Comparison of growth and yield among field-grown potato plants from microtubers of different weight classes

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Abstract

Although the potato microtuber production procedure is well know, there are few studies about the effect of microtuber size on the growth and yield of field-grown potato plants. This study compared the shoot and tuber growth of field-grown potato plants from microtubers of different weight classes. The experiment was carried out at the Hokkaido University, Sapporo, Japan, using microtubers of four weight classes (SS: 0.3-0.5 g; S: 0.5-1.0 g; M: 1.0-3.0 g and L: 3.0-5.0 g) of a late maturity cultivar Norin 1. The microtubers were planted by hand on the beginning of May, 1998 in a completely randomized block design with three replications. Plants were sampled at four growth stage and at harvest. No difference in the days from planting to emergence among the microtuber classes was observed, but, the percentage of emergence and days from emergence to flowering was greater in the heavier microtubers. At the initial growth stage, root and tuber dry weight and leaf area index were smaller for the lighter microtuber class, but as the growing season advanced, these differences disappeared. No difference in the number of tubers, fresh and dry tuber yields was observed among the microtuber classes, suggesting that microtubers could be used as seed tubers in countries where is difficult to produce healthy tubers in the field.

Key words: Leaf area index, *Solanum tuberosum*, tuber growth, tuber seed.

Introduction

Potato microtubers (MT) have long been studied and its production procedure is well documented (GODWIN and ADISARWANTO, 1980; UYEN and ZAAG, 1985; BRYAN, 1988; STRUIK and LOMMEN, 1990; ZAAG, 1990). Since MT are produced in vitro, countries with adverse environment conditions for field potato seed production, like Brazil, could be self-sufficient in potato seed production if MT were adopted in their potato seed program.

At present, however, potato MT use is restricted to production of basic potato seed stocks in potato seed production programs across several countries (Jones, 1988). One of the causes linked to the low utilization of MT as potato seed by the growers in field cultivation, is the high production cost of the MT (Zaag, 1990).

There are studies comparing the growth and yield of field-grown potato plants from conventional seed tubers and MT (e.g., KAWAKAMI et al., 2003); study about the effect of cultivar maturity period (KAWAKAMI et al., 2004); study about the effect of planting date (KAWAKAMI et al., 2005); study about the effect of water stress (KAWAKAMI et al., 2006) on the growth and yield of MT plants, but there are few studies about the effect of potato MT size on the field performance of potato plants originated from them.

Generally large MT took more time to be produced, raising then the production costs. The production of small MT (lower than 0.1 g) is cheaper than large MT, however, small MT are known to have a poor growth in the field (HAVERKORT et al., 1991; LOMMEN and STRUIK, 1994). So, it is important to investigate the minimum size of microtubers that can achieve a reasonable growth and yield in field conditions.

The present study compared the shoot and tuber growth of field-grown potato plants from MT of different weight classes.

Materials and Methods

The experiment was conducted at the Experimental Farm, Faculty of Agriculture, Hokkaido University (43° 04' N, a Brown Lowland silty loam soil). Microtubers of four different weight classes (SS: 0.3-0.5 g; S: 0.5-1.0 g; M: 1.0-3.0 g and L: 3.0-5.0 g) of cultivar Norin 1 (late maturity) produced in a private company (Kirin Brewery CO., LTD.) were planted by hand on May 7th, 1998. All MT classes were planted at a depth of about 3 cm and planting distance of 75 cm between rows and 25 cm between hills. Fertilizer was given in accordance of the usual

rate given by the potato growers of the region in a proportion of 70, 110, 90 and 30 kg ha^{-1} of N, P_2O_5, K_2O and MgO, respectively. The experimental design was the completely randomized block design with three replications.

Emergence, number of days to 70% of emergence (emergence) and days from emergence to 70% of flowering (flowering) were recorded three times a week. Number of days from emergence to 70% of leaf yellowing (growth period) was also recorded.

Plants from all MT classes were sampled at four stages: 22, 36, 58 and 77 days after emergence (DAE) with the exception of the lightest MT (SS) which was sampled just at 77 DAE. The number of tubers was recorded and the dry weight (DW) was measured after ovendrying at 70° C for 72 hrs. Leaf area index (LAI), and mother tuber (until 58 DAE), root (at 22 DAE), stem, leaf and tuber DW were measured for four plants of each replication. Total number of tubers and its fresh and dry tuber yield were recorded after leaf yellowing for 10 plants of each replication.

Daily total rainfall and radiation, and average temperature data were taken from the agro-meteorological station of the Experimental Farm, Hokkaido University.

Analysis of variance (ANOVA) was performed and when it was significant, a test of comparison among treatment means (Tukey, 5%) was carried out. Regression analysis was done to fit the best line and its significance was calculated. In the presentation of the data with figures, only standard error of the mean (SE) was presented.

Results and Discussion

The year of 1998 presented a normal average monthly temperature with mild average temperature during the summer (June, July and August). The total radiation did not vary from the average values. On August and October a slight drought was observed, whereas on September the rainfall was 50% higher compared with the average values (Table 1).

No significant difference in the days from planting to emergence among the MT weight classes was observed (Table 2). Percentage of emergence and days from emergence to flowering, however, were significantly greater in the heavier MT. Probably, this fact was caused by the more delicate sprout and the high proportion of tubers reserves necessary to cause emergence in lighter MT. Similar result was observed by Lommen & Struik (1994).

At 22 DAE, root DW was lowest for MT from the lightest weight class. A significant positive correlation between root DW and mother tuber DW of MT classes at early growth stage (22 DAE) was observed (Figure 1). Plants from the lightest

Table 1. Climatic features during the potato growing season in 1998, Sapporo, Japan.

Month	Mean Temperature °C		Total Radiation MJm^{-2}		Total Rainfall mm	
	1998	Aver.[1)]	1998	Aver.	1998	Aver.
May	13,0	12,0	550	546	56	55
June	15,2	16,1	499	555	80	66
July	19,9	20,2	468	533	73	69
August	20,7	21,7	373	474	90	142
September	18,7	17,2	362	381	210	138
October	12,7	10,8	283	291	74	116

1) Average values are calculated based on the data from 1961 to 1990.

Table 2. Percentage of emergence, days from planting to emergence and days from emergence to flowering of potato plants from microtubers of four different weight classes, Sapporo, Japan, 1998.

Microtubers Size	Percentage of Emergence	Days to Emergence	Days to Flowering
SS [1]	83 [2] b [3]	19	43 a
S	89 ab	19	43 ab
M	88 ab	19	40 b
L	97 a	19	33 c
ANOVA	* [4]	ns	**

1) SS: 0.3-0.5 g, S: 0.5-1.0 g, M: 1.0-3.0 g and L: 3.0-5.0 g.

2) Calculation made after data transformation to arc sine (x/100)-0,5.

3) The same letter in each column are not singificantly different at Tukey Test (P<0.05).

*4) *: significant at P<0.01 and 0.05, respectively; ns: not*

MT had the lowest initial increase of LAI. Until 36 DAE, the smaller the MT size, the lower the initial LAI increase was. Thereafter, the difference in LAI between plants from MT of different weight classes was not observed (Figure 2). We can speculate that the initial slower LAI increase in the plants from the lightest MT was due to the relatively smaller root system of these plants (Figure 1). These results is supported by the findings of Lommen (1994) who claimed that in the plants from lighter tubers the root system had to provide water and nutrients to relatively larger shoot (higher shoot: root ratio).

The patterns of increase in tuber DW showed a similar trend observed in increase in LAI. Figure 3 shows that at early growing stage the increase in tuber DW was greater for plants from the heavier MT, but at later growth stage, the difference in tuber DW among the MT classes was no more evident. The

Figure 1. Relationship between root dry weight (DW) and mother tuber DW of potato plants from microtubers of different weight classes at early growth stage (22 days after emergence), Sapporo, Japan, 1998.

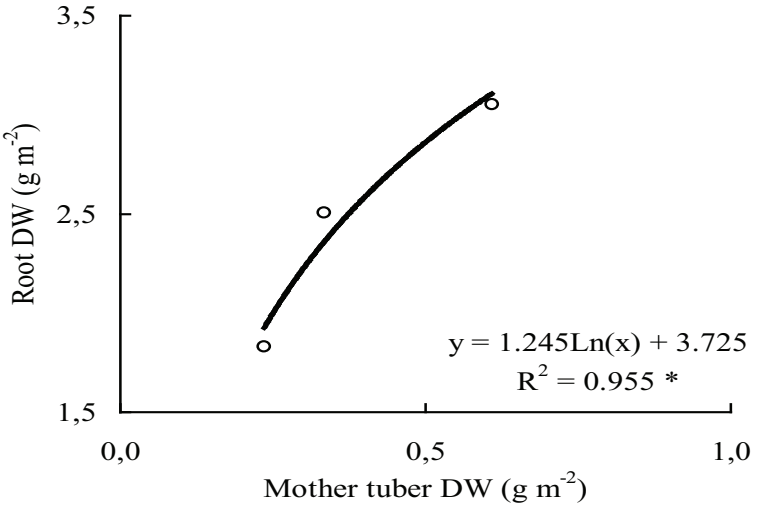
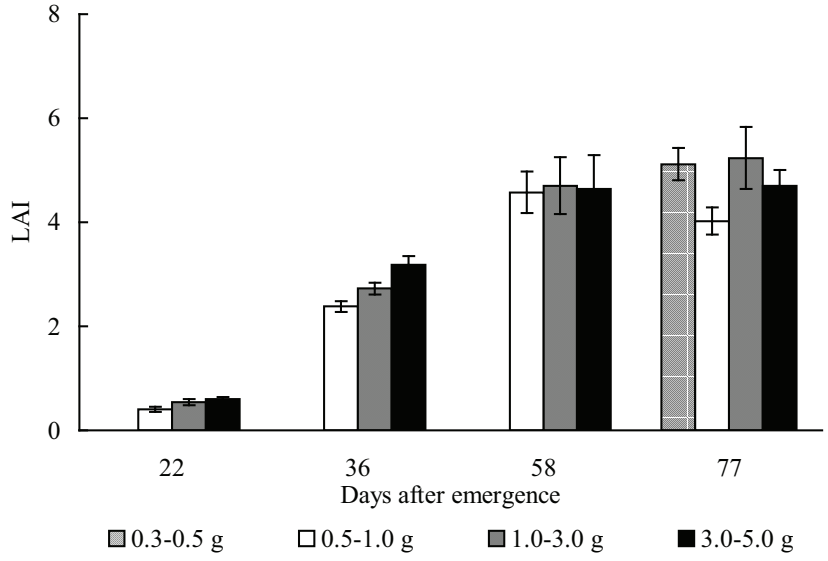


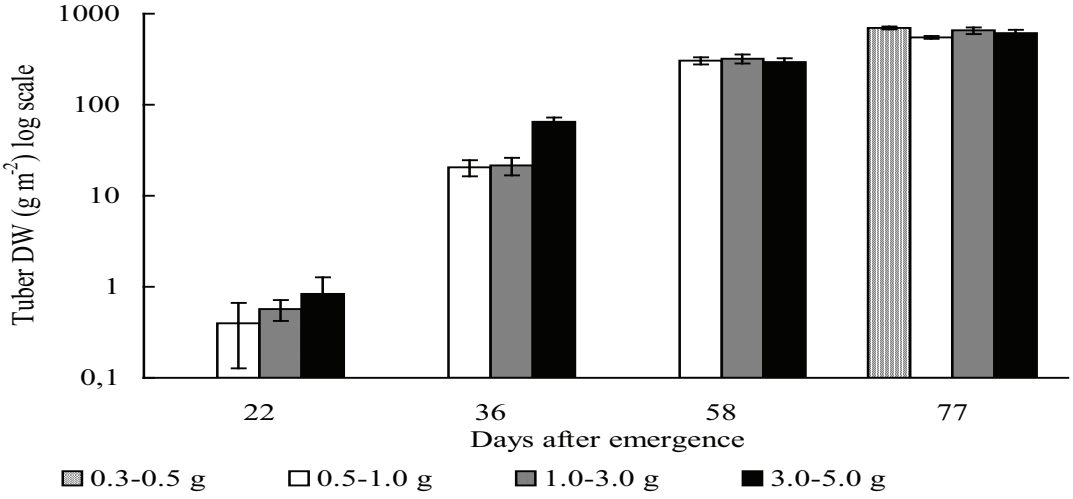
Figure 2. Comparison of leaf area index (LAI) among potato plants from different microtubers weight classes, at four growth stages, Sapporo, Japan, 1998.



Vertical bars are the standard error of the mean (SE, n=12).

plants from larger MT (MT-L) had larger number of tubers than the others MT at 36 DAE (data not shown). This result corroborates with the findings of Kawakami et al. (2003) who found that plants grown from heavier tubers had higher allocation of DW to the tubers at early growth stage compared with plants grown from lighter tubers. Lommen (1999), however, found that plants from lighter MT started to allocate dry matter to the tubers early in the growing season. Transplanting the plants to the field could have influenced the rate of allocation of dry matter to the tubers in the Lommen's (1999) work, since the pre-transplanting environment (glasshouse) was probably warmer than the field temperature.

Figure 3. Comparison of tuber dry weight (DW) among potato plants from different microtubers weight classes at four growth stages, Sapporo, Japan, 1998.



Vertical bars are the standard error of the mean (SE, n=12).

Table 3. Days from emergence to leaf yellowing (LY), number of tubers, fresh and dry tuber yield of plants from four different microtubers weight classes, Sapporo, Japan, 1998.

Microtuber Size	LY		Number of Tubers	Tuber Fresh	Tuber Dry Yield
	days		m^{-2}	t ha^{-1}	t ha^{-1}
SS [1)]	144	a [2)]	57	71,3	15,1
S	136	b	53	60,1	12,6
M	139	ab	47	68,3	15,1
L	143	a	43	66,0	13,7
ANOVA	* [3)]		ns	ns	ns

1) SS: 0.3-0.5 g, S: 0.5-1.0 g, M: 1.0-3.0 g and L: 3.0-5.0 g.

2) The same letter in each column are not singificantly different at Tukey Test (P<0.05).

*3) *: significant at P<0.05; ns: not significant (P≥0.05).*

Difference in the days from emergence until leaf yellowing (growing period) among the plants from MT of different classes was observed (Table 3). This difference, however, was not correlated with the MT size, since plants from the MT-S had a significantly shorter growing period compared with plants from the lighter (MT-SS) and the heavier (MT-M and MT-L) MT. This result contradict other studies (LECLERC and DONNELLY, 1990; LOMMEN and STRUIK, 1993) which reported that plants from lighter tubers had a longer growing period than those plants from heavier tubers.

No significant difference in the number of tubers, fresh and dry tubers yield was observed among plants from different MT classes. However, plants from the lighter MT tended to have more tubers (P=5.62 %) than heavier MT weight class, corroborating with the finding of WATTIMENA et al. (1983) and RANALLI et al. (1994).

STRUIK and LOMMEN (1990) stated that the use of MT as seed tubers would only be feasible when they were larger than 0.5 g. In our experiment, no significant difference in fresh and dry tuber yield among plants from different MT classes was observed, suggesting that the use of the MT at least heavier than 0.3 g as potato seed under field condition may be a feasible practice.

Conclusion

Potato MT have potential for direct use as seed tuber under field cultivation because of the high yield and great number of marketable tubers. The use of the lighter MT (0.3-0.5 g) is especially hopeful, since it is cheaper and produced faster than the heavier MT and can achieve a high yield. The heavier MT used in our experiment (3.0-5.0 g) may be adopted in the potato seed production system for production of conventional seed tubers, since it can produce a large number of tubers early in the growing season (*i.e.*, 36 DAE), and this characteristic will be desirable to avoid contamination of virus by early harvest.

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