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Evaluation of Agronomic Technology for Potato Production 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 scientists in national potato programs with technologies that have been generated at the International Potato Center (CIP) and that 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 for 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 to facilitate the adaptation of the technologies to local conditions. It is important to CIP's efforts for improving potato productivity that national scientists feed back the results of their technology evaluations. 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 AGRONOMIC TECHNOLOGY FOR POTATO PRODUCTION FROM TRUE POTATO SEED

J. P. Malagamba

INTRODUCTION

Several field practices that are important in potato production from true potato seed (TPS) are presented here as a standard procedure for evaluation. The purpose is to develop technology that is appropriate for use by farmers in relation to local conditions.

Growing potatoes from TPS is advantageous in areas 1) where climatic conditions permit potato production during three to four months of the year, 2) where the cost of seed tubers represents a high proportion of crop production costs, 3) where potato yields are low due to poor seed tuber quality, and 4) where labor skilled in vegetable growing practices is abundant and cheap. The presence of these four basic factors will increase the potential use of TPS and must be considered before starting research activities.

Because of differences in climate and availability of required elements, the agronomic knowledge on TPS must be adapted to conditions already present. This paper attempts to explain the different steps involved in potato production from TPS, to indicate problems we have already experienced in our work, and to propose some alternatives for evaluation. Suggested experiments are presented in Appendix A.

TPS TECHNOLOGY AND ALTERNATIVES[1]

The first step in assessing the potential of TPS in an area is to select a TPS progeny adapted to the prevailing conditions in that area.

[1] For more information refer to Potato Production from True Seed, by P. Accatino and P. Malagamba, International Potato Center, 1982.

Open-pollinated seed of a uniform progeny is very useful for research purposes since it can be readily obtained. Although hybrid seed usually produces higher yields than open-pollinated seed, it is more difficult to obtain.

Two primary alternatives should be considered for growing potatoes from true seed: true seed can be directly sown in the field, or it can be grown in a field nursery for transplanting later to the field. Either method can be used for producing potatoes for consumption or for producing seed tubers to be planted the following season.

Our experience indicates that direct sowing of true seed in the field involves a higher risk. Direct sowing requires more intensive and skillful management and improved soil and moisture conditions than potato production via seedling transplanting.

Two stages deserve special attention when producing potatoes via seedling transplanting: seedling production in the nursery, and transplanting and field establishment.

SEEDLING PRODUCTION STAGE

Seed Production

TPS, depending on the progeny, quickly germinates when sown six months or more after harvesting the berries. To break seed dormancy before this period, immerse the seed in a gibberellic acid solution of 1500 ppm (1.5 g of GA per liter of water) for 24 hours.

Seedbed Characteristics

Most vegetable seedlings for transplanting are produced in seedbeds in a field nursery or in trays made of wood or plastic.

Different types of seedbeds can be found in vegetable growing areas. One type of seedbed consists of a few furrows, 10 to 15 cm deep, in which the seed is sown on both sides of the furrow, just above the water line. Another type of seedbed is on a well-prepared and leveled piece of land (usually rectangular) where the organic matter content of the soil is higher

than the rest of the field. This is normally accomplished with applications of farm manure, compost, or other organic materials. On this piece of land, the seed is broadcast or sown in shallow furrows. Seedbeds for potato seedling production have the same characteristics as those described above. In Peru, potato seedlings have been grown satisfactorily in different types of seedbeds; however, these seedlings may have higher requirements for nutrients and good soil structure than seedlings of other crops.

Climatic conditions, particularly temperature, are also important during this period of seedling growth. An adequate minimum temperature range for growth is between 10° to 20°C, when the maximum temperature does not exceed 30°C. With temperatures out of this range, lack of uniformity and loss of seedling vigor occur.

In areas of high temperature, protect the seedbed during early growth by locating it under the shade of a tree, or by covering it with branches, leaves, or other elements. Shading reduces temperatures at the seedbed level quite significantly, but it should not reduce sunlight more than 20% to 30%, to the extent of causing etiolation. Remove the shading 10 to 15 days before transplanting (25-30 days after sowing). This exposure to direct sunlight will result in more vigorous seedlings that will survive transplanting in better condition. In heavy rain areas, a polyethylene sheet can be placed under the material used for shading. An adequate protective structure made of chicken wire, a plastic sheet and leaves, with supporting poles, can be placed 50 to 100 cm over the seedbed. Sometimes it is necessary to fence off the nursery area to avoid the entrance of small animals. If sowing is done when the minimum temperatures are below 10°C, it may be necessary to warm up the seedbed environment by constructing a small plastic tunnel, or to utilize greenhouse facilities whenever available. A good example of how to increase seedbed temperature is to observe methods used by local farmers who are growing other vegetables (e.g., tomato, celery, eggplant) during the same period.

Seedbed Substrates

This is an area where adaptive research is highly recommended. Possible materials to use as seedbed substrates are extremely variable and so are

their characteristics and requirements. The structure of a seedbed substrate is a very important factor. Seedlings develop better when their roots grow in a well-aerated medium that permits good drainage. The medium adheres to the roots and forms a root block (a seedbed substrate block covering the roots) when the seedlings are lifted for transplanting.

Soils of high organic matter are excellent substrates that may not require additional fertilization. In some areas of intensive farming, compost preparation is a common practice. Well-prepared composts have enough properties for growing seedlings and can be used either alone or mixed with the soil in fairly large amounts to improve soil structure and fertility. Composts, depending on their nature and preparation procedures, may have a high salt concentration, which can cause poor seedling growth. Here, the excess salt has to be removed by washing before using the compost (Appendix A, Example 1)

Manure is also used to improve seedbed characteristics. The use of fresh manure, or any organic material that will decompose when used as a substrate or mixed as a substrate component, is harmful for potato seedling growth. Only well-decomposed materials (including manure), or those that because of their composition are quite stable (e.g., with high content of lignin), are recommended. Manure that has completely decomposed has excellent properties as a seedbed "improver" when mixed with the soil in correct proportions.

In locations where peat moss is available, a mix of peat moss and sand (1:1 volume basis) with fertilizers can be used. Add the following amount of nutrients, per kilogram of mix, to the mix: 100 mg of N, 300 mg of P_2O_5, and 100 mg of K_2O. For N the nitrate form is recommendable--avoid using urea. Superphosphate (20% P_2O_5) is a good source of P, and potassium chloride (60% K_2O) a good source for K. Add fertilizers very carefully to achieve a uniform distribution (Appendix A, Example 2).

In areas with a high population of parasitic nematodes (e.g., Meloidogyne), the application of chemicals with both nematicide and insecticide action, such as carbofuran 10 G at a rate of 5 g/m^2, may be used effectively without harming the seedlings. The chemicals must be distributed on the seedbed and added to the surface layer of the soil before sowing. Open-air nurseries

can be protected from cutworm damages by surrounding the seedbed with a powdered contact insecticide such as Sevin. For other foliage-feeding insects, apply insecticides to the leaves.

For experimental purposes, the effect of seedbed sterilization can be compared to the more practical method of applying recommended fungicides to eliminate the predominant soil-borne diseases.

SOWING OF TPS

Sow the seed in shallow furrows that are 0.5 to 1.0 cm deep and spaced 5 cm apart. This will ensure higher efficiency in potato seedling management and safer transplanting. Make the furrows with an appropriate instrument and distribute the seed 1.5 cm apart in each furrow. Ten days after emergence the seedlings are thinned leaving them approximately 3 cm apart.

Water carefully during the seedling production period. When the seedbed is furrow-irrigated, only the moisture must reach the seedling root zone.

SEEDLING EMERGENCE AND GROWTH

Emergence of seedlings usually occurs between 5 to 10 days after sowing. In hot climates, seedling emergence takes longer. Optimum temperature for TPS germination is between 15° to 20°C.

Seedling growth progresses slowly during the first 20 days after sowing. After this period, which coincides with the development of the first pair of leaves, the growth rate increases very fast, and in a few more days the seedlings are ready for transplanting (about 35 days after sowing).

Temperature has a strong effect on seedling growth rate. Also, seedlings of the same progeny react differently to sub-optimal temperatures, which results in a severe lack of uniformity and a longer seedling production period.

TRANSPLANTING AND FIELD ESTABLISHMENT

Transplant the potato seedlings from the nursery to the field when the seedlings have developed their fifth leaf (8 to 10 cm high).

The following recommendations will ensure successful transplanting:

1. The soil in the field must be well prepared, properly fertilized, and watered at transplanting. Fertilizer requirements depend on the soil type, source, method of application, and should be determined by experimentation. In our experience, the best results are obtained by adding fertilizer to the soil in a strip close to the transplanting furrow. Nitrogen rates are divided into partial applications: at transplanting and at every hilling operation.

The difference in soil moisture content from the seedbed to the field should be kept to a minimum to avoid the shock of transplanting. Therefore, soil moisture content the first few days should be sufficient to permit fast establishment of the seedlings. Also, the time between lifting the seedlings from the seedbed and placing them in the soil must be as short as possible.

2. Transplant the seedlings with as much substrate adhered to the roots as possible. This seedbed substrate block reduces root damage to a minimum when the seedlings are lifted from the seedbed. Excellent results are obtained by growing the seedlings in a proper substrate mix in small cups made of different materials such as paper or plastic, or small containers made of banana leaves or other materials (Fig. 1). Also, small blocks (5 x 5 x 5 cm) can be prepared where one or two seedlings can be grown. Compost, peat moss, and other organic materials mixed with soil in a 1:1 ratio are excellent mixes for preparing the root blocks. An inexpensive wooden frame with removable partitions can also be used for making the root blocks. Fill the frame with the mix already moistened and sow two or three seeds in the center of the block at a depth of 0.5 cm. In 35 to 40 days the blocks can be taken to the field and transplanted without exposing the seedlings to major stress. The blocks should be planted in rows 0.20 m apart.

Since different materials have different adhering properties, it is recommended to look for adequate substrates for root blocks and alternative ways of producing them when needed (Appendix, Examples 3 and 4).

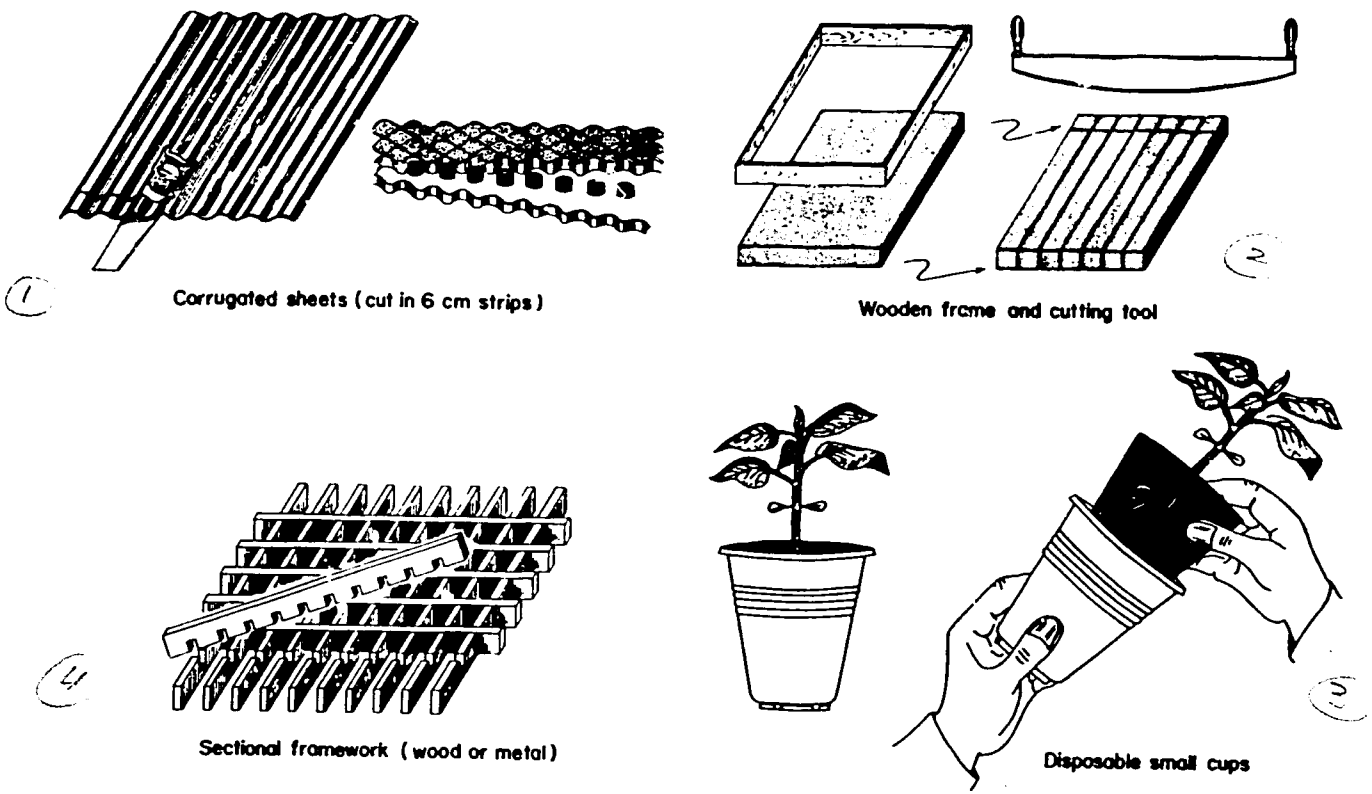

Figure 1. Materials for preparing root blocks.

3. In areas of low rainfall, availability of irrigation water is critical. Maintenance of a proper soil moisture is very important at transplanting time and for the first few days to reduce seedling losses. In irrigated areas, transplant the seedlings on one side of the ridge and at the level slightly above the water line. At this level individual holes are opened for placing the seedlings.

4. Temperature has a large influence on seedling establishment. In hot climates, transplant late in the afternoon to facilitate seedling recovery and to prevent wilting. Also, in these climates the combination of shading during the first 25 days and exposure to direct sunlight the last 15 days to 20 days will provide the seedlings with the strength required to tolerate the shock of transplanting.

To reduce soil temperature during the field establishment period of TPS seedlings in hot climates, use straw mulch to cover the ridges, or use other types of protection placed over the seedlings during the first 10 days after transplanting to improve seedling survival (Appendix A, Example 5).

5. In cold climates, the growth rate recovery after transplanting may take a long time. Some TPS progenies, however, have the ability to recover faster when the temperatures are cooler.

Plastic sheets (mulch) for covering the ridges are excellent for increasing soil temperature and for improving seedling establishment and growth in cooler climates. The plastic sheets will also maintain soil moisture for longer periods after irrigation and will restrict weed growth. The soil is ridged and the plastic sheet is placed over the row where the seedlings will be transplanted. Transplant the seedlings by making openings in the plastic sheets at the corresponding transplanting distances and place two or three seedlings in each hole 10 cm deep. A simple experiment for observing the advantages of this method can be made by using two progenies, if possible of different adaptation responses to temperature (Appendix A, Example 6).

6. For potato seedlings it is recommended to have a first small hilling 10 to 15 days after transplanting, particularly in heavier soil, to provide better conditions for the rooting zone. The other hillings are carried out at a similar plant stage, as with potatoes from seed tubers. Proper hilling is especially important in TPS.

7. Potato seedlings are sensitive to herbicides. Those recommended for potatoes as post-emergence applications may affect seedling survival. However, when herbicide use is required the available herbicides, which are used for other vegetables propagated by transplanting, need to be evaluated (Appendix A, Example 7). Rapidly inactivated contact herbicides (such as paraquat), applied two days before transplanting, have given good results in controlling weeds without affecting potato seedlings. Apply the herbicide to soil that has already been ridged and watered a week earlier to allow seeds to germinate.

8. Transplanting potatoes as an intercrop or as a relay crop increases seedling survival under heat stress conditions. The benefit of this system depends, however, on the type of crop involved since a proper combination of radiation reduction and duration of the crop association must be considered. When working under these conditions where intercropping is a common system, it is necessary to investigate locally the best combinations (Appendix, Example 8). In our experience, relay cropping has proved successful for improving seedling survival in hot, humid areas when potatoes from TPS were transplanted in between rows of mature maize, soybean, and Crotalaria. These crops were then removed once the potato seedlings were established in the field.

APPENDIX A

Example 1. Different Seedbed Substrates

Several seedbed substrates made out of locally available materials can be compared using equal numbers of seed per tray (e.g., 100 seeds) with two to four replicates. The control could be the substrate used by farmers for growing seedlings of other vegetables.

Treatment 1: Peat moss (if available), sand, and fertilizers.
Treatment 2: Locally prepared compost.
Treatment 3: Mix of compost (50%) and soil (50%) plus additional phosphorus (e.g., 200 mg P_2O_5 per kg of mix).
Treatment 4: Farmer's substrate (control).
Treatment 5: Farmer's substrate plus additional P_2O_5 (e.g., 200 mg per kg of substrate).
Treatment 6: Soil.

Example 2. Fertilization Rates

Improvements by adding fertilizers could be evaluated in comparison with the most common substrate utilized by farmers for growing other vegetables. This is particularly important when the soils of the area are known to be deficient in some nutrients. For example, if available phosphorus in the soil is low (but not due to low pH), as is the case with many volcanic soils that have good structure conditions for seedbeds, increasing rates of P can be applied and evaluated. If necessary, other nutrients can be applied at a common rate. Sow an equal number of seeds in each tray.

	P in substrate (mg/kg)
Treatment 1:	0 (control)
Treatment 2:	50
Treatment 3:	100
Treatment 4:	200
Treatment 5:	300
Treatment 6:	400

In experiments 1 and 2, seedlings can be evaluated 35 or 40 days after sowing for vigor, height, weight, and other characteristics (use those at the center area of the tray). Depending on growth uniformity, 25 seedlings per tray is an adequate sample size. Type of data to be recorded in these experiments are shown in Appendix B.

Example 3. Root Block Formation by Different Proportions of Organic Materials

Thoroughly mix different proportions of soil and recommended organic materials (peat moss, composts, etc.), and a common rate of fertilizers (100, 300, 100 mg of N, P, K, respectively, per kg of mix). Their properties in producing good seedlings and as a substrate to be used in making root blocks can be evaluated (see Appendix B for data recording).

	Soil (%)	Organic material (%)
Treatment 1:	100	0
Treatment 2:	75	25
Treatment 3:	50	50
Treatment 4:	25	75
Treatment 5:	0	100

The root blocks can be prepared by using a wooden frame with internal divisions (suggested dimensions, 5 x 5 x 5 cm). Evaluate seedling vigor and height 35 days after sowing. Also at this time observe the ability of the different mixes to keep their shape when being handled for transplanting. Seedlings produced in separate trays but using the same mix as Treatment 3 can be used as a control to evaluate 1) possible improvements in seedling survival at transplanting, and 2) the length of the establishment period in the field.

Example 4. Evaluation of Methods to Improve Seedling Establishment

Cups of different materials (plastic, paper or others) filled with substrate can be compared to root blocks and other methods of producing seedlings under stress. A 1:1 mix of soil and recommended organic materials (compost, peat moss), plus fertilizers (100, 300, 100 mg of N, P, K, respectively, per

kg of mix) could be used for the different treatments. The following treatments can be compared:

Treatment 1: Seedlings grown in cups.
Treatment 2: Seedlings grown in root blocks.
Treatment 3: Seedlings grown in a seedbed or tray and transplanted with bare roots.

Differences in survival are evaluated 20 days after transplanting.

Example 5. Reducing Soil Temperature During Field Establishment in Hot Climates

Different methods can be evaluated to reduce soil temperature in hot climates: use mulches made from locally available materials, such as straw, coffee husks, and dry leaves, to cover the ridges; and use sections of banana leaves or straw bundles to cover the transplanted seedlings. Plot size: 3 rows x 6 m per replication with four replications per treatment in a randomized block design.

Treatment 1: Mulch of straw, husks, and dry leaves covering the ridges during the complete growth cycle.
Treatment 2: Banana leaf sections (bent in the middle) or straw bundles covering the transplanted seedlings for 5 days.
Treatment 3: Banana leaf sections (bent in the middle) or straw bundles covering the transplanted seedlings for 10 days.
Treatment 4: Banana leaf sections (bent in the middle) or straw bundles covering the transplanted seedlings for 20 days.
Treatment 5: Control.

Example 6. Effect of Plastic Mulch on Seedling Establishment and Growth (Cool Environments)

Use two progenies that have different adaptation responses to temperature to observe the beneficial use of plastic for covering the ridges in cool environments.

Treatment 1: Progeny A, plastic mulch.
Treatment 2: Progeny A, bare soil.
Treatment 3: Progeny B, plastic mulch.
Treatment 4: Progeny B, bare soil.

The treatments could be arranged in the field in split-plot designs, using progenies as subunits. Each subunit consists of 4 rows, 6 m long, with four replications (requests for field layout chart should be sent to the author).

Example 7. Effect of Herbicides

Three different post-transplanting herbicides at recommended rates can be applied at three different periods. Plot size: 4 rows x 6 m.

Treatment 1: Herbicide A, 5 days after transplanting.
Treatment 2: Herbicide A, 10 days after transplanting.
Treatment 3: Herbicide A, 15 days after transplanting.
Treatment 4: Herbicide B, 5 days after transplanting.
Treatment 5: Herbicide B, 10 days after transplanting.
Treatment 6: Herbicide B, 15 days after transplanting.
Treatment 7: Herbicide C, 5 days after transplanting.
Treatment 8: Herbicide C, 10 days after transplanting.
Treatment 9: Herbicide C, 15 days after transplanting.
Treatment 10: Control without applications.

Four replications of each treatment, using a split-plot design, are adequate. Evaluate seedling survival 15 days after the corresponding application. Evaluate weed control through observations and weed counting in each plot 30 days after transplanting. If necessary, three controls corresponding to the three herbicide application dates (only water will be applied) can be included (requests for field layout chart should be sent to the author).

Example 8. Relay Cropping for Improving Seedling Establishment

Evaluation can be made on improving seedling establishment by relay cropping with the most common crop of the area or with the crop that precedes the potato (or could precede) in the cropping system. Potato seedlings can be

transplanted in between rows of that crop at regular spacing. The companion crop could be harvested 10, 20, and 30 days after transplanting the seedlings. Plot size: 5 rows x 10 m with four replications per treatment in a randomized block design.

Treatment 1: Relay period of 10 days.
Treatment 2: Relay period of 20 days.
Treatment 3: Relay period of 30 days.
Treatment 4: Relay period of 40 days.
Treatment 5: Control.

Type of data to be recorded in Examples 7 and 8 are shown in Appendix B.

APPENDIX B

INTERNATIONAL POTATO CENTER (CIP)

DATA RECORDING FOR EXAMPLES 1 AND 2

Treatment	Replication	Germination at 15 days (%)	Vigor[a] at 35 days	Height[b] at 35 days (cm)	Fresh weight 25 seedlings at 35 days (g)				Stolons at 35 days (No.)	Tubers[c] at 35 days (No.)
					Tops	Roots	Stolons	Tubers[c]		
1	I									
	II									
	III									
	IV									
	Mean									
2	I									
	II									
	III									
	IV									
	Mean									
3	I									
	II									
	III									
	IV									
	Mean									
4	I									
	II									
	III									
	IV									
	Mean									
5	I									
	II									
	III									
	IV									
	Mean									
6	I									
	II									
	III									
	IV									
	Mean									

[a] Vigor: 1 = Poor (small seedling, weak stem, stunted growth); 2 = Moderate; 3 = Good; 4 = Excellent (tall seedling, strong stem, several leaves 5-6, ready to transplant).

[b] Average of 25 seedlings.

[c] Tuber formation usually starts before 30 days in many progenies or as a reaction to stress conditions (heat, lack of soil moisture and nutrients).

DATA RECORDING FOR EXAMPLES 3 AND 4

Treatment	Replication	Vigor[a]	Height (cm)	Uniformity[a]	Compaction[b]	Field establishment (% survival)	Fresh weight 50 seedlings (g)			
							Tops	Roots	Stolons	Tubers
1	I									
	II									
	III									
	IV									
	Mean									
2	I									
	II									
	III									
	IV									
	Mean									
3	I									
	II									
	III									
	IV									
	Mean									
4	I									
	II									
	III									
	IV									
	Mean									
5	I									
	II									
	III									
	IV									
	Mean									
N	I									
	II									
	III									
	IV									
	Mean									

[a] Vigor and uniformity: 1 = Poor; 2 = Moderate; 3 = Good; 4 = Excellent.

[b] Compaction: 1 = Adequate; 2 = Inadequate. Refers to resistance of the root block to handling and transport.

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DATA RECORDING FOR EXPERIMENT 5

Plot area ..... m^2

Transplanting date .....

Treatment	Replication	Survival[a] (days)		Vigor[b] (days)		Maturity[c]	Yield (kg/plot)	
		15	30	15	30		Total	Marketable
1. Prog. A, mulch	I							
	II							
	III							
	IV							
	Mean							
2. Prog. B, mulch	I							
	II							
	III							
	IV							
	Mean							
3. Prog. A, bare soil	I							
	II							
	III							
	IV							
	Mean							
4. Prog. B, bare soil	I							
	II							
	III							
	IV							
	Mean							

[a] Survival: Number of dead plants per plot.

[b] Vigor: 1 = Poor (small seedling, weak stem, stunted growth); 2 = Moderate; 3 = Good; 4 = Excellent (tall seedling, strong stem, several leaves 5-6, ready for transplant).

[c] Maturity: To be taken at 70 days after transplanting and repeated later if necessary. Estimate number of days from transplanting to maturity.

DATA RECORDING FOR EXPERIMENT 6

Treatment	Replication	Seedling survival		Treatment efficiency
		No.	%	
1. Herb. A, 5 days after transplanting	I			
	II			
	III			
	IV			
	Mean			
2. Herb. A, 10 days after transplanting	I			
	II			
	III			
	IV			
	Mean			
3. Herb. A, 15 days after transplanting	I			
	II			
	III			
	IV			
	Mean			
4. Herb. B, 5 days after transplanting	I			
	II			
	III			
	IV			
	Mean			
5. Herb. B, 10 days after transplanting	I			
	II			
	III			
	IV			
	Mean			
6. Herb. B, 15 days after transplanting	I			
	II			
	III			
	IV			
	Mean			
7. Herb. C, 5 days after transplanting	I			
	II			
	III			
	IV			
	Mean			
8. Herb. C, 10 days after transplanting	I			
	II			
	III			
	IV			
	Mean			
9. Herb. C, 15 days after transplanting	I			
	II			
	III			
	IV			
	Mean			
10. Control	I			
	II			
	III			
	IV			
	Mean			

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DATA RECORDING FOR EXPERIMENTS 7 AND 8

Plot area ..... m^2

Transplanting date .....

Treatment	Replication	Survival[a]		Vigor[b] (days)		Yield (kg/plot)		Other observations
		No.	%	15	30	Total	Marketable	
1	I							
	II							
	III							
	IV							
	Mean							
2	I							
	II							
	III							
	IV							
	Mean							
3	I							
	II							
	III							
	IV							
	Mean							
4	I							
	II							
	III							
	IV							
	Mean							
Control	I							
	II							
	III							
	IV							
	Mean							

[a] Survival: Number of dead plants per plot.

[b] Vigor: 1 = Poor; 2 = Moderate; 3 = Good; 4 = Excellent.