Participatory bread wheat breeding in Ethiopia: A socio-economic assessment

Regassa Ensermu Namara and Winfried Manig

Regassa Ensermu Namara, University of Göttingen, Institute for Rural Development, Waldweg 26, D 37073, Göttingen, e-mail renserm@gwdg.de
Prof. Dr. Dr. Winfried Manig, University of Göttingen, Institute for Rural Development, Waldweg 26, D 37073 Göttingen, e-mail wmanig@gwdg.de

Abstract

In Ethiopia, cereal productivity growth rates are not consistent with the rate of human population growth. This may be partly attributed to the lack of proven methodologies to adapt seed-fertiliser technologies to the country's variable agroecologies and socio-economic set-ups. This poster presents the experience of a bread wheat breeding project initiated to circumvent some of the flaws in Ethiopia's conventional wheat breeding. This project revealed important issues. First, farmers use multiple criteria in their variety selection effort, while researchers rely on just few variables and this leads to significant selection bias. Second, there is substantial difference in variety selection methods, farmers variety choice decisions follow approximately the Bayesian analytical approach. Finally, one can conclude that the efficiency of Ethiopian wheat breeding program can be substantially enhanced through making it sensitive to the differential needs of farmers.

Keywords: Participatory, interdisciplinary, innovation, variety, wheat

1. **Introduction**

Increasing the production of foodstuffs in developing countries against the background of rapid population growth, widespread food shortage, malnutrition and the destruction of the natural resource base still remains important for the future. This is of special concern to Ethiopia because the country often faces food shortages mainly due to low cereal crop productivity. Therefore, the country needs to intensify crop production through application of relevant innovations including better crop varieties adapted to varying agroecological conditions and socio-economic set-ups. The capacity to innovate and adapt is thus essential. However, successive adoption studies consistently show that the rates of seed-fertiliser technology adoption are disappointingly poor particularly in less favoured environments (Chilot ET AL, 1996; MULUGETA MEKURIA, 1995; LEMMA KEBEDE, 1988 AND ITANA AYANA, 1985). For these reasons breeding gains to farmers is localised and sub-optimal. Ethiopia's natural and socio-economic environments are characterised by complexity, diversity and risk proneness, necessitating the need for a different technology (variety) development paradigm.

This poster describes and assesses the experience of a bread wheat-breeding project being implemented in Ethiopia since 1996. Specifically, it describes the elements that explain the differential bread wheat variety reception (cognitive adoption decisions) of wheat farmers and how researchers react to these identified reception variables in the actual variety selection processes.

2. Background of the project

The low rate of adoption of seed-fertiliser technologies among small-scale farmers is usually attributed to multitude of factors. However, beginning late 1970s, some scholars have stressed that many improved technologies, although technically sound were not relevant to the objectives and socio-economic circumstances of smallscale farmers, and in some cases were not even appropriate to the agroclimatic conditions.

Farmers' objectives and rationale may be very different from those of the scientist. They have to be aware of risk and may have a multiplicity of objectives, and have to make complex decisions about allocation of scarce resources, taking in to account the interlinkages between different enterprises. These decisions are made in a context of the whole household economy, including consumption and non-farm income and the multiplicity's of objectives (MANIG, 1991).

It was with the above rationale that a bread wheat breeding project has been developed and is being implemented jointly by the Ethiopian Agricultural Research Organisation and Göttingen University with a fund obtained from *Brot für die Welt*. Its objective is to develop bread wheat varieties with **multiple resistance** to four or five major fungal wheat diseases and with **acceptable** characteristics to the end users.

The aims of the project as stipulated in the project document have evolved over time due to insights and influences from different angles. However, the original written objectives were development of basic wheat material with multiple resistance to yellow rust, stem rust, leaf rust, septoria and tanspot and with better yield and quality. Disciplines wise the participants were socioeconomists, phytopathologists and breeders at various levels and capacities. The intended beneficiaries of the project are primarily Ethiopian small-scale bread wheat farmers and the respective participating institutions.

The approaches followed by this breeding project deviates from the conventional crop breeding approaches in at least three important ways. These are: the **participation** of farmers early in the breeding process (beginning from the fourth generation of the breeding cycle), reduction of the **research lag** (almost by half) through use of innovative methods, and the **interdisciplinary** aspect. It has an active socio-economic component side to side to breeding/pathology component to bring farming systems perspective into the breeding process.

The project addresses some of the flaws in conventional plant breeding, which is usually done on well-managed research stations. These have all the best agronomic practices and necessary inputs. But, for small-scale farms in the tropical environment, these may be lacking. Breeders also assume that varieties must be suitable for wide geographic areas (broad adaptation). But, local varieties often show great diversity in different production areas (specific adaptation).

The breeding program is a shuttle program. The laboratory activities, incorporation of disease resistance genes, subsequent evaluation for disease resistance are done in Gottingen. The successive segregating populations are then taken to Ethiopia for further evaluation for disease tolerance and adaptability.

3. **Methodology**

Both qualitative and quantitative research tools were used to generate the necessary data to both meet the routine project needs and for further evaluations. Qualitative research methods were used to unveil the informal structures of the breeding programs and researchers covert behaviour in relation to how they react to the perceived needs of the farmers. While quantitative research methods were used to study the factors that influence farmers' wheat variety reception and adoption.

3.1 Socio-economic baseline survey

Socio-economic survey has been undertaken in April 1997.
The sampling design used in the study is stage sampling design which includes an aspect of stratified random sampling and cluster sampling. Based mainly on variations on agroecological variables the project area is grouped into four: Holleta -representing the central highlands, Kulumsa-representing the mid-altitude potential wheat growing areas, Arsi-Robe-representing mid-altitude high rainfall vertisol areas and Asasa -representing mid-altitude moisture-stressed areas. Target Grouping helps to strike a balance between two extreme alternatives: (a) The impossible task of developing recommendations for each farmer and (b) the inappropriate one of developing one recommendation for the whole farming community despite differences in farming systems, goals and circumstances.

The list of Peasant Associations (PAs) maintained by Woreda Ministry of Agriculture and that of farmers maintained by Woreda Ministry of Finance Offices were used as sampling frame. First, in each of the project areas the PAs were stratified into two based on the prevailing soil condition (as mainly indicated by soil colour). From these lists of PAs, 4 PAs (2 each from black and reddish brown soils) were selected using probability proportional to size sampling design. Second, from each stratum about 12 farmers were selected for interview using simple random sampling design. The total sample size was about 125. Questionnaires were elaborated and administered to a random sample of farmers by the investigator and trained enumerators. Relevant statistical tools were employed to analyse the resulting data.

3. 2 *Participatory Action Research during breeding and test phase*

During the breeding and test phase of the project, a section of the sample farmers in the socio-economic survey has been purposively selected mainly based on **accessibility** during the wet season for planting participatory field trials. The on-farm research methodology used here is dynamic in a sense that no fixed experimental design has been followed (Table 1).

Table 1. Type and number of on-farm trials during the three seasons

Stages of trials	1997/98		1998/99		1999/2000	
	sites	No. Of wheat lines	sites	No of wheat lines	sites	No of wheat lines
POVTS I[1]	5	51	5	93(84)*	6	102
POVTS II[2]	-	-	25	16(7)	6	15(12)
POVTS III[3]	-	-	-	-	30	12(7)
Verification	-	-	-	-	-	-

*Numbers in parenthesis show number of new wheat lines

On-farm research practitioners usually raise numerous methodological issues. Most of the issues deal with level of farmer participation in the conduct of the trials, design and statistical validity considerations, at what level to set the non-experimental variables and evaluation criteria (MUTSAERS ET AL., 1997; NORMAN ET AL., 1995; WERNER, 1993; MAURYA ET AL., 1988). Here, the participatory variety trials were designed in such a way that co-operating farmers understand the design of a trial so that they can implement them independently and provide comments from their independent observations. For this reason, the trials were non-replicated and some of the non-experimental variables were set at the will and capability of co-operating farmers.

The trials vary in their degree of complexity and level of farmer participation. Through out the growing seasons farmers were allowed to evaluate the bread wheat genotypes included in the trials both individually and in-groups. The evaluations were done at different wheat development stages. The farmer's spontaneous responses were

[1] Participatory on-farm bread wheat variety trial set I
[2] Participatory on-farm bread wheat variety trial set II
[3] Participatory on-farm bread wheat variety trial set III

recorded using a Dictaphone and field data record sheets designed specifically for this purpose. The frequency of farmers spontaneous responses were used to now the relative importance of the evaluation criteria.

4. Elements of wheat variety reception and adoption

4.1 Wheat production constraints

Farmers' varietal choices are influenced very much by the prevailing production constraints, which in turn is the manifestation of the prevailing biophysical and socio-economic circumstances. Tolerance / resistance to these constraints is valued highly as they are usually risk averse.

An attempt has been made to know the relative severity of the various constraints elicited for each of the areas (Table 2). At the higher level of abstraction (i.e., at Woreda level), the constraints can be prioritised based on the farmers' relative frequency of response. Overall, *diseases*, *low soil fertility*, *low moisture stress*, *frost* and waterlogging are the major constraints to wheat production. However, the relative importance of these constraints varies from location to location and from farmer to farmer.

The farmers' subjective evaluation of the relative importance of a production constraint is based on the constraint's frequency of occurrence, the level of yield loss it inflicts and the degree of control the farmer can exercise on the constraint. When asked different farmers put different weights on these aspects of the constraints. The ability of the farmer to exercise control over the constraints is influenced by human capital variables, such as level of literacy and experience (age), socio-economic status and the availability of infrastructures and services.

4.2 Utilisation of wheat

The form of utilisation of wheat in the household has also an important bearing on the pattern of choice of varieties**.** In the study area wheat is utilised in various ways (Table 3). Certain forms of consumption are specific to certain culture. For instance, Muslim Oromos of Arsi-robe area specifically consume **Qamasha**.

Table 2. Wheat production constraints

Constraint	Arsi-Robe	Hetosa	Asasa	Wolmera	Bekoji/Meraro	Average
Disease	79.3	33.3	32.1	86.7	100	60.9
Root wilt				10.0		2.6
Insects	48.3	25.0	35.7	26.7	25.0	33.9
Weeds	24.1	25.0	17.9	16.7	25.0	20.9
Lodging	13.8	4.2	-	16.7	50.0	10.4
Frost[4]or Qoorraa	65.5	50.0	21.5	70.0	75.0	53.1
Soil fertility	31.0	45.8	64.3	63.3	-	49.6
Waterlogging	86.2	12.5	14.3	16.7	50.0	33.9
Low moisture stress[5]	62.1	33.3	42.9	33.3	50.0	43.4
High moisture stress[6]	10.3	-	-	26.7	-	9.6
Input market constraints [7]	10.3	10.3	35.7	13.3	-	17.3
Others[8]	6.9	16.7	14.3	6.7	-	10.4
N	29	24	28	30	4	115

Table 3. Indigenous wheat consumption pattern (% of the farmers reporting)

Dishes	**Kulumsa**	**Holetta**	**Arsi-Robe**	**Asasa**	**Bekoji/ Meraro**	**overall**
Injera	91.7	85.2	96.4	55.6	100.0	82.7***
Bread (Dabo)	95.8	100.0	100.0	96.3	100.0	98.2
Porridge	54.2	14.8	96.4	76.9	75.0	61.5***
Kitta (dry bread)	0.0	0.0	14.3	23.1	75.0	11.9***
Kolo(roasted grain)	83.3	96.3	96.4	42.3	75.0	79.8***
Nifro(boiled grain)	83.3	59.3	96.4	34.6	75.0	68.8***
Local drinks*	8.3	59.2	40.0	3.8	0.0	28.2***
Kinche	16.7	29.6	78.6	15.4	75.0	37.6***
Qamasha	0.0	0.0	35.7	0.0	25.0	10.1***
Chachabsa	0.0	0.0	17.9	3.8	0.0	7.3

*** Indicates that χ^2value is significant at P≤0.001.

[4] Frost or Qoorraa implies lack of adequate moisture especially at the critical crop development stage which is usually exacerbated by extremely low temprature and windy weather conditions resulting in deccication and hence shrivelled seeds

[5] This refers to three situations: in certain cases moisture may be scarce in the middle of the season (dry spell) at some locations late on set of rain fall is a critical problem and still in the other locations early finish of rainfall may be of higher priority. The late on set of rain fall in addition to its effect on planting date affects wheat yield indirectly through its effect on land preparation and weed control. Therefore, there is urgent need to determine the nature of low moisture stress problem in an area.

[6] High moisture stress as differentiated from waterlogging, which is the result not only of high precipitation but also of the nature of the soil, refers usually to the excessive rainfall at the end of the season when the crop is at full maturity complicating the harvesting process or at heading and flowering stage which according to farmers causes sterility through disturbing pollination and leads to yield loss.

[7] Input supply constraint is the aggregate name for unavailability of combine harvester, lack of improved seeds, late arrival of fertiliser, high fertiliser price and untimely supply of fertiliser

[8] Other wheat production constraints include hail damage, wildlife damage, lack of skill or know how, lack of oxen resulting in improper land preparation and late planting and land shortage.

It can also be marketed to generate cash. Different varieties of wheat fetch different prices in the market.

Besides its grain, wheat straw/stubble has also importance among the farming community. The most important uses of wheat straw/stubble are livestock feed, thatching material, fuel, source of cash, storage construction and as plastering material for coating wall. Differences have been observed among the locations pertaining to priority uses of straw/stubble. For instance in Holetta area, no farmer reported to have used wheat straw as a plastering material for coating walls because of the availability of better alternative, namely tef (*Eragrostis tef*) straw. Wheat straw has market value in some locations.

The implication of the various straw uses on the desired wheat varietal stature demanded by farmers is worth noting. For animal feed farmer need leafy, sheathy and flexible/soft straw varieties like pavon 76 and dashen. For roof thatching, the farmers demand tall, thin and very stiff straw varieties such as Israel, K 6290 Bulk, Bonde and Enkoy. Hence, the ideal plant stature for wheat depends on various elements such as the intended use of straw in the farming system. The intended use of straw in turn depends on various biophysical and socio-economic variables. For instance, the high level of wealth of the farmer may preclude the use of straw for roof thatching, for such a farmer may have the ability to construct corrugated roofed houses.

4.3 Cognitive acceptance or symbolic adoption of the new wheat lines

The **efficiency** and **efficacy** of a crop breeding programme is conditioned by a range of factors one of which is the degree to which its outputs (varieties) conform to the preferences of the intended beneficiaries. Releasing varieties that farmers (consumers) need accelerates the paces of subsequent adoption and diffusion process. Farmers were asked to elicit the **criteria**, which they would use in selecting potential wheat varieties fit to their condition (Table 4). The most important criteria are disease tolerance, yield potential, waterlogging tolerance, frost tolerance, marketability and food quality.

Table 4. Elements of varietal reception and their relative importance- results from base line survey (% of farmers reporting)

Criteria	ArsiRobe	Kulumsa	Asasa	Holetta	Bekoji/Meraro	Overall
Yield (yield potential)[9]	59.3	60.8	48.2	18.5	75.0	47.2
Disease tolerance	55.6	17.4	29.6	77.8	100.0	48.1
Performance on less fertile soils	7.4	8.6	14.8	59.2	0.0	22.4
Waterlogging tolerance	74.1	8.7	18.5	29.6	100.0	35.5
Weed tolerance	11.1	8.7	3.7	7.4	33.3	8.4
Shattering resistance	7.4	4.3	0.0	0.0	33.3	3.7
Shrivelling	7.4	8.7	0.0	3.7	0.0	4.7
Tolerance to low moisture stress	40.7	21.7	14.8	11.1	33.3	22.4
Insects	14.8	0.0	7.4	7.4	0.0	7.5
Lodging resistance	3.7	0.0	0.0	0.0	0.0	0.9
Frost tolerance	55.6	30.4	7.4	33.3	100.0	34.3
Marketability[10]	40.7	52.1	66.7	22.2	33.3	46.2
Ease of harvesting	3.7	0.0	0.0	0.0	0.0	0.9
Ease of threshing	7.4	0.0	0.0	0.0	0.0	1.9
Germination vigour	3.7	0.0	0.0	0.0	0.0	0.9
Cleanness at threshing	3.7	0.0	3.7	0.0	0.0	1.9
Malt quality	0.0	0.0	0.0	3.7	0.0	0.9
Food quality	48.1	30.4	33.3	3.7	66.7	29.9
Straw yield	3.7	4.3	0.0	3.7	0.0	2.8
Straw stiffness	7.4	0.0	0.0	3.7	33.3	3.7
Height of straw	7.4	8.7	0.0	3.7	33.3	7.5
Straw palatability	3.7	0.0	0.0	3.7	0.0	1.8
Maturity length	0.0	8.7	7.4	0.0	0.0	3.7
Straw quality for thatching	3.7	0.0	0.0	0.0	0.0	0.9
Tolerance to desiccating wind	0.0	4.3	3.7	0.0	0.0	1.9
Other[11]	7.4	0.0	7.4	7.4	0.0	5.6

[9] Indicators of yield potential mentioned by farmers‘ include number of tillers, spike size and number of kernels per spike

[10] Market acceptability was judged usually by the perceived level of price a variety fetches in the local and regional markets and this also is indirectly affected by factors such seed colour, seed size and plumpness.

[11] Other factors found to have an influence on farmers symbolic adoption of the new wheat varieties include aesthetic value, tolerance to high moisture stress, tolerance to wildlife and hail damage. In areas where state/community owned forest development programmes are operating, wildlife damage is a common threat to wheat production. The farmers also claim that the wildlife prefer certain wheat varieties to the other. For instance, awnless varieties such as Israel and Bonde were reported to be the most susceptible. The extent of yield loss caused by haildamage is generally dependent on wheat crop development stage at which the hail occurs than the nature of the varieties themselves.

The farmers' wheat varietal evaluation criteria elicited during participatory on-farm trials are also presented in Table 5. The evaluation criteria can be summarised under four related headings. These are **Yield potential**, **system compatibility, stresses tolerance and market acceptability**. When we compare these four sets of farmers varietal evaluation criteria, yield potential stands to be the most useful, followed by stresses tolerance and system compatibility variables respectively.

Table5. Elements of varietal reception- results from on-farm trials

No	Criteria	Frequency of spontaneous responses	% of total responses
	Yield potential	**131**	**41.6**
1	Head size	64	20,3
2	Tillering capacity	29	9,2
3	Grain filling	10	3,2
4	Good stand (population)	21	6,7
5	yield	6	1,9
6	Compactness of head	1	0,3
	System Compatibility	**52**	**16.5**
7	Eearliness	34	10,8
8	adaptable	17	5.4
9	Does not select land	1	0,3
	Stress tolerance	**69**	**21.9**
10	Sprouting tolerance	5	1,6
11	Rust tolerance	43	13,7
12	Frost tolerance	7	2,2
13	Germination Vigour	1	0,3
14	Weed tolerance	13	4,1
	Others	**63**	**19.9**
15	Plant height	26	8,2
16	uniformity	12	3,8
17	Ease of harvesting	5	1,6
18	Straw strength	5	1,6
19	Seed quality	8	2.5
20	Vegetative thriving	4	1,3
21	Deep green (leaf size)	3	0,9
	Total	315	100

5. Feedback of the information into the actual variety selection process

The information presented in the preceding sections were documented and submitted to the breeders and pathologists so that the various elements of the new genotype can be taken into consideration in accordance with the cultivators' receptive conditions.

5.1 The congruence of breeders and farmers selection methods and criteria

The researchers disentangle few variables from among many and concentrate on those few variables. The other factors are either effectively controlled or deferred for consideration in the future or may even be considered as the task of other groups. On the other hand, farmers try to manage them iteratively and make use of opportunities. The main criteria utilised by researchers in their variety selection exercise are yield and disease resistance. However, farmers consider multiple criteria in their selection process. These criteria are usually multidimensional.

In the participatory on-farm trials, for instance, farmers were allowed to evaluate the new wheat lines on 1-5 rating scale, where 5 denotes the best scenario and 1 denotes the worst case. The scale may be considered as an index number measuring the utility of the different wheat lines given the various selection criteria such as yield potential, stress tolerance, system compatibility and market acceptability, etc. These evaluation scores were subjected to ANOAV (Table 6). There was significant difference in mean evaluation scores among varieties. Wheat lines, FH8-2 and FH4-2-11 had the least mean evaluation score.

Table 6. Farmers' evaluations of lines included in the on-farm participatory trials

Variety	Asasa	Holetta	Bekoji	Arsi-robe	Me-raro	Mean Evalua-tion score***	Mean grain yield (kg/ha)	Level of disease resis-tance
Fh6-1-7w	3,5	3,0	3,1	3,7	3,8	3,4	2451	MR[12]
Fh6-1-7 r	3,6	3,4	3,2	3,5	4,0	3,5	2499	MR
Fh4-2-11	2,1	2,8	1,9	2,4	3,0	2,4	2076	R
Fh9-3-4	3,3	3,3	3,7	3,7	3,5	3,5	2747	MS
Fh8-1(T)	4,2	4,5	4,0	4,7	3,7	4,2	2304	MR
Fh8-2 (S)	1,9	2,9	2,0	1,7	2,8	2,2	1870	MR
Fh7-1-5	2,8	3,5	2,9	2,9	4,3	3,2	2247	R
Fh13-7-5		4,0	3,6		4,3	3,9	1761	R

**** Indicates that mean evaluation score for Varieties is significantly different (P<0.001)
Location by variety interaction effect is non-significant

[12] MR means moderately resistant, R is resistant and MS is moderately susceptible. These categorisations were based on pathologist/breeder field observation and subjective evaluation

If we base our judgement on breeders/phytopathologists commonly used selection criteria, i.e., yield and disease resistance, we would be tempted to discard wheat line FH13-7-5 from further consideration. However, in terms of farmers mean evaluation score, this variety is only second to FH8-1 (T). Actually, the breeders have already dropped this variety from the trial scheme mainly for its perceived shattering problem. Moreover, wheat line Fh4-2-11 has been assessed to be one of the best according to researchers for its good spike, disease resistance and vegetative thriving in on station trials. But, its mean evaluation score is one of the least. This is evidence to the inherently observed bias in the selection and breeding process.

5.2. How receptive were technical researchers to the perceived varietal needs of farmers?

Farming system research methodologies assume that the concerned technical researchers are sympathetic to the farmers and that they strive to consider their pressing problems. However, the limited evidence from this study suggests that researchers have also their own expectations from projects in which they are involved. Some of such expectations include career development, academic achievement, pride, material benefits, etc. At a more general level one can therefore, hypothesis that the degree of researchers openness to the farmers pressing problems (varietal requirement in the present case) is variable (i.e., it varies from one individual researcher to the other).

Innovation diffusion theory can help us in formalising the above relationship or hypothesis. In this study it has been observed that the degree of reaction of researchers to the farmers observed wheat production constraints depends on the researchers training background, age (experience), socio-economic background and the prevailing incentive structures.

6. Conclusion and implications

The wheat production environment is highly diverse in the study areas. This diversity is the result not only of the biophysical factors such as altitude, precipitation, soils, topography, etc., but also of socio-economic factors. This situation in turn leads to the diversity in the farmers varietal requirements even within a given small geographic area. Farmers consider various interrelated elements in their varietal choice decisions. Hence, breeders/pathologists may drop varieties that are required by farmers in their selection exercise and/or they may maintain genotypes that are not wanted by farmers, if they fail to consider these inter-related elements. The multiple resistance project has tried to circumvent these problems of wheat research program in Ethiopia by testing wheat genotypes under the actual production conditions, allowing the participation of end users specifically small-scale farmers in the breeding process and reducing varietal development time through innovative use of off-season and green house breeding works.

This study revealed a set of important issues. First, the project objectives as originally conceived by breeders or pathologists were too restrictive. The objectives were later made more comprehensive with the participation of farmers and socio-economists in the project. Second, participatory crop breeding should be conceptualised as a two-way flow of information between farmers and breeders/pathologists to enable optimal decision in variety selection process. Third, the responsiveness of breeders to the information emanating from farmers depends on many factors related to the researchers socio-economic attributes as well as farmers' biophysical and socio-economic circumstances. Finally there is substantial divergence between the two groups in variety selection process. Farmers' selection criteria or indices are multidimensional and varietal choice decisions are made sequentially. At earlier growing seasons, they make tentative choices mainly based on indicators related to yield potential. The farmers often make no mention of yield in their varietal choice exercise at this stage. They make use of indirect indicators of yield potential like number of tillers, circumference and colour of leaves, etc. As more and more information is gathered about the varieties the original choice decisions may be revised or maintained.

Therefore, the efficiency of Ethiopian wheat breeding program can be substantially enhanced through adopting participatory action research methodologies. At earlier breeding stages one can benefit from an assessment and compilation of checklist of criteria that farmers or stakeholders consider relevant in recepting the new varietal candidates. At more advanced stages like beyond F5 stage the appropriate varieties may be developed with participation of farmers and other stakeholders in the actual production and consumption environments.

7. References

Chilot Yirga, B.I. Shapiro and Mulat Demeke. 1996. Factors influencing adoption of new wheat technologies in Wolmera and Addis Alem areas of Ethiopia. Ethiopian Journal of Agricultural Economics 1(1): 63-84.

Itana Ayana. 1985. An analysis of factors affecting the adoption and diffusion of packages of agricultural technologies in subsistence agriculture: A case study in two extension districts of Ethiopia. Addis Ababa University (Ethiopia). School of graduate studies. 160pp.

Lemma Kebede. 1988. An evaluation of factors that influence the use of recommended farm practices in Nazareth area, Ethiopia. Guelph Univ. (Canada). Faculty of graduate studies.

Manig, W. 1991.Rural Social and Economic structures and Social Development. In: Manig, W. (Ed.): Stability and change in Rural Institutions in North Pakistan, socio-economic studies on Rural Development, Aachen: Alano.

Mulugeta Mekuria. 1995. Technology development and transfer in Ethiopian agriculture: empirical evidence. In: Mulat Demeke, Wolday Amha, Simon Ehui and Tesfaye Zegeye (Eds). Proceedings of the inaugural and first annual conference of the AESE 8-9 June 1995, Addis Ababa, Ethiopia.

Mutsaers, H.J.W., G.K.; G.K. Weber; P. Walker and N.M.Fisher. 1997. A field guide for On-farm experimentation: IITA/CTA/ISNAR.

Norman, D.W.; Worman, F.D.; Siebert, J.D. and Modiakgotla, E., 1995. The farming systems approach to development and appropriate technology generation. FAO, Rome.

Werner, J.1993. Participatory development of agricultural innovations: procedures and methods of on-farm research.