Better understanding of tubers formation for better management of size class yields

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Introduction

Tuber diameter is a quality criterion which now appears in all production specifications, with the precise stipulations varying as a function of the market in question. Hence, each market defines an optimal diameter for which the highest purchase price is payable. Consequently, producers seek to maximize the production of tubers in the best-paid size class (e.g British Potato Council, 1999).
A 2002 survey of potato producers in the Picardy region of Northern France showed that it is difficult to discriminate between factors which influence the overall yield and those which influence distribution of the crop into size classes. So, it is necessary to have a better understanding of the factors impacting on size class distribution and to quantify their effects (see Figure 3, Influence Diagram, in MacKerron et al. 2004).
In order to answer these questions, a work programme entitled "QUALTEC POTATO" was initiated in 2003 by the AGRO-TRANSFERT section of the ALTERNATECH organisation in partnership with the INRA, the ARVALIS Technical Institute for Cereals and Forage, the Picardy and Nord-Pas-de-Calais Chambers of Agriculture, the "Nord Plant" Committee and the EXPANDIS and UNEAL cooperatives. In 2004, one of the objectives of the programme was to see whether one can describe the kinetics of tuber formation and whether it is possible to characterize the principal physiological and environmental determinants of this process. The following production factors were tested in 2004: availability of water, nitrogen and P_2O_5, the diameter of the seed potato, planting density, the variety and the preparation of the seed potato. This abstract presents the initial results obtained in the "variety" trial.

Materials and methods

Four varieties (Amandine, Saturna, Desiree, Bintje) were tested in this trial. Frequent (two or three times a week) samplings on an observation block allowed us to describe the formation of the pool of initiated tubers. –Allen & Scott (1992, p845) pointed out that in many experiments it is not possible to determine the onset or duration of tuber initiation because of infrequent observations; MacKerron (1992) stressed the importance of assessing tuber initiation from frequent counts rather than by backward extrapolation of tuber growth. – Samples of 2 plants (2 adjacent plants in 1 row) were taken as soon as the first plants emerges so as to monitor the appearance of the stolons. Samples of 8 plants (8 adjacent plants in 1 row) were taken over three or four weeks, from as soon as the first stolon appeared, to record the number of tubers formed.
Plant variables recorded at each sampling were :
- Per plant : Size of the swelling or initiated tuber and stolons that bear them (with slide calliper).
- For 8 plants : Number of tubers and fresh weight of tubers per grade (Grade as >15mm in 5mm diameter classes ([15-20 mm], [20-25 mm], [25-30 mm] …)).
Measurements were made with a Vernier calliper.

Results and discussion

The measurement taken during the trial enabled us to describe the **kinetics of tuber initiation**. Figure 1 illustrates the change in total tuber number over time (expressed as days after emergence (DAE)) for the Bintje variety.

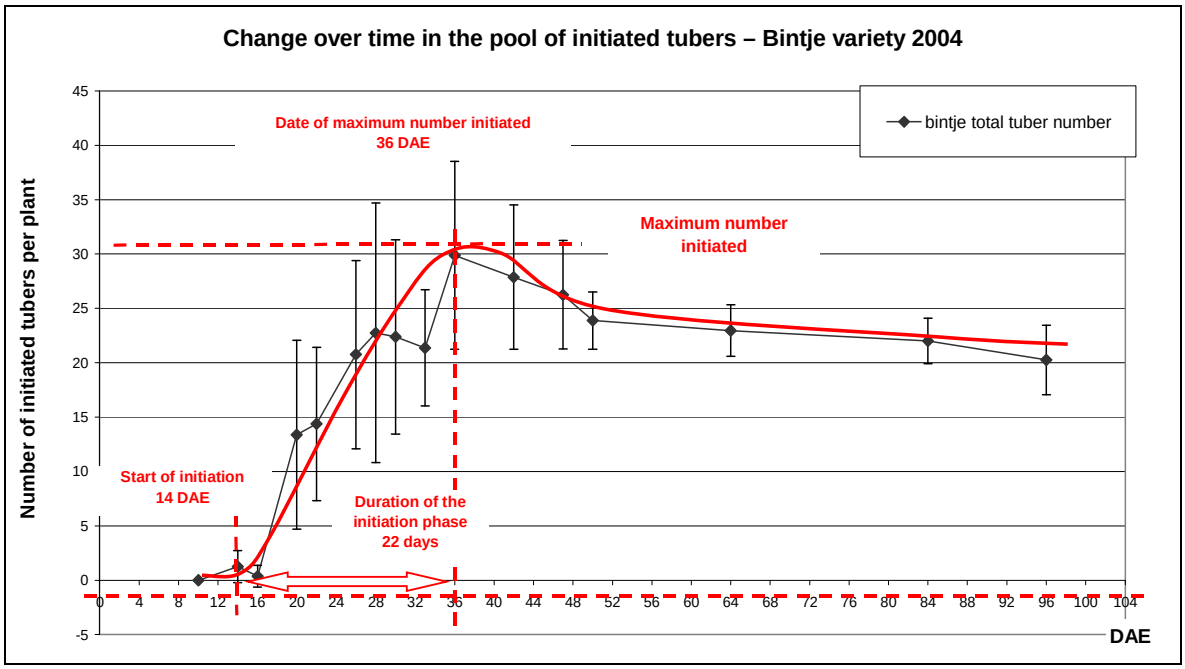

Figure 1 : Change over time in the pool of initiated tubers – Bintje variety 2004

In this figure the first tubers appear 14 DAE. After a slow increase between 14 and 16 DAE, the tuber number increases linearly between 16 and 28 DAE. After an apparent regression between 30 and 33 DAE, this increase in the number of initiated tubers continues to a maximum at 36 DAE. The date on which this maximum is reached marks the end of the tuber initiation period. It is followed by a decrease in the total tuber number until this parameter reaches a value which more or less corresponds to a plateau. The red curve is a manual description of the kinetics of tuber initiation.

The results obtained with the 3 other trialled varieties (Figure 2) confirm the qualitative description of the kinetics of tuber initiation described for the Bintje.

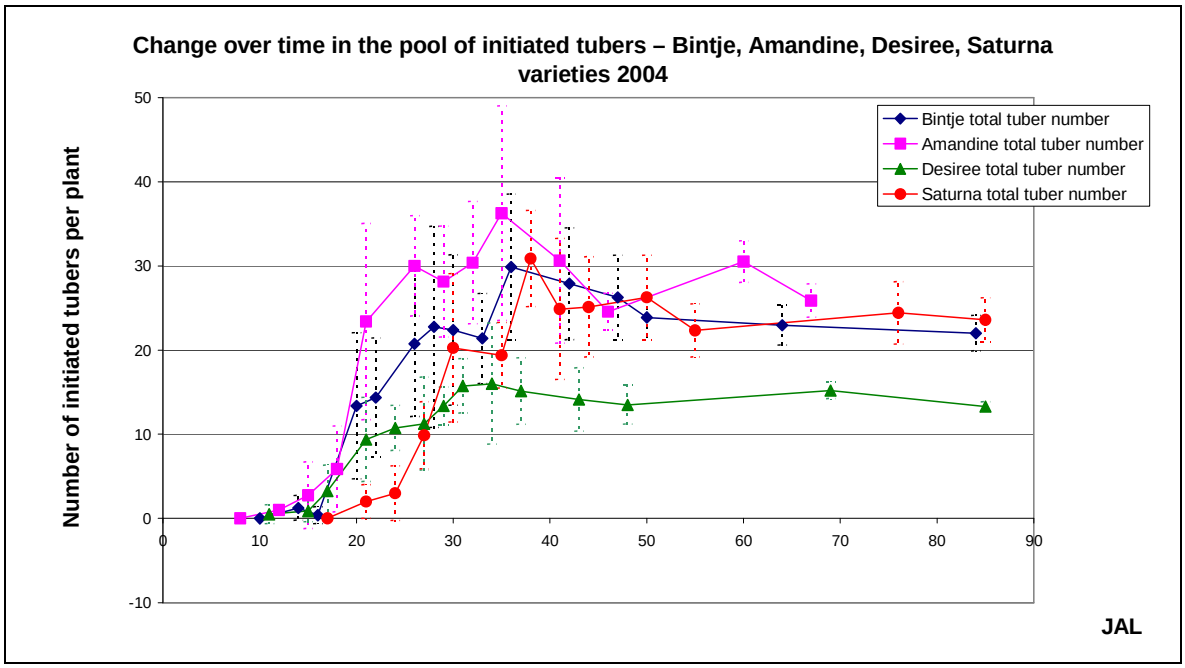

Figure 2 : Change over time in the pool of initiated tubers – Bintje, Amandine, Desiree, Saturna varieties 2004

In this figure, with the 3 other trialled varieties we can also determinate

- a date on which the first tubers appear

- a slow increase, and then a linear increase in tuber number
- an apparent regression, and then an increase in the number of initiated tubers to a maximum
- a decrease in the total tuber number until this parameter reaches a value which more or less corresponds to a plateau.

In contrast, the variety seems to play a key role in the quantitative expression of the phenomenon described here. The "variety effect" thus appears to be expressed in terms of the intensity of the initiation acceleration phase, the maximum number of initiated tubers and the intensity of the regression phase.

The trial measurements enabled us to describe the **kinetics of early-stage tuber enlargement.** Figure 3 illustrates the change in the number of tubers with a diameter >15 mm and >10 mm over time (expressed as days after emergence) for the Bintje variety. Indeed, in this variety, a diameter of 15mm seems to represent the threshold diameter for tubers likely to grow further.

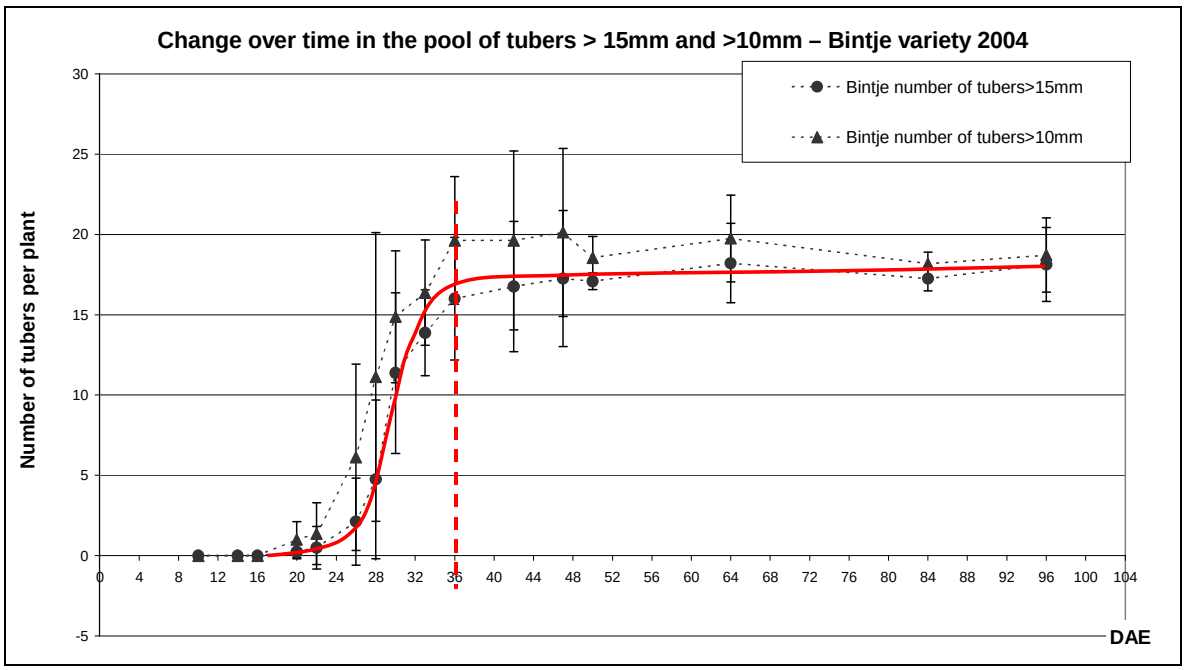

Figure 3 : Change over time in the pool of tubers > 15mm and >10mm – Bintje variety 2004

In this figure, the first tubers > 15 mm in diameter appeared 23 DAE, i.e. well before the day on which the maximum number of initiated tubers is reached and which marks the end of the initiation period (36 DAE). The number of tubers > 15mm in diameter then increases almost linearly up to 36 DAE. After this time, i.e. after the day on which the maximum number of initiated tubers is reached (the end of initiation), the number of tubers > 15mm in diameter remains stable. Furthermore, tubers >10 mm but < 15 mm in diameter undergo a resorption effect which is identical to that observed for the total number of tubers in Figure 1. The red curve is a manual description of the kinetics of early-stage tuber enlargement.

The form of the fitted curve in Fig. 1 approximates the schematic representation given by Struik & Wiersema (1999, page 42 of that text) but the form of that in Fig. 3 promises to be more useful and instructive as it obviates the need to quantify the decline from a maximum number of tubers.

The results obtained with the 3 other trialled varieties (Figure 4) differ in some respects from the qualitative description of the kinetics of tuber growth observed for Bintje. This is consistent with the report of van Ittersum & Struik (1992).

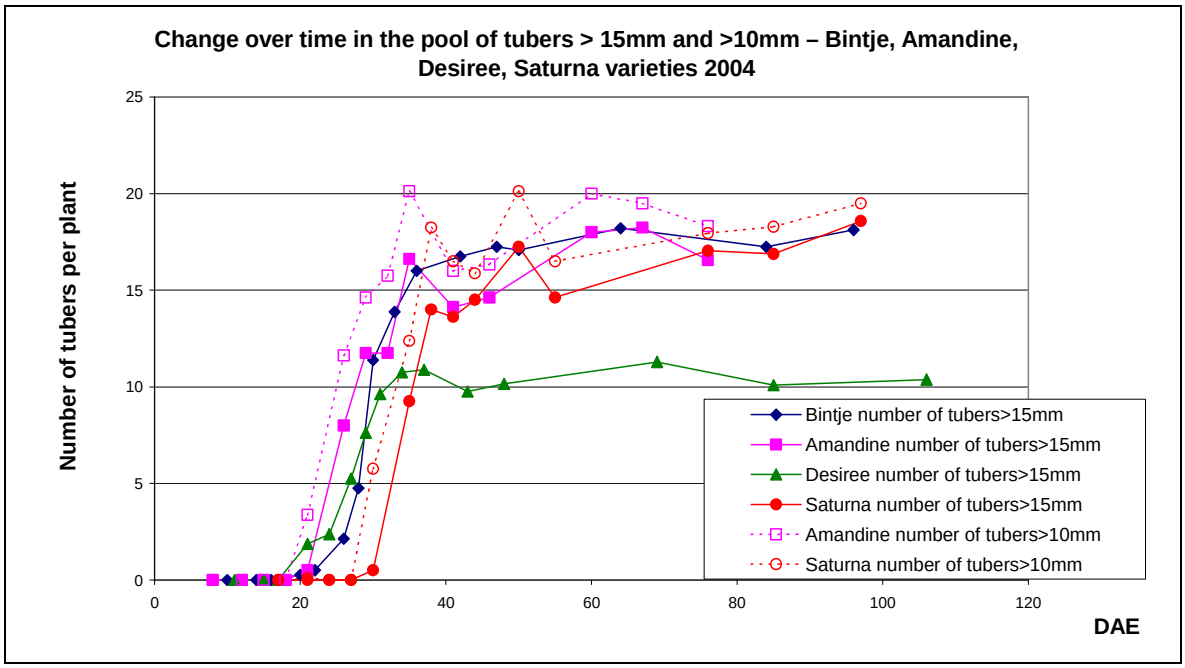

Figure 4 : Change over time in the pool of tubers > 15mm and >10mm – Bintje, Amandine, Desiree, Saturna varieties 2004

In this figure, the number of tubers > 15mm in diameter then increases linearly up to the day on which the maximum number of initiated tubers is reached but it doesn't remain stable for all the varieties. For Amandine and Saturna, this increase in the number of tubers > 15 mm in diameter continues. Furthermore, the number of tubers > 10 mm in diameter seems to remain stable. A "variety effect" thus appears to be expressed in terms of the critical size of tubers likely to grow further, which varies between 10 and 15 mm according to the variety tested.

Conclusions and Perspectives

It appears that one can distinguish between two physiological processes during tuber initiation:

- the creation of tubers (a swelling whose diameter is twice that of the stolon)
- the early-stage enlargement of the tubers up to a critical size

Tuber creation is a finite process characterised by a start, an end, and therefore a duration. The kinetics of this process are divided into 2 phases : a starting phase and an acceleration phase up to a maximum. Each stage can vary in intensity. Attainment of a maximum number of initiated tubers appears to mark the end of the tuber creation phase. In fact, this is followed a regression phase where the tuber number falls and then reaches a sort of plateau. The final tuber pool is also never constituted by the total set of tubers created. Only tubers having reached a critical size at the end of the tuber creation phase appear to participate in the determination of yield. In 2005, a new trial network will be set up in order to clarify and validate our understanding of the phenomena described above. Analysis and modelling of the results for the full two years of trials should enable us to suggest new decision rules for crop production.

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