Original Papers Plant Tissue Culture Letters, **10**(3), 255-259 (1993)

Resting Period and the Field Performance of Potato Tubers Propagated in a Jar Fermentor

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(Received March 10, 1993)
(Accepted June 2, 1993)

The resting period and field performance of potato (*Solanum tuberosum* L.) tubers derived from a jar fermentor culture were investigated. About 40% (w/w) of the tubers easily lost more than 40% (w/w) of their weight during the first week after being removed from the jar fermentor and stored under room conditions. Sprouting of such easily wilting tubers was clearly delayed whereas other tubers sprouted within 3 months under the same conditions. When the tubers were transplanted and cultivated under field conditions, a yield decrease was observed with the late sprouting tubers. This suggested that the tubers could be selected according to the decrease in their weight after culture.

Introduction

Since *in vitro* propagated potato (*Solanum tuberosum* L.) tubers are quite small, they are known as "microtubers". However they have sufficient potential for direct transplanting to field conditions without acclimatization. The potential for field cultivation of *in vitro* derived tubers in the field cultivation has been investigated by numerous researchers[1-4] and their results indicate that such tubers can be directly used to commercially produce seed tubers. Thus, *in vitro* derived tubers are valuable for agricultural use because disease free seed plants can be easily transferred, stored and distributed. Culture conditions and techniques for the *in vitro* propagation of tubers have been studied and improved by numerous researchers[3,5-10].

Of special note is the liquid shaken culture for rapid propagation of tubers reported by Estrada *et al.* (1986)[11]. Their method is applicable to large scale culture thereby improving the economic advantages[12]. The present authors scaled up the culture even further to a jar fermentor[13]. Subsequently, the culture technique has undergone continued study and culture efficiency has also improved[14].

On the other hand, there is little information concerning the dormancy and field performance of the jar fermentor derived tubers, except for a brief description in a patent[14], whereas potent use of the tubers propagated on a small scale have been thoroughly observed. In this report, we investigated the dormancy and field performance of tubers mass propagated by the jar fermentor culture technique.

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Materials and Methods

1. *Plant material*

In vitro virus-free plant of potato (*Solanum tuberosum* L. cv. Yukishiro) was established from an apical meristem and was maintained by serial subculture on solid medium (solidified by gelrite 2 $g l^{-1}$) as shown below. Culture vessels were 25×125 mm test tubes containing 10 ml of the solid medium. A single nodal segment of a plant was transplanted into a test tube and cultured every month for maintenance.

2. *Culture medium and culture conditions*

Culture medium consisted of MS mineral salts plus organic constituents including thiamine-HCl (0.4 mg l^{-1}), myo-inositol (100 mg l^{-1}), pyridoxine-HCl (0.5 mg l^{-1}), nicotinic acid (0.5 mg l^{-1}), glycine (2.0 mg l^{-1}) and sucrose. A sucrose concentration of 30 $g l^{-1}$ was used for the maintenance of the stock plants. 2000 ml of the 30 $g l^{-1}$ sucrose containing liquid medium was used for shoot multiplication in the jar fermentor, and 6000 ml of the 90 $g l^{-1}$ sucrose containing medium was used for the induction and development of tubers. Each medium was sterilized by autoclaving (20 min., 121°C) after the pH was adjusted to 6.2 with NaOH.

The grass jar fermentor (an airlift type, total vessel volume was 8000 ml), culture method and culture conditions were the same as reported in our previous report[15].

3. *Stock of tubers*

The cultured shoots were taken out from the jar fermentor and then the tubers were separated from the shoots. The tubers were thoroughly washed with deionized water and then stocked at 4 °C in sawdust until transplanting.

4. *Field cultivation*

The *in vitro* derived tubers (n=300) were cultivated in a field located in Abashiri city, Hokkaido. 100 kg/10a of chemical fertilizer (N=8%, P=20%, K=14%, Mg=4%) was applied to the field before transplanting as is generally done in this area. Every tuber was planted to approx. 3 cm depth, with a 28×72 cm planting density. Tubers were planted on May 9 and harvested on October 14.

Results and Discussion

1. *Tuber resting period*

Most of the *in vitro* derived tubers showed a clear resting period. When 120 tubers were randomly selected and kept under room conditions (25 °C, RH=60% (approx.)), the mean weight decrease over one week was approx. 36% (w/w). This decrease of tuber weight is thought to be mainly due to their loss of water. **Fig. 1** shows the relationship between the initial tuber weight and the desiccated weight one week after harvesting. Sprouting was not observed within a 3 month period in tubers whose weight had decreased by over 40% (w/w) during the first week.

Fig. 2 clearly shows that there was no relationship between the percentage of weight decrease and the weight of the tubers. This result also suggests that tubers which have longer resting periods lose weight more easily under room conditions than other tubers. This indicates that the late sprouting tubers could be selected within a week of the end of culture. About 40% of the tubers propagated in a jar fermentor were such easily wilting tubers though we could not observe the difference between the easily wilting tubers and others in appearance. For example, tubers which were propagated in the jar fermentor had almost the same dry matter content as the field grown tubers, irrespective of the size and the location in which they were formed in the jar fermentor[15]. Because

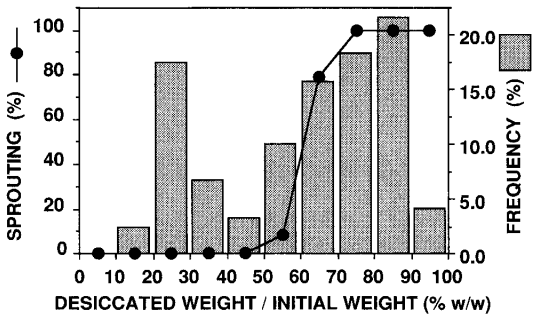

Fig. 1 Relationship between the percentage of desiccated weight to the initial weight of *in vitro* derived tubers and the percentage of sprouting over a 3 month period.
Tubers were stored under room conditions (25°C, RH=60% (approx.), continuous dark) for 1 week and measured for weight decrease. Then, all of the tubers were kept under the same conditions. The percentage of sprouting was measured after 3 months.

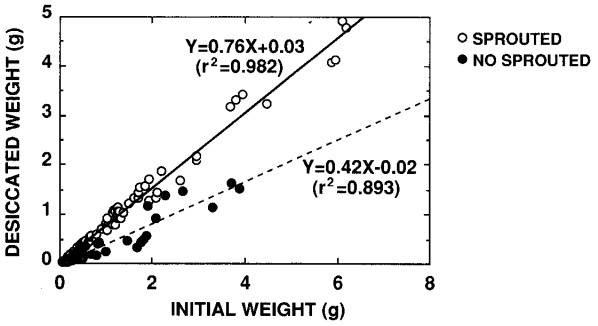

Fig. 2 Relationship between the initial weight of *in vitro* derived tubers and the desiccated weight.
120 tubers were randomly selected and stored under room conditions (25°C, RH=60% (approx.), continuous dark) for one week and then the weight was measured. The closed circles indicate the tubers which had not sprouted over the 3 months.

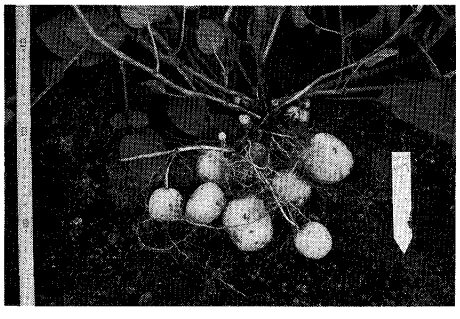

Fig. 3 Growth of plants and the formation of tubers on plants cultivated under field conditions (August, 3. Initial tuber weight was 0.28 g).

tubers with longer resting periods did not always lose the potential to sprout, it is necessary to apply dormancy breaking techniques such as the application of chemicals (*e. g.* ethylene chlorhydin, thiourea) in the future[16]. Further study is also required to avoid the development of easily wilting tubers because such tubers not only have delayed sprouting but also might require special treatment for storage and breaking out of dormancy.

2. *Field performance of the tuber*

Tubers which were propagated in the jar fermentor could be directly transplanted to the field.

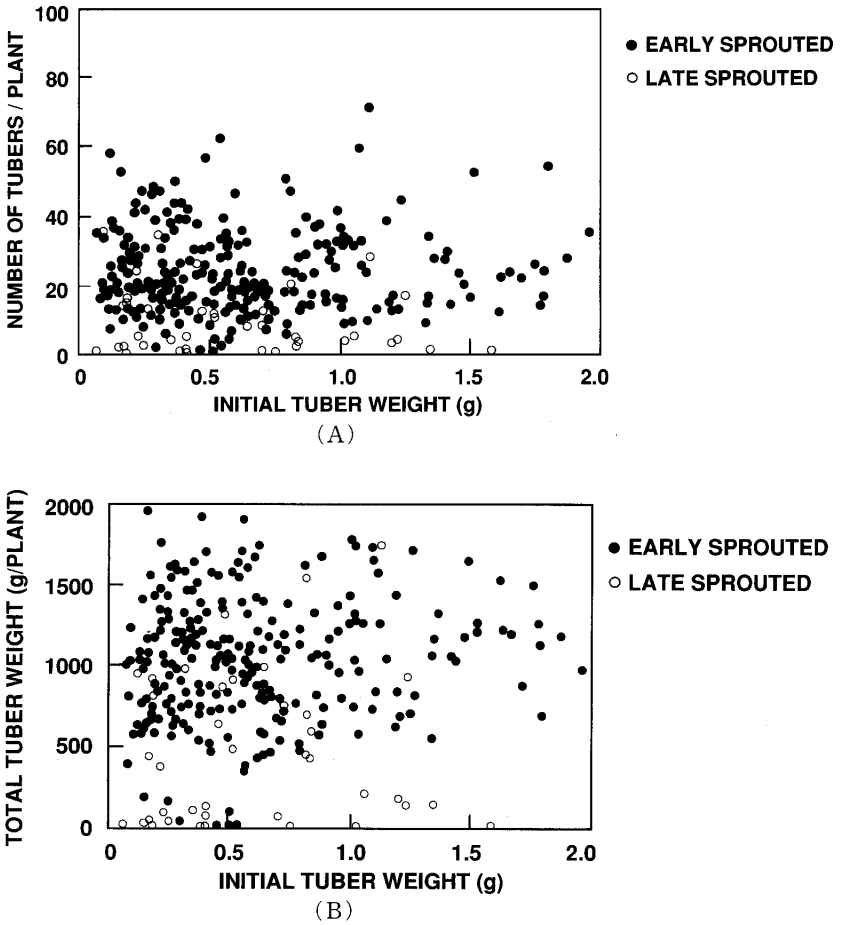

Fig. 4 Relationship between the initial weight of tubers and the tuber yield under field conditions.
(A) total number of tubers per a plant, (B) total weight of tubers per a plant. The open circles indicate plants which did not sprout during 1 month of field cultivation.

After 3 months storage under 4 °C and transplanting, almost all of the tubers sprouted within 1 month. Mutated plants were not observed.

Yields from the tubers are shown in **Fig. 4**. Though most of the tubers weighed less than 0. 2 g, the yield potential of such small tubers is not different from that of tubers which weighed up to 1 g. When the acclimatized shoots of the same cultivar were transplanted to the field, the yield potential did not differ between the tuber derived plants (data not shown). Thus, the major factor affecting the yield may not be related to the size of the tubers but to the conditions after sprouting. However, it should be noted that the late sprouting plants tended to have less yield than others, especially regarding the total weight of the tubers. This means that the yield can be improved by preventing the delay of sprouting, though the decrease of the yield was not due entirely to this delay.

In conclusion, tubers derived from a jar fermentor could be directly transplanted and cultivated under field conditions. The yield potential is not related to the tuber weight. Decreases in yield are thought to be partially prevented by synchronizing sprouting. The tubers with longer resting periods could be selected by their loss of weight during the first week after culture.

Acknowledgements

The authors are grateful to Mr. Takehiko Sasaki and Nishi Abashiri Nokyo for their excellent management of the field. The authors are also grateful to Mrs. Kumiko Miyamoto and Ms. Sayuri Iijima for their technical assistance.

References

1) Wang, P. J., C. Y. Hu, 1982. American Potato Journal, **59** : 33–37.
2) Wattimena, G., B. McCown, G. Weis, 1983. American Potato Journal, **60** : 27–33.
3) Wang, P. J., C. Y. Hu, 1985. In "Potato physiology" (ed. by Li, P. H.), p. 503–577, Academic Press, Orlando.
4) Powell, W., J. Brown, P. D. S. Caligari, 1989. Ann. Appl. Biol., **115** : 123–128.
5) Forsline, P. L., A. R. Langille, 1976. Canadian Journal of Botany, **54** : 2512–2516.
6) Hussey, G., N. J. Stacey, 1984. Annals of Botany, **53** : 565–578.
7) Miller, S. A., L. Lipschuts, 1984. In "Handbook of cell culture" (eds. by Evans, D. A. *et al.*), Vol. 3, p. 419–456, Macmillan Publishing Co., New York.
8) Chandra, R., J. H. Dodds, P. Tovar, 1988. Newsletter International Association for Plant Tissue Culture, **55** : 10–20.
9) Kwaitkski, S., M. Martin, C. R. Brown, C. J. Sluis, 1988. American Potato Journal, **65** : 369–375.
10) Carigari, P. D. S., W. Powell, 1989. Ann. Appl. Biol., **115** : 115–121.
11) Estrada, R., P. Tovar, J. H. Dodds, 1986. Plant Cell, Tissue and Organ Cult., **7** : 3–10.
12) Levin, R., I. K. Vasil, 1989. Newsletter International Association for Plant Tissue Culture, **59** : 2–12.
13) Akita, M., S. Takayama, 1988. Acta Horticulturae, **230** : 55–61.
14) Onishi, N., K. Hayashida, K. Mamiya, 1991. Process for producing tuber, PCT/JP91/00382 (Patent), Japan.
15) Akita, M., S. Takayama, 1993. Plant Tissue Culture Letters, **10** : 242-248.
16) Hemberg, T., 1985. In "Potato physiology" (ed. by Li, P. H.), p. 354–388, Academic Press, Orlando.

《和文要約》

ジャーファーメンター由来ジャガイモ塊茎の休眠と圃場栽培特性

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ジャーファーメンターを用いて大量培養したジャガイモ塊茎の休眠と圃場における生育および収量を調べた．培養終了後1週間で，約40%以上の重量を失う塊茎では，他と比べ明瞭な萌芽の遅れが見られた．圃場における生産性は，播種した塊茎重量にはあまり関係しなかったが，萌芽の遅れが生産性の低下をもたらす一因となっていた。これらのことから，圃場における生産性の低い塊茎の一部は培養終了後の重量変化によって選別できるものと考えられた．