# True Potato Seed in the Middle East and Africa

Proceedings of an international workshop
held in Cairo, Egypt,
April 9-15, 1994

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# Contents

# Foreword

Since the early 1960s, potato production has expanded more rapidly than that of any other major root or tuber crop in Asia, Africa, or Latin America. Although consumption trends show that potato is a popular food in the developing world, greater consumption is constrained by the elevated cost or lack of availability of high-quality seed tubers. Therefore, for the past sixteen years, scientists at CIP have been improving true potato seed (TPS) technology to provide a low-cost alternative to vegetative propagation. To date, results from selected countries indicate that TPS could make a major contribution to potato agriculture of this century.

CIP's strategy is to concentrate collaborative efforts in strategically located countries where local interest and probabilities of success are highest. In the Proceedings of this workshop, it can be seen that in Egypt TPS has already reached farmers' fields and is at the commercial level. Small farmers, large farmers, and private companies are involved in potato production from TPS. In Uganda, Kenya, Ethiopia, Cameroon, Rwanda, and Burundi, TPS technology has reached the level of on-farm trials, but is far from being adopted on a substantial scale. Clearly, CIP and these partner countries need to intensify their collaboration in order to help TPS technology reach full adoption. TPS research in other countries where there is little or no interest by farmers or national programs should be terminated or at least put on hold. The recommendations from this workshop provide valuable guidelines for future action by CIP in the countries mentioned. The recommendations also imply a sharp research focus on developing TPS progenies with even better late blight resistance, earliness, and storability, which are also the top TPS research priorities on a global level.

Another highlight of the recommendations is the need for a continuing supply of high-quality, low-cost TPS for the Middle East and Africa. During the next few years, the focus will be on Turkey, but in the longer term additional production sites, possibly in Sub-Saharan Africa, may well be needed.

I expect that during the next five to ten years TPS technology will spread substantially from the countries indicated to most potato-growing countries of the Middle East and Africa. CIP intends to fulfill its commitment to this goal through a combination of highly focused strategic and adaptive research coupled with a continuing role as a catalyst of technology transfer.

Peter Gregory

Deputy Director
General for Research
International Potato Center

# Welcome and Introduction

On behalf of the International Potato Center (CIP) staff, I would like to thank and acknowledge the host country of this workshop and the Ministry of Agriculture and Land Reclamation, universities, governmental and nongovernmental institutions, and companies in Egypt for their excellent collaboration with CIP.

We are pleased to welcome all of you to Egypt.

Allow me to introduce you to all the participants who arrived in Egypt from Africa and the Middle East to attend this workshop.

It is a great pleasure to introduce our special guests from Egypt, Dr. Amin Okasha, who is representing his Excellency Dr. Yousef Wally, the Deputy Prime Minister of Agriculture and Land Reclamation, Dr. Ahmed Momtaz, the former Director General of the Agricultural Research Center and Research Advisor to the Deputy Prime Minister.

As you may know, potato is one of the most important food crops in both developing and developed countries.

Today, developing countries produce about 30% of the world's potatoes, and production in those countries is expanding more rapidly than for most other food crops. As a result, potato cultivation is becoming increasingly important for rural employment, income, and food for growing populations. In monetary terms, potatoes are now the fourth most important food crop worldwide after wheat, rice, and maize.

Africa and Middle Eastern countries produce more than 28 million tons annually, with average per capita consumption at about 20 kg, ranging from 1 kg in Sudan to 50 kg in Turkey. Potato production in our region has increased by more than 150% during the past 25 years.

We believe that much impact and many achievements were made as a result of fruitful cooperation among CIP, national agricultural research institutions, and the private sector in our region. Collaboration includes activities such as seed production, introduction of germplasm materials, improvement of traditional store conditions for seed and ware potato, integrated control of potato tuber moth, intercropping and other cultural practices, true potato seed (TPS) and seedling tuber production, sweetpotato improvement, and training and communications.

Today, I would like to concentrate on two areas for future development in our region in order to achieve technologies that maximize our farmers' income and minimize production costs.

Because the importation of certified seed is still a heavy financial constraint to the economy of several countries, we urgently need further close cooperation between CIP and national program scientists to influence policies in the region in order to obtain improved local seed and seedling tuber production from tissue culture and true potato seed. This will decrease production costs and reduce the need for expensive imported potato seed. In Egypt, two TPS hybrids have been released, and some private companies began producing seedling tubers from TPS on their own farms.

Another area for future development concerns the potato tuber moth (PTM), one of the most important potato pests in the region, which still causes severe damage, especially in the spring crop in the field as well as in stores. Current research on tuber moth at CIP is aimed at identifying and testing potential components of an integrated PTM control program, including biological and cultural practices. These will then be combined appropriately to minimize or even avoid the use of toxic insecticides in fields and stores. Here I would like to recognize the efforts made in Egypt to use a biocontrol agent that will reduce the use of toxic insecticide significantly in potato production.

You are scheduled later this week to visit our experimental station at Kafr El-Zayat as well as some potato fields, cold and nawalla stores, and packing stations.

I am optimistic that the close cooperation between CIP and national programs has a place in our region and could increase potato and sweetpotato production to meet the demand of fast-growing populations.

Once again, I would like to welcome and thank our guests for attending this TPS workshop.

Participants, we will do our best to help you have a successful workshop. Please let us know if you have any special interests so that we can help you while you are here in Egypt. Thank you.

Ramzy El-Bedewy*

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* Breeder and liaison for the International Potato Center (CIP) in Kafr El-Zayat, Egypt.

# Opening Address - TPS Workshop

Distinguished guests, workshop participants, ladies and gentlemen:

On behalf of the International Potato Center (CIP) and the Regional Office for North Africa and the Middle East, I welcome you to this Workshop on True Potato Seed in the Middle East and Africa. It is a real pleasure to have you here and I thank you for taking the time to participate in this event.

Although when we first planned this workshop, we only included countries from North Africa and the Middle East, we later thought that participation by other countries with a similar agroecology could also benefit the discussions. In this regard, I also want to welcome those participants from CIP's Sub-Saharan Region (Kenya, Ethiopia, Rwanda, Uganda, and Burundi) who made a special effort to come to Cairo to contribute with their experiences in this meeting.

During the next few days we will evaluate progress and constraints encountered in the utilization of true potato seed (TPS) in Africa. We will also review in detail the future alternatives for making this technology available and successful at all levels of the agricultural socioeconomic system, such as governments, the private sector, and large and small farmers.

Most people regard the use of TPS for potato production as a new technology. Reports from South America indicate that the system of varietal selection and production of good-quality seed from TPS has been practiced since ancient times by native farmers from the Andean highlands.

Probably the first attempt to cultivate potatoes from TPS on a large scale was made in the 1950s in China. Today, more than 20,000 hectares are being cultivated with TPS in northern China for the production of high-quality seed.

TPS research started at CIP in the late 1970s. Current results and experiences in China, Sri Lanka, Rwanda, Egypt, Nicaragua, Indonesia, Peru, and other countries show that TPS can be used to advantage in potato production. However, reaching that state has not been easy and several conditions have to be met in order to make this technology profitable at the farmer's level.

We have selected Egypt as the site for this workshop because it is in this country where TPS has had the greatest impact in Africa, because it is here where this technology has already reached the farmer's level, and because the Ministry of Agriculture and people of this country, through their friendship and excellent collaboration, have constantly supported CIP's activities.

Finally, I would like to express my deepest appreciation to all the local collaborators who have made it possible for us to meet here. I especially want to thank Dr. Ramzy El-Bedewy, CIP's scientist posted in Egypt, and his collaborators for making all the local arrangements.

Once again, thank you for participating in this workshop. I warmly welcome participants attending this meeting. We hope to have a fruitful one.

Carlos Martin*

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* Regional Representative for North Africa and the Middle East, International Potato Center (CIP).

# Principal Conclusions and Recommendations

The principal conclusions and recommendations of the group that participated in the TPS workshop follow. These recommendations were fully discussed during the fourth day of the workshop and the draft developed at that time was reviewed again by most participants in May 1994 during the African Potato Association meetings in Sousse, Tunisia.

The group believes that these recommendations not only should be addressed to CIP's management in Lima, Peru, but should also be widely distributed among TPS researchers in Africa and other CIP regions. These recommendations reflect the opinions of a widely diverse group of CIP's collaborators in Africa, representing a wide range of agroecologies, and agricultural and cultural traditions.

1. The group recognizes the great achievements in TPS research developed by CIP. CIP's contributions to the use and adoption of this technology have made and will continue to make a great impact on potato production in several developing countries, not only in Africa but also worldwide.

2. The working group identified three clear levels of TPS utilization and adoption in Africa. CIP's management should carefully consider these levels when reevaluating future activities there:

   - The first level is one in which TPS has been tested only at experimental stations and has never reached farmers' fields. The reasons for this are multiple (e.g., no interest by farmers or national programs), but all reflect the lack of any potential for this technology in the mid term. CIP should reevaluate this activity and probably stop it until more favorable conditions determine a more positive approach to this technology. This could be the case for Morocco and Tunisia.

   - The second level is one in which TPS has reached the farmers' level (preliminary on-farm trials), but final adoption and dissemination have not been achieved for various reasons. In this regard, the group recommends that CIP continue and if possible increase its support to those countries at this level so that this technology could reach full adoption. This is the case of Uganda, Kenya, Ethiopia, Cameroon, Rwanda, and Burundi.

   - The final level is one in which TPS has already reached farmers' fields and is at the commercial level. Small farmers as well as large farmers and private companies are involved in potato production from TPS.

This is the case of Egypt only. CIP should use this example in order to disseminate the potential of TPS utilization in Africa. The group observed that the main factors contributing to the adoption of TPS in Egypt are: the presence of a strong private sector, and the presence of CIP's liaison officer, who has excellent local contacts.

3. CIP should reevaluate its priorities on TPS research and utilization according to the levels mentioned above. CIP should concentrate its efforts and resources only on those cases for which a positive achievement (impact) could be obtained in the short to mid term.

4. The group feels that CIP should continue and expand the dissemination of up-to-date information on TPS to its collaborators worldwide. We need an updated technical bulletin describing the newly available technologies for TPS production and utilization. Especially important is the need to produce a technical bulletin covering aspects of TPS production, quality, storage, and handling.

5. The group also recognizes that we need better interaction among NARS. The exchange of information among TPS researchers in Africa should be stimulated. For this, the group recognizes the great opportunity provided by CIP to participate in this workshop. We recommend that CIP organize these types of TPS workshops or seminars every three years if possible.

6. The group also recognized the need for better availability of large quantities of TPS in Africa for the near future. A supplier in this part of the world should produce the required amounts at the highest quality and lowest cost. The group suggested that CIP continue its support to Turkey, especially technical support to assure that minimum quality standards are met, and at the same time identify other production sites in Sub-Saharan Africa (SSA).

7. The potential for TPS utilization should be studied in those countries in which the technology is not clearly known and/or understood. This is the case of Syria, Jordan, Yemen, and also Sudan in CIP's Middle East and North Africa (MENA) region and Malawi, Zambia, Nigeria, and others in SSA.

8. CIP should encourage and support in-country activities aiming to develop socioeconomic studies on the adoption and utilization of TPS in Africa. Country participants will also encourage this type of research. These socioeconomic studies should not only be directed to those cases in which TPS technology is fully adopted but should also cover cases at the mid-level of adoption to determine constraints and ways to overcome them.

9. Although during the meetings the improvement of CIP's TPS progenies was extensively discussed and achievements properly recognized, the group still wants to mention that new TPS progenies with better virus and late blight resistances are needed in the short term. The same can be said for TPS progenies with better seedling vigor and short maturity cycles.

10. The group also suggests that better and more detailed research studies be conducted on storability of seedling tubers from the most important TPS progenies distributed worldwide. Thus, when TPS progenies are distributed for in-country evaluation, some of this important information on seedling tuber storability should also be included.

11. The group recognizes the workshop's good organization and expresses its thanks to CIP's liaison officer in Egypt (Dr. Ramzy El-Bedewy), CIP's Regional Representative for MENA (Dr. Carlos Martin), and other local members of the Egyptian Potato Program.

CHAPTER 1

# CIP Strategies in the Middle East and North Africa for TPS

Carlos Martin*

As I indicated during the opening ceremony, one objective in planning this workshop has been to review the status of TPS in Africa, determine its main constraints and achievements, and develop a set of recommendations that will form the backbone for future activities and research collaboration with countries in the region. This close interaction between CIP and national programs is currently a basic issue, and we would like to improve it as much as possible.

To my knowledge, presently there is no clear updated strategy for the near future on TPS research in this region. Strategies developed several years ago are probably out of focus today and need to be reviewed and updated. We have some general considerations, ideas, and expectations for the near future, but I really believe that one of the main reasons for this workshop is to develop those strategies in a realistic and simple way. CIP has not escaped the financial constraints that affect all other international centers and we are currently trying to keep our support for all those activities that are high priorities in each of our research programs.

Although I have worked with CIP for almost 20 years, and I have been deeply involved in several aspects of TPS research in different countries during the past few years, I'm relatively new in this region, and my knowledge of the local situation is still limited. I assumed the responsibility for the Middle East and North Africa (MENA) region only one year ago, and I'm still learning a few things. However, I believe that I have already developed a global idea on TPS use and future expectations for this region. I intend to explain these global ideas to you, get your reactions, and from them draw some specific conclusions and make plans for the future.

No doubt several positive achievements have been made in the use of TPS worldwide. This is the case of Indonesia, Peru, Egypt, Nicaragua, Sri Lanka, and India, where TPS is presently being used (under different

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systems) by farmers. But in several other cases, TPS technology has not advanced as expected and beyond routine testing of new progenies being produced, no breakthrough has taken place.

For North Africa and the Middle East, we intend during this meeting to review in detail the status of TPS, country by country, and to develop some conclusions on the future of TPS utilization.

During the past few months, I have been reviewing the MENA region in detail, and have found the following situation: for general potato production, TPS achievements, and future perspectives, we can clearly separate two subregions within MENA: North Africa and the Middle East.

In North Africa (mainly Morocco and Tunisia), several progenies and related TPS technologies have been tested. The results show clearly that to date neither these progenies nor the TPS technology as a whole have reached farmers, and in some cases have not even left the experimental stations. There are several reasons for this, but it is mainly the type of potatoes being planted/consumed and the tremendous influence of European potato exporters on the local market. No more than two to three varieties are planted in these countries, and no room is left for new genetic materials throughout the potato system (e.g., seed producers, intermediaries, consumers, etc.). Spunta is probably by far the most important variety planted in North Africa (95% in Tunisia). It represents what I have called the "Spunta syndrome," meaning that nothing inferior to Spunta is accepted. Although I recognize the positive and negative traits of Spunta, we will not get involved now in why this is the current situation. The important consideration is that under present conditions, TPS will always have a difficult time.

I have also noted that in North Africa, private-sector involvement in seed production and potato processing is rather limited, which accounts for the dependence upon foreign seed and poor competitiveness at all levels of the potato marketing chain.

As a conclusion from my observations during the past year, I could say that the future of TPS utilization in North Africa is limited. If TPS progenies with Spunta's traits could be developed, it might be possible to adopt this technology, but, as far as I know, this is not the case.

The other subregion within MENA is the Middle East, which has a rather different situation for potato that could result in better adoption and utilization of TPS technologies. In most of the countries in this subregion, one single variety does not control the entire market, and, because of the distance from the main European potato producers, potato programs in the Middle East have more interest in developing their own seed sources and similar technologies. In some of these countries, the private sector and processing technologies are more developed than in the other subregion I already mentioned. Thus, TPS may have more chances for acceptance than in North Africa.

Egypt is probably a unique case for achievements in TPS adoption and use in the Middle East. Also, in Middle Eastern countries such as Syria, Jordan, Yemen, and others, CIP's involvement has been somewhat restricted during recent years, and efforts should probably concentrate there.

In summary, I believe that the possibilities for future breakthroughs in North Africa in TPS adoption and use are limited. The rather specialized potato market for production and consumption doesn't allow the introduction of planting materials other than those similar to some European varieties. This situation may change in the future because of internal pressure for better-quality processing potatoes. Nevertheless, possibilities are limited.

After making observations in several countries, I have also concluded that in many cases TPS technology has never reached farmers' fields because it has never been properly evaluated. I have the feeling that in many cases the people who have received the proper training on the use of TPS are not the ones who carry out the trials. I believe we all recognize that TPS is not an easy technology to use when it is tested for the first time. Moreover, to find the most acceptable way to use TPS may require a lot of time, research, and efforts. If those conditions are not met, it is easy to reject this technology. Testing of this technology must therefore be done properly by experienced personnel.

With this in mind, we should concentrate on evaluating our goals and priorities and then come up with some clear projections for the future. Personally, I sincerely believe that a reduction in TPS activities must take place in North Africa.

### Advances in TPS Production and Use

Originally, Dr. Patricio Malagamba, from CIP-Lima, planned to present this subject and the following discussion. However, some unexpected problems forced him to cancel his trip to Egypt, and, as a consequence, he asked me to assume this responsibility. Although my experience with TPS covers more than a decade of CIP's research on this matter, I'm not fully aware of the latest advances on TPS use worldwide. Dr. Malagamba has sent me some information on this topic, which, together with my own information, I will present and discuss with you. In no way do I intend to cover all the information available at CIP's headquarters, and neither will I try to establish new policies, apart from those already established.

I will start with advances in TPS use.

Experiences reported from around the world have so far indicated that the possibilities for producing potatoes in a given environment by using TPS are much greater when the following conditions are present:

1. Potatoes can be grown during 3-4 months of the year (acceptable climatic conditions for crop development).
2. Normal yields are low because of the high incidence of pests and diseases transmitted by seed tubers.
3. The cost of seed tubers represents a high proportion of the total potato production cost.
4. Fields under potato cultivation are rather small.
5. Specialized manual labor in horticultural practices is abundant.
6. Consumers do not request perfect tuber uniformity.
7. The cost of potatoes on the market is high.

One of the many advantages of using TPS as a source of planting material is its flexibility in uses. Thus, it can be used to produce consumption tubers directly after the first generation (F1), or as a source of planting material for consecutive clonal generations.

For production of consumption tubers, seedlings must be transplanted, like any horticultural plant, from nursery beds into the field, keeping an adequate distance between plants in order to produce good-sized tubers. On the other hand, to produce seedling tubers for use as future seed tubers, seedlings are also produced in nursery beds at a high plant density (usually 100 plants/$m^2$) and kept under those conditions for the production of many small-sized tubers, which will be used later as basic seed material.

This latter system, with several variations, has become more generalized worldwide, especially in countries where the availability of good-quality seed (imported or local certified, Table 1) is limited.

Trials carried out under farmers' conditions have shown the advantages in the use of seedling tubers and/or transplants (Table 2).

We can define two principal production systems according to the final destination of the product: seedling tubers as a source of good-quality seed, and tubers for direct consumption. Both systems have pros and cons and their implementation will depend on local potato production and marketing conditions. Thus, for direct consumption, we can think about those tropical areas where potatoes are not normally cultivated and could become a good source of cash or a food source for small farmers. This is especially the case for those areas between 500 and 1,000 m elevation, and where tuber uniformity and other tuber traits are not as important as in temperate countries with a long history of potato production. We have proposed a scheme for small farmers for seed production from TPS (Table 3).

However, where potato production is better organized, and climatic conditions are more suitable for it (compared with the mid-elevation tropics), possibilities exist for an expanded scheme for seed production (farmers' cooperatives, larger scale farmers, national potato programs, etc.) (Table 4).

Table 1. Approximate cost of seed tubers to plant one hectare of potatoes (in US$).

| Country | Imported seed | Certified local seed | Farmers' seed |
|---|---|---|---|
| Indonesia | 930 | n.a. | 420 |
| Sri Lanka | 1,200 | 1,065 | n.a. |
| Philippines | 1,820 | 675 [a] | 700 |
| Thailand | 2,300 | n.a. | 200 |
| Tunisia | 980 | 400 | 300 |
| Korea | n.a. | 690 [a] | 320 |
| Peru | n.a. | 480 | 360 |

a. Subsidized.
n.a. = not available.

Table 2. Approximate yield (t/ha) from potato fields planted with different planting materials under farmers' conditions.

| Country | Transplant | Seedling tubers | Local seed |
|---|---|---|---|
| Bangladesh | 30.9 | 32-37 | 10-18 |
| India | 18.2 | 32 | 24 |
| Vietnam | 6-15 | 17-24 | 15 |
| Rwanda | 20 | 21 | 15 |
| Venezuela | 16.7 | 28.3 | 13 |
| Peru | 10-29 | 18-35 | 14-21 |

Table 3. Proposed scheme for seed production starting from TPS for small farmers (0.5-1.0 ha).

| | | | |
|---|---|---|---|
| First season | 40 g | 100 $m^2$ | 1,000 kg seed (10 $kg/m^2$) |
| Second season | 1,000 kg | 0.5-1.0 ha | 10,000 kg ware |

In general, as climatic conditions improve for potato production, the different possibilities (schemes) for the use of TPS as a source of improved seed also become more complex. Thus, we could reach situations in which the use of TPS could replace the traditional scheme for seed production. The high rate of multiplication that you can obtain when using TPS results in a highly efficient system for the production of good seed, especially from the pathological viewpoint, as viruses are not transmitted by TPS.

To conclude, I would like to summarize some recent TPS releases and uses around the world.

During 1992-93, eight TPS progenies were released for commercial use in five countries: two TPS varieties for Sri Lanka, two for Nicaragua, two for Egypt, and one each for Paraguay and India (Table 5).

Table 4. Proposed scheme for seed production starting from TPS to plant 2,000 ha.

| | | | |
|---|---|---|---|
| Exp. station or private farm: | | | |
| First season | 50 g TPS | 150 $m^2$ | 100,000 tubers (670 tubers/$m^2$) |
| Second season | 100,000 tubers | 2 ha | 40 tons (20 t/ha) |
| Seed farmers: | | | |
| Third season | | 20 ha | 400 tons |
| Fourth season | | 200 ha | 4,000 tons |
| Fifth season | | 2,000 ha | 40,000 tons |

Table 5. TPS releases by country.

| Country | Variety names | Yield (t/ha) | TPS-1993 Area or t | Producers |
|---|---|---|---|---|
| Sri Lanka | Manike, Lakshmi | 20.3-35.0 | 320 t | Seed farms, private |
| Paraguay | Villa Serrana | 14.3-27.2 | 780 t | NGOs, public, private |
| Nicaragua | Papanica, Estela | 12.9-42.8 | 500 ha | Co-ops, private |
| India | HPS I/13 | 22.7-40.0 | 2,000 ha | Private |
| Egypt | Serrana x LT-7<br>Serrana x DTO-28 | 18.6-28.0 | 250 ha | Private |

Data collected from nine countries currently using TPS at the commercial level show that the level of TPS use increased remarkably in the past two years, with direct involvement in many cases from the private sector.

## Present Status of TPS Production

Because of the continuous improvement in the agronomic characteristics of TPS progenies produced at CIP, the demand for TPS has increased substantially during the past few years. This increase has been reflected in the number of TPS trials conducted by national collaborators, as well as in distribution to farmers for potato production. To meet this increasing demand, CIP has contracted with the National Agricultural Research Institute of Chile (INIA) for the production of approximately 10 kg/year of the best selected progenies. However, this amount has not been enough to meet the increased demand.

Presently, there are projects for TPS production in Chile, India, Turkey, and Indonesia, and one has just begun in Kenya. CIP selects TPS hybrids to be included in the large-scale TPS production in Chile on the basis of the best 20-25 progenies, which are each evaluated in the "International TPS Trial" conducted in about 10 countries. In addition to those country evaluations, several additional tests are conducted at CIP-Lima to help in the final selection of the progenies to be produced in Chile. Approximately 40 TPS hybrid progenies are also produced at CIP-Lima under controlled conditions, and are included later in regional evaluation trials.

As mentioned before, a few countries are producing some TPS for specific local demand. In India, during the 1992-93 season, approximately 5 kg were produced from crosses selected under local conditions. The country expects to increase TPS production substantially in the next two years to meet growing demand from local farmers.

As Dr. Kusman explained yesterday in his presentation, a TPS production project was begun a few years ago with CIP's support; it is presently able to produce large amounts of TPS to fulfill specific requests. CIP's initial idea was that Turkey, because of its favorable conditions for TPS production (flowering, fruit setting, etc.), could produce TPS to meet the expected demand from the MENA region. TPS from some progenies has been evaluated in Tunisia and its performance has been as good as that of any of the TPS produced in Chile. Virus detection techniques have also been developed in Turkey and all TPS is tested routinely, including a test for PSTVd. As Dr. Kusman indicated, the expected price Turkey will charge per kilogram of TPS will be, in general, lower than the one charged by INIA in Chile. Egypt is now the only country in the region with an increasing demand for TPS and efforts will be made in the near future to consolidate an agreement with the Egyptian private sector for the commercialization of large amounts of TPS.

As far as I know, a TPS production project has also begun in Kenya. Dr. Kidane-Mariam will probably cover more details on it in his presentation tomorrow.

The idea behind the formation of these TPS production sites is to develop capabilities in countries that have certain comparative advantages in TPS production, so that they can meet the expected and/or growing demand for TPS in that area. Thus, in our case, Turkey should produce TPS for future demand in the Middle East and North Africa. Kenya should produce TPS for countries having similar agroecological conditions and production constraints. Turkey will probably concentrate on producing TPS progenies adapted to Mediterranean conditions, with high levels of virus resistance, compared with Kenya, where problems such as late blight and bacterial wilt are the most important ones in potato production. This concept should eliminate the problems caused by transportation and physiological adaptation when producing TPS in different environments and continents. CIP will provide all the needed technical support and linkages between demand and production. We will always supply the TPS producer country with information on the best TPS progenies being selected in a given region, as well as clean parental lines. Therefore, interaction between CIP and countries conducting TPS progeny evaluations is essential.

Some of these points will be discussed in more detail this afternoon when we review needs for TPS production in the region.

I believe I will stop here and allow sufficient time for discussion. I know this is one of the most important issues for future collaboration between CIP and NARS, and you should have plenty of questions. Nothing more needs to be added to this subject because several aspects of the use and future prospects for TPS production were already discussed. Many more will be discussed before this workshop concludes. Thank you very much for your attention.

CHAPTER 2

# True Potato Seed: An Alternative to Improve Potato Production in Burundi

Donald E. Berríos*

## Introduction

Burundi is a small (27,834 km$^2$), densely populated (5,500,000) country, located in East Africa. It borders Tanzania, Zaire, and Rwanda.

Burundians have specific objectives for developing the country in agriculture:

1. Maintain self-sufficiency in food production combined with improved nutritional levels for the population.
2. Increase the monetary income of the rural population (which is around 95% of the total population).

Potato is an important crop because it is preferred over other root and tuber crops. Production of carbohydrates and proteins in a short period of time, good yield, and favorable prices provide good incentives for growing potatoes.

## Constraints to Potato Production

In Burundi, the most serious diseases to avoid during potato production are:

- Bacterial wilt race 3 caused by *Pseudomonas solanacearum.*
- Late blight caused by *Phytophthora infestans.*
- Nematodes caused by three *Meloidogyne* species *(hapla, javanica,* and *incognita).*

Other constraints are the lack of appropriate agronomic technology and sufficient quantities of clean and high-quality seeds for farmers' conditions, complemented by a lack of good methods for multiplying and distributing seeds under Burundian conditions.

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One of the Burundi Potato Research Program's objectives is to improve cultural techniques in seeking and testing technologies adapted to farmers' conditions in order to increase potato production in their fields.

The main objectives for TPS in the BPRP are to:

- Identify suitable, uniform TPS progenies for potato production under different agroecological conditions in the country.
- Gradually incorporate advanced progenies with good agronomic characteristics in multilocational on-farm trials and in new areas.

Certain conditions must be met in order to achieve these objectives:

1. Identify, evaluate, and diffuse new selected progenies.
2. Use a technological package for small farmers, especially in subsistence farming areas.
3. Adopt new TPS technology that can increase potato production in Burundi.
4. Produce good-quality planting material from TPS seedling tubers at the ISABU station and under farmers' conditions.
5. Compare the first and second seedling tuber generation with conventional seed from commercial potato varieties.

## Materials and Methods

Trials are carried out in four locations at the ISABU-Gisozi experimental station, ISABU centers, and under farmers' conditions in potato areas and nontraditional areas:

1. ISABU-Gisozi station at 2,100 m.a.s.l. (Mugamba region).
2. Munanira seed farm at 2,500 m (Mugamba region).
3. Ngozi-Kayanza swamps at 1,800 m (Bwero region).
4. Mparambo ISABU center at 850 m (Imbo region, lowland conditions).

During the 1991 season B, 17 progenies (15 hybrids and 2 open-pollinated progenies were evaluated and produced seedling tubers at the Gisozi station in potato program screenhouse facilities (Table 1).

Those materials were sent from CIP in February, 1991, and were planted in March at the Gisozi station, and harvested in July after 90 days (Table 2). Plot size for each progeny was 1 $m^2$, with 200 seeds per $m^2$.

Seedling tubers from those 17 progenies produced at the ISABU-Gisozi station were evaluated as first-generation seedling tubers in the 1992 season B (Table 3).

Table 1. TPS progenies from the 1991 season B at the ISABU-Gisozi station.

| TPS CIP number | Progeny |
|---|---|
| 988116 | F 3 x 104.12 LB |
| 989016 | LT-8 x 4.1 LB |
| 987004 | CFK-69-1 x 104.12 LB |
| 989018 | LT-9 x DTO-28 |
| 989015 | LT-7 x DTO-28 |
| 989017 | LT-9 x 4.1 DI |
| 989007 | LT-8 x 104.12 LB |
| 985011 | CFK-69-1 x 4.1 DI |
| 990001 | Achirana x 104.12 LB |
| 990002 | Achirana x DTO-28 |
| 988006 | Achirana x LT-7 |
| 989019 | Maine-28 x DTO-28 |
| 989020 | Maine-28 x 104.12 LB |
| 989021 | Serrana x 4.1 DI |
| 982002 | 4.1 DI open-pol. |
| 982003 | 104.12 LB open-pol. |
| | 80N-37.11 x 104.12 LB. |

Sixteen advanced progenies (hybrids) sent from CIP in April, 1992, were evaluated during the 1993 season A (Table 4). Those materials were planted in September and harvested in December after 90 days.

Seedling tubers from those advanced hybrid progenies will be planted in the next season, 1994 A, as a first generation. Percentage of emergence, number of tubers at harvest, and production per m$^2$ are shown in Table 5.

Table 6 shows the results from the second-generation seedling tubers with 12 progenies, previously selected from the 17 hybrids planted in the 1992 B season as a first seedling tuber generation in comparison with a commercial variety Muruta (check), which is well adapted to swamps.

Trials were carried out during the 1993 season C in swamp conditions at Ngozi and Kayanza. Table 6 shows performance in terms of percentage of emergence, percentage of bacterial wilt at harvest, color and uniformity for shape at harvest, and average yield.

Currently, 15 TPS progenies sent from the CIP SSA region in Nairobi in March, 1994, were planted in the Gisozi screenhouse to produce seedling

Table 2. Seventeen advanced true potato seed progenies—evaluation and production of seedling tubers under ISABU-Gisozi screenhouse conditions, season 1991B.

| Progeny | Emergence (%) | No. of tubers at harvest | Color unif. at harvest[a] | Yield ($kg/m^2$) |
|---|---|---|---|---|
| 988116 | 100 | 285 | 8 | 4.9 |
| 80N-37-11 | 100 | 607 | 8 | 4.7 |
| 989016 | 90 | 257 | 6 | 4.3 |
| 987004 | 100 | 468 | 9 | 4.1 |
| 989018 | 100 | 350 | 9 | 3.8 |
| 990001 | 95 | 371 | 8 | 3.7 |
| 982002 | 100 | 354 | 6 | 3.5 |
| 989015 | 90 | 350 | 9 | 3.4 |
| 989017 | 95 | 303 | 9 | 3.4 |
| 989004 | 90 | 242 | 8 | 3.1 |
| 990002 | 95 | 294 | 8 | 3.1 |
| 988006 | 90 | 224 | 5 | 3.0 |
| 985011 | 90 | 271 | 6 | 3.0 |
| 982003 | 90 | 269 | 9 | 3.0 |
| 989019 | 90 | 292 | 9 | 2.8 |
| 989020 | 90 | 232 | 9 | 2.4 |
| 989021 | 85 | 178 | 8 | 2.4 |

a. On a scale of 1 to 9, where 1 = poor and 9 = excellent.

tubers for further evaluation as first and second seedling tuber generations under farmers' conditions.

## Results and Discussion

For season 1991 B (Table 2), number of tubers per $m^2$ varied from 607, 468, and 371 for progenies 80N-37.11 x 104.12 LB, 987004, and 990001, respectively, to 178 for 989021. Progenies 988116, 80N-37.11 x 104.12 LB, 989016, and 987004 yielded more than 4 $kg/m^2$.

Sixteen progenies evaluated during season 1992 B at the Gisozi-ISABU station (Table 5) used the same parameters as Table 2. Average emergence is 95%, number of tubers ranged from 336 to 110 per $m^2$. But yield per $m^2$ increased compared with that shown in Table 2. Progeny 989013 produced 6.9 kg, followed by 900881 with 6.1 kg. If we can extrapolate production per hectare, the first two progenies should yield 69 and 61 t/ha. No problems with diseases and rotting were observed during growing or at harvest.

Table 3. First-generation seedling tubers with 17 advanced selected progenies at the ISABU-Gisozi station, season 1992B.

| Progenies[a] | | Emer. at 30 DAP (%) | Vigor at 60 DAP[b] | Unif. at harvest[b] | Total yield (t/ha) | Marketable yield (%) |
|---|---|---|---|---|---|---|
| 988116 | (M) | 100 | 7 | 8 | 42.1 | 95 |
| | (G) | 100 | 7 | 8 | 47.0 | 90 |
| 988006 | (M) | 100 | 8 | 9 | 53.8 | 90 |
| | (G) | 100 | 8 | 9 | 64.6 | 85 |
| 990002 | (M) | 100 | 7 | 6 | 59.0 | 85 |
| | (G) | 100 | 7 | 6 | 51.5 | 85 |
| 990001 | (M) | 96 | 8 | 7 | 70.0 | 85 |
| | (G) | 96 | 8 | 6 | 72.3 | 90 |
| 989020 | (M) | 100 | 7 | 7 | 69.2 | 90 |
| | (G) | 96 | 6 | 7 | 58.5 | 90 |
| 989015 | (M) | 100 | 7 | 6 | 60.0 | 80 |
| | (G) | 100 | 7 | 7 | 47.7 | 90 |
| 989018 | (M) | 100 | 7 | 7 | 51.8 | 70 |
| | (G) | 98 | 7 | 7 | 62.6 | 75 |
| 989017 | (M) | 98 | 7 | 7 | 62.5 | 75 |
| | (G) | 100 | 7 | 7 | 60.2 | 70 |
| 987004 | (M) | 100 | 7 | 7 | 74.1 | 60 |
| | (G) | 100 | 6 | 6 | 62.8 | 70 |
| 982002 | (M) | 94 | 7 | 6 | 34.7 | 85 |
| | (G) | 96 | 8 | 5 | 36.1 | 90 |
| 989021 | (M) | 100 | 7 | 6 | 34.7 | 85 |
| | (G) | 96 | 8 | 5 | 36.1 | 90 |
| 989016 | (M) | 100 | 8 | 5 | 58.9 | 90 |
| | (G) | 100 | 8 | 6 | 53.3 | 95 |
| 80Nx104 | (M) | 100 | 9 | 9 | 58.1 | 90 |
| | (G) | 100 | 9 | 9 | 71.9 | 80 |
| 982003 | (M) | 100 | 8 | 6 | 49.0 | 80 |
| | (G) | 100 | 9 | 6 | 48.4 | 90 |
| 989007 | (M) | 100 | 8 | 5 | 70.8 | 95 |
| | (G) | 98 | 8 | 5 | 60.3 | 85 |
| 985011 | (M) | 100 | 7 | 7 | 49.7 | 90 |
| | (G) | 100 | 7 | 7 | 63.4 | 95 |
| 988116 | (M) | 100 | 7 | 6 | 91.9 | 80 |
| | (G) | 100 | 7 | 6 | 70.7 | 75 |

a. M = Munanira, G = Gisozi.
b. On a scale of 1 to 9, where 1 = poor and 9 = excellent.

Table 4. TPS progenies evaluated during the 1993 season A.

| TPS CIP number | Progeny |
|---|---|
| 978001 | Atzimba x R-128.6 |
| 978004 | Atzimba x DTO-28 |
| 985012 | Atzimba x Katahdin |
| 989003 | Serrana x Katahdin |
| 985003 | Serrana x LT-7 |
| 989012 | Serrana x TS-3 |
| 989013 | Serrana x 104.12 LB |
| 989014 | Serrana x Katahdin |
| 989024 | Maine-28 x TPS-113 |
| 990004 | LT-9 x TPS-113 |
| 989009 | LT-9 x 104.12 LB |
| 989004 | I-1035 x Katahdin |
| 900881 | |
| IP 88002 | HPS-I/67 |
| IP 88004 | HPS-II/67 |
| IP 88005 | HPS-7/13 |

Table 3 shows the 17 progenies evaluated during the season 1992 B to produce seedling tubers under screenhouse conditions, and results from the first generation are promising at Munanira and Gisozi. The average percentage of emergence in the field is 98%, vigor at 60 days after planting (DAP) is between 6 and 9, which is good; there were no symptoms of late blight at 75 DAP; tuber uniformity at harvest was from 5 to 9 in terms of color; and the total and marketable yields in tons per hectare range from 74.1 for progeny 987004 to 34.7 for 982002 and 989021. The percentage of marketable tubers averaged 80%.

Table 6 shows results from the second evaluation in the field of 12 advanced progenies selected from the previous 17 progenies (first seedling tuber generation) and one commercial variety as a control. Emergence at 30 DAP ranged from 90 to 100%, late blight score from 1 to 2 (because of the dry season in swamps), and bacterial wilt averaged 1.5%. Progeny 989018 had 5.8% BW, followed by Muruta with 4.0%, but progenies such as 987004, 990001, 985007, 989020, and 988006 didn't show any symptoms. Yields among the first five progenies showed no differences, with production of more than 30 t/ha. Although Muruta had a low yield, it is well adapted to swamps.

Table 5. Production of seedling tubers with 16 advanced progenies (international trials) at Gisozi-ISABU station, season 1992A.

| Progeny | Emergence (%) | No. of tubers at harvest | Color unif. at harvest[a] | Yield (kg/$m^2$) |
|---|---|---|---|---|
| 989013 | 100 | 336 | 8 | 6.9 |
| 900881 | 95 | 292 | 7 | 6.1 |
| 985003 | 100 | 276 | 8 | 5.8 |
| 989024 | 95 | 262 | 7 | 5.6 |
| 989003 | 100 | 255 | 9 | 5.2 |
| IP 88002 | 100 | 305 | 8 | 5.2 |
| 990004 | 100 | 286 | 8 | 4.9 |
| 985012 | 95 | 294 | 8 | 4.8 |
| 989014 | 90 | 241 | 8 | 4.8 |
| IP 88005 | 100 | 249 | 9 | 4.7 |
| 978001 | 100 | 227 | 7 | 4.2 |
| 989004 | 100 | 225 | 8 | 4.2 |
| IP 88004 | 95 | 168 | 9 | 3.9 |
| 978004 | 90 | 190 | 7 | 3.7 |
| 989009 | 85 | 160 | 7 | 3.7 |
| 989012 | 80 | 110 | 6 | 2.9 |

a. On a scale of 1 to 9, where 1 = poor and 9 = excellent.

## Conclusions

TPS is a good alternative for producing high-quality planting material free of diseases and with low bacterial wilt latent infection, which is one of the major constraints to potato production in Burundi.

The availability of cheaper potato seed, in a short time and in the off-season, shows the good potential of TPS, because the absence of good-quality seed and the high cost limit potato production in this country.

TPS has a better possibility of being adopted in crop rotations and associations in the basic farming system, in hills during the two rainy seasons, and in swamps (marshy valleys) during the dry season, according to small farmers' needs.

Because farmers in Burundi's potato areas are well trained on horticultural crop production, seedling tubers from TPS could be easy to use and could complement their activities.

Table 6. Second seedling tuber generation, field performance with 12 advanced selected progenies and check variety Muruta in Burundi, season 1993C, marshy valley conditions.

| Progenies | Emer. at 30 DAP (%) | Bacterial wilt (%) | Unif. at harvest[a] | Yield (t/ha) | |
|---|---|---|---|---|---|
| 988116 | 100 | 2.2 | 8 | 34.80 | a |
| 987004 | 100 | 0 | 8 | 33.63 | a b |
| 990001 | 95 | 0 | 9 | 33.63 | a b |
| 985007 | 100 | 0 | 8 | 31.55 | a b c |
| 989020 | 90 | 0 | 8 | 30.95 | a b c |
| 989015 | 95 | 1.3 | 7 | 29.50 | b c |
| 988006 | 100 | 0 | 9 | 28.40 | c d |
| 989017 | 100 | 0.8 | 7 | 28.38 | c d |
| 989021 | 100 | 2.5 | 6 | 27.38 | c d |
| 989019 | 95 | 1.3 | 8 | 26.98 | c d |
| 985011 | 100 | 2.5 | 6 | 26.75 | c d |
| 989018 | 90 | 5.8 | 7 | 24.58 | d |
| Muruta | 100 | 4.0 | 9 | 24.40 | d |
| Average | 97.1 | 1.5 | 8 | 29.30 | |
| C.V. | | | | 7.3 | |

a. On a scale of 1 to 9, where 1 = poor and 9 = excellent.

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CHAPTER 3

# Seedling Tubers and Potato Production from True Potato Seed: A New Technique for the Crop In Egypt

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## Introduction

The potato is an important vegetable crop in Egypt. It occupies about 20% of the total area intended for vegetable production. It has continuously gained importance under the pressure of increasing population. More than two million tons of potatoes are produced. About 10% is exported to Europe and the Middle East, 10% is kept for seed, and the rest is consumed locally. Annual per capita consumption is 30 kg (El-Bedewy and Sharara, 1990). To increase local consumption, both the price of consumer potatoes and production costs have to be reduced (Vander Zaag and Horten, 1983). The use of true potato seed (TPS) instead of tubers for propagation offers this possibility (Sadik, 1983; Malagamba et al., 1984).

Potatoes in Egypt are traditionally grown in three seasons. Farmers plant a spring crop in January and February, followed by an autumn crop between August and mid-October, and then a winter crop, planted from mid-October to late November (Figure 1). They harvest the last crop early for export. Producers import seed tubers from Europe for planting in the spring, averaging more than 40,000 tons annually (El-Sadany and Salam, 1991). They also save seed from the spring crop and store it for use in autumn or winter, though this system has several problems (Engels and Schwenkel, 1986).

Because of the high cost of both imported seed tubers and locally produced improved seed (Crissman et al., 1990), there is an interest in an alternative source of planting material. Recent applied research done by the International Potato Center (CIP) in cooperation with the Ministry of Agriculture in Egypt has shown that it is possible to produce seedling tubers from TPS.

Because of a reduction in planting rate of seedling tubers relative to regular seed tubers, 750 kg/ha versus 4-5 tons/ha, respectively, the cost per

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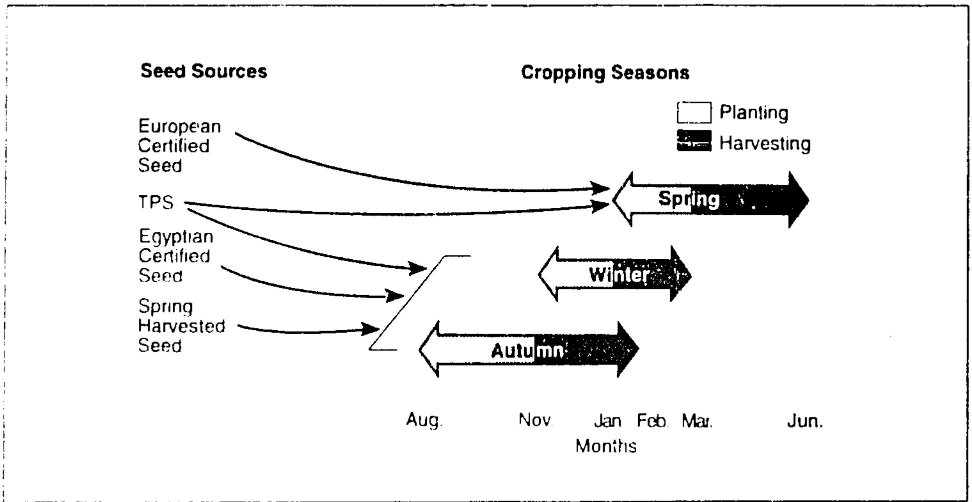


Figure 1. Flow of seed from different sources for planting during three planting seasons.

unit area planted is dramatically reduced. Specifically, the cost of seedling tuber production was only 53% and 44% of the cost of regular seed tubers used during the fall seasons of 1988 and 1989, respectively (El-Bedewy and Crissman, 1991; Sabaa et al., 1991). This technology provides a clear economic alternative.

CIP has continued efforts since 1976 to improve production technology and to expand potato cultivation to new areas in the developing world (Sadik, 1983; Wiersema, 1984; CIP, 1988a, 1988b, 1989, 1992; Upadhya et al., 1990). In Egypt, private companies (Pico, Egaseed, High Tec, and Pioneer) are producing seedling tubers from two TPS registered progenies and distributing them as high-quality seed materials to potato growers (Rizk et al., 1991).

Our studies noted the superiority of TPS progenies Serrana x LT-7 and Serrana x DTO-28 that were officially released by the Egyptian Ministry of Agriculture. Other superior progenies were CFK-69.1 x 104.12LB, Atzimba x DTO-28, and Serrana x 104-12-LB. Average yields were 8.7, 7.7, and 8.7 kg/m$^2$ in 1990, 9.8, 8.2, and 8.8 kg/m$^2$ in 1991, and 11.0, 8.6, and 8.8 kg/m$^2$ in 1992, respectively. Larger seedling tubers (5-20 g) yielded higher than smaller sizes (< 5 g). Seedling tubers compared well with European varieties in farmers' fields, and can be stored at ambient temperature for about three months instead of in costly cold stores needed for seed tubers.

Results from research on potato production from TPS included screening of several TPS progenies, seedling tuber production with promising progenies at different locations, and performance of seedling tubers at the Kafr El-Zayat Research Station as well as in growers' fields.

## Materials and Methods

Research was carried out at the Kafr El-Zayat station (30"40" N, 30"50" E) in the Governorate of Gharbia, which is one of several centers for potato production. The soil type is sandy loam. The experiment station is situated in the center of the Nile Delta, an area characterized by low rainfall (less than 100 mm), moderate winter temperatures (average from November to April about 17°C), and high summer temperatures (average from May to October about 27.6°C). Crop production in this area depends on irrigation throughout the year.

Day-night temperature differentials are large, and the optimal growing period for potato is shortened by low minimum temperatures from December to February (with the possibility of frost) and high maximum temperatures from May to September (average maximum temperature around 36.5°C). Daylength increases from 10.2 h in December to 14.0 h in June and then decreases again from July through November.

The following experiments were carried out during 1990, 1991, and 1992.

### Screening of TPS progenies

In the spring of 1990, 1991, and 1992, we sowed several TPS introductions from CIP (Lima, Peru) in soil nursery beds of 1 $m^2$ each at Kafr El-Zayat. The nursery beds were arranged in a complete randomized block design with three replications. We sowed about 200 seeds per square meter. We mixed peat moss in the top 3 cm of the soil, and applied phosphorus (P) in the form of 15% calcium superphosphate as a single dressing (400 $g/m^2$) before sowing. Care was taken to mix the fertilizer thoroughly in the seedbed. Potassium (K) and nitrogen (N) in the form of sulfate, as well as urea, were split in three doses of 5 g of N and 5 g of $K/m^2$. We applied the first dose 14 days after emergence and the other two every two weeks (El-Bedewy et al., 1987). Plants were thinned to $100/m^2$. We used normal soil for hilling.

We used insecticides and fungicides to protect the plants from aphids, potato tuber moth (PTM), and early and late blight infection. We irrigated with sprinkling cans in the early stages after planting and during emergence, and by flooding following seedling establishment. We used plastic tunnels to protect seedlings against low temperatures during the first two months after planting. Harvesting was done manually at 130 days. We also tested late blight resistance.

### Seedling tuber production of promising progenies at different locations

During 1990, 1991, and 1992, five TPS progenies were planted at two locations, namely, the CIP station at Kafr El-Zayat and the Agricultural Research Center (ARC) at El-Kurashia. The progenies were Serrana x DTO-28, Serrana x DTO-33, Atzimba x DTO-28, Serrana x LT-7, and Atzimba x LT-7. The total nursery area was about 282 $m^2$ during the three years. Seedbed preparation, fertilizer application, and other cultural practices were similar to those of the first experiment.

**Effect of storage conditions, seedling tuber size, and planting density on productivity of fall-crop potatoes**

This experiment was designed to test the effects of TPS progenies, tuber size, plant density, and storage conditions on the productivity of seedling tubers.

Treatments were:

1. Four TPS progenies: Serrana x DTO-33, Atzimba x LT-7, Serrana x LT-7, and Atlantic x LT-7.
2. Two seedling tuber sizes: < 5 g and 5-20 g.
3. Two storage conditions: cold store (4°C) and Nawalla.*
4. Two plant densities: 1 and 2 tubers per hill.

Treatments for progeny seedling tuber size and plant density were laid out in a factorial arrangement in a complete randomized block design for each of the two storage conditions separately.

The experiment was planted during 1990, 1991, and 1992 in October, in plots 4.7 $m^2$ with three replications, and harvested in February. Row distance was 75 cm and planting distance within rows was 25 cm. NPK was added at the rate of 350 kg N, 178.5 kg $P_2O_5$, and 171 kg $K_2O$ per ha. Starting from the fifth week, the crop was regularly sprayed every two weeks to protect it against fungal diseases and PTM. Aphids and white flies were controlled by spraying the crop with insecticide as required.

**Productivity of seedling tubers versus Alpha seed tubers**

Seedling tubers (5-20 g) of four TPS progenies were planted together with variety Alpha tubers in October using a complete randomized block design with three replications and were harvested in January of 1990, 1991, and 1992. Plot area was 9.4 $m^2$. Plant density and fertilizer were similar to those of the third experiment.

**Performance of seedling tubers in growers' fields versus commercial cultivars during the fall season of 1990, 1991, and 1992**

TPS seedling tubers (5-20 g) of Serrana x LT-7 and Serrana x DTO-28 were compared with commercial varieties in the Delta and newly reclaimed

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* The nawalla is a traditional Egyptian store for keeping potatoes at ambient temperature.

areas in growers' fields. They were planted in September/October and harvested in January of 1990, 1991, and 1992. We advised farmers to use cultural practices similar to those of the third experiment.

## Results and Discussion

### Screening of TPS progenies for seedling tuber production

Progenies CFK-69.1 x 104.12.LB and Serrana x DTO-28 were superior (Table 1). Other promising progenies were Serrana x LT-7 and Serrana x 104.12.LB. Average yield of seedling tubers in 1990 was, respectively, 9.0, 9.1, 8.7, and 8.7 kg/m$^2$ compared with 9.8, 8.5, 8.8, and 8.4 kg/m$^2$ in 1991, and 11.0, 7.8, 8.8, and 8.0 kg/m$^2$ in 1992. Number of tubers/m$^2$ in 1990 was, respectively, 824, 640, 743, and 870/m$^2$ compared with 860, 570, 740, and 675/m$^2$ in 1991, and 916, 540, 833, and 636/m$^2$ in 1992. Progeny CFK 69.1 x 104.12.LB was consistent in performance and had the highest yield (9.9 kg/m$^2$) as a mean of three years. A similarly high number of tubers per unit area was obtained compared with the rest of the TPS progenies included in this study. CFK-69.1 x 104.12.LB is resistant to late blight, which is one of the major production constraints in Egypt, and therefore yielded consistently better than other progenies. Atzimba x LT-7 yielded the lowest, with a mean yield of 6 kg/m$^2$.

In the multilocational trials, all TPS progenies except for Atzimba x LT-7 (Table 2) had more or less similar yields, ranging from 7.4 to 7.7 kg/m$^2$. Atzimba x LT-7 was again found to yield the lowest, and its uniformity for both foliage and tuber characters was not acceptable. The relatively low yield at the ARC El-Kurashia station, however, may be related to soil type and poor drainage.

Table 1. Comparison among different TPS hybrid progenies in nursery beds in 1990, 1991, and 1992, Kafr El-Zayat, Egypt. Numbers in all columns are an average of three replications.[a]

| Pedigree | 1990 | | 1991 | | 1992 | | Mean yield of 3 years |
|---|---|---|---|---|---|---|---|
| | No. of tubers/m$^2$ | Yield/m$^2$ | No. of tubers/m$^2$ | Yield/m$^2$ | No. of tubers/m$^2$ | Yield/m$^2$ | |
| CFK 69.1 x 104-12-LB | 824 | 9.0 | 860 | 9.8 | 916 | 11.0 | 9.9 |
| Serrana x DTO-28 | 640 | 9.1 | 570 | 8.5 | 540 | 7.8 | 8.5 |
| Serrana x 104-12-LB | 743 | 8.7 | 740 | 8.8 | 833 | 8.8 | 8.8 |
| Serrana x LT-7 | 870 | 8.7 | 675 | 8.4 | 636 | 8.0 | 8.4 |
| Atzimba x LT-7 | 685 | 5.9 | 682 | 6.0 | 702 | 6.1 | 6.0 |
| Atzimba x DTO-28 | 666 | 7.7 | 776 | 8.2 | 732 | 8.6 | 8.2 |

a. Dates for sowing were 17-I-90, 13-I-91, and 5-I-92. Harvest dates were 29-V-90, 25-V-91, and 2-VI-92.

Table 2. Seedling tuber production of five TPS progenies at two locations in 1990, 1991, and 1992, Kafr El-Zayat and El-Kurashia, Egypt.

| Factor | Year | | | | | | Mean yield/m$^2$ |
|---|---|---|---|---|---|---|---|
| | 1990 | | 1991 | | 1992 | | |
| | Kafr El-Zayat | El-Kurashia | Kafr El-Zayat | El-Kurashia | Kafr El-Zayat | El-Kurashia | |
| **Serrana x DTO-28** | | | | | | | |
| Area (m$^2$) | 96 | 45 | 24 | 24 | 48 | 20 | |
| Total yield (kg) | 912 | 185.4 | 240 | 180 | 437 | 100 | |
| Average yield (kg/m$^2$) | 9.5 | 4.1 | 10 | 7.5 | 9.1 | 5 | 7.5 |
| No. of tubers/m$^2$ (<5 g) | 376 | 696 | 420 | 243 | 413 | 515 | |
| (>5 g) | 426 | 753 | 996 | 298 | 505 | 611 | |
| **Serrana x DTO-33** | | | | | | | |
| Area m$^2$ | 24 | 0 | 0 | 0 | 0 | 0 | |
| Total yield (kg) | 177.6 | 0 | 0 | 0 | 0 | 0 | |
| Average yield (kg/m$^2$) | 7.4 | 0 | 0 | 0 | 0 | 0 | 7.4 |
| No. of tubers/m$^2$ (<5 g) | 466 | 0 | 0 | 0 | 0 | 0 | |
| (>5 g) | 426 | 0 | 0 | 0 | 0 | 0 | |
| **Atzimba x DTO-28** | | | | | | | |
| Area m$^2$ | 24 | 21 | 24 | 0 | 0 | 0 | |
| Total yield (kg) | 225 | 112 | 216 | 0 | 0 | 0 | |
| Average yield (kg/m$^2$) | 9.4 | 5.3 | 9 | 0 | 0 | 0 | 7.9 |
| No. of tubers/m$^2$ (<5 g) | 478 | 185 | 432 | 0 | 0 | 0 | |
| (>5 g) | 474 | 266 | 960 | 0 | 0 | 0 | |
| **Serrana x LT-7** | | | | | | | |
| Area (m$^2$) | 24 | 12 | 20 | 0 | 20 | 0 | |
| Total yield (kg) | 206 | 48 | 168 | 0 | 170 | 0 | |
| Average yield (kg/m$^2$) | 8.6 | 5 | 8.4 | 0 | 8.5 | 0 | 7.6 |
| No. of tubers/m$^2$ (<5 g) | 380 | 185 | 350 | 0 | 362 | 0 | |
| (>5 g) | 426 | 112 | 419 | 0 | 450 | 0 | |
| **Atzimba x LT-7** | | | | | | | |
| Area (m$^2$) | 24 | 12 | 0 | 0 | 0 | 0 | |
| Total yield (kg) | 182 | 68.4 | 0 | 0 | 0 | 0 | |
| Average yield (kg/m$^2$) | 7.6 | 5.7 | 0 | 0 | 0 | 0 | 6.7 |
| No. of tubers/m$^2$ (<5 g) | 448 | 180 | 0 | 0 | 0 | 0 | |
| (>5 g) | 360 | 248 | 0 | 0 | 0 | 0 | |

It is noteworthy that seedling tuber yield continued to improve. El-Bedewy and Crissman (1991) reported an average yield of 6 kg/m$^2$. Yield reported herein thus represents a 22% increase over previous records.

### Productivity of seedling tubers versus Alpha seed tubers

The average yields for the four tested progenies ($G_1$) for three years were 23.9 t/ha for Serrana x LT-7, 18.1 t/ha for Atlantic x LT-7, 23.1 t/ha for Atzimba x DTO-28, and 25 t/ha for Serrana x DTO-28 (Table 3). TPS progeny Serrana x DTO-28 was outstanding, and was almost equal to variety Alpha in spite of its small tuber size (5-20 g). Serrana x DTO-28 was also a top yielder in Bangladesh (Sikka, 1985), but Serrana x LT-7 has more tuber uniformity and more acceptable shape than the other three progenies.

### Performance of seedling tubers in growers' fields

Data from the on-farm trials conducted from 1990 to 1992 (Table 4) demonstrated that TPS progenies Serrana x DTO-28 and Serrana x LT-7 gave high total yields in both the Delta and reclaimed area. These yields ranged from 23.7 to 32.3 t/ha, with a mean of 26.6 t/ha for the two TPS progenies. The mean yield of the five European varieties was 27.3 t/ha, ranging from 23.2 to 31.5 t/ha.

The results suggest that seedling tubers compared well with European varieties in farmers' fields and could provide alternative planting materials for production, at least for consumption in rural areas (Sikka et al., 1990). Seedling tubers should thus be part of a comprehensive seed program.

Table 3. Comparison between different seedling tubers of different progenies ($G_1$) and variety Alpha in 1990, 1991, and 1992.

| Progeny or variety | Pedigree | Yield | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1990 | | 1991 | | 1992 | | Mean |
| | | kg/9.4 m$^2$ | t/ha | kg/9.4 m$^2$ | t/ha | kg/9.4 m$^2$ | t/ha | t/ha |
| 985003 | Serrana x LT-7 | 25.3 | 24.1 | 24.8 | 23.7 | 25.6 | 24.1 | 23.9 |
| 986001 | Atlantic x LT-7 | 18.8 | 17.9 | 19.1 | 18.3 | 18.6 | 18.0 | 18.1 |
| 978004 | Atzimba x DTO-28 | 24.4 | 23.4 | 23.6 | 22.6 | 24.8 | 23.2 | 23.1 |
| 980001 | Serrana x DTO-28 | 29.0 | 23.3 | 30.0 | 23.3 | 30.2 | 28.4 | 25.0 |
| Mean | | | 23.3 | | 23.3 | | 23.7 | |
| Alpha | | 29.9 | 28.6 | 31.1 | 29.8 | 28.9 | 28.7 | 30.0 |

a. Planting dates were 2-X-89, 10-X-90, and 5-X-92. Harvest dates were 22-I-90, 3-II-91, and 27-I-92. Plot size was 9.4 m$^2$, with three replications.

Table 4. Performance of seedling tubers from TPS versus that of commercial varieties in growers' fields in 1990, 1991, and 1992, in the Delta and reclaimed area.[a]

| Year and location | Seedling tubers | | European varieties | |
|---|---|---|---|---|
| | Progeny | Yield (t/ha) | Variety | Yield (t/ha) |
| **1990** | | | | |
| Reclaimed area | Serrana x LT-7 | 25.9 | Spunta | 21.5 |
| | Serrana x DTO-28 | 22.5 | Cara | 24.8 |
| | Mean | 24.2 | | 23.2 |
| Delta | Serrana x LT-7 | 25.9 | Cara | 26.8 |
| | Serrana x DTO-28 | 27.4 | Nicola | 26.1 |
| | Mean | 26.7 | | 26.5 |
| **1991** | | | | |
| Reclaimed area | Serrana x LT-7 | 24.5 | Nicola | 28.5 |
| | Serrana x DTO-28 | 20.9 | Spunta | 23.0 |
| | Mean | 22.7 | | 25.8 |
| Delta | Serrana x LT-7 | 32.6 | Draga | 28.4 |
| | Serrana x DTO-28 | 27.2 | Diamant | 33.4 |
| | Mean | 29.9 | | 30.9 |
| **1992** | | | | |
| Reclaimed area | Serrana x LT-7 | 25.0 | Nicola | 27.5 |
| | Serrana x DTO-28 | 22.3 | Cara | 25.1 |
| | Mean | 23.7 | | 26.3 |
| Delta | Serrana x LT-7 | 35.1 | Draga | 29.0 |
| | Serrana x DTO-28 | 29.5 | Diamant | 34.0 |
| | Mean | 32.3 | | 31.5 |
| Overall mean | | 26.6 | | 27.3 |

a. Seedling tubers were planted in September and October and were harvested in December and January all three years.

Based on this experience, several companies are now using mechanical direct seeding of TPS and are considering launching commercial seedling tuber production in Egypt to supply local farmers.

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CHAPTER 4

# True Potato Seed Research in Ethiopia and Future Trends

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## Abstract

To improve the potential of true potato seed (TPS) for potato production in Ethiopia, research on various aspects of TPS has been conducted in two different agroecologies. The results have shown that several open-pollinated (OP) and hybrid progenies gave high yields of fairly uniform tubers, especially in the off-season. During the main rainy season, yields of both progeny types were low mainly because of heavy late blight pressure. The hybrid progenies performed significantly better than the OP progenies in the off-season and the reverse held true during the main season. A comparison of direct field sowing and transplanting revealed that the latter method was advantageous over the former for large-scale planting in the field. In a nursery, however, both methods worked equally well. The optimum age of seedlings for transplanting was found to be 35 days from sowing. Research on nursery bed management showed that a medium composed of 50% topsoil and 50% decayed farm-yard manure was the most suitable, and the one with 50% topsoil and 50% sand was least suitable. Application of N up to 80 g/m$^2$ and P up to 70 g/m$^2$ as a starter fertilizer increased both seedling tuber number and yield. Both seedling tuber number and yield were positively related to seedling population. The performance of seedling tubers in the production of ware potatoes is discussed and the path TPS research should follow in the future is also proposed.

## Introduction

Potato (*Solanum tuberosum* L.) has been grown in Ethiopia since its introduction by Schimper, a German botanist, in about 1858 (Pankhurst, 1964). Since then, its importance has increased markedly. In spite of its long history of cultivation and the conducive environmental conditions the country has, potato cropping has been limited to about 50,000 ha, with a national average yield of 6 t/ha, which is very low by any standard.

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The major limitation to potato production in Ethiopia is the acute shortage of seed tubers. The conventional method of propagation with tubers in developing countries is constrained by limited availability and high costs of healthy and quality seed tubers (Wiersema, 1984). According to Brown (1982), the cost of certified seed accounts for 50-70% of the total production cost and this is substantiated by experience in Ethiopia. Furthermore, the perishable nature of seeds and their bulkiness create additional storage, transportation, and distribution problems. The high cost of seed tubers and other problems associated with them have forced most Ethiopian potato growers to use small and inferior tubers from their previous harvests as planting material. This has promoted virus buildup in the seed stock.

The use of true potato seed (TPS) as an alternative means of potato production is promising in developing countries as it is a low-cost planting material, it reduces disease transmission, it is easy and cheap to store and transport, and the human food "tuber" is not buried (Malagamba, 1984; Wiersema, 1984; Umaerus, 1987). Moreover, a large quantity of healthier, first-generation seed tubers can be produced from a small nursery area. These tubers can be used successfully as planting material, as has been practiced in Vietnam (Malagamba and Monares, 1988) and China (Li and Shen, 1979). Propagation by TPS, however, is not without disadvantages, for it is characterized by lack of uniformity and the first-generation tubers are often small. These drawbacks can be overcome partially by careful selection of genotypes that give reasonable yields of acceptable-quality tubers from TPS. Currently, both open-pollinated (OP) and hybrid TPS are in use, and the hybrid TPS, although more expensive, performs better (Kidane-Mariam et al., 1985; Tuku et al., 1991).

The objective of this paper was to review TPS research in Ethiopia and to indicate the path it should follow in the future.

## TPS Research Locations

To improve the potential of TPS as an alternative means of potato production in Ethiopia and to develop local experience, research related to improvement, agronomy, and evaluation of seedling tubers has been conducted at the Institute of Agricultural Research (IAR), Holetta Agricultural Research Center (HARC), and Alemaya University of Agriculture (AUA).

The HARC is located in the central highlands at an altitude of 2,400 m. It has two distinct growing seasons. The main rainy season (June to September) is characterized by high rainfall (accounting for 82% of the annual rainfall), monthly mean relative humidity of 77%, and monthly mean minimum and maximum temperatures of 9.2°C and 20°C, respectively. Potato production during this season is limited because of heavy late blight pressure. The off-season (dry) extends from October to May. Within this period, the time between October and early January is not conducive to potato production because of frost. Between February and May, potatoes are produced using irrigation, and a small amount of rain (accounting for 17% of the annual rainfall) falls in March and April. This period is designated as a short rainy season. The monthly mean relative humidity during the dry season is 46%, and the monthly mean minimum and maximum temperatures, respectively, are 7.4°C and 24.9°C.

The AUA is located in the semi-arid tropical belt of eastern Ethiopia at an altitude of 1,980 m. The number of seasons per year, as well as dry, rainy, and frost months, is similar to that of Holetta, except that at Alemaya the short rainy season extends from March to May. The annual mean rainfall is about 750 mm, of which more than 50% falls between June and September. The monthly mean minimum and maximum temperatures are 9.9°C and 23.6°C, respectively.

## TPS Research Related to Improvement

TPS of different progenies vary considerably in their yield and tuber uniformity for color, shape, and size. To select the best-performing progenies, hybrid and open-pollinated TPS progenies were evaluated at AUA, IAR, and HARC. At AUA, some OP TPS progenies were evaluated for tuber uniformity and yield during the 1985 and 1986 crop seasons. Results (Table 1) show that progeny AL-148 yielded the highest (29 t/ha). This yield can be considered significant when compared with those of the other progenies, but the tubers lacked uniformity. On the other hand, AL-575, AL-624, AL-100, and AL-601 gave reasonable yields of uniform tubers. Although AL-450 and CIP-378194.21 gave good yields, tuber quality was not satisfactory.

At Holetta, 11 and 14 OP and hybrid progenies, respectively, were evaluated in the 1988 off- and main seasons. Detailed results were published in the Proceedings of the 2nd Triennial Meeting and Conference of the African Potato Association, which was held in Reduit, Mauritius, 23-27 July 1990. Here, we summarize the performance of some of the progenies.

Table 2 shows that plants started from OP and hybrid TPS varied considerably in their vigor and tuber uniformity. For both parameters, the hybrid progenies were superior to the OP progenies. This agrees with the results of Kidane-Mariam et al. (1985). The relatively poor performance of the OP progenies might have ensued from selfing. The progenies within each group differed remarkably among themselves in both vigor and tuber uniformity, with the differences being more pronounced among the hybrid progenies. OP progenies CIP-378371.5, AL-560, OK-86-235, and a few others

Table 1. Flower and tuber uniformity and tuber yield of open-pollinated progenies in 1985 and 1986 at Alemaya.

| Progeny | Flower color[a] | Skin color | Tuber shape | Eye depth | Tuber yield (t/ha) 1985 | 1986 | Mean |
|---|---|---|---|---|---|---|---|
| AL-100 | W | W | R | 0 | 10.6 | 16.2 | 13.4 |
| AL-148 | PW | WP | FR | 0 | 17.5 | 40.3 | 28.9 |
| AL-450 | PW | WP | R | 0 | 11.4 | 19.0 | 15.2 |
| AL-575 | P | W | FR | 0 | 18.2 | 17.5 | 17.8 |
| AL-601 | W | W | R | 0 | 14.6 | 7.9 | 11.2 |
| AL-624 | W | W | R | 0 | 17.9 | 16.3 | 17.1 |
| CIP-378194.21 | WP | WP | FR | – | NT | 16.8 | 16.8 |
| Mean | | | | | 15.0 | 19.1 | |

a. W = white, P = pink, R = round, F = flat, 0 = medium, - = shallow, NT = not included.

SOURCE: Teshome Todesse and Soloman Yilma, unpublished.

were more vigorous than hybrid progeny CIP-978004. Tuku et al. (1991) showed that at Holetta some hybrid lines received a tuber uniformity score of 4 and 3.9 out of the maximum 5, whereas the highest uniformity score for the OP was 3.6. This indicates that the hybrid progenies are more suitable for the production of uniform tubers from TPS. Progeny CIP-987004 was the most vigorous, followed by CIP-985002 and CIP-985001.

During the off-season, the hybrid progenies produced a significantly higher number of tubers/m$^2$ and yield than the OP progenies (Table 3). This corroborates the findings of Bedi and Smale (1978), Accatino (1980), Kim et al. (1983), Macaso-Khwaja and Peloquin (1983), and Kidane-Mariam et al. (1985). Tuber yields of the OP progenies ranged from 26 t/ha for UK-80.3 to 34 t/ha for AL-560, with an average yield of 31 t/ha, whereas that of the hybrids ranged from 28 t/ha for CIP-978004 to 67 t/ha for CIP-987004, with an average yield of 46 t/ha. Whether or not these yield advantages can offset the high cost of hybrid seed has not been investigated in Ethiopia. However, according to Bedi et al. (1979), hybrid seed offers fewer economic advantages than OP seed. Yields of both progeny types can be considered significant when compared with the national average of 6 t/ha. Tuber size distribution reveals that the OP progenies tend to produce smaller tubers than the hybrids; however, both produced acceptable tuber sizes. There was a positive relationship between vigor and tuber yield (Table 2).

Unlike in the off-season, in the main rainy season the OP progenies yielded much higher than the hybrids. During this season, CIP-378371.5

Table 2. Plant vigor and tuber uniformity of open-pollinated and hybrid TPS progenies during the off-season.

| Progeny | Vigor[a] | Tuber uniformity[b] | | | |
|---|---|---|---|---|---|
| | | Size | Shape | Color | Mean |
| **Open-pollinated** | | | | | |
| AL-560 | 6.8 | 3.0 | 3.0 | 3.0 | 3.0 |
| CIP-378371.5 | 8.5 | 2.5 | 2.0 | 2.3 | 2.3 |
| AL-459 | 6.5 | 2.8 | 2.5 | 2.8 | 2.7 |
| AL-563 | 6.5 | 3.5 | 3.5 | 3.8 | 3.6 |
| OK-86-235 | 6.8 | 3.3 | 2.8 | 3.5 | 3.2 |
| OK-86-240 | 5.8 | 2.5 | 3.0 | 3.1 | 2.8 |
| UK-80.3 | 4.8 | 2.8 | 2.8 | 3.5 | 3.0 |
| Mean | 6.5 | 2.9 | 2.8 | 3.1 | |
| **Hybrid** | | | | | |
| CIP-987004 | 9.8 | 3.0 | 3.0 | 2.8 | 2.9 |
| CIP-985001 | 9.0 | 3.0 | 2.8 | 3.0 | 2.9 |
| CIP-980003 | 8.0 | 3.3 | 3.3 | 3.3 | 3.3 |
| CIP-985002 | 9.3 | 3.0 | 3.0 | 3.3 | 3.2 |
| CIP-987001 | 7.8 | 2.8 | 2.5 | 4.3 | 3.2 |
| CIP-987002 | 6.8 | 3.3 | 2.8 | 3.8 | 3.3 |
| CIP-978004 | 5.8 | 3.0 | 2.8 | 3.0 | 2.9 |
| Mean | 8.1 | 3.1 | 2.9 | 3.4 | |

a. 1 = least vigorous, 10 = most vigorous.
b. 1 = least uniform, 5 = most uniform.

SOURCE: Tuku et al., 1991. The original table by Tuku et al. has LSD values.

yielded significantly higher than the rest of the progenies included in both TPS types. This cultivar flowers profusely and is also reasonably resistant to late blight. Both OP types performed poorly because of heavy late blight pressure, with average yields of 4.9 and 2.8 t/ha for the OP and hybrid progenies, respectively. From this and other research, we can conclude that using TPS for potato production in the main season does not seem feasible without the application of fungicides. We can also conclude that, with proper selection of progenitors, it is possible to develop TPS progenies that will give high yields of tubers that are fairly uniform in size, shape, and color, especially for off-season production.

## TPS Agronomy Research

To develop an improved agronomic package for potato production from TPS, several experiments were conducted. This paper presents results from the most significant ones.

## Planting System

TPS can be used to produce potatoes either by direct sowing of the seed in the field or by transplanting seedlings raised in nursery beds. At Holetta, a comparison of these two planting systems was made in 1991 and 1992 with OP (AL-624) and hybrid (AL-624 x CIP-378371.5) progenies. Number of tubers and yield were not affected by the different planting methods (Table 3). While this result agrees with that of Wiersema (1984), it conflicts with results obtained at Alemaya (Teshome Tadesse and Solomon Yilma, unpublished) and in Uganda (Kanzikwera et al., 1991). In this experiment, however, transplanting was done in a small nursery area with great care. Other experiences at Alemaya and Holetta have shown that transplanting is superior to direct field sowing in a relatively larger scale field planting. The hybrid progeny performed significantly better than the OP progeny except for number of tubers/$m^2$ in 1991 (Table 3). This agrees with the findings of many researchers, including Kidane-Mariam et al. (1985).

### Spacing and seedling density

To determine the optimum intrarow spacing for TPS at AUA, seedlings were planted at within row spacings of 10, 15, 20, and 30 cm, in rows 70 cm apart. Means of five consecutive years indicated that tuber yield was highest (23.0 t/ha) with the closest intrarow spacing and lowest (15.4 t/ha) with the widest spacing (Table 4). The difference, however, was not significant. The proportion of larger tubers increased with wider spacing (data not shown). Tuber yields varied by year, but without a trend toward increased or decreased yield.

At Holetta, the effect of number of transplants/hill and intrarow spacing on different aspects of potato production was studied in the 1992 and 1993 crop seasons. One, two, three, and four transplant seedlings were planted at 10, 20, and 30 cm intrarow spacings, in rows 75 cm apart. Both number of tubers and yield were significantly lower with one transplant per hill and with wider intrarow spacing (Table 5). However, the opposite was true for average tuber weight. Increasing the number of seedlings from one to three per hill was found to be advantageous for both parameters, but a further increase in the number of transplants did not result in a corresponding yield increase. This result substantiates results obtained in Alemaya from a somewhat similar experiment conducted from 1983 to 1986 (data not shown) and that of Kemal Mussa (1993). A decreasing number of

Table 3. Effect of direct sowing and transplanting on number of tubers and tuber yield of two TPS progenies.

| Progenies | No. of tubers/m² | Tuber yield (kg/m²) |
|---|---|---|
| **1991** | | |
| AL-624 | 840 | 5.38 |
| AL-624 x CIP 378371.5 | 829 | 7.05 |
| LSD 0.05 | NS[a] | 0.68 |
| Planting system | | |
| Direct sowing | 860 | 6.22 |
| Transplanting | 808 | 6.22 |
| LSD 0.05 | NS | NS |
| **1992** | | |
| AL-624 | 1212 | 25.71 |
| AL-624 x CIP 378371.5 | 1400 | 30.60 |
| LSD 0.05 | 142 | 3.3 |
| Planting system | | |
| Direct sowing | 1323 | 27.40 |
| Transplanting | 1290 | 28.90 |
| LSD 0.05 | NS | NS |

a. NS = not significant.

SOURCE: Berga Lemaga et al., 1994b.

Table 4. Effect of intrarow spacing on yield (t/ha) of TPS seedlings at Alemaya.

| Year | Spacing in cm | | | | |
|---|---|---|---|---|---|
| | 10 | 15 | 20 | 30 | Mean |
| 1981 | 20.0 | 28.9 | 27.5 | 15.5 | 26.0 |
| 1982 | 27.9 | 29.0 | 25.5 | 23.3 | 26.8 |
| 1983 | 27.4 | 12.1 | 23.5 | 13.3 | 18.3 |
| 1984 | 10.1 | 8.3 | 8.5 | 9.0 | 9.0 |
| 1985 | 16.0 | 12.8 | 12.6 | 11.3 | 13.2 |
| 1986 | 24.6 | 20.4 | 20.0 | 23.1 | 22.0 |
| Mean | 23.0 | 17.8 | 19.6 | 15.4 | |

SOURCE: Teshome Tadesse and Solomon Yilma, unpublished.

transplants per hill and wider spacing also exerted a similar effect on tuber size distribution (Table 5). Both increased the percentage of larger tubers. Although the interaction between number of transplants in a hill and spacing was not significant, the highest yield of 34.8 t/ha was obtained when planting three seedlings per hill at a 10 cm spacing, while the lowest yield (18.4 t/ha) was obtained with one seedling per hill planted at a spacing of 30 cm (Figure 1).

### Seedling age

The effect of transplanting TPS seedlings at an age of 49 days after sowing (DAS) was studied for seedling establishment, growth, yield components, and tuber yields at Alemaya (Kemal Mussa, 1993). The results (Table 6) show that percentage of seedling survival and tuber yield were significantly affected by seedling age at transplanting at 35 DAS, which brought about a better overall performance than transplanting at earlier or later ages. However, this optimum age of seedlings for transplanting may vary according to prevailing weather conditions, especially rainfall and temperature, and soil factors, especially fertility.

### Method and time of fertilizer application

At AUA, the effects of both method and time of fertilizer application on TPS seedling performance were studied. Fertilizer application on one side of the seedling, two sides of the seedling, in a circular form, or under the seedling did not result in significant yield differences. Comparatively, however, application on both sides of the seedling and under the seedling gave better yields (Table 7). Time of fertilizer application (data not shown) did not influence tuber yields of the seedlings. These results, however, are not conclusive and therefore merit further investigation.

### Optimization of seedling tuber production

To optimize nursery management practices with the aim of increasing seedling tuber production, experiments related to nursery bed substrate, fertilization, and seedling populations have been conducted with different progeny types at Holetta. Results from most of the experiments have been reported by Berga Lemaga et al. (1994b); here, we include only the important ones.

### Media and seedling population

The effects of various media and seedling populations on the production of seedling tubers were studied with AL-624 OP TPS. AL-624 (CIP-800946) is a good progenitor and we usually use it as a female parent. Three media with different ratios of topsoil (S), manure (M), and sand (SA) on a v/v basis were used. The seedling populations were 50, 100, and 150 seedlings/$m^2$ arranged in a factorial experiment in an RCBD. The highest

Table 5. Effect of number of transplants/hill (TPH) and intrarow spacing on number of tubers, average tuber weight (ATW), tuber yield, and tuber size distribution (%) at Holetta.

| Treatment | | No. of tubers/m$^2$ | ATW (g) | Yield (t/ha) | Size distribution (%) | | |
|---|---|---|---|---|---|---|---|
| | | | | | <20 mm | 20-50mm | >50 |
| **1992** | | | | | | | |
| No. of TPH | | | | | | | |
| | 1 | 67.7 | 30.3 | 20.5 | 3.9 | 81.1 | 15.0 |
| | 2 | 114.7 | 22.7 | 26.0 | 4.8 | 84.9 | 10.3 |
| | 3 | 131.3 | 21.4 | 28.1 | 5.4 | 83.8 | 10.9 |
| | 4 | 144.4 | 20.0 | 28.9 | 6.2 | 84.3 | 9.5 |
| Mean | | | | | 5.1 | 83.5 | 11.4 |
| LSD 0.05 | | 21.2 | 2.7 | 3.9 | | | |
| Intrarow spacing (cm) | | | | | | | |
| | 10 | 156.4 | 18.8 | 29.4 | 6.1 | 85.6 | 8.3 |
| | 20 | 107.7 | 22.6 | 24.3 | 5.3 | 85.3 | 9.3 |
| | 30 | 85.4 | 27.9 | 23.8 | 3.8 | 79.6 | 16.6 |
| Mean | | | | | 5.1 | 83.5 | 11.4 |
| LSD 0.05 | | 18.3 | 2.3 | 3.4 | | | |
| **1993** | | | | | | | |
| No. of TPH | | | | | | | |
| | 1 | 59.5 | 25.5 | 15.4 | 12.2 | 74.8 | 13.2 |
| | 2 | 89.0 | 21.0 | 18.5 | 8.7 | 84.3 | 6.9 |
| | 3 | 97.2 | 23.6 | 22.2 | 13.7 | 77.7 | 8.6 |
| | 4 | 144.4 | 17.9 | 21.1 | 11.8 | 83.0 | 5.2 |
| Mean | | | | | 11.6 | 80.0 | 8.5 |
| LSD 0.05 | | 16.9 | 2.97 | 44.1 | | | |
| Intrarow spacing (cm) | | | | | | | |
| | 10 | 127.6 | 20.6 | 24.6 | 13.7 | 80.9 | 5.3 |
| | 20 | 83.4 | 21.0 | 17.9 | 5.3 | 83.7 | 9.1 |
| | 30 | 64.7 | 24.5 | 15.4 | 13.5 | 74.7 | 11.7 |
| Mean | | | | | 11.5 | 79.8 | 8.7 |
| LSD 0.05 | | 14.6 | 2.97 | 38.2 | | | |

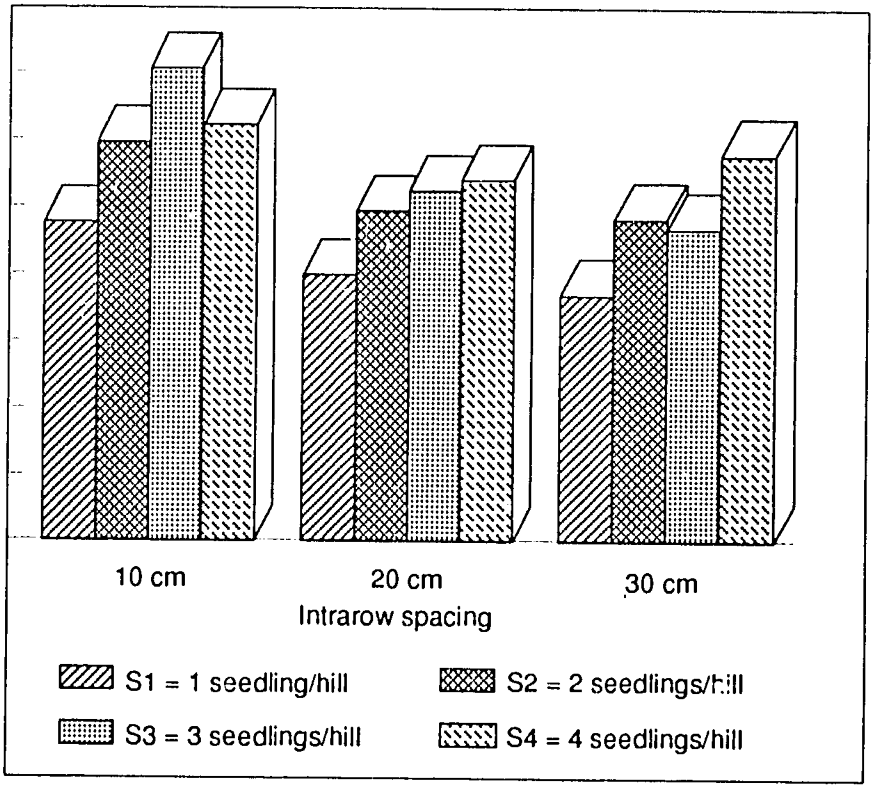


Figure 1. Ettect of number of transplants and intrarow spacing on tuber yield of TPS, 1993.

Table 6. Effect of age of seedlings on percentage transplant survival (20 days after transplanting, DAT), days to 75% flowering, senescence, number of tubers, and yield.

| Age (days) | Transplants at 20 DAT (%) | Number of days from transplanting to: Flowering | Senescence | Number of tubers/$m^2$ | Tuber yield (t/ha) |
|---|---|---|---|---|---|
| 28 | 92.9 b* | 56.6 a | 111.5 a | 161 a | 39.8 a b |
| 35 | 97.9 a | 54.3 a | 111.9 a | 163 a | 43.3 a |
| 42 | 92.3 b | 55.6 a | 109.6 a | 166 a | 41.8 a b |
| 49 | 91.4 b | 56.8 a | 107.0 a | 151 a | 38.0 b |

* Means within a column followed by the same letter do not differ significantly at the 5% level by Duncan's Multiple Range Test.

SOURCE: Kemal Mussa, 1993.

Table 7. Effect of method of fertilizer application on tuber yield of open-pollinated seedlings at Alemaya (means of 4 years).

| Fertilizer application | Tuber yield (t/ha) |
|---|---|
| One side dressing | 18.3 |
| Two side dressings | 20.9 |
| Circular form | 17.5 |
| Under the seedling | 20.9 |

SOURCE: Berga Lemaga et al., 1994a.

yield of seedling tubers was obtained in a 5:5:0 (S:M:SA) and the lowest in a 5:0:5 medium (Figure 2 and Table 8). The results are not consistent with those of Wiersema (1984), who reported that a medium containing 50% sand and 50% peat moss or 50% sand and 50% compost was a more suitable nursery medium for seedling tuber production than those that contained soil. Seedling tuber yield increased with increasing seedling populations. Number of tubers/$m^2$ and seedling population were also positively related (Table 9). The positive relationship between seedling population and number of tubers and yield was also reported by several authors, including Wiersema (1984). A large proportion of sand in the medium increased the proportion of smaller tubers.

### Media and fertilization

The effects of three mixed media whose basic ingredients were as above and three levels of nitrogen and phosphorus on number of seedling tubers and yield were determined in the main season of 1991. Fungicide was applied to control late blight as the need arose.

The medium containing 5:5:0 (S:M:SA on a v/v basis) followed by the 5:3:2 medium produced a significantly greater number and yield of seedling tubers than a 5:0:5 medium (Table 9). Increasing the levels of N and P brought about a significant increase in the number and yield of seedling tubers with only one exception. Conversely, Wiersema (1984) concluded that a pre-sowing application of NPK was not necessarily advantageous in the promotion of seedling growth.

### Type of progeny and seedling population

Differences in seedling tuber production between AL-624 (OP) and AL-624 x CIP-378371.5 (hybrid) progenies were determined where populations of 50, 100, and 150 seedlings/$m^2$ were used (Table 10). The hybrid progeny was superior to the OP progeny in both number of tubers and yield, and most differences were significant. This agrees with the findings of Kidane-Mariam et al. (1985). The number of seedling tubers increased with an increase in seedling population. On the contrary, yield

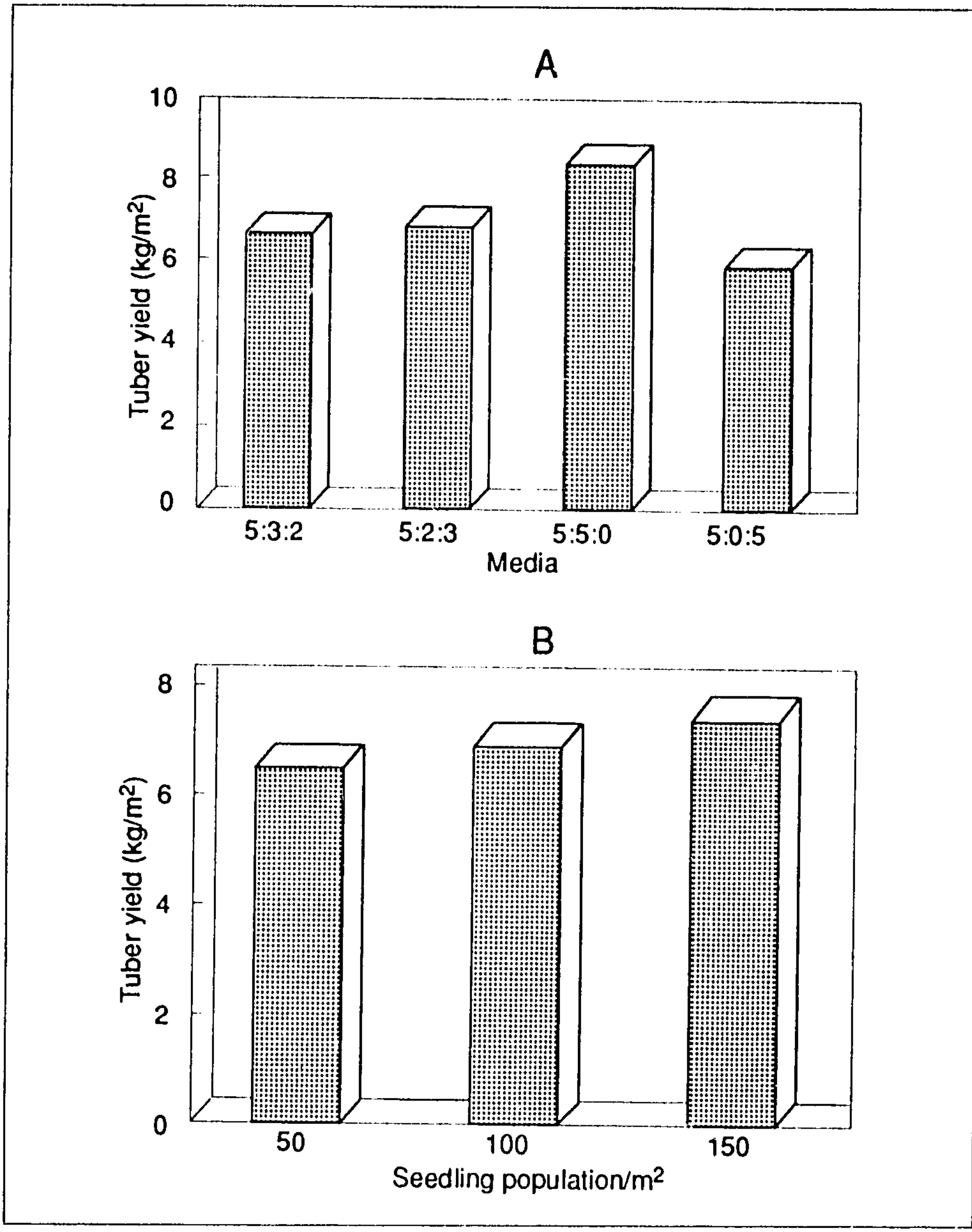


Figure 2. Effect of media (A) and seedling population (B) on seedling tuber production, 1989. The ratio is for topsoil to manure to sand.

was not affected by varying seedling population. At Holetta, we used 100 seedlings/$m^2$.

**Evaluation of seedling tubers**

The performance of different sizes of seedling tubers for the production of ware potatoes was studied at Holetta during the 1989 and 1990 growing

Table 8. Effect of different growing media (GM) and planting density (PD) of TPS on number of tubers, average tuber weight (ATW), tuber yield, and tuber size distribution (%) at Holetta, 1993.

| Treatment | No. of tubers/m² | ATW (g) | Yield (t/ha) | Size distribution (%) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Tuber yield | | No. of tubers/m² | |
| | | | | <20 mm | 20-40 mm | <20 mm | 20-40 mm |
| **GM**[a] | | | | | | | |
| 5:3:2 | 811 | 5.8 | 47.1 | 37.5 | 62.5 | 83.8 | 16.2 |
| 5:2:3 | 881 | 5.6 | 49.3 | 34.3 | 65.7 | 79.0 | 21.0 |
| 5:5:0 | 957 | 5.4 | 50.8 | 38.1 | 62.0 | 81.4 | 18.6 |
| 5:0:5 | 591 | 4.0 | 23.5 | 55.2 | 44.8 | 89.6 | 10.5 |
| Mean | | | | 41.3 | 58.7 | 83.4 | 16.6 |
| LSD 0.05 | 117 | 1.2 | 9.5 | | | | |
| **Planting density** | | | | | | | |
| 50/m² | 663 | 5.9 | 40.8 | 33.8 | 66.2 | 18.3 | |
| 100/m² | 826 | 5.3 | 45.2 | 40.1 | 59.9 | 84.5 | 15.4 |
| 150/m² | 941 | 4.4 | 42.1 | 43.1 | 57.0 | 82.0 | 18.0 |
| Mean | | | | 39.0 | 60.1 | 82.7 | 17.2 |
| LSD 0.05 | 101.5 | 1.0 | 86.1 | | | | |

a. GM = ratio of topsoil to manure to sand.

seasons. In 1989, although number of tubers produced increased significantly with increasing sizes of seedling tubers, tuber yield was not affected (Table 11). This is because of the negative relationship between tuber number and average tuber weight (Berga Lemaga and Caesar, 1990). In 1990, the smallest mother tubers (5-10 g) produced significantly lower yields than the intermediate size (10-25 g). The yield obtained from the largest (25-50 g) mother tubers did not vary significantly from that of the smallest. However, they yielded 4.3 t/ha higher than the smallest-sized mother tubers. The yields obtained in 1990 indicate that seedling tubers of all sizes can be used as planting material to give reasonably high yields of ware potatoes.

## Future Trends

As mentioned elsewhere, TPS can be used for potato production by (a) direct field sowing, (b) transplanting, and (c) seedling tubers. Research conducted in the past has shown that for relatively large-scale production in the field, transplanting seedlings from a nursery bed to the field has produced a

Table 9. Effect of seed-bed substrate and NP fertilization on seedling tuber production, 1991.

| Substrate | No. of tubers/$m^2$ | Tuber yield ($kg/m^2$) |
| --- | --- | --- |
| **TS:M:SA**[a] | | |
| 5:5:0 | 601 | 8.25 |
| 5:3:2 | 565 | 7.32 |
| 5:0:5 | 504 | 5.00 |
| LSD 0.05 | 59.7 | 0.86 |
| **Nitrogen** | | |
| 0 $g/m^2$ | 531 | 5.13 |
| 40 $g/m^2$ | 546 | 7.53 |
| 80 $g/m^2$ | 593 | 7.90 |
| LSD 0.05 | NS[b] | 0.86 |
| **Phosphorus** | | |
| 0 $g/m^2$ | 521 | 6.22 |
| 35 $g/m^2$ | 552 | 6.98 |
| 70 $g/m^2$ | 598 | 7.36 |
| LSD 0.05 | 59.7 | 0.86 |

a. TS = topsoil, M = manure, SA = sand.
b. NS = not significant.

SOURCE: Berga Lemaga et al., 1994b.

Table 10. Effect of TPS progenies and seedling population on tuber yield, 1991.

| Treatment | No. of tubers/$m^2$ | Tuber yield ($kg/m^2$) |
| --- | --- | --- |
| **Progenies** | | |
| AL-624 | 782 | 5.44 |
| AL-624 x CIP-378371.5 | 686 | 6.68 |
| LSD 0.05 | 118 | 0.80 |
| **Population** | | |
| 50 seedlings/$m^2$ | 512 | 5.68 |
| 100 seedlings/$m^2$ | 769 | 6.15 |
| 150 seedlings/$m^2$ | 921 | 6.33 |
| LSD 0.05 | 83 | NS |

SOURCE: Berga Lemaga et al., 1994b.

Table 11. Effect of size of seedling tubers on number of tubers, average tuber weight (ATW), tuber yield, and tuber size distribution (%) at Holetta.

| Size (g) | No. of tubers/m² | ATW (g) | Yield (t/ha) | Size distribution (%) (no. of tubers/m²) | | |
|---|---|---|---|---|---|---|
| | | | | <20 mm | 20-50 mm | >50 mm |
| 1989 | | | | | | |
| 5-10 | 53.3 | 17.4 | 9.1 | 12.9 | 84.2 | 2.9 |
| 10-25 | 54.4 | 15.8 | 8.6 | 12.3 | 85.3 | 2.4 |
| 25-50 | 68.6 | 14.8 | 10.2 | 13.6 | 85.0 | 1.9 |
| Mean | | | | 12.9 | 84.8 | 2.4 |
| LSD 0.05 | 14.4 | 0.6 | NS[a] | | | |

| Size (g) | No. of tubers/m² | ATW (g) | Yield (t/ha) | Size distribution (%) (tuber yield) | | |
|---|---|---|---|---|---|---|
| | | | | <20 mm | 20-50 mm | >50 mm |
| 1990 | | | | | | |
| 5-10 | 77.8 | 28.2 | 21.3 | 7.8 | 83.8 | 8.4 |
| 10-25 | 89.8 | 30.3 | 27.0 | 6.7 | 72.3 | 21.0 |
| 25-50 | 91.3 | 28.4 | 25.6 | 7.6 | 77.3 | 15.1 |
| Mean | | | | 7.3 | 78.6 | 14.4 |
| LSD 0.05 | NS | NS | 5.1 | | | |

a. NS = not significant.

better overall performance than direct field sowing. Our experience has shown that, with both of these methods, seedlings should be watered frequently and shaded to increase seedling establishment and maintain optimum plant populations for high yield. The methods are therefore not only tedious and expensive but also not very practical. This will seriously limit the adoption of TPS technology by Ethiopian potato growers.

Future research should therefore give more emphasis to developing technologies that will help maximize the production of seedling tubers for use as planting material. Important research areas should include:

1. Identification of suitable progenies for the different agroecologies. Progenies that flower and produce berries/seeds and give reasonably high yields of fairly uniform tubers will be considered suitable.

2. Identification of good progenitors.

3. Generation of appropriate agronomic packages for TPS for the different agroecologies.

4. Development of appropriate storage facilities. The widely accepted and used diffused light stores are not very suitable for storage of small first-generation tubers because the tubers dry up before sprouting. These small tubers account for about 20% of the total seedling tubers produced.
5. The number of generations of seedling tubers that can be used as planting material without deterioration should be studied.
6. Marketing of seedling tubers. To make TPS a reliable option for potato production, farmers should participate in research at all levels, and some activities should be carried out in farmers' fields. It is also important to strengthen the cooperation and collaboration we have with the Ministry of Agriculture, Ministry of State Farms, and other national institutions.

Internationally, the strong cooperation and collaboration we have with CIP, especially in germplasm exchange, should be further strengthened. It is also important to exchange germplasm and share experiences with other NARS by visiting each other's programs.

## Conclusions and Recommendations

Research conducted so far in Ethiopia has shown that potato production by TPS is a promising alternative. Progenies that can give high yields of fairly uniform tubers have been identified and required agronomic techniques have also been developed.

Potato production by TPS is economically feasible during the off-season, when late blight pressure is low. In the main rainy season, we recommend application of fungicides. We also recommend that TPS should be used to produce healthier seedling tubers and that both direct field sowing and transplanting be discouraged at least for some time to come.

We are convinced that TPS technology has a good chance to become successful in Ethiopia mainly because of the acute shortage of seed potatoes and absence of a seed-potato production program. However, to achieve this success, Ethiopia needs material and technical and financial support from CIP.

## Acknowledgments

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CHAPTER 5

# Seed Multiplication in Syria

Mohamed Abdellatif*

The General Organization for Seed Multiplication (GOSM) started producing seed potatoes in 1976 and depended on the multiplication of imported class "E" seed potatoes from European companies to obtain locally produced class "A" seed potatoes, which are planted to produce ware potatoes for consumption.

## Multiplication Plan

The organization chooses appropriate farmers from specific areas to multiply seed potatoes. Areas should have good soil and be isolated from other potato, eggplant, and tobacco crops, and almond trees.

Our specialists supervise the multiplication fields during the growing period and give the necessary instructions, in addition to clearing fields of plants with virus disease. The specialists also supervise the procedures of plucking, sorting, grading, certifying, and receiving seeds before storing or distributing them.

Until 1979, the organization dealt with only two varieties, Aran Panner and Aran Councel, which were well known in Syria at that time. The Scientific and Agricultural Research Service tested many varieties and recommended some of them. The export committee estimates the country's needs in seed potatoes and specifies varieties and quantities to be imported yearly.

The organization imports 10-50 tons of new varieties to be tested, and, if these are successful, imports larger quantities. The most important varieties in Syria are Draga, Spunta, Diamant, Nicola, and Marfona. Lower quantities of the following varieties are also planted: Sahel, Famosa, Ilona, Escort, and Planta. Varieties Lira and Monaliza are newly certified for export. Some varieties, such as Penella, Picaso, Mariana, and Oblex, are still being tested by the organization and the Scientific and Agricultural Research Service for certification if they outperform the traditional varieties.

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### Planting Dates

Potatoes are planted in Syria in three periods:

1. Spring: begins in January for the coastal region and Al-Ghab (middle region) and in February for the interior region. The crop matures from June until the end of August according to the regions.
2. Summer: planted in April for the high and cold areas centered around Damascus and Al-Kalamoun. The crop matures beginning in September and October.
3. Autumn: planted in August for interior regions. The crop matures from November until March of the next year (at that time the European market will need ware potatoes and there will be a good opportunity to export them).

Seed production fields are planted in the spring sowing period and ware potato fields are planted in all three periods.

### Distribution of Locally Produced Seeds

The needs of seed for the autumn crop are met by seed locally produced from the spring planting season, which uses imported seeds. Thus, there is no need to preserve seeds in cold stores. But seeds for the spring and summer planting periods are stored in special cold stores for seed potatoes at 2-4 °C and relative humidity of 90-95% until distribution time.

Here is a list of the quantities of seed imported, produced, and distributed for the seasons 1986 to 1993.

The Tissue Culture Department of GOSM produces seed potatoes of high quality that are nearly free of virus diseases to cover part of the country's needs.

| Year | Imported | Produced | Distributed quantity | | |
|---|---|---|---|---|---|
| | | | Autumn | Spring | Summer |
| | | | (tons) | | |
| 1986-87 | 4,425 | 32,693 | 15,558 | 12,785 | 3,350 |
| 1987-88 | 6,273 | 39,556 | 20,410 | 11,800 | 4,436 |
| 1988-89 | 7,000 | 46,377 | 8,866 | 15,553 | 2,322 |
| 1989-90 | 5,400 | 35,987 | 17,244 | 10,784 | 1,500 |
| 1990-91 | 7,900 | 51,478 | 26,825 | 11,537 | 3,500 |
| 1991-92 | 7,875 | 52,883 | 20,709 | 2,300 | 900 |
| 1992-93 | 7,166 | 35,144 | 23,000 | 10,200 | 1,300 |

Imported quantities Class "E"

| Season | Quantity (tons) | Season | Quantity (tons) |
|---|---|---|---|
| 1979-80 | 1,921 | 1987-88 | 6,273 |
| 1980-81 | 2,634 | 1988-89 | 7,000 |
| 1981-82 | 2,478 | 1989-90 | 5,400 |
| 1982-83 | 2,162 | 1990-91 | 7,900 |
| 1983-84 | 2,568 | 1991-92 | 7,875 |
| 1984-85 | 3,819 | 1992-93 | 7,166 |
| 1985-86 | 7,350 | 1993-94 | 6,160 |
| 1986-87 | 4,425 | | |

## Seed Production with Tissue Culture Techniques

The following steps are followed to produce seed with tissue culture techniques.

- Use tubers of the desired variety free of disease and insect injuries.
- Plant the tubers in petri dishes.
- Use the ELISA test. Then take stem cuttings (part of the stem with a leaf and a bud) of the healthy plants to be sterilized and planted in artificial media in test tubes.
- The stem cuttings grow and produce a root system after 20-25 days.
- Multiply plants by planting stem cuttings several times until obtaining the required quantity of plants in tubes.
- Plants are transferred from tubes to small flowerpots with peat moss in an air-conditioned greenhouse to harden and are then transferred after 15 days to tables with special soil inside the greenhouse until minitubers are obtained.

ELISA tests are made during the hardening and planting on tables to ensure plant healthiness. Tubers produced are planted in an insect-proof screenhouse to undergo ELISA tests to produce healthy tubers. Those tubers are multiplied in isolated fields supervised by our technicians, and the product is distributed to farmers for multiplication.

CHAPTER 6
# Performance of TPS in Tunisia

M. Souibgui*

## Introduction

True potato seed (TPS) trials began in Tunisia in 1984. Over a three-year period (1984-1986), potato production from TPS through direct sowing in the field or transplanting seedlings to the field proved to be less suited to Tunisian growing conditions than the use of seedling tubers produced in nurseries. Therefore, the latter technique was adopted in 1987.

This paper presents the performance of TPS hybrids and open-pollinated (OP) progenies in nurseries and of seedling tubers in the field in three different crops from 1988 to 1993.

## Materials and Methods

All TPS hybrids tested were supplied by the International Potato Center (CIP) in Lima, Peru. OP progenies, however, were collected locally from European or CIP material.

Nursery stage

TPS sowing in nurseries is usually done in February in beds filled with a substrate consisting of a mixture of soil and manure. The seeding rate is 400-500 seeds/m$^2$. After emergence, thinning is done to obtain 100 plants/m$^2$.

The amounts of fertilizer (N, P, K) applied are those recommended in the CIP Circular (Vol. 13, No. 1, March, 1985). Weeding is done by hand. From sowing until plants are well established, the nursery is irrigated by water cans, then by flooding.

Plants are hilled several times by sieving substrate over them. Plastic covers are usually removed by the end of March, when the risk of frost damage is over.

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Fungicides and insecticides are applied whenever necessary. Seedling tubers are lifted manually, usually in late June.

Appendix 1 shows the number of progenies tested, sowing and harvest dates, length of growing period, plot size, and number of replicates.

**Field stage**

After harvest, seedling tubers to be planted in the late season (September) are treated with an insecticide to prevent tuber moth damage and then stored traditionally. Those reserved for the early and main crop planting (November and February, respectively) are kept in a refrigerated store.

Performance of seedling tubers in the field was evaluated on two farms:

- One belonging to CPRA Essaida, a mainland location.
- One belonging to the Centre de Formation et de Perfectionnement Agricole (CFPA), Jammel, situated at Monastir on the eastern coast of the country, where the risk of frost damage is absent.

Seedling tuber plots are cultivated at these two locations as normal potato plots grown from clonal seed tubers with regular cultural practices (spacing, fertilizer amounts, irrigation, hilling, etc.).

Appendix 2 shows the number of progenies, growing seasons, planting and harvest dates, length of growing period, plot size, number of replicates, and locations.

## Performance of TPS Progenies in Nurseries

Seedling emergence usually begins two weeks after sowing. We see differences in the speed and rate of emergence within hybrids. Some are generally slower to emerge and have lower rates of emergence.

Several progenies are late maturing, and develop huge foliage and long stolons. Symptoms of virus infection, particularly PVY, are often noticed.

The number of seedling tubers/$m^2$ and weight/$m^2$ obtained (Tables 1, 2, 3, 4, 5, and 6) compare well with those reported in other countries.

Hybrids are generally superior to OP progenies in yield. Average yields improved remarkably over the years: in 1993, progeny Achirana x LT-7 yielded up to 18 kg of seedling tubers/$m^2$.

## Performance of Seedling Tubers in the Field

In the late season, slow emergence, low stem density, poor soil cover, and high incidence of diseased plants (mainly secondary infection from PVY) are usually observed, which cause unsatisfactory yields (Tables 7, 8, and 9).

Probably because of their long dormancy period and late maturity, most of the progenies tested would not be suited to the late-season crops, particularly in mainland areas such as CPRA Essaida, where the available growing period is restricted by high temperatures in its beginning and by frost at its end.

In the early and main season, some progenies appear to yield better than in the late season (Tables 10, 11, 12, and 13). This is probably because by planting time and after a long period of cold storage, these progenies have broken dormancy and have a better physiological status than in the late season.

## Conclusions

Research at the station proves that potato production from TPS is technically feasible in Tunisia. But it is still too early to envisage transferring this technology to farmers.

In our opinion, before this could be done, and before any official variety could be released from a TPS progeny, two conditions would have to be met:

- The progeny should yield as well as or better than the leading variety in Tunisia in the two successive crops (i.e., the main and late season) in order to ensure reasonable income for farmers.
- Production should be marketable, i.e., it has to be acceptable to consumers who have been influenced by European varieties for decades

Long, oval-shaped, large-sized, and yellow-skinned tubers are highly appreciated by Tunisian housewives.

Table 1. Performance of TPS progenies in a nursery, main season 1988, sowing date 22/II, harvest date 29/VI, growing period 127 days.

International trial (unreplicated), plot size 0.5 $m^2$

| Progeny | No. of seedling tubers/$m^2$ | Weight (kg/$m^2$) | Progeny | No. of seedling tubers/$m^2$ | Weight (kg/$m^2$) |
|---|---|---|---|---|---|
| 384061 | 326 | 1.9 | 384078 | 326 | 3.3 |
| 384088 | 214 | 1.7 | 384111 | 28 | 0.2 |
| 384161 | 24 | 0.1 | 384163 | 264 | 2.6 |
| 384175 | 170 | 1.6 | 385006 | 162 | 1.4 |
| 385046 | 436 | 3.9 | 385058 | 240 | 1.2 |
| 385061 | 80 | 0.4 | 385073 | 260 | 1.7 |
| 385248 | 290 | 1.9 | 385357 | 42 | 0.5 |
| 386180 | 32 | 0.4 | 386191 | 52 | 0.5 |
| 386405 | 320 | 2.3 | 386431 | 270 | 2.1 |
| 386438 | 392 | 2.6 | 387439 | 170 | 1.2 |
| 387471 | 274 | 4.5 | 387472 | 100 | 0.9 |
| 387473 | 452 | 2.5 | 387474 | 282 | 2.9 |
| 386294 | 300 | 1.8 | 978991 | 26 | 0.2 |
| Mean | – | 1.9 | | 208 | 1.7 |

Other progenies (4 replicates), plot size 1 $m^2$

| Progeny | No. of seedling tubers/$m^2$ | Weight (kg/$m^2$) |
|---|---|---|
| 984001 | 211 | 1.3 |
| 985003 | 211 | 1.6 |
| 986004 | 160 | 0.8 |
| 987001 | 119 | 0.8 |
| 983011 | 168 | 1.2 |
| Mean | 174 | 1.2 |

Table 2. Performance of TPS and open-pollinated (OP) progenies in a nursery, main season 1989, sowing date 20/II, harvest date 14/VI, growing period 114 days.

International trial (unreplicated), plot size 0.4 m²

| Progeny | No. of seedling tubers/m² | Weight (kg/m²) | Progeny | No. of seedling tubers/m² | Weight (kg/m²) |
|---|---|---|---|---|---|
| 381445 | 770 | 8.4 | 384061 | 1,027 | 8.8 |
| 384078 | 1,020 | 10.5 | 384088 | 825 | 9.0 |
| 384129 | 1,312 | 11.3 | 384142 | 1,057 | 11.7 |
| 384161 | 695 | 7.2 | 384175 | 1,135 | 9.4 |
| 384276 | 1,052 | 11.4 | 384515 | 1,125 | 11.1 |
| 384605 | 787 | 10.4 | 385034 | 742 | 6.9 |
| 385043 | 555 | 11.9 | 385059 | 975 | 8.8 |
| 385061 | 917 | 6.9 | 385084 | 1,127 | 8.9 |
| 385376 | 1,067 | 9.5 | 386431 | 997 | 6.9 |
| 387504 | 1,012 | 7.1 | 388145 | 782 | 8.0 |
| 388146 | 1,570 | 12.0 | 388147 | 595 | 6.5 |
| 388148 | 552 | 5.5 | 388149 | 950 | 6.8 |
| 388150 | 1,315 | 9.6 | 388151 | 787 | 6.6 |
| 388152 | 737 | 7.7 | | | |
| Mean | | | | 944 | 8.8 |

OP progenies (unreplicated), plot size 0.8 m²

| Progeny | No. of seedling tubers/m² | Weight (kg/m²) |
|---|---|---|
| Desirée | 1,855 | 7.6 |
| 382139 | 1,501 | 7.0 |
| Y-18,5 | 910 | 4.4 |
| YP7401-4 | 1,145 | 5.5 |
| ZPC 739/189 | 986 | 5.1 |
| Mean | 1,279 | 5.9 |

Table 3. Performance of TPS progenies in a nursery, main season 1988, sowing date 4/II, harvest date 22/VI, growing period 148 days.

International trial (unreplicated), plot size 0.4 $m^2$

| Progeny | No. of seedling tubers/$m^2$ | Weight ($kg/m^2$) | Progeny | No. of seedling tubers/$m^2$ | Weight ($kg/m^2$) |
|---|---|---|---|---|---|
| 384111 | 443 | 7.8 | 389401 | 330 | 2.2 |
| 384142 | 1,183 | 13.4 | 389402 | 323 | 4.9 |
| 385058 | 848 | 7.8 | 389403 | 760 | 6.6 |
| 385084 | 1,150 | 10.8 | 389404 | 468 | 4.1 |
| 385127 | 470 | 6.4 | 389405 | 390 | 5.6 |
| 386405 | 608 | 8.7 | 389406 | 220 | 1.4 |
| 387996 | 648 | 7.0 | 389429 | 703 | 8.3 |
| 388206 | 868 | 8.3 | 389430 | 840 | 10.2 |
| 388208 | 565 | 4.5 | 389431 | 663 | 9.0 |
| 388968 | 390 | 3.6 | 389432 | 540 | 5.2 |
| 389075 | 530 | 5.3 | 389433 | 493 | 7.7 |
| 389394 | 935 | 7.0 | 389434 | 843 | 12.9 |
| 389395 | 458 | 2.4 | 389435 | 708 | 8.1 |
| 389396 | 275 | 2.4 | 389436 | 688 | 7.6 |
| 389397 | 273 | 2.4 | 389437 | 430 | 4.2 |
| 389398 | 150 | 1.8 | 389438 | 503 | 6.7 |
| 389399 | 315 | 4.1 | 389439 | 568 | 8.0 |
| 389400 | 543 | 6.5 | – | – | – |
| Mean | – | – | | 581 | 6.4 |

Italian and OP progenies (3 replicated), plot size 0.8 $m^2$, sowing date 14/II, harvest date 22/VI, growing period 128 days.

| Progeny | No. of seedling tubers/$m^2$ | Weight ($kg/m^2$) | Progeny | No. of seedling tubers/$m^2$ | Weight ($kg/m^2$) |
|---|---|---|---|---|---|
| 985004 | 807 | 5.5 | 988001 | 573 | 3.8 |
| 988005 | 797 | 5.5 | 988006 | 684 | 5.5 |
| 988007 | 914 | 6.2 | 988008 | 791 | 5.7 |
| 988009 | 623 | 5.4 | 988010 | 630 | 5.3 |
| 988011 | 815 | 5.7 | 988012 | 841 | 4.2 |
| 988013 | 886 | 6.2 | 988014 | 1,044 | 7.7 |
| Baraka OP | 547 | 4.1 | Yesmina OP | 583 | 3.9 |
| Mean | – | – | – | 752 | 5.4 |

Table 4. Performance of TPS progenies in a nursery, main season 1991, sowing date 2/II, harvest date 14/VI, growing period 132 days.

International trial (unreplicated), plot size 0.5 $m^2$

| Progeny | No. of seedling tubers/$m^2$ | Weight ($kg/m^2$) | Progeny | No. of seedling tubers/$m^2$ | Weight ($kg/m^2$) |
|---|---|---|---|---|---|
| 390729 | 1,218 | 13.4 | 390741 | 1,916 | 19.2 |
| 390730 | 812 | 12.0 | 390742 | 1,350 | 14.3 |
| 390731 | 886 | 12.6 | 390743 | 1,454 | 12.3 |
| 390733 | 1,120 | 13.1 | 390744 | 624 | 7.3 |
| 390733 | 1,006 | 13.5 | 399745 | 1,904 | 12.9 |
| 390734 | 986 | 10.8 | 390746 | 1,358 | 12.0 |
| 390735 | 1,156 | 11.5 | 390747 | 1,316 | 11.1 |
| 390736 | 1,494 | 14.6 | 390748 | 1,558 | 7.9 |
| 390737 | 834 | 8.1 | 978001 | 1,282 | 12.1 |
| 390738 | 1,742 | 12.2 | 978004 | 1,394 | 10.4 |
| 390739 | 1,188 | 11.8 | 985003 | 1,162 | 11.4 |
| 390740 | 1,456 | 12.7 | 985003 | 786 | 10.4 |
| Mean | – | – | | 1,246 | 12.0 |

Variety trial and OP progenies (3 replicated), plot size 1 $m^2$

| Progeny | No. of seedling tubers/$m^2$ | Weight ($kg/m^2$) | Progeny | No. of seedling tubers/$m^2$ | Weight ($kg/m^2$) |
|---|---|---|---|---|---|
| 978001 | 1,041 | 11.1 | 978004 | 1,365 | 13.6 |
| 985003 | 912 | 12.6 | 985012 | 1,189 | 9.8 |
| 986001 | 931 | 12.3 | 989001 | 745 | 9.0 |
| 989003 | 1,032 | 10.1 | 989004 | 970 | 9.7 |
| 989008 | 1,242 | 13.2 | 989009 | 1,302 | 14.6 |
| 989012 | 1,052 | 11.6 | 989013 | 1,451 | 13.7 |
| 989014 | 1,094 | 11.7 | Baraka OP | 908 | 7.7 |
| Yesmina OP | 1,076 | 9.4 | | | |
| Mean | – | – | | 1,087 | 11.3 |

Table 5. Performance of TPS progenies in a nursery, main season 1990, sowing date 4/II, harvest date 22/VI, growing period 135 days.

International trial (unreplicated), plot size 0.4 m²

| Progeny | No. of seedling tubers/m² | Weight (kg/m²) | Progeny | No. of seedling tubers/m² | Weight (kg/m²) |
|---|---|---|---|---|---|
| 391387 | 1,102 | 11.0 | 391397 | 1,145 | 13.5 |
| 391388 | 857 | 9.0 | 391398 | 1,407 | 12.3 |
| 391389 | 1,400 | 9.2 | 391399 | 1,375 | 13.6 |
| 391390 | 1,340 | 12.0 | 391400 | 1,192 | 10.8 |
| 391391 | 1,545 | 14.3 | 391401 | 1,220 | 13.0 |
| 391392 | 1,110 | 12.3 | 978001 | 1,687 | 13.4 |
| 391393 | 772 | 13.4 | 978004 | 1,950 | 15.7 |
| 391394 | 1,160 | 12.8 | 985003 | 1,577 | 14.3 |
| 391395 | 1,275 | 12.8 | 986001 | 1,605 | 17.0 |
| 391396 | 1,512 | 15.3 | | | |
| Mean | – | – | | 1,329 | 12.9 |

Verification trial (3 replicated), plot size 0.6 m²

| Progeny | Mean no. of seedling tubers/m² | Mean weight (kg/m²) | Progeny | Mean no. of seedling tubers/m² | Mean weight (kg/m²) |
|---|---|---|---|---|---|
| 978001 | 1,206 | 7.4 | 978004 | 1,885 | 11.0 |
| 985003 | 1,637 | 11.4 | 989006 | 1,501 | 11.3 |
| 989008 | 1,578 | 9.9 | 989020 | 2,188 | 10.0 |
| 990001 | 1,452 | 9.4 | IP 88002 | 1,160 | 9.1 |
| IP 88004 | 1,092 | 9.2 | IP 88005 | 631 | 6.3 |
| IP 88006 | 1,319 | 7.6 | IP 88007 | 757 | 7.6 |
| IP 88008 | 864 | 8.2 | 990004 | 1,346 | 9.7 |
| 989024 | 1,097 | 7.9 | Achirana x LT | 2,370 | 11.5 |
| Serrana x LT | 2,265 | 10.4 | Pent. Crown x Granola | 1,549 | 9.4 |
| Yasmina OP | 1,462 | 8.3 | | | |
| Mean | – | – | | 1,451 | 9.2 |

Table 6. Performance of TPS progenies in a nursery, main season 1993, sowing date 5/II, harvest date 23/VI, growing period 138 days.

Verification trial (2 replicates), plot size 1 $m^2$

| Progeny | No. of seedling tubers/$m^2$ | Weight ($kg/m^2$) | Progeny | No. of seedling tubers/$m^2$ | Weight ($kg/m^2$) |
|---|---|---|---|---|---|
| Atz x R-128-6 | 1,364 | 13.7 | Achirana x LT-7 | 1,884 | 18.3 |
| Atz x DTO-28 | 1,373 | 13.3 | Granola x TS-2 | 1,731 | 12.8 |
| Serrana x LT-7 | 1,919 | 14.0 | P. Crown x TS-2 | 1,569 | 13.7 |
| LT-9 x TS-3 | 1,400 | 13.7 | Gran. x Huinkul | 1,931 | 11.7 |
| IP 8800 | 1,340 | 11.3 | Serrana x LT-7 | 2,095 | 17.6 |
| | | | Serrana x DTO-33 | 1,521 | 14.5 |
| | | | Serrana x LT-7 (CIP) | 1,776 | 17.2 |
| Mean | 1,539 | 13.2 | | 1,789 | 15.0 |

Verification trial C (unreplicated), plot size 1 $m^2$

| Progeny | Mean no. of seedling tubers/$m^2$ | Mean weight ($kg/m^2$) | Progeny | Mean no. of seedling tubers/$m^2$ | Mean weight ($kg/m^2$) |
|---|---|---|---|---|---|
| 978001 | 922 | 8.9 | 989022 | 942 | 8.8 |
| 978004 | 1,050 | 5.3 | 989025 | 1,338 | 10.6 |
| 985003 | 1,486 | 9.7 | 989020 | 1,282 | 10.9 |
| 989008 | 1,568 | 11.6 | IP 88002 | 1,034 | 13.2 |
| 989009 | 456 | 5.2 | IP 88005 | 1,216 | 13.4 |
| 989012 | 642 | 5.6 | IP 88007 | 1,560 | 11.8 |
| 989013 | 1,340 | 9.8 | | | |
| Mean | – | – | | 1,458 | 9.6 |

Table 7. Performance of TPS progenies in a nursery, main season 1988, planting date 22/IX, harvest date 28/XII, growing period 97 days.

International trial A (2 replicates), plot size 25 plants

| Progeny | Mean marketable yield ($kg/m^2$) | Progeny | Mean marketable yield ($kg/m^2$) |
|---|---|---|---|
| 384061 | 0.76 | 385357 | 0.18 |
| 384078 | 1.48 | 386180 | 0.25 |
| 384088 | 0.67 | 386191 | 0.18 |
| 384111 | 0.27 | 386294 | 0.43 |
| 384161 | 0.36 | 386405 | 0.24 |
| 384163 | 0.61 | 386431 | 0.33 |
| 384175 | 0.53 | 386438 | 0.30 |
| 385006 | 0.40 | 387439 | 0.29 |
| 385046 | 0.61 | 387471 | 0.29 |
| 385061 | 0.20 | 387472 | 0.44 |
| 385073 | 0.20 | 387473 | 0.20 |
| 385248 | 0.69 | 987001 | – |

Other progenies (4 replicated), plot size 40 plants

| Progeny | Mean marketable yield[a] ($kg/m^2$) |
|---|---|
| 984001 | 0.80 |
| 985003 | 0.71 |
| 986004 | 0.81 |
| 987001 | 0.45 |
| 983011 | 0.81 |

a. Marketable yield = tubers > 35 mm.

Table 8. Performance of seedling tubers in the field, late season 1993, planting date 27/IX, harvest date 28/XII, growing period 92 days.

International trial A (2 replicates), plot size 80 plants

| Progeny | Mean marketable yield (kg/m²) | Progeny | Mean marketable yield (kg/m²) |
|---|---|---|---|
| 344088 | 1.73 | 385061 | 1.80 |
| 381445 | 1.38 | 385084 | 1.65 |
| 384061 | 1.96 | 385376 | 1.78 |
| 384078 | 2.20 | 386431 | 1.89 |
| 384129 | 1.89 | 387504 | 1.69 |
| 384142 | 1.58 | 388145 | 1.80 |
| 384161 | 1.62 | 388146 | 2.29 |
| 384175 | 1.69 | 388147 | 1.85 |
| 384176 | 1.22 | 388148 | 1.51 |
| 384515 | 1.47 | 388149 | 1.07 |
| 384605 | 1.74 | 388150 | 0.88 |
| 385034 | 1.13 | 988151 | 1.33 |
| 385043 | 1.69 | 988152 | 1.15 |
| 385059 | 1.67 | | |
| Mean | – | – | 1.62 |

Other progenies (3 replicated), plot size 80 plants

| Progeny | Mean marketable yield (kg/m²) |
|---|---|
| Desirée | 1.02 |
| 382139 | 1.68 |
| Y. 18.5 | 1.62 |
| YP 7401.4 | 1.05 |
| ZPC 739189 | 0.99 |
| Mean | 1.27 |

Table 9. Performance of seedling tubers in the field, late season 1990, planting date 9/X, harvest date 8/I/91, plot size 40 plants.

International trial A (unreplicated)

| Progeny | Mean marketable yield ($kg/m^2$) | Progeny | Mean marketable yield ($kg/m^2$) |
|---|---|---|---|
| 384111 | 0.40 | 389401 | 0.57 |
| 384124 | 0.68 | 389402 | 0.99 |
| 385058 | 0.55 | 389403 | 1.80 |
| 385084 | 0.66 | 389404 | 0.70 |
| 385127 | 0.66 | 389405 | 1.01 |
| 386405 | 1.23 | 389406 | 1.22 |
| 387996 | 0.88 | 389429 | 1.17 |
| 388206 | 0.97 | 389430 | 0.59 |
| 388208 | 0.33 | 389431 | 0.99 |
| 388968 | 0.55 | 389432 | 0.55 |
| 389075 | 0.70 | 389433 | 0.92 |
| 389394 | 0.70 | 389434 | 0.44 |
| 389395 | 0.88 | 389435 | 0.66 |
| 389396 | 0.48 | 389436 | 0.55 |
| 389397 | 0.46 | 389437 | 0.46 |
| 389398 | 0.57 | 389438 | 0.94 |
| 389399 | 0.99 | 389439 | 0.92 |
| 389400 | 0.79 | – | |
| Mean | – | – | 0.75 |

Italian and OP progenies (3 replicates), plot size 40 plants

| Progeny | Mean marketable yield ($kg/m^2$) | Progeny | Mean marketable yield ($kg/m^2$) |
|---|---|---|---|
| 985004 | 0.66 | 988001 | 0.70 |
| 988005 | 0.84 | 988006 | 0.84 |
| 988007 | 0.44 | 988008 | 1.06 |
| 988009 | 1.06 | 988010 | 1.21 |
| 988011 | 1.10 | 988012 | 0.60 |
| 988013 | 0.53 | 988014 | 0.79 |
| Baraka OP | 0.13 | Yesmina OP | 0.53 |

Table 10. Performance of seedling tubers in the field, main season 1993, planting date 9/XI, harvest date 5/III/94, plot size 40 plants.

Italian and OP progenies (3 replicated), plot size 40 plants

| Progeny | Mean marketable yield (kg/m$^2$) | Progeny | Mean marketable yield (kg/m$^2$) |
|---|---|---|---|
| 985004 | 0.54 | 988001 | 0.55 |
| 988005 | 0.50 | 988006 | 0.52 |
| 988007 | 0.39 | 988008 | 1.45 |
| 988009 | 1.62 | 988010 | 1.67 |
| 988011 | 1.56 | 988012 | 0.64 |
| 988013 | 0.47 | 988014 | 0.59 |
| Baraka OP | 0.16 | Yesmina OP | 0.25 |

Table 11. Performance of seedling tubers in the field, early season 1991, planting date 20/XI/91, harvest date 13/IV/92, growing period 144 days, plot size 80 plants.

Verification trial (4 replicates)

| Progeny | Mean marketable yield (kg/m$^2$) | Progeny | Mean marketable yield (kg/m$^2$) |
|---|---|---|---|
| 978001 | 2.58 | 985003 | 2.27 |
| 985003 | 1.82 | 989008 | 1.69 |
| 989009 | 1.91 | 989012 | 1.96 |
| 989013 | 2.09 | 989014 | 1.96 |
| Mean | | | 2.04 |

Table 12. Performance of seedling tubers in the field, late season 1992, planting date 26/II, harvest date 19/VI, growing period 113 days.

International trial (unreplicated), plot size 80 plants

| Progeny | Mean marketable yield ($kg/m^2$) | Progeny | Mean marketable yield ($kg/m^2$) |
|---|---|---|---|
| 390729 | 1.64 | 390741 | 2.91 |
| 390730 | 2.05 | 390742 | 3.39 |
| 390731 | 1.81 | 390743 | 1.45 |
| 390732 | 2.48 | 390744 | 1.95 |
| 390733 | 2.53 | 399745 | 1.51 |
| 390734 | 1.56 | 390746 | 2.09 |
| 390735 | 2.34 | 390747 | 2.04 |
| 390736 | 2.04 | 390748 | 2.13 |
| 390737 | 1.66 | 978001 | 0.85 |
| 390738 | 1.40 | 978003 | 1.44 |
| 390739 | 1.29 | 985004 | 1.00 |
| 390740 | 1.30 | 986001 | 2.20 |
| Mean | – | – | 1.88 |

Verification trial and OP progenies (unreplicated), plot size 80 plants

| Progeny | Mean marketable yield ($kg/m^2$) | Progeny | Mean marketable yield ($kg/m^2$) |
|---|---|---|---|
| 978001 | 2.68 | 988001 | 3.38 |
| 985004 | 2.60 | 988006 | 2.72 |
| 986001 | 2.88 | 988008 | 2.05 |
| 989004 | 0.77 | 988010 | 2.04 |
| 989009 | 0.84 | 988012 | 2.60 |
| 989013 | 2.55 | 989014 | 3.00 |
| LT-7 | 1.64 | LT-9 | 3.63 |
| 382169-1 | 2.83 | | |
| Yesmina OP | 1.32 | Baraka OP | 2.07 |
| Mean | | | 2.37 |

Table 13. Performance of seedling tubers in the field, main season 1995, planting date 4/II, harvest date 19/VII, growing period 147 days.

$G_1$ seedling tubers (3 replicates), plot size 60 plants

| Progeny | Marketable yield (kg/m²) | Progeny | Marketable yield (kg/m²) |
|---|---|---|---|
| 985003 | 2.74 | 298006 | 2.16 |
| Achirana x LT-7 | 2.32 | 391391 | 1.78 |
| 391398 | 1.65 | 391396 | 1.61 |
| 391397 | 1.52 | 391399 | 1.71 |
| 381401 | 1.57 | 986001 | 2.30 |
| Spunta (control) | 1.65 | 390746 | 2.09 |
| Mean | – | – | 1.91 |

$G_1$ Seedling tubers produced in 1992.

$G_2$ seedling tubers (3 replicates), plot size 60 plants

| Progeny | Marketable yield (kg/m²) | Progeny | Marketable yield (kg/m²) |
|---|---|---|---|
| 985003 | 2.84 | 985012 | 2.68 |
| 986001 | 2.42 | 989001 | 2.07 |
| 986003 | 2.65 | 989012 | 1.91 |
| 989014 | 2.49 | LT-7 | 3.89 |
| 382196-1 | 1.22 | | |
| Spunta (control) | 3.09 | | |

$G_2$ Seedling tubers produced in 1991.

Appendix 1. TPS progenies: number, sowing and harvest dates, length of growing period, plot size, number of replicates, location: CPRA Essaida.

| Year | Number of progenies | Sowing date | Harvest date | Length of growing period (days) | Plot size ($m^2$) | No. of replicates |
|---|---|---|---|---|---|---|
| 1988 | 26+ | 22/II | 29/VI | 127 | 0.50 | 1 |
| | 5 | 22/II | 29/VI | 127 | 1.00 | 4 |
| 1989 | 27+ | 20/II | 14/VI | 144 | 0.40 | 1 |
| | 5++++ | 20/II | 14/VI | 144 | 0.80 | 4 |
| 1990 | 35+ | 4/II | 22/VI | 138 | 0.40 | 1 |
| | 12+++ | 14/II | 22/VI | 128 | 0.80 | 3 |
| | 2++++ | 14/II | 22/VI | 128 | 0.80 | 3 |
| 1991 | 24+ | 2/II | 14/VI | 132 | 0.50 | 1 |
| | 13++ | 2/II | 14/VI | 132 | 0.64 | 3 |
| 1992 | 19+ | 17/II | 1/VII | 135 | 0.40 | 1 |
| | 20++ | 17/II | 1/VII | 135 | 1.00 | 3 |
| 1993 | 5++(A) | 5/II | 23/VI | 138 | 1.00 | 2 |
| | 8++(B) | 5/II | 23/VI | 138 | 1.00 | 3 |
| | 13++(C) | 5/II | 23/VI | 138 | 1.00 | 1 |

Appendix 2. Seedling tubers: number of progenies, growing seasons, planting and harvest dates, length of growing period, plot size, number of replicates, and location.

| Year | Growing season | No. of progenies | Plant. date | Harvest date | Length of growing period (days) | Plot size (no. of plants) | No. of replicates | Location |
|---|---|---|---|---|---|---|---|---|
| 1988 | Late | 5 | 22/IX | 28/XII | 97 | 40 | 4 | Essaida |
| | | 26+ | 22/IX | 28/XII | 97 | 25 | 2 | |
| 1989 | Late | 27+ | 27/IX | 28/XII | 92 | 80 | 2 | Essaida |
| | | 5++++ | 27/IX | 28/XII | 92 | 80 | 3 | |
| 1990 | Late | 35+ | 9/X | 8/I | 90 | 40 | 1 | Essaida |
| | | 12+++ | 9/X | 8/I | 90 | 40 | 3 | |
| | | 2++++ | 9/X | 8/I | 90 | 40 | 3 | |
| | Early | 12+++ | 9/XI | 5/III | 116 | | 3 | Essaida |
| | | 2++++ | 9/XI | 5/III | 116 | | 3 | |
| 1991 | Early | 8++ | 20/XI | 13/IV | 144 | 80 | 4 | Monastir |
| 1992 | Main | 24+ | 26/II | 19/VI | 113 | 80 | 1 | Essaida |
| | | 16++ | 26/II | 19/VI | 113 | 80 | 1 | |
| 1993 | Main | 10* | 4/II | 2/VII | 147 | 60 | 3 | Essaida |
| | | 9* | 4/II | 2/VII | 147 | 60 | 3 | |

Legend:
+ International trial
++ Verification trial
• $G_1$ seedling tubers
+++ Italian progenies
++++ OP progenies

CHAPTER 7

# TPS Production in Turkey to Meet the Needs of Middle East and North African Countries

Noyan Kusman*

## Introduction

Studies on true potato seed (TPS) in Turkey started soon after the establishment of the National Potato Research and Training Project. Early practices mostly concentrated on observing the morphological and physiological characteristics of promising parental lines. The aim of these initial applications may not have been directly related to TPS production, but the information obtained from those studies served as a basis for knowledge about the applicability of TPS production in Turkey. A joint evaluation of results from observations of some production practices and TPS parental lines obtained from some crosses made at the International Potato Center (CIP), in Peru, has shown that TPS production could take place in Turkey. As a result, the project on "TPS Production in Turkey to Meet the Needs of the Middle East and North Africa" was developed and applied in Turkey with support from CIP.

## Materials and Methods

In these studies, several crosses (Tables 1-3) obtained from CIP were used. In the first two years of the three-year project, practices concentrated on the observation of parental lines (Tables 4-7).

In the observation plots (Figures 1-3), plants of each genotype were planted in two replications. In 1990, studies were conducted with genotypes V-3, LT-8, and I-1039; one replication characterized female parents and the other replication characterized male parents. One replication evaluated cultivar Achirana INTA as a male parent and the other replication was used for crossing and for evaluation as a female parent.

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Table 1. Description of TPS crosses.[a]

| Female | Male | Date of first pollination | Date of last pollination | Number of flowers pollinated | Number of fruits harvested | Seed extraction date | Seed weight (g) | 100-seed weight (g) |
|---|---|---|---|---|---|---|---|---|
| Serrana | LT-7 | 10-VIII-90 | 11-IX-90 | 291 | 235 | 13-XII-90 | n a | 0.08 |
| Serrana | DTO-28 | 20-VII-90 | 19-IX-90 | 60 | 34 | 12-XI-90 | 1 | 0.09 |
| Atlantic | LT-7 | 19-VII-90 | 07-IX-90 | 90 | 57 | 19-IX-90 | 2 | 0.07 |
| Granola | TS-2 | 24-VII-90 | 14-IX-90 | 287 | 262 | 23-X-90 | 38 | 0.08 |
| Pentland Crown | Granola | 21-VII-90 | 29-IX-90 | 146 | 96 | 12-X1-90 | 6 | 0.06 |
| Granola[b] | Huinkul | 08-VIII-90 | 03-IX-90 | 61 | 39[c],13[d] | 12-X1-90 | 1 | 0.05 |
| Granola[b] | POOS-16 | 02-VIII-90 | 03-IX-90 | 83 | 47[c],10[d] | 12-X1-90 | 0.8 | 0.07 |
| Achirana INTA | LT-7 | 02-VIII-90 | 03-IX-90 | 273 | 249 | 12-X1-90 | 16 | 0.09 |

a. Planting date May 29, 1990, harvest date September 27, 1990.
b. These crosses were made in the cv. Granola production plot. Because some fruits dropped onto the ground, only fruits remaining on the plants were collected in order to prevent mixing with self-pollinated ones.
c. Total fruit set.
d. Number of fruits harvested.

Table 2. Description of TPS crosses.[a]

| Female | Male | Date of last pollination | Number of flowers pollinated | Number of fruits harvested | Seed extraction date | Seed weight (g) | 100-seed weight (g) |
|---|---|---|---|---|---|---|---|
| Atlantic | LT-7 | 09-VIII-91 | 284 | 232 | 16-X-91 | 8,538 | 0.06 |
| Atlantic | I-1039 | 11-VIII-91 | 330 | 285 | 16-X-91 | 12,018 | 0.06 |
| Pentland Crown | LT-7 | 20-VIII-91 | 226 | 192 | 16-X-91 | 11,072 | 0.05 |
| Pentland Crown | TS-2 | 19-VIII-91 | 258 | 238 | 16-X-91 | 29,975 | 0.06 |
| Granola | TS-2 | 18-VIII-91 | 563 | 527 | 15-X-91 | 75,203 | 0.07 |
| Granola | Huinkul | 19-VIII-91 | 475 | 409 | 15-X-91 | 48,205 | 0.07 |
| Serrana | LT-7 | 25-VIII-91 | 1761 | 1719 | 06-XI-91 | 134,442 | 0.07 |
| Serrana | DTO-33 | 18-VIII-91 | 597 | 534 | 05-XI-91 | 35,104 | 0.08 |
| Serrana | DTO-28 | 19-VIII-91 | 441 | 408 | 05-XI-91 | 20,593 | 0.08 |

a. Planting date June 12, 1991, harvest date October 1, 1991; all crosses were first pollinated on July 26, 1991.

Table 3. CIP TPS crosses in 1992.

| Female | Male | Date of first pollination | Period of pollination (days) | Number of flowers pollinated | Number of fruits harvested | Seed production (g) | Seed per fruit (g) | 100-seed weight (g) |
|---|---|---|---|---|---|---|---|---|
| Serrana | DTO-28 | 10-VIII-92 | 32 | 270 | 182 | 6.9 | 0.04 | 0.07 |
| Serrana | LT-7 | 05-VIII-92 | 35 | 15,832 | 13,210 | 500.5 | 0.04 | 0.07 |
| Serrana | Granola | 05-VIII-92 | 27 | 816 | 736 | 47.2 | 0.06 | 0.09 |
| Serrana | TS-2 | 05-VIII-92 | 32 | 150 | 120 | 10.5 | 0.09 | 0.09 |
| LT-8 | LT-7 | 05-VIII-92 | 14 | 119 | 20 | 1.1 | 0.06 | 0.08 |
| LT-8 | Granola | 06-VIII-92 | 12 | 327 | 113 | 9.5 | 0.08 | 0.09 |
| LT-9 | LT-7 | 05-VIII-92 | 9 | 89 | 22 | 0.7 | 1.03 | 0.07 |
| LT-9 | Granola | 06-VIII-92 | 10 | 159 | 92 | 6.7 | 1.07 | 0.09 |
| Ach. INTA | Huinkul | 05-VIII-92 | 6 | 42 | 27 | 2.5 | 1.09 | 0.08 |
| Ach. INTA | I-1039 | 05-VIII-92 | 9 | 108 | 96 | 7.2 | 0.08 | 0.09 |

Table 4. Female parent characteristics.[a]

| Genotype | Number of plants observed | Stigma excerption | Number of inflorescences/ plant | Number of flowers/ inflorescence | Flowering score[c] | First flowering date | Duration of flowering (days) | Bud drop | Self-fertility | Growth habit |
|---|---|---|---|---|---|---|---|---|---|---|
| V-3 | 3 | Medium | 20 | 18 | 3 | 23-VII-90 | 76 | Low | - | Prostrate |
| LT-8 | 2 | Medium | 23 | 14 | 3 | 27-VII-90 | 67 | Low | - | Semi-erect |
| I-1039 | 1 | Long | 22 | 15 | 3 | 25-VII-90 | 68 | Low | + | Semi-erect |
| Achirana INTA | 4 | Medium | 16 | 15 | 4 | 20-VII-90 | 47 | Low | - | Erect |
| Serrana[b] | 4 | Medium | 13 | 12 | 3 | 18-VII-90 | 53 | Low | | Semi-erect |
| Serrana[b] | 2 | Medium | 29 | 14 | 3 | 30-VII-90 | 53 | Low | | Semi-erect |
| Atlantic[b] | 8 | Medium | 7 | 13 | 4 | 18-VII-90 | 22 | Medium | | Prostrate |
| Granola[b] | 8 | Medium | 8 | 19 | 4 | 21-VII-90 | 55 | Low | | Semi-erect |
| Pentland Crown[b] | 7 | Medium | 6 | 7 | 4 | 20-VII-90 | 42 | Medium | | Erect |

a. Planting date May 29, 1990, harvest date September 27, 1990.
b. Because all flowers were crossed, self-fertility could not be observed.
c. On a scale of 1-5, where 1 = poor or nil and 5 = abundant.

Table 5. Male parent characteristics.[a]

| Genotype | Number of plants observed | Number of inflorescences/ plant | Number of flowers/ inflorescence | Flowering score[b] | First flowering date | Duration of flowering (days) | Self-fertility | Pollen abundance |
|---|---|---|---|---|---|---|---|---|
| Achirana INTA | 4 | 22 | 16 | 4 | 16-VII-90 | 48 | 0 | Little |
| I-1039 | 3 | 25 | 16 | 3 | 26-VII-90 | 67 | 5 | Much |
| LT-8 | 2 | 19 | 11 | 2 | 07-VII-90 | 59 | 0 | None |
| V-3 | 4 | 29 | 22 | 3 | 30-VII-90 | 69 | 0 | Little |
| DTO-28 | 8 | 10 | 11 | 3 | 15-VII-90 | 48 | 0 | Little |
| LT-9 | 6 | 11 | 15 | 1 | 26-VII-90 | 52 | 0 | None |
| Granola | 8 | 9 | 17 | 3 | 17-VII-90 | 47 | 3 | Much |
| LT-7 | 8 | 20 | 19 | 5 | 15-VII-90 | 60 | 1 | Much |
| TS-2[c] | 8 | 6 | 21 | 4 | 18-VII-90 | 23 | 1 | Much |
| Huinkul[c] | 8 | 13 | 16 | 4 | 16-VII-90 | 36 | 2 | Much |
| POOS-16 | 6 | 19 | 17 | 4 | 18-VII-90 | 44 | 2 | Much |

a. Planting date May 29, 1990, harvest date September 27, 1990.
b. On a scale of 1-5, where 1 = poor or nil and 5 = abundant.
c. All pollen was used for crossing.

Table 6. Observations on female parents.[a]

| Progenies | First flowering date | Flowering duration (days) |
|---|---|---|
| Granola | 19-VII-91 | 36 |
| Serrano | 17-VII-91 | 48 |
| Atlantic | 15-VII-91 | 27 |
| Pentland Crown | 23-VII-91 | 33 |
| Achirana INTA | 28-VII-91 | 35 |

a. All showed stigma excerption classified as medium.

## Findings

Details from the first-year (1990) studies follow:

1. As the first female clone to flower, Atlantic was crossed to LT-7 instead of TS-2, which did not produce pollen at that moment. But this cross resulted in small fruits with low amounts of seed.

2. Because LT-9 produced no pollen, cultivar Granola was crossed to TS-2. But because of the rather short flowering period of TS-2, subsequent flowers of Granola were removed.

Table 7. Observations on male parents.

| Genotype | First flowering date | Flowering duration (days) | Relative pollen abundance |
|---|---|---|---|
| TS-2 | 23-VII-91 | 26 | Much |
| LT-9 | 28-VII-91 | 35 | None |
| DTO-28 | 23-VII-91 | 25 | Little |
| Huinkul | 20-VII-91 | 33 | Much |
| LT-7 | 17-VII-91 | 48 | Much |
| I-1039 | 23-VII-91 | 48 | Much |
| LT-8 | 27-VII-91 | 44 | None |
| DTO-33 | 24-VII-91 | 26 | Medium |

3. Because of another deformity and the poor pollen yield of male parent DTO-28, it was not possible to cross all the Serrana flowers. Therefore, flowers that were not pollinated were removed.

4. Serrana x LT-7 and Pentland Crown x Granola crosses were achieved successfully.

5. Additional crosses with Granola were made because Huinkul and POOS-16 flowers produced abundant pollen in the same field.

Other information obtained from the 1990 crossing studies is in Table 1.

In 1991, the same work was done at the Bozdağ substation as in the previous year. Figure 2 shows the field plan of the material. Agronomic practices for plants were similar to those applied in 1990, but because of weather conditions planting was done on June 12, 13 days later than in 1990. This affected the growth and flowering habits of genotypes. Plants were generally shorter on the trellis, and flowering duration was lower than in the previous year, except for Atlantic and TS-2, which had the shortest flowering periods in both years.

Crossing work started on July 26, 1991, and finished on August 25, a month earlier than in 1990. Flowers that had been pollinated toward the end of the growing season produced berries with fewer seeds. Fruit set was 92% in pollinated flowers and a total of 343.5 grams of seed was extracted from 21.3 kg of berries. Table 6 describes crosses in detail.

In 1992, flowering was weak and pollen amount low in males. Females were refreshed by extensive fertilization and irrigation in the second half of growth. However, no crosses were made with cultivar Atlantic because the flowering period had already passed. Other crosses yielded low fruit set and low seed weight because of the late pollination period. Fruit set was

81%, whereas it was 92% in 1991. Overall, 582 grams of seed was obtained from ten crosses (Table 3).

After 1992, the samples of TPS material obtained from the studies were used to study different cultural practices for potato in both Turkey and in Egypt. Because these cultural studies have only been under way for a year in Turkey, it is difficult to say anything about the performance of TPS under local practices. Although results from the study made in Egypt have not been officially released yet, we already have some promising information.

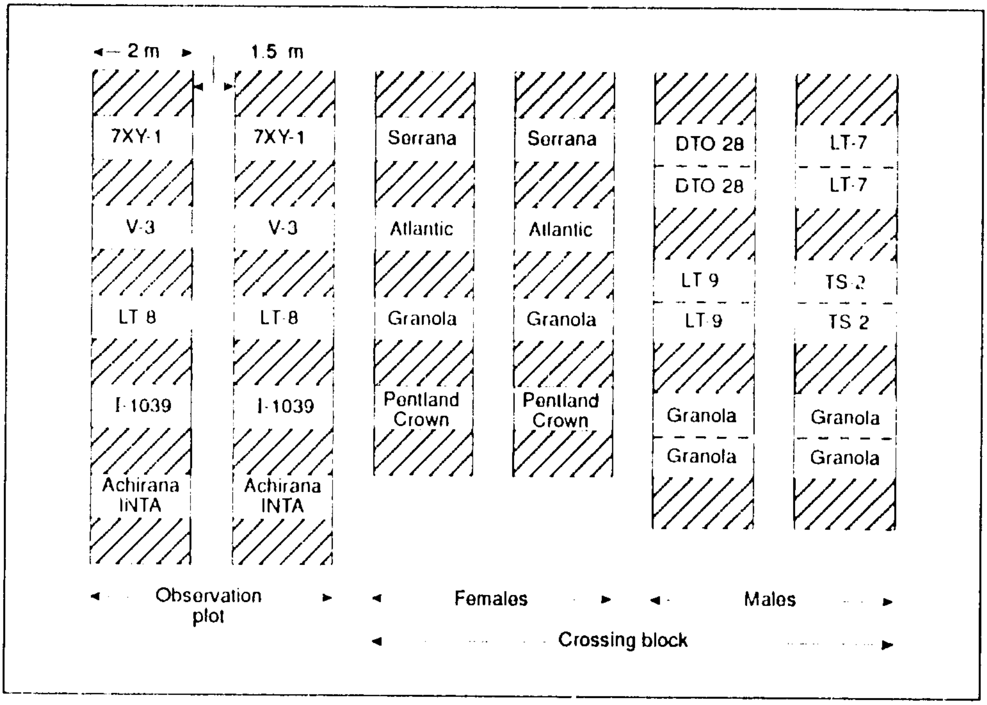


Figure 1. Field plan of TPS production project in 1990.

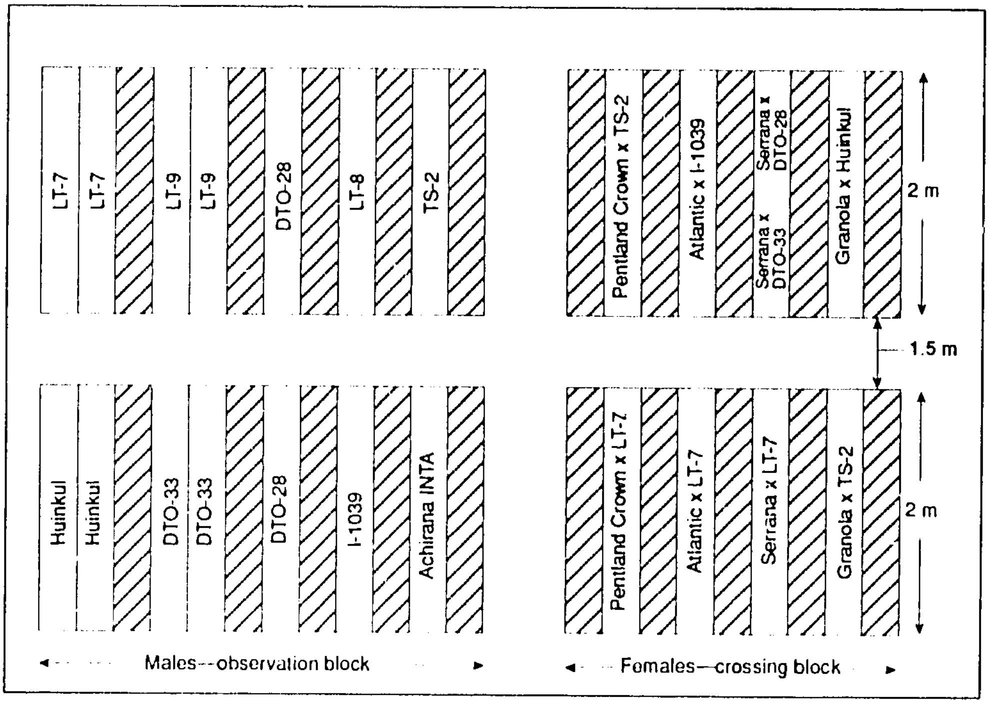


Figure 2. Field plan of TPS production project in 1991.

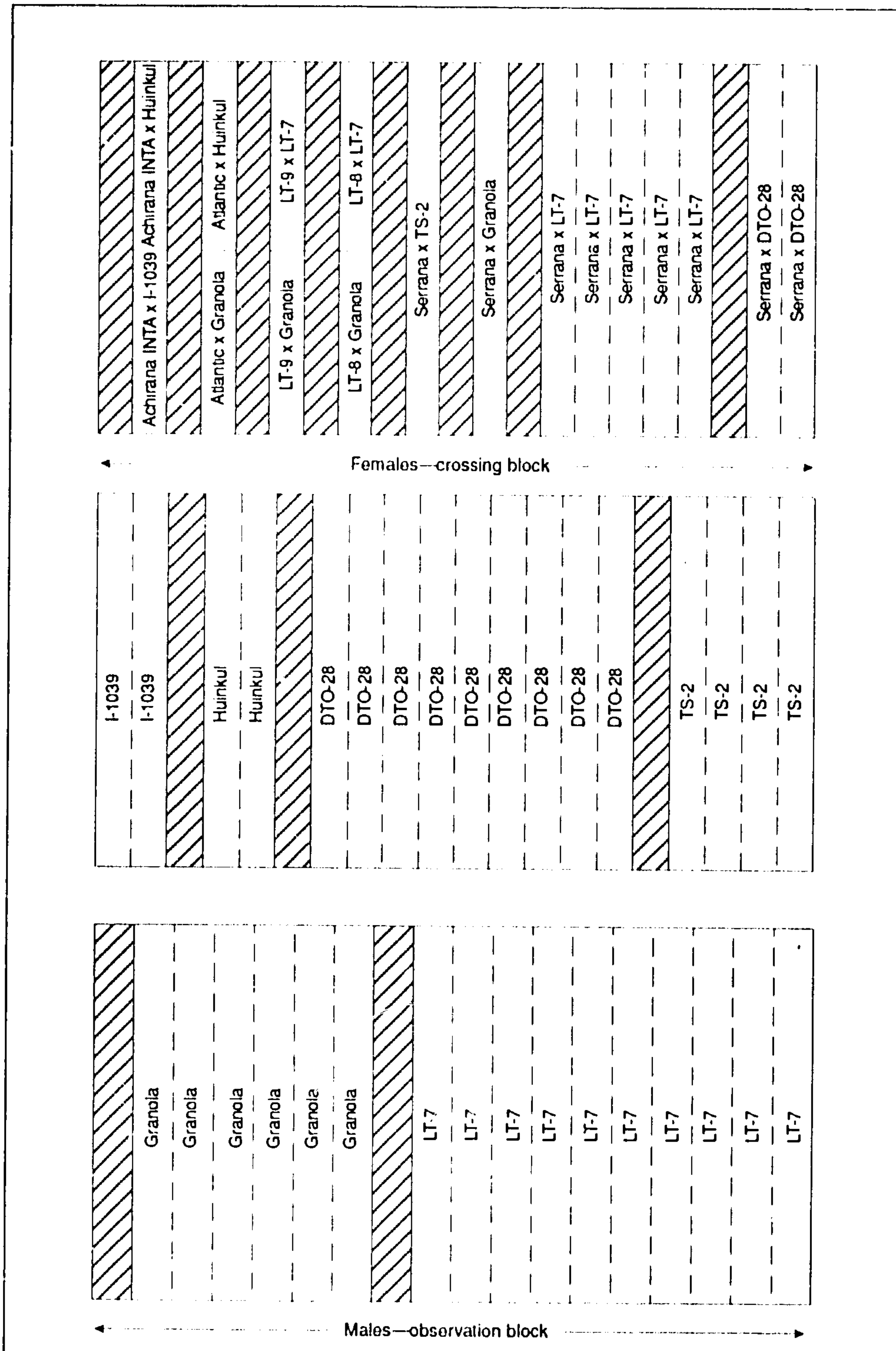


Figure 3. Field plan of TPS production project in 1992.

CHAPTER 8

# Experiences in TPS Research and Development in Uganda

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## Abstract

Trials to study the production of planting materials from true potato seed (TPS) using both transplants and seedling tubers were promising. Transplants gave mean fresh tuber yields of 26.8 t/ha during 1992/93 and 21.7 t/ha in 1993/94, which compared well with the yield of clonal seed tubers of 20.5 t/ha. TPS raised in nursery beds of 3 m$^2$ produced many seedling tubers, averaging 224 m$^2$ and 119 m$^2$ during 1992/93 and 225 m$^2$ in 1994, with mean tuber weights of 20 g, 27 g, and 23 g. Trials to study the degeneration of seed tubers derived from TPS showed that there was no consistent decline in fresh tuber yields as the number of generations increased. Yields of TPS in the third and fourth generations were similar to those of the first generation. Extensive on-farm trials in the mid and low altitudes showed that seed tubers derived from TPS had mean yields of 24.6 t/ha, which were similar to those of the established varieties that yielded 26.2 t/ha.

## Introduction

Potato (*Solanum tuberosum*) is an important food crop and source of income in Uganda. Estimated production is 340,000 tons on 40,000 ha, with an average yield of 8.5 tons per ha. However, in the southwest region, yields average 15-20 t/ha. Annual per capita consumption is about 19.1 kg, but in the main production areas it is more than 100 kg. Most potato production is on a subsistence level in small family farms in the southwest and eastern highlands. Following the release of new, widely adapted potato varieties in 1991, potato growing has rapidly expanded to mid- and low-elevation areas

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of the country. The result has been a dramatic reduction in prices of potato, which is now affordable to most income groups. Nevertheless, yields are still quite low.

Uganda's National Potato Research and Development Program recognizes the following constraints as being responsible for low yields:

- Insufficient low-cost clean seed of well-adapted varieties.
- Late blight (*Phytophthora infestans*).
- Viruses and virus-like pathogens.
- Potato tuber moth, aphids, and nematodes.
- Poor agronomic practices and unsuitable environments.

However, lack of enough low-cost clean seed of the well-adapted varieties is still the most serious constraint to increasing area under production and yield per unit area. It was in this context that research was undertaken to study the use of TPS as a supplementary/alternative source of clean seed and for direct use to produce ware potato.

## Evaluation of TPS Progenies as Both Transplants and Seedling Tubers to Produce Propagating Material

### Materials and methods

During 1992/93, three TPS progenies (IP 88004, IP 88005, and IP 88006), and in 1993/94, 11 TPS progenies (IP 88001, IP 88002, IP 88003, IP 88004, IP 88005, IP 88006, IP 88008, CIP 989003, CIP 985001, CIP 989012, and OP Rutuku 720097) were evaluated in the highlands at Kalengyere (2,400 m.a.s.l.). Seedlings were raised in nursery beds of 3 $m^2$ and when ready they were transplanted singly at 50 cm between rows and 20 cm within rows. In 1992/93, plots of 5 $m^2$ were used, while in 1994/95 plot size was 6.75 $m^2$. Plots were replicated three times in a completely randomized design. The fertilizer dose was 100 N, 20 $P_2O_5$, and 20 $K_2O$ kg/ha of NPK (25-5-5).

For the production of seedling tubers, 18 TPS progenies were evaluated during 1992/93: OP 982003, 982002, 978001, 989003, 989004, 989007, 989010, 989013, 988009, IP 88001, IP 88002, IP 88003, IP 88004, IP 88005, IP 88006, and OP Rutuku in two different trials at Kalengyre. In 1993/94, 11 TPS progenies were studied for their suitability to produce seedling tubers: IP 88001, IP 88002, IP 88003, IP 88004, IP 88005, IP 88006, IP 88008, CIP 989003, CIP 985001, CIP 989012, and OP 720097. They were spaced at 15 cm x 10 cm in nursery beds of 3 $m^2$. They were laid out in a completely randomized design replicated three times. The fertilizer dose was 100 N, 20 $P_2O_5$, and 20 $K_2O$ kg/ha of NPK (25-5-5). Hilling was done by adding soil on the beds. Substrate used was natural volcanic soils from the subsoil layer, without sterilization. Four preventive fungicide applications were made.

## Results and discussion

The transplants gave good yields, ranging from 22.1 to 31.8 t/ha during 1992/93 and 4.6 to 35.6 t/ha during 1993/94, with means of 26.8 and 21.7 t/ha, respectively (Tables 1 and 2). This compared quite well with the performance of the clonal seed tubers of Rutuku, which yielded 20.5 t/ha (Table 2). This implied that when TPS is transplanted it has a potential to produce ware potatoes.

However, the TPS tended to produce many smaller tubers that are more suited for subsequent use as seed. For example, mean tuber weight was 29

Table 1. TPS performance as transplants during 1992/93. Tuber weight was 29 g for each progeny.

| Progeny | Stems ($m^2$) | Tuber yield (t/ha) | Yield/plant (g) | Tubers/plant |
|---|---|---|---|---|
| IP 99004 | 5 | 22.1 | 446 | 16 |
| IP 88005 | 7 | 26.6 | 390 | 13 |
| IP 88006 | 7 | 31.8 | 458 | 16 |
| Mean | 6 | 26.8 | 431 | 15 |

a. Date of sowing was 13-XI-93, transplanting was done 22-I-93, harvesting was 1-VI-93, and net plot size was 5 $m^2$.

Table 2. TPS performance as transplants during 1993/94.[a]

| Progeny | Tuber yield (t/ha) | Yield/plant (g) | Tuber weight (g) | Tubers/plant |
|---|---|---|---|---|
| IP 88001 | 28.2 | 501 | 49 | 10 |
| IP 88002 | 22.6 | 405 | 41 | 10 |
| IP 88003 | 15.4 | 420 | 46 | 9 |
| IP 88004 | 19.6 | 440 | 36 | 12 |
| IP 88005 | 22.8 | 440 | 50 | 9 |
| IP 88006 | 21.7 | 407 | 33 | 12 |
| IP 88008 | 29.5 | 580 | 50 | 12 |
| 985001 | 35.6 | 694 | 56 | 13 |
| 985003 | 29.2 | 543 | 51 | 11 |
| 989013 | 4.6 | 310 | 38 | 8 |
| OP Rutuku | 9.6 | 264 | 34 | 8 |
| Rutuku | 20.5 | 457 | 80 | 6 |
| Mean | 21.7 | 455 | 44 | 10 |

a. Date of sowing was 4-X-93, transplanting was done 16-XI-93, harvesting was 25-III-94, and net plot size was 4.5 m x 1.5 m = 6.75 $m^2$.

and 44 g during 1992/93 and 1993/94, respectively, compared with the regular-sized seed tubers of Rutuku of 80 g (Tables 1 and 2). TPS, therefore, lends itself quite favorably for exploitation for both purposes by a farmer picking the larger sized tubers for use as ware, while keeping the smaller, more uniform ones as seed. Hence, the main benefit of transplanting, although it is more labor-demanding and more prone to damage by both biotic and abiotic factors that reduce survival rates, is to produce ware and seed potatoes.

Seedling tubers raised in nursery beds tended to be smaller (Tables 3, 4, and 5), with mean tuber weights of 20, 27, and 23 g. The small size of tubers

Table 3. TPS performance of seedling tubers during 1992/93.[a]

| Progeny | Tuber yield (kg/m$^2$) | No. of tubers/m$^2$ | Tuber weight (g) |
|---|---|---|---|
| IP 88001 | 5.13 | 235 | 22 |
| IP 88002 | 3.74 | 168 | 22 |
| IP 88003 | 4.98 | 254 | 20 |
| IP 88004 | 4.13 | 191 | 22 |
| IP 88005 | 4.16 | 272 | 15 |
| IP 88006 | 3.51 | 221 | 16 |
| Mean | 4.28 | 224 | 20 |

a. Date of sowing was 13-XI-92 and harvesting 1-VI-93.

Table 4. TPS performance of seedling tubers during 1992/93.[a]

| Progeny | Tuber yield (kg/m$^2$) | No. of tubers/m$^2$ | Tuber weight (g) |
|---|---|---|---|
| CIP 978001 | 4.94 | 161 | 18 |
| CIP 985001 | 6.57 | 362 | 18 |
| CIP 989001 | 0.74 | 12 | 61 |
| CIP 989003 | 1.11 | 40 | 28 |
| CIP 988009 | 1.22 | 69 | 18 |
| CIP OP 982003 | 2.75 | 124 | 22 |
| CIP OP 982002 | 2.41 | 65 | 37 |
| OP Rutuku | 2.89 | 210 | 14 |
| Mean | 2.61 | 119 | 27 |
| LSD 0.05 | 1.36 | – | – |
| C.V. (%) | 30.85 | – | – |

a. Date of sowing was 8-IX-92 and harvesting 21-IV-93.

can be attributed to the higher stem density of seedling tubers compared with that of transplants. Nevertheless, the rationale of seedling tubers is to produce many small-sized tubers because earlier studies showed that the yield potential of the seedling tubers is similar regardless of size (Uganda National Potato Research and Development Program Report, 1991). Hence, large quantities of seedling tubers were generated in the trials, with a mean of 4.28 and 2.61 kg/m$^2$ during 1992/93 (Tables 3 and 4) and 5.85 kg/m$^2$ during 1993/94 (Table 5), with mean number of tubers per m$^2$ ranging from 168 to 272 and 12 to 362 during 1992/93 and 88 to 428 during 1993/94, compared with 38 to 76 tubers per m$^2$. Moreover, TPS also produced more tubers per m$^2$. There is therefore a real potential for generating large quantities of planting materials as seedling tubers from a small area. The main advantage here would be that besides the benefits associated with TPS of freedom of seed-borne diseases and pests and its heterozygosity, farmers could pay more attention to this smaller area and produce clean planting material.

In conclusion, studies since 1989 have confirmed that the use of TPS as both transplants and seedling tubers has a high potential in Uganda. The technology has already been adapted by some farmers, the only snag so far being the lack of high-quality TPS for use by farmers. But this is now being addressed by a special project involving one Ph.D. and three M.Sc. theses

Table 5. TPS performance of seedling tubers during 1993/94.[a]

| Progeny | Tuber yield (kg/m$^2$) | No. of tubers/m$^2$ | Tuber weight (g) |
|---|---|---|---|
| IP 88001 | 5.88 | 316 | 19 |
| IP 88002 | 8.93 | 335 | 27 |
| IP 88003 | 4.57 | 188 | 24 |
| IP 88004 | 4.13 | 218 | 19 |
| IP 88005 | 6.33 | 345 | 18 |
| IP 88006 | 7.09 | 353 | 20 |
| IP 88008 | 6.63 | 241 | 28 |
| 985001 | 6.97 | 428 | 16 |
| OP 982002 | 3.47 | 88 | 40 |
| 989003 | 9.18 | 338 | 27 |
| 989012 | 3.10 | 132 | 24 |
| OP Rutuku | 3.90 | 23 | 17 |
| Mean | 5.85 | 267 | 23 |

a. Date of sowing was 4-X-93, harvesting was 25-IV-94, with three replications and nursery beds of 3 m$^2$.

students at Makerse University in collaboration with the National Agricultural Research Organization (NARO) and CIP.

## Evaluation of TPS Filial Generations Compared with Clonal Seed Tubers of Established Varieties: TPS Degeneration Studies

### Materials and methods

Two TPS degeneration studies were conducted during 1992/93. One was located in the high hills of Kalengyere (2,400 m.a.s.l.). The other was located in the swamp represented by the Bubare experimental farm (1,800 m.a.s.l.). The third was also at Kalengyere, during 1993/94.

The first trial at Kalengyere (1992/93) involved three TPS progenies and three filial generations. The first generation was studied separately as transplants and seedling tubers. The following TPS progenies (treatments) were used: IP88002 $C_1$ transplants (TP), IP 88002 $C_1$ seedling tubers (ST), IP 88002 $C_2$, IP 88004 $C_1$ TP, IP 88004 $C_1$ ST, IP 8004 $C_3$, IP 88005 $C_1$ TP, IP 88005 $C_1$ ST, IP88005 $C_2$, and IP 88005 $C_3$ compared with basic seed tubers of Rutuku (720097), Sangema (800949), and Cruza-148 (720118). These were laid out in a randomized complete block design (RCBD) replicated three times in plot sizes of 6.3 $m^2$ spaced at 70 cm between rows and 30 cm between hills. The fertilizer dose was 100 N, 20 $P_2O_5$, and 20 $K_2O$ kg/ha of NPK (25-5-5). The crop was weeded twice. Four preventive fungicide sprays were made. The crop was hilled and weeded two times.

At Bubare, six TPS progenies involving four generations were compared with two established commercial varieties (basic seed tubers of Cruza and Sangema). The TPS progenies were 88004 $C_1$, 88004 $C_3$, 88005 $C_1$, 88005 $C_2$, 88005 $C_3$, 88005 $C_4$, 88007 $C_1$, 88007 $C_2$, 88007 $C_4$, 985001 $C_1$, 985001 $C_2$, 985001 $C_3$, 985003 $C_1$, 985003 $C_3$, 982002 $C_1$, and 982002 $C_3$. These were laid out in an RCBD replicated three times with net plot sizes of 6.5 $m^2$. The fertilizer dose was 80 N, 80 $P_2O_5$, and 50 $K_2O$ kg/ha of C.A.N., SSP, and KCl.

In 1993/94 at Kalengyere, five TPS progenies in four generations were studied with Cruza and Sangema. The TPS progenies were 88002 $C_1$, 88002 $C_2$, 88003 $C_2$, 88003 $C_4$, 88004 $C_1$, 88004 $C_3$, 88005 $C_1$, 88005 $C_2$, 88005 $C_3$, 88006 $C_1$, and 88006 $C_2$. These were laid out in an RCBD replicated three times with net plot sizes of 6.3 $m^2$. The fertilizer dose was 100 N, 50 $P_2O_5$, and 50 $K_2O$ kg/ha of NPK (20-10-10) at planting.

### Results and discussion

All three TPS progenies in the high hills, regardless of generation, yielded similar to the clonal seed tubers (Table 6) during 1992/93. This implied that the use of TPS as propagating material had the same potential as that of clonal tubers. Second, it showed that TPS could be used up to

Table 6. Yield and yield components of TPS generations compared with basic clonal seed tubers in the high hills at the Kalengyere Research Station.[a]

| Progeny | Survival yield (%) | Fresh tuber yield (t/ha) | Yield/plant (g) | Tuber weight (g) | Tubers/ plant |
|---|---|---|---|---|---|
| 88002 $C_1$ TP | 90.0 | 27.8 | 648 | 55 | 12 |
| 88002 $C_1$ ST | 85.6 | 29.3 | 719 | 62 | 12 |
| 88002 $C_2$ | 94.4 | 27.3 | 607 | 59 | 10 |
| 88004 $C_1$ TP | 88.9 | 21.2 | 500 | 59 | 9 |
| 88004 $C_1$ ST | 91.1 | 29.2 | 673 | 62 | 11 |
| 88004 $C_3$ | 93.3 | 34.1 | 767 | 69 | 11 |
| 88005 $C_1$ TP | 98.9 | 30.6 | 649 | 55 | 12 |
| 88005 $C_1$ ST | 86.7 | 28.1 | 681 | 69 | 10 |
| 88005 $C_2$ | 93.3 | 25.9 | 582 | 49 | 12 |
| 88005 $C_3$ | 80.0 | 33.0 | 865 | 57 | 15 |
| Rutuku | 91.1 | 30.9 | 712 | 99 | 7 |
| Sangema | 91.1 | 28.1 | 648 | 90 | 7 |
| Cruza | 98.9 | 29.2 | 620 | 64 | 10 |
| Mean | 91.0 | 28.8 | 667 | 65 | 11 |
| LSD 0.05 | – | NS | – | – | – |
| C.V. (%) | – | 31.2 | – | – | – |

a. Date of planting was 12-XI-92, harvesting was 17-III-93, plot size was 6.30 $m^2$, with three replications in an RCBD. TP = transplants, ST = seedling tubers.

three generations without a significant yield reduction in the high hills represented by the station.

However, for the health of the crop during 1992/93, 88002 $C_2$ had one plant with stunted growth, which represented 0.56% of the genotype. Progeny 88004 $C_3$ had 3.89% of the plants with chlorotic, plasma-like, and mycoplasma-like symptoms. This indicates that as the number of generations increases, the health of the planting material may decline, although this did not reduce fresh tuber yield potential.

During 1993/94, the trend was similar, although fresh tuber yields were lower (Table 7). However, the TPS generations generally yielded more than the basic clonal seed tubers at Kalengyere.

In the swamp, at the Bubare station, there were significant yield differences (Table 8). Cruza, which is generally a tolerant variety for biotic stresses, outperformed the rest. The yields of TPS were still average. No evidence showed any yield decline associated with an increased number of generations from $C_1$ to $C_4$.

Table 7. Yield and yield components of TPS generations compared with basic clonal seed in the high hills at Kalengyere during 1993/94.[a]

| Progeny | Tuber yield (t/ha) | Yield/plant (g) | Tuber weight (g) | Tubers/plant |
|---|---|---|---|---|
| 88002 $C_1$ | 16.3 | 354 | 49 | 7 |
| 88002 $C_2$ | 16.2 | 414 | 59 | 7 |
| 88003 $C_2$ | 17.6 | 443 | 74 | 6 |
| 88003 $C_4$ | 8.6 | 263 | 37 | 7 |
| 88004 $C_1$ | 14.0 | 335 | 64 | 5 |
| 88004 $C_3$ | 11.9 | 280 | 48 | 6 |
| 88005 $C_1$ | 14.5 | 397 | 60 | 7 |
| 88005 $C_2$ | 15.0 | 131 | 59 | 6 |
| 88005 $C_3$ | 16.2 | 374 | 49 | 8 |
| 88006 $C_1$ | 14.7 | 320 | 40 | 8 |
| 88006 $C_2$ | 14.7 | 355 | 55 | 7 |
| Cruza | 9.0 | 216 | 27 | 8 |
| Sangema | 11.4 | 272 | 41 | 7 |
| Mean | 13.9 | 320 | 51 | 7 |

a. Date of planting was 11-XI-93, harvesting was 24-III-94, plot size was 6.30 $m^2$, with three replications in an RCBD.

These trials therefore demonstrated that tubers derived from TPS transplants and seedling tubers can be used as planting materials for three to four generations without significant decreases in fresh tuber yield. Farmers could improve on this by selecting in each generation tubers that are uniform in color and shape, with desirable attributes such as smooth skin and shallow but many eyes.

**Farm-level research on true potato seed**

A number of on-farm trials have been carried out in order to train farmers on TPS technology using either transplants or seedling tubers. During 1992, extensive on-farm trials in the warm areas (low and mid altitudes) of Uganda tested the adaptability and acceptability of potato varieties.

**Materials and methods**

Six TPS progenies were compared with six commercial varieties and three landraces as controls in three districts of southern and central Uganda. The six TPS progenies were CIP 982002 $C_2$, CIP IP 88001 $C_1$, CIP IP 88003 $C_1$, CIP IP 88005 $C_1$, CIP 985001 $C_1$, and CIP 978004 $C_1$. The potato varieties were Victoria (381381.20), Kisoro (381379.9), Kabale (374080.5),

Table 8. Yield and yield components of TPS generations compared with basic clonal seed in the swamp at Bubare in experimental plots.[a]

| Progeny | Survival (%) | Tuber yield (t/ha) | Yield/ plant (g) | Tuber weight (g) | Tubers/ plant | Tuber rottage (%) |
|---|---|---|---|---|---|---|
| 88004 $C_1$ | 89.8 | 23.7 | 474 | 53 | 9 | 0.0 |
| 88004 $C_3$ | 86.1 | 15.4 | 321 | 55 | 6 | 8.9 |
| 88005 $C_1$ | 82.4 | 19.4 | 423 | 48 | 9 | 4.0 |
| 88005 $C_2$ | 88.9 | 21.5 | 435 | 59 | 7 | 0.3 |
| 88005 $C_3$ | 89.8 | 19.4 | 389 | 61 | 6 | 0.5 |
| 88005 $C_4$ | 88.0 | 17.3 | 353 | 46 | 8 | 0.7 |
| 88007 $C_1$ | 76.9 | 12.7 | 298 | 40 | 7 | 1.0 |
| 88007 $C_2$ | 88.9 | 24.5 | 495 | 64 | 8 | 0.1 |
| 88007 $C_4$ | 85.2 | 16.5 | 348 | 55 | 6 | 13.9 |
| 985001 $C_1$ | 83.3 | 14.2 | 307 | 38 | 8 | 0.0 |
| 985001 $C_2$ | 83.3 | 13.2 | 285 | 40 | 7 | 2.9 |
| 985001 $C_3$ | 95.4 | 18.4 | 348 | 47 | 7 | 0.0 |
| 985003 $C_1$ | 69.7 | 5.6 | 143 | 25 | 6 | 0.0 |
| 985003 $C_3$ | 80.6 | 13.7 | 306 | 39 | 8 | 0.9 |
| 982002 $C_1$ | 69.7 | 13.1 | 336 | 37 | 9 | 1.0 |
| 982002 $C_3$ | 82.4 | 18.3 | 400 | 40 | 10 | 0.2 |
| Cruza | 87.0 | 31.4 | 650 | 59 | 11 | 0.1 |
| Sangema | 59.3 | 8.5 | 259 | 42 | 6 | 1.0 |
| Mean | 82.6 | 17.0 | 365 | 47 | 8 | – |
| LSD 0.05 | – | 7.4 | – | – | – | – |
| C.V. (%) | – | 25.54 | – | – | – | – |

a. Date of planting was 9-IX-92, harvesting was 1-I-93, with three replications in an RCBD.

Malirahinda, Rutuku (720097), and Sangema (800949). The local controls were "local," "local red," and "Mali-Kabera."

The genotypes were planted in an RCBD in plots of 3.15 $m^2$ at a spacing of 70 cm x 30 cm replicated three times. A fertilizer dose of 100 N, 20 $P_2O_5$, and 20 $K_2O$ kg/ha of NPK (25-5-5) was applied at planting. Marshall 5G was incorporated in the soil at planting. Two weedings and preventive fungicidal sprays were made, with more when necessary.

**Results and discussion**

Fresh tuber yields of the six TPS progenies varied from 21.3 to 30.0 t/ha, comparing favorably with the newly released varieties (Victoria, Kisoro, Kabale), with wide adaptability. TPS yields averaged 24.6 t/ha compared with those of basic clonal seed tubers, which yielded 26.2 t/ha (Table 9). This was much higher than the average yield of farmers' seed from local cultivars, which was only 5.5 t/ha. Moreover, TPS tended to produce many average-sized tubers. The study therefore demonstrated the potential use of TPS as an alternative source of seed.

Farmers expressed general satisfaction with uniformity of color, size, and shape of the tubers derived from TPS. When palatability tests by farmers were done, some TPS progenies had high preference, notably IP 88003 $C_1$.

In conclusion, it is evident that TPS has wide adaptability, as it can perform well in the cool highlands and at warm, low altitudes. But we need to know how it degenerates in warm areas. A study by an M.Sc. student is in progress to learn this.

Table 9. Fresh tuber yield and yield components of TPS progenies compared with basic tuber seed for the districts of Iganga, Mukono, and Masaka during long rains, 1992.[a]

| Genotype/variety | No. of trials | Survival (%) | Yield (t/ha) | Yield/ plant (g) | Tubers per plant | Tuber weight (g) |
|---|---|---|---|---|---|---|
| CIP 982002 $C_2$ | 4 | 87.8 | 22.0 | 549 | 10 | 54 |
| CIP IP 88001 $C_1$ | 5 | 83.0 | 24.9 | 591 | 13 | 45 |
| CIP IP 88003 $C_1$ | 4 | 85.6 | 22.0 | 544 | 12 | 45 |
| CIP IP 88005 $C_1$ | 5 | 86.0 | 23.1 | 598 | 13 | 45 |
| CIP 985001 $C_1$ | 3 | 80.6 | 21.3 | 511 | 13 | 43 |
| CIP 978004 $C_1$ | 6 | 70.8 | 30.8 | 777 | 12 | 66 |
| Mean | | 82.3 | 24.6 | 612 | 12 | 51 |
| Victoria | 15 | 94.3 | 35.1 | 779 | 9 | 88 |
| Kisoro | 15 | 93.7 | 34.8 | 780 | 14 | 55 |
| Kabale | 15 | 84.5 | 33.8 | 771 | 11 | 63 |
| Malirahinda | 15 | 90.6 | 23.9 | 546 | 12 | 45 |
| Rutuku | 13 | 51.2 | 17.0 | 536 | 7 | 80 |
| Sangema | 15 | 43.3 | 11.2 | 475 | 9 | 57 |
| Mean | | 76.3 | 26.2 | 650 | 10 | 64 |
| Local | 6 | 50.8 | 4.1 | 169 | 9 | 20 |
| Local red | 1 | 52.8 | 8.9 | 276 | 6 | 60 |
| Mali-Kabera | 1 | 84.4 | 10.3 | 255 | 11 | 23 |
| Mean | | 62.7 | 5.5 | 193 | 9 | 25 |

a. Date of planting was 19-29-IX-92, harvesting was 4-12-I-93, with three replications in an RCBD.

## General Conclusions on Uganda's TPS Research and Development

1. Clean, acceptable seed tubers can be produced from TPS by use of seedling tubers and transplants. The use of seedling tubers is easier and requires less labor. Transplants are good when it is necessary to produce ware potato.
2. Seed tubers derived from TPS can be used for 3-4 generations without significant reductions in fresh tuber yields.
3. Seed tubers derived from TPS have wide adaptability and are acceptable to farmers.
4. There is thus a need to develop local capacity to produce good-quality TPS.

# Acronyms

| | |
|---|---|
| AARI | Aegean Agricultural Research Institute, Turkey |
| ARC | Agricultural Research Center, Egypt |
| AUA | Alemaya University of Agriculture, Ethiopia |
| BW | bacterial wilt |
| CFPA | Centre de Formation et de Perfectionnement Agricole, Tunisia |
| CPRA | Centre de Perfectionnement et de Recyclage Agricole de Saïda, Tunisia |
| DAP | days after planting |
| DAS | days after sowing |
| GOSM | General Organization for Seed Multiplication, Syria |
| HARC | Holetta Agricultural Research Center, Ethiopia |
| IAR | Institute of Agricultural Research, Ethiopia |
| INIA | Instituto Nacional de Investigaciones Agropecuarias, Chile |
| ISABU | Institut des Sciences Agronomiques du Burundi |
| MENA | Middle East and North Africa, CIP region |
| NARO | National Agricultural Research Organization, Uganda |
| NARS | national agricultural research systems |
| NGO | nongovernmental organization |
| OP | open-pollinated |
| PSTVd | potato spindle tuber viroid |
| PTM | potato tuber moth |
| PVY | potato virus Y |
| RCBD | randomized complete block design |
| SSA | Sub-Saharan Africa |
| ST | seedling tubers |
| TPS | true potato seed |

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