I. Progress Report 2002

A. Cover Page

Project Title:

Adaptation of Soybean to Low Phosphorus Soils of Tropical and Subtropical South China: A Radical Approach

Principal Investigators:

Dr. Xiaolong YAN (PI-China)
Root Biology Center
South China Agricultural University
Guangzhou 510642, P. R. China
Tel 86-20-85283380 Fax 86-20-85281829
Email<xlyan@scau.edu.cn>

Dr. Yaoguang LIU (coPI-China)
Laboratory of Genetic Engineering
South China Agricultural University
Guangzhou 510642, P. R. China
Tel 86-20-85280187 Fax 86-20-85282693
Email<ygliu@scau.edu.cn>

Dr. Jonathan LYNCH (PI-USA)
Department of Horticulture
Penn State University
University Park, PA16802, USA
Tel 814-863-2256 Fax:814-863-6139
Email<jpl4@psu.edu>

Dr. Hong MA (coPI-USA)
Department of Biology
Penn State University
University Park, PA 16802, USA
Tel 814-863-6414 Fax 814-863-1357
Email<hxm16@psu.edu>

Executive Summary

Systematic research and training work has been undertaken towards developing soybean varieties with better adaptation to low P soils in South China. The following progress and results were achieved during the past year: 1) A 'core collection' of 308 soybean germplasm materials was formed based on GIS analysis and these materials were screened and selected for P efficiency in two separate field sites for two consecutive seasons. Promising materials with superior root traits and P efficiency have been identified. Meanwhile, a series of conventional breeding programs were implemented. 2) Physiological studies were conducted to identify important root traits useful for improving P efficiency in soybean; our preliminary results indicated that root architecture and root organic acid exudation appeared to be correlated with soybean performance in low-P soils, which is consistent with the premise of our project. 3) Genetic systems were being established for mapping and cloning of genes conferring superior root traits and P efficiency, and satisfactory progress was made. 4) Agroecological studies were conducted in the field to assess the effects of P-efficient varieties on soil P bioavailability, soil P cycling and soil fertility in various cropping systems. Preliminary results indicated that intercropping with P-efficient soybean genotypes could significantly improve maize growth. 5) Extensive agroeconomic and social survey was conducted in over 100 farmer families in South China to obtain the background information on the project. 6) Activities directly related to this project, including a planning workshop, series of scientific lectures, and joint-training programs, were undertaken to ensure efficient and sustainable operations of the project.

B. Research and Training Progress (by Module)

1. Module 1: Germplasm Screening and Conventional Breeding

1) Core Collection of Soybean Germplasm

At the end of 2001, a name list of soybean germplasm materials was assembled with available collections from the Chinese Academy of Agricultural Sciences, Jilin Academy of Agricultural Sciences, Guangxi Academy of Agricultural Sciences, EMBRAPA (Brazil), as well as some local collections. These materials, with a total number of 20884 accessions, represented a great biodiversity of cultivated and wild germplasm from many parts of the world. Based on GIS analysis of the soil type and phosphorus status of the original collection site, growth habits, flower color, seed weight, seed color, seed shape, and other parameters, a 'core collection' of 308 soybean genotypes was formed (Fig.1). These germplasm materials were obtained from the above-mentioned sources for field screening and selection for phosphorus efficiency in year 2002.

2) Germplasm Screening and Selection

In 2002, two seasons (Spring and Fall) of field trials were conducted in two representative low-P red soil regions in South China: Boluo of Guangdong Province and Long'an of Guangxi Province (Fig 2). The 308 soybean germplasm materials from the core collection were screened on a red soil upland field with an area of 15 hm^2 (Boluo) and 10 hm^2 (Long'an). The land was prepared with irrigation and drainage infrastructure built. Before planting, the fields were treated with or without added P. During the growth period, biomass and P uptake at seedling stage, final grain yield and phenological data were taken for each accession. Root samples were also taken from the field to study root morphology and architecture.

Great genetic variability was found for soybean germplasm materials grown on these low P red soils. Some promising soybean materials were identified (Fig. 3). For example, at the Boluo field site in Guangdong Province, some P-efficient genotypes outperformed some local varieties by more than 200% in both biomass and grain yield under low P conditions (Fig. 4).

3) Conventional Breeding

According to the original workplan for this project, conventional breeding work will start in 2003. However, in order to increase breeding efficiency, the following breeding programs were carried out in 2002 in the three breeding nurseries located at SCAU, Boluo and Guangxi:

- Hybrid breeding: In early 2001 before the project started, 13 crosses were made between a local soybean variety and some exotic materials, including those from Brazil. The crosses were successful and F3 seeds were obtained at the end of 2001. In 2002, F3 populations were grown and selected in various environments, including the low-P fields in Boluo for two seasons. The retained progenies have been advanced to F4 by the end of 2002. Some of the lines showed good combinations of good traits from both local varieties (early maturity) and exotic materials (phosphorus efficiency) (Fig 5). These lines will be further advanced to later generations for more stable traits.

In addition, more than 50 new crosses were made at the second half of 2002 with different genotypes identified from the screening work described above. The F1 seeds have been obtained and will be propagated and the segregating populations will be selected during the next few years.

- Recurrent breeding: a diallel crossing program with five contrasting soybean genotypes (GZ1, BD2, GD2, B10 and B13) was carried out in 2002. Reciprocal crosses among these genotypes have been completed and seeds of F2 have been obtained.
- Mutation breeding: this work was not included in original workplan, but was added to increase breeding efficiency. Over 10 soybean genotypes were treated with ^{60}Co radiation to induce mutation both in 2001 and 2002. The treated seeds were grown in the field to see their adaptation to low P conditions. Seeds of M3 have been obtained from the first treatment and some mutants have been identified in the field. Seeds of M1 have been obtained from the second treatment and will be screened and selected in the field.

2. Module 2: Physiological Mechanisms and Root Traits Identification

1) Root Morphology and Architecture

During the field trails for germplasm screening, root traits for all the 308 soybean genotypes were evaluated. Root system architecture was observed and scored (shallow, deep, and intermediate) by digging soil trenches and careful recovery of the roots from the soil profile. Roots were also sampled for laboratory analysis of root morphological parameters such as root length, root diameter, root branches, and specific root length. Our preliminary results indicated that there was great genetic variability in root traits, which appeared to be correlated with soybean performance in these soils (Fig. 6). This is consistent with the premise of our project.

Root traits of contrasting genotypes from the field screening were further characterized in the lab with the paper pouch system. Preliminary results indicated that changes in root morphology and root architecture are induced by P treatments, indicating a plasticity of soybean root system in response to P nutrition (Fig 7).

With the matching efforts from the South China agricultural University, a phytotron-rhizotron complex was constructed in 2002 for the Root Biology Center. This complex has been equipped with various facilities and instruments (such as minirhizotrons with root image capture and analysis systems, soil column percolators, etc). This complex will be devoted to root biology studies related to this project.

At Penn State University, a soybean collection was acquired from USDA that contains a good representation of wild (*Glycine soja*) and cultivated (*Glycine max*) genotypes from all over the world, with emphasis in genotypes from countries with soils with problems in phosphorus availability. This collection is being screened for root hair and other traits and selected genotypes will be used in further studies.

2) Root Exudation

Greenhouse studies were conducted to investigate root exudates as related to P uptake and utilization efficiency in soybean. Root exudates were collected from roots of contrasting genotypes grown in solution culture, and organic acid profiles were analyzed using ion chromatography and HPLC. Preliminary data indicated that soybean genotypes differ in the type and quantity of organic acids excreted from the roots under P stress, and higher P uptake in P-efficient genotypes than P-inefficient genotypes are probably attributed to higher exudation of organic acids (Fig. 8). Further studies are underway to characterize the physiological and molecular mechanisms of P-induced root exudation and its significance in phosphorus efficiency.

3. Module 3: Molecular Biology of Root Traits and Development of Genetic Systems for Improving Root Traits and P Efficiency

1) Gene Mapping

Work was carried out in 2002 on mapping root traits conferring P efficiency using existing populations developed in the past few years in collaboration with the Jilin Academy of Agricultural Sciences (JAAS). One of the F9 recombinant inbred line (RIL) populations derived from two contrasting parents, Changnong4 and Xinmin 6, was grown in a low P filed in Jilin Province. Phenotypic data of both shoot and root traits have been collected and will be used for linkage analysis.

Meanwhile, more RILs and other genetic populations of soybean are being developed for use in molecular mapping of root traits. By using B2 as male parent, BD2, GZ1 and GD 2 as female parents, 3 crosses have been developed, and F1 progenies have been obtained. A new frame genetic map is being constructed with these materials by using SSR (simple sequence repeat) markers.

2) Gene Cloning

Molecular genetic systems are being established to identify and isolate candidate genes conferring important root traits and P efficiency. In 2002, we focused on two approaches: homologous gene cloning and suppression subtraction hybridization (SSH). At SCAU, the SSH technique was employed to construct a low P induced cDNA library with the roots of a P-efficient soybean genotype. Nineteen cDNA clones were identified, 9 of which were specific to the roots and 10 with enhanced expression in the roots. Several positive clones were confirmed by Northern Blot to be specifically expressed in the root and the expressions are enhanced under low P availability (Fig. 9). These clones are being sequenced and characterized for their physiological functions.

At PSU, the homologous gene cloning technique is being established to identify and isolate genes related to P nutrition in soybean. For the first year of the project, Dr. Hong Ma, together with Dr. Kathy Brown and Jonathan Lynch, have successfully recruited Ms. Catalina Posada, a student who had just completed most of her course work as part of the EMPP (Ecological and Molecular Plant Physiology) option of the IBIOS (Integrated BioSciences) graduate program at the Pennsylvania State University. She has been reviewing the literature on genes affecting root and root hair development, planting soybean plants to begin preliminary experiments, and learning about available resources on soybean genomics and genetics. She has identified a number of genes that could be used as the starting point for candidate gene approach to the isolating of soybean genes. She has also obtained several Arabidopsis mutants defective in root or root hair development and begun testing them for phosphorus nutrition phenotypes. Catalina also attended a meeting on soybean genomics and learned about the resources available, including information about efforts on analysis of gene expression using cDNA microarrays.

4. Module 4: Agroecological Analysis

1) Phosphorus-efficient Soybean Genotypes in Different Cropping Systems

Field experiments with previously identified soybean genotypes contrasting in P efficiency were carried out to study the effects of P-efficient genotypes on crop yield of soybean and maize when the two crops are intercropped and/or rotated. Preliminary results of the first year indicated that intercropping with soybean could significantly improve maize growth. Interestingly, the effects of soybean on maize growth varied with different genotypes: the P-efficient (B10) genotype had significantly greater effects on maize yield than the P-inefficient genotype (BD2); such a difference seemed to be related to greater overlapping of the root systems between soybean and maize (Fig. 10).

Field experiments were also conducted to investigate the effects of P-efficient genotypes on soil fertility and biological nitrogen fixation. Rhizosphere and non-rhizosphere soil samples have been collected and are being analyzed for P bioavailability in the lab. Besides, nodulation (number and size of nodules), nodule activity (ARA and H production), and plant N content are being evaluated for different soybean genotypes with contrasting P efficiency.

2) Phosphorus Cycling

Experiments are being conducted to study the impacts of adopting P efficient genotypes on nutrient cycling in low-P red soils. At PSU, several soil and crop models were selected from the literature to estimate the impact of P-efficient soybean varieties on the dynamics of soil phosphorus. At SCAU, field trials were implemented in Boluo to monitor and quantify P cycling in plots with either P-efficient genotypes or P-inefficient genotypes. Field plots were designed with run-off and percolation collection facilities (Fig. 11).

In the second half of 2002, these systems were tested with actual planting of four genotypes (2 P-efficient and 2 P-inefficient) with both low and high P treatments. Phosphorus budget in the field system was estimated by analyzing the P input (P from seeds, irrigation water, fertilizers, rain etc.) and P output (P runoff, percolation, harvest etc). Genotypic effects on soil P fractions (Ca-P, Fe-P, A1-P, O-P and organic P) are also being characterized.

5. Module 5: Agroeconomic Studies and Impact Assessment

1) Before the project started in 2001, data were collected on soybean production in China's major soybean production regions, USA, Brazil, and Argentina. Meanwhile, Dr. Weaver collaborated with Dr. Hai Nian, and the project funded graduate student, Yi Xu, to develop an extensive bi-lingual survey instrument targeted at recording baseline, and progress data to monitor the farm-level production decisions, productivity, and returns for soybean production. A draft survey instrument was developed in May 2002 just following the Workshop. The survey was field tested (Fig. 12), and a team of SCAU students were trained in administering the survey. Dr. Weaver, Dr. Nian, and Yi Xu interacted through email to support a final revision of the survey. The survey was then administered to a group of several dozen farms by Dr. Nian and the trained students. Initial data were analyzed to determine needs for further revision. The final survey instrument was delivered by Dr. Weaver to Dr. Nian by email in late June 2002. Since that time, Dr. Nian has continued to organize implementation of the survey in over 100 farmer families in South China's Guangdong and Guangxi Provinces, emailing completed surveys back to Penn State for analysis.

2) Several production experiments were conducted involving the participation of farmers from different cultivation systems or input levels. Different cultivation systems and different inputs are being compared in terms of economic benefits as affected by the adoption and diffusion of P-efficient soybean genotypes.

3) At PSU, Dr. R. Weaver and his Ph.D. students are conducting analysis of field level data collected from South China for assessment of economic performance of P-efficient genotypes. Farm-level decision modeling is also being developed to predict adoption of new field practices, technologies, or genotypes. Work is also being done to cover development of databases from the above-mentioned household survey data. They have also completed a draft overview of the soybean subsectors in China and more specifically in South China. The review is being finalized. It reviews current production, processing, markets, and policy affecting the economic performance of soybeans in China.

6. Module 6: Joint-Training, Communication and Management

1) A Planning Workshop

From May 6 to 11, 2002, we organized a planning workshop entitled "Adaptation of Crops to Low-phosphorus Soils in the Tropics and Subtropics: Innovative Approaches for Sustainable Development" (Fig 13). The workshop received primary funding from The McKnight Foundation with additional support from the Guangdong Provincial Department of Science and Technology. Dr. Rebecca Nelson, Director of the McKnight Foundation's CCRP Program, attended this workshop while she was in a site visit to China.

One of the primary goals of the workshop was to educate Chinese scientists in a topic of great relevance to China. In this regard the meeting was a success, attracting more than 80 scientists and students from all parts of China, representing a variety of disciplines including agronomy, soil science, plant breeding, plant physiology, plant molecular biology, ecology, and economics. Five plenary presentations were given by Chinese scientists, and 6 presentations were given by project participants based at US universities. Each presentation was followed by active and far ranging questions and discussion by the audience that typically ran over schedule. Everyone was impressed by the quality of the questions and participation of the Chinese scientists and students.

Another important goal of the workshop was to provide an opportunity for project participants to discuss and plan research activities. Another McKnight CCRP project led by Dr. Schaffert was represented by Drs. Schulze, Raghothama, and Kochian, who together with Drs. Ma, Weaver, and Lynch from our project had very productive discussions with the Chinese team led by Drs. Yan and Liu concerning collaborative activities to be undertaken the first year. A field trip to one of the principal field research sites was particularly informative for those participants who were not familiar with Chinese agriculture. During the field visit, workshop participants saw the results of field screening of soybean genotypes, showing substantial genetic variation in crop adaptation to low P soils, which appeared to be correlated with root architecture and is consistent with the premise of our project. Tours of the facilities of the Root Biology Center prompted some discussion of the possibility for extension of project expertise and results to African and other developing countries.

2) Short Lectures

During the above-mentioned planning workshop, a series of short lectures were given at SCAU by the participants, including Drs. J. Lynch (Plant nutritionist from PSU), H. Ma (Plant Molecular Biologist from PSU), R. Weaver (Agroeconomist and Rural Sociologist from PSU), D. Schulze (Soil Scientist from Purdue University), K. G. Raghothama (Plant Nutritional Geneticist from Purdue University), L. Kochian (Plant Physiologist from Cornell University), F. Zhang (Plant nutritionist from China Agricultural University), W. Shi (Plant Stress Physiologist from Chinese Academy of Sciences), and Y. Dong (Soybean Germplasm Specialist from Jilin Academy of Agricultural Sciences).

Also during the workshop, Dr. R. Weaver and his associate from PSU gave a lecture series to a number of SCAU staff members and students participating in the field survey on agroeconomic conditions of potential soybean growing regions. The lectures covered topics such as methods and procedures of field and farm surveys, collection and analysis of field data, and approaches and techniques for impact assessment of agricultural research.

3) Joint-Training

Three trainees for joint training in the US have been selected from SCAU staff members and graduate students. One of the trainees, Ms Qingping Xu, has been sent to PSU for collaborative research on phosphorus uptake mechanisms of soybean under the supervision of Dr. Jonathan Lynch. She is staying at PSU for 6 months as part of her SCAU M.S. program. Two other trainees, Drs. Hong Liao and Hai Nian, are also being sent to the US universities for collaborative trainings on plant physiology and agricultural economics, respectively.

At PSU, a total of 5 international graduate students were recruited for our project in 2002. During their graduate studies at PSU, they will be trained as participants in the various modules proposed, including plant physiology, molecular biology, agroecology, and agroeconomics. These students are now taking courses at PSU while at the same time participating in research directly related to our project. Some of them will conduct field research in China in 2003 as parts of the joint-training activities.

4) Communications

The two PIs representing SCAU and PSU partnerships, Drs. Yan and Lynch, have been in regular email contacts since the project started. Periodically, Drs. Yan and Lynch would also have telephone calls to discuss scientific and management issues related to the project. Besides, personal contacts were made between participants of the project whenever there was an opportunity. For example, during the CCRP grantee conference held in Mexico in March 2002, Drs. Yan, Mei, Nian, and Liao met and exchange information with other participants from PSU and other institutions. On the way home to China, they also paid a visit to PSU where they visited many related labs and had detailed discussions about the project. Reciprocally, Drs. Lynch, Ma, and Weaver from PSU visited SCAU during their participation in the planning workshop held in China in May 2002. These contacts greatly facilitated mutual understanding and collaborations between the partners.

5) Management

As soon as the project commenced in 2001, we organized a steering committee to oversee and manage the ongoing research and training activities. The committee consists of the major participants from both SCAU and PSU and is chaired by Dr. Yan and Dr. Lynch. Operationally, Dr. Yan has mainly managed project activities at SCAU, whereas Dr. Lynch has managed project activities at PSU. On each side a sub-committee composing of principal scientists and representative graduate students was also formed. At SCAU, the sub-committee met periodically, sometimes on module basis, to report project progress and discuss problems and constraints encountered. At the end of 2002, an annual report meeting was held followed by a New Year Party to promote a warm camaraderie and friendship among the project participants.

C. Problems and Constraints

In general, this project is progressing very well and many preliminary results are promising and encouraging. However, we have also encountered a few problems and constraints which we should overcome to achieve more productive results.

1. Severe Drought Problem at the Long'an Field Site

As reported previously, we obtained promising results from the germplasm screening work at the Boluo field site in Guangdong Province. However, results from the other field site at Long'an of Guangxi Province were not satisfactory due to severe drought for two consecutive seasons. Although we tried to irrigate the field sites with tap water, the soil was a sandy upland soil with high leakage, so irrigation could not help very much to alleviate the problem. Under these conditions, the major limiting factor became water deficiency instead of phosphorus deficiency. According to the local farmers, severe drought is often encountered here in this region, so we might have to look for another field site to repeat this experiment.

A question arises from this experience if we should screen soybean germplasm for P-efficient only under P-limiting conditions, eliminating other limiting factors. This is scientifically correct when we want to focus on the P deficiency problem. For example, at the Boluo field site, we kept soil water content and other nutrients at optimum levels so that our main goal of selecting P-efficient genotypes could be fulfilled. Nevertheless, this is often difficult to achieve in practice, since there are always some kind of constraints which might interact with P deficiency. In South china, rainfall is generally abundant so water deficiency does not seem to be an important issue for soybean growth. However, regional and seasonal drought is also not unusual. Therefore, it would be ideal if we could include in our future breeding objectives a coupled efficiency for both water and phosphorus.

2. Vacancy of a Chinese Agroeconomist

At the initial phase of the project, we had Dr. Baojun Niu, Professor of Agroeconomics, involved in our project responsible for agroecinimic studies of this project at SCAU. However, Dr. Niu was transferred to a full-time administrative job and left SCAU in July 2002, and his position for this project has been vacant since then. Since we still have not found an interested and qualified person to replace Dr. Niu's position, we temporarily assigned Dr. Nian, the soybean breeder for this project, to be responsible for activities pertaining to the agroecinimic module. After discussing this issue with Drs. Lynch and Weaver at PSU, we decided to send Dr. Nian to PSU for some basic training on agroeconomics so that he can assist Dr. Weaver and his PSU associates to conduct relevant studies in China. In fact, Dr. Nian is now actively participating in the collection of background information and field survey data according to the design by Dr. Weaver and his associates. Now we are actively seeking out other candidates and are in process of reviewing opportunities for bringing in a replacement for Dr. Niu.

D. Summary of the Status of the IP Plan

As soon as the project was funded in 2001, the partnership of this project began preparation of the Intellectual Property Management Plan (IP Plan) required for CCRP grantees with the expectations and guidelines provided by the McKnight Foundation. During the Mexico conference in March 2002, an outline of the IP plan was presented for comments and suggestions from the partners as well as from IP professionals. Later in July 2002, a draft of the IP plan was sent to the Central Advisory Service (CAS) selected by the McKnight Foundation. With the assistant of professionals from CAS, an IP plan is being completed. The following table is a summary of the activities, outputs, possible IP assets, possible 3rd Party inputs, constraints, and possible new IP ownership for our project.

Table of IP-related information for IP Management Plan for the China/Soybean Project

Activity Module 1: Germplasm Screening & Breeding	**Output**	**Probable IP asset**	**3rd Party IP inputs**	**IP constraints**	**Probable Ownership of new IP**
Core Collection of Soybean Germplasm	1)Survey/Criteria tools 2)GIS-based reports 3)Identification (Collection) Report 4)Data	1)Methods for GIS- based soils selection 2)Methods for GIS-based Soybean biodiversity selection 3)Survey Reports 4)Soybean collection 5)Databases 6)Publications 7)Know-how	a)Farmer information (Biodiversity) b)Local scientist/herbarium information (Biodiversity) c) GIS mapping Methods d)GIS/mapping information Soil characterization (Purdue) e) Germplasm	a) Consent of farmers to collect and use data b) Consent of Chinese government to distribute data c) Consent of Brazil to use germplasm	1)South China Agricultural University (**SCAU**), 2)Jilin Academy of Agricultural Sciences (**JAAS**), 3)**EMBRAPA** 4) **Purdue**
Soybean Germplasm Screening and Selection	1)Growing methods (+/-P addition) 2)Field-data: a) biomass b) yield c) phenology 3)Indexing methods 4) Stratified sand methods 5)Growth pouch system methods 6) Correlation methods 7) Soybean lines	1) Methods for: a)field growing (+/- P) b)testing for biomass, yield, phenological characteristics c) indexing d) stratified sand environ e) growth-pouch system f) correlation comparison 2)Data 3)Databases 4)Soybean seeds 5)Publications 6)Know-how	a)Methods b)Germplasm	a)3rd party input into methods b)Germplasm (China and Brazil)	1) **SCAU** 2) **PSU**

Activity **Module 1, (cont'd)**	**Output**	**Probable IP asset**	**3rd Party IP inputs**	**IP constraints**	**Probable Ownership of new IP**
Conventional Breeding	1)Breeding schemes 2)Selection methods 3) Data 4)Soybean lines	1)Methods for: a)breeding for root traits b)selection methods 2)Data 3)Databases 4)Soybean seeds 5)Characterized soybean lines 6)Publications 7)Know-how	a)Germplasm b) Methods	a)3rd party input into methods b)Germplasm (China and Brazil)	1) **SCAU**
Activity **Module 2: Physiological Mechanisms**	**Output**	**Probable IP asset**	**3rd Party IP inputs**	**IP constraints**	**Probable Ownership of new IP**
Root Archi-tecture	1)Data 2)Data analysis methods 3)Experimental methods a)root architecture b)field and greenhouse comparative methods 4)Soybean lines/varieties/ RILs	1)Data 2)Databases) 3)Soybean seeds 4)Data analysis methods 5)Other experimental methods 6)Publications 7)Know-how	a)Germplasm b)Methods developed by EMBRAPA/Purdue c)Data analysis methods	a)Biodiversity-related issues (China/Brazil) b)3rd party (proprietary inputs)	1) SCAU 2) PSU
Root Exudation	1)Data 2)Data analysis methods 3)Experimental methods: root exudate 4)Soybean lines/varieties/ RILs	1)Data 2)Databases 3)Soybean seeds 4)Data analysis methods 5)Experimental methods 6)Publications 7)Know-how	a)Germplasm b)Dionex IP, methods, resins c)Methods developed by EMBRAPA/ Cornell	a)Biodiversity –related issues (China/Brazil) b)3rd party inputs	1)SCAU 2)PSU 3) Cornell

Activity **Module 3: Molecular Biology of Root Traits**	**Output**	**Probable IP asset**	**3rd Party IP inputs**	**IP constraints**	**Probable Ownership of new IP**
Gene Mapping	1)Data 2)QTL analysis of root traits/P efficiency 3)Genetic tools 4)Cloning methods 5)Soybean lines, RILs, mapping populations	1)Data 2)Databases 3)Soybean seeds 4)Genetic tools 5)Experimental methods 6)Publications 7)Know-how 8)Mapping clones 9)Analytic methods 10)Plasmids w/cloned soybean DNA/cDNA	a)Soybean mapping populations (JAAS) b)Mapping/other experimental methods c)Molecular markers d)Transgenic materials e)Other prior art f)3rd Party transformation technologies: Agrobacterium, Particle gun g)Gene promoters h)Arabidopsis mutants i)Tobacco plant/TC materials	a)Biodiversity -related issues (China/Brazil) b)Use of JAAS lines c)Other 3rd Party inputs	1)JAAS 2)SCAU 3) PSU
Gene Cloning	1)Data 2)Identification of candidate genes 3)Cloning of candidate genes 4)Genetic markers 5)Soybean lines, RILs, varieties	1)Data 2)Databases 3)Isolated genes 4)Genetic markers 5)Soybean clones 6)Soybean seeds 7)Publications 8)Know-how	a)Differential display reverse transcription (DDRT) PCR methods b)Suppression subtraction hybridization (SSH) methods c)Other methods d)germplasm e)Molecular markers f)Transgenic methods materials h) Candidate genes from expression analysis and other studies	a)Biodiversity -related issues (China/Brazil) b)3rd Party inputs	1)SCAU 2)PSU

Activity **Module 4: Agroecological Analysis**	**Output**	**Probable IP asset**	**3rd Party IP inputs**	**IP constraints**	**Probable Ownership of new IP**
Effect of P efficient soybean genotypes on agroecosystems in South China	1)Survey methods 2)Data 3)Experimental methods: soil analysis 4)P flux analysis	1)Data 2)Databases 3)Experimental methods 4)Publications 5)Know-how	a)3rd party experimental methods/techniques b)Germplasm	a)Biodiversity -related issues (China/Brazil) b)3rd Party inputs	1)SCAU 2)PSU 3)Purdue 4)EMBRAPA

Activity **Module 5: Agroecono-mic Studies**	**Output**	**Probable IP asset**	**3rd Party IP inputs**	**IP constraints**	**Probable Ownership of new IP**
Assessment of agroeco-nomic conditions and impact of P efficient technologies	1)Survey methods 2)Data 3)Simulation models 4)Data analytical methods	1)Surveys 2)Data 3)Databases 4)Computer models 5)Analytical methods 6)Publications 7)Know-how	a)Computer modeling software b)Analytical methods	a)Consent of participating households to use information b)3rd Party inputs	1)SCAU 2)PSU

Activity **Module 6: Joint Training & management**	**Output**	**Probable IP asset**	**3rd Party IP inputs**	**IP constraints**	**Probable Ownership of new IP**
Enhancement capacity of SCAU faculty	1)Training materials 2)Training methods: a)GIS methods b)soil testing and analysis c)field screening and selection d)organic acid analysis 3)Distance learning methods 4)Distance learning materials	1) Publications 2)Training methods 3)Training materials 4)Know-how	a)3rd Party inputs	a)3rd Party inputs	1)SCAU 2)PSU 3)Purdue 4)Cornell 5)EMBRAPA

E. Emails from PIs

1. An Email From Dr. Jonathan Lynch (PI-PSU)

Subject: Re: A complete Annual Report
Date: Tue, 28 Jan 2003 09:06:14 -0500
From: Jonathan Lynch <jpl4@psu.edu>
To: xlyan <xlyan@scau.edu.cn>
References: 1

Xiaolong,
this is an excellent report, thank you for doing it.
We will talk this morning- there may be a few changes, but I agree with your overall plan.
Talk to you soon,
Jonathan

Jonathan Lynch
102 Tyson Building
Dept. Horticulture
Penn State University
University Park, PA, 16802
814-863-2256, fax 3-6139
JPL4@psu.edu
http://hortweb.cas.psu.edu/dept/faculty/lynch/lynch.html
"Science is the belief in the ignorance of experts"
Richard Feynman

2. An Email From Dr. Yaoguang Liu (coPI-SCAU)

Subject: Re: A complete Annual Report
Date: Tue, 28 Jan 2003 21:50:40 +0800
From: "ygliu" <ygliu@scau.edu.cn>
To: "xlyan" <xlyan@scau.edu.cn>
References: 1

Xiaolong:
The report was prepared very well. I have no special comments on it.

Yaoguang

Yaoguang Liu
Professor of Molecular Biology
Laboratory of Genetic Engineering
South China Agricultural University
Guangzhou 510642, China
Tel. 86-20-85281908, Fax. 86-20-85280200

3. An Email From Dr. Hong Ma (coPI-PSU)

Subject: Re: A complete Annual Report
Date: Mon, 27 Jan 2003 10:00:21 -0800
From: Hong Ma <hxm16@email.psu.edu>
To: xlyan <xlyan@scau.edu.cn>
References: 1

Dear Xiaolong:

Thanks very much for writing the report. I was hoping to discuss with Jonathan and Kathy about Module 3 before sending you an email. But since it is late and I have not heard from Kathy, I will submit my email today. Sorry about the delay.

I have read the report, and agree with its content, as far as my knowledge permits.

Hong

Hong Ma, Ph.D.
Professor of Biology
Department of Biology and
The Huck Institute for Life Sciences
315 Wartik Laboratory
Penn State University
University Park, PA 16802
Tel. 814-863-6414
Fax 814-863-1357