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Tuber Yield and Size Distribution of Potato 'Dejima' (*Solanum tuberosum* L.) Affected by Stem Cutting Ages and Harvest Time in Aeroponics

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Abstract. This study was carried out to investigate the effects of stem cutting ages and harvest time on the growth and yield of potato 'Dejima' in aeroponics. The stem cuttings were produced from *in vitro* plantlets and transplanted into an aeroponic system with 20, 30, 40 and 50 day-old stem cuttings (DOS). Tubers were harvested 60, 70, 80 and 90 days after transplanting (DAT) and sorted into following categories: 1~5, 5~10, 10~20, 20~30, 30~40 and over 40 g. Plant height from the 40 DOS was the highest during the growing periods but no significant difference was observed on 75 DAT. The tuber weight increased until 90 DAT with the greatest weight of tubers in the 20 and 40 DOS. However, there was no significant difference among 20, 30 and 40 DOS in the number and weight of tubers. Harvesting at 80 and 90 DAT increased the number of tubers over 5 g, which are usually considered as appropriate for direct field planting.

Key words : basic seed, growing period, physiological age, seed potato, stem cutting

Introduction

Basic seed production of potato in Korea has been usually accomplished by aeroponics of potato stem cuttings or plantlets derived from either tissue culture or sprouting. Aeroponics has been adopted worldwide to produce seed potatoes of various cultivars such as 'Superior' (Kang et. al., 1996; Kim et.al., 1999), 'Irish Cobbler' (Kang et. al., 1996), 'Zorba' (Farran and Mingo-Castel, 2006) and 'Nagora' (Ritter et. al., 2001). In the southern part of Korea, seed potatoes of 'Dejima' have been produced via aeroponics.

Plant materials for aeroponics vary, including sprouting, *in vitro* plantlet, and stem cutting. Using sproutings or *in vitro* plantlets directly for aeroponics had to be avoided be avoided due to the difficulty in obtaining large number of transplants at once (Kang et. al., 2006). Stem cutting is relatively easy method to produce large number of transplants, reducing production cost and effort. Therefore, stem cutting method is widely used in aeroponics and various ways to produce stem cuttings were examined in 'Dejima' (Kang et. al., 2006). However, the methods for the stem cutting were mainly focused on fitting transplants to proper quality, not on its physiological state. Besides, to our knowledge, there is no report to investigate the effect of physiological age of stem cuttings.

'Dejima' has been usually harvested 90 DAT in aeroponics and plants grown in aeroponics for relatively long period can be susceptible to disease infection and lenticel enlargement and have a large variation in tuber size (Chang et. al., 2005; Kang et. al., 1996; Wurr et. al., 1993). The optimum harvest time in aeroponics was examined well and determined in 'Superior' (Chang et. al., 2005) but not in 'Dejima' which needs relatively long growing season.

Therefore, this study was conducted to investigate the optimum physiological age of stem cuttings and proper harvest time in 'Dejima' grown in aeroponics.

Materials and Methods

Experiments were conducted in spring 2007 at the plastic film greenhouse of Namhae Sub-station of Na-

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Table 1. Composition of nutrient solution (Chang et al., 2000) used in the culture of stem cuttings of potato plants 'Dejima'.

Fertilizers	Concentration (mg/L)	Fertilizers	Concentration (mg/L)
KNO_3	379	$MnSO_4 \cdot 4H_2O$	2.02
$Ca(NO_3)_2 \cdot 4H_2O$	325	H_3BO_3	2.86
$NH_4H_2PO_4$	80	$ZnSO_4 \cdot 7H_2O$	0.22
$MgSO_4 \cdot 7H_2O$	215	$CuSO_4 \cdot 5H_2O$	0.08
Fe-EDTA	23	$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$	0.02

tional Horticultural Research Institute (NHRI) in Gyeongsangnam-do, Southern part of Korea (34° 50' N). Stem cuttings of potato 'Dejima' (*Solanum tuberosum* L.) were obtained from *in vitro* plantlets through replicated node culture on standard MS medium. A 5-7cm piece of stem was cut from the *in vitro* plantlets and the bottom leaves were removed, leaving 3 leaves at the top. The stem cuttings were then planted in perforated plastic drain box (32.0×41.5×7.5 cm) filled with perlite (Parat, Kyungdong-ceratech. Co., Korea) and 1L of half strength nutrient solution (Chang et al., 2000) was applied at two and three-days intervals (Table 1). The cutting procedures were replicated four times at 10-days intervals and stem cuttings were maintained in a tissue culture room under 16 h light and 8 h dark cycles at 18±1°C. Twenty, 30, 40 and 50 DOS with roots were transplanted into aeroponic system (Kang et. al., 1996) and grown with the potato nutrient solution. Electrical conductivity (EC) and pH were maintained at 1.0±0.2 $dS \cdot m^{-1}$ and 6.0±0.5, respectively. Experimental design was a completely randomized block and each block contained 12 plants. Experiments were replicated three times. Tubers were harvested at 60, 70, 80 and 90 DAT and sorted into following categories: 1~5, 5~10, 10~20, 20~30, 30~40 and over 40 g. Plant heights were measured at the time of transplanting and 30, 45, 60 and 75 DAT. Tuber number and weight were investigated on 60, 70, 80 and 90 DAT.

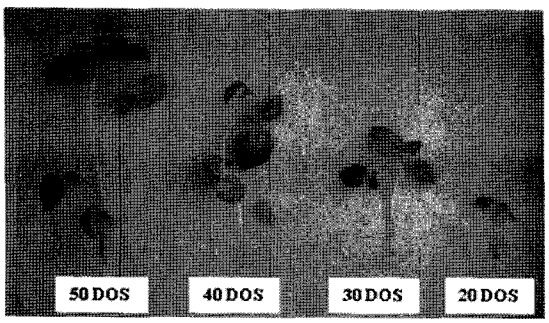

Fig. 1. Stem cuttings as influenced by physiological age. DOS means days-old stem cuttings. Picture was taken at the time of transplanting.

Results and Discussion

Plant height was significantly affected by physiological age of the stem cuttings (Fig. 1). The height of stem cuttings increased as the stem cutting age increased but there was no significant difference between 40 and 50 DOS at the day of transplanting (Fig. 2). Similar patterns were observed in the fresh weights of stem cuttings and its roots (Fig. 1).

All stem cuttings grew vigorously especially between 30 and 45 DAT and then the rate of growth stagnated after 60 DAT (Fig. 2). Plant heights of 40 and 50 DOS were higher than those of 20 and 30 DOS at the day of

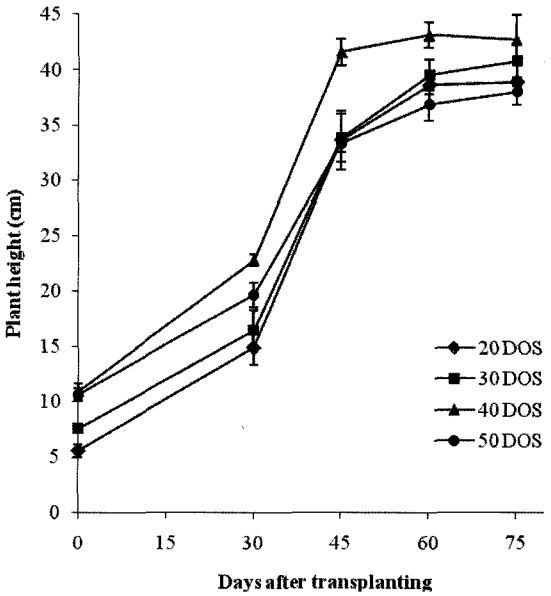

Fig. 2. Time course of plant height from the 20, 30, 40 and 50 days-old stem cuttings (DOS) of potato 'Dejima' grown in aeroponics. Vertical bars indicate standard errors of means.

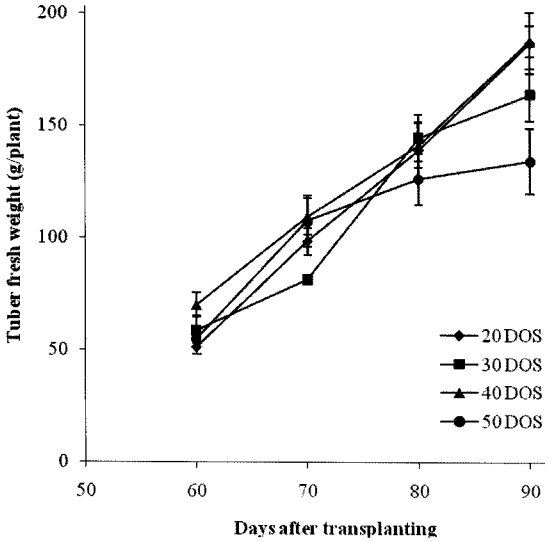

Fig. 3. Time course of fresh weight of tubers produced from 20, 30, 40 and 50 days-old stem cuttings (DOS) of potato 'Dejima' in aeroponics. Vertical bars indicate standard errors of means.

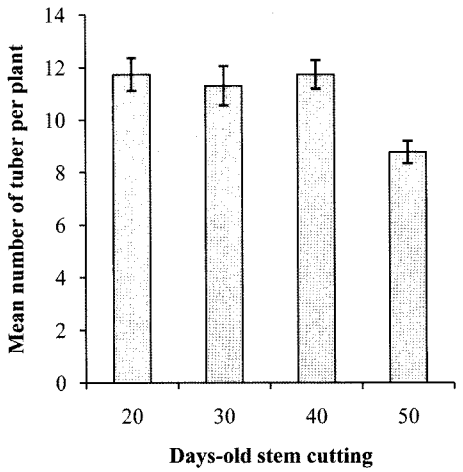

Fig. 4. Effects of stem cutting ages on the number of tubers in potato 'Dejima' grown in aeroponics. Data were collected at 90 days after transplanting. Vertical bars indicate standard errors of means.

transplanting but this difference was diminished by degree. Plant height of 40 DOS was the highest during the growing period in spite of its advanced physiological age, but that of 50 DOS was lowest compared to others after 45 DAT. However, this difference was not significant (Fig. 2). These results indicate that physiological age of stem cuttings has no significant effect on the vegetative growth of potato plants in aeroponics.

Tuber fresh weight of 20, 30 and 40 DOS increased linearly after tuberazation (Fig. 3). However, the quadratic curve was observed in the fresh weight of 50 DOS. The fact that tuber fresh weight of 40 DOS was highest and that of 20 DOS was lowest at 60 DAT indicates that advanced physiological age of stem cuttings has a positive effect on the tuber production in early growth stage. However, as the growing period lengthened, the effect of physiological age on the tuber yield decreased and after 80 days, no difference was observed among the 20, 30 and 40 DOS. Interestingly, tuber yield of 40 DOS was high but that of 50 DOS was low at all harvests, which may be due to the shift from vegetative to reproductive growth during the culture of stem cuttings in 50 DOS. Tuber formation of 50 DOS at the day of transplanting supports this presumption.

Tuber formation was observed in about 20~30% of 50 DOS investigated before transplanting. The number of tubers produced was also affected by the physiological age of stem cuttings (Fig. 4). Significant decrease was observed in the 50 DOS compared to others. The number of tubers was about 25% lower in 50 DOS than in the other stem cuttings. The decrease in the number of tubers in 50 DOS can be attributed to the developmental stage shifting to reproductive growth in older stem cuttings before transplanting. The transplants from 50 DOS with tubers seem to return to vegetative growth after transplanting, which showed normal growth pattern in aeroponics (Fig. 2) and then resumed tuberization, resulting in irregular tuber formation, one of symptoms of secondary growth (Fig. 5).

We cannot find any comparable study about physiological age of stem cuttings in potato but in other fruit vegetables, near relatives of potato. Seedling age did not significantly affect the plant height of tomato (Lee and Kim, 1999) and advanced seedling age increased the yield of tomato in the early stage (Choi et. al., 2002a) but not in the late stage (Choi et. al., 2002b; Kemble et. al., 1994). Although it is difficult to compare the results of tomato with that of potato due to different developmental mechanism lain between fruit and tuber, it is presumable that yield of fruit or tuber can be possibly affected by physiological age of either seedling or stem cutting, respectively.

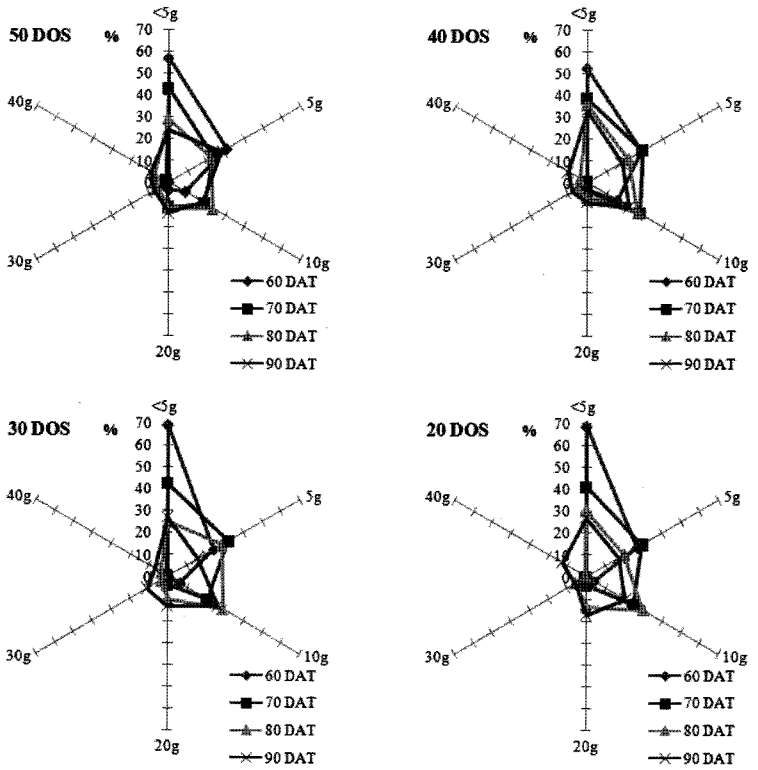

Fig. 5. Polygonal plots illustrating the effect of stem cutting age and harvesting date on the tuber size distributions of potato 'Dejima' grown in aeroponics. The axes represent the percentage of the mean number of tubers ranging from 0 to 70% for each of 6 tuber weight classes.

Early harvest increased the number of small tubers (less than 5 g) but the harvest at 80 and 90 DAT decreased that of small tubers in 20, 30, and 40 DOS, shifting smaller tuber size to larger one (Fig. 5). About 70% of tubers harvested were less than 5 g at 60 DAT while about 30% of tubers were less than 5 g at 80 and 90 DAT. The percentage of the number of tubers over 5 g, which are considered as appropriate for direct sowing (Kim et. al., 1999b), remained relatively constant after 80 days of planting (Fig. 5). Chang et. al. (2005) reported that harvesting tubers at 70 and 80 DAT increased the number of tuber weighing 5 to 30 g in aeroponically grown potato 'superior'. In this study, however, harvesting dates producing tuber over 5g were at 80 and 90 DAT and this difference is thought to be due to the growth habit of 'Dejima', which need longer growing season than 'Superior'. Considering the results, 20 DOS was determined to be an appropriate plant material for transplanting into aeroponics since it need shorter production period than 30 and 40 DOS. The early harvest of potato 'Dejima' in aeroponics could be possible at 80 and 90 DAT.

Literature cited

1. Chang, D.C., S.Y. Kim, K.Y. Shin, Y.R. Cho, and Y.B. Lee. 2000. Development of a nutrient solution for potato (*Solanum tuberosum* L.) seed tuber production in a closed hydroponic system. Kor. J. Hort. Sci. Technol. 18:334-341.
2. Chang, D.C., J.C. Jeong, Y.H. Yun, C.S. Park, S.Y. Kim, and Y.B. Lee. 2005. Tuber number, size, and quality of 'Superior' potato (*Solanum tuberosum*) grown in hydroponics as affected by harvest time. J. Kor. Soc. Hort. Sci. 46:21-25.
3. Choi, Y.H., J.L. Cho, H.C. Lee, D.K. Park, J.K. Kwon, and J.H. Lee. 2002a. Transplant quality and the yield of 'Momotaro-Yoku' tomato as affected by seedling age and container size used for rasing seedling in summer. J Bio-Environment Control 11:12-17.

4. Choi, Y.H., J.L. Cho, H.C. Lee, J.K. Kwon, J.H. Lee, and D.K. Park. 2002. Effect of seedling age on growth and yield of tomato and cucumber in forced culture. J. Kor. Soc. Hort. Sci. 43:681-685.
5. Farran, I. and A. M. Ningo-Castel. 2006. Potato mini-tuber production using aeroponics: Effect of plant density and harvesting intervals. Amer. J. Potato Res. 83:47-53.
6. Kang, H.S., K.H. Hyun, H.G. Lee, and Y.K. Kang. 2006. Effects of transplant raising method on growth and tuber yield of potato grown in aeroponics system. Kor. J. Hort. Sci. Technol. 24:32-36.
7. Kang, J.G., S.Y. Kim, H.J. Kim, Y.H. Om, and J.K. Kim. 1996. Growth and tuberization of potato (*Solanum tuberosum* L.) cultivars in aeroponics, deep flow technique and nutrient film technique culture systems. J. Kor. Soc. Hort. Sci. 37:24-27.
8. Kemble, J.M., J.M. Davis, R.G. Gardner, and D.C. Sanders. 1994. Spacing, root cell volume, age affect production and economics of compact-growth-habit tomatoes. HortScience 29:1460-1464.
9. Kim, H.S., E.M. Lee, M.A. Lee, I.S. Woo, C.S. Moon, Y.B. Lee, and S.Y. Kim. 1999. Production of high quality potato plantlets by autotrophic culture for aeroponics systems. J. Kor. Soc. Hort. Sci. 40:26-30.
10. Kim, K.T., S.B. Kim, S.B. Ko, K.H. Kim, and S.K. Jeong. 1999. Increase in field growth and yield characteristics of mini-tubers of potato (*Solanum tuberosum* L.) produced by hydroponics. RDA J. Hort. Sci. 40:140-144.
11. Lee, J.W. and K.Y. Kim. 1999. Effects of seedling age and transplanting depth on growth and yield of tomato. J. Kor. Soc. Hort. Sci. 40:412-415.
12. Ritter, E., B.Angulo, P. Riga, C. Herran, J. Relloso, and M. San Jose. 2001. Comparison of hydroponic and aeroponic cultivations systems for the production of potato minitubers. Potato Res. 44:127-135.
13. Wurr, D.C.E., J.R. Fellows, J.R. Lynn, and F.J. Allen. 1993. The impact of some agronomic factors on the variability of potato tuber size distribution. Potato Res. 36:237-245.

경삽묘 연령과 수확시기가 분무경재배 씨감자 '대지'의 생육과 수량에 미치는 영향

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적 요. 본 연구는 경삽묘의 생리적 서령과 분무재배시 수확시기가 감자 '대지' 품종의 생육과 수량에 미치는 영향을 조사하기 위하여 실시되었다. 경삽묘는 조직배양묘를 삽목하여 생산하였고 삽목 후 20, 30, 40, 50일된 경삽묘를 분무재배에 이용하였다. 분무재배시 정식 후 60, 70, 80, 90일에 각각 괴경을 수확하였고 수확한 괴경은 1~5, 5~10, 10~20, 20~30, 30~40, 40g 이상의 크기로 분류하였다. 삽목한 후 40일이 경과된 경삽묘의 평균 초장이 전생육기간에 걸쳐 가장 길었지만 정식 후 75일에는 모든 연령의 경삽묘 간의 초장에 대한 유의차는 없었다. 주당 괴경중은 정식 후 90일까지 꾸준히 증가하였으며 삽목 후 20일과 40일된 경삽묘를 정식할 때 가장 무거웠고 주당 괴경수도 가장 많았다. 그러나 50일된 경삽묘를 제외하고 20, 30, 40일된 경삽묘 간에 통계적으로 유의한 차이는 없었다. 정식 후 80일과 90일에 수확하는 것이 5g 이상의 괴경 수확을 증가시키는 것으로 나타났다.

주제어 : 경삽, 기본종, 생리적서령, 생육기간, 씨감자