COMPARATIVE FIELD PERFORMANCE OF POTATOES FROM SEEDLINGS AND TUBERS[1]

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Abstract

A field trial was conducted at Freeville, NY to compare yields from hybrid families of *Solanum tuberosum* L. with yields from their corresponding full sib, first clonal generation tubers. Unselected tubers were saved after harvesting transplanted seedlings of four Neo-Tuberosum x Tuberosum hybrids in 1982. The following year these tubers were planted for comparison with seedlings of the same hybrids in a split plot design. Total yields and yields of tubers ≥38 mm in diameter were respectively 34% and 38% higher from tuber propagated plants than from seedlings. The biggest difference was in tubers ≥ 63 mm diameter, where plants from tubers gave yields more than double those from seedlings. Seedlings had twice as many large axillary branches per stem as plants from tubers. Uniformity of tuber size and shape, and overall appearance ratings of tubers were better with seedling propagation; however, these comparisons are biased by the tendency of seedlings to produce smaller tubers, which inherently receive higher ratings.

Resumen

Un ensayo de campo fue conducido en Freeville, NY, para comparar los rendimientos de familias de plántulas híbridas de *Solanum tuberosum* L. con los rendimientos de las correspondientes progenies de los tubérculos de la primera generación clonal.

En 1982, se reservaron tubérculos, no seleccionados, después de la cosecha de las plántulas transplantadas de cuatro híbridos Neo-Tuberosum x Tuberosum.

Estos tubérculos fueron sembrados al año siguiente para ser comparados con plántulas de los mismos híbridos, en un diseño de parcelas divididas.

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Los rendimientos totales y aquellos de tubérculos de diámetro ≥ 38 mm fueron respectivamente 34% y 38% mayores en las plantas propagadas por tubérculos que en aquellas propagadas mediante plántulas.

La mayor diferencia fue la obtenida con tubérculos de ≥ 63 mm, encontrándose que las plantas procedentes de tubérculos rindieron más del doble de tubérculos de este tamaño que aquellas procedentes de plántulas.

Las plántulas tuvieron el doble de ramas axilares largas por tallo que el plantas procedentes de tubérculos. La uniformidad del tamaño y de la forma de los tubérculos, y las apreciaciones de la apariencia general de los tubérculos, fueron mejores en la propagación por plántulas; sin embargo, estas comparaciones fueron influenciadas por la tendencia de las plántulas a producir tubérculos más pequeños, los cuales inherentemente reciben calificaciones más altas.

Introduction

Hermsen (6) observed that although potato breeders generally thought plants grown from tubers produced higher yields than plants grown from true seeds, no systematic research had proven the statement or quantified the difference. If populations grown from true seed produced lower yields than their first or second clonal generations, then it might be preferable to recommend planting seedling tubers.

Most true seed work to date has included comparisons of seedling yields with yields of standard clonal cultivars; the cultivars were often grown in adjacent trials and not as treatments in the seedling trials. Tubers were smaller and yields generally lower from seedlings; however, a few (usually hybrid) seedling families approached or surpassed standard cultivars in total yields. Yield differences have varied widely with germplasm, climate, length of growing season, and health status of tuber seed (5, 9, 10, 11, 15, 17, 21).

Thompson (16) compared seedling and first clonal generation tuber propagation of 20 hybrid families at Lima and San Ramon in Peru. Although he obtained 15 to 22% higher yields and larger tuber sizes with tuber propagation, the yield differences were not significant. Transplant loss was high and yields low because of adverse growing conditions; the author suggested retesting the best families at other locations.

Researchers at the International Potato Center (8) compared seedling yields from one open pollinated clone with yields from corresponding large (40 to 60 g) and small (5 to 20 g) seedling tubers. Both tuber groups outyielded seedlings; yields from 40 to 60 g tubers were about 50% higher than seedling yields.

This study was undertaken to compare yields from hybrid seedling families with yields from their corresponding full sib first clonal generation tubers.

Materials and Methods

Growing procedures and Neo-Tuberosum x Tuberosum hybrid families were as described for a selection trial (14). Transplanted seedlings were grown in 1983 as an additional treatment for comparison with unselected tubers saved from the same seedling families grown in 1982 (14). The four families were chosen for inclusion in the 1983 trial based on high yields and low incidence of virus diseases in 1982. Families were main plots, with seedlings and unselected tubers as subplots, in a split plot design with four replications.

Remnant true seeds from 1982 were sown on 27 April, 1983. Transplants were grown in a plastic greenhouse for 5 weeks; flats were set outside for 5 days of hardening before being transplanted in the field. Both seedling and tuber treatments were planted on 13 June in 3-row plots. Plots were 4.6 m long with 30 cm between plants, 86 cm between rows, and one plant per hill, giving 45 plants per plot. Seedlings were transplanted by hand and watered immediately with about 0.5 l per plant of 20-8.7-16.6 NPK fertilizer solution (6 g/l). Tubers had been given a 10-day curing period after harvest and were then stored at 4 C until just before planting. Tuber diameter ranged between 38 and 48 mm.

Plots were irrigated four times in 1983 because of very hot, dry conditions in July and August. Vines were killed on 19 September; the center row of each plot was harvested for data on 3 October (112 days after planting). Potato grading and ratings for plant and tuber characters were as described previously (14).

Results

Treatment effects are described in terms of yields, vine characteristics, and tuber traits; treatments were compared with a linear contrast (seedlings vs. tubers). There were no significant differences among the four families (main plots), with the exception of ratings for tuber size uniformity and eye depth.

Yields. Compared to results from seedlings (Table 1), tuber propagation resulted in 34% higher yields of tubers ≥ 25 mm in diameter, 38% higher yields ≥ 38 mm in diameter, and 62% higher yields of U.S. Size A tubers (≥ 48 mm). Total tuber numbers per plant were not significantly different. Figure 1 illustrates differences in size distributions of tuber yields with the two propagation methods. Seedlings gave significantly ($p \leq 0.01$) greater numbers and weights of tubers in the 25 to 38 mm and 38 to 48 mm sizes, whereas plants from tubers gave significantly ($p \leq 0.01$) greater numbers and weights of tubers in the 63 to 83 and 83 to 102 mm sizes.

Vine characteristics. Early vine growth was much faster from tubers, and plants from this treatment gave full ground cover considerably earlier than did transplants. By 45 days after planting there were no significant differ-

TABLE 1. — *Effects of propagation method on numbers and yields of tubers ≥ 25 mm, ≥ 38 mm, and ≥ 48 mm diameter. Values are means of four hybrid families, each replicated four times.*

	Tubers (≥ 25 mm)		Tubers (≥ 38 mm)		Tubers (≥ 48 mm)	
Treatment	No. per plant	Wt. (t/ha)	No. per plant	Wt. (t/ha)	No. per plant	Wt. (t/ha)
Seedlings	8.5	21.9	6.9	20.6	3.9	15.1
Tubers	8.1	29.3	8.2	28.5	5.0	24.5
	NS	**	NS	**	**	**

**Means within column significantly different @ p≤ .01.

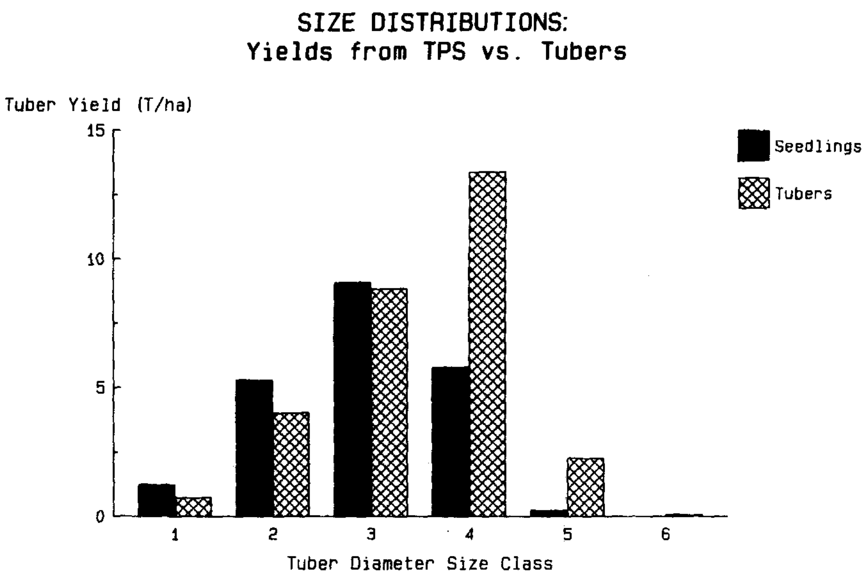

FIG. 1. Size distributions of tuber yields of TPS families and their full sibs grown from tubers. Values are means of 4 families X 4 replications. Tuber diameters in each size class were: 1=25-38 mm, 2=38-48 mm, 3=48-63 mm, 4=63-83 mm, 5= 83-102 mm, 6=>102 mm.

ences among ratings of seedling and tuber propagated plants for size, row cover, vigor, or uniformity (data not shown). Eighty-eight days after planting, seedling plots were rated slightly earlier in vine maturity (6.2 on a scale where 1=very immature to 9=mature and dead) than tuber plots (5.7), but this difference was also not significant. Seedling-propagated plants had many more large, above-ground axillary branches than tuber propagated plants; numbers of main stems and large (≥ 1 cm diameter) axillary branches were counted in each plot from two replications at midseason. Axillary branches originating below the soil surface were not observed in plants from seedlings. Seedlings had only a single main stem but twice as many large axillary branches per stem as plants from tubers (Table 2). Since tuber propagated plants averaged more than two main stems, the total number of branches per plant equalled the number from seedlings.

TABLE 2. — *Numbers of axillary branches (≥1 cm diameter) associated with seedling and tuber propagation. Means are from four hybrid families, each with two replications.*

Treatment	No. main stems	Axillary branches (≥1 cm) per main stem	Axillary branches (≥1 cm) total
Seedlings	1.0	14.4	14.4
Tubers	2.2	6.8	14.1
	**	**	NS

**Means within column significantly different @ $p \leq .01$.

Tuber Characteristics — Tubers from seedlings received significantly better scores for depth of eyes, uniformity of size, uniformity of shape, and overall appearance; but average tuber weight was much higher from plants grown from tubers (Table 3).

TABLE 3. — *Effects of propagation method on tuber characteristics. Means are from four hybrid families, with four replications.*

Treatment	Unif. shape[1]	Unif. size[1]	Eye depth[1]	Appearance[1]	Avg. wt. (g)
Seedlings	3.7	3.9	3.8	3.7	68
Tubers	2.8	2.9	3.2	2.5	97
	**	**	**	**	**

[1]Uniformity, eye depth, and appearance rated on 1-5 scales: 1=least uniform, very deep eyes, or poor tuber type; 5=most uniform, smooth, or very good tuber type.
**Means within column are significantly different @ $p \leq .01$.

Discussion

Plants from seedlings produced about the same number of tubers as plants from tubers, but fewer tubers reached U.S. Size A with seedling propagation. The difference in tuber size is probably best explained by the difference in early growth of the two treatments. We did not make weekly estimates of ground cover in the two treatments; but it was obvious that although sprouting tubers and six-week old seedlings were planted on the same day, the plants from tubers quickly surpassed the transplants in size and filled in the rows much sooner. By 45 days after planting, the differences in size were no longer detectable. Even with transplanting shock minimized (i.e., by using Speedling planter flats, starter solutions, and immediate irrigation), seedlings seemed to grow very slowly for a few weeks following transplanting.

About 80% of the dry matter in the mother tuber is translocated to the developing plants (12). It is to be expected that these extra food reserves will enable the young plant to undergo more rapid growth. Martin (11) observed that direct seeded plants started tuberizing much later than tuber propagated cultivars planted at the same time. Time of tuberization was not determined in our experiment.

The comparison of the two propagation methods required several arbitrary decisions. For example, we elected to transplant the same day that tubers were planted. Where frost is a hazard, tubers could actually be planted earlier. In this sense our procedures put tubers to a disadvantage. On the other hand, we used the same spacing for tubers and transplants, even though tubers had more stems per plant. It could be argued that a higher population of transplants should have been employed to equalize the number of stems per given area (7). Calculation of total tuber number per main stem rather than per plant shows 8.5 for the transplants compared to 3.7 for plants from tubers. However, it seems doubtful whether higher planting densities would have improved market sized tubers from transplants, since tubers from the two treatments differed in average size, not in number per plant. Increasing the transplant population would have led to still smaller tubers, even if total yields could have been increased. Increasing stem numbers per hill does not increase yields when spacings are already optimal (4) if plant survival is near 100%. Very high seedling densities may be useful when the emphasis is upon high yields of small tubers (19, 20).

Profuse branching of seedlings reported here has also been observed by other workers (7). This phenomenon, like later tuber initiation, could be related to physiological differences associated with absence of a mother tuber. Wattimena, *et al.* (18) described plant characteristics from clonal microtubers strikingly similar to seedling characteristics: plants were single stemmed, branched profusely, and produced more stolons than seed tuber propagated plants of the same cultivars. In addition, tuber initiation occurred over a longer period and early harvest yields were much lower from microtubers than from seed tubers. Total yields were the same, although plants from microtubers produced more and smaller tubers. The authors suggested that early tuber biomass accumulation might be related to the presence and size of the mother tuber. Both microtuber and seedling propagation methods appear to have similar disadvantages in areas with short growing seasons.

Natural and inadvertent selection could also account in part for higher yields from tubers. Very late maturing progenies occur even in crosses between early maturing Tuberosum clones; more late maturing genotypes occur when parental clones have not been selected for tuberization under long days. In our trials, a few plants formed tubers very early while still in the seedling flats; others had produced only very small tubers by harvest time. Since tubers smaller than 25 mm were not used for planting, very late genotypes were not represented in the tuber propagated treatment in 1983. Although only a few of these plants were observed in 1982, their absence in 1983 may have given a slight yield advantage to the tuber propagated treatment.

Differences in early growth and in the presence of very late genotypes were not reflected in vine maturity ratings. Seedlings were scored slightly later than tubers for two families but earlier than tubers for the other two. Real differences are probably difficult to detect using visual ratings determined by mentally averaging a range of maturity responses found in each plot. Single stemmed seedlings eventually grew as large and vigorous as tuber propagated plants; it appears that large axillary branches compensate for fewer main stems. Working with tuber propagated cultivars, Goodwin *et al.* (3) showed that plants with single, well branched main stems gave similar yields to those with many main stems.

Tubers were more uniform from seedlings than from tuber propagated plants; but this was largely associated with smaller average tuber size from seedling propagation. There were significant negative correlations between shape uniformity scores and yields of tubers 63 to 83 mm ($r=-0.53$) and 83 to 102 mm ($r=-0.35$). Similarly, tuber size uniformity ratings were positively associated with yields of small tubers and negatively correlated with yields of tubers larger than 63 mm. Better tuber appearance ratings with seedling propagation were also associated in part with higher yields of small and medium size tubers (25 to 63 mm). Tuber defects, deep eyes, and growth abnormalities are not as likely to be expressed in small and medium size tubers as in large tubers. Another factor in appearance ratings was that more scab lesions were observed on tubers from tuber propagated plants, probably because inoculum was present on the seed tubers saved from 1982.

Presumably inherent disadvantages of seedling propagation would be minimized by selecting only highly adapted parental clones (13) or by modifying cultural and management practices. Overall growing conditions were favorable in this experiment, and the hybrids tested seemed well adapted. With only 98 days between planting and vine killing, average yields from tuber propagated plants exceeded 29 t/ha, almost equaling yields of standard cultivars grown nearby under similar conditions. Adequate irrigation and soil fertility are essential for producing high yields from seedlings. Transplanting earlier may be feasible in some locations; using soil blocks should be beneficial also (1, 2, 8). Any practice which promotes rapid, early growth and reduces transplanting shock is likely to result in higher yields and larger tubers from seedlings.

This study demonstrates large yield advantages with tuber propagation in a temperate climate with a short growing season. Although many developing countries have more frost-free days, optimum growing periods for potatoes are often bounded by conditions of high temperatures or water scarcity.

Seedling propagation of potatoes is labor and management intensive; if disease spread is not too serious, growers using true potato seed will probably prefer to grow seedlings in small plantings to produce tuber seed for the next season's planting (19, 20). This permits planting of larger, less intensively managed plots in the traditional manner. Earlier, more rapid growth from tubers helps growers avoid problems of establishment and of lower yields associated with seedling propagation. The growing of ware potatoes from seedlings may be advantageous in areas where tuber-borne pathogens are prevalent or where facilities to store seed tubers are inadequate, if the cost of imported seed tubers is high.

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