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Design, Implementation, Evaluation, and Evolution of the National Farming Systems Research Program of Niger

by

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ABSTRACT

The National Agronomic Research Institute of Niger (INRAN) has successfully designed, implemented and evaluated a nation-wide Farming Systems Research (FSR) program in Niger. The historical background of this program is reviewed. The results of INRAN's on-farm trials in 1985 and 1986 are discussed. An itinerary is proposed for augmenting the geographic scope of the program, addressing plural farming systems issues, refining the methodology, focusing on key linkages between farming systems research, marketing and policy, and adding "extension" to the present FSR program.

Suggestions are made with regard to the potential roles Alabama A&M University may consider to play in the next five years of the Niger Cereals Research Project.

RESUME

L'Institut National de Recherches Agronomiques du Niger (INRAN) a mis au point, implanté, et évalué un programme de recherches sur systèmes de production agricole avec succès. L'historique de ce programme est présenté. Les résultats des essais en milieu réel que l'INRAN a menés en 1985 et 1986 sont discutés. Une démarche est proposée pour accroître la couverture géographique de ces essais, se pencher sur de nouveaux aspects de cette recherche, rafiner la méthodologie, porter l'emphase sur les liens entre le programme de recherche sur systèmes de production et la commercialisation ainsi que la politique agricole, et enfin, ajouter une dimenssion "vulgarisation" à ce programme.

Des suggestions sont faites quant aux rôles que Alabama A&M University souhaiterait jouer dans la prochaine phase du Projet.

1.0.0 Introduction

The Niger Cereals Research Project (NCRP) was designed to provide the Institut National de Recherches Agronomiques du Niger (INRAN) with assistance in three major areas: research, training, and institution building. Within the research area, the Project Paper called for the design, implementation and evaluation of three programmes: crop improvement, production systems research, and farming systems research (USAID, 1982). The design, implementation, evaluation, and evolution of the National Farming Systems Research Program of Niger is the subject of this paper.

2.0.0 Historical perspective

It would be preposterous to imply that INRAN's current Farming Systems Research Program was "imported" into the Institute by expatriates serving on the NCR Project. In fact, the present FSR Program at INRAN is the result of an evolution in which the main actors are the national researchers. The early history of this evolution is best documented in a paper presented at the FSR/E Symposium, at Kansas State University, in 1985 (Ly et.al., 1985b). It seems appropriate to retrace briefly the history of this evolution to date.

2.1 On-station research and the "extension recommendation themes"

In the past, INRAN's researchers concentrated their research exclusively on the research station. The research themes addressed only technical production problems, were commodity-oriented, and did not pay much attention to the fit of the technology within the farming system. Findings were summarized in "recipes" called "extension and recommendation themes", the fiches techniques (INRAN, 1982). These themes were all written under the assumption that the subsistence Nigerien farmer maximizes yield, regardless of the socio-economic effect of the recommended technology on the farming system and ignoring both yield and income risks.

To our knowledge, the only theme that was ever adopted on a significant scale by Nigerien farmers is the treatment of seed with fungicide. All other themes were rarely adopted by farmers.

2.2 Multilocational trials

At the end of the 1970's, INRAN undertook a program of multilocational trials. INRAN scientists provide the experimental designs, some supervision, and analyze the results. The Extension Service carries out the trials. The rural development projects (Projets Productivité) provide additional supervision. The goal of the multilocational trials is to evaluate varieties and fertilizer levels before extending them. These trials are carried out in a low-rainfall zone (annual mean under 400 mm) and in a moderate rainfall zone (annual mean over 400 mm). Varietal trials are implanted on dune (sandy) and valley (sandy-clay) soils. Since 1984, INRAN has simplified the experimental design of these trials, improved their supervision and refined the analysis of their results.

These trials, however, are almost exclusively managed by extension or research personnel, as opposed to being farmer-managed. Although they capture yield variations by variety and fertilizer level in different agro-climatic zones and different soil types, they do not provide any information on the economic profitability of the technologies tested, nor on the fit of the technologies in the farming system, nor on their expected yield and income stability over time. Thus, from the results of these trials, it is

difficult to predict the adoptability of the technology at the farmer's level.

2.3 Monitoring the "test farmer" at Tarna

In 1977, a model farm was established on INRAN station at Tarna to study the impact of INRAN's recommended package and to evaluate its profitability. This was done through the monitoring of a "test farmer" (paysan pilote). With unconstrained access to capital (fertilizer, improved seed varieties, and animal traction equipment) and to expert management (advice and supervision from research station agronomists) the test farmer showed that the recommendations package could be profitable (Roesch, 1982a). However the profitability of individual recommendations and the returns to capital investments were never evaluated. Again, the recommendation package was tested under the assumptions of perfect access to capital markets and of top grade management skills. Clearly, these assumptions are rarely met at the subsistence farm level, if ever, and consequently, the results of such trials cannot be used to serve as a basis for extending technology. Moreover, the results are born of a sample of one.

2.4 Monitoring Farmer Training Centers

From 1979 to 1981, The Maradi Rural Development Project monitored two training graduates from the farmer training centers (Centres de Promotion Rurale). In 1981, the study was expanded to include 28 additional farms. The study was useful in pointing out problem areas to INRAN, notably: the feeding and training of draught animals, the consideration of economic and production risks in making recommendations, the high cost of the equipment needed to practice the recommended techniques, intercropping, and the management of organic matter (Roesch, 1982b).

2.5 The "Experimental Agricultural Production Units" operation

This program was established in 1980 and continues to this day. From a sample of 113 farms in the Filingué arrondissement[1], six farms were selected to become the subject of an in-depth study and are known as "Experimental Agricultural Production Units" (Unités de Production Agricole Expérimentales") or UPAE. The objectives of the UPAE operation are: (1) the identification of real constraints encountered in the application of INRAN's recommendations themes, and (2) the search for solutions that will relax or remove the observed constraints through combining all factors of production, including socio-economic parameters which have long been neglected (DECOR 1983a, p.14).

The UPAE operation has been successful in sofar as it has brought to the attention of station researchers the factors constraining the adoption of their recommendations by subsistence farmers and underlined the importance of elaborating on-station research programs based a priori on farmers' objectives and constraints. However, in our view, its success has been limited by three factors: (1) it is a case study, i.e. it is based on too small a sample (six farmers) to have statistical representativeness, (2)

1. An arrondissement is an administrative unit below the département (equivalent to a province) in the Nigerien administration.

It studies the adoption of INRAN's technical themes in a very marginal region (low rainfall, poor soils, severe pest problems, and low level of technical skills) which may not be representative of the areas for which the technology was developed, and (3) it is an a posteriori study: although it identifies constraints to the adoption of recommendations born out of research done exclusively on station, it does not identify adoptable technologies to be developed. Furthermore, as INRAN has shifted its emphasis from research based on stations to a mix of on-station and on-farm research, the UPAE operation has outlived its usefulness.

2.6 The present farming systems research program

In 1984, INRAN experimented with the implantation of a series of on-farm trials in the Kolo area. For the first time, partial budgeting methods were used to attempt to evaluate INRAN's recommendations on the farmers' fields from an economic standpoint (Kennedy et.al., 1985). Concurrently, the General Agronomy section of INRAN conducted a series of experiments on station to determine the yield maximizing levels of intercropped millet-cowpea varieties and densities, as well as optimum fertilizer rates and modes of application (Reddy et.al., 1985). Recognizing for the first time the importance of making recommendations by domain, INRAN identified distinct recommendation domains (Swinton and Ly, 1984). Base line socio-economic studies conducted by INRAN's department of agricultural economic research (Département de Recherches en Economie Rurale), DECOR, provided a first profile of the farming systems in each recommendation domain (in Filingué: Numa and Ly, 1983; in Kolo: Ly and Deuson, 1985; and in Madarounfa: Swinton et.al., 1985).

Concurrent with the development of extendable technologies on the research station and of a farming systems research methodology, steps were taken to institutionalize the FSR approach at INRAN. In 1984, INRAN established a technical working group to monitor the development of the farming systems research program. The objectives of the group are as follows:

> (1) To establish within INRAN, a multidisciplinary team of researchers from different fields (biologists and economists) and extension agents (developers).
>
> (2) To formulate research programs on farming systems and after their execution by the multidisciplinary team, to evaluate the results and generate feedback for future programs.
>
> (3) To inform INRAN administrators of the progress achieved in these programs and to insure administrative support for them (Ly et.al., 1985, p. 9).

The group is involved in identifying potential research topics at the farm level through the implementation of rapid reconnaissance surveys (sondeos) and in designing on-farm trials and insures that the administrators of INRAN's major research departments are kept abreast of the farming systems research program. The group has been particularly

instrumental in gaining respectability for the program and in helping to redesign the on-farm trials in light of the results and of farmers' reactions to the early trials.

3.0.0 1985 On-Farm Trials

The first large-scale, on-farm trials were implemented by INRAN during the 1985 cropping season on 75 farms situated in three distinct recommendation domains. Based on the on-station experiments carried out by the General Agronomy section, it was decided to test technologies of varying complexity whose components meshed, thus permitting a greater flexibility in the separate adoption of each of these components.

3.1 Agronomic and Economic Results

A randomized block design was used. Varieties of improved millet were planted in association with cowpeas at two different density levels, with and without fertilizer. These were compared with traditional varieties and densities. For millet, Analysis of Variance (ANOVA) showed a significant increase in grain production for the improved varieties on two of the three sites. The improved varieties, at the recommended densities, with fertilizer, gave the best yields on all three sites. Where fertilizer was not used, the improved variety at the farmer's traditional density performed better than at the recommended density on one site.

For cowpeas, there was no pod production because of an end-of-season drought. However, the forage yield of this legume was significantly higher at the recommended densities, whether with or without fertilizer, than at the traditional low densities on all sites.

Partial budget and dominance analyses showed that the high density with fertilizer was superior on two of the three sites. In contrast, on the third site where rainfall was low, the improved variety of millet at low density without fertilizer was the most profitable. Sensitivity analysis revealed that these results were very sensitive to the price of cowpea hay.

These results were presented at the Farming Systems Research Symposium at Kansas State University in October, 1986 (Ly et.al., 1986).

3.2 Institutional Results

To these technical results, one must add the institutional impact of these trials on INRAN. First of all, one can safely say that these trials substantially reinforced the "esprit de corps" of INRAN. In effect, nothing more closely links people than group effort and sacrifices made in order to accomplish a common goal. Together, national and expatriate researchers, agronomists, soil scientists and economists developed and successfully implemented trials which reflect a new agricultural research approach centered on the principal user of that research, that is, the farmer. In fact, during the presentation, at Kansas State University, in October, 1985, of the document on the evolution of the Farming Systems Research Program at INRAN (Ly et.al., 1985), the moderator who evaluated and discussed the presentation of the document by Mr. Maliki Kadi acknowledged the institutional impact of the new approach and even spoke of the "Nigerien model" (personal communication, Scott Swinton).

The second institutional result was to attract the attention of other INRAN researchers who had chosen during the first year not to participate in these on-farm trials to the inevitable lacks and errors which occur in any new program begun without the assistance of all specialists. The cowpea breeder, Mr. Issaka Magah, for example, proposed, for the 1986

trials, cowpea varieties which were better adapted to the target zones as well as crop protection practices to assure the production of pods. These proposals were adopted and permitted a significant improvement of the 1986 program. Other researchers, such as Mr. Jika and Mr. N'Diaye, the millet breeder and entomologist respectively, proposed the addition to the program of completely new trials whose objective was to test specific varieties or technologies. For example, Mr. Jika tested the on-farm behavior of dwarf millet (3/4 HKP) in pure stand and crop associations. Mr. N'Diaye tried to discover on a large scale if millet varieties characterized by high compacity of flowers and grain can discourage egg laying by raghuva. He also attempted to define the effectiveness of treatment and the best timetable for applying it. Furthermore, the researchers who had implemented on-farm trials in 1985, such as Mr. Moussa Goubé, conducted them again in 1986 (for example, the fertilizer application methods trial).

These precise examples show an evolution of the Institute's research approaches toward the implementation of agricultural technologies which are agronomically viable, economically profitable and rapidly extendable because they have had preliminary testing on the farm.

4.0.0 1986 On-Farm Trials

The experimental design of the 1986 on-farm, crop association trials included several improvements which resulted, on the one hand, from lessons learned from the results of 1985 and, on the other, from the 1986 contribution to the common effort of other INRAN specialists. In this way, a supplementary treatment was added to the four used in 1985, i.e. three crop protection treatments against cowpea pests.

In addition to the crop association trials, specialized trials were implemented on the farms:

- A trial at Kolo and Kouka consisting of four methods of fertilizer application on plots of pure millet.

- A trial on each of the three sites to evaluate the agronomic and economic impact of two crop protection apparatuses (Electrodyne and Fontan) used with two different products applied in one or two doses depending on the treatment.

- A trial to compare the behavior of dwarf millet (3/4 HKP) planted in association with millet and in pure stand.

- A trial on the varietal resistance of millet to the head borer (Raghuva).

Analysis of the 1986 on-farm trials for crops in association has been completed. A final report is to be presented by DECOR during 1987. The preliminary results of the 1986 on-farm trials can be summarized as follows:

4.1.0 Agronomic results

4.1.1 Millet Grain Yields

On two of the three sites, treatments 4 and 5 (T4 and T5) showed a significant difference at a level of 5% (Duncan's test). At Kouka, a significant difference exists between T5 and the other treatments, which is

probably due to the insecticide applied to the cowpeas which would have also benefited the millet. The only significant difference between treatments 1,2 and 3 was observed at Kandamo where T3 showed the lowest yield.

4.1.2 Cowpea Pod Yields

At Liboré, comparison of the averages by Duncan's test at a level of 5% gave the following classification: T5=T4=T3>T2=T1. At Kouka the classification is: T5>T4>T3>T2>T1. At Madarounfa the classification is: T5>T4>T3>T2=T1.

4.1.3 Cowpea Forage Yields

The forage weight was recorded at Liboré and Kouka. At Liboré the classification is T5=T4=T3>T2=T1.

In general, the treatments with the most inputs gave the best yields of millet and cowpeas. However, the results at Kouka and Liboré must be interpreted carefully given the high coefficients of variation observed at these two sites.

4.2.0 Economic Results

4.2.1 Partial budget results

Partial budget and dominance analyses of the 1986 trials lead to the following preliminary conclusions:

1. At Madarounfa, whether on the basis of the harvest prices or the January, 1987 prices, treatments 2,4 and 5 are not dominated. Only T1 and T3 are dominated. Consequently, one can always recommend INRAN's improved seed (T2). Furthermore, the recommended densities are not economically profitable (T3), unless one applies fertilizer (T4) and the cowpeas are treated (T5). These recommendations are exactly the same as those of 1985, based on the prices of January 1986 and 1987 (not including those recommendations for T5 which didn't exist in 1985). Given that the quality of data base collected at Madarounfa is good, one can say that these recommendations over a period of two years are relatively stable.

2. At Kouka when one compares the results of 1986 with those of 1985 on the basis of harvest price, one arrives at the same recommendation: T2 is profitable in 1985 and 1986. T1, T3 and T4 are not. In contrast, for 1986, T5 is also profitable. However, when one uses the prices of January, 1987, T3 which was dominated at harvest prices, becomes a profitable option with a marginal rate of return of 60%. Even though the yields of millet and cowpeas are practically the same for T2 and T3, the price of millet increased by 60% and the price of cowpea pods doubled between the harvest and January, 1987, without changing production costs.

3. At Liboré, preliminary results obtained in 1986 and calculated on the basis of harvest price seem to indicate that the only treatment not dominated is T3. This recommendation does not correspond to those of 1985 where none of the modern treatments (2, 3 and 4) were dominated. However, the results from Liboré must be interpreted carefully because of the small size of the sample (n=14) and the high coefficient of variation of yields observed on this site. It would perhaps be preferable not to

use the 1986 Liboré results given the difficulties of carrying out these trials.

4.2.2 Analysis of Economic Risks

Two types of preliminary analysis of economic risks encountered by farmers participating in these on-farm trials were used:

1. calculation of the minima, maxima and standard deviations of monetary income per hectare and per treatment, and
2. the percentage of farmers whose net revenue is less than zero (thus indicating a loss) per treatment.

These analyses led to the following conclusions:

1. The standard deviation of the monetary income increases as the complexity of proposed technologies increases, indicating in this manner the uncertain nature of modern technologies.

2. The percentage of farmers whose net income is less than zero varies more between the sites than between the technologies, which would seem to indicate that there are fairly significant differences in technical competence involved. When all the sites are mixed, it seems that the farmers follow a bimodal distribution: approximately 50% of them show profits and 50% show losses whatever treatment is applied.

4.3.0 Mathematical modeling of on-farm trials

A linear programming analysis of intercropped millet and cowpea production in the Madarounfa arrondissement of Niger demonstrates how the availability and management of family labor and hired labor may affect the choice of crop technology. Four treatments from the 1986 on-farm research trials were evaluated in this analysis. The four treatments range from traditional practices and crop varieties (treatment 1) to a combination of fertilizer applications, high plant densities, and improved varieties (treatment 4). Although economic budget analyses of the on-farm trial results indicate that returns to labor and management per hectare for the fourth treatment are superior to those for the other treatments, the linear programming analysis indicates that labor availability may often limit the area on which farmers adopt the package of new crop technologies.

Limits on the proportion of time family members are willing to do fieldwork, consideration of possibly large replanting requirements, consideration of capital costs, and perceptions of substantial production risks all tend to limit the adoption of the labor-intensive crop technology. Capital costs supplement the effect of limited labor availability on the choice of technology, but do not act independently.

Hired labor can greatly increase the land area on which labor-intensive crop technology can profitably be adopted. Hiring labor is profitable during the optimal planting and first weeding periods, provided that it is available and provided that the interest rate is moderate.

It appears that the additional requirements for urea applications during the optimal periods for cowpea planting and first weeding may discourage Nigerien farmers from using fertilizers. If practices which reduce labor requirements for urea applications, cowpea planting, millet and cowpea replanting, and first weeding, can be developed, these would tend to increase the use of fertilizer and increase food production. The possibility of using phosphate fertilizer, applied before the first rains,

without urea fertilizer should be investigated, and has been included in INRAN's 1987 on-farm trials for intercropped millet and cowpea.

It also appears that a lack of low-cost credit in rural areas may be limiting the use of fertilizer. A lower interest rate would not only reduce the cost of fertilizer and seed, but also make it profitable to hire more labor in periods when family labor constraints limit fertilizer use. Development of rural credit institutions in Niger could make fertilizer more available to farmers and more profitable to use.

The package of improved crop varieties, increased plant density, and fertilizer applications developed by INRAN for intercropped millet and cowpea has shown a strong potential in on-farm trials for increasing food production. It also appears to provide attractive economic returns to labor and management. However, labor and institutional constraints in rural Niger may limit the adoption of this technology unless changes in economic conditions reduce the effect of these constraints, or until this technology can be better adapted to them (Krause et.al., 1987, pp. 20-21).

5.0.0 Charting the future

The future of the National Farming Systems Research Program of Niger will be determined by its capacity to model closely the subsistence farming environment. The closer the model to reality, the more useful its results will be in terms of helping INRAN's decision makers in recommending new technologies for extension. To get closer to reality, the model will need to be expanded in terms of geography, the number of variables, the methodology, and its link to the marketing, agricultural policy and extension issues.

5.1.0 Extending the number of sites

At present, the FSR Program covers only three sites (Madarounfa in Maradi Department, Kolo and Kouka, in Niamey Department). These sites correspond to well defined recommendation domains. However, they represent only a small percentage of the potential number of recommendation domains which need to be identified in Niger. In fact, on-farm trial sites should be identified in the Departments of Dosso, Tahoua, Zinder and Diffa, preferably in the vicinity of the research stations and sub-stations, to facilitate proper supervision. If INRAN's decision makers are to make recommendations that will be extended over the national territory, they need evidence that the proposed technologies are tailored to the specific agro-climatic environments where they will be extended and that these technologies can be expected to be profitable in those areas.

5.2.0 Plural Farming Systems

Naturally, the first on-farm trials have been designed to address the development of yield and income increasing technologies for the two most important subsistence crops: millet and cowpea. However, Nigerien subsistence farms include many more permutations of cropping systems. For example, INRAN identified 37 different cropping systems on 75 farms in Madarounfa arrondissement alone (Swinton et.al., 1984). It is evident that farmers make decisions on adopting new technologies not only on the basis of the impact that technology may have on one cropping system but also on the basis of their whole-farm plan.

Another element which is not included in INRAN's present modeling of farming systems is animal husbandry. Considering that animals are partly a capital investment in Niger and provide cash flow, and given that improved

technologies often require cash outlays for the purchase of modern inputs (e.g. fertilizer, pesticides), it is paramount that animal husbandry be modeled as well. In addition to small ruminants, the introduction of draught animals and animal traction technologies must also be studied. Animal traction may prove a valuable labor saving technology. Such introduction would in turn affect the crop mix as farmers must secure forage.

A third area of qualitative expansion in Niger's FSR program is the design, testing, and modeling of water retention technologies. For example, the Purdue Farming System Unit/Semi-Arid Food Grain Research and Development (FSU/SAFGRAD) designed, tested and modeled tied ridging fertilization technology combination with donkey traction on the Central Plateau in Burkina Faso (Nagy et.al., 1987).

5.3.0 Refining the methodology

The 1985 on-farm trial results were analyzed by means of ANOVA and partial budgets to estimate the significance of yield and net return differences between treatments. Dominance analysis was used to identified non-dominated treatments. Sensitivity analysis was performed to determine the stability of the recommendations in light of output price variations.

In 1987, a linear programming model was constructed, using the 1986 on-farm trial data. It represents 18 time periods thought to be critical to plant establishment and growth. Multiple linear regression analysis of 1986 on-farm trial data linked millet and cowpea yield to planting and first weeding dates. Based on the regression results, yield adjustment coefficients were calculated for each possible combination of planting and first weeding date periods. These coefficients were included in the model.

Albeit very useful in determining the impact of increased labor requirements called by the new technology, the model is not a whole-farm model and needs to be turned into one. The treatment of risk needs to be improved as well. Finally, crop growth modeling is a feasible alternative to on-farm trials repeated overtime and should be considered. All models can be operated, modified, and enhanced by field personnel with little experience in modeling if they are driven by an Expert System (ES). ES components can be built in those models relatively easily and make them user-friendly.

5.3.1 Whole-farm programming

As the name suggests, a whole-farm programming model portrays the farm as a complete entity, i.e. all farming systems within the farm are represented. In fact, a well designed whole-farm model views the farm the way the farmer does: it sizes all activities, the different ways to combine them, the demands placed on farm resources per unit level of each activity, the variable costs per unit level of each activity, the yield and net return expected from each activity, and a measure of both yield and price risks.

To construct such a model, INRAN needs to collect data on activities presently not in its linear programming model and include them in its model. Those activities are primarily cropping systems other than millet-cowpea, especially systems that include a cash crop, and animals (small ruminants and draught animals).

The model needs to be validated, using on-farm trial and survey data from INRAN as well as from the productivity projects. Modeling the Nigerien subsistence farm requires team work between agronomists and economists. Combining the experience of INRAN's cadres with the newly acquired technical know-how of INRAN's personnel presently in training in the U.S. should facilitate this effort.

The objective function of the farmer deserves special modeling attention. Until now, INRAN's model assumes that farmers essentially maximize profit subject to production constraints. Risk avoidance and other objectives are not included in the present model. Goal programming could be used to minimize deviations from specified levels of two or more goals (e.g., Barnett et.al., 1982).

5.3.2 Analysis of risk

Farmers in the Sahel face both yield, price, and resource risks. Farmers living at the edge of subsistence cannot afford a single poor farm management decision: they have no margin for error and any mistake would spell disaster for the farm family. Many empirical studies have demonstrated that farmers behave in risk-averse ways (e.g. Dillon and Scandizzo, 1978). Typically, farmers in the Sahel (in particular) will be prepared to trade higher yield and income, coupled with higher risks, for lower yield and/or income, on the average, to guarantee some acceptable level of food and/or income security. Ignoring farmer's risk-averse behavior in the model will lead to the recommendation of technologies that may be unacceptable to the farmer.

Fortunately, there are a number of well documented techniques for incorporating risk-averse behavior in mathematical programming models (see Hazell and Norton, 1986, ch. 5). Several of these techniques may be experimented within INRAN's model.

5.3.3 Crop growth modeling

INRAN has the awesome responsibility to recommend improved varieties and cultural practices that, when extended, will impact on the lives of over 90% of the Nigerien population which is employed in agriculture. Understandably, INRAN scientists are cautious in terms of the recommendations they are willing to propose for extension on a national level. INRAN is reluctant to give access to new recommendation packages to the subsistence farmer through the Extension Service because it fears that such recommendations may become unstable in face of the yield and income variability inherent to farming conditions in the Sahel. Such instability may result in low rates of adoption or, worse, the jeopardizing of the survival of those subsistence farmers who have been early adopters. In either case, INRAN will be ultimately accountable for the outcome.

The traditional way of testing the yield and income stability associated with the recommendations is to repeat on-farm trials for many years. There are three problems with this approach. First, it is a very costly prospect in research resources. Second, the economic environment may change overtime so that by the time an acceptable level of confidence in the recommendations has been reached, the proposed technologies may be obsolete. Third, many of the farmers in Niger are on the edge of subsistence and cannot wait for recommendation packages born out of lengthy experimentation. Politically, INRAN is under mounting pressure to come up with more effective production systems which are accessible to the subsistence farmer in the immediate future.

Thus INRAN's dilemma: to extend a recommendation package without sufficiently verifying its yield and income stability or to delay extension until stability is tested?

This dilemma can be resolved through the use of nonspecific crop growth simulation models. Nonspecific crop growth models reduce the cost and the time required for model development and make simulation analysis

possible for crops with small research budgets. GROWIT, developed by Smith and Loewer (1981), is the best known generic crop growth model. It has been used for a wide variety of crops. The model and associated software is very flexible. The use of GROWIT for additional crops has been facilitated by the spreadsheet version developed by Peart and Li(1985), and Lowenberg-DeBoer and Cherney (1987). The spreadsheet version can be operated on any microcomputer with 640K memory and can be modified without knowledge of a programming language.

Simulation is particularly useful in accessing risk (Musser and Tew, 1984). The two primary ways in which stochasticity is incorporated are: 1) to run the simulation model over various historical data periods, treating each outcome as an observation on the random process and 2) to estimate probability functions for the stochastic variables and incorporate those in the model, so that each run of the model is treated as an observation on the random process (Blackie and Dent, 1979). The simulated observations can be used to estimate the yield means and variances for use in budgeting and programming models (Musser and Tew, 1984). Stochastic dominance techniques can be applied directly to the simulated observations to give pairwise rankings of production strategies (Anderson et.al.,1977).

The general objective of this type of research is to accelerate the determination of yield and income variability that occurs under newly developed crop production methods and to use this information on yield and income stability in ranking new technologies for use in certain agronomic and farm resource situations. The primary research tool is a generic, crop-growth simulation model, which can be rapidly validated for new sites, varieties and cultural practices, and which can simulate the performance of the new technologies over a wide variety of environmental situations (weather, soil, fertility), as well as economic conditions (Deuson et.al., 1987).

5.3.4 User-friendly models: with Expert Systems

At this point, the INRAN scientists may ask themselves: "Are these models for us? We are not computer specialists nor a mathematical programers. Is this an appropriate methodology for testing technology in Niger?" The answer is yes on both counts. The word model has a very broad meaning. When an agronomist performs an analysis of variance and adds to the results of such analysis his experience and his formal and informal field observations to come up with a judgement as to the appropriateness of a technology, he uses a model. INRAN's future whole-farm model will explicitly incorporate all observations on all farming systems in a given recommendation domain. INRAN scientists need to use a methodology which closely mimics the decision process of the Nigerien farmer in order to maximize the probability that extended recommendations will be adopted by a majority of farmers.

As to the use and maintenance of these models by non-specialists, recent developments in artificial intelligence (AI) make it possible to build in those models Expert Systems (ES) elements that make the models "user-friendly". For example, Kline et.al. (1986) developed a Farm Level INtelligent Decision Support System (FINDS) for seizing and selecting machinery for whole-farm cropping systems. FINDS integrates a whole-farm management linear program (LP) with a knowledge-based expert system. FINDS automates many of the tedious LP modeling procedures. The knowledge base of FINDS is organized into two frames. The first frame directs the proper input to the LP and controls its execution. The second frame interprets the LP

solution and makes recommendations on possible farm machinery changes. A similar ES can be developed for INRAN whole-farm model.

5.4.0 The link with marketing and policy

When a farming systems research program is first implemented, it tends to focus primarily on the crop and livestock production process. This is true for the Niger FSR Program. Yet, in addition to yield and price risks, farmers in Niger face risks tied to the structure and performance of the input and output markets and to the government's agricultural policy. These risks need to be assessed carefully prior making recommendations. Recommendations cannot be made solely on the basis of technology evaluation at the production level. For example, a technology calling for the application of phosphate fertilizer may be agronomically sound (i.e. it has the potential to increase yield in a statistical significant fashion over traditional cultural methods) and be economically profitable (i.e., net return increases with the new technology) and fit well in the existing farming system (e.g., does not create labor bottlenecks). Yet, if the marketing system is not structured to deliver efficiently (at the right place, at the right time, in the right quantity) the phosphate fertilizer, it will do little good to extend recommendations based on that technology.

Little is known at INRAN about the marketing system. To be sure, INRAN has collected price and quantity data weekly on markets in the vicinity of the on-farm trial sites since 1985. These data were used to construct farm budgets for the economic evaluation of the 1985 and 1986 on-farm trials. Yet, most of the information available on market structure and performance comes from studies done outside of INRAN. One example of these is the now dated Niger Agricultural Sector Assessment commissioned by USAID (Bordsdorf, vol. II, part F, 1979). This type of study emphasizes the official marketing channels. Little is known quantitatively about the traditional channels. INRAN has here a unique opportunity to launch a study of output (cereals and legumes) and input markets and link its findings on the evaluation of technology to the findings of the marketing study. This linkage would add realism to recommendations. Within DECOR's organizational chart, there is a unit which must address marketing problems. This unit has never been activated due to lack of personnel. It is essential that INRAN staff that unit as soon as possible.

Recommendations for extension should take into consideration the implications of agricultural policy. For example, a cereal price stabilization scheme will inevitably affect production incentives of farmers and therefore their rate of adoption of technologies designed to improve cereal yield. Likewise, government intervention in the input market may have a significant impact on the adoption of technologies designed to use modern agricultural inputs. These statements seem evident, yet there is no formal mechanism to coordinate agricultural policy and the design, evaluation and extension of new agricultural technologies in Niger. At a minimum, INRAN ought to collaborate closely with the statistical unit (Division des Statistiques) of the Ministry of Agriculture which plays an increasingly important role in providing policy makers with useful information on production, productivity and prices. In addition to investigating the implications of current policy on the design of new technologies, INRAN needs to identify the type of policies needed to make new promising technologies extendable and adoptable. Policy makers need this type of input from INRAN.

5.5.0 Extension

Extension in Niger has a relatively young history. In the colonial period, technology transfer was done only for cash (export) crops by imposing constraints on the Nigerien farmer. Extension services as they are known today started out with the Zinder Project in 1972. Leading farmers were trained as extension agents at first. With the inception of the Productivity Projects, the level of technical know-how of extension agents was raised.

The link between extension and research in Niger is a tenuous one. It is limited to the following linking mechanisms: (1) participation to the respective annual meetings of INRAN and the Ministry of Agriculture services (among which Extension); (2) joint management of multilocational trials; (3) delivery and extension of the technical recommendations (fiches techniques); and (4) INRAN's liaison unit to bridge research and extension. Each one of these linking mechanisms has weaknesses. Annual joint meetings are useful but insufficient to design, implement and monitor joint activities. The multilocational trials have been ill-managed, partly because Extension is not implementing INRAN's protocols properly (due to lack of trained personnel and/or conflicting demands on that personnel's time), and partly due to the lack of supervision by INRAN of the implantation of said protocols (also due to lack of personnel and time). In the past, protocols have been too complicate for Extension agents to implement, but this has been remedied since 1986 by the General Agronomy section of INRAN. The technical themes are in a period of transition as new technologies are being developed on the station and tested in the farmers' fields. It is questionable whether this extension medium should be the only one used to disseminate research results or whether it is appropriate at all. The liaison cell of INRAN is essentially unstructured, under-staffed, and lacks purpose and direction.

Having reviewed some drawbacks of the present linkage system between research and extension, one must now make proposals for improving it. No one is better equipped to do so than Dr. Idrissa Soumana, the Director General of INRAN. In a recent paper, he presented four propositions to improve the linkage between research and extension:

(1) Redefining the role of extension agents
(2) Improving multilocational trials
(3) Improving the fiches techniques
(4) Increasing and improving communication with extension

In his first proposition, we find an idea which, if implemented, might greatly improve the transfer of technology from INRAN to the Extension service and might increase the quality of both the extension and FSR Programs. It is proposed that extension agents be assigned to INRAN's FSR program to participate actively in the testing and the evaluation of new technologies. There are three advantages to this proposal: (1) extension agents will be kept abreast of INRAN's research work, (2) INRAN's researchers will benefit from the experience of extension workers while evaluating new technology, and (3) when the new technologies will be ready to be extended, the Extension service will be current with all its aspects (Soumana, 1987). This proposal should be implemented without delay.

6.0.0 Phase III of the NCR Project

Many of the improvements proposed above will have to be implemented in Phase III of the NCR project. This will mostly be done by national researchers as INRAN enters stage three of technology transfer.

6.1.0 Stages of technology transfer

Hayami and Ruttan (1971) described technology transfer in three stages. The first stage is direct material transfer of technology (seeds, machinery, pesticide, fertilizer) with some adaptive trials. The second stage is design transfer: the transfer of designs, blueprints, and methods, with local training to allow local scientists to use technology more effectively. The third stage is capacity transfer: investment in human capital through long term training to the research institute with scientific and technical leadership capable of promoting national agricultural development with little or no outside help.

Looking back at the history of Purdue and Alabama A&M Universities assistance to INRAN, one may find elements of each of Hayami and Ruttan's three stages of technology transfer in the first two phases of the NCR Project, with the National Cereals Project (NCRP phase I) corresponding more closely to Hayami and Ruttan's first stage of technology transfer and the NCRP II corresponding more with the second stage of technology transfer. The NCRP I, from 1976 through 1981, had four fundamental components: the building of research infrastructures (especially seed multiplication centers), cooperative development, agricultural extension, and applied research. Long term training also began during that project. The NCRP II provided INRAN with three interrelated blueprints for improving its capacity to do research: a sorghum breeding program, a general agronomy research program, and a a farming systems research program. Long term training continued and intensified during that period (1982-87).

We are now about to enter the third phase of the NCR Project and also the third stage of technology transfer. The 20 INRAN scientists trained in the U.S. are now returning or about to return to the Institute. We will hear later on today presentations by four of them. These young men and women will play a pivotal role in bringing INRAN in stage three. We urge them to appreciate their privilege to have been trained to do a challenging job. With privilege comes responsibility. They must rise to the challenge for Africa's problems will ultimately be solved by Africans.

6.2.0 Alabama A&M University

Alabama A&M University has blessed the current project with much appreciated expertise in the field of agronomy. As far as we can determine, USAID request for proposal (RFP) will call for an assistance team of six: a team leader with research management experience, an agricultural economist, an irrigation agronomist, a dry-land agronomist, a plant breeder, and an irrigation engineer. Alabama A&M should attempt to fill at least two of the positions (possibly in agronomy). The RFP will also call for approximately 36-person months of short term consultants. In the current phase of the Project, visits by Alabama A&M staff have been confined to administrative visits. This is one area in which Alabama A&M might want to partake more actively. Participant training (long and short term) will no doubt be increased. Alabama A&M is already involved actively in administering about half of the current long term participant training programs. This activity should be maintained at least at the current level in Phase III. Alabama A&M might also want to consider designing and carrying out short term training programs both here and in Niger.

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  FINDS: Farm Level Intelligent Decision Support System, 11
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