

Workplans and Budget
Decision Aids for Integrated Soil Nutrient Management
February 2001

PROJECT YEAR 5 - February 11, 2001 to February 10, 2002

Objective 1: Develop an integrated computerized knowledge base for global use in diagnosing and recommending practical solutions to soil acidity and nutrient problems, which considers differences in resource availability and soil, climate, crop and management factors contributing to location-specific acidity and nutrient constraints.

Baseline:

Soil nutrient deficiencies rarely occur in isolation and their correction usually requires more than one amendment. The initial version of the Nutrient Management Support System software (NuMaSS 1.0) was released during year 3. NuMaSS works in an integrated, object-oriented programming language to address soil acidity, N and P constraints. The *Diagnosis* module assesses whether nutrient constraints exist or not for a variety of pasture, grain and tuber crops. If a nutrient constraint exists, the *Prediction* module estimates corrective amendments needed for the particular soil conditions and selected crop. The *Guidance* module enables users to compare economic outcomes for different nutrient sources, crops and price scenarios; it also provides advice and cautions on nutrient management practices for the existing soil conditions and selected crop.

NuMaSS was evaluated by national agricultural research and extension service staff from 17 countries in Africa, Asia and Latin America. During year 3 it was also tested in various on-farm trials with collaborators at intensive testing sites in Ultisols at Ilagan, Isabela, Philippines and in Alfisols at Cinzana, Mali. Feedback from these evaluations led to modifications and the interim release of version 1.5 in year 4. Feedback has also provided guidance for further development. Programmatic and technical refinements have been determined and outlined for the final version of NuMaSS in year 5. Planned refinements include additions of crop and soil coefficients gathered from literature synthesis and laboratory and field research at core testing sites in Costa Rica, Mali and Philippines. These coefficients are used in both the diagnosis and correction of soil acidity, N and P constraints. A new economics component for the *Guidance* module will improve evaluations of nutrient interactions.

Information from investigations in Costa Rica and Brazil with peach palm for heart-of-palm production, as our test tree crop, have now progressed to the point that it can also be added to NuMaSS. The growth curve for this perennial crop is now sufficiently defined to identify distinct phases of crop growth; allometric equations were developed to predict biomass and nutrient accumulation with crop age. Prediction equations were also developed for nutrient release and recycling of decomposing crop litter. Information on acidity tolerance and N and P requirements from ongoing trials give are now sufficient to define the software decision-making structure which will be finalized during the coming year. On-farm trials will be initiated in Costa Rica to test the diagnostic component of the peach palm knowledge base in NuMaSS. Ongoing field trials in Costa Rica to characterize peach palm response to applied N and P need an additional year to achieve their objectives.

Laboratory and field investigations continue at the intensive testing sites. An additional year for on-farm trials in Mali and the Philippines will enable evaluation of how NuMaSS recommendations compensate for residual effects of lime and fertilizers applied during preceding years. The core experiments in the Philippines enable evaluations of residual effects and interactions among lime, N and P for existing and new crop commodities. This information will eventually lead to refinement of coefficients used in NuMaSS. Trials will be continued in Mali to evaluate the dynamics of nutrient contributions in the traditional practice of fertilizing fields with composted mixtures of manures, crop residues and household organic wastes. As part of project effort to document impact, socio-economic surveys will be conducted in year 5 at the core testing sites to complement baseline measure made in year 1 and interim assessments made in year 3.

Output 1: Nutrient Management Support System (NuMaSS) software

Description: Acidity, nitrogen and phosphorus single-nutrient modules merged into an improved, fully functional integrated decisions support system software that accounts for interactions between N, P and lime.

Participants and estimated completion dates for suboutputs and activities for NuMaSS software development during project year 5.

SUBOUTPUT	ACTIVITIES	INVESTIGATORS		ESTIMATED
		RESPONSIBLE	CONTRIBUTORS	COMPLETION
1. Final release of NuMaSS, version 2.0	Continue refinements from year 4 based on feedback from user evaluations of NuMaSS 1.5 and newly acquired data: - refine interface and algorithms - add additional data - release final prototype for final review (September 2001) - release NuMaSS version 2.0	Osmond (NCSU)	Reid (CU) Smyth (NCSU) Yost (UH)	February 2002
2. Environmental concerns	1. Incorporate environmental effects into NuMaSS 2. Write up units on agricultural effects on environment	Osmond (NCSU)	Reid (CU) Smyth (NCSU) Yost (UH)	February 2002
3. Predicting residue nutrient value	1. Develop algorithms that account for residue nutrient content and economic value 2. Incorporate algorithms into NuMaSS 3. Validate the algorithms	Reid (CU)	Osmond, Smyth (NCSU); Yost (UH)	February 2002

SUBOUTPUT	ACTIVITIES	INVESTIGATORS		ESTIMATED
		RESPONSIBLE	CONTRIBUTORS	COMPLETION
4. Predicting organic effects	<ol style="list-style-type: none"> 1. Develop algorithms that account for organic effects on nutrient deficiencies 2. Incorporate algorithms into NuMaSS 3. Validate algorithms 	Reid (CU)	Osmond, Smyth (NCSU); Yost (UH)	February 2002

Budget:

OBJECT	AMOUNT IN US\$
Personnel	21,030
Supplies	1,027
Equipment	618
Travel	5,805
Domestic	5,805
International	0
Other Direct Costs	92,695
Total	121,175

Equipment:

All items under \$5,000

International Travel Events:

None; all travel events are domestic for purposes of interaction between individuals involved in NuMaSS programming efforts at Cornell, Hawaii and N.C. State Universities.

Output 2: Field evaluation and refinement of NuMaSS software

Description: Testing NuMaSS under multiple environments and agricultural conditions, and refining it to achieve desired performance.

Participants and estimated completion dates for suboutputs and activities for field evaluation and refinement of NuMaSS software in project year 5.

SUBOUTPUT	ACTIVITIES	INVESTIGATORS		ESTIMATED
		RESPONSIBLE	CONTRIBUTORS	COMPLETION
1. Costa Rica - peach palm production on acid Andisols in a perudic moisture regime	1. Complete field experiment to characterize peach palm response to P	Molina, Alvarado (UCR)	Ares (USDA), Yost (UH)	January 2002
	2. Complete on-farm trials to evaluate NuMaSS software components for peach palm	Alvarado, Molina (UCR)	Ares (USDA), Yost (UH); Smyth, Osmond (NCSU)	January 2002
	3. Complete N fertilization field trial on peach palm	Molina, Salas (UCR)	Ares (UH); Smyth, Wagger (NCSU)	January 2002
	4. Complete greenhouse P fertilization trial for peach palm seedlings on Costa Rican soils	Molina, Alvarado (UCR)	Cox (NCSU), Yost (UH)	August 2002
	5. Final impact survey; progress assessed by comparison with baseline and mid-term surveys	Smith (NCSU); Alvarado (UCR)	Molina, Salas (UCR); Smyth (NCSU)	February 2002

SUBOUTPUT	ACTIVITIES	INVESTIGATORS		ESTIMATED
		RESPONSIBLE	CONTRIBUTORS	COMPLETION
2. Mali - millet/cowpea production on acid, sandy Alfisols of the African Sahel	1. Complete on-farm trials to develop yield and nutrient input-output budgets for millet fields, and evaluate compost efficiency and nutrient composition	Hossner (TAMU); Doumbia (IER)	Juo, Hons (TAMU); Osmond (NCSU)	June 2001
	2. Complete on-farm evaluations of NuMaSS soil nutrient diagnosis and recommendations	Doumbia (IER)	Hossner (TAMU); Reid (CU); Smyth (NCSU); Yost (UH)	September 2001
	3. Complete on-farm and on-station trials on predicting placement and use of organo-mineral fertilizers	Doumbia (IER)	Kablan, Yost (UH); Hossner (TAMU)	September 2001
	4. Final impact survey; progress assessed by comparison with baseline and mid-term surveys	Smith (NCSU); Hossner (TAMU); Doumbia (IER)	Coulibaly, Kouyate (IER); Hons (TAMU); Smyth (NCSU)	October 2001
3. Philippines - upland rice, peanut, soybean, corn production on Ultisol/Oxisol associations in an ustic moisture regime	1. Complete core experiment to acquire crop yield response and interactions among N, P and lime rates.	Yost (UH) George (IRRI)	Corton (PhilRice); George (IRRI); Hue (UH) Corton (PhilRice)	June 2001 September 2001
	2. Continue on-farm testing of module and integrated module diagnoses and predictions, estimates of nutrient balance	Friday (UH); Corton (PhilRice); George (IRRI)	Smith (NCSU); Yost (UH)	February 2002
	3. Final impact survey; progress assessed by comparison with baseline and mid-term surveys			

Budget:

OBJECT	AMOUNT IN US\$
Personnel	53,084
Supplies	20,200
Equipment	0
Travel	24,000
Domestic	2,400
International	21,600
Other Direct Costs	118,000
Total	215,284

Equipment: None

International Travel Events:

TRAVELER	DESTINATION	COST IN US\$
Frank Smith	Costa Rica	1,600
Frank Smith	Mali	3,000
J. Bajita	Philippines	2,500
Aragon	Hawaii	2,500
J.B. Friday	Philippines	4,000
Frank Smith	Philippines	5,000
Russell Yost	Philippines - Thailand	3,000

Objective 2: Improve the diagnosis and recommendations for acidity and nutrient problems by identifying and resolving knowledge gaps through extensive literature reviews and, when necessary, developmental research.

Baseline:

Acidity - in collaboration with IITA, Ca and Mg movement was monitored for two cropping seasons in an experiment in Oxic Paleustalfs following installation of treatments comparing different combinations of N fertilizers (urea and ammonium sulfate) and prunings. Soil samples were taken from incremental depths to 30 cm to evaluate soil acidification, Ca and Mg movement. Ammonium sulfate decreased topsoil pH from 6.2 to 4.5, whereas *Alchornea* residues delayed acidification, and leaching of Ca, Mg and NO₃-N. Movement of NO₃-N in the soil profile mirrored that of Ca and Mg. Two experiment comparing Ca sources and rates in two soils of the toposequence at Cinzana, Mali cropped to millet revealed no significant movement of Ca below 7.5cm. Millet yields were only increased by the Ca treatment with Tilemsi phosphate rock, but there was not evidence of a residual effect on yields in the second crop. Members of the acidity group continue to monitor treatments for lime, Ca and Mg movement, and organic inputs in core experiments at Mali and Philippines. We have compiled soil data for over 20 published lime trials on Inceptisols, Oxisols and Ultisols in Africa, Asia and Latin America. Five of these trials address long-term residual effects of lime. We are currently analyzing these data for differences in soil acidity buffer coefficients and prediction of residual lime effects. Results of these investigations will be added to NuMaSS 2.0.

Nitrogen - a review of N fertilization and green manure trials with corn, millet and sorghum throughout Africa, Asia and Latin America was completed during year 4. Findings of this review provide default mean values and suggested ranges for various coefficients used in estimating crop N recommendations in NuMaSS. Their addition to the next version of NuMaSS will provide users with suggested values for crop N accumulation, native soil N supply, legume cover crop N supply and fertilizer N efficiency for different crops and regions. Similar data sets are being collected for other crops. The N team continues to assist in core experiments and on-farm trials at the intensive testing sites. Evaluations of biological N₂ fixation for cowpea in Mali indicated that native *Bradyrhizobium* populations were equally effective to the introduction of competitive isolates from Zimbabwe. Soil P availability had a greater impact on the symbiotic system than soil acidity in the Cinzana Alfisols and Ilagan Ultisols. A preliminary model to predict N derived from BNF by legumes was developed based on data collected during early soybean growth. Peanut, soybean and mungbean BNF were determined in field trials at Ilagan. Total N uptake was closely related to P uptake in all legumes.

Phosphorus - successful diagnosis of soil P conditions and, when needed, fertilizer P recommendations depend on good estimates of critical soil P levels for the targeted crops and the soil's P buffer coefficient. The latter is defined as the change in soil available P per unit of applied fertilizer P; the existing data for field based estimates of this variable is very limited throughout the world. Laboratory incubations to estimate P buffer coefficients were completed for 62 soils from Central America (primarily Andisols and Ultisols). In Andisols clay content was not related to P buffer coefficients as previously documented for Ultisols and Oxisols. The best predictors for P buffer coefficients in Andisols were either oxalate- or KOH-extractable Al. Comparisons of estimated P buffer coefficients from laboratory P incubations

with predicted values from NuMaSS based on clay content were remarkably similar for a variety of soils in Mali. This finding shows promise for P predictions by NuMaSS in West Africa where soil test data may be difficult and costly. Critical soil P levels were defined for various crops grown on soils in Sinoloan and Ilagan, Philippines. Critical levels varied among crop seasons and increased with yield plateau levels. A modified nonlinear regression procedure was developed to extend the applicability of the linear response plateau. Peach palm response to fertilizer P in mature stands has been less than initially hypothesized; if current results are confirmed during the last year of trials in Costa Rica this could lead to adjustments in soil P critical levels and significant reductions in fertilizer P requirements.

Output 1: Enhancing the knowledge base for the acidity module of NuMaSS

Description: Collecting, developing and synthesizing soil, plant and management information to improve the diagnosis and recommendations of location-specific problems related to the soil acidity syndrome.

Participants and estimated completion dates for suboutputs and activities acidity in year 5.

SUBOUTPUT	ACTIVITIES	INVESTIGATORS		ESTIMATED
		RESPONSIBLE	CONTRIBUTORS	COMPLETION
1. Diagnostic criteria and recommendations for Ca & Mg deficiencies, excess Mn, and lime equivalence of organic inputs	Complete lab, greenhouse & field studies of Al detoxification, lime equivalence, and Mn toxicity of organic inputs - includes monitoring selected treatments of core experiments in Costa Rica and Philippines, and on-farm trials in Mali	Hue (UH); Smyth (NCSU)	Salas (UCR); Coulibaly, Sidibe (IER); Corton (PhilRice), Juo (TAMU)	February 2002

Budget:

No funds are specifically allocated to acidity during year 5.

International Travel Events:

None

Output 2: Enhancing the knowledge base for the nitrogen module in NuMaSS

Description: Collecting, developing and synthesizing soil, plant and management information to improve the diagnosis and recommendations of location-specific N problems.

Participants and estimated completion dates for suboutputs and activities on N in year 5.

SUBOUTPUT	ACTIVITIES	INVESTIGATORS		ESTIMATED
		RESPONSIBLE	CONTRIBUTORS	COMPLETION
1. Calibrating N coefficients	1. Complete updating coefficients and major crops to be considered by NuMaSS. Evaluate N predictions at various sites	Reid (CU)	Israel, Osmond, Luna (NCSU); Hons (TAMU); George (IRRI); Corton (PhilRice); Molina (UCR); Coulibaly, Doumbia (IER) Molina (UCR); Yost (UH); Wagger, Smyth (NCSU); Ares (USDA)	February 2002
	2. Summarize and interpret peach palm response to N, compute N budgets in plantations, add information to NuMaSS			
2. Prediction of BNF contributions	1. Summarize existing literature data on important legumes with respect to acidity, P and Rhizobia constraints	Israel, Luna (NCSU)	Reid (CU); Osmond, Wollum (NCSU); George (IRRI)	February 2002
	2. Incorporate information into NuMaSS			

SUBOUTPUT	ACTIVITIES	INVESTIGATORS		ESTIMATED
		RESPONSIBLE	CONTRIBUTORS	COMPLETION
3. Guidance for legume management	<ol style="list-style-type: none"> 1. Complete assembly of information on legume N contributions to subsequent crops in terms of nutrient needs for legume growth, C constituents, plant age, soil conditions, and timing/method of incorporation 2. Add assembled information to NuMaSS Guidance module 	Reid (CU)	Israel, Waggoner, Wollum (NCSU); Hons (TAMU), George (IRRI)	February 2002

Budget:

OBJECT	AMOUNT IN US\$
Personnel	87,537
Supplies	6,632
Equipment	114
Travel	16,932
Domestic	4,432
International	12,500
Other Direct Costs	37,613
Total	148,828

International Travel Events:

TRAVELER	DESTINATION	COST IN US\$
Jot Smyth	Costa Rica	1,500
Jot Smyth	Togo and Benin	4,000
Deanna Osmond	Togo and Benin	4,000
Dan Israel	Brazil	3,000

Output 3: Enhancing the knowledge base for the phosphorus module in NuMaSS

Description: Collecting, developing and synthesizing soil, plant and management information to improve the diagnosis and recommendations of location-specific P problems

Participants and estimated completion dates for suboutputs and activities on P in year 5 of the project.

SUBOUTPUT	ACTIVITIES	INVESTIGATORS		ESTIMATED
		RESPONSIBLE	CONTRIBUTORS	COMPLETION
1. Rock phosphate	1. Develop a diagnostic protocol to identify soil/crop/climate/economic conditions in which rock phosphate is likely economic	Yost (UH)	Doumbia (IER; Sene (ISRA)	February 2002
	2. Test diagnostic criteria that identify soil/crop/climate/economic conditions in which rock phosphate is economic		Doumbia (IER); Sene (ISRA); George (IRRI); Corton (PhilRice)	

Budget:

OBJECT	AMOUNT IN US\$
Personnel	54,938
Supplies	15,200
Equipment	3,000
Travel	12,000
Domestic	0
International	12,000
Other Direct Costs	4,605
Total	89,743

International Travel Events:

TRAVELER	DESTINATION	COST IN US\$
Richard Kablan	Mali - Senegal	4000
Aminata Sidibe	Hawaii	4,000
A. Bationo	Hawaii	4,000

Objective 3: Develop auxiliary tools to the integrated knowledge base to enable local agriculturalists to diagnose and solve soil acidity and nutrient problems that predominate within the social, economic and agronomic characteristics of their regional domains.

Baseline:

In order to ensure that NuMaSS systems are user-friendly and have high user value, the software must be piloted under a variety of location-specific conditions. Evaluation is occurring via an extensive network of evaluators. This network includes (a) individuals with knowledge that should be incorporated into products, (b) individuals with field and laboratory data sets that could be used to evaluate products for their specific conditions, and (c) established groups who would be interested and benefit from testing our products in their programs.

The initial version of the project's decision support software for diagnosing and correcting soil acidity, N and P constraints (NuMaSS version 1.0) was released in August 1999. Release of the software at the project's midterm was specifically intended to elicit user feedback. User evaluation and feedback on NuMaSS 1.0 was the central focus of a project workshop held on September 6-10 at the Philippine Rice Research Institute (PhilRice) in Maligaya. Both PhilRice and IRRI co-sponsored the workshop which was attended by 55 participants, including representatives from national agricultural research and extension services in Africa (Ethiopia, Gambia, Ghana, Mali, Senegal, South Africa, Tanzania and Zambia), Asia (Indonesia, Laos, Philippines and Vietnam) and Latin America (Bolivia, Brazil, Costa Rica, Ecuador and Venezuela). Participants endorsed continued development of NuMaSS and are willing to contribute by providing data and testing software performance within their regions. Since the workshop, U.S. team-members met to review workshop participant feedback and determined programmatic and technical refinements to be implemented in the next version of NuMaSS. The final release will contain significant modifications and a simplified user interface.

Since the release of NuMaSS 1.0 several opportunities developed wherein NuMaSS software could be either tested with existing field and lab data sets or implemented into ongoing projects. Previously reported opportunities included evaluation of extensive data sets on P fertilization at multiple locations in Colombia with collaborators at IFDC/CIMMYT and CIAT, assessment of existing soil nutrient management practices used by farmers who are adopting production of banana and peach palm as alternatives to their traditional coca fields in the Chapare Region of Bolivia. During the past year collaborators in Central Thailand provided opportunities to compare estimates of soil P diagnosis and fertilizer requirements for maize between NuMass and local systems. Post-harvest soil P values were close to the values predicted by NuMaSS. Although amounts of fertilizer P recommended by local systems and NuMaSS were similar, the latter did a better job of predicting sites where there would be a response. Collaborators in Ecuador provided field and lab data for P fertilization trials with potato in Andisols. These data enrich the NuMaSS database by providing estimates of critical P levels for this commodity and field-based data from predictions of residual fertilizer effects. Collaborators in Kwazulu-Natal, South Africa provided field and lab data on lime trials with *Phaseolus* beans in four different soils. These data also expand the NuMaSS database and strengthen the decision options for acidity management of this commodity.

Version 2.0 of NuMaSS is scheduled for release in November 2001. Thereafter we will request network members to evaluate the software and provide feedback to us. We believe that it would be cost- and time-effective to gather feedback on the software via small regional group meetings within Africa, Asia and Latin America - as opposed to one major workshop as was done in the Philippines in year 3. Venues for these regional meetings have not yet been defined and will depend on whether the project must undergo another budget cut in year 5 as it did in year 4. Our interaction with network members during year 4 was severely curtailed by such a budget cut.

Output 1: Extensive evaluation network

Description: Evaluation of products and capturing knowledge under a variety of location-specific conditions.

Participants and estimated completion dates for suboutputs and activities for the extensive evaluation network during year 5.

SUBOUTPUT	ACTIVITIES	INVESTIGATORS		ESTIMATED
		RESPONSIBLE	CONTRIBUTORS	COMPLETION
1. Final evaluation and release of NuMaSS	1. Evaluation format and meeting(s) venue(s) defined; financial resources available 2. Network member organizations identified and invited 3. NuMaSS evaluated, feedback elicited 4. Feedback analyzed/discussed and strategy for incorporation into NuMaSS developed 5. Final release of NuMaSS	Osmond (NCSU)	Reid (CU); Smith, Smyth (NCSU); Yost (CU); others as needed	February 2002

Budget:

OBJECT	AMOUNT IN US\$
Personnel	34,041
Supplies	7,797
Equipment	28
Travel	82,397
Domestic	271
International	82,126
Other Direct Costs	98
Total	124,361

International Travel Events:

TRAVELER	DESTINATION	COST IN US\$
Multiple, yet to be identified participants from U.S., Africa, Asia and Latin America	Regional NuMaSS software evaluation meetings in Africa, Asia and Latin America, November 2001 - February 2002	82,126