

Effect of physiological age on growth vigour of seed potatoes of two cultivars. 4. Influence of storage period and storage temperature on growth and yield in the field

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Zusammenfassung, Résumé p. 448

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Summary

The influence of storage period and temperature on growth and yield was investigated for 3 years in a field study with cvs. Jaerla and Désirée, stored at 4 °C or 12 °C, in darkness, as a part of a combined study on the effect of physiological age on growth vigour. The seed of cv. Jaerla proved to age more rapidly than that of cv. Désirée: 'little potato' occurred in Jaerla, but in Désirée only when seed had been stored at 12 °C and planted late. The 4 °C treatments emerged more rapidly, produced more stems per plant and the onset of senescence was earlier than the 12 °C treatments. There was no difference in time of tuber initiation between the two treatments. There were usually more tubers per stem in the 12 °C treatments. Final tuber yield of Jaerla 12 °C was lower than that of Jaerla 4 °C, but the difference was only statistically significant at early harvest. There was no difference in yield between Désirée 4 °C and 12 °C, except for the 2nd planting time in 1981, when the 12 °C treatment yielded significantly less.

Introduction

During the rest period, and when they are exhausted at the end of their life cycle, seed potatoes do not produce plants. Growth vigour is impaired in the period just after the rest period and shortly before exhaustion (Perennec & Madec, 1980). In countries where two potato crops are grown per year, the period between harvest and the next planting time is often only 2–3 months. After planting, such young seed develops slowly, and produces only a few stems (Kawakami, 1962). When climatic conditions allow only one potato crop a year, the seed has to be stored for a period of 7–8 months. Prolonged storage of seed tubers at too high temperatures may lead to exhaustion, particularly if the cultivars only have a short incubation period, and this results in the 'little potato' phenomenon (Madec, 1956). The effect of the stage of physiological development of a seed tuber on plant growth and yield is obvious for physiologically very young and very old tubers, but is much less clear for intermediate development stages (see van der Zaag & van Loon, 1987).

To compare the relationship between physiological age of the seed and the variables sprouting capacity, peroxidase activity in the sprout and incubation period (Hartmans & van Loon, 1987; van Es & Hartmans, 1987) with plant behaviour, seed potatoes of different physiological age were planted in the field.

The research reported here was done within the framework of the Dutch working group 'Growth vigour of seed potatoes'. Detailed information about the experiments and the results of the combined study is available as a report (Working group, 1987). The aims of the research programme and an explanation of terms used are presented by Hartmans & van Loon (1987).

Materials and methods

In the years 1979–1981, seed potatoes, size 40/45 mm, of cvs. Jaerla and Désirée, both stored in darkness at 4 °C or 12 °C from the beginning of September until planting (see Hartmans & van Loon, 1987), were planted in a sandy loam soil. The experiments used randomized block designs with 4 replicates. In 1979 the seed had been desprouted on 2 March and then re-sprouted in daylight. However, in 1980 and 1981 the seed was desprouted the day before planting. The planting dates were 14 May 1979, 14 April 1980, and 15 April 1981 (storage days 269, 240 and 240, respectively). Moreover, in 1981 there was a second (II) planting date, on 15 May. Plant spacing was 75 cm × 33 cm.

P and K fertilizers were applied in standard amounts in response to the requirements revealed by soil analysis. The amounts of nitrogen applied per hectare before planting in 1979, 1980 and 1981 were 135 kg, 205 kg and 125 kg, respectively.

During the growing season the following observations were made: degree of emergence by making plant counts, time of tuber initiation (in 1980 and 1981) by checking 2 or 3 times 5 plants per plot in border rows, ground coverage by green foliage during the growing season by visual estimation and the number of main stems per plant. In 1979 and 1981 the number of tubers per plant was determined and for cv. Désirée the length of lateral stems ($n-1$) was ascertained, following the diagram of Reestman & Schepers, cited by van der Zaag (1980). The final harvest took place on about 20 September. In 1979 there was also a harvest on 23 July. The yield was recorded on plots of 7 m² (1979 and 1980) and 11.5 m² (1981).

Results

Emergence

With the exception of cv. Désirée in 1979, in both cultivars the degree of emergence differed between the two temperature treatments (Table 1). Plants growing from seed from the 12 °C treatments emerged more slowly than those from the seed that had been stored at 4 °C. There was almost 100% final emergence from the early planting for both treatments of Désirée. However, the seed of cv. Jaerla that had been stored at 12 °C showed a very incomplete emergence, because of the occurrence of 'little potato'. This phenomenon was also the cause of the gaps in the Jaerla 4 °C crop in 1979.

Désirée 12 °C planted on the later date in 1981 had only a 65 % emergence, because of rotting of the tubers and 'little potato' formation. In both cultivars the late-planted 12 °C treatments emerged irregularly, whereas the late-planted 4 °C treatments did not.

Tuber initiation

In 1980 and 1981 there was no difference in time of tuber initiation between the two

Table 1. Emergence (% of planted tubers) on two dates in 1979, 1980 and 1981.

| | Normal planting | | | | Late planting | | | |
|--------------------|-----------------|---------|--------|----------|---------------|----------|--------|----------|
| | 1979 | | 1980 | | 1981 | | 1981 | |
| | 2 June | 23 July | 25 May | 19 Sept. | 22 May | 21 Sept. | 5 June | 21 Sept. |
| Jaerla 4 °C | 60 | 93 | 84 | 100 | 55 | 100 | 70 | 90 |
| Jaerla 12 °C | 20 | 54 | 10 | 62 | 3 | 6 | 0 | 0 |
| Désirée 4 °C | 84 | 100 | 64 | 100 | 98 | 100 | 90 | 100 |
| Désirée 12 °C | 82 | 99 | 41 | 100 | 60 | 99 | 50 | 65 |
| LSD ($P < 0.05$) | 6.8 | 3.7 | 13.8 | 0.8 | * | 1.5 | * | 4.4 |

* Average of only 2 replicates – *Durchschnitt von nur 2 Wiederholungen* – *Moyenne sur deux répétitions.*

Tabelle 1. Auflauf (%) zu zwei Daten, 1979, 1980 und 1981.

Tableau 1. Levée (%) sur deux dates pour 1979, 1980 et 1981.

Désirée treatments. Because 'little potato' occurred, even on many of the emerged plants of Jaerla 12 °C, it was impossible to make a reliable comparison of the time of tuber initiation between the two treatments of this cultivar.

Foliage growth

By comparing *ground coverage* by green foliage about 4 weeks after emergence and at the beginning of September the initial development of the crop and the extent of senescence at that time can be ascertained (Table 2). The results for Jaerla 12 °C were

Table 2. Ground coverage (%) by green foliage about 4 weeks after emergence and 2 weeks before harvest (see also % emergence in Table 1).

| | 26 June | 23 June | 9 July | 7 Sep. | 12 Sep. | 4 Sep. | 11 Sep. |
|--------------------|---------|---------|---------|--------|---------|--------|---------|
| | 1980 | 1981 I | 1981 II | 1979 | 1980 | 1981 I | 1981 II |
| Jaerla 4 °C | 71 | 65 | 71 | 3 | 1 | 0 | 1 |
| Jaerla 12 °C | 45 | 45 | * | 15 | 6 | * | * |
| Désirée 4 °C | 72 | 74 | 77 | 21 | 48 | 2 | 3 |
| Désirée 12 °C | 64 | 59 | 70 | 27 | 54 | 12 | 19 |
| LSD ($P < 0.05$) | 19 | 7 | 10 | 8 | 10 | 7 | 12 |

I = Normal planting time – *Normale Pflanzzeit* – *Date de plantation normale.*

II = Late planting time – *Späte Pflanzzeit* – *Date de plantation tardive.*

* Not estimated (see text) – *Nicht berechnet (vgl. Text)* – *Non estimé (voir texte).*

Tabelle 2. Bodenbedeckung (%) durch grünes Blattwerk 4 Wochen nach Auflauf und 2 Wochen vor Ernte (vgl. auch % Auflauf in Tabelle 1).

Tableau 2. Couverture du sol (%) par le feuillage environ 4 semaines après la levée et 2 semaines avant la récolte (voir également % de levée dans le tableau 1).

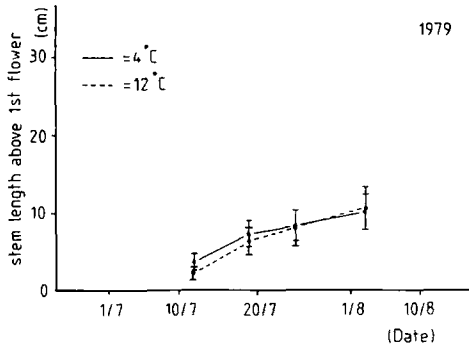
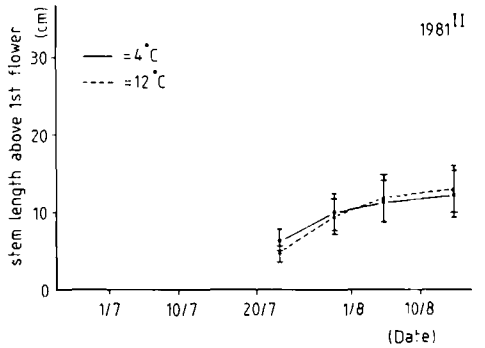
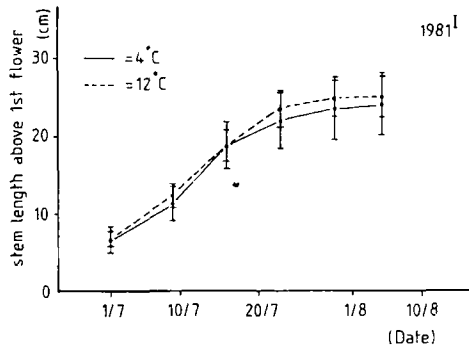


Fig. 1. Lateral stem development after the formation of the first flower for cv. Désirée 4 °C and 12 °C in 1979 and 1981 (planting times I and II).

Abb. 1. Laterale Triebentwicklung nach Bildung der ersten Blüte bei der Sorte Désirée bei 4 °C und 12 °C, 1979 und 1981 (Pflanzzeiten I und II).

Fig. 1. Développement des tiges latérales après la formation de la première fleur pour Désirée conservée à 4 °C et 12 °C en 1979 et 1981 (dates de plantation I et II).



greatly affected by the high incidence of little potato, which caused many gaps in the field. The few plants that did emerge continued to grow for a long period and developed much foliage. For this reason, ground coverage was not estimated in 1981. The foliage of Jaerla 12 °C probably developed more slowly than that of Jaerla 4 °C because there were fewer plants of the former treatment per m², rather than because the physiological age of the seed tubers differed. The lower plant density may also have caused the slower senescence for Jaerla 12 °C. Table 2 shows that the initial development of Désirée 12 °C was somewhat slower than that of Désirée 4 °C. In 1981 Désirée 12 °C became senescent later than Désirée 4 °C.

Lateral stem development after the formation of the first flower, as an indication of foliage growth, is shown in Fig. 1 for Désirée in 1979 and 1981. There was little difference between the two temperature treatments. Lateral stem development of Jaerla was not measured because the plants developed unevenly because of gaps.

Stems per plant

The number of stems per plant showed the same pattern in all years (Table 3). In both cultivars the number of main stems per plant for the 4 °C treatments was somewhat higher than for the 12 °C treatments. There was a large difference between the two Désirée treatments for both planting dates in 1981.

Table 3. Number of main stems per plant at final harvest in 1979, 1980 and 1981, for cvs. Jaerla and Désirée stored at 4 °C or 12 °C.

| Treatment | 1979 | 1980 | 1981 I | 1981 II |
|--------------------|------|------|--------|---------|
| Jaerla 4 °C | 2.3 | 2.9 | 2.7 | 3.6 |
| Jaerla 12 °C | 2.0 | 2.2 | | |
| Désirée 4 °C | 3.9 | 3.4 | 5.8 | 5.7 |
| Désirée 12 °C | 3.2 | 3.0 | 3.2 | 2.0 |
| LSD ($P < 0.05$) | 0.4 | 0.6 | 0.8 | 0.4 |

Tabelle 3. Zahl der Haupttriebe bei der späten Ernte 1979, 1980, 1981; Sorten Jaerla und Désirée, bei 4 °C oder 12 °C gelagert.

Tableau 3. Nombre moyen de tiges à la récolte finale de 1979 à 1981, pour les variétés Jaerla et Désirée conservées à 4 °C et 12 °C.

Table 4. Number of tubers per main stem and per plant in 1979 and 1981 for cvs. Jaerla and Désirée stored at 4 °C or 12 °C.

| Treatment | Tubers per main stem | | | Tubers per plant | | |
|--------------------|----------------------|--------|---------|------------------|--------|---------|
| | 1979 | 1981 I | 1981 II | 1979 | 1981 I | 1981 II |
| Jaerla 4 °C | 2.8 | 2.9 | 3.5 | 6.5 | 7.7 | 12.5 |
| Jaerla 12 °C | 2.8 | | | 5.6 | | |
| Désirée 4 °C | 2.4 | 2.2 | 3.0 | 9.4 | 12.6 | 17.1 |
| Désirée 12 °C | 3.3 | 3.0 | 4.2 | 10.5 | 9.8 | 8.4 |
| LSD ($P < 0.05$) | 0.5 | 0.3 | 0.6 | 1.9 | 1.1 | 2.3 |

Tabelle 4. Zahl der Knollen pro Haupttrieb und pro Pflanze 1979, 1981. Sorten Jaerla und Désirée, bei 4 °C oder 12 °C gelagert.

Table 4. Nombre moyen de tubercules par tige et par plante en 1979 et 1981, pour les variétés Jaerla et Désirée conservées à 4 °C et 12 °C.

Number of tubers per main stem and per plant

The number of tubers per plant depends on the number of stems per plant and on the number of tubers per stem. In both years, Désirée 12 °C had more tubers per main stem than Désirée 4 °C, but because in 1981 there were fewer stems per plant, in that year there were fewer tubers per plant for Désirée 12 °C than for Désirée 4 °C (Table 4). In 1979 there was no difference in number of tubers per stem between Jaerla 4 °C and Jaerla 12 °C.

Tuber yield

The pattern of tuber yield was similar in the three experimental years (Table 5). In 1979 and 1980 tuber yields of Jaerla 12 °C were lower than those of Jaerla 4 °C, but this difference was significant only at early harvest. Désirée 12 °C differed from Désirée 4 °C only in the second crop in 1981, when the yield of Désirée 12 °C was significantly lower than that of Désirée 4 °C.

Table 5. Total tuber yields in 1979 (early and final harvest), 1980 and 1981 (final harvest) tonnes/ha for the cvs. Jaerla and Désirée, stored at 4 °C or 12 °C.

| Treatment | 1979 | | 1980 | 1981 | |
|--------------------|---------|---------------|---------------|---------------|------|
| | 23 July | final harvest | final harvest | final harvest | |
| | | | | I | II |
| Jaerla 4 °C | 23.6 | 47.1 | 57.2 | 52.6 | 46.6 |
| Jaerla 12 °C | 13.9 | 44.8 | 49.1 | | |
| Désirée 4 °C | 21.2 | 46.9 | 51.4 | 54.0 | 47.1 |
| Désirée 12 °C | 19.8 | 47.9 | 53.2 | 53.3 | 39.8 |
| LSD ($P < 0.05$) | 2.7 | 2.7 | 9.5 | 2.3 | 5.4 |

Tabelle 5. Knollen-Gesamterträge 1979 (frühe und späte Ernte) in Tonnen pro ha bei den Sorten Désirée und Jaerla, bei 4 °C und 12 °C gelagert.

Tableau 5. Rendement total en tubercule en 1979 (récoltes précoce et finale), 1980 et 1981 (récolte finale) en tonne/ha pour les variétés Jaerla et Désirée conservées à 4 °C et 12 °C.

Discussion

Although some authors have found that physiologically older seed has a faster emergence than younger seed (Iritani, 1968; O'Brien et al., 1983), others have found no difference (Madec & Perennec, 1962; Bus & Schepers, 1978 and pers. comm.). Iritani (1968) and O'Brien et al. (1983) planted seed when it had its first sprout, which was much longer for the older seed, but in our experiments the physiologically older seed (12 °C treatments) emerged more slowly in all years, except Désirée in 1979, than the seed stored at 4 °C. This is in accordance with results of Fischnich & Krug (1963) who found almost no difference in time of emergence when using resprouted seed, as we did in 1979. However in our experiments seed stored at 12 °C emerged later than seed stored at 4 °C after desprouting just before planting.

In all three years, the sprouting capacity of both Jaerla 4 °C and Désirée 4 °C on the planting dates of the field experiments was just before or at its maximum. On those dates the sprouting capacity of the 12 °C treatments had already passed its maximum, with Jaerla being further from its maximum sprouting capacity than Désirée (Hartmans & van Loon, 1987). The results obtained from the Jaerla seed that had been subjected to the 12 °C treatment indicate that these tubers were physiologically very old. However, with the exception of the tubers planted on the second planting date in 1981, the Désirée tubers subjected to the 12 °C treatment did not behave as if they were physiologically very old: crop development and yield were good. Compared with the 4 °C treatments the *initial development* of the 12 °C treatments was slower for both cultivars in the 1980 and 1981 experiments. This contrasts with the findings of Madec & Perennec (1962), Kawakami (1963), Rønsen (1977) and others, who reported faster initial development of crops from physiologically older, but pre-sprouted seed. In our experiments, the seed tubers were desprouted the day before planting. This might be why they behaved differently. In Désirée the time of *tuber initiation* was not influenced by the previous storage temperature of the seed. This

implies that the 12 °C treatment, which emerged later than the 4 °C treatment, had a somewhat shorter period between emergence and tuber initiation than the 4 °C treatments. In both cultivars, physiologically young seed tubers produced more *stems* per plant than the old seed tubers; this agrees with the results of the growth chamber experiments (Bodlaender & Marinus, 1987) and with those of Madec & Perennec (1955) and Allen et al. (1978).

The *number of tubers per plant* differed between treatments. The lower number of tubers per plant of Désirée 12 °C in 1981, which was also found in the growth chamber experiments (Bodlaender & Marinus, 1987), is in contrast with the findings of others (Kawakami, 1952; Goodwin et al., 1969; Hossain & Rybáček, 1978), who obtained more tubers from physiologically older seed than from younger seed.

In all three years, including the 2nd planting in 1981, the *senescence* of Désirée 12 °C was later than that of Désirée 4 °C. This contrasts with reports of Toosey (1963), Iritani (1968), Rozier-Vinot (1971) and Wurr (1978b), who found earlier senescence for the physiologically oldest seed. For Jaerla a comparison of senescence rates is only possible for 1979 and 1980. Just as for Désirée, the 12 °C treatment matured latest, but here the cause might be the low plant density (poor emergence), which would have boosted the development of the individual plants because each plant had more space and more nitrogen.

The main reason that in 1979 and 1980 the *final tuber yield* of Jaerla 12 °C was lower than that of Jaerla 4 °C is probably the lower plant density. The lower tuber yield obtained from Désirée 12 °C planted at the later date in 1981 might also be attributable to the reduced plant density (only two thirds of the seed tubers emerged, resulting in a lower percentage of soil cover in the first part of the growth period). It seems that the slower senescence of Désirée 12 °C could not compensate for the lower plant density.

Désirée 4 °C and 12 °C yielded almost the same in 1979, 1980 and the earlier planting of 1981. The lack of a yield difference between physiologically older and young seed agrees with the findings of Hossain & Rybáček (1978) and Bus & Schepers (1978), but not with those of Iritani (1968) and Reust (1982) who found that the physiologically oldest seed gave lower yields. However, in Reust's experiments, little potato occurred in the oldest seed, resulting in reduced plant density.

Wurr (1978a) found contrasting results between years when comparing physiologically younger and older seed. He inferred that environmental conditions during plant growth had an influence on the effect of physiological aging of seed on yield potential. The contrasting results that many authors have reported on the effect of physiological age of the seed tuber on plant development and yield seem to fit into the theory developed by Kawakami (1962) based on his own results and those of others. He suggested that a tuber exhibits its own characteristic growth pattern, according to its stage of physiological development. If planted at the proper physiological age the plant emerges quickly, develops several stems and will give high yields. However, if at planting the tuber is at an unsuitable age (i.e. before or after the 'proper age'), plant development will be slower and yields will be sub-optimal. Regarding the yield level, one should remember that the 'proper age' of the seed varies, depending on the length of the growing period of the crop. To obtain high yields in a short period, the seed should be physiologically older than when a long growing period is available. Kawakami's ideas seem to be confirmed by results obtained by Perennec & Madec (1980).

The results of the research with Jaerla and Désirée reported here agree with those of Kawakami (1962) and Perennec & Madec (1980).

Acknowledgement

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Zusammenfassung

Einfluss des physiologischen Alters auf die Wachstumsintensität von Pflanzkartoffeln bei zwei Sorten. 4. Einfluss von Lagerperiode und Lagertemperatur auf Wachstum und Ertrag im Feld

In einer Feldstudie mit den Sorten Jaerla und Désirée wurde der Einfluss von Lagertemperatur und -periode in der Periode 1979–81 untersucht, bei Lagerung im Dunkeln bei 4 °C oder 12 °C, als Teil einer kombinierten Studie über die Auswirkung des physiologischen Alters auf die Wachstumsintensität der Pflanzknollen. 1979 wurden die Pflanzknollen einige Zeit vor Pflanzung entkeimt und anschliessend vorgekeimt. 1980 und 1981 dagegen wurden die Knollen unmittelbar vor der Pflanzung entkeimt.

Die 12 °C-Behandlungen liefen langsamer auf als bei 4 °C gelagerte Pflanzknollen (Tabelle 1). Jaerla zeigte bei 12 °C unvollständigen Auflauf wegen der Bildung von Knöllchen. Im Gegensatz zu den 4 °C-Behandlungen liefen die Knollen bei 12 °C unregelmässig auf. Bei den Behandlungen mit Désirée ergaben sich keine Unterschiede bei der Zeit der Knollen-Initiierung. Wegen des Auftretens von Knöllchen konnte bei Jaerla kein zuverlässiger Vergleich gemacht werden. Das initiale Blattwachstum war bei den 4 °C-Behandlungen schneller. Es ergaben sich bei den Behandlungen mit Désirée fast

keine Unterschiede bei der lateralen Triebentwicklung oberhalb der ersten Blüte (Abb. 1). Es ergab sich eine unterschiedliche Rate bei der Seneszenz mit einem langsameren Rückgang der Bodenbedeckung bei den 12 °C-Behandlungen (Tabelle 2). Bei beiden Sorten ergab junges Pflanzgut mehr Triebe pro Pflanze als älteres (Tabelle 3). Bei Désirée ergaben sich bei 12 °C mehr Knollen pro Trieb als bei 4 °C. Dennoch zeigte sich kein durchgehender Trend bei der Knollenzahl je Pflanze (Tabelle 4).

In allen drei Jahren zeigte der Knollenertrag ein ähnliches Muster (Tabelle 5). 1979 und 1980 waren die 'späteren' Knollenerträge von Jaerla bei 12 °C niedriger als bei 4 °C, aber der Unterschied war nur signifikant bei der früheren Ernte. 1979 und 1980 gab es keinen signifikanten Unterschied in dem Ertrag zwischen den zwei Behandlungen von Désirée. 1981 war kein Unterschied beim 'späteren' Ertrag zwischen den Temperatur-Behandlungen für das erste Pflanzdatum, der Ertrag von Désirée bei 12 °C, bei Pflanzzeit II gepflanzt, war signifikant niedriger als bei 4 °C.

Résumé

Effet de l'âge physiologique sur la vigueur de croissance du plant de pomme de terre de deux variétés. 4. Influence de la durée et de la température de conservation sur la croissance et le rendement au champ

L'influence de la température et de la durée de conservation sur la croissance et le rendement sont évalués de 1979 à 1981 dans un champ d'essais avec les variétés Jaerla et

Désirée, conservées à 4 °C et 12 °C, à l'obscurité, dans une étude concertée ayant pour objectif de mettre en évidence l'effet de l'âge physiologique sur la vigueur du plant. En

1979, le plant était égermé quelque temps avant la plantation et remis en prégermination; en 1980 et 1981, il était égermé juste avant la plantation.

Les plants traités à 12 °C lèvent plus lentement que ceux conservés à 4 °C (tableau 1). Jaerla à 12 °C présente une levée incomplète résultant d'un boulage. A l'inverse du traitement à 4 °C, le traitement à 12 °C donne une levée irrégulière. Il n'y a pas de différence dans le temps d'initiation des tubercules de Désirée pour les deux traitements. Dans la mesure où Jaerla produit du boulage, il ne peut être établi de comparaison dans ce domaine. La croissance initiale du feuillage est plus rapide avec la conservation à 4 °C. Il n'y a pratiquement pas de différence entre les deux traitements de Désirée pour le développement des pousses latérales au-dessus de la hampe florale (figure 1). On observe une différence au niveau de la senescence avec une plus lente déclinaison dans la couverture du sol pour le traitement à 12 °C (tableau 2).

Dans les deux variétés, le plant jeune produit plus de tiges par plante que le vieux plant (tableau 3). Il y a plus de tubercules par tige pour Désirée à 12 °C qu'à 4 °C, sans pour cela montrer une tendance logique à plus de tubercules par plante (tableau 4).

Le rendement en tubercules montre un modèle identique pour les trois années (tableau 5). En 1979 et 1980, le rendement final en tubercules de la variété Jaerla conservée à 12 °C est plus faible que celui de cette variété conservée à 4 °C, mais la différence n'est significative que pour la récolte précoce. En 1979 et 1980, il n'y a pas de différence significative dans le rendement des deux traitements de Désirée. En 1981, il n'y a pas de différence dans le rendement final entre les deux températures de conservation pour la première date de plantation mais le rendement de Désirée conservée à 12 °C et plantée à la deuxième date est significativement plus faible que celui obtenu avec du plant conservé à 4 °C.

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