A STUDY ON PHOTOBLASTISM IN SEEDS OF SOME TROPICAL WEEDS

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SUMMARY

The influence of light on germination of seeds of a number of tropical weeds was studied. The same types of light sensitivity known from seeds of plants of the temperate zone were found.

In addition to the expectation that the behaviour of tropical seeds resembles that of the temperate zone, also was found that seeds of Ruellia tuberosa probably show a very fast "inverse dark reversion" and that gibberellic acid may delay or inhibit the onset of a secundary dormancy.

1. INTRODUCTION

At the Agronomical Faculty of the Central University of Venezuela in Maracay a study was made of the influence of light on the germination of many tropical weeds. Although much is known about the light sensitivity of weeds from temperate climates (EVENARI 1965), comparatively few tropical weed seeds have been studied.

As was expected, all the different types of light sensitivity known from seeds of plants of the temperate zone were found among the tropical seeds too.

For providing good examples for further studies we shall give a survey of our study mentioning especially some rather extreme species.

2. MATERIALS AND METHODS

Seeds of tropical weeds were collected in fields and plantations of sugar cane, cocoa and coffee. The seeds were stored dry at tropical room temperature in plastic flasks.

The conventional filter paper method was used. Lots of 100 seeds were spread on filter paper (Whatman Nr. 1). The filter paper was wetted with 4 ml of deionized water. Two dishes were generally used for one treatment. Immediately after wetting the dishes were placed in darkness, white, red or far red light depending on the experiment at constant temperature of 25 °C.

The source of white light consisted of three fluorescent lamps (Philips, TLD 15 W/54). The intensity at seed level was approximately 4.10^{-3} Watt cm^{-2}. The Red light was obtained from one red fluorescent lamp (Philips, TL 40 W/15) in combination with a red perspex filter (Röhm und Haas,

Table 1. Strongly light-sensitive seeds.

Name	germination percentage	
	in white light	in darkness
Hyptis suaveolens (L.) Poit.	60	2
Ludwigia spec.	89	0
Portulaca oleracea L.	96	2
Leonurus sibiricus L.	55	0
Ageratum conizoides L.	83	0
Leptochloa filiformis (Lam.) Pal. Beauv.	55	0
Flaveria trinerva (Spreng.) Mohr	98	0
Verbesina caracasana Rob. & Greenm.	67	4
Impatiens sultani Hook f.	83	0
Melinis minutiflora Pal. Beauv.	92	24
Galinsoga parviflora Cav.	82	0
Tibouchina longifolia Baill.	92	0
Tridax procumbens L.	65	7
Orthrosanthus chimboracensis (H.B.K.) Baker	91	0
Euphorbia hirta L.	64	1

Table 2. Germination percentages of photoblastically indifferent seeds in white light, far-red light and darkness and the percentages in Red light and darkness after a prolonged far-red treatment.

Name	germination percentage				
	white light	darkness	FR	after a prolonged FR irradiation	
				red light	darkness
Bidens spec.	86	79	6	89	13
Synedrella nodiflora (L.) Gaertn.	88	70	1	74	3
Calotropis procerea (Ait.) R.Br.	100	100	0	100	0
Mentzelia aspera L.	84	79	0	54	0
Ruellia tuberosa L.	99	98	1	100	97

Table 3. Light indifferent seeds.

Name	germination percentage		
	white light	darkness	Far Red
Pennisetum setosum (Sw.) L. Rich.	97	77	85
Echinochloa colona (L.) Link	78	53	49
Senecio formosus H.B.K.	36	34	37

Darmstadt Nr. 501, thickness 3 mm). The intensity at seed level was approximately 130 μWatt cm^{-2}. The source of the far red light was a set of five normal incandescent bulbs of 40 Watt each, in combination with one perspex filter (Nr. 501) and two blue perspex filters (Röhm und Haas Nr. 627, thickness 3 mm). The far red light had an intensity at seed level of approximately 100 μWatt cm^{-2}.

Symbols used: R = Red light; FR = Far Red light.

3. RESULTS

3.1. Photosensitivity to white, red and far red light

Of the 81 species collected the most striking positivily photoblastic seeds are listed in *table 1.*

Some seeds seem to be photoblastically indifferent, but in far red light germination is inhibited. After several hours of FR irradiation most seeds become light-sensitive (*table 2*).

Calotropis procera is a good example of a seed which seems to be non-photoblastic but which after prolonged FR irradiation proves to be very strongly light sensitive. *Ruellia tuberosa* produces seeds which also seem to be non-photoblastic. Germination can also be inhibited by a far red irradiation. But this inhibition is finished immediately after the end of the FR irradiation. Then the germination in darkness is again as high as in light.

A few seeds are indifferent to light and germinate even during a FR irradiation (*table 3*).

One of the investigated species, *Amaranthus dubius* Mart., produces seeds which are more or less negatively photoblastic to white light. When irradiated with R an FR light however they show positive photoblasticity to these irradiations. In R light germination is higher than in FR (*table 4*).

The seeds of *Portulaca oleracea* are very interesting because of their strong light sensitivity. Although in darkness there is practically no germination at all, after 9½ hours of dark incubation 1 min of red light already causes a germination of about 40%. However, 1 hour of red light does not increase the germination percentage to more than 60, and continuous red light is necessary to obtain 96% germination.

When the logarithm of the duration of the red irradiation is plotted against the germination percentage (*fig. 1*) it is interesting to observe that during the first 5 minutes there is a sharp increase in germination; then follows an irra-

Table 4. Germination of Amaranthus dubius Mart. seeds in white-, red- and far-red light and in darkness.

Name	germination percentage			
	white light	darkness	Red	Far Red
Amaranthus dubius Mart.	29	48	46	6

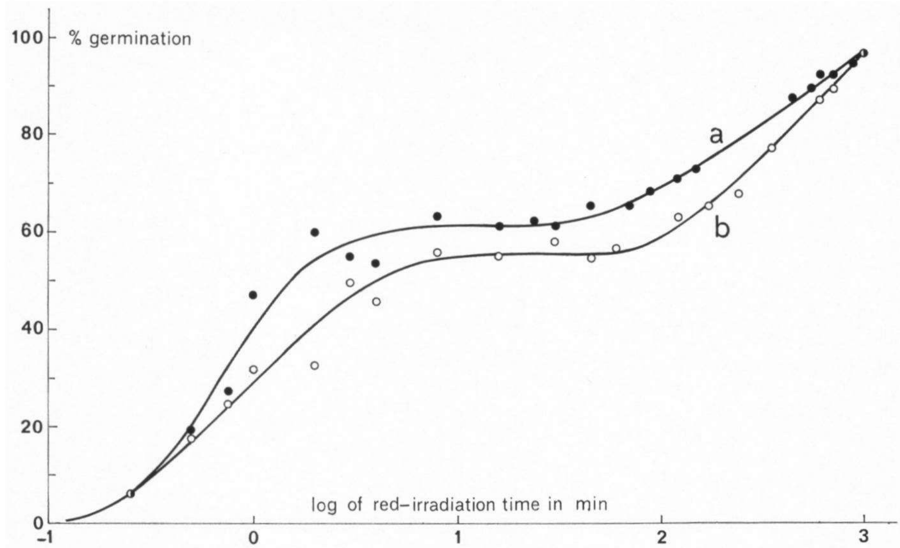

Fig. 1. The logarithm of the irradiation time in minutes of red light needed to promote germination of Portulaca oleracea L. seeds plotted against the germination percentages. a And b are two identical experiments carried out within two weeks.

diation period from 5 till 80 minutes without any obvious effect, after which an increase of the germination percentage is resumed.

The same relation between irradiation and germination is found by KARSSEN (1970) for seeds of *Chenopodium album L.*

3.2. Changes in germination caracteristics

During dry storage the different stages of after-ripening of the seeds (primary dormancy, light sensitivity, no dormancy) may slowly shift from the first to the last stage. In some seeds this occurs faster than in others. A few examples are given in *table 5.*

3.3. Red – far red antagonism

The phytochrome present in the seeds of a.o. *Portulaca oleracea, Melinis minutiflora, Galinsoga parviflora, Amaranthus dubius* and *Calotropis procera* seems to be strongly light sensitive and shows a very fast R – FR reversiblility.

When irradiation of 2 minutes R an FR were alternatively given after a dark incubation of 9½ hours the results shown in table 6 with seeds of *Portulaca oleacea* were obtained.

In this kind of experiment seeds of *Calotropis procera* should especially be mentioned for their extreme reversibility. Freshly collected seeds germinate for 100% in light as well as in darkness but germination is completely inhibited in FR. After 9 month of dry storage the seeds still exhibit the same phenomenon.

Table 5. Changes in germination percentages during dry storage.

Name	date of trial	germination percentage	
		in white light	in darkness
Amaranthus dubius Mart.	30- I-'69	10	2
	21- II-'69	13	22
	12-III-'69	33	44
Merremia aegyptia (L.) Urb.	29- I-'69	14	25
	8-IV-'69	71	82
Echinochloa colona (L.) Link	15- II-'69	52	25
	12-VI-'69	89	47
Eleusine indica (L.) Gaertn.	29- I-'69	0	0
	6-IV-'69	0	4
	12- V-'69	6	8
Flaveria trinerva (Spreng.) Mohr	6- II-'69	41	0
	19-III-'69	92	0
	6-IV-'69	96	0
Mentzelia aspera L.	29- I-'69	12	18
	29-IV-'69	40	67
	26-VI-'69	84	78
Ipomoea coccinea (L.) Moench	6- II-'69	23	33
	29- II-'69	52	59
	8-VI-'69	97	99
Hyptis suaveolens (L.) Poit.	29- I-'69	8	0
	12-III-'69	62	0
	12- V-'69	70	0
Chloris inflata Link	10- II-'69	100	6
	19-III-'69	100	26
	29-IV-'69	100	44
	27- V-'69	100	92
Pennisetum setosum (Sw.) L. Rioh.	28- I-'69	98	17
	12-III-'69	89	51
	23-IV-'69	96	63
	14-VI-'69	97	78

Table 6. Portulacca oleracea. Germination percentages of seeds after alternated R-FR treatments of 2 min. each.

	germination %
2 min.R	61
2 min.FR	1
2 min.FR – 2 min.R	71
2 min.FR – 2 min.R – 2 min.FR	3
2 min.FR – 2 min.R – 2 min.FR – 2 min.R	65
2 min.FR – 2 min.R – 2 min.FR – 2 min.R – 2 min.FR	1
2 min.FR – 2 min.R – 2 min.FR – 2 min.R – 2 min.FR – 2 min.R	67
2 min.FR – 2 min.R – 2 min. FR – 2 min.R – 2 min.FR 2 min.R – 2 min.FR	2
continious R	91
continuous darkness	1

Table 7. Calotropis procera. Germination percentages after alternated R-FR treatments given after 3 days FR.

	germination %
continuous white light	100
continuous darkness	100
3 days FR then darkness	0
3 days FR – R	64
3 days FR – R – FR	0
3 days FR – R – FR – R	94
3 days FR – R – FR – R –FR	0
3 days FR – R – FR – R – FR – R	100

After a FR treatment of 3 days the seeds were alternately irradiated with 15 minutes FR. The results are shown in *table 7.*

If the last irradiation has been FR germination is completely inhibited. If the last irradiation was R then germination is high and is increasing the more times R has been given. This phenomenon was also shown by seeds of *Galinsoga parviflora.*

3.4. Secondary dormancy

Many light sensitive seeds develop a secondary dormancy during the time of incubation in darkness. So in darkness they pass through a peak of highest light sensitivity after which germination in Red light gets less and less. In some species this maximum of sensitivity and the onset of secondary dormancy occur after a few hours, in others after many hours (*table 8*).

In some seeds which are normally strongly light sensitive and therefore practically show no germination in darkness, this inhibition of germination can be completely alleviated by adding gibberellic acid (GA) to the imbibition water. Other seeds do not show any visible response to GA when kept in darkness. However it seems that GA can prevent or at least strongly delay the onset of secondary dormancy as shown in *table 9*. The concentration of the GA used was 500 mg/1.

3.5. Abscisic acid

All seeds tested were completely inhibited by imbibition in water containing 20 ppm abscisic acid (ABA). But with most seeds germination occurred soon after rinsing the seeds with tap water. Only seeds of *Hyptis suaveolens* remained dormant during another week. As these seeds are surrounded by a slimy hull it may be possible that the loss of ABA is much slower than in other species.

It may be of interest to mention that the inhibition of *Portulaca oleracea* seeds by ABA shows exactly the same picture as KARSSEN (1968) described for the seeds of *Chenopodium album,* except that the *Portulaca oleracea* seeds are much smaller. In ABA the seeds proceed to "incomplete germination" so that

Table 8. Germination percentages of seeds of different species after a single light exposure of 15 min. of Red light after different periods of dark incubation.

Name	Light sensitivity to a single exposure of 15 min. of Red light			
	Maximal sensitivity		state of sec. dormancy	
	germ %	after ...hrs of dark incubation	germ. %	after ...hrs of dark incubation
Portulaca oleracea L.	60%	8 hrs.	25%	48 hrs.
Ageratum conyzoides L.	48	16	5	72
Melinis minutiflora Pal. Beauv.	45	4	7	48
Galinsoga parviflora Cav.	70	86	17	144

Table 9. Germination of different seeds incubated in water or gibberellic acid (500 mg/l) in white light and in darkness. The development of a secondary dormancy in water and in gibberellic acid (500 mg/l).

Name	germ. %			development of a secondary dormancy	
	in light	in darkness			
	in water	in H_2O	in GA	in water	in GA
Hyptis suaveolens (L.) Poit.	70	5	90		
Portulaca oleracea L.	96	2	2	strong	none
Ageratum conyzoides L.	83	0	26	strong	none

the rootlet protrudes from the black testa. Then the seed gets dormant and can remain like that for more than a month. When the ABA is washed away growth immediately starts anew.

4. DISCUSSION

After a prolonged FR irradiation of one week the seeds of *Ruellia tuberosa* have not germinated. After having been removed from the FR light irradiation into darkness, the seeds germinate within 24 hours (*table 2*) Probably *Ruellia tuberosa* shows a very fast "inverse dark reversion". In darkness the conversion of inactive P_r into active P_{fr} takes place (BOISARD *et al.* 1968, BOISARD 1969).

One of the influences of gibberellic acid on germination seems to be an inhibitory effect on the development of secondary dormancy (skotodormancy). BLACK & RICHARDSON (1965) found the same effect on germination for chloramphenicol. One of the actions of chloramphenicol is that it arrests an inhibitory process which commences in darkness when the seeds imbibe water (secondary dormancy).

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