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Germination of *Cynara* seeds ; effect of light and temperature and function of the endosperm

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SUMMARY

The germination behaviour of globe artichoke (*Cynara scolymus* L.) seeds is described. Germination was partially inhibited by light and/or by elevated temperatures (30°-35° C). At 30 °C seeds exuded a greyish mucilage which seemed to originate from vestiges of the endosperm. The resulting discontinuity of this tissue did not affect subsequent germination at 20° of seeds which previously failed to germinate at 30 °C. The excretion of this exudate at higher temperatures may induce a kind of dormancy which is immediately alleviated at lower temperatures.

Additional key words : *Cynara scolymus* L., *Cynara syriaca* Boiss., artichoke, mucilage, water.

RÉSUMÉ

Germination des semences de Cynara. Effets de la lumière et de la température ; fonction de l'albumen.

La germination des akènes d'artichaut (*Cynara scolymus* L.) est décrite. Elle est partiellement inhibée par la lumière et/ou par des températures élevées (30°-35 °C). A 30 °C, les akènes excrètent un mucilage grisâtre, provenant probablement des vestiges de l'albumen, dont la désaggrégation n'empêche pas la germination, à 20 °C, des akènes auparavant inhibés à 30 °C. L'excrétion du mucilage à haute température pourrait induire une sorte de dormance qui serait levée immédiatement par des températures plus basses.

Mots clés additionnels : *Cynara scolymus* L., *Cynara syriaca* Boiss., artichaut, mucilage, eau.

I. INTRODUCTION

Globe artichokes (*Cynara scolymus* L.) are usually propagated vegetatively. This method is intricate and expensive and growers, therefore, often replant their fields when yields decrease (RYDER *et al.*, 1983). Today, production costs can be cut drastically since true-to-type breeding varieties can be grown from seed (FOURY, 1979). Moreover, since artichokes from seed are virus-free, this method of production minimizes the inherent danger of yield depression characteristic of traditional stocks (PECAUT, 1983 ; MIGLIORI *et al.*, 1984). A better understanding of the developmental biology of artichokes (FOURY, 1980 ; BASNIZKI *et al.*, 1981 ; BASNIZKI, 1984) provides a sound basis for modern agrotechnical methods.

Seed-grown artichoke production is therefore feasible in areas with mild winter climate — especially in central and southern Mediterranean areas. The germination of seeds in autumn is generally not a problem. Problems arise, however, when temperatures and humidity are high. Within this framework we

studied the germination of artichoke seeds and will report on some special aspects of their behaviour.

II. MATERIALS AND METHODS

Seeds of two varieties of *C. scolymus* cv. 'Camus' and cv. 'Violet de Provence' were obtained from open-pollinated plants growing in isolated plots used for head production. The third variety, 'Talpiot', was a true-breeding commercial variety obtained from Hazera seed company. In addition we used seeds of the wild species *Cynara syriaca* Boiss., which were obtained from selected capitula.

Germination was normally in 9-cm Petri dishes with one Whatman No. 3 filter paper, 12 ml water and 25 seeds, unless otherwise stated. Prior to sowing, seeds were immersed for 60 s in 1 % HgCl₂ and then rinsed. The seeds were selected for intactness, since mechanical damage impairs germination.

Germination experiments were usually in 4 replicates and germination defined as root protrusion.

Observations were made every 24 h. Speed of germination was calculated as described by CÔME (1967). Germination was either in the dark or in incandescent light, $4\text{--}4.8 \times 10^4 \text{ erg.cm}^2.\text{s}^{-1}$. Germination temperatures were as stated.

Preliminary field experiments indicated that *C. scolymus* cv. 'Talpiot' and *C. syriaca* failed to germinate in the dark at 30°–35 °C, while exuding a greyish mucilage. At high temperatures in the field, they germinated poorly when irrigated to 30–40 % of class A-pan evapotranspiration, but under heavy irrigation — 100 % E.T.P. — they germinated rapidly. This led us to study the effect of the amount of water on germination as well as the effect of rinsing seeds.

The anatomy of the seeds was studied on hand-cut sections stained with ruthenium red.

III. — RESULTS AND DISCUSSION

Optimal germination of *C. syriaca* in darkness occurred at 10°–20 °C (fig. 1A), as may be expected in a wild plant which germinates during the rainy season of the Levant. The cultivars of *C. scolymus* had slightly higher temperature requirements — their optima were 15°–20 °C for cv. 'Camus' and 'Violet de Provence' respectively. At 10 °C the germination capacity of both cultivars was low, whereas 35 °C impaired germination of both wild and cultivated artichokes. Root formation at 35 °C showed unusual features: the roots were peg-like, abnormally thickened and therefore their ability to function is questionable.

Light depressed germination by 10 % in *C. syriaca* and 82 % in 'Camus' (fig. 1B). Optimal germination in light was at 20 °C. This contrasts with germination in darkness where there was no clear optimal temperature. At 35 °C, germination in light was inhibited. The interaction of temperature and light as described here for artichokes, has frequently been reported for a variety of other seeds (MAYER & POLJAKOFF-MAYER, 1982; BEWLEY & BLACK, 1982).

The mean speed of germination (table 1) in darkness was fastest at 20–35 °C, whereas at 10 °C it was significantly slower. Under light conditions the mean

Figure 1

Germination percentage after 10 days of cultivated and wild *Cynara* seeds at various temperatures in darkness (A) and in light (B).

Pourcentage de germination d'akènes d'artichaut (*C. scolymus* et *C. syriaca*), après 10 jours, à différentes températures, à l'obscurité (A) et à la lumière (B).

I = S.E.

●—● cv. 'Violet de Provence' ○—○ cv. 'Camus' Δ—Δ *Cynara syriaca*.

speed of germination was somewhat slower as compared with darkness. At 35 °C in darkness the germination capacity of seeds was impaired, but the mean speed of germination was unaffected. In the light germination was inhibited.

The data on germination in darkness resemble results obtained by PATOUREL *et al.* (1980/1981). Discrepancies between the two studies may be due to differences in plant material. PATOUREL *et al.* worked with inbred lines and hybrids whereas our work was done with unselected natural seed populations. Differences in growth conditions of the mother plant as pointed out by PATOUREL, as well as effects of the age of mother plants on 1 000-weight, and germination capacity of seeds (BASNIZKI, not published) can also cause discrepancies.

Under East Mediterranean and presumably also under South Mediterranean conditions, globe artichoke seeds must be sown until mid-October, i.e. under rather hot climatic conditions. Since the irrigation regime appeared to influence germination in the field, we tested the effect of the amount of water on germination.

TABLE 1

Mean speed of germination (days) of cultivated artichokes and *Cynara syriaca* Boiss. at various temperatures in darkness (D) and light (L).
Vitesse moyenne de germination d'artichauts cultivés et de *Cynara syriaca* à différentes températures à l'obscurité (D) et à la lumière (L).

cv. Violet de Provence			cv. Camus			<i>Cynara syriaca</i>		
Temp. °C	Number of Days		Temp. °C	Number of Days		Temp. °C	Number of Days	
	D	L		D	L		D	L
10°	6.7b	6.2a	10°	9.4b	10.2c	10°C	8.4b	7.2b
15°	5.7ab	5.8a	15°	7.9b	7.7b	15°	5.7a	5.8a
20°	4.9a	5.3a	20°	6.0a	5.7a	20°	5.6a	5.7a
25°	5.1a	6.9b	25°	7.0a	5.8a	25°	6.9a	5.8b
35°	5.3a	—	35°	5.8a	—	35°	6.6a	—

Values followed by the same letter do not differ significantly at 0.05 level of Neumann-Keul's Q-test.

The mean speed of germination is :
$$\frac{N_1 T_1 + N_2 T_2 + N_3 T_3 \dots + N_n T_n}{N_1 + N_2 + N_3 \dots + N_n}$$

where n stands for the individual germinating seed at time T (CÔME, 1967).

Seeds were germinated in Petri dishes containing various amounts of water from 3 to 40 ml. At 20 °C in darkness, and increase from 3 to 30 did not affect germination (fig. 2). Immersion of seeds in 40 ml probably resulted in anoxia and germination was impaired.

Figure 2

Germination and swelling of artichoke seeds at 20 °C ●—● or 30 °C △—△ in relation to volume of water added.

Germination et gonflement d'akènes d'artichaut à 20 °C ●—● ou 30 °C △—△ en fonction du volume d'eau.

At 30 °C no germination occurred — the seed only showed swelling and splitting of the seed coat. Moreover, a slight increase in the volume of water (from 6 to 9 ml) drastically reduced even these phenomena (fig. 2), and the seeds showed the typical exudate. Removal of the exudate by rinsing failed to cause germination at 30 °C — indicating that no leachable germination inhibitor is involved. Transfer of mucilage-covered seeds to 20 °C after 15 days at 30° restored normal germination after a lag of 2-3 days. The exudate could not therefore be respon-

sible for failure of germination. However, continued rinsing of seeds with exudate seriously impaired germination at 20 °C.

Cynara seeds are rather heat-resistant and germination of wetted seeds at relatively high temperature is prevented. Similar heat resistance was reported by PATOUREL *et al.* (1980/1981) but exudation was not mentioned. In their experiments, seeds maintained at 40 °C for 29 days germinated 70 % at 20 °C. But after 44 days at 40 °C only 30 % of the seeds germinated at 20 °C. Whether removal of exudate or prolonged exposure to high temperatures affect the same systems remains to be investigated.

The exudate originated in a layer 1 or 2 cells thick within the pericarp. It is probable that these cells are vestiges of the endosperm (fig. 3). Some properties of the endosperm of Compositae, including ability of cell walls to swell, have been described by NETOLITZKI (1926) for *Cnicus benedictus* L., *Matricaria chamomilla* L. and *Taraxacum officinale* Weber. The physiological role of the endosperm in the germination of *Lactuca sativa* L. and *Lactuca scariola* L. was described by EVENARI & NEUMANN (1952). CORNER (1976) describes seeds of Compositae as having «thin, papery, generally albuminous seed coats». FOURY (1982) followed lysis of the endosperm by the growing embryo of *Cynara* and mentions the existence of a layer of endosperm «... above the embryo» — 140 hours after zygote formation. Our study indicated the existence and possible function of the endosperm in artichokes.

IV. CONCLUSIONS

Seeds of *C. syriaca* germinate readily after maturation in July but climatic conditions for seedling

a

b

Figure 3

a. Section through young artichoke seed showing endosperm layer. b. Section through seed coat of mature seed, partially imbibed, showing cotyledons (C) residual mucilage (M) attached to seed coat (S) or free. (E) endosperm.

Magnification × 137.

a. Coupe d'un jeune akène d'artichaut montrant l'albumen. b. Coupe à travers l'enveloppe d'un akène mûr d'artichaut, partiellement imbibé, montrant les deux cotylédons (C), les résidus de mucilage (M) attachés ou séparés de l'enveloppe (S). (E) albumen.

Grossissement × 137.

establishment rarely exist before December, when the soil is moist enough for root growth. Earlier germination as a result of early rains can jeopardize seedling survival but the heat and light sensitivity of the seeds prevent premature germination. The excretion of mucilaginous exudate might be a way to prevent germination. It has indeed been suggested that mucilaginous layers act as barriers to gaseous diffusion, especially to O₂ (e.g. in *Blepharis persica*) (GUTTERMAN *et al.*, 1967; GUTTERMAN, 1973). Although this has not been proven (MAYER & POLJAKOFF-MAYBER, 1982), it is possible that the mucilaginous layer in *Cynara* seeds fulfils similar functions.

However, mucilage-covered seeds germinate readily at lower temperatures. They also germinate well after long exposure to high temperatures (PATOUREL *et al.*, 1980/1981). This contradicts the above suggestions, but might indicate thermo-regulatory functions of the *Cynara* seed endosperm.

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