evaluation of new varieties and experimental lines of cantaloupes, honey dews, watermelons, and other exportable muskmelon types. Principal effort should be focused on cantaloupes. Strong working relationships should be developed with U.S. seed companies and Universities where important breeding programs exist, and these sources should be encouraged to provide samples of new materials for trial. Trials should be located in all growing areas in order to observe performance under various conditions. Varieties will be best managed

by a local Extension person, with coordination of FPX personnel.

F. Conclusions

Growers are using soil analyses to plan their fertilizer programs. This is good practice and should be continued, although some of the interpretations provided are not consistent with those which would be made by California soil scientists. Plant analyses are not in general use but should be encouraged for the value they have in determining how well the fertiizer programs are meeting the needs of the plants.

There is a strong need to establish local research programs which will correctly guide growers regarding K fertilization requirements and the practices used to control minor element deficiencies. Research is also needed to determine the best management practice for nitrogen fertilization . All research work should be the responsibility of properly qualified personnel, ideally by scientists from Honduran agricultural schools if they can be encouraged to participate.

There needs to be an investigation regarding the availability of climatological data which could be put to use in the development of procedures which would guide growers to irrigate on a crop demand system. This would conserve water and soluble nutrients.

The evaluation of new cantaloupe varieties should be a continuing program with the objective of seeking improvements with genetically enhanced Brix and net expression.

SECTION 2. COSTA RICA

A. Introduction and Background. The melon production areas are widely separated to the south and northwest of the central mountain range in Guanacaste and Puntarenas provinces. Cantaloupes are the crop of principal interest, but honey dews and watermelons are also grown. Plantings begin in October and continue into February with harvest for export from December through April. Cropping time is about 60 days from planting to harvest. Temperatures during the season range 30-35 C day and 20-25 C night. Most of the acreage is under drip irrigation, but furrow irrigation is being used on some farms. The harvested product is packed in modern packing sheds and cooled by hydrocooling or the use of forced air cooling. Export shipment is by ship. in refrigerated containers with a period of 11-12 days to U.S. markets. There is general concern among producers regarding Brix levels, less than high quality net on cantaloupes, and soft fruit in both cantaloupes and honey dews.

B. Fertilization Practices

1) Observations and Analysis. Soil analysis is widely used by growers to plan fertilizer programs. A principal source of analyses and recommendations is A & L Southern Soil Laboratory in Pompano Beach, FL. This laboratory analyzes by two separate extraction methods to provide their consultant with his basis for interpretation.

Soils are on the acid side in the range of pH 5.8 - 6.8. Organic matter is 1.5 - 2.5%. Soil phosphorus is generally low (5 - 10 ppm). Potassium (K) levels are high to very high by California standards but lab recommendations are for additional K at planting as well as during plant development. The justification for K application is that it is needed to assure firm fruit arrival in the market although no evidence of this effect could be provided by the lab. Some justification supporting improved yield is provided from the results of a recent field experiment in Guanacaste, conducted by University of Costa Rica scientists, although original soil levels were not reported, and there was no indication that fruit quality was evaluated.

Soil analyses report levels of calcium (Ca) and magnesium (Mg) which are adequate and in good ratio by California standards, yet additional Ca is frequently recommended. Cation exchange capacity is in good to excellent range. Sodium (Na) levels are low.

Plant analysis is not a general practice although one grower has used the procedure occasionally. The figures shown on one of his reports are interpreted by the lab as being low to medium, but would be interpreted as high by California guidelines.

Most laboratory analyses indicate deficiency of minor elements, notably zinc (Zn), copper (Cu), and boron (B). Manganese (Mn) is in adequate supply. Growers are applying minor elements by foliar sprays, and frequently by a complete mix including Mn (labeled 'Metalasato') in several applications during plant growth.

Fertilizer programs include applications at planting time of some of the required nitrogen (N), all of the phosphorus (P), and an application of potassium (K). Mixed fertilizers such as 10-30-10 and 15-15-15, or 18-46-0 plus KCl are the materials in use. Nitrogen applications during crop development are at various timing frequencies such as 10, 15, and 20 days post emergence, or in relation to flowering period. Amounts of N used are in the range of 100 to 150 lbs N/acre. Nitrogen sources include urea and potassium nitrate, and occasionally ammonium nitrate or calcium nitrate.

The small growers who are not mechanized are placing all fertilizer materials on

top of the bed around plant sites either in small holes or in a groove cut by a machete.

2) Recommendations : There are some practices used by growers which are challengeable and which need to be resolved locally by controlled experimentation. The need for K additions on soils which appear to be adequately supplied is one of these practices. If K is largely fixed due to the nature of the clay fraction, as has been suggested, then the need may be real. Additional detail from the Guanacaste experiment and discussion with local soil scientists may help resolve the question. Since the Guanacaste experiment did not include quality evaluation of the fruit to assess fruit firmness effects there is justification for conducting another experiment to include data on that subject as well as the K status of the soil site.

Experimental work is needed to compare current minor element spray practices with application to the soil prior to planting. Soil application should provide the advantage of long term correction of deficiencies at lower cost. In either case only those elements shown to be deficient should be applied since continued application of elements in good supply can lead to toxicities or antagonistic responses.

The total amount of N applied is in an adequate range but timing of applications should be the subject of investigation to determine the effects of rate and timing on fruit quality. Urea is acidic in reaction and upon continued use can increase soil acidity. Potassium nitrate is a more expensive source of N but is a good choice if additional K is justified. Calcium nitrate is also an expensive N source. Ammonium nitrate is fairly neutral in reaction and, if attractively priced, is probably the best N source.

The practice of applying fertilizer on top of the beds around the plants is only justified if rainfall is expected. During the dry season the practice is inefficient, and should be discouraged, since the fertilizer cannot be effectively moved into the root zone.

Soil analysis is an excellent means of planning fertilizer programs. Annual analysis may not be necessary on every block of land but should be often enough to monitor the status of minerals known to be in short supply.

Plant analysis should be a regular part of the fertilizer program as a means of determining how well the program is meeting the needs of the plants. Published guidelines for tissue nutrient levels in melon plants, based upon extensive field research by University of California scientists, are available for the interpretation of laboratory analysis. Detailed laboratory extraction procedures are also available.

The concern expressed regarding soil and plant analysis results and interpretation may be due to the extraction procedures used. This prompts the recommendation that a comparison be made of analyses from a locally used laboratory and a U.S. laboratory which uses University of California analytical procedures. This will allow interpretation by guidelines which are based upon extensive field work in California. The procedure would include soil samples taken prior to the application of any fertilizer materials before planting, and plant tissue samples taken at the early male flower stage and again during the early fruit development stage. Adequate sample sizes should be taken so that they could be split between the laboratories. Such an arrangement has been discussed and appears attractive to the management of Exportpak in Liberia. The collection and handling of samples should be the responsibility of Claudio Zumbado, melon agronomist with CTNDE/DIVAGRO. This will require additional support for travel related to the sampling requirements. The cost of laboratory analysis and sample shipment will have to borne by Exportpak. The U.S. laboratory of choice is Charles Babcock and Sons of Riverside, CA. Appended is a listing of their analysis charges, and more detailed information on field sampling

and handling procedures.

C. Irrigation Practices

1) Observations: Rivers are a principal water source and with below normal rainfall during the 1990 wet season growers are concerned that water supplies may be inadequate.

Early season plantings can frequently be grown without irrigation because of residual soil moisture from wet season rains. When wet season soil moisture is prematurely depleted efforts to supply water by furrow irrigation on land which has not been properly leveled for the purpose has resulted in poor yields and quality.

The strategies used to determine irrigation frequency and amounts were not discussed in great detail but information was provided to some growers on the crop demand system of water application based upon evapotranspiration data.

2) Recommendations: In California, where water supplies have been a perennial problem, many growers utilize locally available climatological data, including evapotranspiration data, to adjust irrigation schedules to the needs of the crop. Growers in Costa Rica should work toward the development of a similar system in the interests of water conservation, as well as avoiding the leaching of soluble nutrients from over-irrigation. This may require setting up weather stations and evaporation pans if they are not installed in all growing areas.

High water tables during early season plantings could conceiveably have an adverse effect upon fruit quality. The Parrita area has problems producing cantaloupes of good quality under these conditions. Water tables are often less than one meter below the surface. One possible solution may be the use of very high beds to provide the advantage of a deeper and drier root zone.

Early season plantings areas should be properly leveled to accommodate uniform furrow irrigation applications if they should be needed.

D. Varieties

1) Observations: All growers are using the 'Mission' (Asgrow) and 'Hy Mark' (Petoseeds) hybrids. These are the best of the varieties tested but tend to have lower than desirable Brix and net expression. Some growers have found that 'Hy Mark' fruit become too large during early season plantings. Cantaloupes typically produce low Brix and poor netting in the Parrita area, but in the Orotina area, about 50 km. north at slightly higher altitude and on sandier soil, quality is good. Honey dews have no net to be concerned with and have inherently higher Brix so it is the muskmelon grown where cantaloupes can't be produced successfully.

2) Recommendations: The hybrids in use in Costa Rica were originally developed for use in the southwest U.S.where the climate is quite arid. They are also fairly well adapted to Central America although quality does not easily meet export standards. A continuing program of variety evaluation should be established in all growing areas. A working relationship will need to be developed with all U.S. muskmelon breeding sources including seed companies (especially Asgrow, Petoseeds, and Northrup King) as well as public institutions such as the University of Florida. Seed samples should be requested annually of new releases and experimental material. This should be a function of CINDE/DIVAGRO in addition to the planning and management of the trials. A uniform system of evaluation should be developed to include initial observation trials from which promising varieties are selected for more detailed

replicated trials.

E. Conclusions : A research program is needed to resolve some of the questions involved with the fertilizer programs currently in use since evidence of their validity is little or lacking. These include the need for additional K when soil analyses indicate adequate to high supplies, the need to adjust Ca/Mg ratios by Ca additions which analysis reports do not seem to support, and frequent foliar spray applications to overcome deficiencies of minor elements when soil applications should provide a more economical solution. Some minor elements are being supplied which are not needed. The frequency and timing of N applications requires investigation in order to evaluate the effects on both yield and quality.

In order to obtain valid, confident answers to these questions the research plans, management, data collection, and analysis will require the cooperation and support of scientists and laboratories in local institutions. This type of support may be expected to require extra financial input, involving grower contributions. CINDE/DIVAGRO is the logical organization to organize and coordinate the research program and support.

Irrigation management practices should be based on crop demand but temperature and evapotranspiration data would need to be made available in the growing districts before this practice could be put in place. California growers are conserving water by this method based upon computer-accessed weather station data throughout the state.

Growers should consider the use of plant tissue analysis during crop development as a means of evaluating their fertilizer programs. Guidelines are available which provide levels of adequacy and deficiency in plant parts for melon plants. Soil analysis should continue for it's value in determining soil mineral status, but plant sampling will be helpful in determining how well the fertilizer program is meeting plant needs.

Variety evaluation should be an on-going program to seek improved varieties better adapted to Costa Rica growing conditions. New materials can be obtained for testing by maintaining close contact with U.S. breeding programs. Uniform testing plans need to be developed.

Small acreage growers who traditionally perform all cultural operations by hand should be encouraged to begin to mechanize if they are to compete in the marketplace.This will require careful leveling of land areas to provide uniform irrigation, the proper spacing of plants, and the proper placement of fertilizer materials so that they are efficiently available to the plants. Some source of financial aid may be necessary to help these growers obtain the proper equipment, and a training program to help them learn how to use it properly.

APPENDIX 1: COSTA RICA

This refers to the discussion with Exportpak management regarding split samples to be analyzed by a laboratory of local choice and Babcock and Sons in Riverside.CA

Following are suggested procedures for comparative soil and plant sampling and analysis for a cantaloupe planting.

Soil sampling:

The area to be sampled should be limited to 10 - 20 ha. Take soil from about 30 locations which are randomly distributed over most of the area to be sampled. Preferably, cross the field in a zig zag pattern first in one direction, then again at right angle to the first direction. Sample depth should be about 20 cm. The total amount of soil accumulated should be 3 -4 liters.

Air dry the sample to reduce shipping weight. Mix the sample thoroughly, then package about 0.5 liter sub-samples for each lab.

Plant sampling :

Samples should be taken at three periods of growth: 1) during early growth when plants have short branches, 2) at early fruit set, and 3) at the time of first mature fruit. At each sampling time walk a similar pattern to the one used during soil sampling , and over the same area. Sample the youngest fully expanded leaf; this is usually the 4th or 5th leaf from the branch tip. Collect a minimum of 100 leaves at each sample period. This will provide enough material for sub-samples for both laboratories. Separate the blades from the petioles and place in separate paper bags. Leaf parts should be washed in distilled water to remove dust and pesticide residues before drying. Dry samples in open paper bags at 60 - 70 degrees C.

After drying, mix petioles and blades thoroughly, and separately, then divide petiole and blade samples into two equal groups and ship to labs.

Ship U.S. lab samples to Hunter Johnson, Jr., 5633 Riviera Ave., Banning, CA 92220; Telephone (714) 845-6161.

Analyses to be completed by both labs (see Babcock price list): Soil samples: pH, P, K, Ca, Mg, Cu, Zn, B.

Plant samples: 1) blades - Cu, Zn, B
2) petioles - nitrate-N, phosphate-P, K, Ca, Mg

If there are any questions or concerns, please let me know.

APPENDIX 2. HONDURAS AND COSTA RICA

Re. field research on potassium fertilization, and minor element correction by folior spray vs. soil application.

Recommendations were been made for these research projects but details on treatments and design were not discussed. Before suggestions can be provided there will need to be a soil analysis made for each of the experimental sites in order to know the mineral status of the soils. The bed spacing, irrigation method, and planting date will need to be provided. The analysis should provide data on pH, K, Ca, Mg, Cu, Zn, and B. Send a copy of the analysis via FAX at (714) 845-9564. I will return suggestions by FAX within a few days.

If you wish to plan the experiments in collaboration with local authorities you might consider the following treatments:

Potassium :

1) 200 lbs/acre KCl banded into the soil at planting time, 4 inches to each side of the seed line and 4 inches deep. No additional K to be supplied during growth.
2) 200 lbs/acre KCl as in 1) with additional K which the grower would normally apply during plant growth.
3) No potassium. Use this treatment only if soil is known to have at least 0.3 meq/100gms or 150 ppm K.

Nitrogen and phosphorus applications should be standard grower practice.

Minor elements:

1) Grower foliar spray program which he would normally apply.
2) Broadcast soil application, disced in prior to making beds, of only those elements known to be deficient at the following rates:
   - Zn - zinc sulfate @ 20 lbs/acre
   - Cu - copper sulfate @ 30 lbs/acre
   - B - boric acid or Solubor @ 9 lbs/acre

N, P, and K applications to be standard grower practice.

Let me know if I can be of further assistance with your plans.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CALIF. DHS CERTIFIED
PHONE (714) 684-1881
LABORATORIES
3215 CHICAGO AVE.

ESTABLISHED 1906
EDWARD S. BABCOCK & SONS, INC.
P.O. BOX 432
RIVERSIDE, CALIFORNIA 92502

Soils

Category	Price
Saturation Extract (includes Saturation Percentage)	$ 6.00
Determined on the Saturation Extract:	
X ·Boron (B)	$ 8.00
·Electrical Conductance ($ECx10^3$)	$ 6.00
·Calcium (Ca)	$ 6.50
·Magnesium (Mg)	$ 6.50
·Sodium (Na)	$ 6.50
1:5 Water Extract	$ 5.00
Determined in the Extract:	
·Chloride (Cl)	$ 6.50
·Nitrate Nitrogen (NO_3-N)	$ 6.50
·Sulfate Sulfur (SO_4-S)	$ 6.50
Ammonium Acetate Extract	$ 5.00
Determined in the Extract:	
X ·Calcium (Ca)	$ 6.50
X ·Magnesium (Mg)	$ 6.50
X ·Potassium (K)	$ 6.50
·Sodium (Na)	$ 6.50
Sodium Bicarbonate Extract	$ 5.00
Determined in the Extract:	
X ·Phosphate Phosphorus (PO_4-P)	$ 6.50
DTPA Extract	$ 5.00
Determined in the Extract:	
X ·Copper (Cu)	$ 10.00
·Iron (Fe)	$ 10.00
·Manganese (Mn)	$ 10.00
X ·Zinc (Zn)	$ 10.00
pH	$ 6.00
Cation Exchange Capacity	$ 35.00
Gypsum Requirement	$ 10.00
Particle Size by Hydrometer (Sand, Silt & Clay)	$ 15.00
Sieve Analysis (including Particle Size by Hydrometer)	$ 50.00
Moisture	$ 10.00
Organic Matter (Loss on Ignition or Dichromate)	$ 7.50
Nematode Identification & Count	$ 20.00
Salinity Analysis	$ 30.00
·pH, $ECx10^3$, Boron, SAR, ESP	
Fertility Analysis	$ 30.00
·pH, Water Sol. NO_3-N, Bicarbonate Sol. PO_4-P, Acetate Sol. K	
Corrosion Analysis	$ 30.00
·pH, Eh, Saturated Resistivity, Sulfide	

ices Effective August 1st, 1989

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CALIF. DHS CERTIFIED
PHONE (714) 684-1001
LABORATORIES
3215 CHICAGO AVE.

ESTABLISHED 1900

EDWARD S. BABCOCK & SONS, INC.
P.O. BOX 432
RIVERSIDE, CALIFORNIA 92502

Plant Tissue Analysis

Test Parameter	Price
Sample Preparation	$ 5.00
Moisture Determination	$ 3.00
Total Nitrogen (Kjeldahl)	$ 7.00
Total:	$ 5.00
·Determined in the Digest:	
·Calcium (Ca)	$ 5.00
X ·Copper (Cu)	$ 5.00
·Iron (Fe)	$ 5.00
·Lithium (Li)	$ 5.00
·Magnesium (Mg)	$ 5.00
·Manganese (Mn)	$ 5.00
·Phosphorus (P)	$ 5.00
·Potassium (K)	$ 5.00
·Sodium (Na)	$ 5.00
·Sulfur (S)	$ 5.00
X ·Zinc	$ 5.00
Extractable:	$ 5.00
·Determined in the Extract:	
X ·Calcium (Ca)	$ 5.00
·Chloride (Cl)	$ 5.00
X ·Magnesium (Mg)	$ 5.00
X ·Nitrate Nitrogen (NO_3-N)	$ 5.00
X ·Phosphate Phosphorus (PO_4-P)	$ 5.00
X ·Potassium (K)	$ 5.00
·Sulfate Sulfur (SO_4-S)	$ 5.00
Molybdenum (Mo)	$ 7.00
Boron (B) X	$ 8.00

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