SHORTENING DORMANCY OF SEED POTATOES BY A HAULM APPLICATION OF GIBBERELLIC ACID AND STORAGE TEMPERATURE REGIMES

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Abstract

In three experiments with cvs Diamant (short dormancy) and Désirée (long dormancy), the effect of a haulm application of gibberellic acid (GA) on the dormancy of seed potatoes harvested immature was investigated. Several storage temperature regimes were imposed to examine the interaction between GA and storage temperature. The storage regimes included 18 and 28 C continuously, hot pre-treatments of different duration (different periods at 28 C and subsequently 18 C) and a cold pre-treatment (20 days at 2 C and subsequently 18 C).

A foliar spray of 375-750 g GA/ha 3-6 days before haulm killing shortened dormancy, and minimally induced sprouting before harvest. The magnitude of the GA effect depended on the cultivar and storage temperature regime. Compared to untreated tubers stored at 18 C, dormancy was shortened by about 40 days by a GA application and storage at 18 C (Diamant) or by about 90 days by a GA application and storage at 28 C (Désirée).

Compendio

Se investigó, en tres experimentos, con los cultivares Diamant (de reposo corto) y Désirée (de reposo prolongado), el efecto de la aplicación de ácido giberélico (GA) al follaje sobre el reposo de tubérculos-semillas de papa cosechados inmaduros. Se aplicaron varios regimenes de temperatura en el almacenamiento para observar la interacción entre el GA y la temperatura en el almacenamiento. Los regimenes en el almacenamiento incluyeron 18 y 28 C aplicados continuamente, pretratamientos de calor de diferente duración (diferentes periodos a 28 C y posteriormente a 18 C) y un tratamiento frío (20 días a 2 C y posteriormente a 18 C).

Una aplicación foliar de 375-750 g GA/ha, 3-6 días antes de la eliminación del follaje, acortó el reposo, e indujo el brotamiento, en forma mínima, antes de la cosecha. La magnitud del efecto del GA dependió del cultivar y del régimen de temperatura en el almacenamiento. En comparación con los tubérculos que no recibieron tratamiento, almacenados a 18 C, el reposo se redujo en 40 días con una aplicación de GA y un almacenamiento a 18

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C (Diamant), o en 90 días con una aplicación de GA y almacenamiento a 28 C (Désirée).

Introduction

Since the beginning of this century, researchers have been searching for possibilities to shorten the dormancy period of seed potatoes in order to be able to plant the tubers as soon as possible after their harvest. Numerous chemical methods have been examined, but only a few proved to be useful (3, 5). Since the 1950's, the dormancy shortening effect of gibberellic acid (GA) has been known. It was also shown that the end of tuber dormancy of potatoes coincided with an increase in the activity of endogeneous gibberellins (1, 19).

Dipping or soaking cut tubers in GA appears to shorten dormancy, but the effects of GA on intact tubers are variable (2, 18, 22). Tubers treated with GA may produce abnormally elongated sprouts and morphologically deviating plants (4, 15, 22), and dipping has also phytosanitary disadvantages. There are a few reports in the literature about efforts to shorten tuber dormancy by means of a haulm application of GA at tuber initiation (7) or 1-4 week(s) prior to harvest (12, 24). Such treatments seemed to offer promise, but have not been investigated in further detail.

Van Ittersum & Scholte (10) showed that there are large possibilities to shorten dormancy by means of some storage temperature regimes applied immediately after harvest.

In the present research, we investigated the effect of a haulm application of GA (3-14 days prior to haulm killing) on dormancy of seed tubers harvested immature, as well as its interaction with storage temperature regimes. The effects of GA and storage regimes on the growth vigor of seed tubers will be reported in another paper (11).

Materials and Methods

General Procedure

In 1988-90, three experiments (Expts 1-3) were carried out with cvs Diamant (short dormancy period) and Désirée (long dormancy period). Expts 1 and 3 were conducted at the experimental farm Ir. A.P. Minderhoudhoeve in the East Flevoland polder (52 °N lat.), on a calcareous marine clay soil. Expt 2 was carried out near Wageningen on a sandy soil. Agronomic and experimental details are given in Table 1.

The date of spraying the GA was chosen based on the size of the tubers, aphid pressure, and the weather forecast (calm and dry weather was preferred). "Berelex" powder (ICI, Rotterdam, the Netherlands, 92% gibberellin A_3) was dissolved in a small amount of ethanol. It is not sure whether the active compound in our experiments was indeed GA_3, or a possible impurity (*e.g.* GA_1, personal communication, E. Knegt, Wageningen Agricultural University). The GA solution was sprayed on the foliage in

TABLE 1.—*Experimental details of the Experiments 1-3.*

Descriptor	Expt 1	Expt 2	Expt 3
Year	1988	1989	1990
Planting date	April 21	April 20	April 10
Plant spacing (cm)	25x75	25x75	25x75
Gross plot dimensions (m)	7x3	4.5x4.5	35x3
Net plot dimensions (m)	5x1.5	2.5x3	30x1.5
Total available nitrogen (kg N/ha)	150	175	120
Tuber initiation (DAP[a])[b]	49-55	38-48	40-44
Haulm destruction (DAP)	96	84	83
Harvest (DAP)	118	97	104
Mean soil temperature at -5 cm (C) between haulm removal and harvest	19.8	21.5	19.0
Start of storage regimes:			
-Days after planting (DAP)	123	103	108
-Days after haulm destruction (DAH)	27	19	25

[a]DAP = days after planting.
[b]The first date indicates the date for Désirée and the second that for Diamant.

1000 l water per ha, using a knapsack sprayer. The control treatments were sprayed with a mixture of water and the same amount of ethanol as used for the GA treatments, and all treatments were applied before noon.

The haulms were removed by pulling, except in Expt 1, where the haulms were killed chemically with dinoseb (DNPB in oil, Luxan, Elst, NL, 250 g/l a.i.). Twenty l/ha and 10 l/ha of the trade product were sprayed 96 and 114 days after planting, respectively. Tubers were left in the soil for 2-3 weeks after which they were harvested. Subsequently, tubers ranging in size from 35-50 mm, free from damage, greening, or diseases were taken to the laboratory. If present, the sprouts on tubers from plants treated with GA were removed, unless otherwise mentioned. In Expt 3, tubers were disinfected against *Helminthosporium solani* with imazalil (Fungazalil 10L, Luxan, Elst, NL, 10% a.i.). The seed was immersed for 2 sec in a 1% solution of the trade product. Tubers were stored in darkness at 18 C and 80% RH until the start of the storage regimes.

Dormancy parameters were assessed by regular (2-3 times a week) observations on tuber samples (30 tubers each; the range in the weight of individual samples did not exceed 1.5% within cultivars). Dormancy of each stored tuber was deemed to have ended when at least one vigorous sprout 2 mm long was present. Some (about 15%) of the tubers from GA-treated plants produced very thin and elongated sprouts, without a thickened base. These sprouts often showed necroses and did not continue growth. Therefore, such tubers were not considered to have ended dormancy. Generally, not long after the formation of these sprouts, the tubers produced vigorous sprouts.

The duration of dormancy of a sample was defined as the period in days from haulm destruction until the moment that 80% of the tubers had ended dormancy (17). The spread in duration of dormancy for a sample was characterized by the time lapse between 10 and 90% sprouting (9).

In all experiments, a constant storage temperature of 18 ± 0.5 C was considered as the standard. In Expts 2 and 3, effects of other temperature regimes were related to this standard. Storage took place in dark controlled environments with 80% RH.

Treatments and Observations

Experiment 1—The experimental design of this experiment was a split-plot with four blocks, cultivars as main factor and GA treatments as split factor. Besides the control, the treatments were 70 or 375 g GA/ha 7 or 14 days before chemical haulm killing (DBH).

One 30-tuber sample (individual tubers 35-50 mm and 50-90 g) per plot was taken. All samples were stored at 18 C.

From the GA-treated plants a number of tubers that sprouted in the soil were harvested carefully and stored without desprouting. The dry-matter concentration in the tubers was determined by drying a sample of ca 400 g in an oven at 105 C for 16 h.

The number of sprouts (≥ 2 mm) per tuber was recorded 99 (Diamant) or 150 (Désirée) days after haulm destruction (DAH).

Experiment 2—The experimental design of the field experiment was the same as in Expt 1. Besides the control, the treatments were 375 or 750 g GA/ha 3, 6 or 9 days before haulm pulling (DBH).

Three 30-tuber samples (individual tuber weight 40-80 g) per plot were taken and stored at: 18 C (T18), 28 C (T28) or 20 days at 2 C and subsequently 18 C (T2/18).

At haulm pulling, haulm fresh and dry weights were recorded for the control and the sprays at 9 DBH. Tuber yields at harvest of all treatments were determined, and the dry-matter concentration in the tubers was assessed.

Experiment 3—Two GA haulm treatments (0 and 750 g GA/ha at 6 DBH) were applied in two replications, for both cultivars. Tuber samples were taken, comprising 30 tubers (15 tubers from each of the two replications; individual tuber weight 40-80 g), and stored for 0, 2, 4, 6, 8, 10, or 12 weeks at 28 C before transfer to 18 C (hot pre-treatments of different duration). Three samples per treatment were used.

Possible differences in the GA effect in relation to tuber weight were investigated by also storing 60 small (15-30 g) tubers per cultivar and GA treatment at 18 C.

The number of sprouts ≥ 2 mm per tuber was recorded 3 weeks after the end of dormancy of each treatment.

Experimental Set-up During the Storage Periods

There was one controlled environment (chamber) for each storage temperature, and storage temperatures were randomized over the chambers. Tubers were stored in egg trays (one sample per tray).

In Expts 1 and 2, the samples were ranked according to their plot number of the field experiment. In Expt 3, each chamber was divided into three units (blocks) and these units were subdivided in two subunits. The treatment factors were storage temperature regimes, cultivars and GA treatments. For each replication (block), the cultivars were randomized over the subunits and the GA treatments (and storage regimes if there were more storage treatments in one chamber, *e.g.* hot pre-treatments of different duration after they were transferred to 18 C) were randomized over the egg trays within the subunits. The experimental design was a factorial nested design.

Results

General Effects of GA— Foliar GA spray (especially the higher concentrations) resulted in foliage elongation and in a light-green leaf color, first visible about 3 days after spraying. Approximately 8-10 days after the relatively early (7 to 14 DBH) sprays, some tubers of Diamant started to sprout in the soil. At harvest, many tubers from plants sprayed relatively early showed one or more elongated sprouts and occasionally (375 g GA/ha at 14 DBH, Expt 1) even secondary tubers. Diamant showed more sprouted tubers than Désirée. Tubers from later sprayed plants showed less (6 DBH) or no (3 DBH) sprouting at harvest. However, the slightly elongated buds which sometimes developed on tubers receiving these treatments were damaged at harvest.

During storage, the tubers from GA-treated plants frequently started to sprout from a lateral or basal eye, whereas tubers from untreated plants generally showed apical sprouts. Sprouts on tubers from treated plants initially lengthened rapidly. The sprouts were slightly more elongated than usual, but showed an ordinary thickened base with root primordia.

In all experiments, the interactions among cultivar, GA treatment, and storage regimes (Expts 2 and 3) were highly significant ($P < 0.001$) for dormancy parameters and the number of sprouts per tuber.

Experiment 1— Haulm killing was incomplete after the first spray with dinoseb. At harvest, most tubers from the GA-treated plants showed sprouts up to several centimeters long. These sprouts did not resume their growth during storage until the time that desprouted tubers also resumed sprouting.

Tuber dry-matter concentrations were significantly lowered by GA, up to 1.7% by the earliest spray and the highest concentration (data not shown).

Dormancy was clearly shortened by a spray of 375 g GA/ha at 7 or 14 DBH (Table 2). For Désirée, the application at 7 DBH was more effective than the one at 14 DBH. The low GA concentration only gave a significant shortening for Diamant when applied 7 DBH.

For plants sprayed with 375 g GA/ha at 7 or 14 DBH, 1 and 3%, respectively of the tubers of Désirée did not produce sprouts during storage.

The effects of GA on the spread in duration of dormancy (time lapse between 10 and 90% sprouting) were small, except for Désirée (Table 2). For this cultivar, the spread increased noticeably when the 375 g GA/ha concentration was applied.

Sprout number of tubers from plants sprayed with a high GA concentration was significantly ($P < 0.05$) higher than that of tubers from control plants (Diamant: 1.7 vs 1.2 sprouts per tuber and Désirée: 1.8 vs 1.5 sprouts per tuber). Sprouts on tubers from plants sprayed with 375 g GA/ha showed slightly more calcium deficiency than other treatments.

Experiment 2—Within 20 h after the sprays at 6 DBH, 13 mm precipitation was measured. Consequently, these GA applications were quite ineffective and results are not presented.

For both cultivars, tuber fresh weights were not significantly affected, but tuber dry-matter concentrations were significantly lowered by high concentrations or early sprays of GA (Table 3). The tuber dry weight yield of plants treated with 750 g GA/ha at 9 DBH was significantly lower (ca 9%) than that of the control, whereas the haulm dry weight of this treatment was significantly greater. Total dry weights were not affected by GA.

The 750 g GA/ha treatment tended to shorten dormancy more than the 375 g/ha GA treatment, but this was not clear after cold pre-treatments (Table 4). Differences between the sprays at 3 and 9 DBH were small. For Diamant, GA had the greatest effect on dormancy duration (up to 49 days), when storage took place at 18 C; many tubers started sprouting almost immediately after harvest. For Désirée, the largest effect (up to 36 days)

TABLE 2.—*The effect of different haulm applications of gibberellic acid (GA) on duration of tuber dormancy (days to 80% sprouted) and the spread in duration of tuber dormancy (days between 10 and 90% sprouted), for Diamant and Désirée.*

Treatment	Duration (DAH[a])[b]		Spread (days)[c]	
	"Diamant"	"Désirée"	"Diamant"	"Désirée"
Control	79	142	23	17
70 g GA/ha at 14 DBH[a]	76	139	27	20
375 g GA/ha at 14 DBH	58	122	23	37
70 g GA/ha at 7 DBH	65	142	26	21
375 g GA/ha at 7 DBH	57	115	17	29

[a]DAH = days after haulm destruction; DBH = days before haulm destruction.
[b]LSD = 4.5 ($P = 0.05$), for comparisons within a cultivar.
[c]LSD = 7.2 ($P = 0.05$), for comparisons within a cultivar.

was obtained after storage at 28 C. The treatments 750 g GA/ha at 3 or 9 DBH plus storage at 28 C shortened dormancy of Désirée by more than 100 days compared with the control treatment stored at 18 C. For both cultivars, GA only had a small extra shortening effect (10 days or less), when a cold pre-treatment (T2/18) was applied during storage.

TABLE 3.—*The effect of a foliar spray with gibberellic acid (375 or 750 g GA/ha) at 3 or 9 days before haulm pulling (3 or 9 DBH) on the haulm, tuber and total weights, averaged over two potato cultivars (Diamant and Désirée).*

Parameter	Control	GA application				LSD[a] (P = 0.05)
		3 DBH		9 DBH		
		375	750	375	750	
Tuber fresh weight (g/m²)	3246	3335	3246	3331	3221	ns
Dry matter conc. tuber (g/kg)	204	202	194	191	187	6.7
Tuber dry weight (g/m²)	658	671	644	632	600	51
Haulm dry weight (g/m²)	476	–[b]	–	504	551	55
Total dry weight (g/m²)	1134	–	–	1136	1151	ns

[a]ns = not significant.
[b] – = not recorded.

TABLE 4.—*The effect of different haulm applications of gibberellic acid (GA) on duration of tuber dormancy and the spread in duration of tuber dormancy at various storage temperature regimes, for Diamant and Désirée.*

	cv. Diamant			cv. Désirée		
GA treatment/Storage regimes[a]	T18	T28	T2/18	T18	T28	T2/18
Duration of dormancy (DAH[b])[c]						
Control	95	83	70	152	86	131
375 g GA/ha at 9 DBH[b]	60	65	66	133	60	122
750 g GA/ha at 9 DBH	51	61	65	125	50	121
375 g GA/ha at 3 DBH	50	69	64	134	60	124
750 g GA/ha at 3 DBH	46	63	63	131	50	121
Spread in duration of dormancy (days)[d]						
Control	30	22	14	27	24	26
375 g GA/ha at 9 DBH	33	32	11	40	36	44
750 g GA/ha at 9 DBH	23	35	10	44	36	52
375 g GA/ha at 3 DBH	27	41	11	32	37	32
750 g GA/ha at 3 DBH	21	37	9	36	34	43

[a]T18 = 18 C; T28 = 28 C; T2/18 = 20 days at 2 C and subsequently 18 C.
[b]DAH = days after haulm pulling; DBH = days before haulm pulling.
[c]LSD = 7.1 (P = 0.05), for comparisons between GA treatments within a cultivar and storage regime combination, and 10.3 for all comparisons within a cultivar.
[d]LSD = 8.7 (P = 0.05), for comparisons between GA treatments within a cultivar and storage regime combination, and 10.5 for all comparisons within a cultivar.

Storage at 28 C itself had a much larger effect on dormancy of Désirée than that of Diamant, whereas the effect of the cold pre-treatment was similar for both cultivars.

One percent of the Désirée tubers from GA-treated plants and stored at 28 C did not sprout during storage.

For T28 of Diamant, and all regimes of Désirée, the GA treatments resulted in a much larger spread in duration of dormancy than the control treatment (Table 4).

Experiment 3—For Diamant, GA had a shortening effect of 28 days when storage took place at 18 C (Fig. 1a, 0 weeks), whereas the effects were smaller after hot pre-treatments of 2 or more weeks. For Désirée, the shortening effect of GA was 29 days at 18 C, but the effect increased up to 66 days after hot pre-treatments of 2-4 weeks (Fig. 1b). For both cultivars, the treatments with the shortest dormancy showed sprouted tubers very soon after the start of storage (25 DAH).

All cultivar and GA treatment combinations showed a minimum duration of dormancy, but after different storage durations at 28 C (Fig. 1a, b). The storage duration at 28 C resulting in this minimum duration of dormancy was shorter for tubers from GA-treated plants, and shorter for Diamant than for Désirée.

Two percent of the Diamant tubers from treated plants and stored for 6 weeks at 28 C did not sprout at all. For Désirée, this percentage varied from 1 to 6% for tubers from GA-treated plants and stored for 0-6 weeks at 28 C.

There was no significant difference in the dormancy shortening effect of GA on large tubers and small tubers, when storage took place at 18 C (data not shown).

The spread in duration of dormancy increased by GA, when sprouting took place at 28 C (Fig. 1c, d). For Diamant, hot pre-treatments slightly longer than the ones resulting in the shortest dormancy resulted in very small spreads. Tubers from untreated plants of Désirée and stored for 4 weeks at 28 C showed an extremely large spread.

For Diamant, GA increased the number of sprouts per tuber after storage at 18 C or after short hot pre-treatments, whereas the opposite was true after storage with longer periods at 28 C (Fig. 1e). Without a GA application the sprout number increased the longer the tubers were stored at 28 C, but it decreased again after a maximum number was reached for 8 weeks storage at 28 C. This maximum sprout number followed by a decrease occurred in a treatment with a much shorter storage duration at 28 C for tubers from treated plants. The GA application and storage regimes had little effect on the sprout number with Désirée (Fig. 1f).

Discussion

Effect of GA—A haulm application of GA, shortly before haulm killing, has a tuber dormancy shortening effect of many weeks. Over the range

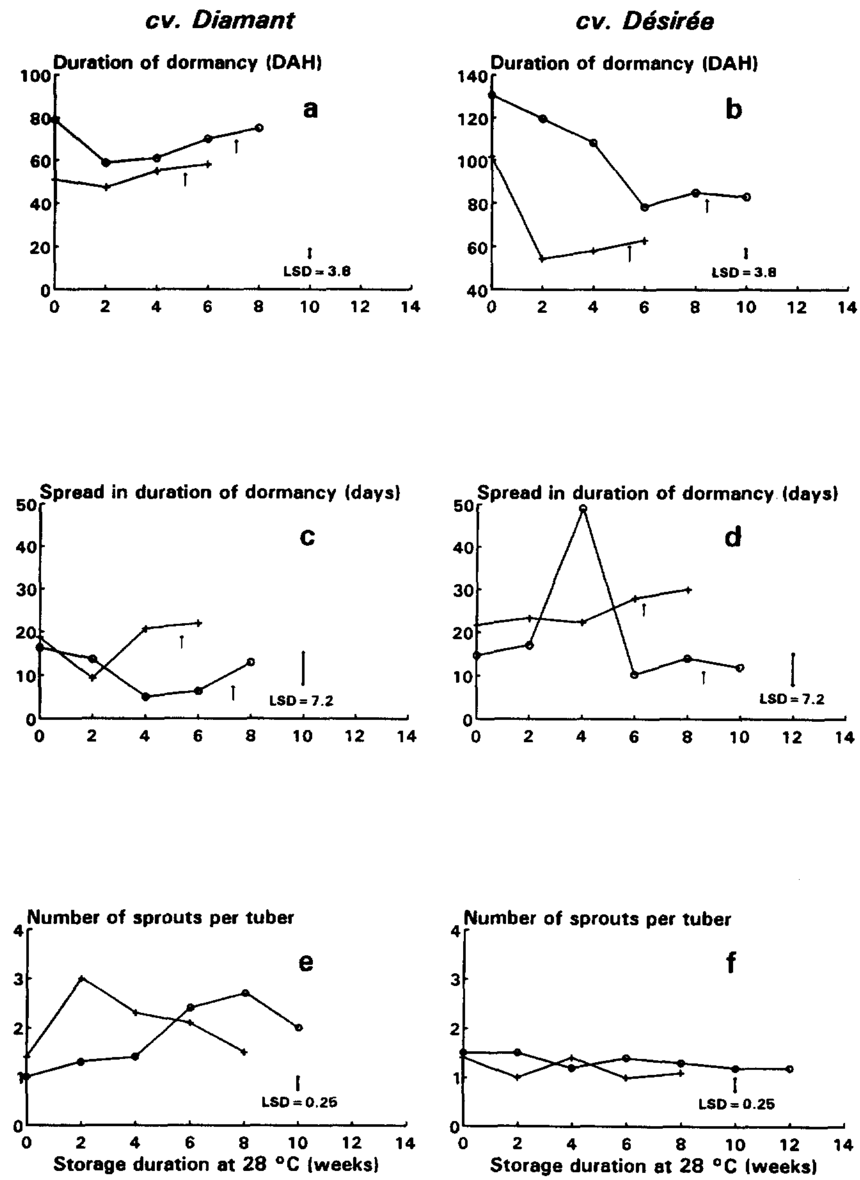

FIG. 1. The effect of a foliar spray of gibberellic acid (750 g GA/ha at 6 days before haulm pulling) and different storage periods at 28 C before transfer to 18 C on the duration of dormancy (a and b; DAH = days after haulm pulling), the spread in duration of dormancy (c and d) and the number of sprouts (≥ 2 mm) per tuber, 3 weeks after the end of dormancy (e and f), for Diamant and Désirée. The vertical bars denote the LSD (P = 0.05) for comparisons between treatments. The arrows indicate the date that 80% (Fig. a, b) or 90% (Fig. c, d) of the tubers were sprouted at 28 C. o = no GA; + = +GA.

of 3 to 14 days before haulm killing, the moment of application did not seem to be of great importance. It seems that exogenous GA is transported readily in the entire conductive vascular system of a plant (14). A late application (3-6 DBH) has several advantages. It resulted in minimal sprouting before harvest and therefore is more favorable from a phytosanitary point of view since at harvest sprouts will break and cause tuber injuries (12). Moreover, a late application did not cause second growth phenomena and had no negative effects on tuber yields (cf. 6, 20). The effect of the concentration of the application seemed to be fairly limited over the range of 375-750 g GA/ha, whereas low concentrations are clearly less effective (16). It is important that the GA is taken up before significant rainfall occurs.

The shape and morphology of the sprouts on tubers from GA-treated plants differed only slightly from those on tubers from untreated plants, in contrast to sprouts on *tubers* treated with GA (8, 15). A small disadvantage of the haulm treatment with GA may be that a few (1-6%) of the tubers (especially of Désirée) lost their sprouting capacity. This was more clear if tubers were stored at 28 C.

Sprouts that were formed when the tubers were still attached to the mother plant did not continue their growth after harvest (or perhaps not after haulm killing). This shows resemblance to the findings of Fischnich *et al.* (6) and Madec & Perennec (13), and to the behavior of heat sprouts formed on tubers when plants were exposed to high temperatures (Van Ittersum & Scholte, unpublished results). Madec & Perennec (13) treated cuttings with GA and the tubers on the cuttings started sprouting subsequently (or regrowing according to their terminology). The sprouts did not continue to grow after harvest, whereas during storage sprouting of tubers from treated cuttings was advanced by several weeks compared with tubers from untreated cuttings. They suggested that absence of bud growth before and after harvest is not controlled by the same factors. Sprouting of tubers when they are still attached to the plant is due to a temporary interruption of the inhibition of the buds by the plant.

In most cases, a haulm application of GA resulted in a larger spread in duration of dormancy within the tuber samples. There is no reason to assume that this larger spread is due to a different GA effect on dormancy of tubers of different sizes (Expt 3).

Generally, the number of sprouts produced by tubers from GA-treated plants was only slightly higher than that produced by tubers from untreated plants, despite the fact that sprouts grown before harvest were removed and some buds may have been damaged at harvest.

Interaction Between GA and Storage Temperature Regimes — For Diamant, the effect of a GA application on dormancy was smaller after hot pre-treatments than after storage at 18 C, whereas for Désirée the effect of GA was larger after short hot pre-treatments than after storage at 18 C (Expt 3). This seems plausible if both high GA concentrations in the tuber and storage at 28 C are effective in releasing dormancy, but that 28 C is a supra-optimum temperature for sprout growth (10). Apparently for Diamant (genetically short dormancy), the spray with GA almost suffices to release dormancy, and subsequent storage at 28 C delays sprout growth. For Désirée (genetically long dormancy), the tubers still respond to storage at 28 C after a GA treatment. In this reasoning, it is also not surprising that the duration of storage at 28 C resulting in the shortest dormancy was greater for both cultivars when the foliage was not sprayed with GA, and greatest for Désirée (Fig. 1a, b). Besides the concentration of plant hormones, the sensitivity of the plant tissue to these substances is important (23). It could be surmised that storage at 28 C increases the sensitivity to GA, because for Désirée the effect of GA was much greater after hot pre-treatments of 2-4 weeks than after continuous storage at 18 C.

The very small spread in duration of dormancy after hot pre-treatments slightly longer than the ones resulting in the shortest dormancy of Diamant (4-6 weeks at 28 C without a GA spray, and 2 weeks at 28 C with a GA spray) supports the assumption that 28 C is favorable to release dormancy, but supra-optimum for subsequent sprout growth. At the end of the 28 C-periods, all tubers are ready for sprouting and buds will grow rapidly when the temperature for sprout growth is optimum (15-20 C; 3). For Désirée, these trends were not evident. It is remarkable that for tubers from untreated Désirée plants, a hot pre-treatment of 4 weeks (slightly shorter than the one resulting in the shortest dormancy) was enough to break dormancy of only some of the tubers, whereas dormancy of other tubers from the same harvest was hardly shortened, giving rise to a very large spread (Fig. 1d). In other experiments we also found that storage treatments with short periods of high or low temperatures may result in a very large spread in duration of dormancy (10).

It is not surprising that a cold pre-treatment had minimal shortening effect on tuber dormancy for Diamant plants sprayed with GA (Table 4), as some tubers from plants sprayed with GA started sprouting almost immediately after harvest. For Désirée, the effect of GA was also small after a cold pre-treatment. An interaction between the effect of GA and a cold pre-treatment is conceivable if a cold pre-treatment results in a higher GA activity (21). This possibly implies smaller effects of GA after cold pre-treatments.

Conclusions

Dormancy of seed tubers harvested immature can be shortened markedly by a foliar spray of GA 3-6 days before haulm killing, with minimal pre-harvest sprouting or negative effects on sprout morphology. The effect of GA on dormancy depends highly on the cultivar and storage temperature regime. The duration of dormancy of Diamant and Désirée was reduced by 30-50 or 80-100 days, respectively, with a foliar spray of GA and storage at an appropriate temperature regime. Part of the interaction among cultivar, GA, and storage temperature regime can be explained by the assumption that both GA and storage at 28 C are effective in releasing dormancy, whereas 28 C is supra-optimum for sprout growth.

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