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# AGROECONOMIC EVALUATION OF DIFFERENT TYPES OF POTATO PLANTING MATERIAL IN EGYPT

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## ABSTRACT

A study was undertaken to evaluate the economic feasibility of using seedling tubers derived from true (botanical) potato seed as source of seed material for Egyptian potato farmers. The new technology differs from common practice in both the source of the planting material (first or second --g1 or g2-- generation hybrid progeny) and the suggested lower seedling rate. Small amounts of seedling tubers were distributed to selected farmers along with suggestions for their use. These farmers planted and managed the seedling tubers similarly to their usual seed material. Data on production practices, costs, yields and revenues were collected during visits to 14 cooperating farmers.

The performance of g1 seedling tubers was below that of g2 seedling tubers or seed tubers. G1 seedling tuber performance also did not meet levels established in on-station experiments. The factors constraining the performance of the g1 seedling tubers were not identified. The lower seeding rate and good performance of g2 seedling tubers resulted in superior net returns to variable inputs for g2 seedling tubers compared to the other types of planting material. The yield per unit of seed showed clear superiority of seedling tubers compared to seed tubers. Average prices received for production from the seedling tuber progeny and the standard seed varieties were nearly identical, indicating that the new seedling tuber progeny may be acceptable to Egyptian consumers.



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# I. INTRODUCTION

The purpose of this study is to evaluate a new seed potato technology. The new technology employs seedling tubers derived from true (botanical) potato seed (TPS). In Egypt, potato farmers typically have three sources of seed tubers; imported seed from Europe available for the spring season, tubers saved by the farmer from the previous harvests, and a limited amount of seed from a seed potato production program of the government. The proposed, new seedling tuber technology makes available a fourth category of seed, complementing the supplies from other sources.

Due to the bulky, perishable characteristics of seed tubers and the low multiplication rate of potatoes, seed potatoes represent a high portion of production costs for potato farmers. Reducing the cost and improving the quality of planting material for potato production can have an important effect on the productivity and profitability of potato production.

Coming from the tomato-like berries of the potato plant, TPS represents an alternative seed technology to potato producers. TPS can be utilized in several different methods and are generally suitable in any environment that favours potato production. Where the growing season is long, TPS can be sown in beds and the seedlings can be transplanted directly to the field. In areas with shorter growing seasons as is the case in Egypt, seedling tubers can be produced in an initial production cycle for use in later cycles (Malagamba and Monares, 1988). The use of seedling tubers may have broad applicability throughout North Africa due to agroecological similarities in the potato food systems (Haverkort, 1987)

## *Potato in the Egyptian food system*

Potato production in Egypt has grown steadily during the last decade with growth coming from increases in potato area and yields (Table 1). The potato is the second most important vegetable after tomato in terms of value of production. Based on 1987 production, exports and estimates of potato balance sheets (Horton, 1988) per capita annual consumption is almost 26 kg.

Potatoes are produced in 19 of Egypt's 26 governorates. However, in 1987, 77 percent of production occurred in four governorates, Beheria, Minufia, Gharbia and Giza, concentrated in areas of suitable soils alongside various channels of the Nile delta (Figure 1). The potato is an important export crop, from 1982 to 1986 an annual average of 140,000 mt were exported, almost 60% to the UK and the majority of the remainder to several Arab countries (Sharara, 1987). However most potatoes are consumed domestically. Potatoes are grown in three seasons (Figure 2): an autumn crop planted from August to October, a winter crop planted in October to November and harvested early for export and a spring crop planted in January and February. The seed potato system is based on importing seed tubers from Europe for planting in the winter and spring seasons. From 1982 to 1986 an average of 45,000 mt per year were imported, most from the UK and the Netherlands (Sharara, 1987). Seed are saved from spring crop production and stored for use in the autumn or winter crop after which the cycle repeats (Engels and Schwenkel, 1986).

## *Limitations of the existing seed system*

Several problems are associated with using traditional seed sources. High cost is a feature of seed from all the categories. Imported seed has especially risen in price as the Egyptian Pound (LE) has devalued against the dollar which has fallen against the European currencies. Due to the

production season in Europe imported seed is physiologically the correct age for planting only during the spring season in Egypt (Figure 2). There are often logistical problems which prevent the arrival of imported seed for timely planting.

Local seed produced from previous seasons has a high rate of disease infection and yields less than the imported seed. The average percentage difference in yields between spring and autumn/winter seasons is 9.3% though there is considerable variation from year to year (Table 2). Most of this difference is attributed to the decline in seed quality. Storage is also a problem as there is insufficient capacity in the refrigerated stores and many farmers must use traditional ambient temperature on-farm stores (nawalla). Seed losses of 15% are reported from the nawalla due to poor ventilation and high summer temperatures (Habashy, 1985).

Seed from the government production program has generally been in very small quantities -- less than three percent of autumn season requirements -- and therefore not available to most producers. Recently however, a major effort is being undertaken to upgrade and expand the production of this seed program in cooperation with local producers cooperatives.

### *A seed system based on seedling tubers*

Seedling tubers, the product of seedlings of TPS in Egypt, are the first generation progeny of selected hybrid crosses and thus possess hybrid vigor. As F1 progeny, the seedling tuber is not technically a variety, though for convenience they may be referred to as such elsewhere in this paper.

Seedling tubers are produced in nursery beds, coming from dense stands of seedlings from TPS directly broadcast in the bed. These first generation seedling tubers, called g1, are typically small, 2 to 20 grams -- about the size of a child's marble. The very small g1 seedling tubers are reserved for seeding a second time in nursery beds, producing a second generation (g2) of seedling tubers. The smaller tubers take up less space in storage, effectively increasing the capacity of the refrigerated stores by making it possible to store a greater percent of the total seed needs in already existing stores. Except for certain viroids, TPS does not transmit diseases and therefore the seedlings from TPS start with an initial low disease level. Further, due to the concentrated area of nursery production, disease problems can be more easily controlled, resulting in seedling tubers meeting high health standards.

Because the production process for seedling tubers involves only one or perhaps two multiplications from TPS, the costs of production should be lower than seed tubers produced in the usual clonal multiplication type seed program. These programs require several generations of multiplications to reach sufficient quantities for sale.

Recommended seedling rates for seedling tubers are being developed. Seedling tubers distributed to the farmers participating in the survey reported here weighed on average 11 grams for g1. G2 seedling tubers were double that size, weighing up to 25 grams. Suggested planting distance for seedling tubers is 25 cm within rows and 75 cm between rows for a total 52,000 plants per hectare. If the seedling tubers weigh less than 5 grams two should be placed in each hill, thus the recommended seedling rate is approximately 580 kilograms of seedling tubers per hectare. The recommendation for seed tubers, which weigh on average 60 grams and should be planted at 25 cm intervals, is 3,143 kg/ha.

The locally adapted technology and recommendations for seedling tuber production and utilization have been developed by research at the International Potato Center (CIP) station in Kafr El Zayat during a period of several years (El Bedewy et al, 1988). The results of the on-

station research have been positive with the yields of standard varieties produced with seed tubers and the progeny produced with seedling tubers being comparable.

The seedling tuber-based technology was originally based on the premise of seedling tubers being supplied to farmers each planting season, who produce consumer potatoes. However the performance of g2 seedling tubers raises the possibility of farmers producing a combined seed/consumer crop from g1 seedling tubers (Figure 3).

The basis for the system is an assured supply of TPS and under the current scenario, Egypt will import this input. The planting material moves through the system in a three year cycle. In January of year one, TPS is planted by the seedling tuber growers producing a crop for harvest in April/May --the g1 seedling tubers. The seedling tuber producers grade the production, keeping the smaller g1 seedling tubers for a second nursery multiplication. The larger g1 seedling tubers are sold directly to farmers for their use in producing consumer potatoes. Autumn or winter are potential planting seasons for the g1 tubers. Year two starts with the harvest of the initial seedling tuber crop. The farmers can then keep or sell the seed-sized tubers -- the g2 seedling tubers. These g2 seedling tubers can be stored until September or dormancy can be broken artificially in time for planting in February. The cycle is completed with the harvest of the autumn crop marking the beginning of year 3. The new system potentially relieves the source of the low yields in the autumn season by providing an alternative source of healthier seed.

The technology of using TPS to produce seedling tubers is now being employed by the Pioneer Overseas Corporation (Egypt) and in the near future large amounts of seedling tubers will be available to Egyptian potato farmers. Thus this preliminary study was undertaken to evaluate the feasibility of this new seed technology for potato production.

## II. METHODOLOGY

This section describes the methodology and data collection procedures for analyzing the feasibility of the new seed technology. As illustrated above, the seed potato system in Egypt requires an injection of new source material at intervals of 12 months. This is due to the degeneration of the health of the seed tuber. There are a variety of diseases and pests which reduce the health and therefore the viability of potatoes. Many of theses diseases are carried from one generation to the next by the seed tubers. The build up of diseases -- particularly viruses -- in a stock of seed potatoes reduces their yield potential. The rate of degeneration of seed potatoes is a fundamental factor governing the structure of either formal governmental or private, or informal farmer-based seed systems. Traditional measures of degeneration usually focus on the decline in yields for a given sequence of generations of planting material derived from a common source. In Figure 4 this is illustrated with experimental data from Tunisia which shows a 30% loss in yields from the first multiplication but which remains relatively stable afterward. The seed tubers had become increasingly more infected with Potato viruses Y and S (Intl. Potato Ctr., 1986).

The new technology being developed in Egypt consists of three basic elements; the new germplasm represented by the F1 progeny, the new type of planting material and a lower recommended seedling rate. These innovations appear to be cost reducing and equally useful to big and small farms. Physically, since the new technology (the seedling tuber) is a finely divisible input and a substitute for the traditional technology (the seed tuber) the rate of adoption can be readily measured on the individual farm level by measuring the intensity of use of the seedling tubers compared to seed tubers relative to the short run limiting fixed factor of production, land. However this is an ex-post measurement of the rate of diffusion of a new technology. The present study is concerned with an assessment of the feasibility of the new seed technology to compete with the existing one.

When a farmer purchases imported seed potatoes in the Egyptian seed system he or she is purchasing an input which delivers benefits across two seasons. These benefits depend in part on the speed at which the health of the seed potato degenerates. The benefits to an Egyptian potato producer of adopting the new seed technology can be described as increases in yields but also as increases in net revenues across the two seasons.

Data were collected on production practices including use and cost of inputs, yields, and prices. Farmgate prices for inputs and output were used. Though a black market exists for several of the inputs, due to imperfections in these markets, the price given by farmers reflected the local subsidized prices at which products are generally available in farm supply outlets.

The two generations of seedling tuber progeny were represented in the sample. Since they did not exist in any market, the prices for the seedling tubers had to be assumed. The g1 seedling tuber prices were assumed to be ($ 0.64/kg) based on an accounting of costs of production at the Kafr El Zayat experimental station (El Bedewy and Crissman, 1990). The g2 seedling tubers though delivered to the farmers as part of the study are valued at the average of the other usual varieties grown by the farmer since in the future they will be in the possession of the farmer or available in the local seed market. The farmer seed used in the sample represents the second generation multiplication of imported seed.

Seedling tubers that were the progeny of three different sets of parents were used. The limited quantity of the seedling tubers restricted the number of farmers receiving them and the number of farmers from which data was collected. A total of 14 farmers were contacted for this study. Prepared questionnaires were administered to cooperating farmers in four visits: immediately after crop establishment, during vegetative growth, at harvest and after harvest to collect sale prices. Fields were systematically sampled at harvest to establish yields.

The farmers cooperating with the survey were not randomly selected, all came from the area in the vicinity of Kafr El Zayat station, had become aware of the existence of the seedling tubers and requested a supply of seed. The sample farmers by indicating their willingness to try a new technology could be considered as progressive farmers. Thus the sample is non-random, small and perhaps biased to progressive farmers and all inferences drawn from the data must be regarded as applying to the cooperating farmers only.

The analysis compares the seedling tuber progeny and the farmer seed tuber varieties as (1) an average across all farmers and varieties, (2) individual varieties and (3) an individual comparison of varieties by farmers. The comparisons are done by three criteria -- yields, returns above variable costs and costs per unit of production. Since the seed technology is of interest yields, returns above variable costs and costs per unit of production. Since the seed technology is of interest yields are compared on a per unit of seed and a per unit of area basis. The average across farmers and varieties gives a general view of the performance of seedling tuber versus seed tuber production, while the variety analysis isolates the genetic performance of individual varieties and progeny. The comparison of varieties on single farms eliminates location effects. The technology should reduce costs of production and thus the costs per unit of production are compared.

## III. RESULTS AND DISCUSSION

This section presents a brief general description of potato production technology as practices by the farmers in the sample. This is followed by a comparative analysis of the net returns to variable inputs where costs of major groups and yields and revenues are presented. Two measures of seed efficiency are also discussed. Three farmers were eliminated from the sample.

One farmer harvested the plot planted with seedling tubers after only 70 days as compared to the usual 110-120 days for production. Another farmer planted the seedling tuber plot along the irrigation canal which frequently flooded, damaging the crop. Finally one farmer received a mixture of g1 and g2 seedling tubers, making individual comparisons impossible.

Seven different potato varieties were grown. The seedling tubers were progeny from the crosses Atzimba x DTO28, Serrana x DTO28 and CFK6901 x DTO33 -- all CIP material -- and four commonly found European varieties -- Cara, Draga, Alpha and Grata.

### *Potato production technology*

Potato production as practiced by the sample farmers is a relatively high-cost activity that depends extensively on purchased inputs. The application of production inputs to the sequence of production activities is illustrated in Table 3. The potato farmers generally cultivate small fields with the areas in the sample ranging on 1/4 to 1 1/4 ha.

The cooperating farmers received amounts of seedling tubers ranging from 20 kg to over 200 kg. These were used to plant plots from .01 to .2 ha within fields along side the farmers' usual variety. The farmers were also given advise on how to plant the seedling tubers.

Among sample farmers land preparation is typically done by tractor. With a single exception planting is done by hand. Fertilization involves incorporation by tractor of about 165 cubic meters of manure per ha in addition to the application of chemical formulations of nitrogen and phosphate at the time of planting. Potash was not available in Egypt during the survey season. Crop management includes hilling up, hand weeding and chemical pest control. The sample farmers applied a total of 15 different formulations of rodenticides, insecticides and fungicides. The pesticides are often applied with motorized backpack sprayers. The crop must be irrigated and motorized pumps are used for that purpose. Harvesting is done by hand with some assistance from tractors in initial earth breaking. The harvest is usually graded for size and bagged in the field.

### *Comparison of seedling tubers and seed tubers*

The use of seedling tubers and the standard-sized seed tuber in production result in distinctly different cost shares. The distribution of variable costs are nearly identical for the g1 and g2 seedling tuber varieties (Figure 5), but the summary data masks differences in the seed costs. While the sample farmers used more than twice the volume of g2 seedling tubers than of g1 seedling tubers, the unit cost was only half and thus the two components canceled out the differential (Table 4).

Average seed prices for the farmer used varieties was $ .18/kg and the farmers planted an average of 4440 kg/ha, well above recommendations. Labor and fertilizer are the other significant cost categories on all plots. This illustrates one of the desired aspects of the new seedling tuber technology: reducing total variable costs by reducing seed costs. The seeding rates varied widely among the three types of planting material with g1 seedling tubers being used at only one fifth the rate as seed tubers. However much of this saving was negated by the higher prices.

When measured on a per hectare basis, the yield performance of g1 seedling tubers was about 75 percent of the yields experienced by sample farmers from plots using their own seed. G2 seedling tuber performance was comparable to the farmers' seed. Though presumably containing more disease than g1 seed, the g2 seed is made up of the larger tubers which produce

more sprouts and contain more energy reserves to support initial growth. Thus the g2 seed contributes relatively more to the final yield than the g1 seed. The g1 result is contrary to on-station and some on-farm experimental results of the progeny used in the study. In the experimental results, g1 seedling tuber performance was usually equal to, and on occasion exceeded, that of farmer seed (CIP, 1988). A possible explanation is that many of the sample farmers planted seedling tubers along field borders where the possibility of accidental damage is more likely. However, the difference may reflect a yield gap, the phenomena of a set of factors adversely affecting yields on the farmer's field and not in the experiment station (De Datta et al, 1978). Yield gaps between experiment station potato yields and potential farm yields may result from environmental differences or from a set of biological and/or socioeconomic constraints.

The calculation of net returns per ha show that the sample farmers earned most from their investment in variable inputs from g2 seeded plots followed by plots with their own seed and finally with g1 seeded plots. Differences in net returns resulted from variation in three aspects as discussed above -- yields per ha, the amount of seed used, and the price of seed.

The prices received by farmers for their production varied little among the three progeny or the farmer varieties, indicating potential market acceptance of the progeny. However the small amounts marketed may have caused the buyers to ignore the differences in varieties.

The new seedling tuber technology is proposed as a means of reducing costs of production, thus raising production efficiency. One measure of the efficiency of seed is the yield of product per unit of seed. In seed production this is known as the multiplication rate. A multiplication rate of 8:1 is considered good for seed production. Here, Table 4 shows a reversal of yield per area results with the g1 seedling tuber performance almost four times that of the tuber seed. A final comparison of efficiency of the seed technologies is the cost per unit of output. Since aside from seed, costs varied little among the seed types, the comparison is also an indication of the contribution of the different seed technologies in reducing per unit variable production costs. With a seeding rate of only 43 percent of that used for seed tubers, yet providing a comparable yield, g2 seedling tubers reduced cots per unit of production by over a quarter compared to seed tubers.

The net returns results provide preliminary data points for developing hypotheses about checking the stream of benefits to farmers as mentioned earlier. Using the net returns from Table 4 trends in net returns can be plotted (Figure 6). The poor performance of g1 seedling tubers cause the net returns lines to intersect. The dotted lines represent assumptions for the portions of the trends not captured in the results of this study. The assumed trend for tuber seed relies on the demonstrated historic patterns of declining yields between the first and second generation of imported seed as seen in Table 2. The flatness of the trend reflects reductions to net returns caused by the higher costs for imported seed compared to local seed. The assumed decline in net returns from seedling tubers reflects the continued presence of seed from that system in field conditions faced by the regular seed tuber system. Caution should be used in interpretation of results since the g1 and g2 observations come from same year and not sequential year observations.

### *Comparison of varieties and progeny*

Using the same general categories as above, one can compare the performance of the individual varieties and progeny (Table 5). The yields from farmer varieties were more consistent than those from TPS progeny. This may reflect actual genetic variability inherent in the germplasm or the experience farmers have with varieties and lack of experience with the progeny. Among the g1 progeny, CFK69-1 x DTO33 performed well along with its second generation and the g2 of Serrana x DTO28. CFK69-1 x DTO33 is a TPS cross selected for its ability to produce fewer

larger tubers from the TPS-derived seedlings. This larger seed may translate into better g1 performance. All of these yielded higher returns than either Cara of Draga, two of the more popular imported varieties.

Some of the differences in costs reflect error compounding as actual data from very small plots is presented on a per hectare basis. The sensitivity of net returns results to seed prices is illustrated in the case of Cara, which adds to the difficulty of generalizing the results due to the low number of observations for the individual varieties.

In Figure 7 the different varieties are compared in terms of the yields per hectare and per unit of seed. The yield returns per unit of seed for the progeny varieties are markedly superior to those of the imported varieties. For CFK6901 x DTO33 the yields per area are similar to those of the tuber seed varieties while the yields per unit are clearly higher. CFK is therefore at least as efficient in returns to the fixed input, land and clearly more efficient in returns to the variable input, seed than the seed tuber varieties.

### *Comparison of locations*

The results from individual locations show a significant location effect (Table 6). The locations also represent individual farmers. As example, despite investing similar amounts in production, farmer 7 enjoyed considerably more success in production than farmer 5 who invested larger amounts in production. This may be due to management effort or to environmental factors such as soil characteristics or timely irrigation.

## IV. SUMMARY

This study reports findings from a small sample survey of potato farmers receiving small quantities of TPS-derived seedling tubers and compares the costs and performance of production from plots planted with seedling tubers to those planted with seed tubers. The study documents a possible form for a seedling tuber-based seed system in Egypt and develops a method for assessing the feasibility of that system.

The performance of the seedling tuber plots compared to seed tuber plots was mixed. Generally g1 seedling tubers did not perform as well and, due to the higher cost of seed, gave lower net returns to variable costs than g2 seedling tubers or seed tubers. There was considerable variation in yields and returns among farmers but due to the small sample it was not possible to distinguish the source of this variation.

The use of seedling tubers was originally promoted as a single-generation multiplication of TPS and the production of consumer potatoes with the seedling tubers. However, the good performance of g2 seedling tubers raises the possibility of a two-generation seedling tuber-based seed system. This system would start with the production of seedling tubers in the spring season of year one, farmer planting of the first clonal generation in the autumn/winter season of year one and the harvest and subsequent planting of the second clonal generation in the spring or autumn/winter seasons of year two. For the year two spring season planting, dormancy must be broken artificially, for the autumn/winter season planting in year two, long storage is necessary.

The use of g2 seedling tubers in the spring season places the seedling tuber-based seed system in competition with the import-based seed system. The quantity of seed imported is limited by the government and there are indications that in the future the imports will be even more restricted. Thus the possibility of g2 seed available for spring season planting will relieve

some of the supply constraint for that season. The production from the TPS progeny will be for domestic consumption as the Egyptian consumers have well defined consumption preferences for their local varieties.

Viewed from a perspective of social costs and benefits, the development of a seedling tuber-based seed system offers several distinct potential advantages. Lowering costs of production can result in both increased production and lowered prices. If demand for table potatoes is elastic, the farmers will earn higher profits. If the use of g2 seedling potatoes is feasible in the spring season, a production constraint on area planted due to seed scarcity is removed. Finally, the greater efficiency of seedling tubers per unit seed improved the technical efficiency of potato production.

## *Implications*

This study has identified several problems which remain unanswered and therefore are suitable for future research. The first of these is the relatively poor yield performance of g1 seedling tubers in farmers' fields. The results documented here are contrary to previous research. Is this yield recoverable? Are the poor results a function of farmer management of a new and unknown technology or are there fundamental biological constraints? Controlled trails conducted with farmer management could help to verify the performance of g1 tubers.

There are potentially two types of g2 seedling tubers in the proposed seed system. Those g2 tubers produced and managed by farmers; what we will call field g2, and those produced and managed by the seedling tuber producers; or nursery g2. The g2 tubers used in this study were the field g2 type. The relative performance of these two sources of g2 tubers should be investigated, again with farmer managed on-farm trials.

The use of g2 seedling tubers implies their storage between seasons and manipulation to artificially break dormancy for the spring season. The performance of g2 tubers under farmer storage conditions and reasonable dormancy breaking technologies should be investigated with on-farm trials.

The survey documented consistent above-recommended seeding rates for all three classes of seed in the study. Farmer reasons for this over application of a costly input should be investigated. This question can be addressed with both on-farm trials to determine optimal seedling rates and with an economic survey of farmer attitudes toward the risky nature of production, the possible over-use of the input as an insurance for poor emergence and the technical efficiency of production, taking risk into account.

The survey provided data for a preliminary application of a simple model testing feasibility of the technology. Given that the first generation use of seedling tubers was shown to be inferior to using farmers' own seed will the future benefits from the g2 cycle be sufficient for farmers to adopt the technology? The benefits to farmers of the new technology and thus the feasibility of the new system should be more thoroughly tested.

Taken together, these research recommendations provide a basic on-farm technology verification program designed to provide feedback to researchers just as a technology is being introduced to farmers. The suggested research will also provide an ex ante view of the feasibility of the new technology to compete with the existing seed technology and win a place in the Egyptian seed potato system.

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Table 1. Potato Area, Production and Yield, Egypt, 1977-87.

| Year | Area '000 ha | Production '000 tons | Yield tons/ha |
|---|---|---|---|
| 1977 | 64.0 | 1,011 | 15.8 |
| 1978 | 53.7 | 737 | 14.4 |
| 1979 | 59.7 | 1,019 | 17.1 |
| 1980 | 70.3 | 1,214 | 17.3 |
| 1981 | 69.9 | 1,233 | 18.4 |
| 1982 | 64.2 | 1,184 | 18.4 |
| 1983 | 57.6 | 1,089 | 18.9 |
| 1984 | 62.1 | 1,089 | 19.1 |
| 1985 | 74.3 | 1,478 | 19.9 |
| 1986 | 71.9 | 1,401 | 19.5 |
| 1987 | 79.8 | 1,801 | 22.6 |

*Source: Central Administration for Agricultural Economics and Statistics, Department of Statistics, Ministry of Agriculture, Cairo, Egypt.*

Table 2. Potato Yields for Spring and Autumn/Winter Seasons, 1977-87.

| Year | Spring tons/ha | Autumm/Winter tons/ha | Percentage difference |
|---|---|---|---|
| 1977 | 16.9 | 14.7 | 13.0 |
| 1978 | 15.5 | 13.3 | 14.2 |
| 1979 | 18.4 | 15.8 | 14.1 |
| 1980 | 17.8 | 15.8 | 11.2 |
| 1981 | 19.1 | 17.8 | 6.8 |
| 1982 | 19.5 | 17.5 | 10.2 |
| 1983 | 19.4 | 18.6 | 4.1 |
| 1984 | 20.2 | 18.3 | 9.4 |
| 1985 | 20.6 | 19.2 | 6.8 |
| 1986 | 20.1 | 19.8 | 1.8 |
| 1987 | 23.9 | 21.7 | 9.2 |

*Source: Central Administration for Agricultural Economics and Statistics, Department of Statistics, Ministry of Agriculture, Cairo, Egypt.*

Table 3. Potato production input use per hectare, Egypt, Autumn Season, 1988-89.

| Activity | Variable Inputs | | | | |
|---|---|---|---|---|---|
| | Labor (days) | Animal (hrs) | Tractor (hrs) | Irr Pump | Motor Sprayer |
| Land Prep. | 13.1 | | 11.9 | | |
| Planting | 13.6 | 28.3 | | | |
| Irrigation | 6.4 | 11.2 | | 41.9 | |
| Fertilization [1] | 25.2 | 22.1 | 25.9 | | |
| Weeding | 20.2 | | | | |
| Pest control [2] | 10.2 | | | | 31.7 |
| Harvesting | 55.7 | 44.0 | 8.1 | | |
| Total | 14[illegible] | 105.6 | 45.9 | 41.9 | 31.7 |

*Source: Own survey.*

Notes: [1] Fertilizer applied was 133 kg active ingredient nitrogen, 89 kg active ingredient phosphate and 70 cubic meters manure.

[2] Due to problems of aggregating active ingredientes of differing toxicities no quantities are given for the 15 different formulations of pesticides used by farmers.

Table 4. Net returns per hectare and seed efficiency for g1 and g2 Seedling Tuber and Seed Tuber Plots Autumn season, 1988/1989.

| | Seedling tubers g1 | Seedling tubers g2 | Seed tubers |
|---|---|---|---|
| Number of observations | 11 | 6 | 11 |
| Returns to Variable Inputs: | | | |
| Seed rate (kg/ha) | 878 | 1,907 | 4,440 |
| Seed price ($/kg) | .64 | .18 | .18 |
| Seed cost [1] | 562 | 343 | 789 |
| Machinery cost | 107 | 105 | 102 |
| Fertilizer cost | 195 | 229 | 180 |
| Pesticide cost | 83 | 48 | 67 |
| Labor cost | 285 | 291 | 264 |
| Animal cost | 49 | 54 | 41 |
| Total variable costs [2] | 1,281 | 1,070 | 1,443 |
| Yield (t/ha) [3] | 21.2 | 27.8 | 28.3 |
| Output price ($/t) | 77.7 | 76.4 | 78.5 |
| Total revenue [4] | 1,647 | 2,124 | 2,224 |
| Net Returns [5] | 366 | 1,054 | 771 |
| Measures of Seed Efficiency | | | |
| Yield (t/t seed) | 24 | 14.6 | 6.4 |
| Costs/ton output | 144 | 91 | 121 |

*Source: Own survey*

Notes:

[1] Seed cost does not equal the product of seed rate x seed price due to rounding error.

[2] All costs in US$. The April 1989 exchange rate was EL 2.42/US$ 1.

[3] "t" indicates metric ton.

[4] Total revenue is the product of yield x output price.

[5] Net returns is the difference between total revenue and total variable costs.

Table 5. Net returns per hectare and seed efficiency by variety.

| | Serrana x DTO28 | | Atzimba x DTO28 | | CFK69.1 x DTO33 | | Draga | Cara | Alpha | Grata |
|---|---|---|---|---|---|---|---|---|---|---|
| | g1 | g2 | g1 | g2 | g1 | g2 | | | | |
| Number of observations | 3 | 4 | 5 | 1 | 3 | 1 | 4 | 4 | 1 | 2 |
| Return to variable inputs | | | | | | | | | | |
| Seed rate (kg/ha) | 993 | 1,669 | 774 | 3,393 | 926 | 1,400 | 4,474 | 4,69 | 3,052 | 3,950 |
| Seed price ($/kg) | .64 | .17 | .64 | .17 | .64 | .17 | .14 | .23 | .12 | .16 |
| Seed cost | 635 | 284 | 495 | 577 | 593 | 238 | 668 | 1,080 | 366 | 630 |
| Total variable costs | 1,337 | 993 | 1,170 | 1,455 | 1,237 | 968 | 1,403 | 1,701 | 1,010 | 1,197 |
| Yield (t/ha) | 18.1 | 29.0 | 20.7 | 22.8 | 26.2 | 28.1 | 27.1 | 27.8 | 33.3 | 29.5 |
| Output price ($) | 74.8 | 76.4 | 77.7 | 78.5 | 79.7 | 74.4 | 78.5 | 76.4 | 78.5 | 82.6 |
| Total revenue | 1,354 | 2,216 | 1,608 | 1,790 | 2,088 | 2,091 | 2,127 | 2,124 | 2,614 | 2,437 |
| Net returns | 17 | 1,223 | 438 | 335 | 851 | 1,123 | 724 | 423 | 1,604 | 1,240 |
| Measures of seed efficiency | | | | | | | | | | |
| Yield (t/t) seed | 18.1 | 17.5 | 26.7 | 6.7 | 28.4 | 20.1 | 5.7 | 5.9 | 10.9 | 7.5 |
| Costs/ton | 74 | 34 | 56 | 64 | 47 | 34 | 52 | 61 | 30 | 41 |

Table 6. Net returns per feddan and seed efficiency by farmer.

| Farmer | Variety | Seed rate | Yields in tons per ton seed | Yields in tons per ha | Seed costs | Total costs | Total revenues | Net returns |
|---|---|---|---|---|---|---|---|---|
| 2 | 2 g1 | 892.8 | 15.2 | 13.6 | 356 | 1,149 | 1,191 | 42 |
| 2 | 5 | 4,302.8 | 6.2 | 29.0 | 1,333 | 2,121 | 2,047 | (73) |
| 3 | 1 g2 | 2,380.9 | 9.8 | 23.3 | 948 | 1,650 | 1,840 | 190 |
| 3 | 2 g1 | 595.2 | 32.0 | 19.0 | 236 | 949 | 1,493 | 544 |
| 3 | 4 | 5,952.4 | 4.3 | 25.5 | 935 | 1,593 | 2,006 | 413 |
| 4 | 4 g1 | 594.2 | 33.6 | 20.0 | 236 | 1,026 | 1,405 | 343 |
| 4 | 4 | 4,621.9 | 4.8 | 21.9 | 752 | 1,452 | 1,728 | 276 |
| 5 | 1 g2 | 2,232.1 | 12.5 | 27.8 | 889 | 1,543 | 2,309 | 776 |
| 5 | 2 g1 | 1,190.5 | 19.2 | 22.8 | 472 | 1,122 | 1,889 | 767 |
| 5 | 4 | 4,761.9 | 5.3 | 25.0 | 590 | 1,398 | 2,066 | 668 |
| 6 | 1 g2 | 1,247.1 | 26.5 | 33.1 | 495 | 1,231 | 2,257 | 1,226 |
| 6 | 2 g2 | 3,392.8 | 6.7 | 22.8 | 1,330 | 2,155 | 1,794 | (361) |
| 6 | 3 g2 | 1,400.5 | 20.1 | 28.1 | 558 | 1,277 | 2,094 | 817 |
| 6 | 4 | 3,759.3 | 9.7 | 36.4 | 466 | 1,177 | 2,708 | 1,531 |
| 7 | 1 g2 | 793.6 | 40.5 | 32.0 | 315 | 1,015 | 2,258 | 1,343 |
| 7 | 2 g1 | 595.2 | 47.6 | 28.3 | 234 | 872 | 1,992 | 1,120 |
| 7 | 3 g1 | 396.9 | 80.0 | 31.7 | 157 | 820 | 2,360 | 1,540 |
| 7 | 5 | 3,052.6 | 11.0 | 33.3 | 379 | 1,010 | 2,625 | 1,615 |
| 8 | 2 g1 | 595.2 | 32.9 | 19.5 | 228 | 812 | 1,374 | 562 |
| 8 | 5 | 4,761.9 | 5.7 | 27.1 | 983 | 1,554 | 201.5 | 461 |
| 10 | 3 g1 | 1,190.5 | 21.6 | 25.7 | 472 | 1,048 | 2,125 | 1,077 |
| 10 | 7 | 2,934.5 | 11.7 | 34.3 | 461 | 942 | 2,833 | 1,891 |
| 11 | 1 g1 | 1,190.5 | 8.3 | 21.4 | 472 | 1,165 | 1,771 | 606 |
| 11 | 5 | 4,960.2 | 5.0 | 24.8 | 779 | 1,452 | 2,053 | 601 |
| 13 | 1 g1 | 1,488.0 | 8.3 | 12.4 | 590 | 1,135 | 878 | (256) |
| 13 | 5 | 4,761.9 | 5.0 | 23.8 | 944 | 1,536 | 1,869 | 333 |
| 14 | 1 g1 | 892.8 | 24.3 | 21.7 | 348 | 1,081 | 1,794 | 713 |
| 14 | 5 | 4,960.2 | 6.3 | 30.9 | 983 | 1,561 | 2,566 | 997 |

Note: 1 = Serrana x DTO28, 2 = Atzimba x DTO28, 3 = CFK x DTO33, 4 = Draga, 5 = Cara, 6 = Alpha, 7 = Grata.

Appendix Table 1. Net returns per feddan and seed efficiency for g1 and g2 Seedling Tuber and Seed Tuber Plots Autumn season 1986/1989

| | Seedling tubers | | Seed |
|---|---|---|---|
| | g1 | g2 | tubers |
| Number of observations | 11 | 6 | 11 |
| Returns to Variable Inputs: | | | |
| Seed rate (kg/f) | 369 | 801 | 1,865 |
| Seed price (LE/kg) | 1.55 | .43 | .43 |
| Seed cost [1] | 572 | 345 | 802 |
| Machinery cost | 109 | 107 | 104 |
| Fertilizer cost | 198 | 233 | 183 |
| Pesticide cost | 84 | 49 | 68 |
| Labor cost | 290 | 296 | 268 |
| Animal cost | 50 | 55 | 42 |
| Total variable costs [2] | 1,303 | 1,085 | 1,467 |
| Yield (t/f) [3] | 8.9 | 11.7 | 11.9 |
| Output price (LE/t) | 188 | 185 | 190 |
| Total revenue [4] | 1,673 | 2,164 | 2,261 |
| Net Returns [5] | 370 | 1,079 | 794 |
| Measures of Seed Efficiency | | | |
| Yield (t/t seed) | 24 | 14.6 | 6.4 |
| Costs/ton output | 146 | 93 | 123 |

*Source: Own survey*

Notes:

[1] Seed cost does not equal the product of seed rate x seed price due to rounding error.

[2] All costs in LE. The April 1989 exchange rate was LE 2.42/US$ 1.

[3] "t" indicates metric ton. "f" indicates feddan (.42 ha)

[4] Total revenue is the product of yield x output price.

[5] Net returns is the difference between total revenue and total variable costs.

Appendix Table 2. Net returns per feddan and seed efficiency by variety.

| | Serrana xDTO28 | | Atzimba xDTO28 | | CFK69.1 xDTO33 | | Draga | Cara | Alpha | Grata |
|---|---|---|---|---|---|---|---|---|---|---|
| | g1 | g2 | g1 | g2 | g1 | g2 | | | | |
| Number of observations | 3 | 4 | 5 | 1 | 3 | 1 | 4 | 4 | 1 | 2 |
| Return to variable inputs | | | | | | | | | | |
| Seed rate (kg/f) | 417 | 699 | 325 | 1,425 | 389 | 588 | 2,005 | 1,973 | 1,282 | 1,659 |
| Seed price (LE/kg) | 1.55 | .43 | 1.55 | .43 | 1.55 | .43 | .34 | .55 | .30 | .38 |
| Seed cost | 646 | 300 | 504 | 613 | 603 | 253 | 695 | 1,085 | 384 | 630 |
| Total variable costs | 1,359 | 1,009 | 1,190 | 1,479 | 1,257 | 984 | 1,426 | 1,729 | 1,027 | 1,217 |
| Yield (t/f) | 7.6 | 12.2 | 8.7 | 9.6 | 11.0 | 11.8 | 11.4 | 11.7 | 14.0 | 12.4 |
| Output price (LE) | 181 | 185 | 188 | 190 | 193 | 180 | 198 | 185 | 190 | 200 |
| Total revenue | 1,376 | 2,257 | 1,636 | 1,824 | 2,123 | 2,124 | 2,173 | 2,158 | 1,668 | 2,484 |
| Net returns | 17 | 1,248 | 446 | 345 | 866 | 1,140 | 747 | 435 | 1,641 | 1,267 |
| Measures of seed efficiency | | | | | | | | | | |
| Yield (t/t) seed | 18.1 | 17.5 | 26.7 | 6.7 | 28.4 | 20.1 | 5.7 | 5.9 | 10.9 | 7.5 |
| Costs/ton | 179 | 82 | 137 | 154 | 114 | 83 | 125 | 148 | 73 | 98 |

Appendix Table 3. Net returns per feddan and seed efficiency by farmer Autumn season 1988/1989.

| Farmer | Variety | Seed rate | Yields in tons per ton seed | Yields in tons per feddan | Seed costs | Total costs | Total revenues | Net returns |
|---|---|---|---|---|---|---|---|---|
| 2 | 2 g1 | 375.0 | 15.2 | 5.7 | 362 | 1,168 | 1,211 | 42 |
| 2 | 5 | 1,807.2 | 6.8 | 12.2 | 1,355 | 2,156 | 2,081 | .75 |
| 3 | 1 g2 | 1,000.0 | 9.8 | 9.8 | 964 | 1,677 | 1,870 | 193 |
| 3 | 2 g1 | 250.0 | 32.0 | 8.0 | 240 | 965 | 1,518 | 553 |
| 3 | 4 | 2,500.0 | 4.3 | 10.7 | 950 | 1,619 | 2,039 | 420 |
| 4 | 4 g1 | 250.0 | 33.6 | 8.4 | 240 | 1,080 | 1,428 | 348 |
| 4 | 4 | 1,941.2 | 4.8 | 9.2 | 765 | 1,476 | 1,756 | 280 |
| 5 | 1 g2 | 937.5 | 12.5 | 11.7 | 904 | 1,568 | 2,347 | 778 |
| 5 | 2 g1 | 500.0 | 19.2 | 9.6 | 480 | 1,141 | 1,920 | 780 |
| 5 | 4 | 2,000.0 | 5.3 | 10.5 | 600 | 1,421 | 2,100 | 679 |
| 6 | 1 g2 | 523.8 | 26.5 | 13.9 | 503 | 1,251 | 2,497 | 1,246 |
| 6 | 2 g2 | 1,425.0 | 6.7 | 9.6 | 1,325 | 2,191 | 1,824 | -367 |
| 6 | 3 g2 | 588.2 | 20.1 | 11.8 | 567 | 1,298 | 2,128 | 830 |
| 6 | 4 | 1,578.9 | 9.7 | 15.3 | 474 | 1,196 | 2,752 | 1,556 |
| 7 | 1 g2 | 333.3 | 40.5 | 13.5 | 320 | 1,032 | 2,295 | 1,263 |
| 7 | 2 g1 | 250.0 | 47.6 | 11.9 | 238 | 887 | 2,025 | 1,137 |
| 7 | 3 g1 | 166.7 | 80.0 | 13.3 | 160 | 834 | 2,399 | 1,566 |
| 7 | 5 | 1,282.1 | 11.0 | 14.0 | 385 | 1,027 | 2,668 | 1,641 |
| 8 | 2 g1 | 250.0 | 32.9 | 8.2 | 238 | 825 | 1,397 | 572 |
| 8 | 5 | 2,000.0 | 5.7 | 11.4 | 1,000 | 1,580 | 2,048 | 467 |
| 10 | 3 g1 | 500.0 | 21.6 | 10.8 | 480 | 1,065 | 2,160 | 1,095 |
| 10 | 7 | 1,234.6 | 11.7 | 14.4 | 469 | 958 | 2,880 | 1,922 |
| 11 | 1 g1 | 625.0 | 8.3 | 5.2 | 600 | 1,154 | 893 | 262 |
| 11 | 5 | 2,083.3 | 5.0 | 10.4 | 792 | 1,476 | 2,087 | 611 |
| 13 | 1 g1 | 625.0 | 8.3 | 5.2 | 600 | 1,154 | 893 | -262 |
| 13 | 5 | 2,000.0 | 5.0 | 10.0 | 960 | 1,561 | 1,900 | 339 |
| 14 | 1 g1 | 375.0 | 24.3 | 9.1 | 354 | 1,099 | 1,824 | 725 |
| 14 | 5 | 2,083.3 | 6.3 | 13.0 | 1,000 | 1,595 | 2,608 | 1,013 |

Note: 1 = Serrana x DTO28, 2 = Atzimba x DTO28, 3 = CFK x DTO33, 4 = Draga, 5 = Cara, 6 = Alpha, 7 = Grata.

**Figure 1.** Major potato producing areas of Egypt

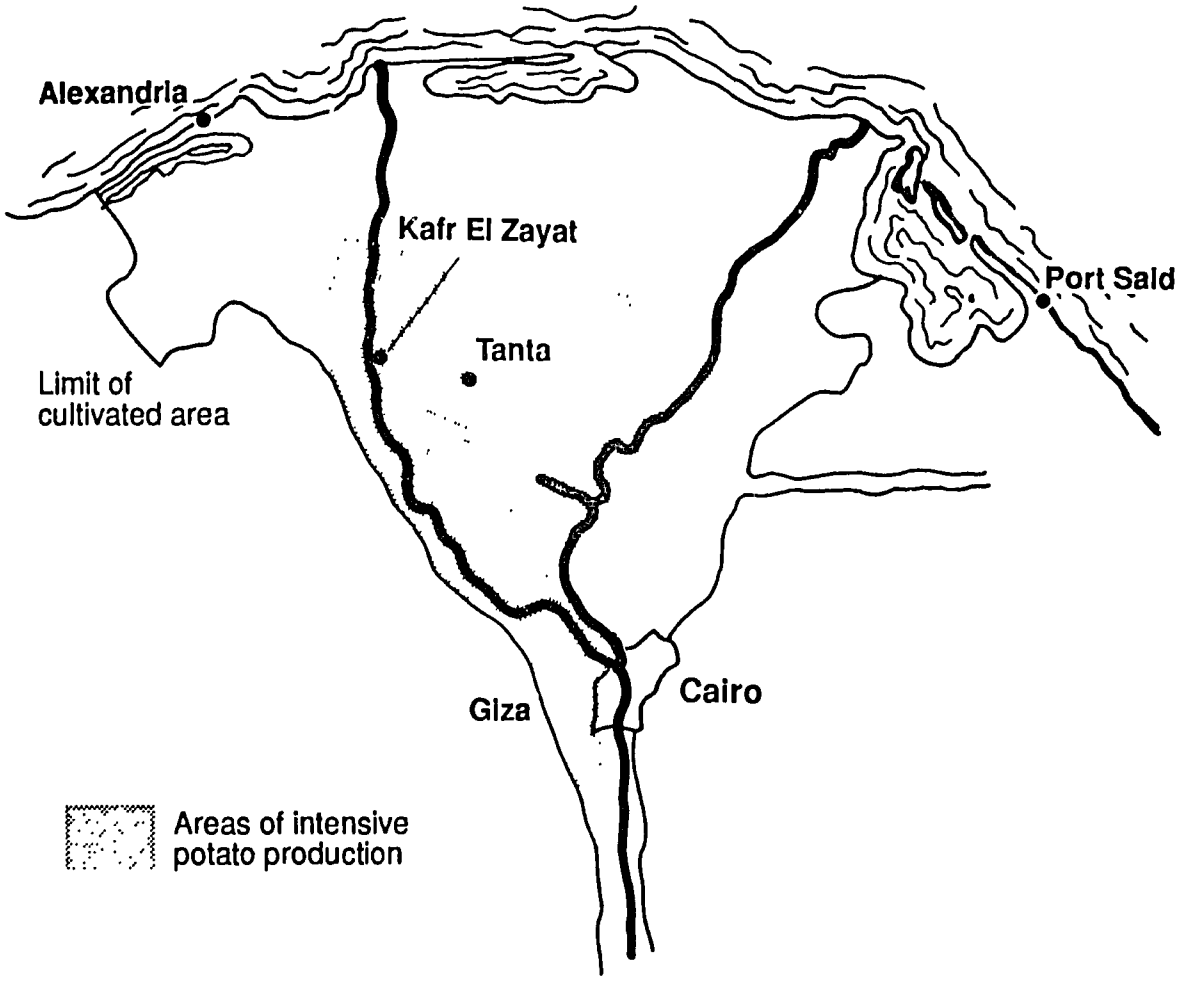
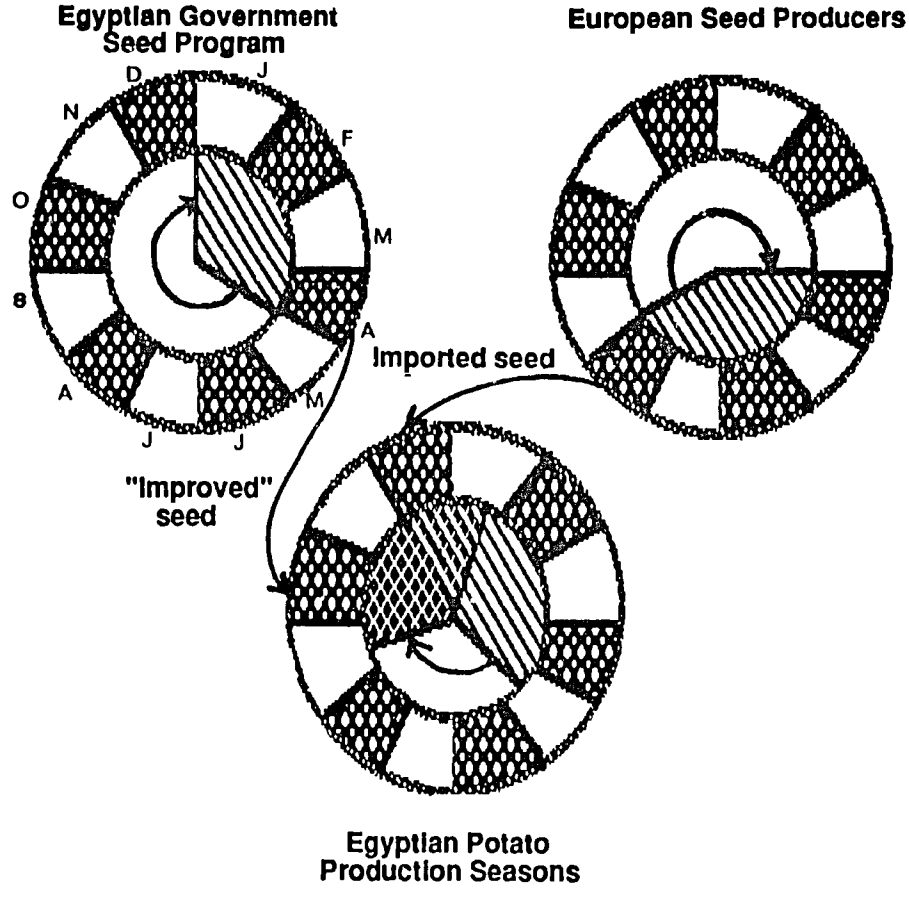


**Figure 2.** Egyptian potato production seasons and seed flows




Source: Adapted from Haverkort, 1987

Notes: Arrows reprent seed flows within and between seed systems. Band represents months of the year. Shaded areas inside bands represent production seasons

**Figure 3. A seedling tuber-based seed system**

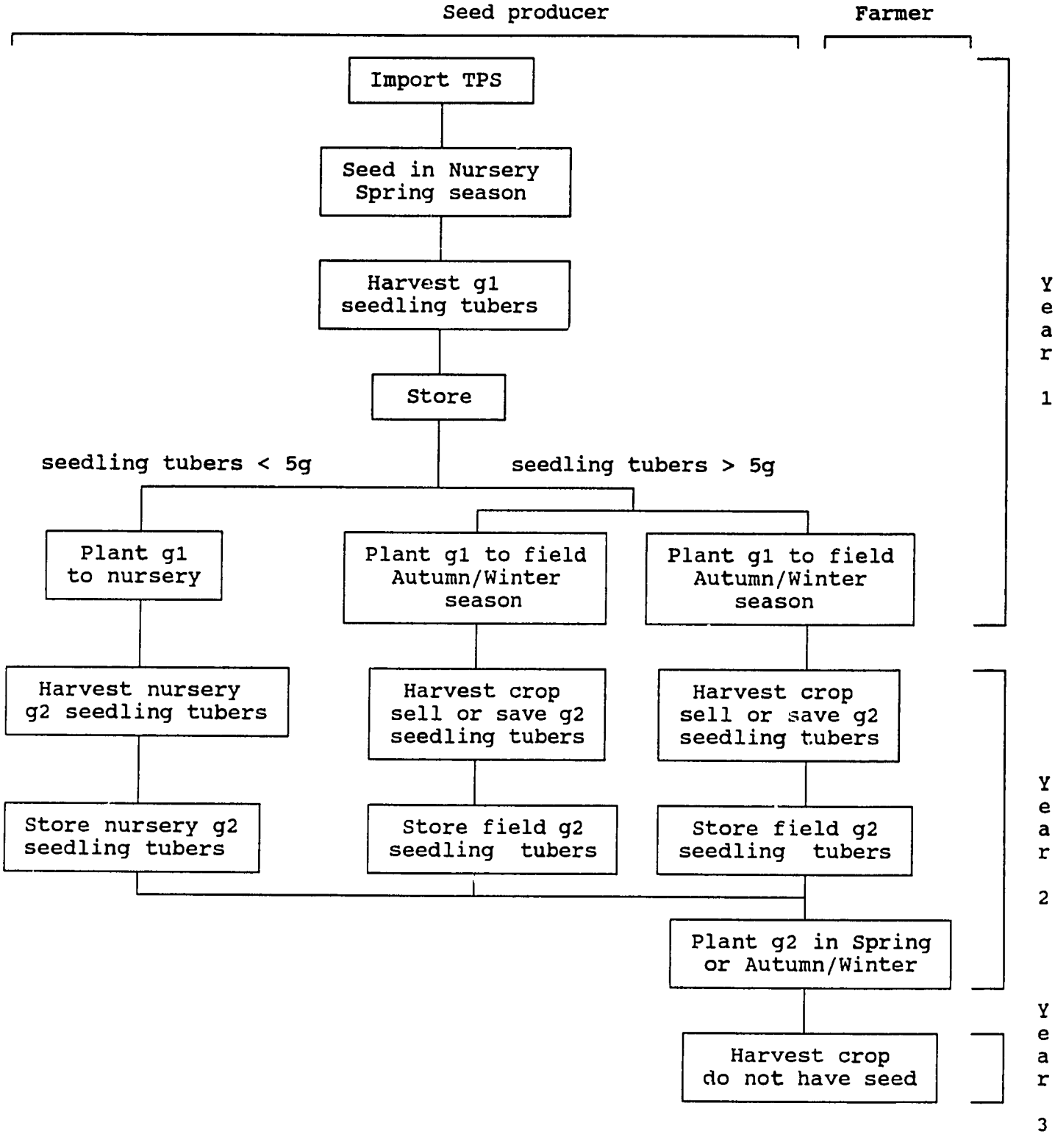
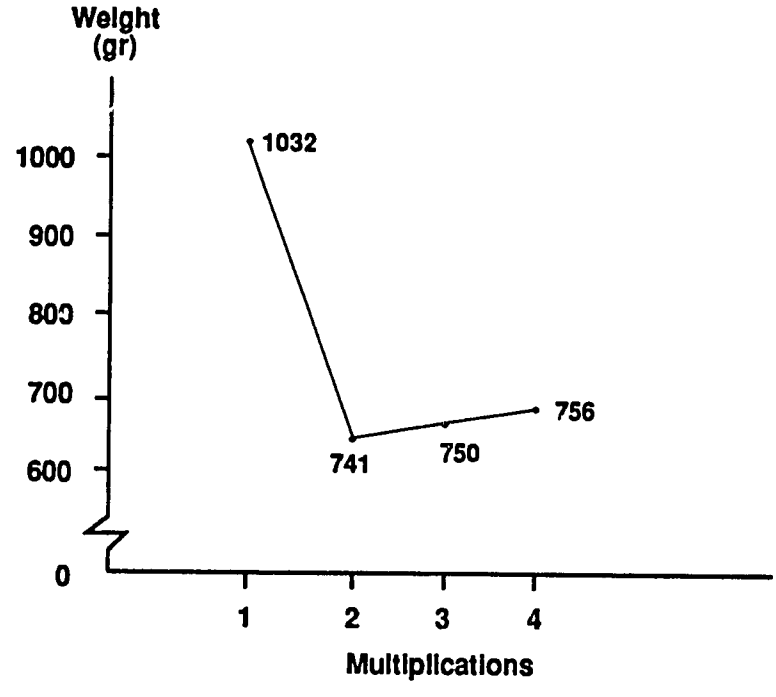


Figure 4. Tuber weight in grams/plant for four multiplications, Saida main crop, Tunisia,1986




Source: International Potato Center, 1986

**Figures 5.** Percentage shares of variable costs of production of plots planted with (a) first generation seedling tubers

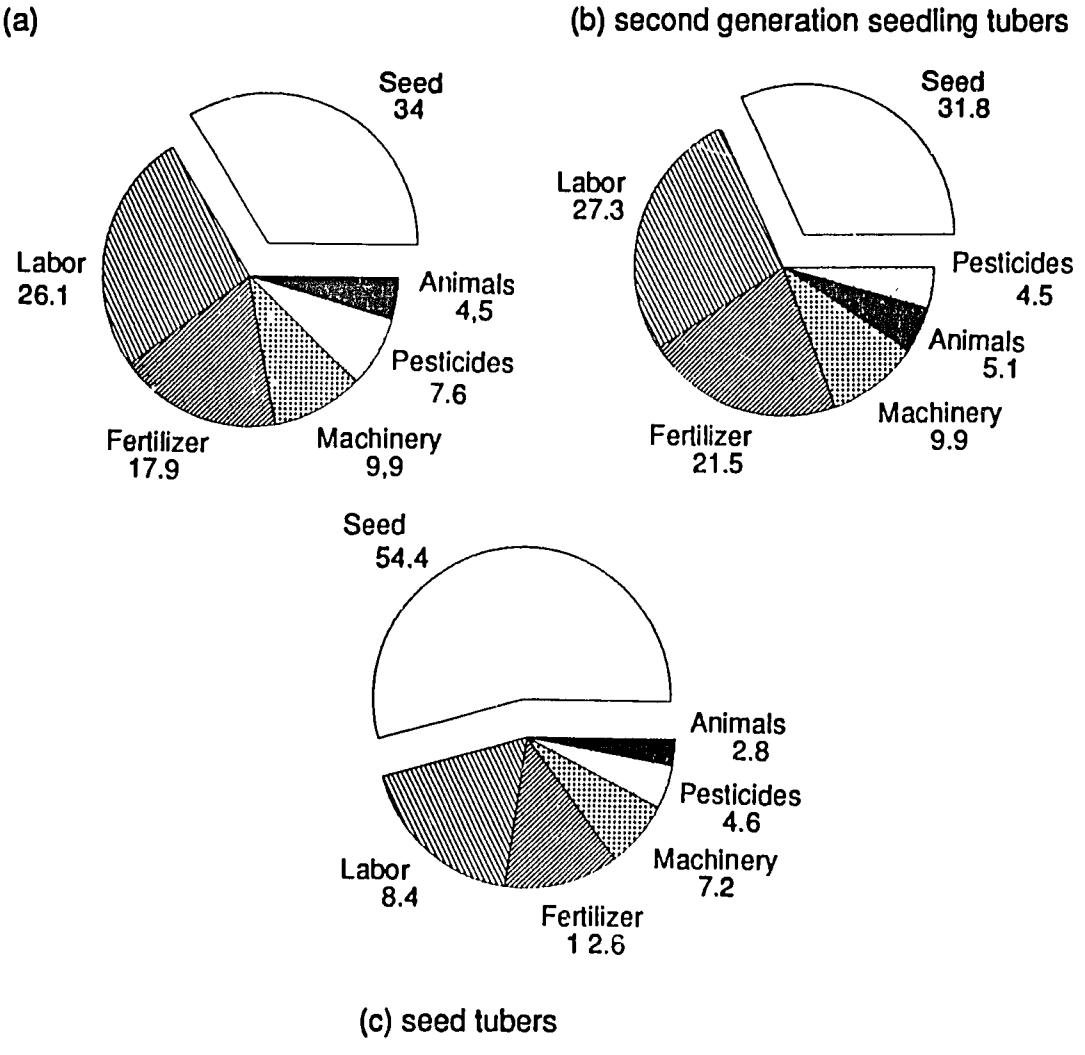
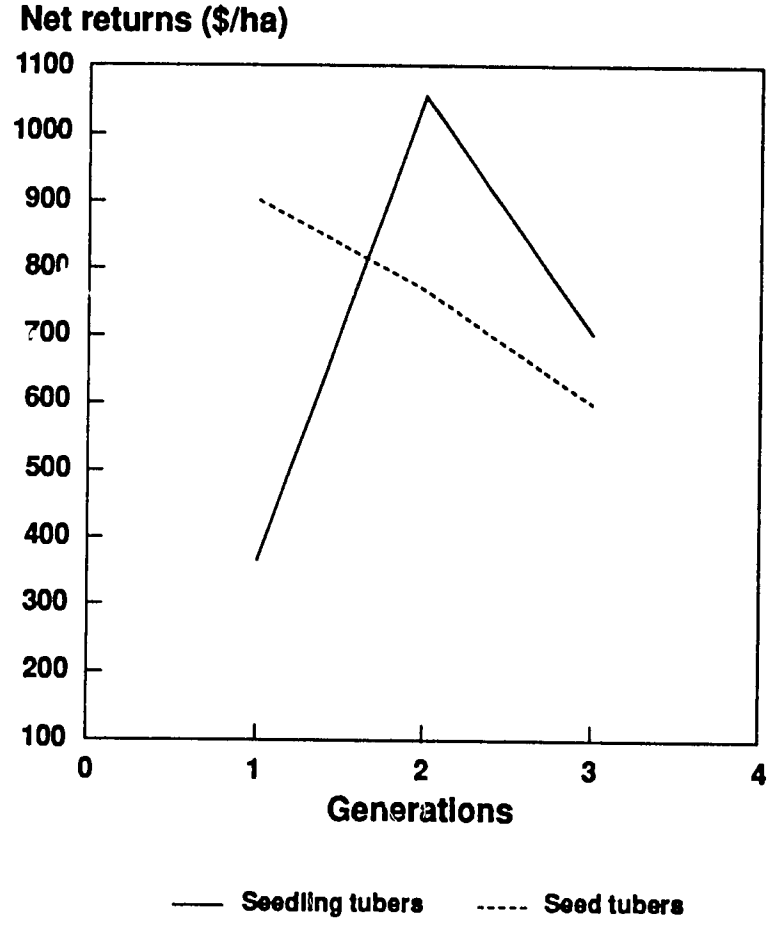
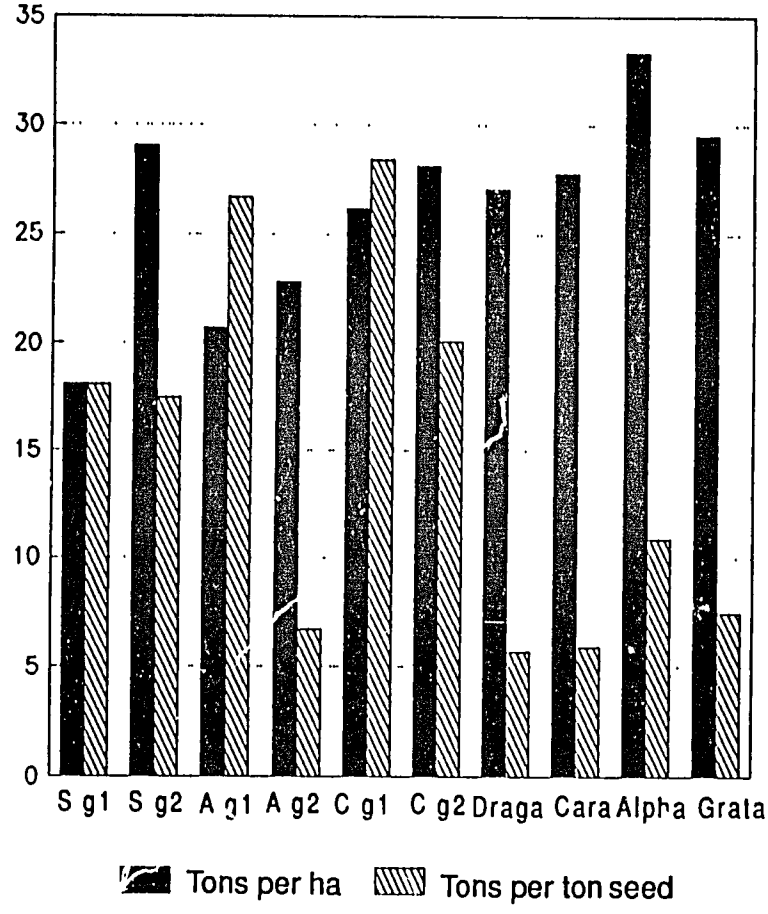


**Figure 6.** Changes in net returns to variable inputs for seedling tubers and seed tubers




Note Dotted lines represent assumed

**Figure 7.** Perfomance of g1 and g2 progeny and sedd tuber varieties in terms of yield to area and to seed used




Note 5 = Serrana x DTO28 , A = Atzimba x DTO 28, c = CFK6901 x DTO 33

Source: Own survey