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Technology Evaluation Series No. 1

Evaluation of Technology for Production of Seed Tubers From True Potato Seed

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INTERNATIONAL POTATO CENTER (CIP)

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TECHNOLOGY EVALUATION SERIES

The purpose of the Technology Evaluation Series is to acquaint national potato program scientists with technologies generated at the International Potato Center (CIP) which are ready for evaluation under local conditions.

Each technology is presented with relevant research results and with sufficient information on materials and procedures that can be used in evaluation. Several experiments including field layouts are suggested. Guidelines and data recording sheets are included.

Through this series CIP is attempting to improve the process of technology transfer to scientists of national potato programs, and facilitate the adaptation of the technologies to farmers' conditions. It is important to CIP's efforts for improving potato productivity that national scientists feed back results of their evaluation of technologies. This information will help to orientate CIP's research and will result in technologies more appropriate to farmers' conditions and needs.

Primo Accatino
Coordinator, Research Transfer

EVALUATION OF TECHNOLOGY FOR PRODUCTION OF SEED TUBERS FROM TRUE POTATO SEED

S. G. Wiersema

INTRODUCTION

Potato production from seed tubers derived from true potato seed (TPS) combines rapid plant development normally obtained from seed tubers with high health standards of TPS. Seed tubers from TPS (seedling tubers) could be produced by national seed tuber multiplication programs as "basic seed" or alternatively by individual growers or cooperatives. Since TPS is easy to distribute to any distant potato growing area, first generation tubers can be produced close to areas where ware potatoes are produced to avoid seed tuber transport over long distances.

This system of seed tuber production may have potential in areas where healthy seed tubers are not available or expensive but where growing conditions are favorable for potato production.

TPS SOURCE

TPS can be obtained from berries collected from commercial varieties (open-pollinated seed). Seed from crosses (hybrid seed) may have great potential because of disease resistance and possibly higher yields, but effective means of hybrid seed production are still under investigation. Open-pollinated seed can be produced at low cost. Good tuber yields from this source have been obtained. It is important that berries are collected from the best local varieties. After seed extraction from berries, small and darkly colored seeds should be removed since these germinate and grow poorly.

TECHNIQUES OF SEED TUBER PRODUCTION FROM TPS

Techniques should be aimed at production of large numbers of healthy, first generation seedling tubers. A large number of first generation tubers is important in order to limit the number of multiplications necessary to obtain a certain quantity. With each multiplication the health standard of the tubers decreases. The number of possible multiplications in a particular region depends on the health degeneration rate of tubers grown in the area and on the health of the first generation seedling tubers.

Although TPS is free from most of the potato diseases, first generation seedling tubers are not necessarily free from diseases. During growth, seedlings may be visited by insects which can transmit virus diseases. In addition, tubers can become infected by soil-borne pathogens like bacterial wilt. It is important, therefore, that first generation tubers are produced in an area protected from diseases.

First generation seedling tubers can be produced in the field or in nurseries. Advantages of production in nurseries are optimum growing conditions resulting in a high health standard. In addition, production can be independent of the main growing season, thus allowing several harvests per year.

PRODUCTION OF FIRST GENERATION SEEDLING TUBERS IN NURSERIES

Nursery structure. Beds, 1 m wide, are convenient for growing seedlings. Depth of the bed does not need to be more than 25 cm since the rooting system of seedlings is rather shallow. In high rainfall areas raised beds with proper drainage may have to be used. A way to improve drainage is to add a layer of gravel under the substrate, connected with drainage channels. Transparent roofs (e.g. plastic) can also be used to avoid seedlings being damaged by heavy rains.

Nursery bed substrate. Potato seedlings require a substrate with high percentage of organic matter and a very limited amount of clay. Too much clay may result in compacted substrates. For example, a suitable substrate on volume basis may be:

- 4 parts sand
- 4 parts organic matter (e.g. plant compost, peat moss)
- 1 to 2 parts soil

When substrate components contain salts they have to be washed. The components should be mixed thoroughly. A certain amount of wetting is needed for proper mixing. Fumigation of the substrate to control diseases may be done to enhance seedling survival; application of "Basamid" at a rate of 40 g/m^2 has given good results. At least three weeks of aeration following Basamid application are required before TPS can be sown.

Fertilization. The amount of nitrogen and potassium applied before sowing should be minimized to avoid high salt concentrations resulting in poor plant growth. The response of seedling growth to phosphate is normally strong and no negative effects of high amounts of phosphate have been observed. Therefore, the total required amount of phosphate can be applied before sowing, while nitrogen and potassium can be split in several applications according to growth requirements. The following is an example of fertilizer application in Lima:

a) Before sowing, mix with the substrate:

400 g of single superphosphate (20% P_2O_5) per m^2 or,
175 g of triple superphosphate (46% P_2O_5) per m^2.

b) After emergence, when plants are still small, foliar fertilizers can be applied. In addition apply nitrogen and potassium dissolved in water (e.g. use watering can).

The following amounts can be applied weekly:

Weeks after emergence	Amonium Nitrate (33% N) g/m^2	Potassium Magnesium Sulphate (22% K_2O 18% MgO) g/m^2
1	0	0
2	5	10
3	10	10
4	20	20
5	25	30
6	25	40
7	25	40
8	25	40
9	15	40
10	15	30
11	10	0
12	10	0

A weekly application of 10 g ammonium nitrate can be continued until plants start maturing. This is an example of fertilizer application and actual quantities depend on local conditions such as original substrate fertility and plant development.

When only compound NPK fertilizers are available use initially a fertilizer with a high level of phosphate like 10-30-10.

Application of fertilizer with irrigation water can cause leaf burning. To prevent this, leaves should be washed with clean water.

Sowing. Direct seed sowing is less labor intensive than transplanting. Before sowing, treat TPS with gibberellic acid for 24 hours at a concentration of 1500 ppm in order to break dormancy. To maintain a soil temperature of 15-25°C, required for proper TPS germination, shading can be used to lower it or plastic to raise it. At sowing, nursery beds should be filled with 15-20 cm of substrate.

Spacing. High plant population has a positive effect on the number of usable tubers produced per unit area. Population density studies at CIP show that optimum plant population (after thinning) should be at least 100 plants per m^2. In order to obtain such population density, TPS can be sown at 10 cm row spacing and 2-3 cm between seeds. Later on, plants are thinned within the row to about 10 cm between plants. This results in a final spacing of 10 x 10 cm.

Thinning. The purpose of thinning is to improve the yielding capacity and homogeneity of the population and its tubers. Off-type seedlings, as well as poorly growing seedlings, should be removed. Thinning at two stages is preferred to avoid unnecessary plant competition, e.g. a first thinning 1-2 weeks after emergence and a final thinning 1-2 weeks later.

Hilling. Hilling tends to increase tuber number per plant. In addition, it may provide a better protection against pests (e.g. tuber moth). Hilling can be done by adding additional substrate to the beds, e.g. 8 cm. This amount can be divided over two hilling operations. Hilling should be completed before plants touch each other.

Shade. Shade should be used only to reduce soil temperature at germination. Shading during growth results in weak, elongated seedlings. Shade should be removed gradually after one to three weeks when plants are established.

Harvest. Harvest provides another opportunity for selection. Off-type tubers should be removed. If the progeny segregates for color, the tubers may be separated into different color categories. This, of course, is only needed when ware markets require uniformity in tuber color.

SEED TUBER PRODUCTION IN THE FIELD

Seedling tubers can be produced in a small field area when soil and climatic conditions are suitable for transplanting. A nursery may also be required to produce the transplants since, in most cases, field conditions do not allow direct TPS sowing.

For transplanting seedlings, a small field area should be selected where water supply, disease, and pest control can be effectively managed. In order to maximize the number of tubers produced per unit area, planting should be done at close spacing (e.g. 50 cm between rows and 10 cm within the row). Tubers can also be produced in beds, as is the practice with several vegetable crops. During growth, off-type plants should be removed and tubers selected at harvest.

STORAGE

In order to reduce the storage period, production of first generation seedling tubers during off-season periods may have advantages. If seedling tuber harvest is programmed about three months before the regular time for field planting, seed tubers will have sprouted by then and should be ready for planting. Sprouting may be somewhat irregular, because tubers represent different genotypes. Desprouting when the longest sprout per tuber is about 0.5 cm followed by a pre-sprouting period of 2-4 weeks in indirect light normally results in well-sprouted seed tubers and less variation in sprout size.

When tubers have to be stored for a longer period (4-6 months), storage in diffused light is required to limit weight losses by reducing sprout growth. Tubers with apical dominance have to be desprouted early during the storage period before sprouts become too thick. In this way damage to the buds in the tuber eye during the desprouting process can be prevented.

MULTIPLICATION

Multiplication of first generation seedling tubers may serve two purposes:

a) an increase of the amount of seed tubers

b) an increase in seed tuber size, as compared to size of first generation seedling tubers produced in nursery beds.

A few multiplications reduce the required nursery space considerably. Based on results at CIP, it was calculated that without multiplication about 100 m^2 nursery bed would be required to produce sufficient seed tubers for one hectare. With one field multiplication this area could be reduced to about 30 m^2 and with two field multiplications to about 3 m^2.

In order to determine how many multiplications are possible in terms of seed tuber health, the proportion of diseased plants has to be evaluated after each multiplication. Final judgement, however, of the number of possible multiplications should be based on <u>yielding capacity</u> of produced seed tubers rather than only on disease level.

USE OF SMALL TUBERS

It is important to know the minimum size tubers that can be used since first generation seedling tubers are normally small.

At CIP, tubers of the 1-5 g grade were multiplied successfully in the field. Disadvantages of planting small tubers compared to larger ones are: slower emergence, slower initial foliage growth and greater susceptibility to adverse growing conditions like drought, disease attack, frost, etc. Advantages are, however, a larger number of sprouts per unit weight, resulting in lower planting rates. In addition, small tubers show a high multiplication to weight ratio. (See table 1.)

When planting small tubers agronomic practices have to be adapted. Since foliage development is limited, row spacing can be narrower (e.g. 60 cm) and tubers can be planted at 10-15 cm spacing (for 5-10 g tubers) within the row. Also, when planting these small tubers, one or two tubers per hill should be considered. The yield per stem may be somewhat lower from small tubers compared with that from larger tubers but this is compensated to some extend by a larger number of stems per unit area.

Table 1. Effect of seed tuber size on planting rate and multiplication rate. Data based on results at CIP.

Tuber grade (g)	Planting rate (t/ha)	Yield (t/ha)	Multiplication rate
1-10	.5	16.5	33
10-20	.8	18.1	23
40-60	1.9	19.8	10

SUGGESTED EXPERIMENTS TO EVALUATE TECHNOLOGY AND TO ADAPT TO LOCAL CONDITIONS

Nursery Experiment

1) Nursery substrate: Use different substrates as treatments, for example:

substrate 1: 50% sand, 40% peat moss, 10% soil

substrate 2: 50% sand, 40% plant compost, 10% soil

substrate 3: 50% sand, 50% plant compost

2) Plant density in nursery bed: The following densities could be tried:

Density 1: 50 plants/m^2 (14 x 14 cm plant spacing after thinning)

Density 2: 100 plants/m^2 (10 x 10 cm plant spacing after thinning)

Density 3: 150 plants/m^2 (8 x 8 cm plant spacing after thinning)

Layout for nursery experiment with two substrates and two plant densities

< 6 m >

< 1.5 m >

^ 1 m v

S1 D1	S1 D2	S2 D1	S2 D2
S2 D2	S2 D1	S1 D1	S1 D2
S1 D1	S1 D2	S2 D2	S2 D1

S1: Substrate 1
S2: Substrate 2

D1: 100 plants/m^2
D2: 150 plants/m^2

Field Experiment

Planting material for ware potato production

In this experiment alternative planting material available to a farmer can be compared. This could include the following treatments:

Planting material 1: seedlings - 15 cm spacing, 3 transplants per hill

Planting material 2: 5-10 g seedling tubers - 15 cm spacing, 2 tubers per hill

Planting material 3: 10-20 g seedling tubers - 15 cm spacing, 1 tuber per hill

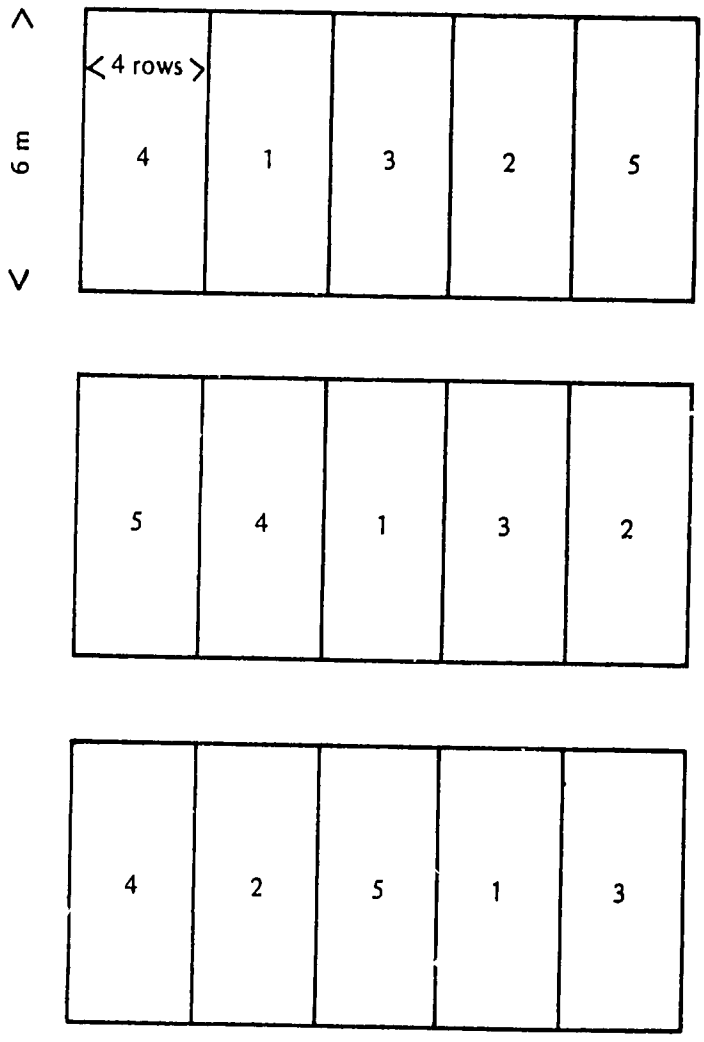
Planting material 4: 20-40 g seedling tubers - 25 cm spacing, 1 tuber per hill

Planting material 5: Seed tubers normally used by the farmer, planted at the same seed tuber weight per ha as the 20-40 g seedling tubers.

Use in all treatments the same row spacing.

The tubers for this experiment can be produced during the nursery experiment.

Layout for field experiment



Material		Spacing
1:	transplants	15 cm
2:	5-10 g seedling tubers	15 cm
3:	10-20 g seedling tubers	15 cm
4:	20-40 g seedling tubers	25 cm
5:	farmers seed tubers	see text

DATA RECORDING SHEET FOR NURSERY EXPERIMENT WITH TPS

Plot size:

Sowing date:

	Replication	Treatment					Observations
		$S_1 D_1$	$S_1 D_2$	$S_2 D_1$	$S_2 D_2$	Date	
1) % final germination	I						
	II						
	III						
2) N° plants after last thinning	I						
	II						
	III						
3) N° plants at time of foliage maximum	I						
	II						
	III						
4) N° plants at harvest	I						
	II						
	III						
5) N° tubers 1-10 g	I						
	II						
	III						
6) N° tubers 10-20 g	I						
	II						
	III						
7) N° tubers 20-40 g	I						
	II						
	III						
8) N° tubers > 40 g	I						
	II						
	III						
9) Total tuber weight (g)	I						
	II						
	III						

DATA RECORDING SHEET FOR FIELD EXPERIMENT WITH SEEDLING TUBERS

Plot size:

Planting date:

	Replication	Treatment						Observations
		1	2	3	4	5	Date	
1) % emergence 1 week	I							
	II							
	III							
2) % emergence 2 weeks	I							
	II							
	III							
3) % emergence 3 weeks	I							
	II							
	III							
4) % soil coverage 4 weeks	I							
	II							
	III							
5) % soil coverage 6 weeks	I							
	II							
	III							
6) % soil coverage 8 weeks	I							
	II							
	III							
7) Number of main stems	I							
	II							
	III							
8) Tuber weight < 20 mm (kg)	I							
	II							
	III							
9) Tuber weight 20-45 mm (kg)	I							
	II							
	III							
10) Tuber weight > 45 mm (kg)	I							
	II							
	III							

EXPLANATION OF DATA RECORDING

Nursery Experiment

1) Percentage of seeds that germinate.

2)-4) Number of plants is counted at different stages of growth because plants are eliminated through competition, pests and diseases. Indicate in "Observations" column why you think plants disappear. Elimination of plants through competition is desirable because weak genotypes are likely to be eliminated.

5)-9) From the number of tubers per size grade, in addition to total tuber weight per plot, treatment effects can be judged satisfactorily.
The tubers separated by size are used for the FIELD experiment.

Field Experiment

1)-3) Intervals of counting may be shorter when emergence is fast.

4)-6) Percentage of soil area that is covered with green foliage. This is an indication for plant vigor and crop development. Intervals of observations may change depending on crop development. Do an observation at the moment when one of the treatments has reached a soil coverage of 100%.

7) Number of main stems can accurately be counted at harvest. Alternatively number of above ground stems can be counted during growth.

8)-10) Tuber weights per size grade in kg.
Harvest only central two rows of each plot to avoid border effects.

If possible, collect meteorological data in both experiments including: min. and max. temperatures, rainfall.