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FIELD BEHAVIOUR OF YAM (*DIOSCOREA ALATA* L.) FROM
IN VITRO CULTURE, IN STAGGERED PLANTINGS

(*Comportement au champ d'igname (D. alata L.) issu de
culture in vitro en plantations échelonnées*)

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SUMMARY

Tissue culture of *D. alata* cv Lupias, supplies in all seasons plantlets of which morphology and development patterns present some similarities with seedlings of closely related species.

Plantings, irrigated and staggered between september and april show that later behaviour of those plantlets depends on planting season. Two effects are observed :

On one hand a reduction of maximum development attained by aerial and underground parts after planting under short or decreasing days ; on the other hand a certain regrouping of dieback dates of aerial parts for all plantings and a regrouping still more drastic of sprouting dates.

The first effect brings about a yield reduction as compared to april planting, sensitive since september and very severe from october to december plantings. The second effect annihilated since next year the initial temporal shift induced by out of season planting. The results are very close of those obtained generally with staggered plantings from yam tubers of *D. alata* presenting signs more or less accused of ageing. As they cannot be here attributed to the mother tuber, we conclude that the difficulty of out of season cultivation of that species is due to a great sensitiveness to environmental factors, (thermo-photo-periodism).

RESUME

La culture *in vitro* de *D. alata* cv. "Lupias" fournit en toute saison des jeunes plantes dont la morphologie et le mode de développement initial sont proches des caractéristiques des jeunes semis d'espèces voisines. Des plantations irriguées échelonnées entre septembre et avril montrent que le comportement ultérieur de ces vitroplants dépend de la saison de plantation. On observe deux effets : d'une part une réduction des développements maximaux atteints par la partie aérienne et la partie souterraine après plantation en conditions de jours courts ou décroissants (la partie souterraine étant relativement moins affectée que la partie aérienne) ; d'autre part un certain regroupement des dates de fanaison de la partie aérienne de toutes les plantations, et un regroupement encore plus net des dates de germination. Le premier effet occasionne une diminution du rendement par rapport à la plantation d'avril, sensible dès la plantation de septembre et très sévère pour les plantations d'octobre à décembre. Le deuxième effet annule dès l'année suivante le décalage temporel initial conféré par la plantation hors saison. Ces résultats sont très voisins de ceux généralement obtenus avec des plantations échelonnées de tubercules de *D. alata* présentant des signes plus ou moins nets de vieillissement. Comme ils ne peuvent, ici, être attribués au tubercule-mère, on en conclut que la difficulté de cultiver cette espèce hors-saison provient principalement d'une grande sensibilité aux facteurs du milieu (thermo-photopériode).

INTRODUCTION

In respect of out-of-season production, *Dioscorea alata* has been the most studied species among cultivated yams. Using chemicals, CAMPBELL et al (1962) shortened the tuber rest period and could plant sets from January to June in Trinidad : neither yield nor growing period were altered. On the other hand, all the experiments of delayed planting revealed that sets planted from July to November had lesser yield and reduced growing period, irrespective of the means used to store the planting material : chemicals (GOODING and HOAD, 1967), disbudding (CLAIRON and ZINSOU, 1980), cooled storage (ARNOLIN, 1981). The subsequent rest period may (CLAIRON and ZINSOU, 1980), or may not (ARNOLIN, 1981), also be shortened so that sprouting occurs at the normal date the following year. When planted in December or January (storage time > 1 year), the sets have "anarchic" (ARNOLIN, 1981) vegetative durations. At last, planting later than January (storage time - 1 year) leads to vigorous plants with normal vegetative cycles (ARNOLIN, 1981 ; MATHURIN, 1982).

From all those reports the behaviour of *D. alata* appears very dependent on the planting date. However it must be pointed out that they are all derived from the use of aged tubers as planting material, so that those results may have two different origins : an internal factor (the ageing of the tuber) and an environmental factor.

The purpose of the present study was to sort out those two effects, through staggered plantings of non-aged material. Since *D. alata* has no seeds, we used in vitro culture, which supplied us with young plants all year long. The growth and development pattern of that material is rather similar to that of usual sets, in spite of a few juvenile characteristics at the early stages (LACOINTE, 1984 ; LACOINTE and ZINSOU, 1986).

MATERIAL AND METHODS

The in vitro culture was initiated with uninodal 2 cm long vine-cuttings, collected from *D. alata* cv. Lupias grown indoor, and inoculated one per culture tube after surface - sterilizing by calcium hypochlorite 7 per cent. The culture medium is MURASHIGE and SKOOG'S (1962) added with vitamins, aminoacids and active coal. The cultures were grown under 150 W/cm² fluorescent light for 12 hr. daily at 25° ± 1°C.

After 3 months the rooted plantlets were either cut into uninodal pieces for the next subculture, or prepared as planting material. In the latter purpose, the plantlets were grown on peat, in a chamber misted for 1 mn every 75 mn. After 1 month they were potted and grown in a greenhouse, and after a further month they were transferred to the field.

One week before planting, the ferral soil of Domaine Duclos (Guadeloupe) was fertilized with N, P, K : 120-70-120, as ammonitrate, supertriple and potassium sulphate. The sets were planted 1 m far from each other, every 40 days from September 1982 to April 1983. Every plant was provided with a 2 m high stake. Whenever the soil became dry under the depth of 5 cm, it was irrigated with sprinklers.

For each planting the variations of total leaf number, total vine length and total leaf area, were derived from monthly samplings (n = 5 to 10 sets). Fresh tuber weight was recorded ; aerial part and tubers were also weighed after drying at 80°C. At the end of the vegetative period, the mature tubers were harvested and weighed ; some of them were weighed after drying, the remaining were stored until sprouting.

The statistical processing of data was carried out with non-parametric methods, mostly Kruskal and Wallis'test.

RESULTS AND DISCUSSION

Aerial part growth and development

The maximum leaf numbers reached by the different plantings were very dissimilar (Fig. 1a). In spite of a very

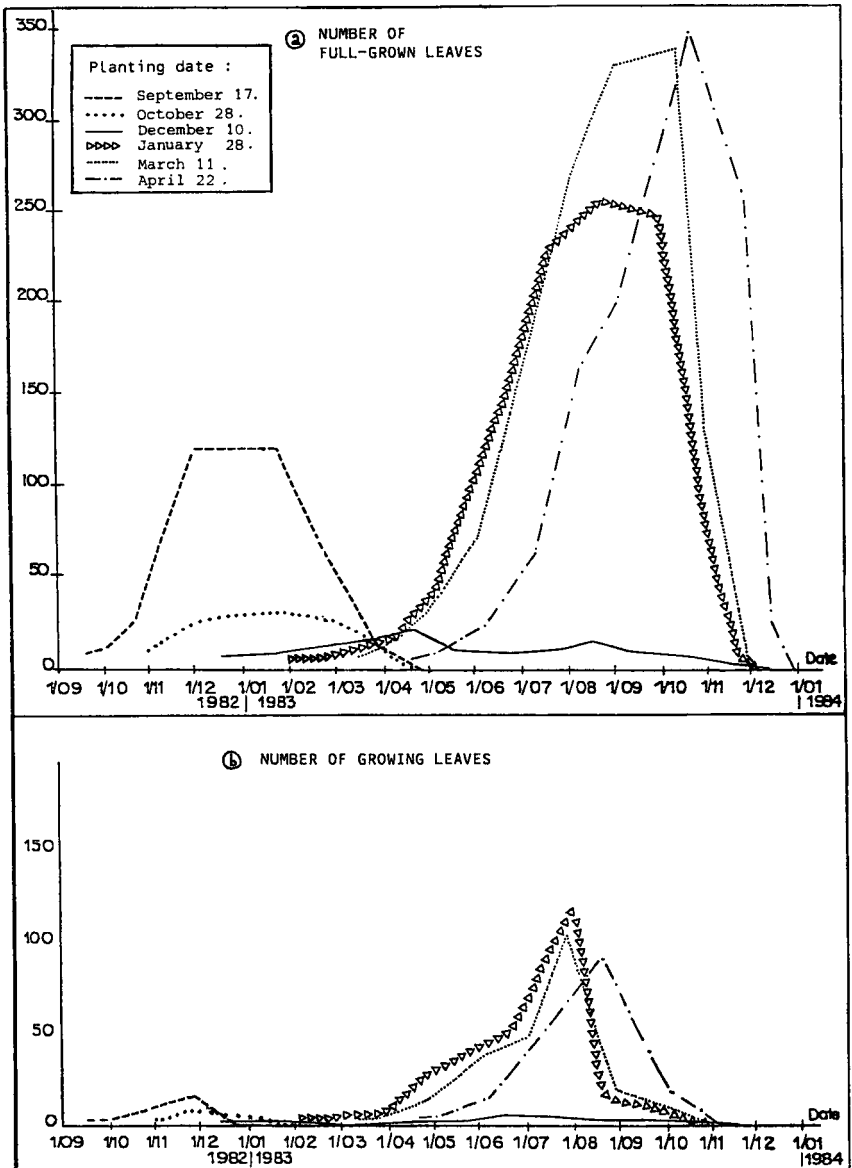


Fig.1 : Variations of total leaf number per plant

high variability within plantings (Fig. 2a), the differences between them were so important that they could be classed into 3 groups significantly different from each other (Fig. 2b). Measurements of any other character of the aerial part led to the same classing.

That classing is clearly related to the planting season : the lowest group (Nr. 1) corresponds to planting under short, decreasing days and the highest group (Nr. 3) corresponds to planting under increasing days. Since the sets we used for the different plantings are assumed to be comparable, that effect appears to be related to environmental variations.

In fact, aerial growth seemed nearly impossible from about December to March, whatever the planting date might be (Fig. 1b) ; it took place before - if it had time enough - or after - if the vines had not died down. The September planting is representative of the first case ; the January, March and April plantings, of the second case. As for the October planting, it could grow in neither period. Neither could most (80 per cent) of the December planting, which had lost their stems before mid-June. The remaining 20 per cent kept them much longer and resumed aerial growth in the same time as the later plantings, up to the dimension reached by the September planting. That is the main origin of the extreme variability (Fig. 2a) of the December planting, similar to the "anarchic" behaviour recorded by ARNOLIN (1981) ; it led us to divide that planting into 2 subpopulations.

When plotting vegetative duration, or other aspects of growth dynamics, versus planting date (Fig. 2c), that partition within the December planting appears as a discontinuity on a curve decreasing anywhere else, with short duration before and long durations after. That effect is very similar to that observed on sets from seed-tubers. It may be considered as an indirect consequence of the unfavourable influence of the December to March period on aerial growth, since stems die 3 or 4 months after they have stopped if there is no replacement before the latest stem dies down, the aerial part disappears completely.

Flowering was observed only for the January, March and April plantings.

Tuber growth and development

Planting date highly affected the maximum tuber weight per plant (Fig. 3a). This effect led to the same classing as for the aerial part (Fig. 3b), which is not surprising since the tuber is fed with photosynthates from the leaves.

Yet, the effect of planting date on the tuber development was not simply a consequence of that observed

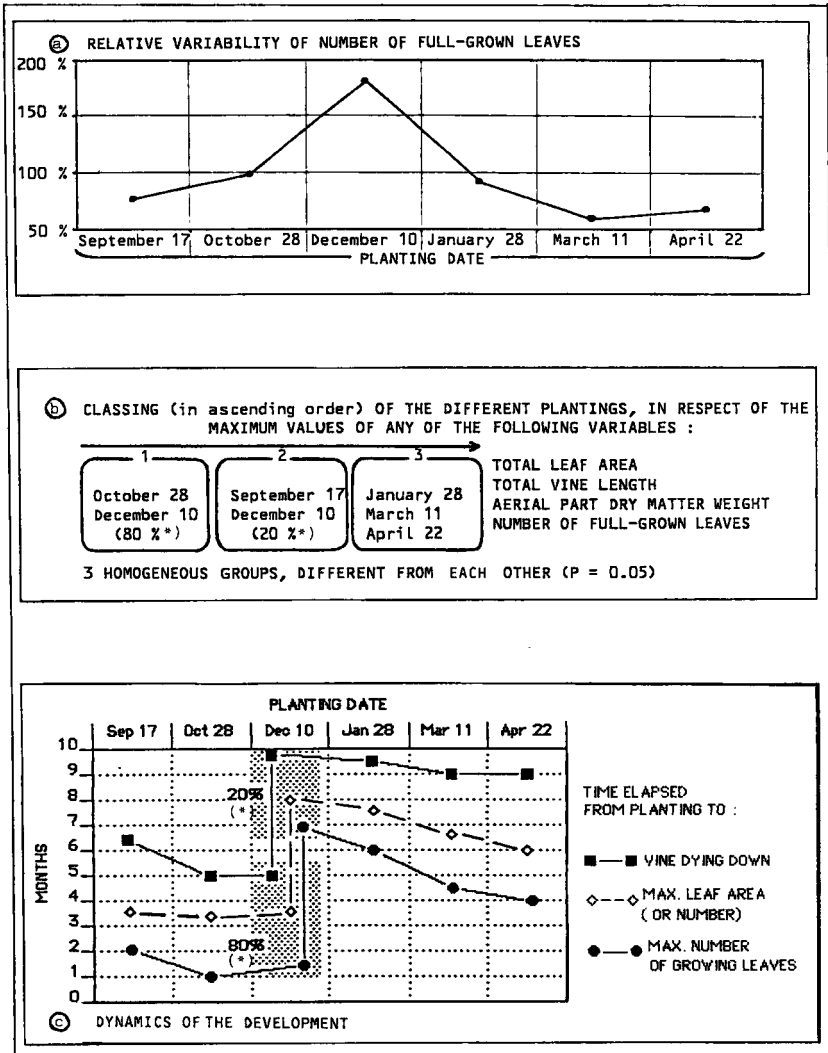


Fig. 2 : Some characteristics of the aerial part development

(*) the December planting could be divided into 2 subpopulations :
 | 80% had lost their stems before mid-June
 | 20% kept them much longer

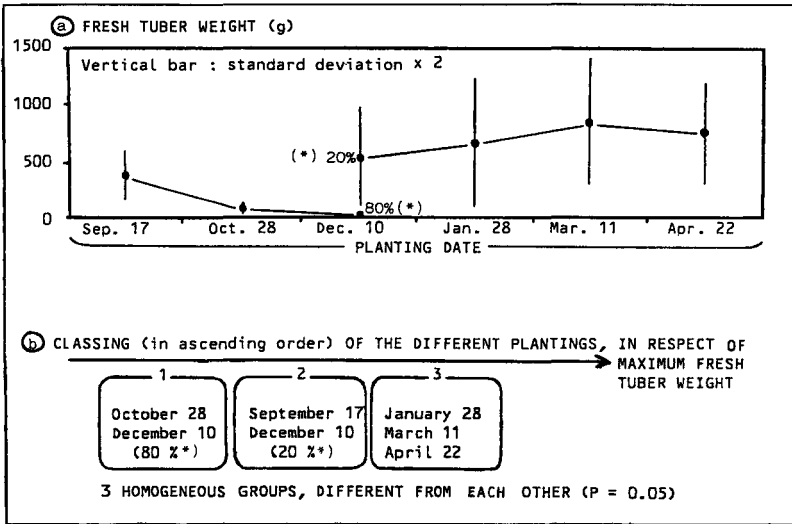


Fig.3 : Maximum fresh tuber weight per plant
(*) see fig. 2

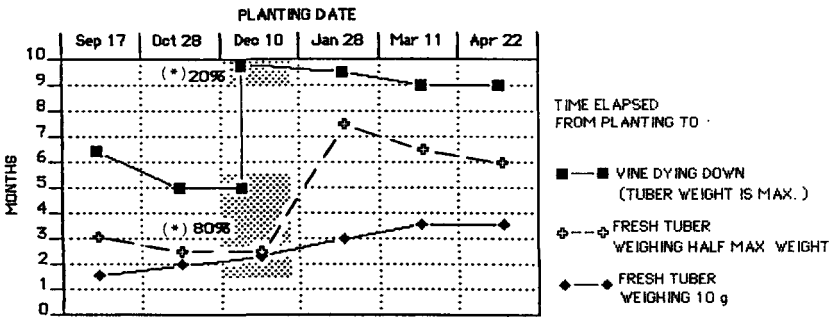


Fig.4 : Dynamics of tuber growth
(*) see fig. 2

on the aerial part. That can be derived from the tuber growth patterns (Fig. 4). The early tuber growth (up to 10 g) was quickest for the September planting and slowest for the March and April plantings, with regular variations for the intermediate plantings. The subsequent growth was regular and comparable for all plantings, except for the January planting, and probably the 20 per cent December subpopulation (but we have not got the figures), which reached half their maximum weight very slowly. Moreover, there was evidence that, for several sets from those 2 plantings, tubers had grown during two successive, clearly separate, periods (LACOINTE, 1984).

All these aspects of growth dynamics are consistent with the hypotheses of a period (- October-February) promoting tuber growth and of another period (- March-July) with the opposite effect. Thus, the season which appears to have an unfavourable influence on aerial growth appears, conversely, to have a favourable influence on underground growth. Seasons with differential effects on aerial and underground growth may also be derived from the variations of aerial part/tuber weight ratio (Fig. 5).

As a consequence, for the September and October plantings the tuber growth was affected to a relatively lesser extent than the aerial part growth. Besides, there was an indirect evidence that photosynthates were transferred to the tuber, and stored, in a relatively more efficient way after planting under decreasing days than after planting under increasing days (LACOINTE, 1984).

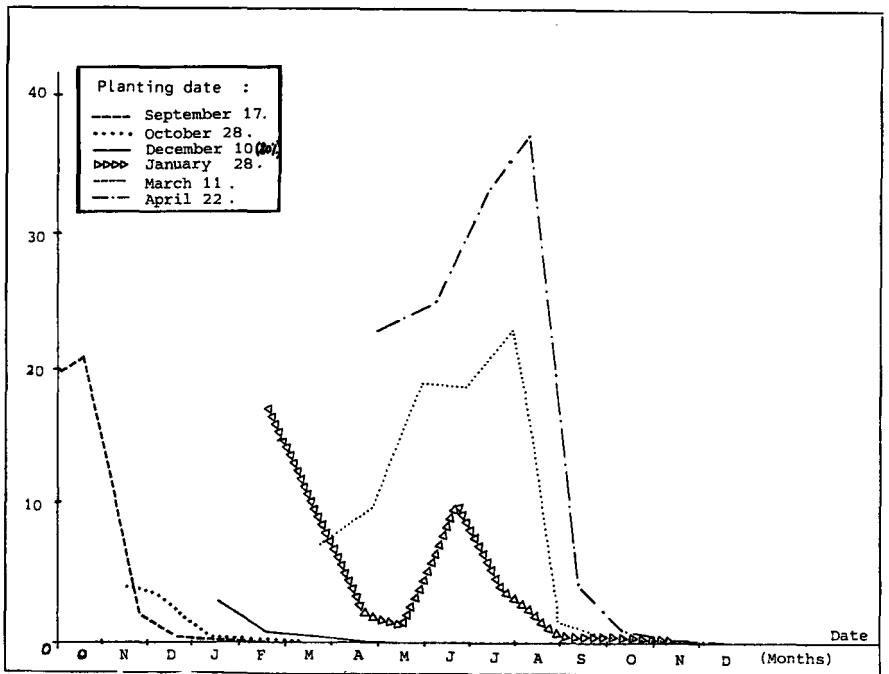


Fig.5 : Variations of the $\frac{\text{AERIAL PART}}{\text{TUBER}}$ dry matter weight ratio

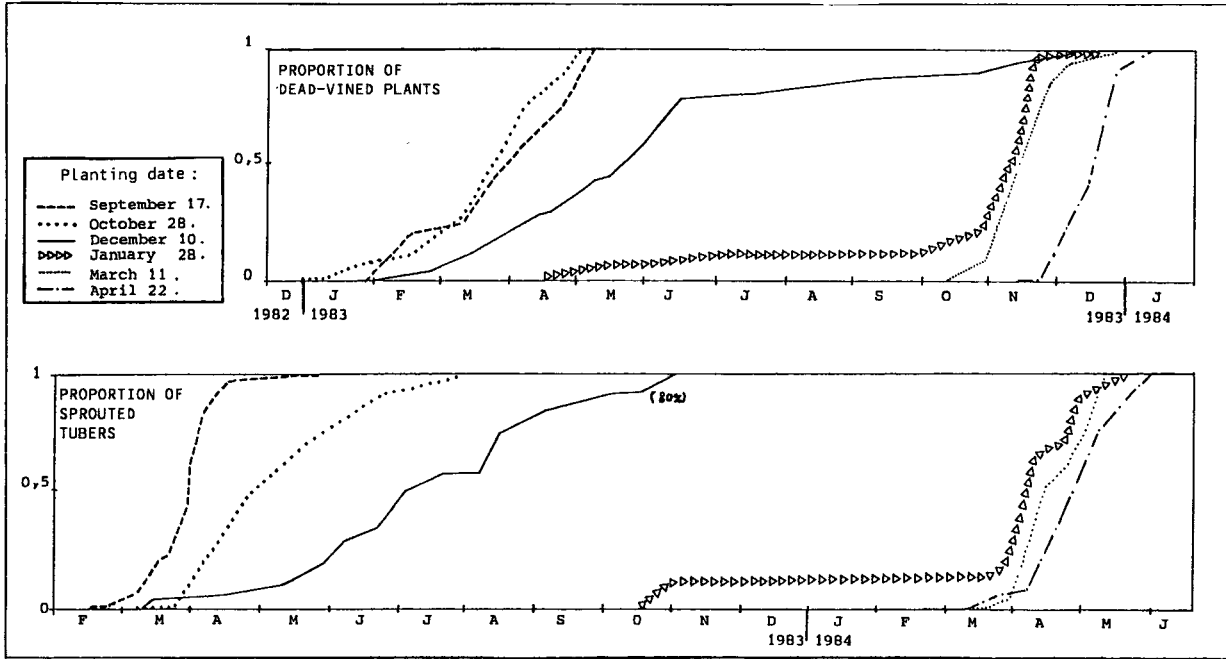


Fig.6 : Time-course of vine dying down and tuber sprouting

The tuber rest period

The beginning of the rest period (Fig. 6a)

The mean dates of vine dying down of all plantings showed a trend to gathering within one season : from November to April (short days). That appeared through the distribution of the plantings in two groups : the first one (September and October plantings) corresponded to the end of this season, and the second one (March and April plantings) to its beginning (the following year). The partition within the December planting appeared here : 80 per cent belonged to the first group and most of the remaining 20 per cent to the second one. The January planting behaved similarly, but with inverse proportion : about 10 per cent for the first group (they have not been mentioned in this report because they were too few) and 90 per cent for the other one.

The end of the rest period : sprouting (Fig. 6b)

The sprouting season of all plantings is even more restricted than the vine dying down season. As a matter of fact, the mean sprouting dates take place between March 15th and May 1st for all plantings except the 80 per cent December sub-population which kept its "anarchic" behaviour. The rest period may be so restricted that sprouting occurs at the same time as vine dying down : that was recorded for several sets from the September planting. In fact the 20 per cent December subpopulation may be interpreted as a case of "negative" rest duration", since aerial growth resumption really looked like tuber sprouting (LACOINTE, 1984) and would have been considered as such if the old stems had disappeared earlier. This interpretation is supported by the often-observed biphasic tuber growth.

CONCLUSION

Planting date clearly affected the behaviour of *D. alata* cv "Lupias" from in vitro culture, through :

a) an important reduction of aerial development and, to a lesser extent, of tuber development, after planting under short and decreasing days. Yield was significantly affected for the September planting and drastically for the October and December plantings.

b) a clear gathering of dates of aerial part dying down, and an even stricter gathering of dates of tuber sprouting. As a consequence, staggering, which could reach 6 months at planting, was completely lost at sprouting the following year.

It is therefore clear that out-of-season production is not possible with this material in our conditions.

These results are very similar to those achieved with sets from seed-tubers, as related in Introduction. Since our plants were free from any seed tuber effects, we think that our results were due to environmental factors ; so were mostly, probably, the former results.

In ours experiments the environmental control could be described as the succession, along the year, of a season promoting aerial growth to the prejudice of tuber growth (March-July), and of a season exerting the opposite influence (October-February).

Which environmental factors may be involved in that control ? Since our field was irrigated, we think it is not water, in spite of the adequation between water supply and the vegetative cycle evolution under natural conditions. Therefore we suspect photoperiod and/or thermoperiod to be responsible for the environmental control. The influence of photoperiod on development of several yam species has already been pointed out by NJOKU (1963) and MIGINIAC (1980), as similar to that reported here.

Unlike that of cv. "Lupias" (CLAIRON and ZINSOU, 1980, and this report), the development of some others cvs of *D. alata* (ARNOLIN, 1981) does not appear as completely determined by environmental variations, since the rest periode may not be shorter than a few months. Yet such behaviours might be explained in the same way, assuming that sprouting result from interaction of environmental factors with a "tuber-factor" whose level would vary during the rest period.

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