AN EVALUATION OF WEED CONTROL PROBLEMS IN SOYBEANS IN THE SELVA ALTA OF PERU AND SUGGESTIONS FOR THEIR CONTROL

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A Consultancy Report to

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College of Agriculture
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and to

INTSOY - Peru

in cooperation with

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ACKNOWLEDGMENTS

I am pleased to submit this report covering my two-week trip to Peru for the purpose of evaluating weed problems in the selva alta region of that country. My especial thanks are due to Dr. Tom Fullerton for initiating the invitation and for his confidence in my ability to assist in solving some weed problems in the country, and to his lovely wife Jane for her gracious hospitality in helping make my stay comfortable. Dr. Fullerton gave unstintingly of his time in arranging travel into the country so that I might become acquainted with the problems. I would like to thank also, Dr. Tom McCowen for his assistance in making arrangements for the trip, and other INTSOY personnel in Peru as well as the many persons associated with MAA. The trip was profitable and rewarding for me and I trust the conclusions regarding weed control for soybeans in the selva alta of Peru will prove beneficial in the future.

BACKGROUND

Although soybeans have been grown along the coastal regions of Peru for some time (under irrigation), it has only been in recent years that interest has grown in their establishment in the selva alta. This is the intermountain region generally east of the high cordilleras of the Andes, and is typified by tropical to sub-tropical climate and by small farms. Major crops grown, in addition to soybeans, would include corn, rice, yucca, fruits, and vegetables. Plant growth, including that of weeds, is luxuriant due to high temperatures and high rainfall.

Soybeans have been known in Peru since 1929 with the introduction of germplasm and subsequent experimentation at the Agricultural Experiment Station of La Molina. It was not until the last decade, however, that fields of significant size began to be planted. In 1968 a total of 205

hectares were recorded for the country and this figure has risen to 2257 hectares by 1977. Although isolated instances of yields up to 2500 kg/ha have been recorded, the average yields for the country for this 10-yr period range from 1078 to 1376 kg/ha. It has been stated that lack of commercialization of the harvested crop has been a major reason for failure of soybeans to be more successful thus far. Low average yields, however, must also exert an influence.

The present INTSOY work in Peru was established in 1978, following pre-planning work dating back to 1974. Briefly, the University of Illinois, through INTSOY, was charged to "provide technical services to improve the Government of Peru's management resources, human and financial, for more effective agricultural sector performance. Emphasis was placed on use of these services to assist and advise the Government of Peru in the design and management of the research required to achieve increased (soybean) production." The present project agreement between USAID and Peru, and to which INTSOY contributes is "to increase productivity, employment, and income and improve nutrition among the poor, the primary goal of the agriculture sector. The project aims at achieving self-sustaining growth in the production and consumption of soybeans, improved corn and soybean food products, thus increasing productivity and incomes among selected segments of the rural poor and increasing the national food supply while improving the quality of foods commonly used by the urban and rural poor." Presently, INTSOY is represented in Peru by Dr. Tom fullerton, Project Director, Dr. Luis Camacho, Soybean Breeder, Dr. Al Harms, Production Economist, and Dr. Al Siegel, Food Scientist.

Although this team has been in Peru less than a year it soon became apparent to most of them, as it already was to their Peruvian counterparts, that uncontrolled weed growth was severely limiting productivity of soybeans.

This was particularly true in the selva alta, for the most part the newer soybean production area of Peru. It was decided, therefore, to request the author's services as a consultant, to assist the Project Director in evaluating the weed problems confronting soybeans in the selva alta, and to suggest possible means of control. Consequently, a trip to Peru encompassing two weeks was arranged for the author from November 18 to December 3, 1978. The time was spent in interviewing personnel of INTSOY, of the Ministerio de Agricultura y Alimentacion (MAA), and in traveling to parts of the selva alta for a first-hand look at problems in the field. Part of the time was also spent in devising applicable methods of weed control, establishing appropriate control demonstrations, and beginning work on an "informe" outlining suggested control measures in Peru.

Following is a brief resume of events during the two-week period.

CHRONOLOGY OF TRIP

Nov. 18-19. My wife and I left Fayetteville, AR on Saturday afternoon late and arrived in Lima the next afternoon. We were met by Dr. Fullerton at the airport and taken to our hotel. We spent a couple of hours planning the work for the two-week period. At this time we also met Mr. and Mrs. (Bede) Paul Klinefelter, a consultant to INTSOY from Central Iowa Bean Mill, Gladbrook, Iowa.

Nov. 20. Dr. Fullerton and I left Lima on an early Aero Peru flight to Tingo Maria where we were met by Ing. Raúl Laos, Agente de Producion - Soya, with the Agencia de Producion at Tingo Maria. After checking into the Hotel Turistawe met with Ing. America Diaz, Director Agencia de Producion, Tingo Maria and Ing. Werner L. Bartra, Director Colonizacion, Tingo Maria - Tocache. In the afternoon we proceeded to Sub-Estacion Experimental Tulumayo. This station is part of the CRIA III area (Centro Regional

de Investigacion Agropecuaria). At the station we met Ing. Antonio Polo (Investigador-yucca), who at the time was Acting Jefe de Estación, and Ing. Pedro Ruiz (Investigador-Soya). Both Ing. Laos and Ing. Ruiz work actively with INTSOY. We reviewed soybean work at the station and became acquainted with some of their weed problems including arrocillo (Rottboellia exaltata), coquito (Cyperus rotundus), and pata de gallo (Cynodon dactylon). We visited soya fields on adjacent lands of the Agencia de Producion and were accompanied by Ing. Gustavo Lopez, in charge of those fields. We saw three fields of Jupiter soybeans - one had just been disked down because it could not be cleared soon enough to keep arrocillo from taking it, one had been cleared within 25 days of planting and the soybeans growing well, and a third which was delayed one day in hand clearing and had arrocillo growing through the canopy. We discussed several possibilities for control.

Nov. 21. In the morning Dr. Fullerton and I worked on data from an experiment at Tulumayo and discussed in detail materials I had brought from Arkansas. In the afternoon we toured Tingo Maria, visiting farm supply stores to determine availability of herbicides. We also purchased a liter of the herbicide Roundup (at S/7000 per liter!) and other materials for demonstrating herbicide application (see next section for details).

Nov. 22. We drove back to Tulumayo where we met Ing. Marco Nureña, Director de Estación, who discussed some of the research being conducted and problems confronting soybean production in the area. We put together some of the materials we had bought the day before, which included wrapping a cane pole with a burlap bag and soaking it with a mixture of Roundup and water (2:1, which was 80 cc herbicide and 160 cc water). We did this twice, then Ings. Laos and Ruiz carried the pole over 4 rows of soya, just above the canopy, "wiping off" the herbicide on the arrocillo. In the afternoon we selected another field where data of planting studies were being conducted.

Soybeans were considerably younger, and although the plots had been hand cleaned, weeds were growing back - primarily Tradescantia and seedling arrocillo. Here we demonstrated applications of Roundup with an ordinary paint roller on either side of the row, using two concentrations to soak the roller - 5% and 30%. Ing. Mario Lopez (Investigador-arroz) assisted us with these demonstrations. That same afternoon we went to the Cooperativa Aucayacu where we met Ing. Victor W. Cueva, Manager. He showed us his soybean expeller facility which had not operated for two years because of lack of soya. He estimated they needed 4,000 ha of soya per year to operate the plant. We met also Ing. Enrique Castañeda, Director of Research, Universidad Nacional Agraria, Tingo Maria, who was also visiting the plant, and arranged a meeting with him later in the week.

Nov. 23. We returned to Tulumayo in the morning to continue our demonstration work. In this instance, we marked off simulated 60 cm rows in a cleared field where weeds were starting to come back in (principally Tradescantia, coquito, and arrocillo). Using a back-pack handpump sprayer (mochilo) we applied Roundup (2% solution) in narrow strips (approx. 10 to 15 cm) over these simulated rows. The idea was to kill out the weeds in these narrow strips and, in a few days, to come back and hand plant soya in these strips, with the hope of getting good seedling establishment without weed interference.

> (Note: Since Roundup translocates in plants slowly, we could not determine the efficacy of our applications on this trip. In a call to Ing. Ruiz a week and a half later from Lima, we were told the applications had been successful, but that a second pass over the arrocillo growing up through the soya canopy would be necessary because of re-growth.)

We examined another soya field on the station heavily infested with several weeds including cypress-leaf morningglory. Cercospera disease was also very prevalent. Spent the afternoon in Tingo Maria beginning to write up ideas for control.

Nov. 24. We went to the University and continued our writing. At noon we met with Ing. Castañeda and discussed research ideas with him. We checkout out of the hotel and went to the airport - after several hours delay we caught a Faucett flight to Lima.

Nov. 25 (Sat.). Worked further in writing up ideas at INTSOY office in Lima. Later in the day we had Thanksgiving dinner with Dr. Fullerton's family and friends.

Nov. 26. We worked again in the INTSOY office and began writing a proposed publication for weed control in Peru (see next section). Had dinner with the Klinefelters in the evening.

Nov. 27. Spent the early morning in the INTSOY office where I met Dr. Luis Camacho. We discussed several problems concerning his breeding program and general production problems. He, too, felt that weed control was a major problem confronting soya production in the tropics and agreed that a certain level of technology was necessary for the crop to be a success, and that very likely it might not be possible to produce soya in the tropics without the use of herbicides. At 11:30, Dr. Fullerton and I took a Faucett flight to Tarapoto (by way of Chiclayo). We were met at the airport by Dr. Al Harms of the INTSOY staff, who took us into town where we registered at the Hotel Edinson. In town, we met briefly with Ing. Jorge Calle, Zona Agraria and coordinator for soya, Tarapoto. Later, at the office of Zona Agraria San Martin (which is under Direcion General de Producion Agricola y Crianzas, MAA) we met Ing. Wilfredo Torres, Agente-soya (Agencia de Producion-Tarapoto) and Ing. Moises Gomez, Director, Agencia de Producion. We also met Mr. Edward Van Es and Mr. Ben Mensink of COPERHOLTA (Cooperacion

Peruana Hollendesa Tarapoto). Mr. Van Es is the director of this cooperative project from Holland and Mr. Mensink is an agronomist with a special interest in weed control. Mr. Mensink worked with us throughout our stay in Tarapoto. We also toured the town during the afternoon, bought some 2,4-D (at S/4000 for a 6 lb gallon) and a mop and a bucket! The latter items will be explained below. During this brief tour we also met Mr. Jack Kradolfer, private citizen from the U.S., who very graciously helped to keep us entertained during our stay in Tarapoto.

Nov. 28. In the morning, despite torrential rains, Dr. Harms, Dr. Fullerton, Mr. Mensink, Ing. Torres and I drove to El Estacion Experimental El Porvenir. This station is also in CRIA III which has its headquarters in Tarapoto. At the station we met and chatted briefly with Ing. Manuel Lescano, Jefe de Estacion and with Dr. Cesar Valles, microbiologist at El Porvenir. Dr. Valles has attended the soybean short course at the University of Illinois and is familiar with many of the soybean-growing areas of the U.S., including my state of Arkansas. We also met Ing. Dario Maldonado who has worked with INTSOY and has considerable weed control experience, Ing. Geraldo Vialvo in charge of seed production, including soya, at the station and Ing. Armando Cueva (Investigador-soils, formerly the INTSOY counterpart). With these people, a meeting was organized to discuss the problems of weed control in soya. Dr. Fullerton led the discussions in the morning and Dr. Valles in the afternoon. Several topics were covered, including Dr. Fullerton's work with reduced rates of herbicides at Tingo Maria, bands vs complete applications, and with and without hand weeding. We discussed the possibility of using herbicides in the selva alta from the standpoints of phytotoxicity, availability, price, capability of farmers, rotations, types of weeds (again Ipomoea spp., arrocillo, and coquito seemed to be the major types of weeds confronting

farmers), and sprayers. We also discussed labor costs and concluded that soya requires a minimum of two hand cultivations per season, which could cost as much as S/7500 per hectare without herbicides. The question raised, then, was how much could this labor requirement be reduced by use of herbicides. This seemed to be a good place for Dr. Fullerton and I to demonstrate some of our ideas developed the week before at Tingo Maria, so we adjourned to some nearby soya plots and demonstrated our paint roller, spraying strips of weeds for later planting, and our newest idea, dragging a herbicide-saturated mop between soya rows to inhibit weed growth. While we used Roundup in these demonstrations, we propose using 2,4-D for situations where Ipomoea is a problem. We believe that these "wipe-off" methods will allow a little herbicide to go a long way.

Nov. 29. We returned to El Porvenir in the morning to continue working with personnel there. My time was spent in devising simplified methods of calibration of back-pack sprayers, again using the hand-pump type commonly found in the selva. I demonstrated to Ing. Torres methods for calculating speed, sprayer output and ground coverage using the sprayer they had available. We returned to Tarapoto for lunch and in the afternoon we went to the Cumbacillo area where soybeans were being produced. One field in particular had been hand-cleaned for weed control. The field was infested with Ipomoea hederacea as well as lobalado (Euphorbia lobatus), coquito, Panicum fasciculatum, Eleusine indica, and Momordica charantia. We figured that roughly 1/5 hectare took 12 man days to clear. We were told the going rate for hand labor was about S/300 per day. Therefore, in that particular field, the cost per hectare for hand clearing would have been about S/18,000 (roughly $90). Since the hand clearing took so long, by the time they were nished, soya had suffered extreme competition from the weeds to the extent that the money was probably spent needlessly. This would have been a perfect

situation for a demonstration of "wiping-on" 2,4-D with a mop between the rows earlier in the season. Other fields in that area were similarly infested. In the evening after dinner we met with Ing. Fernando Rey, head of the Zona Agraria for the Dept. of San Martin, headquartered in Tarapoto.

Nov. 30. After a restless night due to an intestinal upset, I spent the morning at the hotel continuing with my writing. We checked out of the hotel and went to the airport at noon. Both Dr. Harms and Ing. Calle came to see us off - after several hours delay we arrived in Lima late afternoon.

Dec. 1. We spent the day in the INTSOY office. Both Mr. Klinefelter and I were taken to the AID office where we met with Dr. Loren Schulze, Agricultural Technologist. We enjoyed a lengthy conversation with him regarding problems of soya production in Peru. Later in the morning, I met with Ing. Ricardo Villamonte, National Soybean Program Coordinator for Production for Direcion General de Producion Agricola y Crianzas and with Ing. Rodolfo Vargas Saco, National Soybean Program Coordinator for Research, Direcion General de Investigacion. We explained to them our concepts of combining inexpensive herbicide practices with hand labor for weed control and they seemed quite enthused about the possibilities. During the day I also met Dr. Al Siegel, Food Scientist with INTSOY, and in the afternoon I had a lengthy conversation with Ing. Oscar Bullón, weed specialist for CRIA I, located at La Molina experiment station. Ing. Bullón has worked with several crops and is endeavoring to keep current in the field of weed science, although his efforts are often hampered by lack of available herbicides to conduct his work, a very real problem which will be alluded to later. In the evening Dr. Fullerton, his wife Jane and I had dinner with the Klinefelters and then took them to the airport for their return trip to the U.S. We also met my wife, Maria Teresa, who was returning from visiting her parents in Bolivia.

Dec. 2. Again spent the day in the INTSOY office in final discussions with Dr. Fullerton concerning our work, reading reports, and organizing material for this report. In the evening after dinner, Dr. Fullerton and his wife drove us to the airport to catch our plane.

Dec. 3. We left Lima at 12:45 a.m. and arrived home in Fayetteville the next evening about 9:30 a.m. (several hours delay in Atlanta due to weather).

This concludes the day-by-day account of my activities during the two week visit. Obviously, as Dr. Fullerton and I travelled, saw situations, and met people, ideas began to form regarding measures that might be instituted for control of very serious weed situations. I was able to introduce a new concept into our discussions - notably, the "wipe-on" method of applying herbicides, particularly to grasses growing above the soybean canopy. This technique is just being developed for johnsongrass (Sorghum halepense) control in soybeans in the Mid-South region of the U.S. Beyond that, however, Dr. Fullerton and I, through many "brainstorming" sessions, jointly conceived most of the ideas presented here. We just happened to spot a paint roller, for example, in one of the shops in Tingo Maria - the idea of a mop to alleviate the morningglory problem between rows of soya grew from that, etc.

We were attempting to formulate and put into practice what we both already knew about weed control in soya, without the necessity of having to engage in long, expensive research programs. After all, much has already been done in advanced soybean-growing areas of the world, such as in my state of Arkansas. Why not put to practice what we already knew? But of more importance, could we not devise methods of control that would be inexpensive and would serve to assist existing hard labor control

methods? We chose, then, to emphasize older herbicides that have become relatively inexpensive over years of use, though effective for specific weeds. Admittedly, Roundup is one of the more expensive herbicides to buy, but we believe our "wipe-on" method will greatly extend coverage and conserve actual herbicide usage, thus partially circumventing its high unit cost.

With these thoughts in mind, I began writing a guide for weed control in the selva alta of Peru, using vines, arrocillo, and coquito as examples of the worst weeds encountered and suggestions for their control. The following section may be considered a "first draft" of those suggestions, intended, perhaps, for "sectoristas" who will be advising farmers in their attempts to grow soya in Peru. Most of this was written and illustrated during my two-week stay and includes a section on calibrating a back-pack sprayer.

WEEDS INFESTING SOYA OF THE SELVA ALTA AND SUGGESTIONS FOR CONTROL

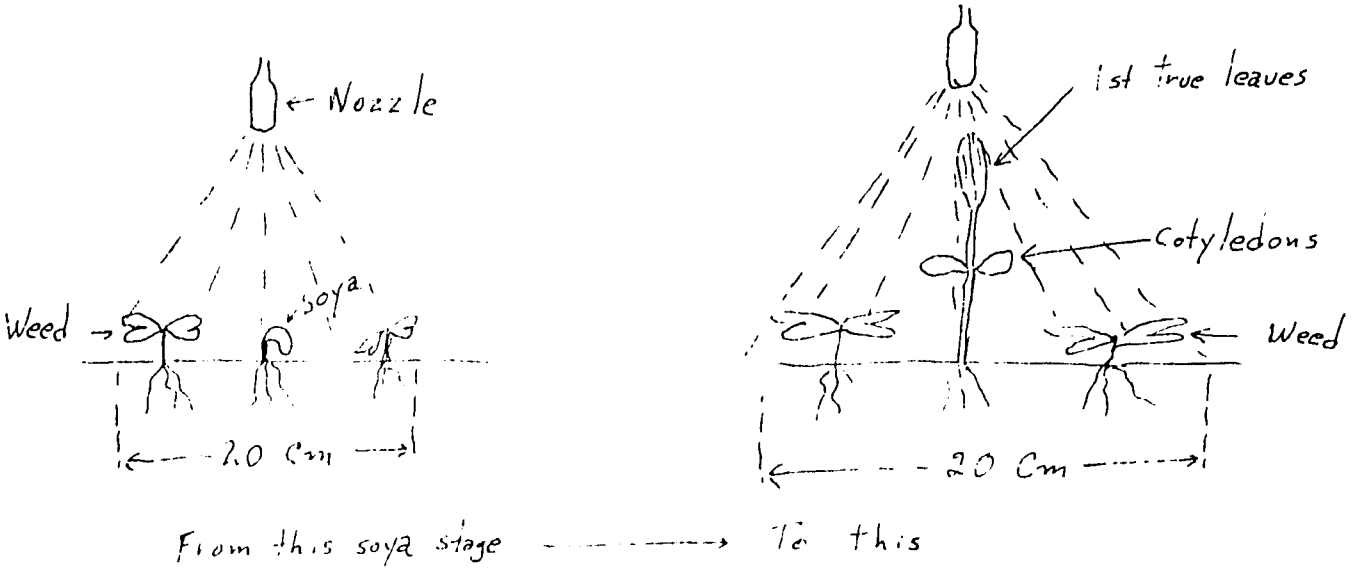
Although there are many weeds infesting soya we have chosen to illustrate a few of the worst ones likely to be encountered in the selva alta, and offer suggestions for their control. We believe that these weeds will be controlled effectively only through use both of hand labor methods and programs of herbicide application. In all cases we emphasize that early control will be necessary to avoid unnecessary competition and to avoid unnecessary hand labor later during soya growth.

Vines

Several weeds of the Ipomoea or Convolvulus spp (also called "morning-glories") become problems early in the life of soya. Herbicides are effect-

ive only after weed emergence, with applications being made directly to the weed foliage. Generally, preemergence herbicides are not effective for these weeds. We will discuss various situations in relationship to stages of soya growth, at which herbicides might be applied for control.

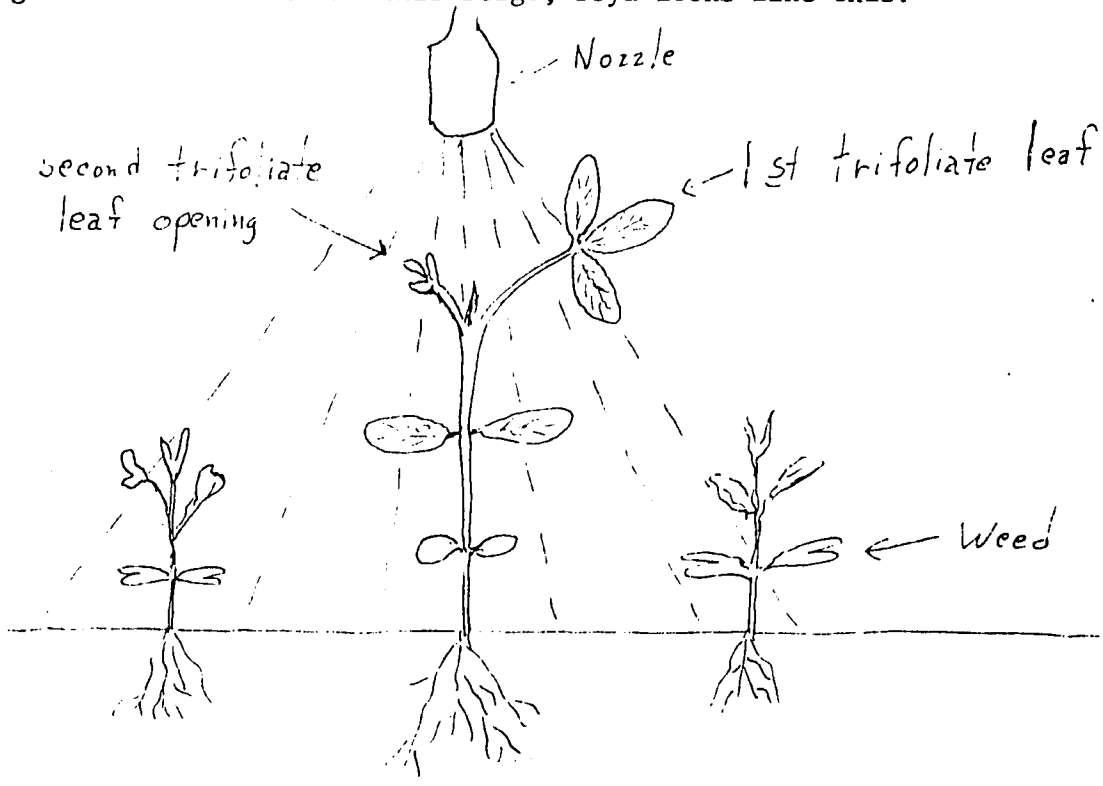
At soya emergence - very often you will find these vine weeds emerging from the soil at the same time soya seedlings are emerging. This is the time to start control! The herbicide dinoseb (example - Dow Premerge) can be applied directly over emerging soya and morningglory species with little or no injury to the soya. The usual rate of application is 1.7 kg/ha of the active ingredient (or about 4.7 liters of the commercial product). This herbicide can be applied from the time of emergence of both the soya and the weeds until just before the first true leaves of soya are opened, or:



From soya emergence until the opening of the first true leaves of soya usually requires about three to four days. Be sure the weeds are present because the young seedling leaves have to be contacted by the spray for control to occur.

If the above application has been missed and the vine weeds are growing up with the soya, it is still possible to apply dinoseb overtop

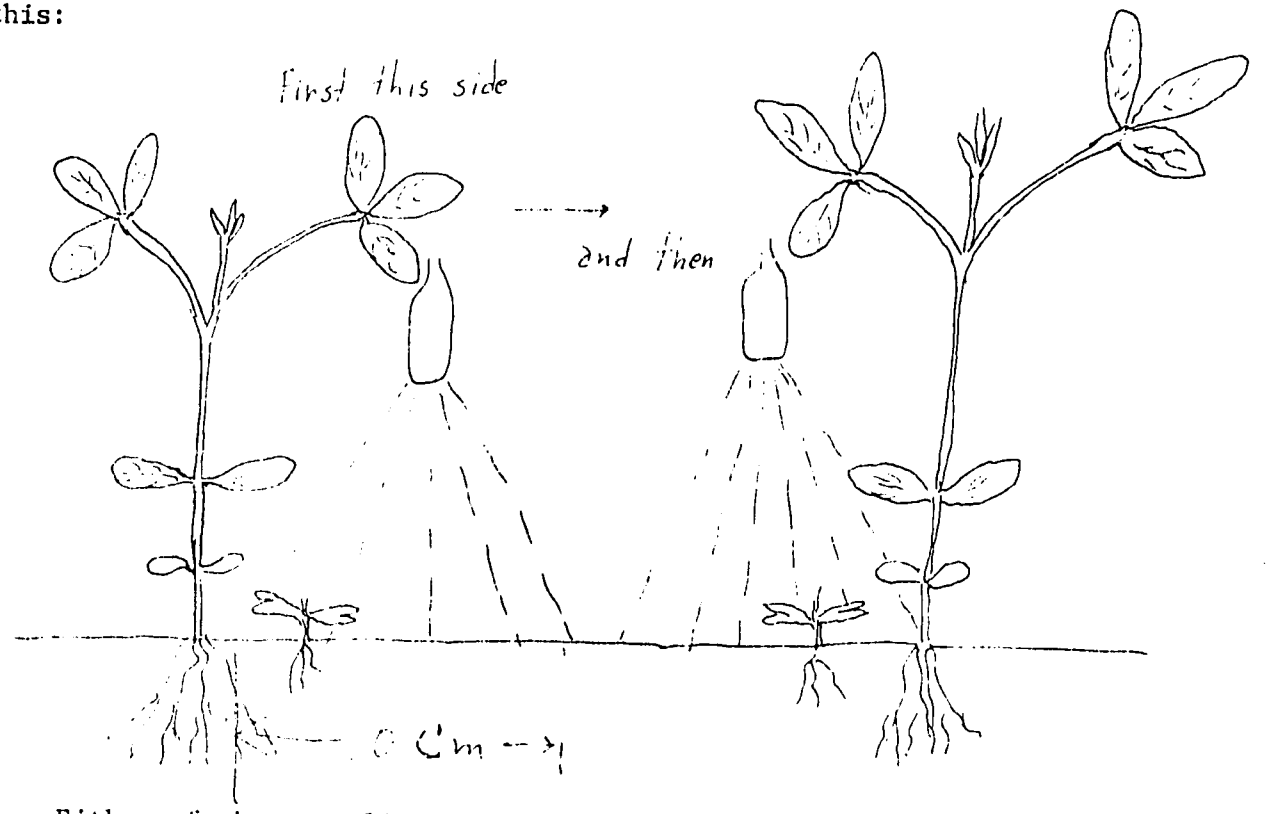
of soya for control. This can be done when soya has obtained the first open trifoliate leaf and the second one is beginning to unfold. The rate of dinoseb must be reduced at this stage, because some injury to the soya leaves may occur. This application should be used only if the weeds threaten to get completely out of control. The earlier "at emergence" stage is much better. At this stage, soya looks like this:



The rate of dinoseb to use should not be over 0.85 kg/ha on the band (or about 2.4 liters of the commercial product). Be sure no wetting agent is used to avoid further injury to the soya.

Once soya plants have achieved 2 to 3 trifoliate leaves, directed applications of herbicides can be considered. These are best used when the soya plants are taller than the weeds and are best when the vine weeds are just emerging or in very early stages of growth. This might occur, for example, if you have used the "at-emergence" dinoseb application, your soya has grown normally, but more vine weeds begin to germinate and emerge. At this stage two herbicides can be sprayed at the base of the

soya plants - dinoseb or 2,4-DB. With dinoseb, you can return to the 1.7 kg/ha rate and wetting agent can be added for good activity. Or, 2,4-DB can be applied by spray at a rate of about 0.2 to 0.23 kg/ha (an example of 2,4-DB is Amchem Butyrac - 240 g/L active or the equivalent of 0.8 to about 1 liter of this formulation). No wetting agent is needed for 2,4-DB. In both these situations, we would suggest spraying a 10-cm band on <u>either</u> side of the row (<u>calibrate carefully</u>!). Your application would look like this:

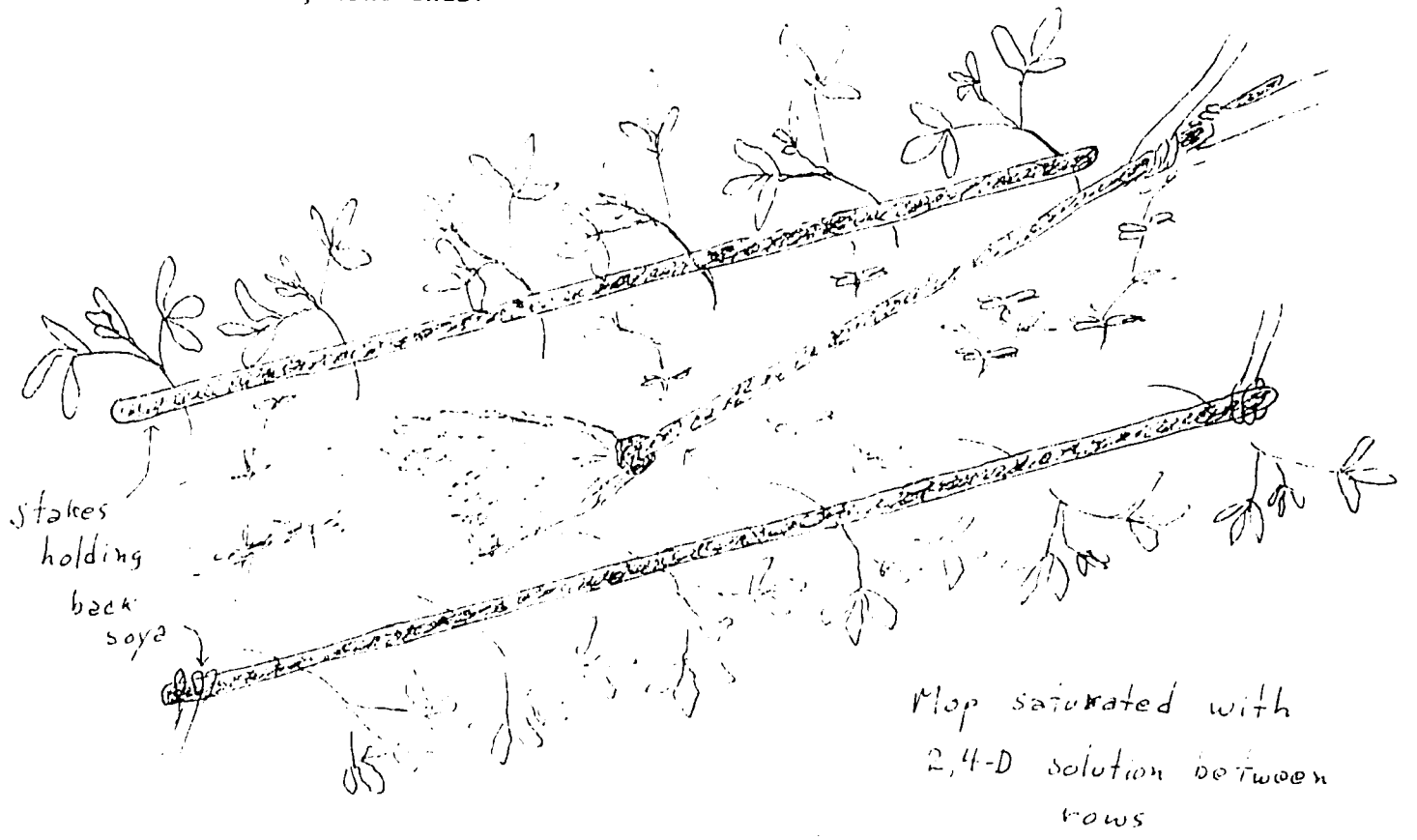


Either of these applications should effectively inhibit small vine weeds and can be repeated once or twice more as needed. Also, if small grass weed seedlings are emerging at the same time, the herbicide linuron can be added to either of the above at a rate of 0.4 kg/ha. Be sure a wetting agent is added with this herbicide for most effective control of grass weeds. An example of linuron is Afalon - a powder that is 50% active, so you would need 0.8 kg of the commercial product to equal 0.4 kg/ha active.

These programs of control should be useful in maintaining good control when the vine weeds or morningglories are the principal weeds present,

until the soybean leaves shade the soil. If these weeds are kept under control until then, they should not be a problem through the rest of the season.

A further suggestion. The herbicides dinoseb or 2,4-DB may not always be available. Another herbicide, 2,4-D, usually can be obtained easily. We suggest considering a "wipe-on" method of applying dilute concentrations of this herbicide down the middle between the rows for control of the vine weeds. You must be careful not to contact the soybean plant, because it is more sensitive to this herbicide. We would suggest making up a solution of 0.4 to 0.5% 2,4-D (or about 4 to 5 cc's of 2,4-D - activity 480 g/L - per liter of water). Use an old mop or a piece of carpet soaked in the solution (and gently wrung out) and drag it between the rows infested with the vine weeds. Be sure to have the rows of soybeans bent back out of the way so that there will be no contact of the crop plants with the herbicide, like this:



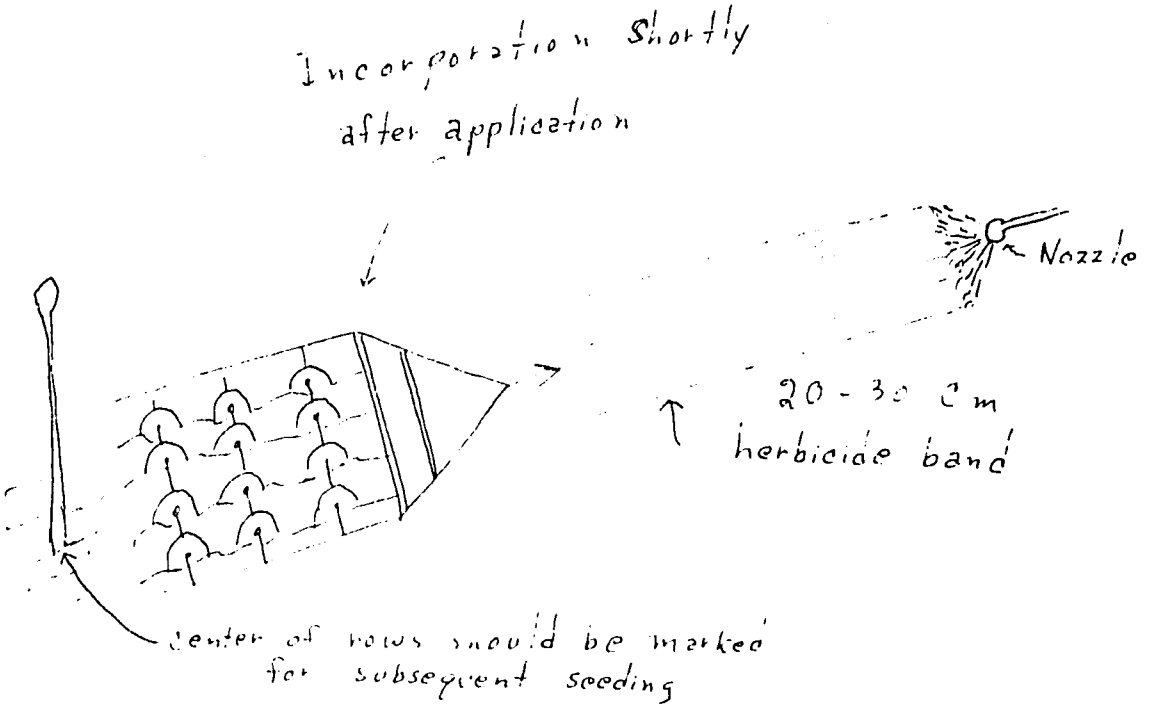
Be sure your mop or piece of carpet is just wet enough to rub off on the vines, but not so wet that it drips - you want to only wet the weeds slightly and to get none on the soya. This herbicide translocates and should kill the entire weed, even if its stem is in the soya now. This treatment could be repeated later in the season as more vine weeds germinate and grow. Other broadleaf weeds will be controlled as well.

Arrocillo - (Rottboellia exaltata)

This is one of the worst grass weeds infesting soya in the selva alta. It is an annual reproducing by jointed seed, breaking apart and scattering to the ground upon maturity. Its rate of growth is very rapid and it must be kept under control early, preferably before the canopy of soya closes, or else it grows up through soya and inhibits their growth and development. Several methods of control should be considered.

The first, and one of the most effective, methods is by use of a pre-plant incorporated herbicide. In those areas where a clean seedbed can be prepared by tractor and disk, the herbicide trifluralin (trade name Treflan) can be applied and worked thoroughly into the soil before seeding soya. Use a rate of 0.85 kg/ha on medium-textured soils (or 1.8 liters of the commercial product - 480 g/L active). A 20 to 30-cm band can be sprayed over predetermined rows and then the material worked into the soil by disking twice the same direction of the rows. The rows must be marked carefully and the herbicide applied accurately, so that at time

of seeding the soya seed are placed in the center of the band of treated soil. Incorporation must be thorough or else the herbicide will be lost by volatility, and should be done immediately after herbicide application:

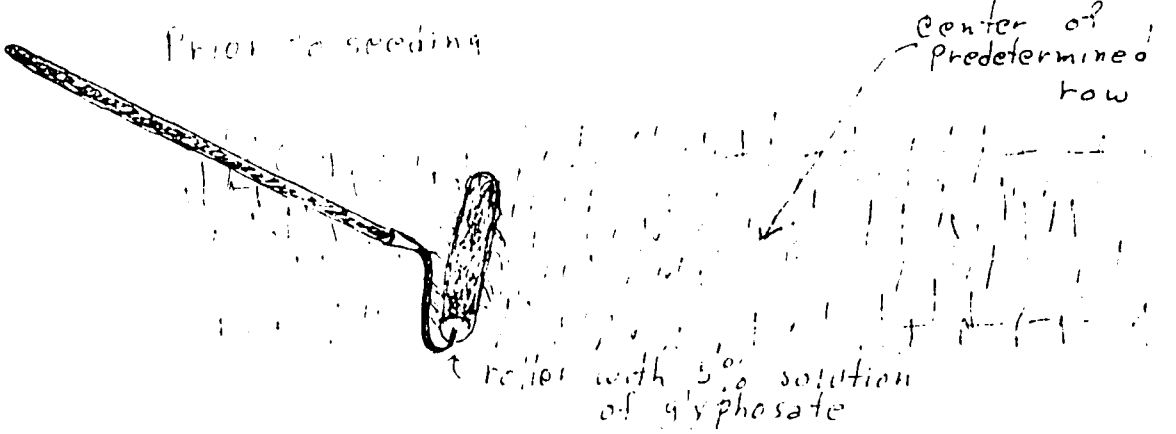


If the above herbicide, or method of incorporation is not available, it may be possible to allow the seedling grass develop and then control it by spraying a band of herbicide over the predetermined rows. Two herbicides are available for this purpose -- dalapon or glyphosate. Dalapon (trade name Basfapon) can be applied to similar width bands at a rate of 5 kg/ha (or about 5.9 kg of the 85% active commercial product). Glyphosate (trade name Roundup) can be applied in a similar manner in about a 2% solution (20 cc in a liter of water) with the same result. The latter herbicide is considerably more expensive so care must be used not to waste it.

Following dalapon, soya can be seeded in the band about 4 to 7 days later - it may take longer to see the effect of glyphosate since it is a slower acting herbicide. Seeding should be done with care so as to avoid

disturbing the soil any more than necessary - otherwise new seed of arrocillo will germinate.

Best control will be obtained by spraying these herbicides; however, it may be possible to "wipe-on" a dilute solutim of glyphosate if a sprayer is not available. Concentration may need to be strengthened since less of the plant surfaces will be contacted - we suggest a 5% solution for this situation (50 cc's/liter of water). Dragging a mop saturated with the solution over the predetermined row may be satisfactory. We have used an ordinary paint roller with a long handle and this should give more accurate coverage of the grass seedlings:



Re-wet the roller as often as necessary to cause wetting of the grass weed seedlings, but it is not necessary to completely saturate it since the herbicide does translocate in plants. Again, seed the soya a few days later in these bands with minimum soil disturbance, once control of the seedling grass has been obtained.

We believe that both glyphosate and dalapon can be used in this manner for later control of arrocillo once soybeans have developed. If early control has been obtained by one of the methods outlined above, then soybeans should be able to become established and make good early growth. However, arrocillo will continue to germinate later and probably cause more infestation. In these cases, we suggest again the "wipe-on" method of attacking the weed, utilizing either glyphosate or dalapon.

Again, neither of these herbicides are selective for growing soybeans, so care must be taken not to contact the soya. Use two persons with a long stick to bend back the plants as the roller is moved down the row.

If glyphosate is to be used at this time, a solution of approximately 5% may be required (50 cc/liter). However, lower concentrations should be tried, particularly on small seedlings. Similarly, the dalapon rate should be kept as low as possible - one should apply only enough material to give good contact of the grass foliage and no more. Excess material of dalapon may drip off the plants onto the soil. Succeeding rains could then carry the herbicide into contact with soya roots, thus causing damage. We would suggest making up a solution of about 20 gm of the commercial product of dalapon per liter of water. Additional surfactant should be added to the solution to insure good wetting of the weeds.

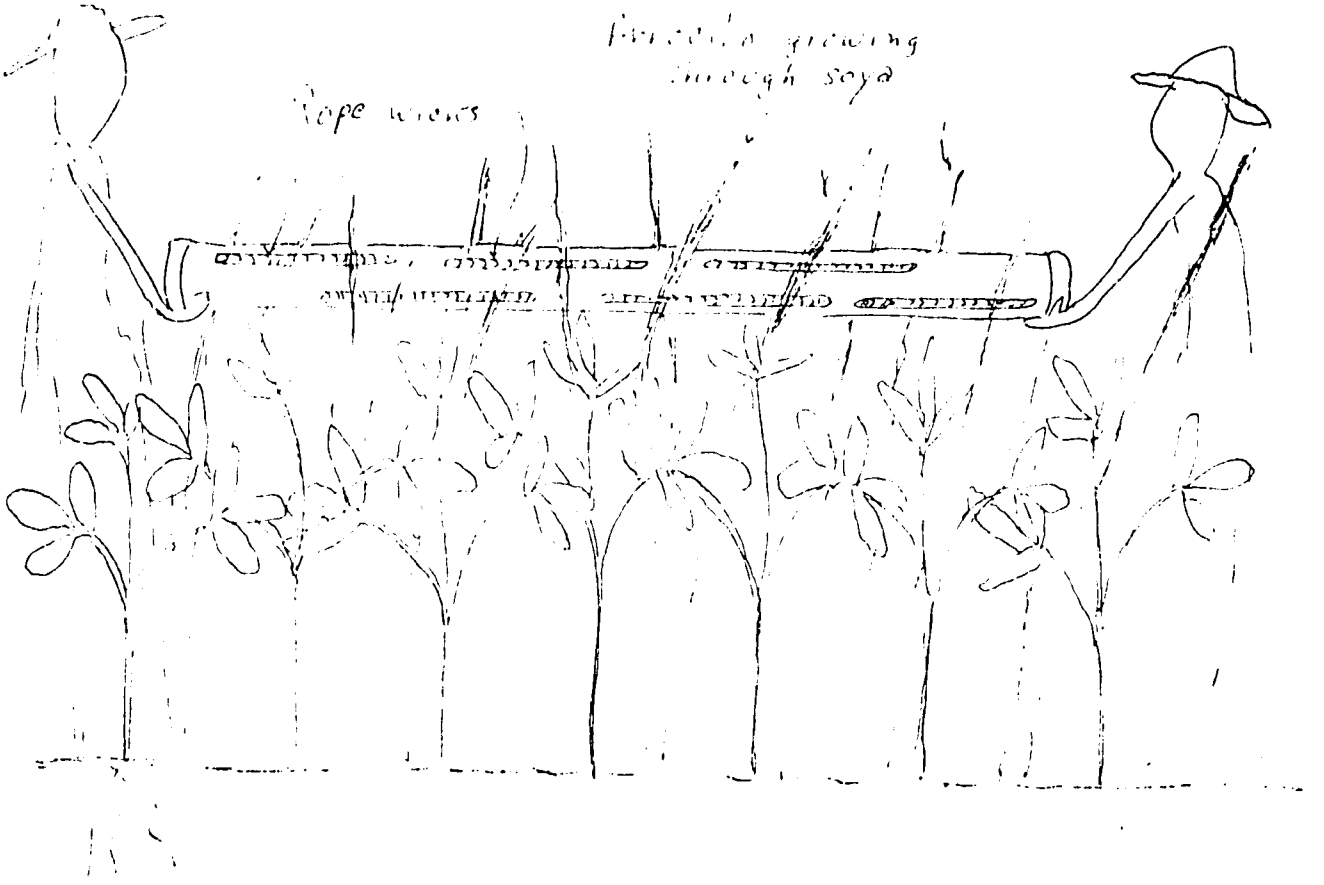
We think these kind of applications of herbicides will give good control of arrocillo close to the row and under the developing soybean canopy. This should reduce considerably the amount of hand labor necessary to remove these weeds close to the row, and thereby reduce injury to the soya.

In spite of best efforts, there will be situations where arrocillo grows up through the soya canopy later in the season. It is important to control the weed even this late for if allowed to continue to grow, it can cause soya to completely lodge and reduce yield severely. We suggest another "wipe-on" method of control that is being used successfully in other areas of the world - notably the U.S. - for control of Sorghum halepense in similar situations.

Briefly, this method uses a system of dragging ropes saturated with glyphosate, just over the canopy of soya, so that the emerged arrocillo will be forced to come in contact with the rope, enough of the material

The ropes should be cemented into place so that the only herbicide coming out of the pipe soaks through on the rope. About 4-5 cm of the rope on either end of each length are allowed to be carried free on the inside of the pipe to insure good "wicking" action. In most cases the pipe should be filled with concentrated solutions of water and Roundup -- we have used 2 parts of water and 1 part of Roundup. Because of the high cost of this herbicide, though, lower concentrations should be tried. The pipe can be emptied and the herbicide stored for future use, once an application is completed.

The pipe is carried by 2 persons like this:



Pipe with herbicide saturated ropes carried just above soya - contacting arrocillo and rubbing herbicide off on leaves

so that the arrocillo makes contact with the ropes as the pipe is being carried forward just above the soya canopy. The grass weeds are bent down under the pipe as it passes. This method allows a very minimal amount of herbicide to be used and in a very efficient manner, since the herbicide is translocated downward in arrocillo. The application should be repeated later if more arrocillo plants grow up through the canopy.

These methods for controlling arrocillo in soya should be considered in supplementing hand labor methods. Almost certainly some hand labor will be required, since it is impossible to get all the grass in the row by the methods described. Nevertheless, a reduction in arrocillo growth in or near the soya row should reduce considerably the hand labor necessary to maintain good soya growth.

Coquito - (Cyperus rotundus)

Coquito has been termed the worst weed problem in the world and is a particular problem of the tropics because of its rapid growth and proliferation of chains of underground tubers, each capable of producing a new plant. In soil which has been cleared for planting a crop, these chains are broken apart, allowing each tuber at the end of a broken chain to germinate and grow. Because of the rapid growth of the seedlings, competition with a newly-planted crop such as soya is severe. Early control is absolutely necessary if young soya plants are to become successfully established. Once soya leaves shade the soil and a complete

canopy is formed, coquito becomes much less of a problem.

We feel that this will be the only practical way for being able to grow soya in coquito-infested fields - taking advantage of the shading capability of soya. We feel, also, that our methods of growing soya in those fields must minimize soil disturbance, so as not to be constantly breaking apart tuber chains beneath the soil surface, thus allowing more tubers to germinate. We would suggest, then, periodic applications of herbicides directly in or alongside the row in narrow bands, and hand clearing between rows until soya forms a solid canopy of leaves.

Before seeding - at present, there are no practical herbicides that we can recommend for application to cleared soil before planting. Certain thiocarbamates, such as Vernam, have been used in soya in other countries preplant incorporated for coquito control. Because of their unavailability and minimal levels of selectivity for soya, however, we will not consider them further. It will probably be best, then, once an area has been cleared for soya, to let the coquito germinate from the disturbed soil, emerge, and then attempt some control with herbicides prior to planting.

We suggest, as in the section for arrocillo, predetermining the soya rows, and then applying herbicides right over the row in narrow bands, then planting the soya in the strips where the weed has been killed. We think the "wipe-on" method of applying Roundup with the paint roller should be tried. Roundup is not likely to give as good control of coquito as it does arrocillo - it does not seem to translocate into the roots and tubers readily. Therefore, about the only control will be of the existing seedling. To accomplish even this, a high concentration will probably be needed. We suggest trying the 2:1 solution (2 parts water:1 part Roundup), and working down from there. The idea is to accomplish enough control to get soya established without competition.

Another herbicide might be considered to be sprayed on narrow bands, and that is paraquat (trade name Gramoxone). An active rate of approximately 0.3 kg/ha will be needed for control, and a surfactant must be added to the spray (0.3 kg is equivalent to about 1.2 L of the commercial material which is 240 gm/L active). This herbicide acts only as a contact material, so it will control only the plants that are present at time of the spray -- there is no activity through the soil, and no translocation in the plant. It kills the plants very rapidly, whereas Roundup works very slowly. Control will only be temporary, but it should allow enough time to get soya planted and established.

Once the killed strips of weeds are evident, plant the soya right down the center of the strip by dropping the seed into evenly-spaced holes. Do not disturb the soil any more than necessary!

After establishment of the soya, control should be continued, and we suggest trying the paint roller application of Roundup on either side of the row as described in the section on arrocillo. Again, control is not likely to be complete, but one should be able to keep the coquito sufficiently inhibited to allow the soya to develop normally.

The herbicide paraquat can also be sprayed at the base of soya on either side of the row later in the season (see illustration for applying 2,4-DB in the section on vines). Soya must have at least 2 to 3 full trifoliate leaves and be growing well before this application is attempted. Cut the rate back to about 0.15 kg/ha for these applications and use extreme care that the spray contact only the base of the soya plants. Any soya leaves contacted by the spray will be killed, but with care, this application will give at least contact control of any new coquito plants, so long as they are smaller than soya. If they have grown nearly as large as soya, then they cannot be controlled by a herbicide. This is

how the plants should look for this application to be successful:

Both the herbicides suggested in this section are expensive, so care must be taken that they are not wasted. Keep the strips to which the herbicide is applied as narrow as possible to keep the cost low. If these steps are followed, we believe that the economics of herbicide use to help remove competition will be favorable, especially when compared to the necessity of having to control coquito entirely by hand. And remember, it is necessary to get good control right in and alongside the row only till the soybean canopy forms.

Backpack Sprayer Calibration

The backpack sprayer will be a useful and often necessary part of the weed control program for soya. Most applications should be made on narrow bands, either before planting or after soybean emergence on either side of the row. Band applications are recommended to help reduce the herbicide cost in soya plantings.

For accuracy in applying herbicides it is necessary to maintain a constant rate of speed in walking, a constant output of spray from the nozzle, and a constant width of band. The last point is especially important, for raising or lowering the nozzle will cause a fluctuation in the rate of herbicide applied. Select the band width desired and try to maintain that width throughout the spray operation.

A constant walking speed is easily obtained with a little practice before actually beginning to spray. Most people can easily train themselves to walk about 5 kph, which is just a little faster than a normal walking rate. Measure out a course of 25 meters and practice walking it until you are able to cover it in 18 seconds, (12.5 meters in 9 seconds would be the same rate). Once this can be done consistently, then your rate of speed is 5 kph.

The rate of delivery of spray can also be determined with a little practice before spraying. Obtain an empty Inca Kola bottle and practice pumping constantly to fill the bottle, noting the time required. With most nozzles on backpack sprayers, you should be able to fill the bottle (approximate volume is 320 cc's) in from 10 to 15 seconds. The following table shows the sprayer output, with a 5 kph walking speed, at these three time intervals:

	When the bottle is filled in		
	10 sec	15 sec	30 sec
For a band width of	then sprayer output on the band is approx.		
10 cm	2300 L/ha	1536 L/ha	768 L/ha
15	1536	1024	512
20	1150	768	384
30	767	512	256
40	575	384	192

Example - suppose we wish to spray Ipomoea spp just emerging from the soil with soya, with the herbicide dinoseb (Dow Premerge), at a rate of 1.7 kg/ha. We are going to spray a 20 cm band right over the soya row. We find we can fill our Inca Kola bottle in 15 seconds evenly and we have practiced our walking speed of 5 kph. The activity of the herbicide is

360 g/L; so:

$$\frac{0.36}{1} = \frac{1.7}{x}$$ and x = 4.7 L of herbicide to equal 1.7 kg

Assume also we have a 20 liter tank on our sprayer and we want to fill it. From the above table we select 768 L/ha as our sprayer output, so our proportion is:

$$\frac{4.7 \text{ L}}{768} = \frac{x \text{ L}}{20}$$ x = 0.12 L or 120 cc of the herbicide to be added to 20 L of water in the tank.

With this proper concentration of herbicide in the tank, holding the nozzle so it covers a 20 cm band, and walking at 5 kph, you will be applying dinoseb at a constant rate of 1.7 kg/ha to the band.

Note: formula used in arriving at above calculations:

$$\text{Sprayer output in L/ha} = \frac{60 \times \text{ml/noz/min}}{\text{kph} \times \text{cm of coverage}}$$

CONCLUSIONS

General concepts. The above draft should give an idea as to our thinking in approaching the weed problem in the selva alta of Peru. It is not radical but we hope it is innovative enough to stimulate thinking. Perhaps the only new concept involved is the "wipe-on" method for applying herbicides. It does recognize the fact that hand labor will continue to be used for a long time in soya weed control in the selva. It is an attempt, however, to make the hand labor count most effectively, recognizing that it must be supplemented by herbicides if soya are to be successful in that region of the world.

It was John L. Hammerton, Agronomist with the University of the West Indies, who made the statement: "It may not be possible to grow soya in the tropics without the use of herbicides." I subscribe to that supposition. On the face of it, the use of herbicides may seem to be too onerous an economic burden for the campesino of Peru to bear. It may be, too, that he is unaware of the effects of weeds upon his crops. He can see insect and disease damage, and sometimes will apply insecticides or fungicides for control - but weeds? It seems there has always been and will always be the machete, so when weeds get big enough to chop down - go after them!

The trouble is, that too much damage has already occurred from competition before much hand weeding takes place. I have alluded already to the low 10-year average yields of soya in Peru through 1977. Although many factors contribute to these low yields, I am sure that lack of control of weed vegetation early in the life of the crop surely heads the list.

We have tried, in the information presented in the preceding section, to emphasize early weed control. It is a generally accepted maxim of

weed science that the first plant to occupy an ecological niche has the competitive advantage, which means the Peruvian soybean farmer must do all he can to insure that it is the soybean plant occupying that niche, and not Ipomoea or arrocillo, or coquito. We see herbicides, then, as assisting this process of getting young soybean plants germinated and established quickly with minimal interference from weeds.

Soybeans are well known for their capacity to form a dense canopy of foliage. There is no better weed control practice than to encourage the earliest formation of this natural shading of the soil, which then in turn discourages the further development of weed competition. Without the canopy weeds grow rapidly between the rows to the point that soybeans are not able to compete well enough to make optimum growth. This is the place for judicious herbicide use.

Available technology. For the most part we have emphasized the use of tried and tested herbicide materials. They may not be the latest, most glamorous compounds being talked about today, but they are inexpensive and they will work. I refer primarily to dinoseb (Premerge), 2,4-DB (Butyrac or Butoxone), and dalapon (Basfapon or Dowpon). These older herbicides should be considered carefully in the soya program for Peru. Unfortunately, the first two are not readily available, if at all, in the country. It would seem entirely appropriate to me to encourage the government to make the necessary contacts with the commercial firms selling them to consider developing a market for them in the country. They will be especially useful for early control of the vine weeds, which, as has been pointed out, grow profusely in tropical climates. While we suggested a technique for possible use of 2,4-D (readily available), I would much rather see 2,4-DB used because of its greater selectivity for soya.

Glyphosate (Roundup) and paraquat (Gramoxone) are available in the country but are quite expensive. Nevertheless, we believe the techniques suggested for glyphosate application will be economically feasible. It would be quite in order, however, to suggest that Monsanto re-consider their pricing structure for sale of this product in the international market. Paraquat may prove to have a place where advantage can be made of its quick knock-down capability. I believe its use will be limited, however, for soya in Peru.

Research vs adaptation of existing technology. I wish to reiterate here that Peru little needs to undertake a complete program of evaluation of new and experimental herbicides to achieve a successful program of control for soya. Such programs are underway in the more advanced soybean growing areas of the world. The transfer of this already available technology should be readily accomplished, particularly through ongoing programs of work as are represented by INTSOY. Furthermore, I do not believe, at present, the newer herbicides are needed to initiate a sound program of weed control. They would add little to what we have already suggested except cost. A further maxim in weed science is that as new products are adopted and used over a period of years, the price tends to decrease. Peru could well take advantage of the experience and adoption of new herbicides in other areas -- after the price comes down.

I do think that any research effort in weed science in Peru should be directed toward developing even more efficient and economic methods of control than the ones suggested here. The experiments initiated by Dr. Fullerton, in cooperation with Ing. Ruiz at Tulumayo and Ing. Maldonado at El Porvenir are a step in the right direction. Reduction of herbicide rates to least amounts possible tc achieve sufficient weed inhibition, allowing maximum soybean growth is a desired goal. In all cases, I would

urge that such experimentation also aim towards achieving the earliest weed control possible.

Often, I have found it of value to be able to demonstrate in research plots the effect of uncontrolled weeds on yield. This is easily accomplished in most weed control experiments by including a hand-weeded check plot kept absolutely weed free the entire season to serve as a benchmark on soya production in the absence of weeds, a check plot with no control, and perhaps a third check in which conventional practices are used. More elaborate experiments could be conducted on time of removal of weeds, density of weed infestations and their various influences on yield, etc. These sorts of results tend to get a farmer's attention rather quickly. I believe it is imperative for farmers attempting to grow soya in Peru to understand the magnitude of the weed problem. Beyond that, they must surely understand how much it costs to hand-clear weeds, especially if they have to hire it done. After all, the S/18,000 per hectare cost cited earlier would pay for some good alternative herbicide practices!

The work already underway by Dr. Camacho is commendable and much needed. Development of varieties adapted to the environment of the selva alta in itself will assist in weed control, for adapted varieties should grow and establish themselves quickly, thus providing maximum competition for weed growth.

Future developments. As soya production becomes more sophistciated in the future, I believe soya farmers will want to look to new techniques that can be adopted under a more mechanized system of farming. I alluded briefly to the use of preplant incorporated herbicides - the dinitroanilines, represented by Treflan - as giving good control of grass weeds. Thorough incorporation is necessary, which means tractor preparation of the seedbed along with mixing the herbicide into the soil. Until more tractor power

is available in the selva, however, I do not see this as an immediately available technique. Furthermore, most soybean producers in advanced soya producing areas commonly use preemergence herbicides applied to clean seedbeds at time of planting. Yet, the best of these - Lasso - is not available in the country. Metribuzin (Sencor) is available for potatoes, but because of the necessity for precise rate application (due to a low degree of selectivity) I would hesitate to recommend it for use now. As proficiency in sprayer calibration advances, however, it might well be considered in the future.

Newer herbicides being put into use in the U.S., for example, include the family of diphenylethers. These have proven to be quite selective for soya. Goal is effective on grass weeds and Blazer for certain broadleaves. These may find a place in the future but I doubt if they are needed at pesent. Bentazon (Basagran) is an effective and selective herbicide for certain broadleaves such as Xanthium spp, but is not particularly effective on the Ipomoea spp, which seems to be one of the worst weeds of the selva. There may be other weed problems develop in the future for which this herbicide could be considered.

At present, I believe the most progress can be made in the immediate future by considering those practices already described which are designed to be applied to existing weed foliage. These suggestions represent the adoption of only a minimal amount of weed science technology, yet I view it as an absolute necessity if soya production is to succeed in the selva alta of Peru. The alleviation of the weed problem will surely help assure successful soya production.