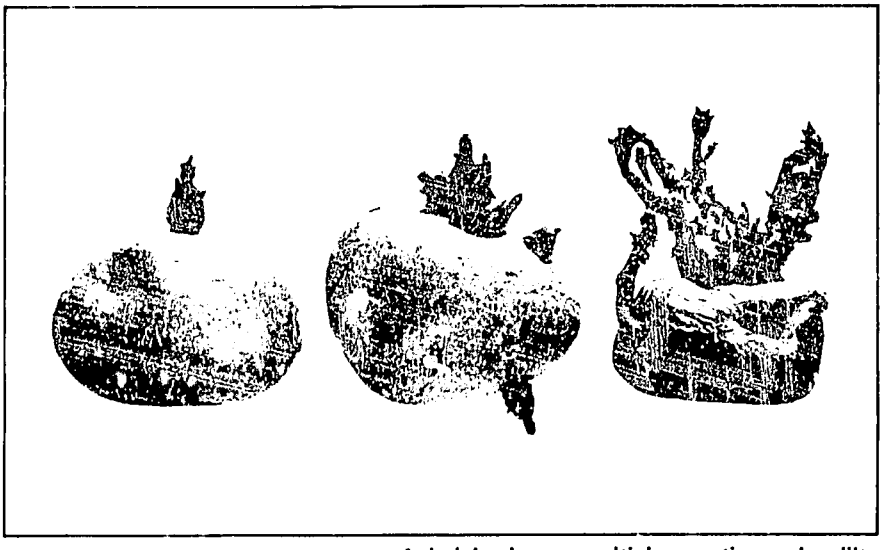
Technical Information Bulletin 20

Physiological Development of Potato Seed Tubers

Siert G. Wiersema



Apical dominance, multiple sprouting, and senility

INTERNATIONAL POTATO CENTER (CIP)

Lima, Peru
1985

Technical Information Bulletin 20

Physiological Development of Potato Seed Tubers

Siert G. Wiersema

International Potato Center
P.O. Box 5969
Lima, Peru

Tel. 366920
Cable CIPAPA-Lima
Telex 25672 PE

Physiological Development of Potato Seed Tubers

Objectives. Study of this bulletin enables you to:

- explain the principle of physiological aging of potato seed tubers,
- describe the four stages of physiological development of potato tubers: dormancy, apical sprout dominance, multiple sprouting, and senility,
- explain the significance of the incubation period,
- describe ways to manage the physiological condition of seed tubers.

Study materials

- Tubers of different physiological ages.

Exercises

- Judge the physiological age of seed tubers during storage.
- Maintain tubers of different varieties under optimum conditions for sprouting (darkness, 15 to 20 °C, relative humidity about 90 %) and observe periods of dormancy and incubation.
- Plant tubers of different physiological ages and observe emergence, crop development, and length of growing period.

Questionnaire

1 What is the difference between chronological age and physiological age?
2 What is the most correct measurement of chronological age?
3 To which process does physiological age primarily refer?
4 What are the physiological development stages of a potato tuber?
5 What are the ideal conditions for sprout growth?
6 When does the dormant period end?
7 What is the difference between total dormancy and post-harvest dormancy?
8 Why is it risky to plant dormant seed tubers?
9 What factors affect the length of the dormant period?
10 How does storage temperature influence the dormant period?
11 How can you promote the development of a large number of sprouts?
12 When may apical sprouts be removed?
13 What is generally the optimum stage to plant seed tubers?
14 How can you maintain seed tubers in the multiple sprouting stage for a long time?
15 How is the senility stage characterized?
16 How can senility be delayed?
17 What is the incubation period?
18 How is the incubation period of a potato variety related to its storage sensitivity?
19 How does physiological age of seed tubers influence sprouting and subsequent crop development?
20 Which growing conditions delay physiological aging?
21 What is meant by "day degrees"?
22 What effect does storage in diffused light have on the physiological condition of potato seed tubers?
23 How can you determine the optimum storage period and temperature for your seed tubers?

Physiological Development of Potato Seed Tubers

The physiological condition of potato seed tubers affects emergence and growth of a potato crop. By choosing seed tubers of a particular physiological age, a farmer can influence the moment of crop maturity. In extreme cases the entire crop may fail when seed tubers are planted that are not at an adequate stage of physiological development. Both growing conditions and storage practices influence the physiological condition of potato seed tubers.

1 PHYSIOLOGICAL AGING

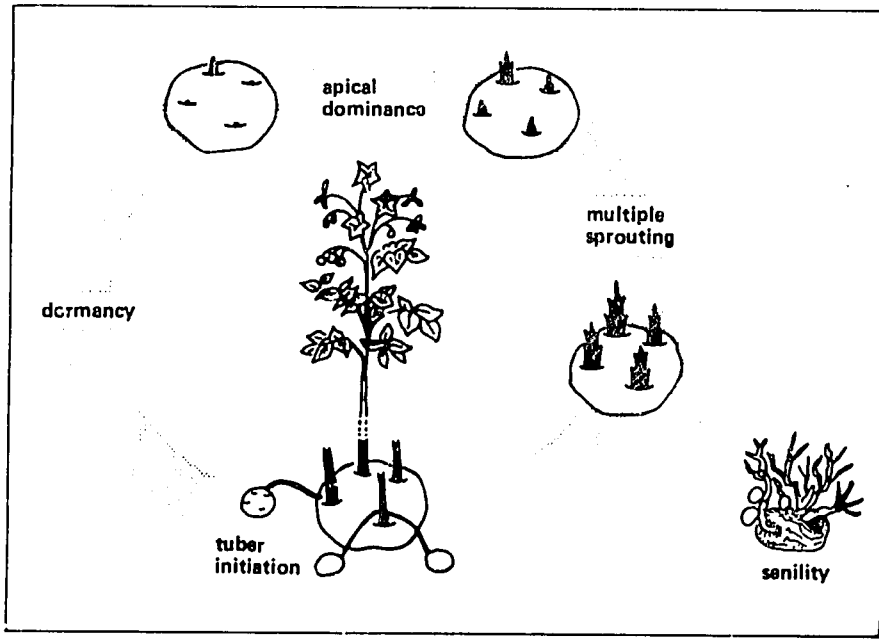
After its initiation, the potato tuber continuously develops, both morphologically and physiologically. At any time, the tuber has two different ages: a **chronological age** and a **physiological age.**

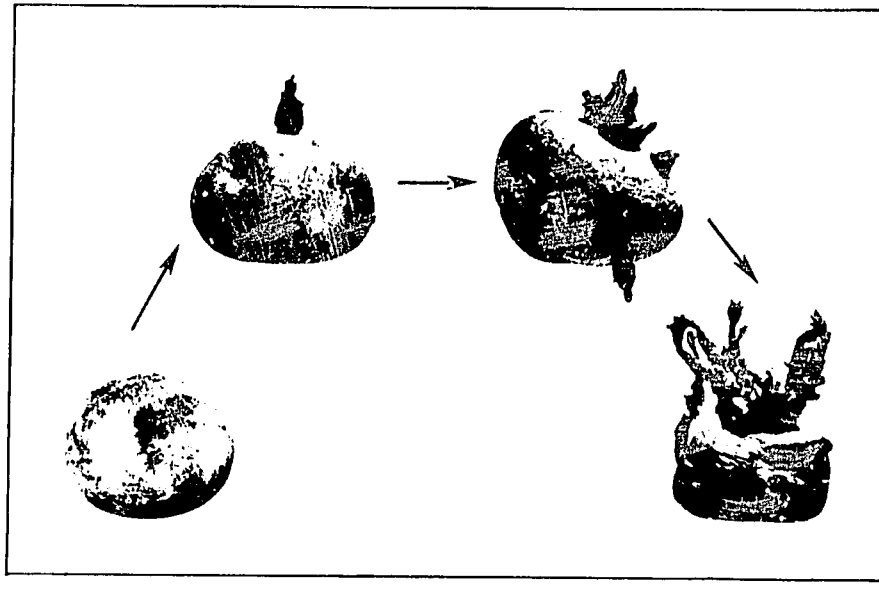
Chronological age refers to the tuber age from the time of either tuber initiation or harvest. It is expressed in days, weeks, or months without reference to environmental conditions. Scientifically, it is more correct to measure the age based on the date of tuber initiation than on harvesting date, but in practice, the first one is more difficult to determine.

Measuring age from the harvesting date is easier and more common. The harvesting date, however, does not represent a fixed point in the tuber's development: tubers from different crops harvested at the same date may differ in physiological age. Some crops may have tubers that are already in the sprouting stage, while others have tubers that remain dormant for some time.

Physiological age, on the other hand, refers primarily to the process of sprout development. It depends on both chronological age of the tubers as well as environmental conditions. Tubers may have the same chronological age, but their physiological age may differ. Similarily, tubers with the same physiological age may have different chronological ages.

During its physiological development, the potato tuber passes through the stages of dormancy, apical dominance, multiple sprouting and senility. During this development, called physiological aging, the tuber changes from *physiologically young* into *physiologically old.*





During its physiological development, the potato tuber passes through the stages of dormancy, apical dominance, multiple sprouting and senility.

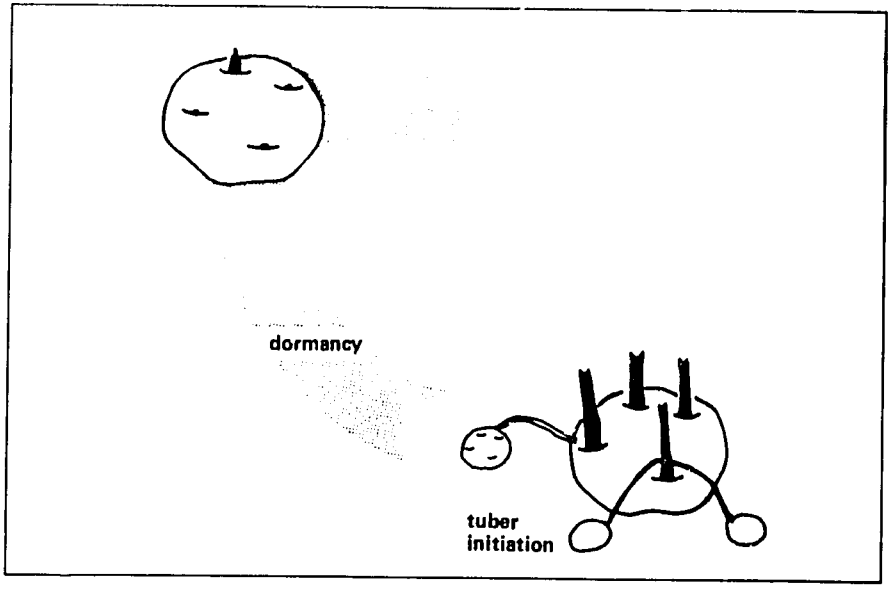
2 DORMANCY

During its physiological development, a potato tuber can remain dormant for several months. At this stage, no measurable sprout growth occurs, even when tubers are placed under ideal conditions for sprout growth (darkness, 15 to 20 °C, relative humidity about 90 %). The dormant period ends when sprout growth starts. In a variety, end of dormancy is defined when 80 % of the tubers (from a sample of at least 20 uniformly sized tubers) have sprouts at least 3 mm long.

There are two common definitions of the dormant period:

- total dormancy: the period from tuber initiation to the end of dormancy;
- post-harvest dormancy: the period from harvest to the end of dormancy.

Scientifically, the concept of total dormancy is more accurate, though more difficult to determine. Thus, post-harvest dormancy is commonly used for practical purposes.



Dormancy. During its physiological development, a potato tuber can remain dormant for several months.

The length of the dormant period determines the planting date. It is risky to plant dormant seed tubers, because the potato crop could emerge with single stems or the tubers could disintegrate in the soil before emergence, which results in crop failure.

Several factors affect the length of the dormant period:

- potato variety,
- previous growing conditions,
- storage temperature,
- tuber injury,
- degree of tuber maturity at harvest.

Potato Variety. Tuber dormancy may last from less than one month to several months, depending upon the variety. The length of the dormant period is not related to the length of the growing period of a variety. For example, an early variety does not necessarily have a short dormant period.

Growing conditions. The conditions under which seed tubers are produced affect the length of the dormant period. For example, high temperatures, low soil moisture, and low soil fertility during tuber growth accelerate physiological development and reduce the dormant period.

Storage temperature. High storage temperatures accelerate the physiological aging processes within the tuber, thus reducing the dormant period. In some varieties, however, a fluctuating storage temperature or a "cold shock" of two to four weeks at reduced temperatures (below 10 °C) is more effective in shortening the dormant period than storage at a constant high temperature.

Tuber injury. Tuber injuries, caused by harvest and handling procedures or by diseases and pests, reduce the dormant period. Cutting seed tubers also results in earlier sprouting.

Tuber maturity. Immature tubers usually have a longer post-harvest dormancy than tubers harvested at maturity. However, because immature tubers are harvested earlier, they may still sprout earlier than mature tubers.

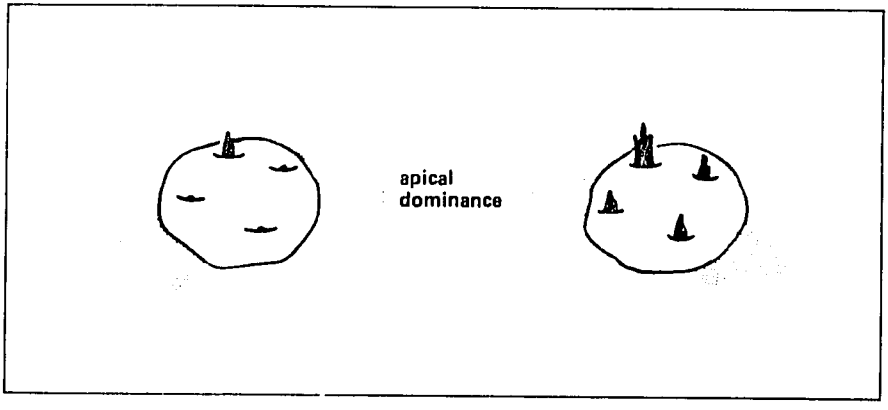
3 APICAL DOMINANCE

At the end of the dormant period, buds in the eyes begin to grow and form sprouts. Frequently, the apical eye begins to sprout first, marking the beginning of the apical dominance stage. Planting seed tubers with apical dominance often results in plants with single stems. This may lead to reduced yields. The duration of apical dominance differs considerably among varieties. Apical dominance is influenced by **storage management** and **desprouting.**

Storage management. The best way to **promote** the development of a large number of sprouts is to delay sprout growth beyond the end of the natural dormancy and apical dominance stages. This can be achieved by storing tubers at low temperature (4 °C) until the apical dominance stage is over. Then, storage temperature should be increased (above 15 °C) to promote sprout growth, which will result in multiple sprouting.

To **limit** the number of sprouts, maintain high storage temperatures (15 - 20 °C) to promote apical dominance.

Desprouting. Removing the apical sprout of the tuber may induce the formation of multiple sprouts, thus contributing to a uniformly sprouted tuber that produces several stems per plant. Sprouts should be removed when they are still young. Desprouting when sprouts are old may cause tuber damage, dehydration and poor resprouting.



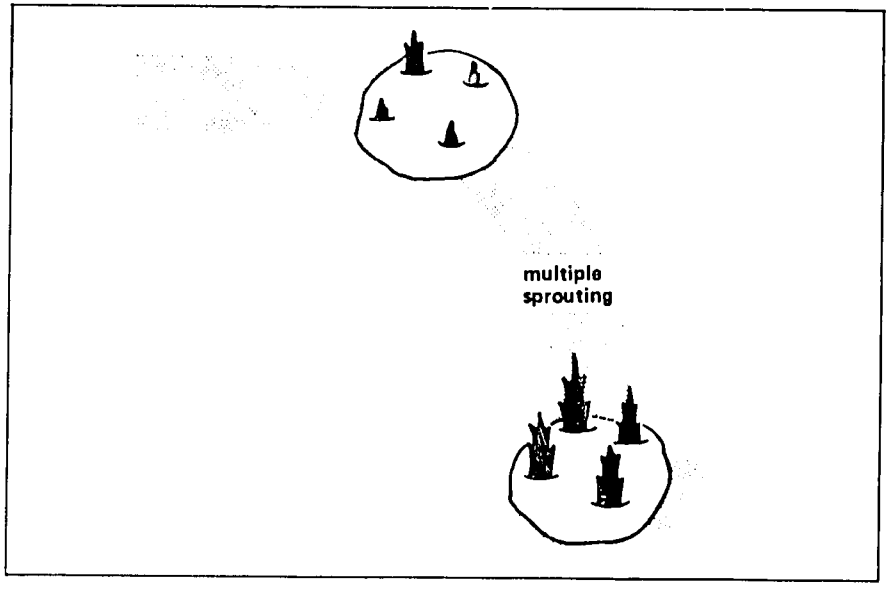
Apical dominance. Frequently the apical eye begins to sprout first.

4 MULTIPLE SPROUTING

After the apical dominance stage, additional sprouts develop and the multiple sprouting stage begins. Generally, this is the optimum stage to plant seed tubers. Tubers in this stage give rise to plants with several stems.

Depending on the variety, the multiple sprouting stage may last for many months, especially when tubers are stored at low temperatures. Diffused light helps to prolong the multiple sprouting stage and to keep sprouts short and strong.

At the beginning of the multiple sprouting stage, a seed tuber is physiologically "young"; at the end, it is "old." Old seed tubers should not be desprouted even when sprouts become long. They may have already lost their resprouting capacity or may only form thin "hair sprouts."



Multiple sprouting. Additional sprouts develop. Generally, this is the optimum stage to plant seed tubers.

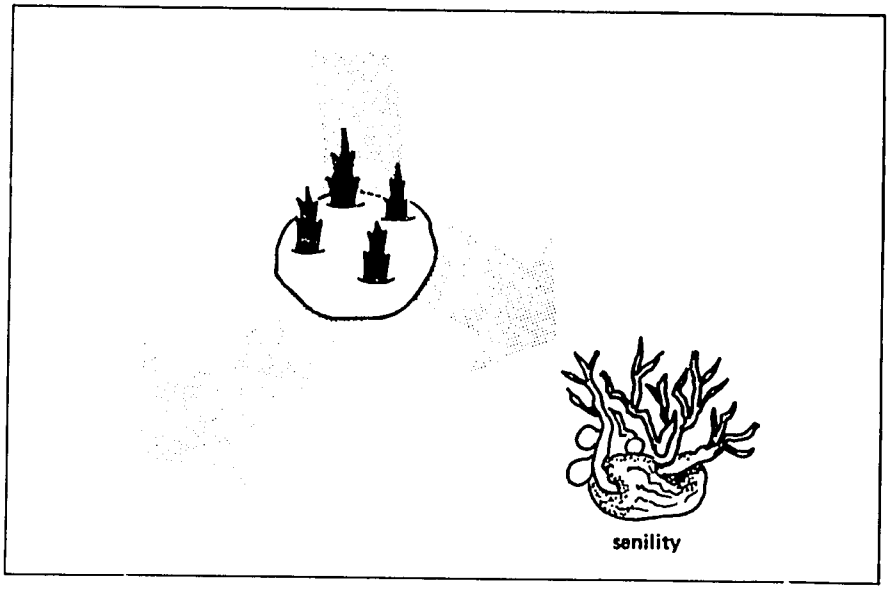
5 SENILITY

The senility stage of tubers is characterized by several symptoms:

- excessive branching of sprouts,
- production of long, weak sprouts, often referred to as "hair sprouts", and
- production of small tubers (little potatoes) directly on the sprouts, either before planting or during emergence.

Seed tubers in this stage no longer produce productive plants.

Senility can be delayed by producing and storing seed tubers under cool conditions. Seed tubers produced during a hot growing season reach the senility stage sooner than those produced during a cool season.



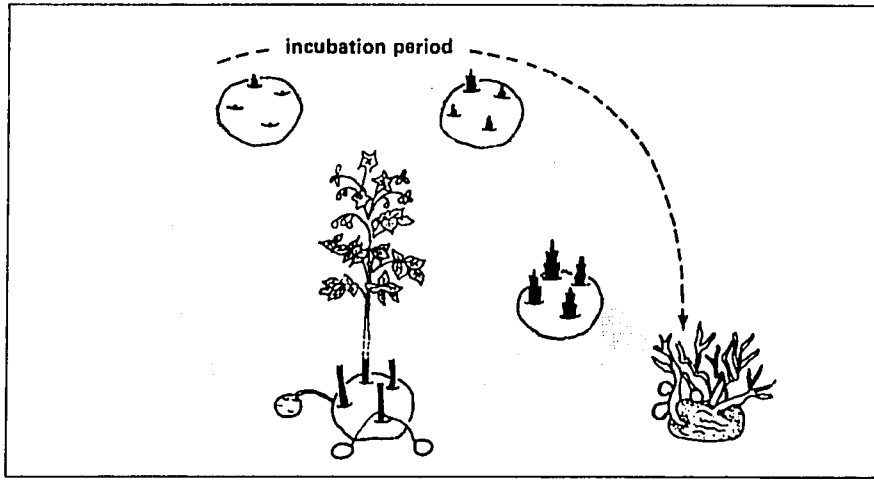
Senility. Seed tubers no longer produce productive plants.

6 INCUBATION PERIOD

The period from the beginning of sprouting to the stage at which 90 % of the seed tubers (from a sample of at least 20 uniformly sized tubers) have produced "little potatoes" is the incubation period. It is normally determined under ideal conditions for sprouting (darkness, 15 to 20 °C, relative humidity about 90 %). The incubation period is expressed in days, weeks, or months.

The length of the incubation period depends on the variety but, like dormancy, is not related to the length of growing period of the variety. In varieties with a short incubation period, physiological aging occurs rapidly. Seed tubers from such varieties remain in optimum planting condition for only a short time and then rapidly become senile. In varieties with a longer incubation period, seed tubers maintain an adequate condition for planting for a longer time.

The incubation period of a variety is a good indication of a variety's sensitivity to storage conditions. Varieties with a short incubation period rapidly become senile and require optimum storage conditions. Varieties with a longer incubation period are less sensitive to storage conditions and are more suited to be stored at ambient temperatures in hot growing areas.



The incubation period is the period from the beginning of sprouting to the stage at which "little potatoes" are produced.

7 MANAGEMENT OF PHYSIOLOGICAL AGE

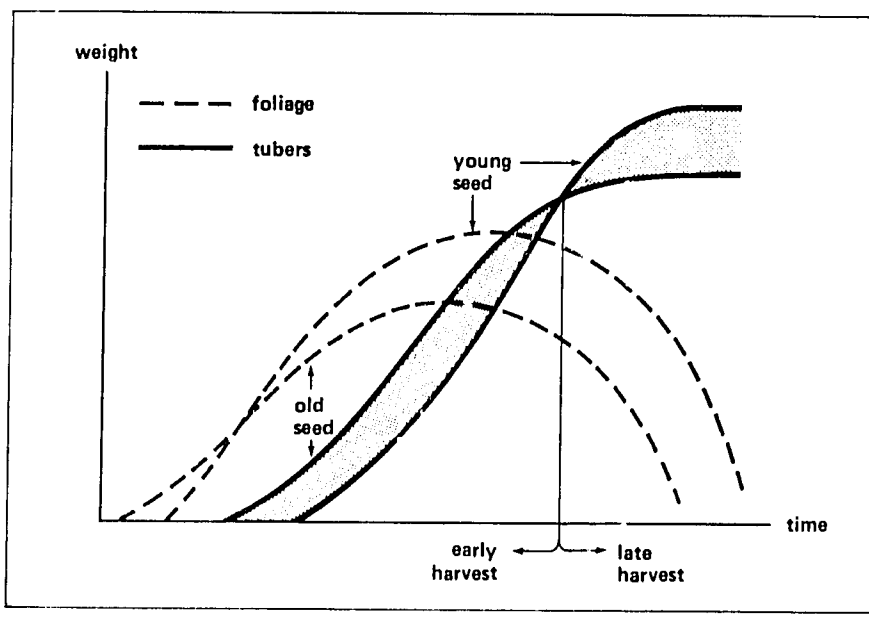
The physiological age of seed tubers influences sprouting and the subsequent crop development.

physiological age	young ---------- old			
physiological stage	dormancy	apical dominance	multiple sprouting	senility
sprouting	no sprouts	apical sprouts only	several sprouts	branching hair sprouts little potatoes
crop condition	no emergence	few stems	many stems	weak plants

young seed leads to:		old seed leads to:	
late	emergence	early	emergence
late	tuberization	early	tuberization
high	foliage production	reduced	foliage production
high	tuber number	reduced	tuber number
late	maturity	early	maturity
high	yield	reduced	yield

In summary, plants grown from physiologically young seed tubers develop their yield potential slowly. However, the potato crop grows during a longer period and the total yield is higher. Plants from physiologically old seed tubers develop their yield potential quickly. However, the potato crop matures early and total yield is reduced.

Therefore, plant physiologically older seed tubers when the available growing period is limited by such factors as restricted rainfall, early frost, late blight, virus incidence, or early market demand. When the available growing period is long, plant physiologically young seed tubers.



Growth of foliage and tubers from old and young seed tubers. Old seed tubers have higher yields with an *early* harvest. Young seed tubers have higher yields with a *late* harvest.

With a given variety, physiological age of the produced seed tubers can be managed by **growing** and **storage conditions.**

Growing conditions. Physiological age of seed tubers at harvest is influenced by climate and soil.

tuber age is advanced by:		tuber age is delayed by:	
hot	climate	cool	climate
light	soil structure	heavy	soil structure
low	soil moisture	high	soil moisture
low	soil (N) fertility	high	soil (N) fertility

Storage conditions. With a given variety, the physiological age during storage depends mainly on the length of the storage period (days) and the storage temperature (degrees Celsius). Both factors can be combined into a mathematical product of "day degrees." The higher the accumulated number of day degrees, the more advanced the tuber is physiologically.

Tubers stored at ambient temperatures in natural diffused light remain in good physiological condition even at a relatively high number of accumulated day degrees.

No single storage regime is appropriate for all varieties and environments. To determine the optimum storage period and temperature expose your seed tubers to various storage periods and temperatures and compare the subsequent crop performance.

8 ADDITIONAL STUDY

Beukema, H.P., Vander Zaag, D.E. 1979. Potato improvement. Some factors and facts. International Agricultural Centre, Wageningen, The Netherlands. pp. 26-36.

Burton, W.G. 1966. The potato. Veenman & Zonen, Wageningen, The Netherlands. pp. 231-246.

Iritani, W.M., Weller, L.D., Knowles, N.R. 1983. Relationships between stem number, tuber set and yield of Russet Burbank potatoes. American Potato Journal 60:423-431.

O'Brien, P.J., Allen, E.J., Bean, J.N., Griffith, R.L., Jones, S.A., Jones, J.L. 1983. Accumulated day-degrees as a measure of physiological age and the relationships with growth and yield in early potato varieties. J. Agric. Sci., Camb. 101:613-631.

Rastovski, A., Es, A. van, et. al. 1981. Storage of potatoes. Postharvest behaviour, store design, storage practice, handling. Centre for Agricultural Publishing and Documentation, Wageningen, The Netherlands. pp. 99-119.

Wiersema, S.G., Booth, R.H. 1985. Influence of growing and storage conditions on the subsequent performance of seed tubers under short day conditions. Potato Research 28:15-25.

Wurr, D.C.E. 1978. Seed tuber production and management. In: Harris, P.M. (ed). The potato crop – the scientific basis for improvement. Chapman and Hall Ltd., London. pp. 333-352.

Technical Information Bulletin Coordinator: Rainer Zachmann

Processed and printed by the Training and Communications Department, CIP, Lima, Peru
March 1985 **Copies printed: 2000**