A REVIEW OF CROP PROTECTION RESEARCH IN ETHIOPIA

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RESEARCH ON INSECT PESTS OF ROOT AND TUBER CROPS IN ETHIOPIA

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1. INTRODUCTION

Roots and tubers are among widely cultivated crops of Ethiopia supporting a considerable portion of the country's population as sources of food. Prominent among these are: Potato *(Solanum tuberosum)*, weet potato *(Ipomoea batatas)*, enset *(Ensete ventricosum)*, godere *(Colacasia esculenta)*, yams (*Dioscorea spp.*) and the Oromo dinich *(Coleus parvilores)*. Insect pests are one of the major limiting factors in the production of these crops in Ethiopia. Experimental work carried out so far on the control of root and tuber crop pests in this country concentrated on the pests of potato (1,2,3, 4,5) and sweet-potato (9). The general pest complex survey on these and many other crops can be found in Crowe et al. (6). Research results on root and tuber crop entomology are reviewed in this paper.

2. PESTS OF POTATO

Well over a dozen insect pests have been recorded on potato in Ethiopia. The potato tuber moth (PTM), *Phthorimaea aperculella* (Zeller), is by far the most important species among these. Consequently, studies on varietal resistance, host range, identification of parasitoids, monitoring adult population with sex phenomones, and chemical control against this pest have been carried out. Each of these aspects is briefly discussed in the following paragraphs.

2.1. Varietal Resistance

Different varieties/clones of potato were grown in the field to see their resistance and tolerance to PTM for three consecutive years starting in the 1980/81 crop season. Of the several varieties of potato tested for relative levels of leaf and tuber infestation by larvae of PTM, none showed evidence of resistance, but a few of them appeared to be tolerant. Varieties such as AL-253, AL-517 and AL-200 were found to be tolerant while AL-560, AL-257, AL-562 and AL-580 were the most susceptible varieties recorded in the study(3).

2.2. Host Range Studies

Studies to determine host preference of PTM were conducted in the field at Melkassa in 1981 and in the laboratory at Awassa in 1982. Results of this study are shown in Table 1. It was concluded that potato and tobacco are the most preferred cultivated plants while *Datura* was the most preferred wild host (4).

2.3. Parasitoid Surveys--PTM

In an attempt to establish integrated pest management of PTM a survey of parasitoid species associated with PTM was conducted during the 1981 and 1982 crop seasons. It was indicated that early instar larvae of PTM were attacked by two parasitoid species. These were *Diadegma molliplum* (Hlmgr.) *(Hymenoptera: Braconidae)* and *Chelonus sp. (Hymenoptera: Ichneumonidae)*. The former parasitized nearly 27% while parasitization by the latter was about 20%.

2.4. Monitoring Adult Populations

In order to make best use of the integrated approach, it has become necessary to forecast periods of PTM build-up. Thus, experiments were conducted at the Awasa Research Station (ARS)

Table 1. Host preference of *Phthorimaea aperculella* in the field and laboratory conditions (After Adhanom, 4)*.

	(Nazret)		(Awasa)	
	Mean Number of		Mean Number of	
Host plants	Mines	Living larvae	Mines	Living larvae
Beta vulgaris	5.7 a	1.5 a	8.8 a	2.5 a
Solanum incunum	7.2 a	1.7 a	10.5 a	3.5 ab
Capsicum sp.	13.7 b	5.0 a	16.8 ab	4.0 ab
Lycopersicum esculentum	21.0 c	10.0 bc	23.5 bc	5.8 ab
Solanum melongena	24.5 c	9.0 b	27.3 cd	9.8 bc
Nicotiana tabacum	34.7 d	13.0 cd	34.5 d	12.5 c
Datura stramonium	47.7 e	15.5 d	36.5 de	14.3 c
Solanum tuberosum	71.7 f	35.2 e	45.8 e	18.3 c
Mean	28.3	11.4	25.4	8.8
S.E.	2.0	1.2	3.3	2.3

* Means followed by the same letter, within a column, are not statistically different from each other at the 5% level (Duncan's New Multiple Range Test = DNMRT)

and at the Arsi-Negelle sub-station (ANS) using traps baited with synthetic sex pheromones.

It was observed that monthly catches at ARS were highest in January, followed by August and October, in that order. On the other hand, no PTM was caught in April. In general, moth catches were low March through June. Moth catches at ANS were highest in July and relatively low catches were recorded between December and February. In summary, PTM was present here all year round (2).

2.5. Biology of PTM under Ethiopian Conditions

Preliminary studies carried out on the biology of *P. operculella* at Awassa indicated that incubation period for eggs was 7.2 days, mean larval development period was 16.7 days, while pupae took 8 days to develop. A total of 6.5 generations were recorded in 198 days (8).

2.6 Chemical Control Studies

Chemical screening trials against PTM both in the field and store were carried out and each is briefly discussed here.

Results obtained from field experiments showed that deltamethrin, cypermethrin, and methamidophos were the most effective insecticides in controlling PTM (8). Among the insecticide treatments applied on stored potatoes (Table 2), profenofos showed significantly superior overall control (5).

Table 2. Effect of insecticide treatments on the infestation by PTM of stored potatoes (modified from Adhanom and Tessema, 5)

Treatment	Rate (ppm) (a.i.)	Number of infested tubers with: 1-2 holes	3-5 holes	Over 6 holes	Total infested tubers / 1500	Mean % Infestation
Check (plain water)	-	285	596	295	1176	78.44
Fenitrothion (dust)	10	363	358	59	780	52.0c
Diazinon (EC)	300	259	258	340	567	20.8bc
Deltamethrin (EC)	25	191	112	9	312	37.8b
Profenos (EC)	3750	30	5	0	35	2.3a
Methamidophos (EC)	500	215	614	476	1365	91.0d
Mean						47.0
S.E.M.						4.94

*Means followed by the same letter are not significantly different from each other at the 5% level (DNMRT).

3. PESTS OF SWEET-POTATO

Survey work carried out in this country so far (6,8) indicated that well over 12 species of insects have been recorded on sweet-potato in Ethiopia. Of these the sweet-potato leafminer (SPL), *Bedellia somnulentella* (Zeller), appeared to be of significance as it sometimes occurred in large numbers especially in southwestern Ethiopia.

Loss assessment studies carried out against SPL at Bako showed that this pest had sporadic importance; in outbreak seasons the insect could cause upto 23% yield loss (9). Among the insecticides tested methamidophos and profenofos appeared to be more effective in the control of SPL (9).

4. PESTS OF ENSET

Entomological work on enset in Ethiopia has been minimal. However, three species of insects were frequently found on wilting and/or healthy enset plants. These were: *Pentalonia migrinervosa* Coquerel, *Poecilocarda nigrinervis* Stal and *Planococcus spp.* These insects have been implicated in the transmission of the causative agent of the bacterial wilt of enset (7).

5. PESTS OF OTHER ROOT CROPS

No entomological work has been done regarding pests of root crops other than those mentioned earlier.

6. FUTURE RESEARCH PLAN

Emphasis must be given to research on screening resistant varieties against the major insect pests. Detailed studies on the biology of important pest species such as PTM is needed in order to achieve integrated control of these pests. Surveys to delineate the pest complex of enset and detailed experiments to determine the role of suspected vector species in the transmission of enset wilt are urgently needed.

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DISCUSSION

Dr. Stroud:

What cultural practices do you recommend for controlling or lessening the infestation of potato tuber moth? Variety selection and insecticide use may be beyond the use, presently, of most small farmers;thus useful alternatives are needed.

Ato Adhanom:

Proper ridging at maturity, deep planting of tubers at planting and avoiding wild alternate host plants from potato fields must be practised.

Ato Fulassa:

1. Pheromone traps show high population of potato tuber moth in some months and low in an other months, what is the reason behind?

2. Where does PTM stay during off-season?

Ato Adhanom/Ato Tsedeke:

1. Population fluctuation is correlated with several factors.
2. It may stay on the wild alternate host plants such as *Datura stramonium* and others.

Ato Kumsa:

Safe use of insecticides has been mentioned at the end of the paper. However, wide spectrum insecticides like the pyrethroids have been recommended for the control of PTM. Use of such insecticides may cause resurgence of new pests. Therefore, care should be taken not to disturb agroecosystem. Safer and selective insecticides should be screened and recommended for the farmers.

Ato Adhanom:

We did not advocate use of only pyrethroids.

Ato Tesfahun:

1. How is yield performance of PTM tolerant potato cultivars?
2. How is the reaction of commercially produced potato cultivars to PTM?

Ato Adhanom:

1. I was not concerned with the yield performance but rather their reaction to PTM since the cultivars have different yielding capacity.
2. Commercially produced potato cultivars such as Anita were found to be susceptible to the attack of the insect.

Ato Yaynu:

Since many farmers realize that potato quickly degenerates after harvest, they extend harvesting of tubers from their fields to prolong the time of storage without sprouting. What do you think the role of the insect (PTM) in such cultural practices? What modifications or improvements can be made to this practice?

Ato Adhanom:

1. By leaving the tubers in the field as a means of longer storage mechanism, we are exposing or encouraging further infestation of tubers by PTM.
2. As to the modification, I can only say that as far as the crop is matured for harvest, try to take out the tubers and store them in clean storage which must be far from the field of harvest, not to give chance to the insect to reinfest the harvested tubers.

Ato Fekadhu:

PTM is becoming a serious problem in tobacco nurseries attacking young seedlings. Since tobacco was also mentioned to be one of the host plant for PTM in the report, it will be appreciated by the state farms if future trials could also include some work on the protection methods of PTM in tobacco seedlings.

Ato Adhanom/Ato Tsedeke:

We will consider it providing we have enough manpower. Moreover, recommendations to control this insect in other crops (potato) may also be applicable to tobacco.

RESEARCH ON ROOT AND TUBER CROP DISEASES IN ETHIOPIA

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1. INTRODUCTION

Root and tuber crops (potato, sweet potato, enset, etc.) are widely grown and deep-rooted in the culture and traditions of the various ethnic groups. They are mainly grown by small farmers and are consumed locally. From 1948 to 1956 the average potato and sweet potato production were 103 and 188 metric tons per annum, respectively (10). The production of these crops (potato and sweet potato) increased to 168.8 and 261.5 metric tons per annum, respectively, from 1960 to 1980. The production of enset was also 409 metric tones per annum (10).

The differences in altitude, latitude, temperature and precipitation of the different root and tuber crops producing regions predispose them to various diseases. Among these late,blight of potato, virus and stem blight of sweet potato and bacterial wilt of enset have been considered the most important ones. Therefore, institutions such as IAR, Addis Ababa University (AAU) and Scientific Phytopathological Laboratory (SPL) have directed most of their research activities towards the control of these diseases.

2. RESEARCH ACTIVITIES

2.1. Disease Surveys

General disease surveys have been made on the different root and tuber crops growing regions. Diseases samples of these crops were collected and identified at IAR pathology laboratories, SPL and AAU. Some of the identified diseases were confirmed by Commonwealth Mycological Institute (CMI). The type of diseases recorded and their status are summerized in Table 1.

2.2. Potato Diseases

Potatoes are generally grown in the highlands where propagation and growth are favoured by cool temperatures. The potato industry in Ethiopia is in the process of expansion and improvement. However, it is subjected to a large number of diseases, amongest which late blight *(Phytophthora infestans)* early blight *(Alternaria solani)* and viruses are the most important ones. Studies have been made on evaluation of varieties, dynamics and race composition and on cultural and chemical control of these diseases. Details of these important areas of potato diseases can be found in the SPL report.

2.3. Sweet Potato Diseases

Seven diseases are identified from this crop (Table 1). Among these stemblight has been observed occuring widely and reported from Melkassa, Awassa, Jima, Melka Werer and at farmers' fields in Hararghe. Studies dealing with identification, survival and host-range of the pathogen as well as screening for resistant lines and chemical control measures have been undertaken since 1978, and the results are reported below.

Table 1. Diseases of Root and Tuber crops recorded in Ethiopia

Crop	Cause	Common name	Disease Status
Potato	*Alternaria solani* (Ell. & G. Martin)	early blight	major
	Ascorbyta hostorum (Speg.) C. O. 5 m.	leaf spot	minor
	Colletotrichum coccodes (Wallr.) Haghes	black dot	"
	Erwenia carotouna	bacterial wilt	intermediate
	Fusarium coerulenm (Lib.) Sacc.	dry rot	minor
	Hypochums solani	black scarf	"
	Leveilluta tauria (Lev.) Am.	powdery mildew	"
	Macrosphomina pheseoti (Maubl.) Ashby	charcoal rot	"
	Meloidogyne javanica (Trueb) Chitwood	root-knot	"
	Oidium spp.	powdery mildew	"
	Phytophtora infestans (Mont.) d By.	late blight	major
	Pseudomones syringae pv *solanacearun* (E.F. Sm.)	bacterial wilt	intermediate
	PVV, PVS, PVA, PVM, PVX, TEN	virus	"
	Rhizoctonia solani Kuehn	root rot	minor
	Sclerotium rolfsii Sacc.	root rot	"
	Spondylocladium atrovirens Harz.	silver scurf	"

Table 1. Continued

Crop	Cause	Common name	disease status
Potato	*Spongospora* (Waller.) Lagh.	powdery scab	minor
	Streptomyces scabies (Thaxt.) Waks. & Henrici	Scab	"
Sweet potato	*Alternaria* tax. sp. IV.	stem blight	intermediate
	Ascochyta hortorum (speg.) C.O. 5m	leaf blight	minor
	Colletotrichum spp.	stem lesions	"
	Helicobasidium purpurenm Pat.	tuber rot	"
	Mycosphaerella spp.	leaf spot	"
	Phyllosticta batatas (Thum.) Cook	leaf spot	"
Enset	*Cladosporium musae* Mason	leaf mold	minor
	Cylindrocladium quinqueseplatum Boedijn & Reitsma	leaf lesions	"
	Fusarium oxysporum (E.S. 5m) Snyder & Hansen	fusarium wilt	"
	Mycosphaerella muicola Leach	leaf spot	"
	Phoma spp.	leaf spot	"
	Phyllosticta spp.	leaf spot	"
	Selenophoma spp.	leaf spot	"
	Septoria sp.	leaf spot	"
	Thielaviopsis state of *Ceratocystis paradoxa* (Dode) Moreau	leaf lesions	"
	Xanthomonas compastris pv *musacearum* D. Yirgaou&J.F. Dradburg	bacterial wilt	major

2.3.1. Biological studies

Identification of the stem blight pathogen formed the major party the work as soon as the disease was first reported in 1977 (7,13). The fungus was identified as *Alternaria spp.* by the plant pathology section of Nazareth Research Station. Disease samples were also sent to CMI for confirmation and species identification which was then proved to be *A. cucumerina*. However, measurement of the pathogen was reported to be different from those of *A. cucumerina* (5). Besides, the beak was often branched with one or two side branches, though, branching was not characterstic of *A. cucumerina*. Thus the species level still remains ambiguous and CMI has prefered to name it *Alternaria* tax sp. iv, since it was unable to find a satisfactory name of the spcies of the stem blight pathogen.

Attempt was also made to study the survival period of the fungus under glasshouse and field conditions. Fifteen to 20 cm half-infected and half-green pieces of sweet potato cuttings were buried at depth of 10,20 and 30 cm for 3,6,9,12,20 and 24 monthes. The chance of survival has reduced to 9 monthes under field conditions.

In other studies, host range of the pathogen was determined. Tomato, onion, sweet potato, muskmelon, *Datura stramonium*, hot pepper and *Edanum zigrum* were included. Each of these plants was inoculated with 25 ml of spore suspension. Fifteen days after inoculation symptoms developed only on sweet potato and tomato (7,14).

2.3.2; Varietal screening

Screening of sweet potato lines has been carried out both under artificial and natural conditions. Under glassline condition 24 cultivars were inoculated with alternaria spore suspension. There was a difference in susceptibility among the cultivars. Koka 9 was most susceptible while Koka 12 remained less infected by the pathogen. Under natural condition, though the weather was not conducive to disease development, the disease was observed on variety A, Koka 18, Melkassa I and Koka 9. The disease intensity was, however, slight.

2.3.3. Chemical control studies

A study on the chemical control of alternaria stem blight was made at the cold frame using benomyl and copper oxychloride fungicides. The two fungicides were dissolved in both cold and hot water. Infected cuttings were then dipped in the solutions for half an hour. Benomyl in hot water solution appeared to be effective in checking the development of the disease (9). Follow up studies using benomyl and chlorothalonil are under way.

2.4. Enset Diseases

Ensete ventricosum has been cultivated to Ethiopia for a very long time thus a major root crop in the south,southwestern and centeral Ethiopian highlands. (1500-3000 m). The most characteristic feature of enset is its high productivity of food per unit of land and its storability for a long time without being spoiled (2). However, the crop is vulnerable to a number of diseases (Table 1). Bacterial wilt(*Xanthomonas musacearum*) of enset is the most important and the limiting factor in the production of enset. This disease was first identified by Dagnatchew and Bradley in 1968 (3). It destroyed a considerable number of enset plants in many areas and consequently studies have been made on the severity of the disease, its transmission, host range and level of resistance of enset clones.

2.4.1. Severity of bacterial wilt

Periodical trips were made to many of the enset growing regions. Notes on disease prevalance and severity were taken from 86 locations in 29 weredas located in eight awrajas. Results of the survey indicated that enset bacterial wilt was widely distributed and was a very serious problem in all of the main enset growing regions (2). Out of the 29 weredas the disease was very severe in 23 weredas, less severe in five weredas and least severe in one wereda. Furthermore this study also indicated the severity that of the disease was more pronouncedduring the rainy season.

It was reported that the bacterium can maintain its viability from three to four days on contaminated knives (2).

2.4.2. Transmission Studies

Attempts were also made to study the transmission mechanism of this disease. The results showed that the bacterium was transmitted both by contaminated knives and vectors (2,3,12). It has been also suggested that the pathogen can be transmitted by cattle browsing (5). Moreover, the bacteria was isolated from three insect species (*Poecilocarda nigrinervis* (leaf hopper), *Pentalonia nigronervosa* (Banana aphid), and *Planococcus ficus* (mealy bag). Of these pests, leaf hopper and banana aphid could be considered as possible vectors of the pathogen (12). Transmission did not take place when young enset plants were planted in soils from where diseases and dead plants have been removed, but this needs further confirmation.

Study on insect vectors so far covered only one Awraja. Such study should be strengthened to include the rest of the enset growing regions.

2.4.3. Host range studies

In the host range test, apart from *Enset ventricosum* and *sp.*, nine plant species were inoculated with bacterial suspension which was isolated from naturally infected plants. Disease symptoms were observed on enset, *Musa spp.* and *Canna archoides* within four to six weeks after inoculation indicating that these three plant species are hosts of *Xanthomonas musacearum* (2). In earlier studies, banana had been proved to be the natural host of this pathogen (4).

2.4.4. Varietal screening

Over 60 enset "clones" as identified by local names of the major enset growing regions were evaluated for their resistance to *X. musacearum*. Wild enset plants from the forest were also included in this study. None of the enset "clones" was completely resistant to the disease. Some clones, however, have been found to be less susceptible than others. The less susceptible clones included: Ado, Kembata, Hedeso, Genticha, Abate, Ounjamu, and Kikile (2), but this should be tested under wider ecological conditions with high disease pressure.

3. SUGGESTIONS/RECOMMENDATIONS

As far as enset bacterial wilt is concerned, mode of transmission by insect and distribution of the vectors should be studied. Moreover, efforts have to be made towards the development of cultivar resistant to bacterial wilt. Cultural practices play an important role in the epidemiology of the disease. Hence, these factors must first be identified for better management and control of disease.

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DISCUSSION

Ato Tibebu Tessema:

Bacterial wilt is said to be vectored by aphids and leafhoppers; is there any attempt made to control the vectors with insecticides?

Ato Tesfaye:

No attempt has been made to control the insect vectors. But it was suggested by the entomologist to be considered. I hope such work will be started pretty soon.

Ato Wondimu:

Enset wilt disease transmissions are not only by insect vectors and small implements. Did you observe its transmission by domestic and wild animals? Sweet potato disease could be controlled using benomyl mixed with hot water. To recommend this result to farmers might be hard to practice. Did you consider this in your research work?

Ato Tesfaye:

1. Yes. The disease could be transmitted both by domestic and wild animals.

2. Benomyl + hot water was found to be effective only in the cold frame. Taking this chemical along with other broad spectrum fungicides, the study is in progress under field conditions. Hence I do not recommend benomyl + hot water treatment to be used by the farmers at this moment.

Ato Lemma Desalegn:

Of the root crops enset is most threatened by diseases. Is there any temporary control measure for the current enset production problem?

Ato Tesfaye:

1. There are some research results. More work is needed to give comprehensive information.
2. Proper sanitation needs to be followed in enset growing regions; we do not have any other control measures yet.

A REVIEW OF POTATO DISEASE RESEARCH IN ETHIOPIA

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1. INTRODUCTION

Potato *(Solanum tuberosum)* is one of the potentially important crops in Ethiopia. At present it is estimated that about 30,000 hectares of potato are grown annually in this country (4). The land varieties of potato grown in Ethiopia are probably introduced in about 1858 by a German botanist called Shimper, but only became popular towards the end of that century, when a long famine hit Ethiopia and people began eating potatoes out of despair. Since then, the potato has gradually become an important garden crop in many parts of Ethiopia. However, the national average yield estimates about 5 tons per ha (9). This is extremely low compared with the Netherlands (40 t/ha), Germany (28 t/ha), Egypt (17.4 t/ha), and Burundi (11 t/ha) (11).

A number of production problems account for the low yield of potatoes: viz. the absence of well adapted varieties, sufficient and high quality seed potatoes, adequate storage, and marketing facilities. Problems of diseases, especially late blight, early blight, bacterial wilt, and tuber rots are economically important (1) and need to be solved in order to expand potato cultivation in Ethiopia. Potato production in some parts of this country has been abandoned because of diseases.

A potato disease is an interaction between a host (the potato) and a pathogen (bacterium, fungus, virus, mycoplasma, nematode or adverse environment) that impairs productivity or usefullness of the crop.

Furthermore, diseases in one portion of the potato life cycle may severely limit effectiveness of production or quality at a later date. For example, field problems frequently become storage problems, which may later limit either market quality or seed performance and, ultimately, yielding ability (6).

2. BRIEF NOTES ON THE IMPORTANT POTATO DISEASES

Late blight caused by *Phytophthora infestans* (Mont.) de Bary, is the most serious of all the potato diseases, especially when conditions are favourable for its development, i.e. during the rainy season. It attacks and kills the foilage and invades the tuber causing rot. Late blight produces symptoms at any stage of plant growth. In the field, the initial symptoms appear on the edges or tips of the foilage as water soaked circular to irregular dark brown to black spots. The spots enlarge and as they are not restricted by veins, the entire leaflets, leaf and finally the entire plant may succumb to the disease.

The disease has forced quite a number of farmers to abandon the production of potatoes under rainfed conditions. Complete destruction of the crop can occur if climate favours the development of late blight and unless effective control measures are taken.

Early blight *(Alternaria solani* (Ell. & G. MartinO) is another fungal disease which causes considerable damage in the potato production. It is a leaf-spot disease that most commonly attacks potato stems and leaves. On stems this disease causes a brown-black necrosis, and the symptoms of this disease have concentric rings on the leaves. Early blight sometimes attacks the tuber. High temperature and high humidity favour development of early blight, but rain is not necessary for the development of the disease (3). Therefore usually the disease dominates potato fields at the end of the rainy season.

Other fungus diseases of potato such as common scab *(Streptomyces scabies*, (W & H)), powdery scab *(Spongospora subterranea)* and black scurf *(Rhizoctonia solani* Kuhm) have been identified in the samples taken from farmers' fields in Shewa, Gojam and Kefa administrative regions (1) but they are of little importance as compared to other diseases.

Virus diseases, although seldom lethal, reduce plant vigor and yield potential of seed tubers (2). Virus infection can cause necrosis, such as mottling, top necrosis and the classic necrosis of the phloem caused by leaf roll virus, ring rot and by stunting. Some virus symptoms such as potato virus X (PVX), potato virus A (PVA), potato virus S (PVS), potato leaf roll virus (PLRV), potato virus Y (PVY) have been identified in the samples taken from farmers' fields of Kefa, Gojam, Sidamo and Shewa administrative regions and research stations. PVX, PVA and PVS are common viruses found in farmers' fields, and the loss caused by such viruses is relatively low as compared with PVY and PLRV. PLRV was identified only at research stations. Therefore it can be considered a potential disease in potato production.

Bacterial wilt *(Pseudomonas solancearum* E. F. Smith) is an extremely destructive disease in tropical and subtropical regions. Field symptoms are wilting, stunting and yellowing of the foilage. The disease is becoming economically important in potato growing regions of Ethiopia. *P. solancearum* was identified from the wilt infected samples of potato plants collected in farmers' fields during the survey in Shewa, Welega, Sidamo, and Welo administrative regions (1). Recently, bacterial wilt was also found at Tseday farm, potato multiplication site. Black leg *(Erwina carotovora* pv. *atroseptica)* and soft rot *(Erwina caratovora* pv. *carotovara)* are common problems during the rainy season on some potato varieties, viz. Anita, Spunta and Kenya Baraka in experimental sites and small state farms.

3. RESEARCH ACTIVITIES

Research on potato diseases carried out in Ethiopia concentrated on the control of late blight, because of its importance here. Work on host resistance, fungicidal control, race identification, seed treatment, loss assessement and maintenance of potato seed foundation has been carried out against blight at Ambo. Each of these is briefly discussed below.

3.1. Host Resistance Studies

Field evaluation is the only practical way to compare reactions of varieties to late blight (7). Most resistant varieties are not immune to late blight but possess varying degrees of resistance to various races of the pathogen (10). In order to select blight resistant and high yielders of potato varieties and clones a screening programme was initiated in Ambo Scientific Phytopathological Laboratory (SPL). About 100 potato varieties and clones were obtained from the International Potato Center through the potato coordinator, Alemaya College of Agriculture, and other sources. After two cycles of preliminary screening at Ambo, an advanced screening trial was conducted at Holetta, Bako and Ambo starting in the 1983 crop season.

Results of late and early blight evaluation are presented in Table 1. Some potato varieties and clones were found to be relatively resistant to late blight; these were: Avena (AL-120), Annet (AL-119), Ind-73 (AL-264), Cebeco (AL-108), and Anita(AL-148).

These varieties gave more than 1 kg tuber yield per plant. At the plant population level used in this trial, a tuber yield of 1 kg per plant is almost equivalent to 40 tons/ha.

Despite the late blight attack, some potato varieties and clones gave reasonable yield. This may be due to late onset of the disease and slow rate of its development observed on some late maturing varieties.

High infestation levels of late blight were observed on different potato clones and varieties in the 1983 crop season as compared with 1982

Table 1. Reaction of some potato varieties to late and early blight at Ambo, 1982 - 1984.

Varieties and clones	1982				1983			1984			
	Late blight progress %			Early Blight %	Late blight progress %			Late blight progress %			Early Blight %
	4.viii	17.viii	3.viii	5.ix	9.viii	20.viii	2.ix	13.viii	21.viii	3.xi	21.viii
Avena (AL-120)	0	0	0	14	0	0	29	0	0	0	0
Annet (AL-119)	0	0	0	38	0	0	22	0	0	0	12
Ind-73 (AL-264)	0	0	0	3	0	0	22	0	0	0	25
Cebeco (AL-108)	0	0	0	39	0	0	51	0	0	0	5
Anita (AL-148)	0	0	0	5	0	0	0	0	0	0	5
Br-112-42 (AL-601)	0	0	52	0	0	0	96	0	0	0	0
R-513-25 (AL-305)	0	0	71	48	0	8	41	0	0	0	0
Br-114-60 (AL-560)	0	0	0	0	0	28	28	0	0	0	0
Br-112-113 (AL-624)	0	50	72	0	0	46	71	0	0	0	5
K.Baraka (AL-100)	0	0	4	8	8	32	40	0	0	0	5
Br-112-64 (AL-615)	0	3	0	0	13	24	24	0	0	0	5
B-5704 (AL-215)	0	0	3	44	64	100	100	0	0	0	0
B-6334 (AL-205)	0	0	0	16	79	100	100	0	0	0	25
Spunta (AL-135)	0	0	0	35	20	54	90	0	0	0	50
R-88-64 (AL-421)	0	0	0	150	59	97	100	0	0	0	0
ATK-79-1 (AL-255)	0	0	25	0	52	66	82	0	0	0	5
Br-114-26 (AL-356	25	50	50	0	46	59	89	0	0	0	18
Br-114-114 (AL-568)	3	10	10	25	0	0	0	40	89	100	0
Cgn-69-1 (AL-252)	0	0	0	43	12	62	99	0	67	70	0
R-96-84	8	12	23	0	29	61	72	0	23	81	5
Local (Ambo)	71	81	85	100	62	74	100	78	100	100	0
Mean			18.8	22.3			59.8			16.7	7.8

Table 2. Yield and blight reaction of some promising potato varieties grown at Ambo, Holetta and Bako in 1983 - 1984

Varieties	AMBO				HOLETTA				BAKO			
	1983		1984		1983		1984		1983		1984	
	Yield (gm/ plant)	L.B. (%) 1.ix	Yield	L.B. (%) 21.viii	Yield	L.B. (%) 1.ix	Yield	L.B. (%)	Yield	L.B. (%) 1.ix	Yield	L.B. (%)
Ind-73 (AL-264)	1260	22	1221	0	1360	8	544	0	390	0	837	0
Cebeco (AL-108)	1180	51	956	0	800	15	582	0	320	0	814	0
Br-112-113 (AL-624)	1050	72	1914	0	790	44	891	0	500	0	932	0
BR-114-60 (AL-560)	1070	32	1114	0	1250	0	535	0	380	0	659	0
Anita (AL-148)	1030	0	916	0	910	0	295	0	360	0	767	0
Avensa (AL-120)	1140	0	1480	0	990	0	530	0	300	33	796	0
K.Baraka (AL-100)	1090	36	1220	54	1180	0	597	0	420	0	685	0
Spunta	650	100	1182	0	390	100	449	0	320	100	935	0
Br-112-42 (AL-601)	-	-	1590	0	-	-	830	0	-	-	937	0
Annet (AL-119)	-	-	1273	0	-	-	548	0	-	-	740	0

and 1984. This may be due to the extended time of rain which caused high disease pressure. In 1984 crop season relatively few entries were attacked by late blight. In contrast to it, early blight infestation was very high because of the unusual dry weather condition.

The preliminary results obtained at Ambo were also supported by advanced screening trials conducted at Holetta, Bako and Ambo. The results of some evaluated potato varieties and clones in three stations are presented in Table 2. High blight intensity was recorded at Ambo for the last three consecutive years as compared to Holetta and Bako.

The results obtained clearly indicate the opportunity to select from the evaluated potato varieties and clones which may have combined characteristics of high yielding capacity and field resistance to late blight. Furthermore, in order to confirm degree of resistance and yield performance, a continuous screening trial should be conducted under different ecological conditions in the country.

3.2. Fungicidal Trials against Late Blight

Field experiments were conducted to evaluate fungicides for their efficacy on late blight. Susceptible potato varieties - local and Cardinal - were used in 1982 and 1984, respectively. Six fungicides consisting of metalaxyl-mancozeb (3 kg/ha), cuprous oxide (3 kg/ha), cupric hydroxide (3 kg/ha), captafol (0.4%), mancozeb (3 kg/ha) and propineb (3 kg/ha) were tested. The fungicides were sprayed at eight-day intervals beginning from the onset of the disease.

Metalaxyl gave the best control resulting in higher tuber yields (Table 3). Besides foilage control of *P. infestans*, metalaxyl treated plots had no tuber and tuber yield on the local variety i.e. significant difference in infestation level and yields were obtained in metaloxyl, mencozeb and captofol as compared to the untreated check.

In the 1984 crop season, significant differences in yields were obtained among the treatments with the exception of propineb, as compared

Table 3. The effects of fungicide treatments on late blight and yield of potato, 1982 and 1984.

	1982					1984				
	Yield	Late blight progress (%)				Yield	Late blight progress (%)			
	(q/ha)	7.viii	15.viii	25.viii	13.ix	q/ha	31.vii	6.vii	14.viii	20.viii
Metalaxyl - Mancozeb	210	28	31	32	32	527	0	0	7.4	36.6
Cuprichydroxide	-	-	-	-	-	460	9.3	15.2	33.7	47.6
Captafol	135	64	66	72	79	460	9.3	15.2	33.7	47.6
Diafolatan	146	65	66	70	73	453	12	16	27	71
Mancozeb	143	56	62	65	68	402	12	15	34	70.7
Propineb	126	56	62	73	81	353	12	16	39	74
Control	96	70	81	86	96	301	11	23	46	84

LSD_{05} = 39 q/ha (yield)

LSD_{05} = 62 q/ha

with the control. Low levels of disease infestation were recorded in metalaxyl and cupric hydroxide treated plots.

Most of the evaluated fungicides except metalaxyl are more protective than curative. They managed to control the disease at early stage, but when severe infestations of late blight occurred, these fungicides were unable to control the disease whereas metalaxyl managed to control it.

3.3. Race Composition of *Phytophthora infestans*

Race analysis of *P. infestans* has been carried out every year on samples collected from some potato growing regions and experimental sites at Ambo, Debre Zeit, Awassa, Jimma, Omo-Garagella, Holetta and Bako.

In the 1982 crop season races 4 ; 8 ; 10 and 11 were identified in the samples taken at Ambo SPL experimental fields in the period from end of July to early August. The same races were also identified in the population taken from Holetta and Debre Zeit in late August. Wide spectrum races were identified at late period of the plant growth on the relatively resistant varieties and clones such as Kenya Baraka, Br-112-113 and IMD-73. Based on the frequency of isolation, races 8; 10 and 11 were designated as dominant races (Table 4).

The 1983 crop season included relatively wider spectrum races as compared with the previous year. Races 1; 2.4; 1.3; 1.2; 3.4 and 14 were additional to the races identified in 1982. Furthermore, the disease pressure was very high due to extended time of rain. It may be possible to correlate the breakdown of resistance of Spunta with the appearance of race 1 and its derivative races 1.2 and 1.3 provided that those races were identified in the population taken from the infected leaves of this potato variety.

In the 1984 crop season the usual race analysis was carried out on the samples taken from Holetta, Ambo and Bako. Despite the recording of some races on different varieties, the aggressiveness and frequency of isolation was relatively very low as compared with the previous years. This can be attributed to the low disease pressure observed during this season.

The results revealed that no significant shift was observed in the racial pattern of *P. infestans* for the period 1982 - 84. However, a slight shift in favour of wide spectrum was recorded at Ambo experimental fields. This may be due the introduction of wide ranges of genetical material. Therefore there may be a possibility of appearing wide spectrum races under optimal disease condition in some potato growing regions of Ethiopia. Consequently, the R-gene resistance may not be very useful in reducing incidence of the disease but may be responsible for increasing pathogenic variability. Hence, to reduce pathogenic variability varieties possessing horizontal resistance should be introduced in the potato growing regions. Chemical protection applied on such varieties in order to delay the appearance of the disease, thereby reducing the number of spore generation produced in a season, may also help in keeping the aggressiveness of races stable (14).

3.4. Seed Treatment Trials

P. infestants survives in the tuber where it acts as a source of inoculum for infection in the following season. The exact pathway by which the fungus progresses to the new plant is not always clear. De Bary (1896) established that sprouts produced by infected tubers may be invaded by the fungus and survive to reach the soil surface where they support the growth of conidia.

In order to study the effect of seed treatment on the incidence of late blight, the trial was conducted on four potato varieties: Spunta, Kenya Baraka, Br-114-34 and local (Ambo). Paired treatment trial was used to compare the yields of two plots in each of four replications. Infected tubers of one plot were treated with metalaxyl (0.5 kg/t) before planting whereas the tubers of other plots were not exposed to treatment.

Table 4. Races of *Phytophthora infestans* identified during the period 1982 - 1984 and their frequency of isolation.

Races identified	Frequency of isolation expressed in percentage			
	1982 66*	1983 68	1984 48	Mean
R_1	-	17.8	-	5.9
R_2	-	-	2.4	0.8
R_3	3.7	1.9	14.7	6.8
R_4	14.8	1.8	19.5	12.0
R_1R_2	-	1.9	-	0.6
R_1R_3	-	1.8	2.5	1.4
R_1R_4	-	-	-	-
R_2R_3	5.5	5.3	14.6	8.5
R_2R_4	-	1.8	4.8	2.2
R_3R_4	-	7.1	-	2.4
$R_1R_2R_3$	-	-	-	-
$R_1R_2R_3R_4$	-	-	-	-
R_5	-	-	-	-
R_7	5.6	-	14.7	6.8
R_8	29.7	17.8	2.4	16.6
R_{10}	16.6	19.6	2.5	12.9
R_{11}	24.1	14.3	21.9	20.1
R_{13}	-	-	-	-
R_{14}	-	8.9	-	3.0

* = Number of samples analyzed.

The results of this trial revealed that the highest yield increment was obtained on local variety for two consecutive years (Table 5). Treated plots of all varieties showed less blight infestation as compared with non-treated ones. Most probably, the systemic action of metalaxyl may have the effect in reducing the source of inoculum that survives in the tuber.

3.5. Loss Assessment Trials

This trial was conducted in order to develop series of crop loss assessments for the estimation of total tuber yield reduction that would occur from all possible types of late blight epidemics.

Paired treatment trials were used to compare the yield and infection level of two plots in each of the four replications. Part of the plot was protected from late blight by metalaxyl (3 kg/ha) using foilar application whereas the other plot has allowed to be damaged by naturally occurring infestation of the disease. Blight severity was assessed and recorded at 8 - 10 day intervals during the period of the plant growth. The trial was conducted on four varieties which got different degrees of resistance; these were: Spunta, Kenya Baraka, Br-112-93 and Local (Ambo).

In 1982, the highest yield loss was recorded in the local variety (Table 6). The disease pressure ranged between 0% in protected Spunta to 91% in the untreated local. In 1983 the disease pressure was high and consequently higher losses occurred. The highest yield loss (80.7%) was obtained from the variety Br-112-93.

3.6. Maintenance of Foundation Potato Seeds

To improve the potato crop and increase yields, better quality seed tubers are needed. In this context, quality means not only the health status but also the physiological conditions of the tuber at the time of planting. The use of seed stocks of poor health quality is often the important single factor causing low yield. It is

Table 5. The effects of seed treatments on late blight and yield of potato*

Variety	Treatment	Yield q/ha	% yield increment	Late blight attack (%) 6.viii	14.viii	22.viii	Yield	% Yield increment	Late blight attack, % 6.viii	14.viii	20.viii
	T	269		10	53	92	678		0	0	0
Spunta			16.8					7.6			
	NT	224		24	64	98	626		0	0	0
Kenya	T	516		0	8	9	459		17	19	26
			42.1					4.5			
Baraka	NT	299		o	26	44	438		13	19	25
	T	-		-	-	-	383		21	34	75
Cardinal			-					-			
	NT	-		-	-	-	353		38	55	82
	T	224		63	69	87	237		37	42	51
Local			42.4					20.7			
	NT	139		72	75	93	188		43	52	72

*T = Metalaxyl treated, NT = non-treated (control)

Table 6. Yield loss estimates due to late blight in potato, 1982 and 1984*

Variety	1982				1983			
	Treatment	Yield (t/ha)	Actual Yield loss (%)	Late blight progress % 25.viii	Yield	Actual Yield loss	Late blight progress, % 10.viii	22.viii
	P	53.0		0	63.0	45.8	0	0
Spunta			3.2					
	NP	54.8		0	46.3	-	64	93
	P	47.5		4	53.5	26.5	0	0
Kenya Baraka			13.8					
	NP	40.8		20	29.0		21	33
	P	-	-	-	64.3	80.7	0	12
Br-112-93								
	NP	-	-	-	12.4		89	100
	P	12.4		15	28.8	67.9	4	5
Local (Ambo)			45.1					
	NP	6.8		91	9.2		75	96

* P = Protected, NP = unprotected

widely recognized that the benefit obtained from using good seed is high as compared with unimproved seed potato.

Maintenance of foundation potato seeds was carried out on different varieties: Kenya Baraka, Spunta, Diamant and Cardinal. Potato seeds of each variety were planted in the field and negative selections were used: i.e. frequent roguing of diseased and poor performing plant samples were taken at random to estimate the quality of the seeds using serological tests and Enzyme-linked immunosorbent assay (ELISA) methods. Healthy potatoes with medium tuber sizes were supplied to ADD and producers' cooperatives for demonstration and multiplication purposes.

The ELISA method was also used for checking the pressence of virus and bacterial diseases in the potato collection (Table 7).

Table 7. Results of identification of viruses and bacteria using ELISA method at Ambo, 1983 - 1984*

	Viruses						Bacteria	
	PVX	PVY	PVS	PVA	PVM	PLRV	Erwinia Caratovora	Coryrebacterium sepedon
Kenya Baraka	+	-	-	-	-	-	-	-
Anita	+	-	-	-	-	+	+	-
Spunta	+	-		-	-	+	-	-
Diamant	-	-	-	-	-	-	-	-
AL-120	+	-	-	-	-	+	-	-
Cardinal	-	-	-	-	-	-	-	-
Ramenski	-	-	-	-	-	-	-	-
AL-255	+	-	-	-	-	+	-	-
Br-112-42	-	-	-	-	-	-	-	-
Cebeco	-	-	+	-	-	-	-	-
K-59	-	-	-	-	-	+	-	-
B-5504	-	-	+	-	-	-	-	-
Br-112-113	-	-	-	-	-	-	-	-
P-9	+	-	-	-	-	-	-	-
IND - 73	-	-	-	-	-	-	-	-
R-28-86	-	-	-	+	-	-	-	+

* + = positive reaction to the respective type of virus and bacterium

\- = negative raction

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DISCUSSION

Ato Bayou Belaineh:

What are the popular varieties of potato grown on the estimated 30,000 ha by the peasant farmers? How is the distribution of late and early blight and how severe are they?

Ato Tesfahun:

The distribution of late blight is everywhere potatoes are grown under rainfed conditions. However, late blight infestation is high in the highlands where moisture (rain) and optimum temperature (18 - 21°C) prevails as compared with lowlands; early blight is a problem when potatoes are grown under irrigation. And this disease dominates usually at the end of the rainy season. At present, there are no established varieties used by farmers. There are some varieties considered as released varieties such as Spunta, Anita and Kenya Baraka. These varieties are cultivated by small state farms only. The hectarage covered by these varieties is very insignificant as compared with the local varieties.

Ato Mohammed Kassahun:

The varieties which you mentioned like Anita, Spunta, and Kenya Baraka are highland varieties; however varieties for the lowland (1000 to 1200 m) should be also studied. This is because late and early blight have been observed in areas like Nura Era and as a result no potato is being grown; we are looking for resistant/tolerant, adaptable varieties to our conditions.

Ato Tesfahun:

Usually late blight is severe in highlands where rainfall and temperature favour the disease. If the relatively resistant varieties are performing good in relation to late blight, in the highlands, the incidence at lowlands will be low. As far as adaptation to lowlands is concerned, agronomic and pathological trials should be conducted parallel. Resistant varieties should be checked for their adaptability to lowlands or Vice Versa.

Ato Seid:

Have you tried to raise seedlings from botanical seeds to get resistant lines against *P. infestans*.

Ato Tesfahun:

No.

Ato Kassahun:

You have indicated in your report that Ridomil has shown an excellent curative effect as compared to the other fungicides. Could you elaborate on the rate and intervals between applications.

Ato Tesfahun:

Ridomil 63.5 mz (WP) was used at 3 kg/ha at ten-day intervals.

A REVIEW OF WEED CONTROL IN ROOT, TUBER AND FRUIT CROPS IN ETHIOPIA

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1. INTRODUCTION

Root and tuber crops are very important horticultural crops grown for local consumption in Ethiopia. These include potato, sweet potato, ensete, carrot, beetroot, Oromodinich, Cassava, taro and yam. These crops are the major sources of carbohydrates, fibre, and other raw materials for about seven million people in southern and southwestern parts of the country.

As far as production per unit of land is concerned, these crops are highest among four major agricultural crops in the world (8). However, the yield potential of these crops and their nutritional value to alleviate food shortage and maluntrition have not yet fully been exploited due to different problems associated with their production. Of the numerous production constraints weeds are one of the major limiting factors. They compete for water, light, nutrients and space. They also reduce the crops' value by altering the size and distribution of the roots and tubers. Moreover, weeds interfere with harvesting. The presence of even low densities of weed species can make farm operations more difficult, costly or impossible (9),

Fruit crops are also important in Ethiopia. Though the importance of fruit crops (citrus, banana, grapes, etc.) has been realized for a long time now, the role of weeds in reducing the quality and quantity of the produce has been neglected (5). Among the fruit crops mentioned above, some weed control experiments have been carried out only on citrus.

Highlights of research activities conducted against weeds in root, tuber and fruit crops in Ethiopia to date are given in this paper.

2. WEED POPULATION SURVEYS

Reports on weed species in roots and tubers are not available. However, observations by these authors indicate that: *Amaranthus spp.*, *Cyperus spp.*, *Galinsoga parviflora*, *Portulaca oleracea*, and *Tribulus terrestris* are some of the common weeds of these crops in Ethiopia.

Weed species recorded in fruit crops at Melka Werer, Abadir and Koka include: *Sorghum spp.*, *Flovaria trinervia*, *Ipomoea plebia*, *Snowdenia polystachia*, *Cyperus esculentus*, *C. rotundus*, *Launea cornuta*, *Eragrostis spp.*, *Euphorbia heterophylla*, *Setaria verticillata*, *Amaranthus spp.*, *Digitaria abyssinica*, *Galinsoga parviflora*, *Datura stramonium*, *Tagetes minuta*, *Pennisetum spp.*, and *Dactyloctenum spp.* (3,6,7).

The most conspicuous of all those weed species were *Digitaria abyssinica* and *Cyperus spp.*

3. CHEMICAL WEED CONTROL TRIALS

3.1. Root and Tuber Crops

Potatoes are traditionally cultivated very thoroughly as yield can be severely reduced by weed competition and because weeds hinder harvesting. But, these practices inevitably cause root damage (9). Damaged tubers are a common occurrence caused during hoeing and/or harvesting. To avoid yield loss as well as injured tubers, the use of herbicides to control weeds and machine harvesting become a necessity. With the former objective, a trial was initiated at Bako Research Station in 1971 (2).

Six different herbicides at three rates each were applied after emergence of the crop, to select the most appropriate herbicide and to determine the right application rate. The herbicides were Chlorofuron, linuron, metabomuron, paraquat, dinoseb acetate and fluorodifen. Each herbicide was applied at two rates.

Higher levels of all herbicides tested, except dinoseb acetate fluorodifen, gave higher yields (140 q/ha). As far as weed control is concerned, the lowest number of broadleaved weeds was found in plots treated with linuron and Metobromuron and grasses seemed to be controlled mainly by linuron (1,2).

3.2. Fruit Crops

It has been reported that paraquat, applied in established citrus, banana, papaya and grape at Melka Werer gave good control of grass as well as broadleaved weeds (3). *Launea cornuta*, a troublesome weed in the area, was also controlled satisfactorily. This herbicide does not have residual effect. It is inactivated in contact with the soil.

It was ineffective against *Cyperus spp.* and other perennial grasses (3).

On the other hand, three levels of each of glyphosate and bromacil were compared with three-times manual weedings at Abadir. Glyphosate at 10 l product/ha and bromacil at 2 kg product/ha were effective against grasses and broadleaved weeds, respectively. No symptoms of phytotoxicity were observed. Glyphosate tended to be less effective where the weed population density was low.

Glyphosate was also tested between 1980 and 1982 in the citrus orchard at Koka and gave effective control of the target weed, *Digitaria abyssinica* (6,7).

Although *Galinsoga parviflora* is not usually considered as an important weed in the citrus orchard at Koka, the population was the highest. At 43 days after herbicide application, it was 30.8% of all the weeds. It was not controlled by paraquat, whereas the herbicide was effective against most other weeds (6,7).

4. CONCLUSIONS AND RECOMMENDATIONS

Broadleaved weeds are more important in root and tuber crops. On the other hand, grass weeds are dominant in fruit crops. Grass weeds such as *D. abyssinica* and *S. verticillata* are highly competitive and difficult to control in citrus. Results so far show that glyphosate at about 5 l product/ha can be applied at a time while the weeds are young or actively growing.

Research conducted on weeds of root, tuber and fruit crops is minimal; efforts must be made to correct this situation by carrying out well planned experiments on control measures against important weeds.

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DISCUSSION

Ato Marcos:

1. Paraquat does control *Setaria* and *Galinsoga* properly in coffee and minimum tillage.

2. All paraquat supplied to Ethiopia is with wetter.

Ato Ahmed:

I did not conclude that paraquat was useless. The result was not conclusive.

Ato Badege:

What is the competition capacity of *Digitaria scalarum* on plantation crops like citrus? Because once the citrus tree has established itself I think it can escape competition.

Ato Ahmed:

We know that it is highly competetive, like all grass weeds in citrus. But we have not done crop/weed competition and yield assessment trials in citrus.

Ato Woldu:

Glyphosate was tried at 10 l/ha;was it the product or active ingredient?

Ato Ahmed:

It was 6, 8 and 10 litre product per hectare.

Ato Ermias:

Ato Ahmed reported that he did not observe *Rottboelia exaltata* in other crops except in fruits in Ethiopia. I want to inform that this weed is observed in the state farms in Welega (Fincha) and northern areas in Gojam. The infestation is severe in these areas.

Ato Ahmed:

Surveys for *Rottboellia* alone were not made. Thank you for the information.

Professor Sam-Aggrey:

Has interrow cultivation been tried in weed control studies if this falls within your brief?

Ato Ahmed:

No, we intend to do that in the future.

Dr. Yilma:

If the problem of planting material is a bottleneck for weed research on root crops, couldn't the possibility of superimposing such trials on state farms production fields be explored?

Ato Ahmed:

Superimposing our trials on those of agronmy (breeding) trials shall be considered. Thank you.

Dr. Stroud:

To overcome your problem of potato seed shortage, I suggest an alternative would be to use farmer's fields for simple experiments. In this way, you could also get information concerning the farmers' cultural practices both in controlling weeds and in general production.

Ato Ahmed:

Using farmers' fields for weed control trials is not bad, but farmers need insurance against damage to their crop.

Ato Terefe:

Orobanche is said to be observed at Alemaya in 1977, but in the 1984 crop season this parasitic weed was observed at Debre Zeit State Farm on small potato growing plots.

Ato Ahmed:

The date I mentioned was Tekemt 1977 (October, 1984). We saw *Orobanche* in potato at Alemaya only. Thank you for the piece of information.

Ato Mulugetta:

There is a need for on-farm trials to understand the cultural practices followed by farmers. The Department of Socio Economics and Farm Management is undertaking a Farming Systems Research project in which a series of on-farm trials for other programmes are included. We would welcome any on-farm trial proposals for weed control on root and tuber crops as well.

Ato Ahmed:

Thank you, Ato Mulugetta. We would be very glad to carry out weed research trials on farmers' fields.