



A review on potato microtuber storability and dormancy

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Abstract: Potato microtubers plays important role in seed potato production technology as it has great advantage of storage, transport and mechanization due to their little size and reduced weight. Dormancy in potato microtubers is very important and storage conditions as well as size of microtubers influences the dormancy in microtubers. Increasing size of the micro-tuber resulted in significant increase in the viability and sprouting ability of microtubers with reduced durations of dormancy and weight loss at the end of storage. Small microtubers are more vulnerable to storage damage. The larger microtubers lost moisture content more slowly and retained firmness longer when stored at 4°C. Development of dormancy during storage strongly affected by the storage condition especially the temperature regime, the presence of light and the relative humidity. The dormancy duration was linearly and inversely correlated with the length of storage. Storage containers and conditions are also important for microtuber storage. Endogenous hormones ABA, ethylene, cytokinin and gibberellic acid play a significant role in tuber dormancy regulation. Microtubers with thick diameter which have passed more times in dormancy and have better functionality than small microtubers with less time in dormancy. Growth regulators like gibberellic acid, thiourea, gibberellic acid + thiourea, ranitidine and carbon disulphide plays significant role in dormancy breaking of microtubers.

Keywords: Dormancy, Microtuber, Potato, Seed and storability

INTRODUCTION

Potato micro-tubers are intermediary phase between “*in vitro*” plantlets/ microplants and minitubers. Microtubers are developed from tissue culture technology and used for solving the problems of transplanting the plantlets/microplants from “*in vitro*” to “*in vivo*” conditions. The microtubers offer a lot of advantages of storage, transport, exchange of a healthy germplasm and mechanization due to their little size and reduced weight (Kefi *et al.*, 2000; Rosu, 2004; Kanwal *et al.*, 2006). They can be planted directly in the light soil of nethouse and greenhouse to produce minitubers as they have similar morphology and biochemical features with traditional tubers.

Storability of microtuber: *In vitro* microtubers can be alternative propagating materials over microplants in seed potato programme provided higher tuberization rate and proper storage for longer time without considerable loss (Lazányi *et al.*, 1998). The length of the dormancy depended on size of the microtubers: smaller microtubers had longer dormancy periods than larger microtubers (Leclerc *et al.*, 1995 and Ranalli, 1997). Dormancy of minitubers is usually longer than the dormancy of normal seed tubers due to small size (Lommen, 1994). Sprouting and growth vigour of normal seed tubers also depend on seed tuber size and

storage conditions (Burton, 1978; Rastovski and van EsA., 1987; Struik and Wiersema, 1999). Larger sizes gave more vigorous sprouting and higher growth vigour of these sprouts and more weight (Wiersema *et al.*, 1987; Van Ittersum, 1992; Struik and Wiersema, 1999). Small microtubers are more vulnerable to storage damage (Naik and Sarker, 1997).

Storage conditions and containers/ packaging materials have influence on storability of potato microtubers. When three grades (4, 6 and 8 mm) of microtuber of Kufri Chandramukhi stored for 8 months at 4°C in perforated poly bags and then kept for 3.5 months in plastic petriplates, ventilated culture bottles and perforated plastic bags under ambient conditions, non-hermetic and hermetic culture rooms at Shimla, weight loss was higher in 4 mm as compared to 6 and 8 mm. Ventilated culture bottles were found to be better container/ storage material than plastic petriplates and perforated plastic bags. In another experiment at CPRI, Shimla when above three grades of microtubers stored for 8 months at 4°C in perforated poly bags and then kept for 3 months in 5 different packaging material *viz.* plastic bag, butter paper, muslin cloth, brown paper and paper box at ambient temperature. The plastic paper bag and butter bag found to be best packaging material with minimum weight loss for all the grades and varieties (Annual Report-CPRI, 2012).

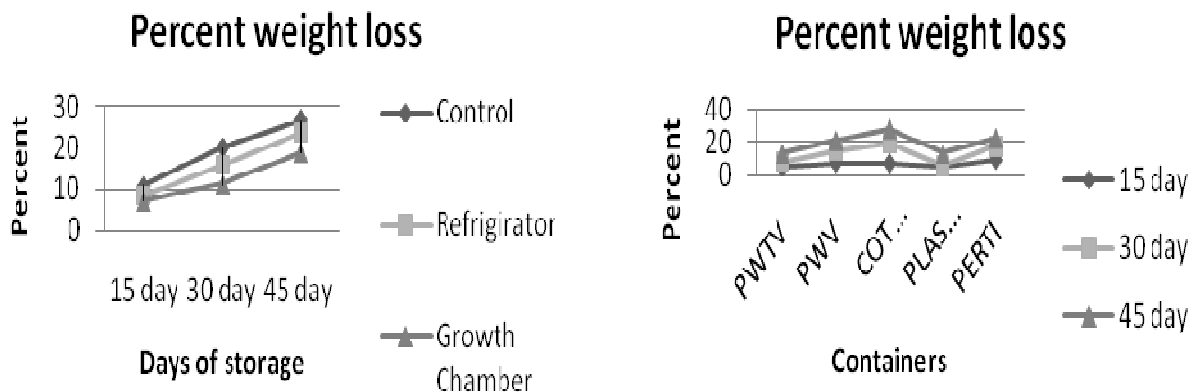
Microtuber weight loss was higher at room temperature (control) followed by refrigerator and growth chamber at 3°C condition (Fig. 1). As far as storage containers are concern, the weight loss was higher in conical flask with cotton plug and least in polythene without ventilation after 45 days of storage at room temperature (Fig. 2). Among varieties, Kufri Chandramukhi recorded higher weight loss followed by Kufri Lauvkar under Gwalior conditions (Annual Report-CPRS, 2012, Annual Report-CPRI, 2012). This confirms the proper storage containers and conditions are important for minimum weight loss and rottage of microtubers. PWTV- Polythene without ventilation, PWV- Polythene with ventilation, COT PLUG- Conical flask with cotton plug, PLASTIC CAP- Conical flask with plastic cap, PETRI- Petriplates.

Size of microtubers can be used as an index for grading their quality as seed potatoes and size should be at least 0.5g to be used as seed potato as larger microtubers lost moisture content more slowly and retained firmness longer when stored at 4°C. In the sprouting test also, the larger ones had less period of dormancy and showed more vigorous sprouting ability (Park *et al.*, 2009). Increasing size of the micro-tuber resulted in a significant increase in the viability and sprouting ability of microtubers with reduced durations of dormancy and weight loss at the end of storage when tested for four grades of microtubers (large, medium, small and micro-tubers with burst lenticels) from six Indian potato cultivars and storage regime: of refrigerated (4°C) conditions for 3 months followed by 2-week storage at 22±2°C and 2-weeks under ambient conditions (about 18°C) (Sharma *et al.*, 2012). Close interactions were recorded between genotype and storage conditions (Van Ittersum and Struik, 1992; Struik *et al.*, 2006) and between seed tuber size and storage conditions (Struik and Wiersema, 1999). Usually, the dormant period was shorter in early cultivars than in later cultivars (Harris, 1992), although this relation was not very strict (Burton, 1968).

Growth conditions during seed production (especially temperature, photoperiod, light intensity, and nitrogen fertilization) and storage condition especially the temperature regime; the presence of light and the relative humidity have a strong impact on development of dormancy in potato (Van Ittersum and Struik, 1992; Struik and Wiersema, 1999). Among three potato cultivar cv Spunta, P-3, DTO-2 and LT-2 stored at three levels of temperature i.e. 1-5 °C. and at various levels of CO₂ concentration showed minimum loss in sprout length and weight except in cv DTO-2, the reduction of sprout length was significant when stored at 30 and 40% CO₂ (Narong, 1988). Sprouting was found to be highly genotype-dependent and was influenced by temperature and storage treatment. Storage in screw-capped bottles with or without GA₃ treatment was also found favorable due to ethylene accumulation which can be used for shortening the lag time from harvest to utilization of microtubers for planting (Paet, 1996).

Dormancy in microtubers: Dormancy of a potato tuber is defined as the physiological state in which autonomous sprout growth will not occur, even when the tuber is placed under conditions for sprout growth (Reust, 1986). Pruski *et al.* (2003) reported that when dormancy of microtubers is not completed, less number of plants is produced. Microtuber dormancy appears to be correlated with field dormancy duration in cultivar specific manner (Leclerc *et al.*, 1995). At harvest, potato tubers are dormant and will not sprout. Endogenous hormones have been posited to plays key role in tuber dormancy regulation. ABA and ethylene are required for dormancy induction but only ABA is needed to maintain bud dormancy. An increase in cytokinin sensitivity and content plays important role in dormancy exit. Changes in endogenous IAA and GA content are more closely related to the regulation of subsequent sprout growth (Suttle, 2004).

Influence of light intensity and storage conditions on microtuber dormancy: The length of tuber dormancy depends on both the genotype and environ-



Figs. 1 and 2 : Weight losses of microtubers in relation to storage conditions and containers.

mental conditions during growth and storage. Tuber formation under cool and wet conditions may extend the dormant period, whereas hot and dry conditions typically shorten dormancy (Burton, 1989). The effects of light intensities depended on the photoperiodic treatments applied for tuber induction. Lower the light intensity longer the dormant period for cultivars and also the dormancy was long and was greatly elongated by low storage temperature (Tábori *et al.*, 2000). The dormancy duration was linearly and inversely correlated with the length of storage. Dormancy decreased from 28.1 to 19.9, 11.1 and 7.8 days with reduced time of storage when microtubers of 13 cultivars were induced and stored in the dark at 3°C for different periods (28, 56, 84 and 105 days), prior to being transferred to 20°C for between 4 and 17 weeks. CvsArsy, Nicola and Jaerla took consistently more time for dormancy release. (Ranalli *et al.*, 1994).

Influence of size of microtubers on dormancy: Size and dormancy of mother microtubers has significant influence on functionality of produced minitubers. Microtubers with thick diameter which have passed more times in dormancy have better functionality than small microtubers with less time in dormancy (Bolandi *et al.*, 2011). After harvest, normal seed tubers show dormancy for about 1–15 weeks, depending on cultivar, tuber size, conditions before harvest and storage conditions. Small tubers, such as minitubers, even have longer periods of dormancy (Lommen, 1993) and are more sensitive to adverse conditions during storage (Struik and Lommen, 1999). Smaller microtubers (≤ 250 mg) had longer dormant periods than did those greater than 250 mg with significant difference in sprouting speed (Leclerc, 1995; Struik and Lommen, 1999). Microtubers with 3 g weight, sprout after 10 days more vigorously with higher sprouting speed than microtubers with 375 and 750 mg (sprout after 15 and 13 days) when tested for six cultivars (Park *et al.*, 2009). The germination percentage was 84%, 86% and 40% in 8 mm, 6 mm and 4 mm grade microtubers respectively after 65 days of storage at ambient conditions in Kufri Lauvkar (Annual Report- CPRI, 2011).

Influence of growth regulators & chemicals on microtuber dormancy: An endogenous plant hormones abscisic acid, cytokinins, gibberellic acid, and ethylene have been implicated in dormancy regulation (Wiltshire and Cobb, 1996, Suttle, 2004). Dormancy is regulated by the relative concentrations of growth promoters and inhibitors. Gibberellins and cytokines are generally considered to be growth promoters, whereas abscisic acid and ethylene are believed to inhibit sprout growth (Sonnwald, 2001). ABA and ethylene are required for dormancy induction but only ABA is needed to maintain bud dormancy. An increase in cytokinin sensitivity and content is the principal factors for dormancy release. Changes in endogenous IAA and GA content are closely related to the regulation of subse-

quent sprout growth (Suttle, 2004).

Dormancy can be removed by setting the store temperature, cutting the tubers, and treating by chemicals. Treating minitubers with chemicals is a safe and confident method. Among the chemicals applied for breaking down the potato nodes dormancy, one can refer to GA₃, thiourea, ethylene, ethyl bromide, and carbon disulphide (Otroshy, and Struik, 2006.). On a commercial scale, Rindite, bromoethane, CS₂, GA₃ and thiourea have been used to break potato tuber dormancy. Exogenous application of thiourea, offers an economical and safe method to break potato minituber dormancy (Hosseini *et al.*, 2011).

Gibberellic acid: GA₃ application efficiently alleviates tubers dormancy (Mosley, 2007). GA₃ application effectively reduced dormancy period and time needed for mini-tubers sprout emergence. However, suitable GA₃ concentration for dormancy soothing of potato minitubers need to be standardized (Hassan-Panah *et al.*, 2007 and Khorshidi-Benam and Hassan-Panah, 2008).

The microtubers treated with GA₃ took 19 days in cultivar 'Desire', while GA₃ and rindite took 31 and 21 days respectively to sprout 50% of the microtubers in cultivars 'Atlantic' and 'Diamont'. The microtubers treated with GA₃ produced thin and elongated sprouts (Rehman *et al.*, 2003). GA₃ application as liquid solutions accelerated eyes growth via sprout emergence and produced more slim accessory shoots (Rehman *et al.*, 2003 and Van Hiele, 1961). Soaking of peeled microtubers treated with 0.1-1.0 mg/l GA₃, 0.1 to 1.0 mg/l IAA and 0.01 to 0.1 mg/l Kinetin for 1 to 25 min and put on water soaked cotton pad containing in petriplates showed >90% sprouting within 7 days while treatment of intact microtuber with GA₃ (0, 5, 10 and 15 mg/l) did not show any significant effect on dormancy breaking (Hossain, 2012). GA₃ application at 160 ppm is the most suitable concentration for dormancy alleviation, acceleration of seedling emergence (Shekari *et al.*, 2010). GA₃ treatment after 2, 3 and 8 week of cold storage of minitubers was found best and most effective dose was 500 mg/l GA₃ in breaking-dormancy and inducing precocious sprouting (Habib, 1999). GA₃ 1500 ppm and 5% thiourea decreases dormancy period from 63 days to 39 days. (Hassan-Panah *et al.*, 2007). GA₃ @30 ppm application is best suitable for dormancy alleviation (Benedetti, 2005) while, 5 ppm GA₃ is appropriate dose for dormancy relief and yield improvement of 'Agria', 'Marfona' and 'Gloria' potatoes (Rehman *et al.*, 2003).

Thiourea: Thiourea is a catalase inhibitor, which triggers potato tubers germination and healing tubers injuries. Thiourea in an appropriate concentrate not only facilitates germination, but also produces more than one sprout in each eyes of potato, so that, thiourea dominates over inhibiting effects of major sprout on minor ones in each eye, and neutralizes terminal buds capacity to stop lower buds growth in seeding tuber.

Using thiourea treatment and/or applying H₂O₂ enable one to remove tubers dormancy (Bajji *et al.*, 2007).

Thiourea 1% breaks dormancy, accelerated plants emergence, increased tuber number per plant, and leading to maximum yield in potato minitubers of Marfona cultivar (Germchi *et al.*, 2011). Thiourea solution with 1% concentration for 1 hour in 25°C through sinking minitubers is better than other treatments (IAA and GA₃) with fast germination and more sprouts. Microtubers treated with thio-urea induced the highest number of sprouts as compare to other treatments (Rehman *et al.*, 2001). The microtubers without insertion treated with GA₃ and thiourea combination resulted complete (100%) sprouting Ju *et al.* (2001).

Gibberlic acid and thiourea: 1500 ppm GA₃ and 5% thiourea reduced the dormancy period by 50% in 'Agria' cultivar (Hassan-Panah *et al.*, 2007). 5 ppm GA₃ in combination with 1% thiourea is more efficient in increasing sprouts number and length than control in 5 varieties of normal tubers of potato (Kasrawi and Alfayyad 1989). GA₃ 1 ppm concentration and thiourea with 1% concentration increases the plant growth and decreases dormancy period significantly in comparison with other treatments (Pietkiewicz, 1983). Combination of 1ppm Gibberlic acid + 1% Thiourea for 30 min dip performed best for growth attributing parameters like emergence and plant height, No. of stems and compound leaves under Gwalior conditions of central India (Annual Report- CPRS, 2012 and Annual Report - CPRI, 2012). GA₃ 1ppm + thiourea 1% with 30, 45 and 60 minutes soaking of microtubers resulted better performance in terms of yield of microtubers at Gwalior and Ooty (Annual Report- CPRS, 2012 and Annual Report- CPRI, 2012).

Randite: Randite (a 7:3:1) by volume mixture containing ethylene cholohydrin, 1, 2- dichloroethe and carbontetracholoride) is effective in breaking microtuber dormancy (Kim *et al.*, 1996, 1999). However the mutagenically, carcinogenically and high toxicity of randite components make this mixture unacceptable to routine use. Cultivar diamond took the least time for 50% of tubers to sprout followed by cultivar Atlantic and highest sprouting ratio in all cultivars when treated with randite. (Rehman *et al.*, 2001).

Corbondisulphide (CS₂): Treatment with CS₂ effectively terminates dormancy and the resulting sprouts are short, thick, robust, and resistant to breakage (Salimi *et al.*, 2010). In CS₂ treated minitubers showed significantly shorter dormancy and better sprouting, higher number of sprouts and length/ minituber. Longer duration of CS₂ treatment exhibited a stronger action on breaking dormancy and sprouting of potato minitubers than shorter treatments. Longer duration with higher concentration of CS₂ led to formation of needle sprouts when post harvest application of carbon disulphide (CS₂) in various concentrations (0, 15, 25, 35, 45 and 55 ml m⁻³) and with different exposure

duration (24, 48, 72 and 96 h) along with two ages (freshly harvested and one week after harvest) and two weight classes (1.5 and 12 g) of potato minitubers of cultivar marfona was done (Salimi *et al.*, 2010).

Conclusion

Microtubers play an important role in seed production programme in relation to prolonged storage in limited space, distance transportation of millions of basic seed planting material, minimization of transportation cost in comparison to seed potato tuber. In spite of these facts, small size, lenticels bursting, drriage/ shrinkage and limited number of eyes are the major constraints in micro-tuber based seed production programme which must be addressed under intensive research programme. Although this technology is being replaced by aeroponic based mini-tuber production. As far as storage is concern, 4°C is best and feasible method but it can be increased depending upon the requirement of dormancy breaking period before planting of microtubers. Microtuber size, storage containers and conditions are significant factor for determining the viability of the microtuber. Gibberlic acid, thiourea and their combinations, randite and carbon disulfide plays important role in dormancy breaking.

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