

Experimental Processes and Diffusion among Qat Farmers in Yemen

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Abstract

Production of qat in Yemen is not supported by any commercial or public sector research and advisory programmes. Nonetheless, production continues to expand rapidly and farmers have developed technologies to solve production problems and to adapt traditional and non-traditional practices to new areas. These developments occur through systematic experimentation and observation. A study in monocrop and mixed cropping qat production areas of the Central Highlands identified twelve instances of technology developed by farmers. Using a grounded theory approach and a methodology adapted to the sensitive nature of the enquiry, the study elicits models of farmer experimentation. It also explores the rich network of informal communication channels through which new information is exchanged among qat producers, traders and consumers. The role of itinerant labourers in the information system is highlighted. While the study confirms the dynamism of farming systems in the absence of formal research and development programmes, it also raises concerns about health and environmental issues.

Keywords: farmer experiments; Yemen; qat; technology development; information system

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Introduction

In recent years, national and international agricultural research and development organisations have become increasingly interested in the involvement of farmers in formal research processes. It is recognised that farmers conduct informal experiments and observations. It is suggested that combining these processes with those of formal research can bring solutions to real problems more quickly, a more efficient use of research resources and more rapid transfer of research findings to other farmers. According to Sumberg and Okali (1997) recent emphasis has been placed on farmers' experiments which lead to the adaptation of an existing technology. It is also recognised that farmers are active in the creation, as well as the modification and diffusion, of innovations. Abedin and Haque (1991) stated that farmers have continuously innovated to improve methods of growing crops and to adapt them to their varying needs. Quiroz (1999) mentioned that farmers try to solve existing problems and attempt to create new alternatives. In addition, Maurya (1989) indicated that farmers continue to innovate in the absence of formal research and technology development. Mahmud and Muqtada (1988) offered an example in Bangladesh where many locally improved rice varieties evolved through farmers' own informal research and only attracted the attention of breeders after they had already spread to other farmers.

In their discussion of informal research, Rhoades and Bebbington (1991) identified three types of farmers' experiments: curiosity, problem solving and adaptation experiments. In a review of the factors influencing farmers' experimentation they argued that a high level of diversification and poor extension services may make farmers more interested in experimenting (Rhoades and Bebbington 1995). Sumberg and Okali (1997) emphasised that the risk and competition that accompany increasing commercialisation stimulate farmers to experiment particularly with high value crops.

Most studies of farmers' involvement in research are based on situations where farmers and researchers collaborate in various ways, sharing their knowledge and insights to different degrees. This paper analyses the processes of farmer experimentation and development of technology in a context where there are no formal government or commercial programmes of research and advice, but where market demand for the product is high. Farmers are on their own. It is in situations like this that the inherent abilities and tendencies of farmers towards the development of technology can be seen most clearly. The paper goes on to analyse how information about new technology is communicated within farmers' agricultural information system.

The paper is based on twelve case studies of the experience and network of communication amongst qat farmers in the Central Highlands of Yemen. Each case is a distinct technology developed for the production of qat. Farmers who grow qat were selected as suitable candidates for the study as technology related to qat production has both developed and diffused in the absence of formal research and extension programmes. Until the early 1980s, farmers in the area grew traditional crops for local consumption (cereals, fruits and vegetables) but they have gradually changed to cash crops, particularly qat. In the study area several development projects have intensive programmes whose aim is to transfer technology to farmers for different irrigated crops. However, no research or extension programmes are directed towards qat production. Indeed, as the consumption of qat is a controversial issue any assistance regarding its production has been avoided. The government view is that qat causes many problems including social and health effects, and competition for resources - particularly scarce irrigation water - with other crops that are considered more important than qat. The situation has created tension between government officials and qat farmers: as a result the government refuses to support the farmers in technical matters relating to this crop.

Methods

The study applied a grounded theory approach, which suited the exploratory nature of an enquiry in which the lack of sufficient information about qat technology meant that appropriate categories could not be established at the outset of the research. The overall approach was to review each day's data to generate tentative hypotheses and models, which were tested the next day by further enquiry. This iterative process continued until no new insights were being generated. A qualitative methodology was used to collect data from the field and derive a suitable model of farmers' experimentation to fit the case studies. One hundred and twenty respondents participated through 44 group interviews and twelve individual interviews. In addition, there were 60 field visits for participant observation.

An inherent constraint in the study was that the stakeholders, particularly farmers and qat dealers, have a vested interest that they believed could be threatened by research which led to the dissemination of information about their activities. They were potentially sensitive, for example, to publicity about their use of large quantities of chemicals (fertiliser and pesticide) which may be linked to numerous health incidents among farmers, rural labours and customers after chewing qat. Kenny (1996) argued that such contexts require particularly sensitive research methods. He claimed that communication skills and an understanding of individuals and their relationship with wider communities of which they are a part are essential. In the present study, the qat farmers' behaviour during interviews was similar to what one might expect from people involved in an illegal activity. In response to the reticence of participants the study applied a range of techniques - document review, individual and group interviews, direct observation and participant observation - to understand and generate more information regarding technology development and information networks among qat farmers.

At the beginning of the study, individual farmers were interviewed; but

the level of suspicion of the study's objectives was high so the farmers suggested to the researcher that he switch to group interviews. The qat sessionⁱⁱ was the main setting for all individual and group interviews. In contrast to an artificial setting in which the farmers do not respond or when they are busy working in the fields, the qat session provided an appropriate environment. Furthermore, the farmers were very active during the qat session and raised many subjects particularly on agricultural matters. Suspicion gradually subsided and the farmers began to express more positive views about the objectives of the study. The group method elicited a fuller picture of farmers' knowledge and skills: during the meeting a farmer would give a partial account of the knowledge and skills related to a particular technology and another farmer would complete or correct the information. In the group meeting the researcher chose a suitable place where all those present could see him. The position assisted in controlling the meeting. At the beginning of the session the number of farmers was typically between seven and twelve. After an hour the number gradually declined, after farmers had heard the objectives of the study. Usually, around four farmers spoke from among those attending. The objectives of the study were offered and the farmers would begin by examining the researcher, asking questions or requesting the researcher to advise on solutions to specific agricultural problems. The attention of the farmers would then turn to talk about agricultural practices of qat from planting through to marketing.

The present study focused on the Central Highlands of Yemen, particularly the areas around Dhamar, Bet Al-Kumani and Radaa. One of the reasons for selecting these different areas was to look separately at qat production in mixed and monocrop farming systems, because initial discussions suggested technology has developed differently in the two types of system.

Findings

The main findings of the study are presented in two parts: the first deals with technologies developed by qat farmers and the second is about qat farmers' agricultural information system. The study identified twelve forms of technology developed by qat farmers in the Central Highlands of Yemen. They are divided into three groups based on the technology development process as follows: (A) Experiments with new ideasⁱⁱⁱ (B) Experiments with local technology^{iv} (C) Experiments with existing technology from outside the farming system^v.

An example of farmers' experimenting with new ideas is the development of technologies to protect qat from frost damage in the winter when production declines and correspondingly prices rise. The farmers have invented two systems to protect the plants from frost damage (Box One). The first system involves covering the plants with cloth whereas the second uses artificial windbreaks. The agricultural specialists believed farmers adapted the technology of a greenhouse. However, evidence from farmers in this study suggests the idea emerged eleven years prior to the introduction of the greenhouse system to Yemen.

Box One

Development of frost protection technologies

1. Some farmers attempted to prevent frost damage by laying the plants down and burying them in the soil during the frost period but the result was unsatisfactory as the plants were damaged by the soil.
2. Some farmers covered the plants with sorghum straw and the result was good. However, as the price of straw is very high in winter the cost prohibited farmers from using this method on a large scale.
3. Some farmers covered each nurseling with paper or plastic bags in half of the field. Although frost damage to the plant was avoided the farmers

discontinued this method, as it was not practical to cover each nurseling.

4. One farmer 34 years ago covered part of his field each night with pieces of old cloth, which were removed in the morning. The covered plants were not affected by frost damage. This experience led him to create the covering system technology.
5. Approximately twenty years later another farmer observed that plants sheltered by the wall of his house and guardhouse were not affected by frost. He tried ways of replicating this effect on a wider scale, which resulted in the development of the artificial windbreak technology to protect his qat from frost damage.

Farmers carried out experiments to develop a new innovation to solve a problem and continued the experiments to adapt the new innovation. Interestingly, the data showed disparity amongst the case studies regarding initial experiments with new ideas and further trials to develop new innovations. Conducting experiments on the basis of a new idea was primarily the domain of small-scale farmers or large-scale farmers. However, experiments to develop the new innovations to be more practical and suitable were generally carried out by large and medium scale farmers. The farmers with greater qat production had more resources to develop new innovations. In addition, new ideas emerging from small scale trials often have to be adapted for large scale production.

The data from the fieldwork showed that farmers have local technologies that they have further developed in response to changes in the farming system, such as using new inputs (for example chemicals, and pumps for irrigation). Farmers' have used their indigenous knowledge to develop local technologies to be more practical and in some cases to imitate new products, such as the use of natural pesticides. Furthermore, local technology has been transferred from region to region and farmers have tried to adapt it to the different regions - new varieties and pruning methods, for example - or from

rainfed systems to an irrigated system, such as the technique of soil rotation (Box Two).

Box Two

Soil rotation technology

The farmers have indigenous knowledge on how to improve the soil nutrient status. Approximately 5-10 cm depth of the soil is moved to the edge of the field and soil is added from another field that has not been sowed for one year (fallow system). The technology is used in the rainfed areas as chemicals and organic fertiliser are unsuitable to add to soil which lacks water, as they encourage the plants to consume more water.

The qat farmers have carried out experiments to adapt this technology to irrigated systems in order to solve many problems such as situations where the top soil has become rigid as a result of using a high quantity of Fe fertiliser, the soil (particularly calcareous soil) is unsuitable for qat growth, or production is gradually decreasing and the plants do not respond to chemical fertilisers.

Numerous chemical pesticides are available to protect field crops, fruits and vegetables from infestation by pests. Furthermore, there are also chemical fertilisers that increase production per unit area. Recommendations from research and extension organisations are available to assist farmers on how to use pesticides and chemical fertiliser effectively on crops other than qat. The qat farmers have adapted the technology that has been developed for other crops. It was found that the farmers who conduct this kind of adaptation experiment for a single pesticide are usually large and medium-scale farmers but most qat farmers have conducted trials on mixing two or more insecticides, or fungicide with insecticide.

The type of farmer conducting the trials were usually better off farmers with large scale production and the financial resources to invest in adaptation

or problem solving experiments. Small farmers implement experiments when the cost and the risk is limited. Table 1 illustrates the characteristics of innovative farmers in the two types of farming system.

Table 1 The characteristics of innovative farmers

Mixed farming system	Monocrop farming system
Large -scale farmers	Small-scale farmers
Have an independent irrigation source.	Have an independent irrigation source.
Have adequate financial recourses	Have more financial recourses
Have some contact with chemical dealers	Have more contact with chemical dealers
Are concerned about the negative effect of chemicals	Are less concerned about the negative effect of chemicals
Are educated	Are educated
Travel outside the region	Travel more outside the region and the country

The examples demonstrate qat farmers in the regions where the research was conducted have substantial experience in conducting informal research.

The second of the main findings of the study concerns qat farmers' agricultural information system. To explicate the information networks amongst qat farmers was one of the primary aims of the study. A significant finding of the study was that the qat farmers depend on eleven diffusion channels to access and transfer information in the study area.

Figure 1 Qat farmer' agricultural information system - about here

The qat farmers' agricultural information system is portrayed in Figure 1 and the components are arranged in numerical order of importance. Thus, number 1, qat sessions, are the most important source of information and meeting farmers in the chemical store is the least important. The ranking exercise was conducted during interviews with the farmers. As the directions of the arrows indicate, some of the sources are interactive channels of communication; others are essentially opportunities for one-way acquisition of

information. Observations of diffusion channels found the following :

- Qat sessions have a major role in information exchange about the latest technology and discussions of agricultural problems farmers face in qat production. Farmers were more willing to discuss and co-operate during the qat sessions than when they were working in their fields.
- Agricultural labourers, ranked second by farmers after the qat sessions, transfer skills and technologies and are one of the main feedback mechanisms between the regions. Agricultural labourers who move from farm to farm and region to region play a very influential role in the development of qat production in the study areas. The labourers are usually found in groups of five to ten and generally come from the same area^{vi}. The group members exchange the skills and experience they have developed from different farms and areas. In addition, therefore, to their physical labour the agricultural labourers transferred the skills and ideas offering feedback from outside the region. Labourers have an incentive to share in this way: imparting knowledge amongst the group increases the members' opportunities for future employment. According to farmers, it is the agricultural labourers who often solve technical problems, either with the owner of the farm or in some cases without him.
- Kinship relationships both within and outside the village have a role in exchanging information and skills, particularly regarding new innovations.
- Neighbours (farmer to farmer): usually the farmers interact often asking, discussing or observing each other's fields and the agricultural practices as well as the quality of the production. However, in some cases the farmers attempt to keep information about changes in production practices secret for at least two to three years particularly when the technology can be hidden.

- Qat dealers move from place to place to buy and collect qat. In doing so, they transfer information, practices and suggestions from area to area, which contributes to an increase in qat quality and production. They also provide feedback on customer preferences and reactions.
- Chemical dealers also contribute to technology development, particularly in the absence of formal research organisations. The study findings indicate that qat farmers buy new inputs (pesticides and fertilisers) with recommendations about application. In addition, farmers ask for solutions to problems concerning production and may bring a sample of a damaged plant. Some farmers are cynical or distrustful of the chemical dealers so usually bring the name of the pesticides or a leaflet they obtained from other farmers, to ensure they get what they want.
- At the wholesale market, farmers meet growers from other areas and observe how different types and quality of qat can command different prices. Observations in the market identified that farmers evaluate qat production and are motivated to seek information about how they can improve their production.
- Drivers of graders, lorries and tractors have a role in transferring agricultural practices between areas. For example, they transferred the idea of soil rotation, through which farmers tackle the problem of decreasing yields of qat (Box Two above).
- Farmers observe fields in other villages. For example, when first considering qat production farmers went to see the agricultural practices outside their village.
- Farmers spy on the chemical shop as farmers who have knowledge about new technology can be secretive and often give the wrong name to other farmers in order to mislead them. For example, farmers observe that their neighbour's qat has a different quality from their production and the neighbour is reticent to give suitable information so

they attempt to see what he buys from the nearby chemical shop.

- Farmers meet in the chemical shop and exchange information and experience on how to solve the problem of decreasing production. Some farmers claimed that they applied such recommendations directly without trials when the information comes from other farmers. However, when the information derives from the chemical dealer, the farmers usually carry out trials.

Discussion

In order to interpret the field data the study adopted Rhoades and Bebbington's (1991) model, which considers the experimenter's motivation and identifies three types of farmers' experiments. The first is curiosity experiments, which are initiated to test an idea and the result may not have an immediate practical end. The second type is the problem solving experiment, in which farmers seek solutions to old and new problems through experimentation. The third is adaptation experiments, where farmers conduct experiments when they first acquire a new technology or observe a technology demonstrated by an extension agency. In relation to Rhoades and Bebbington's classification, the study identified cases of the second and third types. There were no cases of "curiosity experiments" which did not have an immediate and specific goal.

(1) Conceptual model for adaptation experiments

The research findings suggest that the adaptation experiments can be divided into two types depending on the source of the technology. The first comprises adaptation experiments related to existing technology from outside the farming system. These tend to be experiments on chemical fertilisers and pesticides commonly used for vegetable and fruit crops. In one case, qat farmers carried out experiments to adapt agricultural technologies to solve problems of insects and disease specific to qat. During the technology

adaptation process the farmers observed unanticipated new advantages on the plant, such as accelerated growth and an improved appearance of the harvested leaves. The new advantages were concurrent with a high increase in the market demand for qat. These observations led to further experiments to refine the technology to maximise these desirable characteristics.

The second type comprises experiments conducted to adapt existing local technology. These are generally based on local practices used in rainfed farming systems: the experiments are done to adapt them for an irrigated farming system. Furthermore, there is uptake of the adapted local practices outside the local region.

Figure 2 shows a general model of the process of adaptation experiments, inferred from the case study data elicited from farmers. An example, of the adaptation of the use of Fe fertiliser, is given in Box Three.

Figure 2 Model of adaptation experiments - about here

The experiment process can follow three different directions:

- The first finds a solution to the problem that prompted the experiment: for example, the eradication of disease or insects.
- The second direction is that unexpected opportunities are realised from the technology. This might stimulate further experiments, perhaps using different dosages of the same products, to modify the technology in order to derive more benefit and increase production.
- The third direction is overcoming problems with the technology itself. For example, the farmers observed during adaptation experiments with Fe fertiliser that although the new growth had good colour the leaves were hard (see Box Three). Farmers tried to solve the new problem by adding urea fertiliser to produce soft leaves.

Box Three

Adaptation experiments: Fe fertiliser

Fe is bought as powder in kilo packets or big sacks from chemical fertiliser and pesticide dealers. The technology is new and no recommendations are included. Therefore, farmers have to experiment themselves to find the most effective way of using it. The farmers started trying Fe to solve the problem of pale green colour for some plants that is a result of element deficiency.

- Initially iron was applied to single plants that were pale green in colour. The result was unexpected. The leaves became dark green, whereas the growth point became red and the growth of the plant was accelerated.
- A disadvantage was that the leaves became hard. In an attempt to solve this problem the farmers added urea, which they knew produces soft leaves.
- The farmers' objective of using the fertiliser altered, in light of their observations, to accelerate growth and produce a red growth point, which the consumers prefer. The Fe was spread on the soil over the whole field.
- However, the fertiliser was washed to the end of the field by irrigation water giving uneven results.
- The farmers then made a suspension of the fertiliser which they put in a container at the point where irrigation water enters the field, letting the water spread it evenly over the surface of the field. The method gave even results.
- In some areas where the level of the field is uneven and the water for irrigation unavailable or the plant does not need water, the farmers mix the Fe with urea and apply it as foliar feed with a knapsack sprayer.
- In other areas where the field is uneven the farmers mix the iron with wet urea and spread it on the soil.

The farmers calculate an appropriate dose and concentration depending on their objectives. When the objective is to get golden coloured, small leaves with enhanced growth so the leaves can be harvested, the rate of application is low. A high rate is used to get big leaves and strong branches for overall plant growth. The criteria for evaluating experiments are a good colour of plant and the leaves having golden colour.

Farmer perceptions

The negative perceptions of the technology are as follows:

- In mixed farming system: farmers are concerned about the negative effects on the soil. Adding Fe creates a hard surface, making it difficult for water to percolate to qat roots.
- In monocrop farming system: the farmers are aware of the negative effects, but can afford to remove the top soil and replace it with new soil from outside or simply add 5 - 10 cm. of new soil on top of the existing soil. The farmers were applying this method of soil rotation prior to using Fe fertiliser, as they believed the continued application of urea and pesticides was damaging the soil.
- Share croppers in the Radaa area who come from outside the region are unconcerned about the negative effects, as they will move on after 2 or 3 years. In the Dhamar area, sharecroppers are more likely to be from the village and have been using the land for many years so are more concerned about the negative effects.
- Increasing the plant's requirement for water from two irrigations per picking to three is another reason why the use of Fe is more limited in the mixed farming system.

The positive perception of the technology is that adding Fe increases income to qat farmers in the monocrop farming system, by higher production, enhancing growth and good colour. The decrease in quality is unproblematic as the farmers market in the south and coastal area, which

have different criteria for quality from other parts of the country. In the mixed cropping farming system, the technology produces qat with good colour and accelerated growth while maintaining quality as it is not applied as intensively.

Impact on farming system includes increased demand for labour. Reduced risk to income means the farmer is more confident to invest and hire more labour.

(2) Conceptual models for problem solving experiments

Qat farmers created two types of technologies to solve the problem of frost in the winter. Furthermore, the qat farmers also created natural insecticide from local practices combined with ideas imitated from modern technology to avoid using chemical insecticides.

The first type of new technology was based on original ideas. The model in figure 3 illustrates the process of problem solving experiments to solve frost damage in the winter (see Box 1). Previously qat production stopped during this season. Thus, the farmers were highly motivated due to demand and the increase in the price they could command. Ward et al (1998) reported that qat is sensitive to the combination of low temperature and humidity and the aerial part changes in colour to dark brown and has to be cut. There were numerous attempts to solve the problem of frost to enable production in the winter season but a practical solution was not immediately forthcoming.

Figure 3 Problem-solving model showing creation of new technology by farmers - about here

The large-scale farmers conducted further experiments to develop the covered system to be more practical and suitable for large fields. Moreover, adaptation experiments were conducted to fit the new technology to different conditions and areas. The farmer who developed the second technology for protection from frost (see Box 1) conducted experiments to translate his

observation into a practical technology by establishing an artificial windbreak system. The new technology is more practical and less labour intensive than the covered system. Nevertheless, the field data suggested that the other farmers in the region were cynical and paid little attention to the new technology. The existing knowledge with farmers was that frost requires both moisture (dew) and cold but after the new observations the farmer gained new knowledge. After noticing the effect of the shelter from the wind provided by his guardhouse, the farmer concluded that the two factors that make frost were the fall of dew on the plant at night, and a cold wind. He concluded that if he could remove one of the factors the plant would escape frost damage. Then he decided to reduce the cold wind by creating barriers to see if this would protect the field from frost damage.

The second type of process for creating new technology to solve problems derives from traditional practices and ideas adapted from modern technology. Natural pesticides were created and used only in mixed farming systems. The adoption of the technology was due to the lack of resources and farmers' concerns about the negative effects of chemical pesticides on consumers' health and the soil. Furthermore, the farmers sought to achieve good quality production by avoiding using chemical pesticides, which reduce the quality of qat and are expensive. As Rajasekaran (1999) claimed, a major motivation to experiment is economic factors. The experiment involved boiling the branch of an alkali plant in water. The farmer then extracted the new synthesis (natural pesticide) and adapted it to find the suitable dosage.

Figure 4 Problem-solving model showing the creation of new technology from traditional practices and ideas from modern technology - about here

In figure 4 the process of creating a natural insecticide by farmers from a wild alkali plant is illustrated. The traditional practice was to cut a branch off the plant and wipe the qat plants that were affected with insects two to three times during the infection period. The traditional practices were initially used

by the farmers when they had small qat fields, however with larger fields the farmers have found some of the old practices of preventing harmful insects, such as thrips, are no longer practical. Consequently, the farmers embarked on improving the locally available resources to prevent insects. One method employed was to combine the old traditional practices with new ideas (in this case, liquid pesticides) acquired from the “green revolution” activities of Rural Development Authorities and Projects, which began in the early seventies. The ideas come from transferring technologies, particularly chemical fertilisers and pesticides, which had been developed for various crops other than qat.

(3) (3) Qat farmers’ agricultural information system

Qat farmers seek and exchange information from numerous sources about new technology or local practices and technologies that are applied to other crops to improve their production. These are called informal communication channels and are easily accessible, simple, and effective as the farmers are more confident in the relevance of the information than with formal communication channels. These channels such as qat sessions can be used for other crops by extension and advisory services to increase the efficiency of formal channels. The findings of this study indicate the important role of these informal channels on which farmers depend in the absence of formal organisations. Observations and accounts from the farmers confirmed that information from these channels was applied directly. In contrast, when information is diffused from formal organisations it is usually not applied directly. There are sound economic gains that motivate the farmers to access the information. The effect of the numerous sources of information is that they provide the qat farmers with the means for constant agricultural technology development in different regions. On the other hand there are clear dangers of relying on information and advice from people such as chemical dealers and farmers who are not aware of any medium- and long-term negative effects of a particular technology. The study illuminates the

beneficiaries' networks from qat production and their role in technology development and the transfer of skills and practices from region to region. The fact that farmers have many different channels and sources means that it is not possible for anyone to keep a technology development secret for long. Also, qat farmers are in daily contact with other players in the production and marketing chain: this increases the opportunities for exchanging information more so than with an annual or seasonal crop.

Conclusion

Farmers' observations have played a major role in experimentation and new innovations, which have enabled the development of qat production. The farmers observed unanticipated effects of pesticides and chemical fertilisers and continued to experiment to capture the new advantages. Observations were an important skill that enabled the farmers to develop appropriate technologies. Official development organisations often focus on measuring specific outcomes from experiments and minor alterations outside the remit of the experiment are missed or ignored. Informal research is an important complement to formal research. Researchers in the formal system tend to apply set agendas from the International Agricultural Research Centers (IARCs) without any innovation or adaptation to develop suitable technology. Moreover, researchers often have limited skills and knowledge relating to the different regions of the country, while the farmers have a wealth of skills and knowledge for their particular region. Farmers are also free from any obligation to those who helped them to achieve better results. Furthermore, farmers have quite a lot of knowledge in adaptation and problem solving experiments, which might play a vital role in developing technology for other crops.

From the study findings, it seems that farmers were often unaware of the negative long-term effects from technology such as soil damage and health problems derived from chemicals. Co-operation in the field of agricultural

technology development between farmers and formal organisations, through involvement of farmers in the early stages of technology development and particularly in problem solving and adaptation experiments, would guarantee the introduction of more suitable technology which is less harmful for health and the environment. Trials based on farmers' experience can complement formal experiments. The suitable approach to complement formal with informal research is through participatory methods by involving farmers' ideas and skills in the early stages of agricultural development processes. Finally the case studies revealed that farmers were of the opinion "working with us is better than ignoring us".

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- ⁱ Qat (*Catha edulis*) is a plant indigenous to Yemen, Ethiopia and East Africa which has stimulant and euphoriant effect.
 - ⁱⁱ Qat session is a social gathering where the young tender leaves of qat are chewed. Revri (1983) concurs that chewing qat is a socially accepted custom in Yemen and the qat sessions every afternoon are almost a public event.
 - ⁱⁱⁱ Protection from frost damage (covering system and artificial windbreak system).
 - ^{iv} Natural pesticide, soil rotation, pruning technology and new varieties.
 - ^v Chemical pesticides and fungicide (mixing two pesticides, mixing fungicide with insecticide, "ferment" of fungicide application and multipurpose application of perfekthion) and chemical fertiliser (Fe fertiliser and foliate fertiliser).
 - ^{vi} The laborers carry the name of their area such as Autumah, Aanes, Ibb. These areas are famous for qat production.

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Figure 1 Qat farmers' agricultural information system

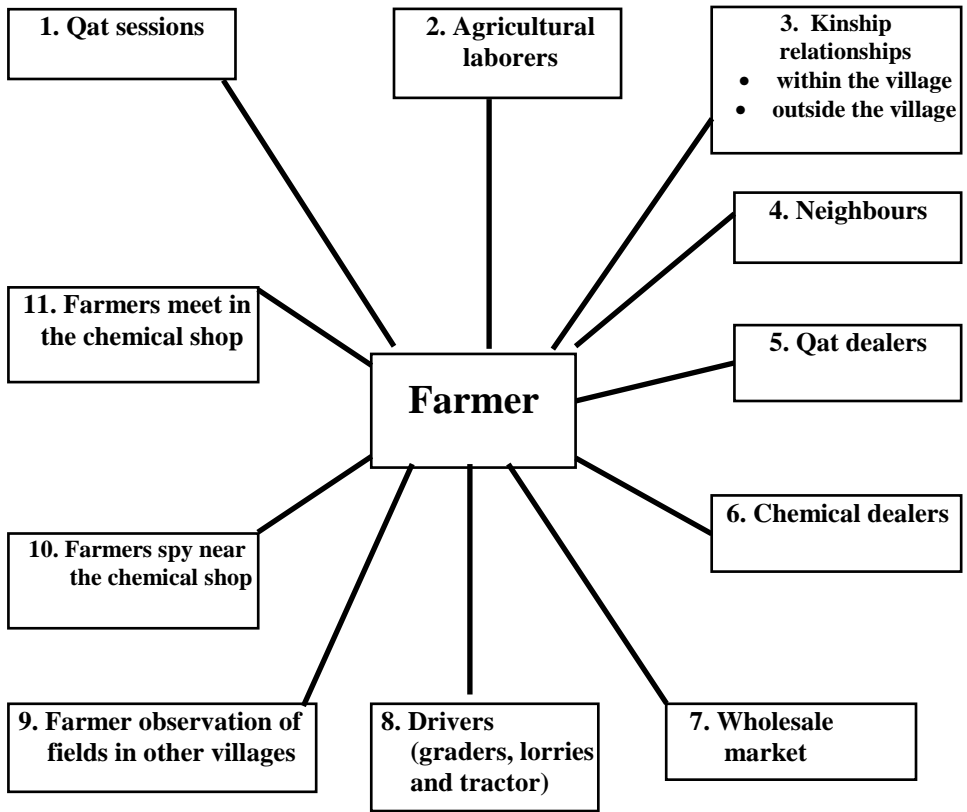


Figure 2 Model of adaptation experiments

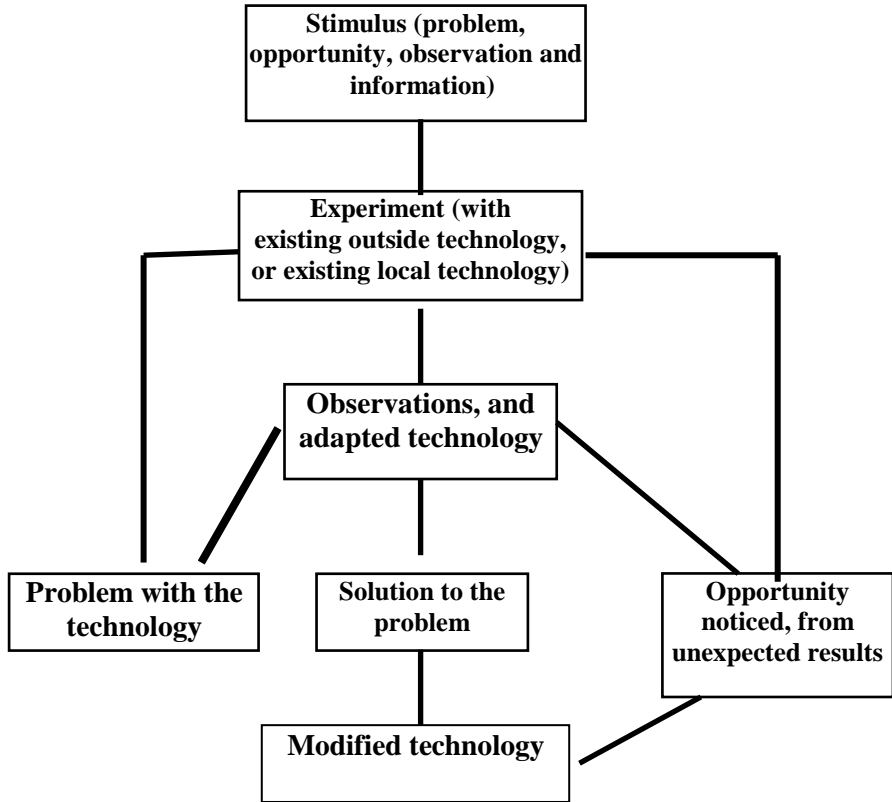


Figure 3 Problem-solving model showing creation of new technology by farmers

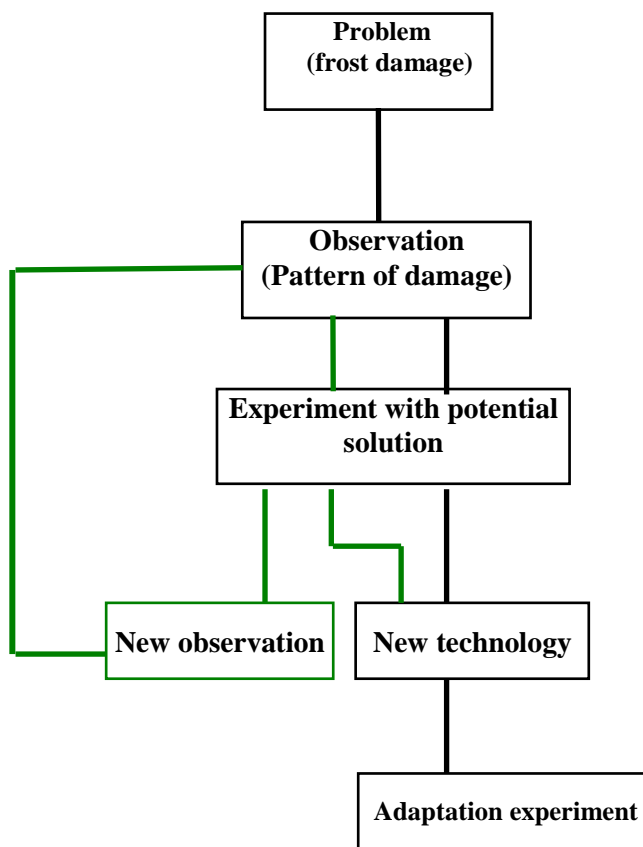


Figure 4 Problem-Solving Model showing the creation of new technology from traditional practices and ideas from modern technology (Natural insecticide)

