

Changes in endogenous growth inhibitors in onion bulbs (*Allium cepa* L.) cv. Sochaczewska during storage

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Abstract

Changes in inhibitor activity in the onion bulbs (*Allium cepa* L.) cv. Sochaczewska during storage were investigated. Onions were dried under an umbrella roof until October 15th or November 15th and thereafter stored in a cold-room at 0-1°C until May 15th. The activity of inhibitors fluctuated markedly during the storage period. At least two peaks and two decreases of inhibitor activity were observed. The weather conditions seemed to strongly influence the level and the date of appearance of inhibitors in onions. Higher inhibitor activity is usually connected with better storage and less sprouting of onions during storage. Prolonged drying under an umbrella roof enhanced onion quality after storage only in these cases when it actually improved the drying of onions.

INTRODUCTION

Onion bulbs show various storage ability depending on the weather conditions during the vegetation season and pre-storage drying. It seemed therefore interesting to investigate the changes of the activity of different hormones during the storage in successive years which differed markedly with their weather conditions.

Endogenous growth inhibitors, discussed in this paper, seem to be an important factor in onion dormancy. Several authors, for instance Isenberg et al. (1974), suppose that dormancy is connected with a high level of inhibitors and a low level of growth promoters. However, it is known today that dormancy is a very complex process with each of its many steps of specific hormonal regulation (Lewak, 1979). Trewavas (1986) also pointed out the complexity of developmental processes of regulation in plants.

Growth inhibitors are produced in onion leaves and translocated into the bulb during ripening (Kato, 1966b; Thomas and Isenberg, 1972, 1975;

Isenberg, 1978). Early removal of leaves prior to harvest (Stow, 1975), or early artificial desiccation of leaves (Aoba, 1963) both result in a shorter dormant period. Thomas (1969) and Isenberg et al. (1974) found high concentration of inhibitors soon after onion harvest.

Syrtanova and Rakhimbayev (1983) observed ABA as unique inhibitor in several bulb plants with short summer dormancy (*Tulipa* sp., *Juno caerulea*, *Korolkowia seversovii*), but, in the bulb plants with long dormancy, besides ABA another unknown inhibitor was found.

In the present work the time-course of changes in inhibitor activity was investigated in onion bulbs during storage. Two pre-storage periods of drying were applied. The investigations were performed during the course of four seasons.

MATERIAL AND METHODS

The investigations were performed with onions cv. Sochaczewska from the mid. of October 1979 until mid. of May 1983.

Onions were cultivated in 1979, 1981 and 1982 at Guzów near Skierniewice (central Poland) on black soils and in 1980 at Leszkowice near Głogów (south-west of Poland) on alluvial soils.

Weather conditions differed from year to year (Fig. 1). The 1979 season was relatively warm and not too wet in the first months of the vegetation period, cold and rainy — in August and September. The year 1980 was relatively dry and warm. In the year 1981 — June and July and also October and November were very humid. Starting from July, the temperatures were below the many-years average. The year 1982 was dry and warm.

The experiments were made in two variants, onions were dried under an umbrella roof: I — to October 15th and II — to November 15th. Thereafter onions from both variants were stored in a cold room at 0-1°C until May 15th. Sampling was repeated every month. At each sampling, hormones were extracted from plugs 1.5 cm in diameter taken from the center of bulbs with the base plate.

Twenty five grams of tissue were homogenized with 50 cm³ of a mixture of 96% ethanol and methanol 4:1 (v/v) and filtered. The residue was extracted 2 times with the same volume of alcohols. The obtained extracts were combined and evaporated in vacuum at 40°C to the aqueous phase, adjusted to pH 3.5 with 10% HCl and partitioned against ethyl acetate 3 times. Ethyl acetate fractions after evaporation to dryness were dissolved in ethanol and put on TLC-plates (Kieselgel 60F-254). Separation occurred in a mixture of isopropanol-ammonia-water (10:1:1) by ascending chromatography. The chromatograms were divided into 1 cm wide sections and eluted with water. The activity of endogenous growth inhibitors was determined by the wheat coleoptile straight growth test according to Nitsch (1956).

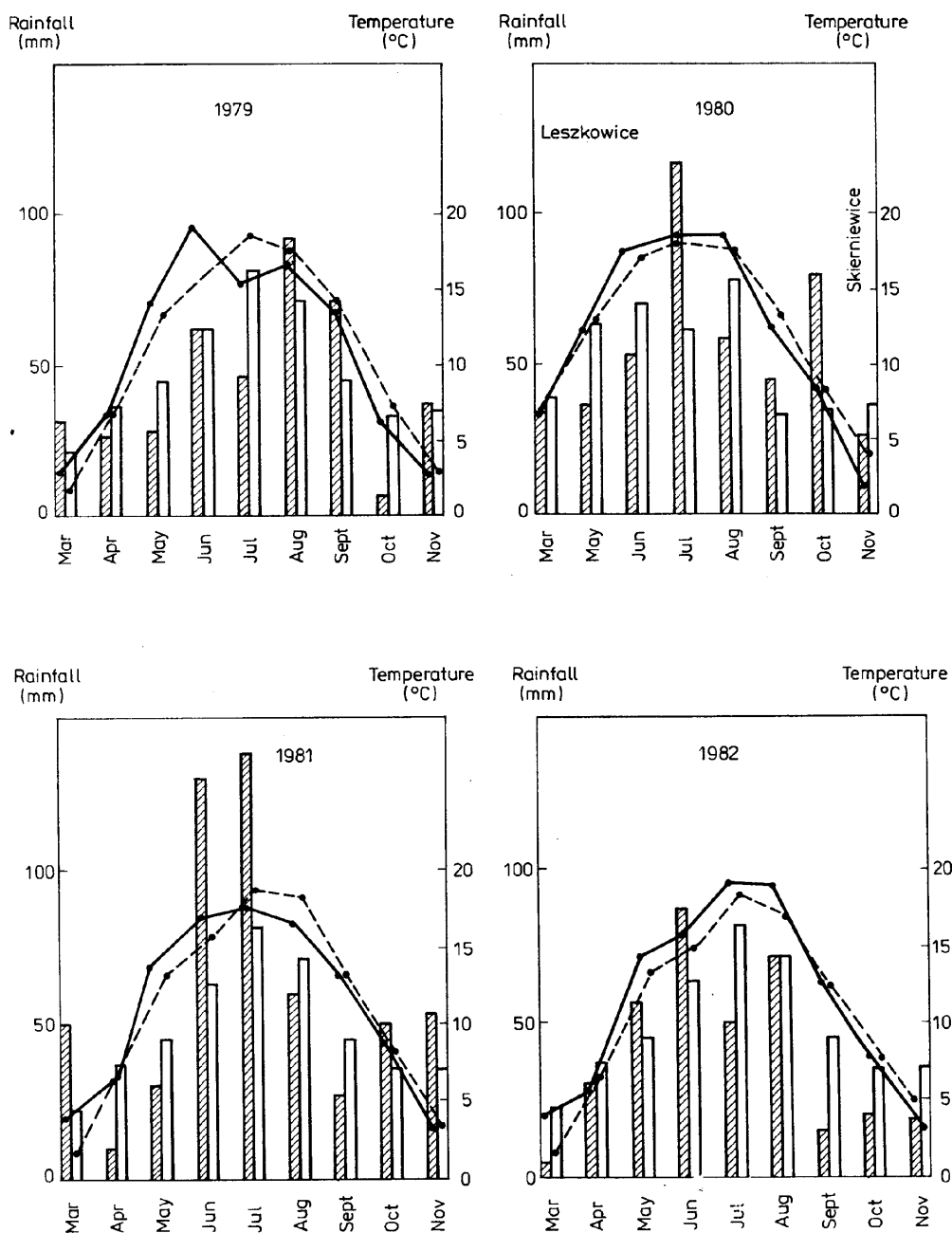


Fig. 1. Average monthly air-temperatures and total rainfall in successive experimental seasons in relation to many-year averages of temperatures (1921-1960) and total rainfall for Skierniewice (Leszkowice)

Parallely the observations of sprouting and rooting of onion bulbs after storage in low temperature were done each month from March to May in the seasons 1980/1981 and 1981/1982. In 1982/1983 observations of internal onion leaf growth and their external sprouting were done. The onions had been placed in perlite pellet medium at room temperature.

RESULTS AND DISCUSSION

Detailed observations of the fluctuation of inhibition activity often showed no activity at the beginning of the experiment — October 15th (Figs. 2, 4, 5). The only exception was the year 1980/1981 (Fig. 3), with a warm and dry July. Possibly due to this the low activity of inhibitors occurred earlier than in October.

The first period of higher inhibitor activity occurred in late autumn — early winter. This peak took place in both variants (onions dried to October 15th and onions dried to November 15th). As mentioned it appeared earlier in warm and dry years.

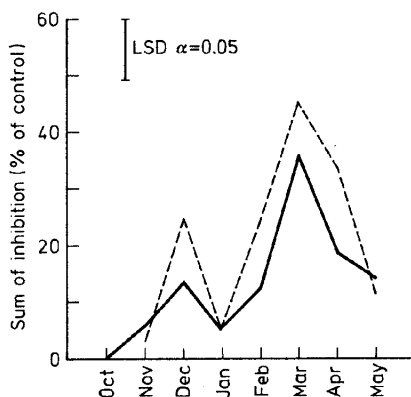


Fig. 2. Changes of endogenous inhibitor activity in onions in the 1979/1980 season.
— Drying to October 15; ---- Drying to November 15

The second peak occurred in late winter — early spring. It was very high and came earlier in the warm and dry years. Only the year 1981/1982 was exceptional, in that the second peak (in March) was much smaller than the first and visible only in the bulbs dried longer (up to November 15th), whereas the last peak in May was well visible (Fig. 4). The weather of this year was exceptional by showing very high precipitations not only in June-July but also in October-November when the bulbs were dried under an umbrella roof.

A third slight increase of inhibitor activity was observed in the years 1980/1981 and 1982/1983 in bulbs dried to October 15th (Figs. 3, 5).

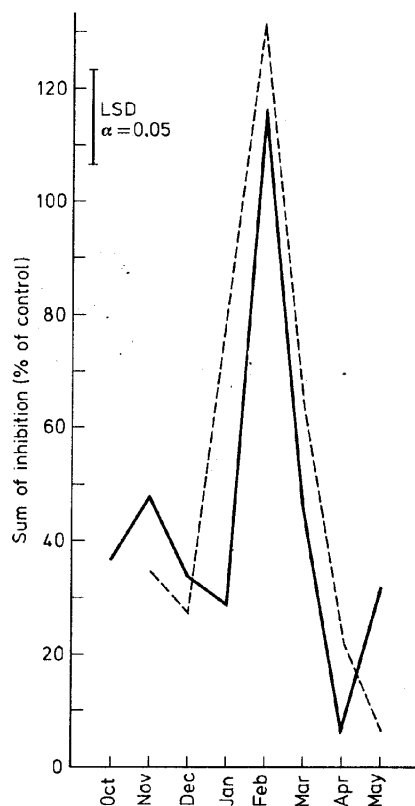


Fig. 3. Changes of endogenous inhibitor activity in onions in the 1980/1981 season.
 —Drying to October 15; -----Drying to November 15

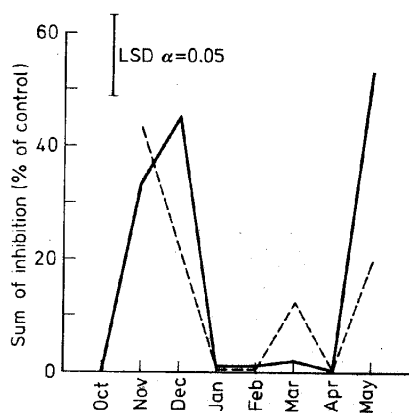


Fig. 4. Changes of endogenous inhibitor activity in onions in the 1981/1982 season.
 — Drying to October 15; -----Drying to November 15

The bulbs dried for the longer period (up to November 15th) showed (in most periods) higher activity in 1979/1980 and 1980/1981. In contrast, in 1981/1982 such bulbs showed lower inhibitor activity in December and May. The differences in other months were insignificant. In 1982/1983 there was less inhibition in February in bulbs dried until November 15th. It seems interesting that in all cases when the material contained more inhibitors, its storage ability was better.

One aspect of better storage is later sprouting. This factor seems to be positively related with inhibitor activity. The higher this activity the later the sprouting (Table 1, 2, 3, Figs. 3, 4, 5).

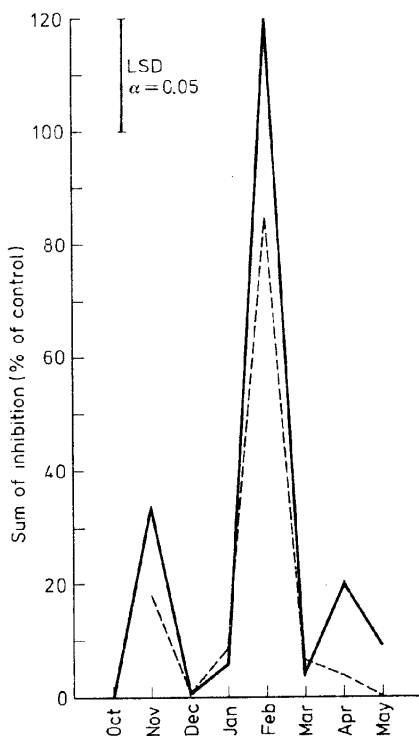


Fig. 5. Changes of endogenous inhibitor activity in onions in the 1982/1983 season.
 — Drying to October 15; -----Drying to November 15

The presented results indicate that drying for one month longer under an umbrella roof is not efficient and does not prolong bulb storage when the weather in October-November is wet, as in 1981/1982 (Table 2).

On the other hand, when the bulbs are already well dried on October 15th, keeping them further under an umbrella roof is not needed and even may provoke some unnecessary stimulation of the growing processes and thus may shorten the storage period (Table 3).

Table 1

Fresh weight of onions with leaves and roots in kg (per 10 kg of onion sample) in 1980/1981 season

Variant of experiment Onions dried	Date of observations		
	March 19th	April 16th	May 20th
Up to October 15th	2.92	5.75	6.75
Up to November 15th	2.70	4.97	6.37

Table 2

Fresh weight of onions with leaves and roots in kg (per 10 kg of onion sample) in 1981/1982 season

Variant of experiment Onions dried	Date of observations		
	March 19th	April 4th	May 5th
Up to October 15th	5.30	6.13	7.85
Up to November 15th	5.10	6.48	8.63

Table 3

Percentage of onion bulbs with internal and external sprouts after 10 days of observations in 1982/1983 season

Variant of experiment Onions dried	Internal sprouts				External sprouts		
	Nov.	Dec.	Jan.	Feb.	March	April	May
Up to October 15th	60.0	93.0	100.0	86.5	93.0	100.0	100.0
Up to November 15th	80.0	82.0	79.0	100.0	100.0	100.0	100.0

The presented results show that the activity of inhibitors fluctuated markedly during the storage period. Earlier papers (Kato, 1966b; Thomas and Isenberg, 1972) showed only a progressive decrease of this activity as dormancy subsided. It is possible that the vernal increase of inhibition observed in the present work is connected with the synthesis of growth inhibitors in the new, growing leaves in spring. This observation is partially confirmed by investigation of inhibitor activity in the green leaves growing outside of the bulbs (Table 4) which show high levels of inhibition (97.7%) in contrast to plugs of bulbs (18.5%).

Table 4
Inhibitor activity in different parts of onions

Analyzed organs	Inhibition in relation to control test in %										Sum of inhibition (in % control)	
	Rf	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9		1.0
Leaves of onions growing outside bulbs		17.6*	7.7*	8.4*	4.5*	5.9*	2.8	1.8	6.4*	10.4*	36.6*	97.7
Plugs of bulbs 1.5 cm ø with a stem		4.7*	0.7	3.0	5.5*	1.8	2.6	1.3	0.6	3.0	8.3*	18.5

* Difference statistically significant at $\alpha = 0.05$.

Since we have not identified the inhibitors, it is not certain if those which occur in the first peak are the same as those in the second one. As mentioned, Syrtanova and Rakhimbayev (1983) have found ABA and an unknown inhibitor in bulb species with a long period of dormancy. More than one inhibitor may occur in onion bulbs with maxima appearing in different time.

The obtained results show two main features:

- there are very marked differences in inhibitor activity from year to year. In warm and dry seasons (1980/1981 and 1982/1983) the second maximum of this activity occurred earlier and was higher;

- the inhibitor activity in onions bulbs fluctuates, showing at least two peaks and two decreases.

CONCLUSIONS

1. Weather conditions seem to strongly influence the level and the date of appearance of inhibitors in onions. Warm and dry weather seems to promote higher and earlier occurrence of inhibitor activity.

2. Higher inhibitor activity is usually connected with better storage and less sprouting of onions.

3. Prolonged drying under an umbrella roof is only efficient in these cases if it actually leads to the better drying of onions. In the cases of a very wet autumn or when onions are sufficiently dried earlier, longer drying under an umbrella roof does not promote better storage.

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Zmiany endogennych inhibitorów wzrostu w cebuli (*Allium cepa* L.) odm. Sochaczewska podczas przechowywania

Streszczenie

Badano zmiany aktywności inhibitorów wzrostu w cebuli (*Allium cepa* L.) odm. Sochaczewska podczas przechowywania. Cebulę dosuszano pod wiatą do 15 października lub do 15 listopada, a następnie przechowywano w komorze chłodniczej o temp. 0-1°C do 15 maja. Stwierdzono znaczne zmiany aktywności inhibitorów podczas przechowywania, występowały co najmniej dwa okresy zwiększonej i dwa okresy zmniejszonej aktywności inhibitorów. Zaobserwowano, że warunki pogody w czasie wegetacji mają znaczny wpływ na aktywność i czas występowania inhibitorów. Wykazano, że lepsze wyniki przechowywania (mniejszy procent wyrosniętych cebul) związane były z wyższym poziomem inhibitorów. Dłuższe dosuszanie pod wiatą tylko w tym przypadku wywierało korzystny wpływ na przechowywanie cebuli, o ile powodowało lepsze jej dosuszenie.