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Effect of Seed Potato Size on Plug Seedling Growth and Field Performance

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ABSTRACT : Potato (*Solanum tuberosum* L.) tubers of 10, 20, 30, 40, and 50 g were planted in plug trays with vermiculite-based root medium on 10 August 2000 and grown for 15 days in a glasshouse to determine the effects of mini-tuber size on plug seedling growth and field performance of plug seedlings. For a control, common potato tubers weighing 50 g were also planted. As size of seed tubers planted increased from 10 to 50 g, seedling height decreased from 24.6 to 20.0 cm while shoot number per seedling increased from 2.0 to 3.5, main stem diameter from 4.3 to 6.1 mm, and fresh weight of root + top from 9.3 to 19.4 g/seedling. At 90 days after transplanting plug seedlings, the total number of tubers per plant increased from 3.62 to 4.72, average tuber weight from 62.9 to 72.8 g, and total tuber yield 20.5 to 23.6 t/ha with increase in seed tuber size. Plug seedlings raised from 50 g tubers produced 22% more tubers per plant and had 21% higher >80 g tuber yield than the directly planted potatoes.

Keywords **:** potato, mini-tuber size, plug seedlings, seedling growth, field performance.

Potatoes are grown on 25,000 ha in South Korea. The demand for seed potatoes in Korea is estimated to be 37,500 tons per year. However, government-run potato seed production facilities can supply only 10,000 tons per year which cover only about 25% of the total demand (Kim, 2000).

Seed potatoes need to weigh 30 to 120 g, have prominent buds, and be scar-free (Kim *et al.*, 1993). Microtubers produced by tissue culture weigh only about 1 g, and thus usually suffer delayed initial growth and low establishment rate, which in turn, result in lower yield when micro-tubers are planted in a field (Choi, *et al.* 1994; Wattimena *et al.*, 1983). Even mini-tubers produced by hydroponics weigh 20 to 30 g at most. Mini-tubers also suffer from lower emergence rate under field conditions and eventually had lower yield (Kim *et al.*, 1998).

Plug seedling was introduced to Korea in the early 1990s and was widely used in recent years because it saves labor for raising seedling, facilitates mass production of uniform seedlings, and allows division of crop production labor (Kim *et al.*, 1999). Lee *et al.* (2000) reported that potato plug seedlings produced from microtubers of 5 to 7 mm had higher emergence rate than from those of 3 to 4 mm. They also found that large microtubers had higher total tuber yield than small microtubers when planted directly in a field but microtuber size did not significantly affect total tuber yield when potato plug seedlings were transplanted. Potato plug seedlings raised from stem cutting had similar tuber yields to seed tubers (Park *et al.*, 1999; Song *et al.*, 1999). However, there is little information on effects of seed potato size on plug seedling growth and field performance of plug seedling. The objective of this study was to determine the effects of tuber size on potato plug seedling growth and field performance of plug seedlings.

MATERIALS AND METHODS

This study was conducted during the 2000 growing season at the glasshouse and research farm of College of Agriculture, Cheju National University (33° 27' 20" N latitude, 277 m altitude). The farm soil was a volcanic ash.

Root medium used in this test was prepared to contain 50% vermiculite (horticultural grade # 4, Silver Green, Misung, Seoul), 10% perlite (horticultural grade, Paragreen, Samson, Seoul), 10% peatmoss (Canadian sphagnum peat, BP-P, Berger Peat Moss, Quebec), and 30% mature compost by volume, and 2 g of complex fertilizer for potato (N-P_2O_5-K_2O, 10-10-14) per liter medium. The chemical properties of the root medium were shown in Table 1.

The mini-tubers of 'Dejima' produced in a field during the 2000 spring season were stored at room temperature. Evenly sprouted mini-tubers were sorted into five groups (10 ± 2, 20 ± 2, 30 ± 2, 40 ± 2, or 50 ± 2 g/tuber). Mini-tubers of 10, 20, and 30 g were planted in 50-cell polyethylene plug trays

Table 1. The chemical properties of the root medium.

pH (1:5)	EC (dS/m)	OM	T-N	P	K	Ca	Mg	Na
		-- (g/kg) --		(mg/kg)	------ (cmol$^+$/kg) -------			
5.9	1.1	207.9	12.8	348.9	2.8	25.0	27.3	5.3

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Table 2. Plug seedling growth of mini-tubers at 15 days after planting.

Tuber size (g/tuber)	Plant height (cm)	No. of shoots /plant	Stem diameter (mm)	Fresh weight (g/plant)			
				Root	Leaf	Stem	Total
10	24.7	2.0	4.3	2.2	3.8	3.3	9.3
20	22.4	2.2	4.5	3.2	4.7	3.2	11.1
30	21.6	2.4	4.9	5.1	5.0	5.1	15.1
40	20.9	3.0	6.0	7.8	5.8	5.8	19.4
50	20.0	3.5	6.1	7.4	6.1	5.9	20.8
Response†	L***	L***Q*	L***C**Qu*	L***	L***	L***C*	L***C*

*, **, ***Significant at the 0.05, 0.01, and 0.001 probability levels, respectively.
†L, linear; Q, quadratic; C, cubic; Qu, quartic. Regression equations relating tuber size are presented in Table 4.

(depth 5.5 cm, volume 78.3 cm^3) and those of 40 and 50 g in 32-cell polyethylene plug trays (depth 5.5 cm, volume 140 cm^3) on 10 August 2000. These tubers were grown in a heated glasshouse (day/night temperature of 20/15°C) for 15 days.

Treatments consisted of the five tuber sizes. Each 50-cell tray was considered as an experimental unit. For 32-cell trays, 50 cells were an experimental unit. Trays were arranged in a randomized complete block design with ten replicates.

After 15 days growth, plant height, the number of shoots per plant, and fresh weight of roots, leaves and stems for ten seedlings per treatment were determined.

The 15-day old plug seedlings were transplanted into 60-cm row with 20 cm spacing on 25 August 2000. For a control, common potato tubers weighing 50 g were also planted. At transplanting or planting, the plots were fertilized with 1,200 kg/ha of the complex fertilizer for potato (N-P_2O_5-K_2O, 10-10-14). Individual plots had four rows with 3 m long. The experimental design was randomized complete block design with three replications. At 90 days after planting, two center 2 m rows were harvested to determine potato yields.

RESULTS AND DISCUSSION

Seedling growth

As size of seed tubers planted in plug trays increased from 10 to 50 g/tuber, plug seedling height at 15 days after planting linearly decreased from 24.7 to 20.0 (Table 2 and 4). This probably resulted from the earlier emergence of the smaller tubers (Data not shown). Kim *et al.* (1998) found that smaller mini-tubers produced in hydroponics need shorter days to emergence. The number of days from planting to emergence of less than 15 g mini-tubers was 28 and 25 days and that of more than 10 g tubers was 30 and 27 days, in spring and fall seasons, respectively. However, they reported that the larger the size of mini-tubers planted directly in field, the greater plant height at 60 days after planting probably because of greater growth rate of mini-tubers after emergence. However, Choi. *et al.* (1994) found that the larger the microtuber size, the earlier emergence. The seedling height is known to be greater for larger microtubers planted in plug trays than for smaller microtubers (Choi. *et al.*, 1994; Lee *et al.*, 2000).

The number of shoots per plant quadractically increased from 2.0 to 3.5 with increased seed tuber size. Stem diameter ranged from 4.3 to 6.1 mm and markedly increased up to 40 g/tuber and then slightly increased. Kim *et al.* (1998) also found that large mini-tubers had more shoots per plant and thicker main stem than small mini-tubers at 60 days after planting. However, there was no significant difference between microtuber sizes for the number of shoots per seedling (Lee *et al.*, 2000).

Root and leaf weights per plant linearly increased from 2.2 to 7.8 g and 3.8 to 6.1 g, respectively, with increase in tuber size. Relationship between stem weight per plant and tuber size was cubic because of no difference between 10 and 20 g tubers, markedly increased stem weight of 30 g tubers and slight increased stem weight of >40 g tubers. These results indicate that nutrients stored in seed potato largely influence the early growth of seedlings.

Field performance of plug seedlings

As the size of seed tubers planted for plug seedlings increased from 10 to 50 g/tuber, the number of >80 g tubers per plant at 90 days after transplanting linearly increased from 2.48 to 3.04, the number of <80 g tubers from 1.15 to 1.67, and the total number of tubers from 3.62 to 4.72 (Table 3 and 4). Kim *et al.* (1998) reported that the number of tubers per plant of potatoes directly planted increased from 9.4 to 13.4 and from 3.3 to 4.1, respectively, with increasing tuber size from <1 to >15 g in spring and fall croppings, respectively. However, there was no significant difference between microtuber sizes for the number of tubers per plant at maturity (Choi. *et al.*, 1994; *Lee et al.*, 2000). Plug seed-

Table 3. Effects of tuber size for plug seedling production on the number of tubers per plant, and average tuber weight, and tuber yield at 90 days after transplanting plug seedlings.

Tuber size (g/tuber)	No. of tubers/plant			Tuber weight (g)	Tuber yield (t/ha)		
	>80 g	<80 g	Total		>80 g	<80 g	Total
10	2.48	1.15	3.62	62.9	11.5	9.0	20.5
20	2.50	1.24	3.74	66.7	12.5	9.4	21.9
30	2.53	1.33	3.86	71.0	13.3	11.4	22.0
40	2.75	1.28	4.02	72.7	17.7	8.6	23.3
50	3.04a[†]	1.67a	4.72a	72.8a	18.8a	7.7a	23.6a
Seed potato[‡]	2.55a	1.33a	3.88b	68.9a	15.5b	8.5a	21.3a
Response[§]	L*	L**	L**	L***	L***	Q**Qu*	L**

*, **, ***Significant at the 0.05, 0.01, and 0.001 probability levels, respectively.
[†]Means followed by the same letter within a column were not significantly different at the 0.05 probability level.
[‡]Common seed potatoes weighing 50 g were directly planted.
[§]L, linear; Q, quadratic; Qu, quartic. Regression equations relating tuber size are presented in Table 4.

Table 4. Regression equations with coefficients of determination relating tuber size to various traits of 15 day-old plug seedlings and agronomic traits of potatoes at 90 days after transplanting the plug seedlings.

Variable	Regression equation	r^2 or R^2
	Plug seedling	
Plant height	$Y=25.126-0.108X$	0.923
No. of shoots/plant	$Y=2.013-0.006X+0.0007X^2$	0.993
Stem diameter	$Y=1.593+0.538X-0.0357X^2+0.001X^3-0.00001X^4$	1.000
Root fresh weight	$Y=0.060+0.179X$	0.975
Leaf fresh weight	$Y=3.344+0.058X$	0.962
Stem fresh weight	$Y=5.219-0.354X+0.0173X^2-0.0002X^3$	0.970
Root + top fresh weigh	$Y=12.339-0.633X+0.0367X^2-0.0004X^3$	0.999
	At 90 days after tansplanting the plug seedlings	
>80 g tubers/plant	$Y=2.246+0.014X$	0.832
<80 g tubers/plant	$Y=1.006+0.011X$	0.728
Total tubers/plant	$Y=3.252+0.025X$	0.822
Average tuber weight	$Y=61.457+0.257X$	0.900
>80 g tuber yield	$Y=8.831+0.198X$	0.911
<80 g tuber yield	$Y=30.114-4.198X+0.2696X^2-0.0067X^3+0.00006X^4$	1.000
Total tuber yield	$Y=19.966+0.076X$	0.926

lings raised from 50 g tubers produced 22% more tubers per plant than the directly planted potatoes probably because plug seedlings had already established root and shoot systems at transplanting. However, potato plug seedlings raised from stem cutting produced much less tubers per plant than seed tubers at 90 days after transplanting plug seedlings (Park *et al.*, 1999; Song *et al.*, 1999).

Average tuber weight linearly increased from 62.9 to 72.8 g/tuber with seed tuber size. Kim *et al.* (1998), however, reported that average tuber weight increased up to 10 g tubers and thereafter leveled off. There was no significant difference for average tuber weight between the transplanted and directly planted potatoes.

Yields of >80 g tubers and total tubers linearly increased from 11.5 to 18.8 and 20.5 to 23.6 t/ha, respectively, with increase in the size of seed tubers, which was similar to previous research (Kim *et al.*, 1998). Yield of <80 g tubers ranged from 7.7 to 11.4 t/ha and considerably increased up to 30 g of seed tubers and thereafter dramatically decreased with seed size. It has been reported that there is a direct correlation between total yield and the size of seed tubers directly planted (Burton, 1989).

Transplanted seedlings produced 21% more >80 g tubers than directly planted potatoes. For yield of <80 g tubers and total tubers, there was no significant difference between transplanted and directly planted potato crops with the same seed tuber size. Potato plug seedlings raised from stem cutting had similar total tuber yield to seed tubers but had higher >80 g tuber yield than seed potatoes (Park *et al.*, 1999; Song *et al.*, 1999).

In conclusion, plug seedlings raised from 10 g tubers had only 4% less total tuber yield than 50 g tubers planted

directly in field, indicating that smaller mini-tubers produced by hydroponics can be used for high-grade seed potato production if plug seedlings are transplanted.

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