The Economics of Producing Potted Miniature Rose by Single-node Cuttings, Budded Cuttings and Microcuttings

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ABSTRACT

The cost of labor and cultural area for the entire production of miniature rose, cvs. Red Sunblaze and Royal Sunblaze, by single-node-cutting, budded-cutting, and micropropagation were estimated. The model procedures followed the optimal results from previous papers, and were performed by three unexperienced graduate students. Costs were estimated at \$7 $hour^{-1}$ for labor and \$1.85 and \$3.25 m^{-2} $week^{-1}$ for greenhouse bench and tissue culture bench, respectively. The cost for producing one 'Red sunblaze' plantlet by microcutting, single-node cutting or budded cutting methods was \$0.07, \$0.09, \$0.65, respectively. Propagation of one 'Royal Sunblaze' plantlet cost\$0.09, \$0.10, \$0.66, by the respective aforementioned methods. The percentage of costs devoted to labor in producing single-node cuttings, microcuttings, or budded cuttings, was 15- 16%, 62-63% and 76-78%, respectively. The final cost of producing a 10-cm pot of 'Red Sunblaze' by planting one microcutting was \$0.71, one single-node-cuttings, was \$0.73, or one budded cutting per pot cost \$1.29. For 'Royal Sunblaze', a 10-cm potted rose was attained by planting three microcuttings at \$0.68, three single-node cuttings at \$0.71 or one budded cutting per pot at a cost of \$1.04.

Our studies concluded that (1) micropropagation is the most efficient propagation method; (2) potentially, the budded-cutting method could compete with single-node-cutting and micropropagation methods in pot rose production, especially for cultivars (e.g. 'Royal Sunblaze) with canopy development dependent on the growth of basal rather than lateral shoots; (3) planting three microcuttings or three single-node cuttings per pot can be more profitable than only one cutting if the greenhouse culture time is reduced.

Key words: pot rose, production, price.

Introduction

In commercial propagation, the primary goal is to achieve the desired plant production at a minimum cost [15]. Studies examining the tissue culture potential of certain plant species have produced theoretical multiplication rates on the order of 1,000,000 plantlets per year from one single shoot apex. In many cases, these figures have not been fulfilled by commercial application of tissue culture and furthermore,have resulted in exaggerated expectations by nurserymen and propagators[9]. In contrast, the successful commercialization of micropropagation of African violet, Boston fern [16], orchid [6] and pyrethrum [11] indicates that tissue culture can compete with conventional propagation methods.

Companies will employ micropropagation when no conventional or efficient clonal propagation system exists, to achieve multiple branching, or to develop disease-free plants [6]. Although a more commercially-desirable compact miniature rose was produced by tissue culture than was typically achieved with cuttings[8, 12], most rose companies continue to produce miniature roses by micropropagation was improved[3, 4, 5], however, the economics of micropropagation versus conventional propagation methods were unknown.

Propagation costs are generally divided into indirect and direct costs. Indirect costs include utilities, depreciation, taxes, loans, sales, administrative expenses, supplies, dues, subscriptions, and meeting attendance. Direct costs include labor, media and production supplies [7]. Moreover, to produce a potted miniature rose not only involves propagation, but also greenhouse production. Consequently, the designated cost per square meter of greenhouse bench area per week is also an important economical factor [10]. Unfortunately, calculation of an average production cost is difficult, because of differences in location, size and structural components of facilities [16]. However, labor is by far the greatest cost in producing tissue-cultured plants, accounting for 60% up to 85% in extreme cases [7]. The objective of this study was to determine costs of labor and cultivation area in tissue culture and greenhouse environments when producing miniature roses by single- node cuttings, budded cuttings (stentlings), and microcuttings.

Materials and Methods

Miniature rose cvs., Red Sunblaze and Royal Sunblaze (Yoder Brothers Ins., Ohio) were transplanted into 15-cm pots and placed on a greenhouse bench on Feb. 12th, 1990. Each pot contained 3-4 plants with 48 pots per cultivar occupying 2.04 m^2 of bench. After March 1st, nodal segments were collected every 2 weeks for 52 weeks for propagation by cutting, budding or tissue culture.

The procedures for producing the optimal 10-cm potted miniature rose were taken from our studies[3, 4, 5] and performed by three unexperienced propagators. Each person repeated each step (Tables 1, 2, and 3) three times. The average time required to perform each step was used to evaluate labor requirements. The cost of labor per hour was estimated at $7.00 (personal communication, cost estimate made by Night Hollow Nursery, Madison, Wl.).

Since budding is a highly skillful technique, budded-cutting was performed by the author only. In addition, the cost of producing *Rose multiflora* internodes for budding was estimated as comparable to producing 'Red Sunblaze' nodal segments.

In micropropagation, the average number of nodal segments produced from 48 pots of stock plants per week was used for initial tissue culture. Eight GA-7 vessels (Magenta Corporation, Chicago) were put on a 7-way, 0.05 m^2 tray (Magenta Corporation, Chicago). Every 4 weeks, multiple shoots were divided and subcultured onto a new medium. Optimal multiplication rates of 4 and 3 [5] were used for 'Red Sunblaze' and 'Royal Sunblaze', respectively. The cost estimation for tissue culture area was based on the $18.83 approximation for the shelf space cost per square meter per week for most laboratories in 1985 [7]. This value was multiplied by consumer price indices [1] of 1.9% and 3.6% for 1986 and 1987, respectively (U.S. Bureau of Census, 1989), and multiplied by 1/6, since we had 6 layers of tissue culture benches per m^2 of shelf area (tissue culture room), to derive a cost of $\$3.25\ m^{-2}week^{-1}$ (18.83*1.019*1.036*1/6= 3.25).

Sixty single-node cuttings or budded-cuttings or 160 microcuttings from in vitro were inserted in a 0.15 m^2 tray. The cost of production on a greenhouse bench also was used for mist bench production. After 4 weeks on a mist bench, plants from each treatment were transplanted to 10-cm pots containing a peat, perlite and vermiculite (1:1: 1; v:v:v) medium, and placed on a 6.08 m^2 bench at a density of 420 pots per bench. The cost estimation for greenhouse bench area was based on the $1.62 average cost estimation of greenhouse area in 1983 [1]. Multiplying this value by consumer price indices of 4.3, 3.6, 1.9 and 3.6% for the years 1984, 1985, 1986 and 1987, respectively (U.S. Bureau of Census, 1989), resulted in a cost of $\$1.85\ m^{-2}week^{-1}$ for greenhouse culture.

The production of 'Red Sunblaze' roses was performed by inserting one plantlet per 10 cm-pot and culturing in a greenhouse for 20 weeks. In contrast, the production of 'Royal Sunblaze' was performed by planting one budded-cutting, three single-node cuttings or three microcuttings per 10-cm pot and culturing in a greenhouse for 12 weeks [3]. The cost of labor and the cultural area to produce one plantlet and one commercially acceptable potted miniature rose through single-node cutting, budded-cutting, and micropropagation methods were calculated.

Results

During 52 weeks, 48 pots of 'Red Sunblaze' and 'Royal Sunblaze' stock plants produced 3,269 and 2,987 nodal segments, respectively. In 12 min. and 54 sec., we collected and treated 100 nodal segments with IBA and inserted these into the appropriate medium (Table 1) .In contrast, 30 budded-cuttings were finished in one hour (Table 2).

In initial culture, 72 nodal segments were explanted to eight GA-7 vessels in 36 min. and 54 sec. In 54 min., 160 multiple shoots were subcultured into forty GA-7 vessels. Furthermore, in 42 min., 160 microcuttings were inserted into the ex-vitro medium (Table 3).

After 4 weeks under mist, the rate of rooted single-node- cuttings, budded-cuttings and microcuttings were 100%, 50% and 85% ('Red Sunblaze') or 75% ('Royal Sunblaze'), respectively. In 30 min. and 24 sec., 100 cuttings were transplanted. In contrast, 300 cuttings were transplanted in 45

Table 1. Time and necessary to produce miniature roses via sing-node cuttings

Procedure	Duration	Explant number	Culture area (m^2)
Explant Production[1]			
'Red Sunblaze'	52 weeks	3269	2.04
'Royal Sunblaze'	52 weeks	2987	2.04
Cutting	12.9 min.	100	----
Rooting	4 weeks	60	0.15
Transplanting[2]			
'Red Sunblaze'	30.4 min.	100	----
'Royal Sunblaze'	45.0 min.	300	----
Culture in Greenhouse			
'Red Sunblaze'	20 weeks	420	6.80
'Royal Sunblaze'	12 weeks	420	6.80

[1] From 48 pots of stock plants.
[2] One 'Red Sunblaze' and three 'Royal Sunblaze' cuttings per pot.

Table 2. Time and area necessary to produce miniature roses via budded cuttings

Procedure	Duration	Explant number	Culture area (m^2)
Scion Production[1]			
'Red Sunblaze'	52.0 weeks	3269	2.04
'Royal Sunblaze'	52.0 weeks	2987	2.04
Rootstock Production[2]	52.0 weeks	3269	2.04
Budded-cutting	60.0 min.	30	----
Rooting	4.0 weeks	60	0.15
Transplanting[3]			
'Red Sunblaze'	30.4 min.	100	----
'Royal Sunblaze'	45.0 min.	300	
Culture in Greenhouse			
'Red Sunblaze'	20.0 weeks	420	6.80
'Royal Sunblaze'	12.0 weeks	420	6.80

[1] From 48 pots of stock plants.
[2] Culture area required for rootstock production was estimated as the same as scion production.
[3] One 'Red Sunblaze' and three 'Royal Sunblaze' cuttings per pot.

min. when 3 cuttings were inserted per pot.

After economic analysis, one single-node cutting of 'Red Sunblaze' cost $0.09 of which 16% was attributed to labor. For 'Royal Sunblaze', 15% of the propagation cost ($0.10) came from labor (Table 4). In contrast, labor to make budded cuttings was 63% of total cost for propagating one 'Red Sunblaze' stentling ($0.65) and 62% for 'Royal Sunblaze' ($0.63) (Table 5).

The most economical plantlets were produced by micropropagation (Table 6 and 7). The cost of one microcutting of 'Red Sunblaze' was $0.07 and 'Royal Sunblaze' was $0.09, respectively. Yet, the percentage of costs devoted to labor (78% for 'Red Sunblaze' and 76% for 'Royal Sunblaze') for microcuttings was the highest of these three propagation methods. The cost of producing one 10-cm-pot of 'Red Sunblaze' was $0.71, $0.73, or $1.29 for one microcutting, single-node cutting or budded-cutting per pot, respectively (Table 8). For 'Royal Sunblaze', the cost of a 10- cm potted product was $0.68, $0.71 or $1.04 for three single-node cuttings, three microcuttings, or one budded-cutting per pot, respectively (Table 8). The percentage of total costs to produce one 'Red Sunblaze' plantlet in pot rose production was 10% for microcuttings, 12% for single-node cuttings or 50% for budded cuttings. In contrast, for 'Royal Sunblaze', the percentage of total costs to produce three microcuttings, three single-node cuttings, or one budded cutting in pot rose production was 40, 42 or 62%, respectively (Table 8)

Table 3. Time and area necessary to produce miniature roses via micropropagation

Procedure	Duration	Explant number	Culture area (m^2)
Explant Production[1]			
'Red Sunblaze'	52.0 weeks	3269	2.04
'Royal Sunblaze'	52.0 weeks	2987	2.04
Initial culture[2]	36.9 min.	72	----
	4.0 weeks	72	0.05
Subculture[2]	54.0 min.	160	----
	4.0 weeks	40	0.05
Microcutting ex vitro	42.0 min.	160	----
Rooting	4.0 weeks	160	0.15
Transplanting[3]			
'Red Sunblaze'	30.4 min.	100	----
'Royal Sunblaze'	45.0 min.	300	----
Culture in Greenhouse			
'Red Sunblaze'	20.0 weeks	420	6.80
'Royal Sunblaze'	12.0 weeks	420	6.80

[1] From 48 pots of stock plants.
[2] In vitro culture, four weeks for each culture.
[3] One 'Red Sunblaze' and three 'Royal Sunblaze' cutting per pot.

Table 4. Economics of producing 10,000 miniature roses plantlets by single-node cutting

A. Cost of production:
   1. a. Area for 'Red Sunblaze' production:[1]
      2.04 m^2 (culture area of stock plants) x 52 wks yr^{-1} ÷ 3269 nodal segments yr^{-1} x 10,000 cuttings = 324.5 m^2 wk
      b. Area for 'Royal Sunblaze' production:[1]
      2.04 m^2 (culture area of stock plants) x 52 wks yr^{-1} ÷ 2987 nodal segments yr^{-1} x 10,000 cuttings = 355.14 m^2 wk
   2. Area for rooting:
      0.15 m^2 $tray^{-1}$ ÷ 60 cuttings $tray^{-1}$ x 10,000 cuttings x 4 wks = 100.00 m^2 wk
   3. Cost of 1 m^2 wk culture area (estimated cost of mist bench and greenhouse the same):
      $1.85
   4. Total culture area cost:
      'Red Sunblaze': $1.85 m^{-2} wk^{-1} x (324.50 + 100.00) m^2 wk = $785.33
      'Royal Sunblaze': $1.85 m^{-2} wk^{-1} x (324.50 + 100.00) m^2 wk = $842.01
B. Cost of labor:
   1. Time required:
      12.9 min ÷ 100 cuttings x 10,000 cuttings - 60 min hr^{-1} = 21.5 hrs
   2. Estimated labor cost per hour:
      $7.00 hr^{-1}
   3. Total labor cost:
      $7.00 hr^{-1} x 21.5 hrs = $ 150.50
C. Cost of one plantlet:
   'Red Sunblaze' (785.33 + 150.50) ÷ 10,000 = $0.09
   'Royal Sunblaze' (842.01 + 150.50) ÷ 10,000 = $0.10

[1] Nodal segments collected from 48 pots of stock plants for one year (52 wks).

Table 5. Economics of producing 10,000 miniature rose plantlets by budded-cutting

A. Cost of production:
   1. a. Area for 'Red Sunblaze' production:[1]
      2.04 m^2 (culture area of stock plants) x 52 wks yr^{-1} ÷ 3269 nodal segments yr^{-1} x 10,000 cuttings = 324.50 m^2 wk
   b. Area for 'Royal Sunblaze' production:[1]
      2.04 m^2 (culture area of stock plants) x 52 wks yr^{-1} ÷ 2987 nodal segments yr^{-1} x 10,000 cuttings = 355.14 m^2 wk
   c. Area for Rosa multiflora internodes production:
      Estimated the same as that for 'Red Sunblaze'
   2. Area for rooting:
      0.15 m^2 $tray^{-1}$ ÷ 60 $tray^{-1}$ x 10,000 cuttings x 4 wks = 100.00 m^2 wk
   3. Cost of 1 m^2 wk (estimated cost of mist bench and greenhouse the same):
      $ 1.85
   4. Total culture area cost:
      'Red Sunblaze': $1.85 m^{-2} wk^{-1} x (324.50 x 2 + 100.00) m^2 wk = $ 1385.65
      'Royal Sunblaze': $1.85 m^{-2} wk^{-1} x (324.50+355.14 + 100.00) m^2 wk = $ 1442.33

B. Cost of labor:
   1. Time required:
      60 min ÷ 30 stentling hr^{-1} x 10,000 stentlings - 60 min hr^{-1} = 333.33 hrs
   2. Estimated labor cost per hour:
      $7.00 hr^{-1}
   3. Total labor cost:
      $7.00 hr^{-1} x 333.33 hrs = $2333.31

C. Cost of one plantlet:[2]
   'Red Sunblaze': ($1385.65 + $2333.31 - $0.09 single-node cutting-1 x 5000 single-node cuttings) ÷ 5000 stentling = $0.65
   'Royal Sunblaze': ($1442.33 + $2333.31 - $0.10 single-node cutting-1 x 4300 single-node cuttings) ÷ 5300 stentlings = $0.63

[1] Nodal segments collected from 48 pots of stock plants for one year.
[2] Since the growth response of budded-cuttings rooting from scion was similar to that of single-node cuttings, the same cost was estimated as for single-node cutting (Chapter 4).

Table 6. Economics of producing (4 subcultures) 'Red Sunblaze' plantlets by micropropagation

A. Number of multiple shoots produced (multiplication rate is 4):
   Initial culture: 3,269 ÷ 52 wks = 63 nodal segments wk^{-1}
   1st subculture: 63 x 4 = 252 shoots
   2nd subculture: 252 x 4 = 1008 shoots
   3rd subculture: 1,008 x 4 = 4032 shoots
   4th subculture: 4,032 x 4 = 16128 shoots
   Total shoots: 16,128 x 0.85 (survival rate) = 13,079 shoots

B. Cost of production:
   1. Area for production of nodal segments:
      2.04 m^2 (culture area of stock plants)
   2. Area in tissue culture:[1]
      0.05 m^2 GA-7-$tray^{-1}$ x (63 ÷ 9 + 63 ÷ 5 + 252 ÷ 5 + 1008 ÷ 5 + 4,032 ÷ 5) vessels - 8 vessels GA-7-$tray^{-1}$ x 4 wks = 27.09 m^2 wk.
   3. Area for rooting:
      0.15 m^2 $tray^{-1}$ ÷ 160 cuttings $tray^{-1}$ x 16,128 cuttings x 4 wks = 60.48 m^2 wk.
   4. Cost of greenhouse and mist bench per m^2 per wk:
      $1.85
   5. Cost of tissue culture bench per m^2 per wk:
      $3.25
   6. Total culture area cost of microcuttings:
      $1.85 m^{-2} wk^{-1} x (2.04 + 60.48) m^2 wk = $115.66
   7. Total in vitro culture area cost:
      $3.25 m^{-2} wk^{-1} x 27.09 m^2 wk = $88.04

C. Cost of labor:
   1. Time required:
      a. Initial culture:
         36.9 min ÷ 72 explants x 63 explants for initial culture ÷ 60 min hr^{-1} = 0.54 hrs.
      b. Subculture:
         54 min ÷ 160 explants x (63 + 252 + 1008 + 4032) explants ÷ 60 min hr^{-1} = 30.12 hrs
      c. Microcuttings ex vitro:
         42 min ÷ 160 microcuttings x 16,128 microcuttings ÷ 60 min hr^{-1} = 70.56 hrs
   2. Estimated labor cost per hour:
      $7.00 hr^{-1}
   3. Total labor cost:
      $7.00 hr^{-1} x (0.54 + 30.12 + 70.56) hrs = $708.54

D. Cost of one plantlet:
   (708.54 + 115.66 + 88.04) ÷ 13709 = $0.07

[1] In initial culture: 9 explants per vessel; in subcultures: 5 explants per vessel.

Table 7. Economics of producing (4 subcultures) 'Royal Sunblaze' plantlets by micropropagation

A. Number of multiple shoots produced (multiplication rate is 3):
   Initial culture:2,987 ÷ 52 wks = 57 nodal segments wk^{-1}
   1st subculture: 57 x 3 = 171 shoots
   2nd subculture: 171 x 3 = 513 shoots
   3rd subculture: 513 x 3 = 1539 shoots
   4th subculture: 1,539 x 3 = 4,617 shoots
   Total shoots: 4,617 x 0.75 (survival rate) = 3,463 shoots

B. Cost of production:
   1. Area for production of nodal segments:
      2.04 m^2 (culture area of stock plants)
   2. Area in tissue culture:[1]
      0.05 m^2 GA-7-$tray^{-1}$ x (57 ÷ 9 + 57 ÷ 5 + 171 ÷ 5 + 513 ÷ 5 + 1,539 ÷ 5) vessel - 8 vessels GA-7-$tray^{-1}$ x 4 wks = 11.56 m^2 wk
   3. Area for rooting:
      0.15 m^2 $tray^{-1}$ ÷ 160 microcuttings $tray^{-1}$ x 4,617 microcuttings x 4 wks = 17.31 m^2 wk
   4. Cost of tissue culture bench per m^2 per wk:
      $1.85
   5. Cost of tissue culture bench per m^2 per wk:
      $3.25
   6. Total culture area cost of microcuttings:
      $1.85 m^{-2} wk^{-1} x (2.04 + 17.31) m^2 wk = $35.80
   7. Total in vitro culture area cost:
      $3.25 m^{-2} wk^{-1} x 11.56 m^2 wk = $37.57

C. Cost of labor:
   1. Time required:
      a. Initial culture:
         36.9 min ÷ 72 explants x 57 explants for initial culture ÷ 60 min hr^{-1} = 0.49 hrs
      b. Subculture:
         54 min ÷ 160 explants x (57 + 171 + 513 + 1539) explants ÷ 60 min hr^{-1} = 12.83 hrs
      c. Microcuttings ex vitro:
         42 min ÷ 160 microcuttings x 4617 microcuttings ÷ 60 min hr^{-1} = 20.20 hrs
   2. Cost of labor:
      $7.00 per hour
   3. Total labor cost:
      $7.00 hr^{-1} x (0.49 + 12.83 + 20.20) hrs = $ 234.64

D. Cost of one plantlet:
   (234.64 + 35.80 + 37.57) ÷ 3,463 = $0.09

[1] In initial culture: 9 explants per vessel; in subcultures: 5 explants per vessel.

Table 8. Economical comparison of propagation methods for two miniature rose cultivars from initial plantlet production through greenhouse pot product

Cultivar	Propagation method	Cost($)		
		Plantlet	After transplanting[1]	Total
'Red Sunblaze'	Single-node-cutting	0.09	0.04[1] + 0.60[2]	0.73
	Budded-cutting	0.65	0.04 + 0.60	1.29
	Micropro-pagation	0.07	0.04 + 0.60	0.71
'Royal Sunblaze'	Single-node-cutting	0.10 x 3[3]	0.05 + 0.36	0.71
	Budded-cutting	0.63	0.05 + 0.36	1.04
	Micropro-pagation	0.09 x 3[3]	0.05 + 0.36	0.68

[1] Labor cost for transplanting: (i) one plantlet per pot: \$7 hr^{-1} x [30.4 min - 100 pots (one plantlets per pot) - 60 min hr^{-1}] = \$0.04; (ii) three plantlets per pot: \$7 x [45 min - 100 pots (three plantlets per pot) - 60 min hr^{-1}] = \$0.05

[2] Cultural area cost: (i) 20 weeks for 'Red Sunblaze': \$1.85 m^{-2} $week^{-1}$ x (6.80 m^2 $bench^{-1}$ - 420 pots $bench^{-1}$ x 20 wks) = \$0.60 pot^{-1}; (ii) 12 weeks for 'Royal Sunblaze': \$1.85 m^{-2} x (6.80 m^2 - 420 pots $bench^{-1}$ x 12 wks) = \$0.36 pot^{-1}.

[3] Three cuttings per pot.

Discussion and Conclusion

Generally, the decision to use tissue culture techniques can be divided with some limitations into four categories: (a) Tissue culture methods (TCM) are superior to conventional propagation methods (CPM); (b) TCM are competitive with CPM; (c) TCM produce pathogen-free plants; (d) TCM are used for special purposes (for example, clone mother plants which are otherwise propagated by seeds) [16]. Our results showed that the cost of producing microcuttings was less than that of single-node cuttings. Although micropropagation is a labor intensive method and the cost of area in tissue culture was higher than that in a greenhouse (\$3.25 vs. \$1.85 $m^{-2}week^{-1}$), the efficiency of culture area for producing cuttings (2400-3200 microcuttings vs. 28-31 single-node cuttings $m^{-2}week^{-1}$) and rooting on a mist bench (160 vs. 60 per 0.15 m^2 tray) was greater.

The quality of budded roses is not always satisfactory for pot roses because the strong rootstock (Rose multiflora) results in too tall and voluminous plants. Our studies revealed [3] that after 20 weeks of growth in a greenhouse, the quality of budded 'Red Sunblaze' plants suffered the same limitations. The height of budded 'Red Sunblaze' cuttings was too tall for a pot plant. In contrast, after 12 weeks of growth in a greenhouse, the quality of one budded cutting of 'Royal Sunblaze' was better than that of either three single-node cuttings or microcuttings.

Budded miniature roses are more vigorous than plants grown on their own-roots[3,13], however, vigor is not particularly an important criteria for indoor plant specimens. Moreover, own-root miniatures are so hardy that they can survive outdoors overwinter without any protection[3]. Therefore, the vigorous growth resulting from budding on rootstock may impart tolerance to diverse environments, yet it unnecessary for midwest outdoor production.

Vigor is important when the canopy is constructed dominantly by basal shoots because a commercially acceptable rose is obtained in only 12 weeks with one rather than three plantlets per pot [3]. Unfortunately, the budded-cutting method was the most labor-intensive among the three propagation methods (Table 2). Consequently, it produced the most expensive single plantlet and commercial pot of 'Red Sunblaze' and 'Royal Sunblaze' (Table 4, 5, 6, 7 and 8).

The labor necessary to produce miniature roses by budded cuttings (2 min. per budding) was four times that for hybrid tea roses (30 sec. per budding, unpublished data). Moreover, the rate of successful stentlings for miniature roses was only half of that for hybrid tea roses [2,3]. These problems resulted from the difficulty of budding both the thin stem of miniature roses (1.5-3 mm diam.) and rootstock (3-6 mm diam.) [3]. In our studies, the mother plants of miniature roses were grown in 20-cm-diam. pots for several months, and Rosa multiflora were grown in 60-cm-diam.pots for an additional year. If the stem diameter of miniature roses and Rosa multiflora was increased to 4-8 mm by using older mother plants [12], the number of successful stentlings and the necessary labor should be comparable to that for hybrid tea rose production. Theoretically, the cost would be reduced to $0.20 for one budded- cutting of 'Red Sunblaze' or 'Royal Sunblaze'. Then, one 10 cm-pot of 'Royal Sunblaze' containing one budded-cutting would cost $0.67, which would be cheaper than either three single-node cuttings or microcuttings.

In Europe, few growers will sell a potted miniature rose with only one plant per pot, unlike the North American practice. The French firm of Meillands has set a standard of three cuttings to a 10-or 15-cm-diam. pot[13,14]. Langhans indicated that the cost per square meter of bench area per week is the most important economical factor in the pot flower industry (10). Our economical studies supported Langhan's suggestion. Since 'Red Sunblaze' with only one plantlet per pot was grown in the greenhouse for 20 weeks, the cost of culture area was extremely high (88-90% of total pot rose cost). Consequently, the cost of a pot of 'Red Sunblaze' containing one microcutting or a single-node cutting was more expensive than that of 'Royal Sunblaze' which contained three microcuttings or single-node cuttings for 12 weeks (Table 8).

In conclusion, our studies revealed the following: (1) Micropropagation is superior to conventional propagation methods for miniature rose production. (2) The budded-cutting method

uld potentially compete with micropropagation and single-node cuttings, especially for cultivars g. 'Royal Sunblaze') whose canopy development is dependent on basal rather than lateral shoots. If : budded-cutting method is to be used instead of micropropagation and single-node cuttings, more :earch on reducing rooting from scions and improving the efficiency of budding work is necessary

In the potted miniature rose industry, three plantlets as opposed to one plantlet per pot could be ›fitable if the greenhouse culture time is reduced.

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利用單節扦插、芽接扦插以及微體繁殖生產迷你玫瑰盆栽之價格分析

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摘　要

本報告對以單節扦插、芽接扦插以及微體繁殖三種方法生產迷你玫瑰 'Red Sunblaze' 和 'Royal Sunblaze' 品種的盆栽時所需的勞力和栽培面積成本做一評估。所有操作方法以三位沒有經驗的研究生按照前所發表的方法執行整個操作程序，工資以每小時7美元估算，栽培面積作成本，溫室和培養室分別以每週每平方公尺1.85美元和3.25美元計算。用單節扦插，芽接扦插和微體繁殖一株 'Red Sunblaze' 種苗的費用分別爲0.07、0.09或0.65美元，而繁殖 'Royal Sunblaze' 則分別需0.09、0.10或0.66美元。在單節扦插、芽接扦插和微體繁殖等不同繁殖方法生產種苗的費用中，工資所佔百分比分別爲15～16%、62～63%或76～78%。

生產 'Red Sunblaze' 迷你玫瑰10公分盆之盆花，若每盆栽植一株單節扦插苗、芽接扦插苗或微體繁殖苗，則最後的生產成本分別爲0.71、1.29、0.73美元。

若生產 'Royal Sunblaze' 迷你玫瑰10公分盆之盆花，則每盆栽植3株微體繁殖或單節扦插苗之成本，分別爲0.68或0.71美元，而栽植1株芽接扦插苗之盆花所需成本則需1.04美元。

最後結論爲：

1. 微體繁殖方法是最有效的繁殖方法。
2. 對樹體是由基部芽所構成之品種，芽接扦插苗之繁殖方法與微體扦插或單節扦插相比較，仍具競爭潛力（如 'Royal Sunblaze'）。
3. 每盆栽植3株微體繁殖苗或單節扦插苗，因溫室栽培時間短，所以比每盆栽一株苗較爲有利。

關鍵字：盆栽玫瑰、生產成本。