SALTANT PRODUCTION BY WAVE LENGTHS OF VISIBLE AND LONG ULTRAVIOLET MONOCHROMATIC IRRADIATION, AND A COMPARISON WITH SALTANTS PRODUCED BY SHORT WAVE LENGTHS OF MONOCHROMATIC ULTRAVIOLET IRRADIATION IN THE FUNGUS CHAETOMIUM GLOBOSUM

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PLATES 4 and 5

(Received for publication, August 2, 1946)

INTRODUCTION

Saltants have been produced by longer wave lengths of ultraviolet monochromatic radiation than has previously been reported. Further experiments have shown that they are also produced by visible radiation. The wave length 365 mμ was tested by McAulay (1938), who concluded that its effectiveness in producing saltants was very small or perhaps zero. Experiments described in this paper were made at the long wave lengths 365 mμ, an ultraviolet line, and 404 mμ, a violet wave length, which has not been tested previously. Saltants produced by the wave lengths 365 mμ and 404 mμ have been compared with those produced by irradiation of the spores at short ultraviolet wave lengths, 265 mμ and 280 mμ.

There is an almost complete absence of the *K* saltation (McAulay, Plomley, and Ford (1945)) at the two longer wave lengths, two only being produced in a total of 1,391 experimental colonies. This is a marked difference from the large numbers produced by the short wave lengths, 372 *K* saltations being produced by 265 mμ and 280 mμ in a total of 1,401 experimental colonies. Other saltants are produced by both the long and short wave lengths. At long wave lengths 50 saltants other than the *K* saltation were produced in 1,391 experimental colonies, and at short wave lengths 114 were produced in 1,401 experimental colonies. In a total of 1,233 control colonies saltants numbered 9 only.

Experiments have indicated that, for optimum saltant production, a greater number of spores are killed by longer wave lengths than are killed by short wave lengths.

Material and Experimental Procedure

The fungus used in the experiments was ***Chaetomium globosum*** and all spores were taken from Fld (McAulay, Plomley, and Ford (1945)) a saltant which appeared in early irradiation experiments and which behaves stably in normal colonies (Fig. 1).

All colonies were of single spore origin. Spores to be irradiated were taken from colonies between 6 and 12 weeks old. The experimental procedure used in the experiments has been described by McAulay, Plomley, and Ford (1945). The only divergence from the technique there described was the use of 2 per cent malt agar instead of 1 per cent malt agar as medium on which the fungal colonies were grown.

The source of irradiation, which was a 125 watt mercury discharge lamp, has been mentioned by McAulay, Plomley, and Ford (1945). The large aperture monochromator described by McAulay and Taylor (1939) has been used for all the irradiation experiments. Measurement of the intensity of radiation produced over the area of the line of the spread fungal spores has also been described in that paper (1939).

Glass filters were used to give a purer separation of the wave lengths of light and to eliminate as much as possible shorter wave length contamination. The filters used at the 4 wave lengths 265 mμ, 280 mμ, 365 mμ, and 404 mμ, and the average doses given for saltant production in 10, 7, 6, and 7 experiments at the 4 wave lengths respectively have been tabulated as follows:—

Wave length	No. of experiments	Average dose for saltant production	Glass filters used during irradiation
mμ		*joules/cm.²*	
265	10	0.52	Quartz slide
280	7	0.24	1 fine corex slide
365	6	900	5 microscope slides
404	7	1800	3 Crookes slides

Air was blown over the spores during irradiation and was first passed through a very weak dettol solution to prevent other fungal spores falling on the line of *Chaetomium* spores. At 404 mμ it was necessary to irradiate the spores 7 to 10 days for optimum production of saltants which were produced by 265 mμ and 280 mμ in a few minutes. The time of radiation of spores for optimum saltant production by 365 mμ was 2 to 4 days. Less dose is required with 280 mμ than with 265 mμ for the same production of saltants, this being in agreement with the lethal dose curve of McAulay and Taylor (1939), which shows that at 280 mμ the spores were killed with a smaller dose than 265 mμ.

RESULTS OF IRRADIATION

In Table I the total number of colonies grown from irradiated (experimental) and unirradiated (control) spores are tabulated for the experiments at the 4 wave lengths, the 2 short ultraviolet wave lengths 265 mμ and 280 mμ, and the 2 long wave lengths 365 mμ (ultraviolet) and 404 mμ (visible violet line). The saltants produced are listed and the average dose for experiments at each wave length is also tabulated. The two lowest rows of the table state the percentage of germinating spores in the irradiated (experimental) and non-irradiated (control) series, and the percentage of germinating spores growing to form adult colonies (McAulay, Plomley, and Ford (1945)). The latter gives a good measure of the effectiveness of the irradiation and, as a rule, the smaller the number continuing to grow to form adult colonies the greater the dose given to the spores. The longer wave lengths appear from Table I to be relatively more lethal than the short wave lengths, *e.g.* the percentage germination of spores irradiated at the violet line 404 mμ is 29 per cent, whereas percentage germinations at 265 mμ and 280 mμ are 53 and 57 per cent. A better indication of this feature is obtained by taking the ratio of the percentage of irradiated spores germinating and the percentage of unirradiated spores germinating, as the figure for the latter varies from experiment to experiment due to the different ages of colonies from which the spores are taken, and the length of time the spores are on glass when irradiation is in progress. The latter varies from a few minutes at short wave lengths to 10 to 14 days at long wave lengths. It will be seen from Table I that there is a steady decline in the ratios of percentage irradiated spores germinating and percentage unirradiated spores germinating with increasingly long wave lengths. The ratios decrease from 83 per cent at 265 mμ to 57 per cent at 404 mμ.

The saltants have been classified according to the general classification set out by McAulay, Plomley, and Ford (1945), the main groups being growth modification saltants, mycelial saltants, and perithecial saltants. The *K*, a mycelial and spore saltant (Fig. 2) described by Ford (1946), is tabulated separately as it is produced selectively by short wave lengths of ultraviolet radiation. It seems probable, especially as a *K* saltation appeared in a colony controlling the 404 mμ experimental colonies, that the two *K*'s in the experimental series of 365 mμ and 404 mμ are due to contamination by short wave lengths which is difficult to eliminate entirely. A marked difference between the saltants of the short and long wave lengths is noted in that large numbers of *K* saltants are produced by short ultraviolet radiation. Omitting the *K* saltant, the total percentages of other saltants are as follows: 8.1 per cent, 8.2 per cent, 3.9 per cent, and 3.4 per cent for progressively long wave lengths. The average physical doses necessary to obtain these percentages are approximately 0.52 joules/cm.^{2}, 0.24 joules/cm.^{2}, 900 joules/cm.^{2}, and 1800 joules/cm.^{2} for progressively long wave lengths. The saltants other than *K* produced by the four wave lengths are similar in kind, and examples are shown in Figs. 3 and 4, Fig. 3 showing examples of saltants produced by the two short wave lengths 265 mμ and 280 mμ, and Fig. 4 showing examples of saltants produced by the two long wave lengths 365 mμ and 404 mμ.

Table II shows that combining the figures for the two long and two short wave lengths, 372 *K* saltations were produced out of a total of 1,401 experimental colonies at 265 mμ and 280 mμ, whereas only two *K* saltants appeared in 1,391 experimental colonies at the long wave lengths 365 mμ and 404 mμ. Only one *K* appeared in the 1,233 control colonies for all experiments and was probably due to short wave length contamination of the spores. The total number of other saltants produced by the two short wave lengths was 114 in

TABLE I

Total saltants produced by the 4 wave lengths, 265 mμ, 280 mμ, 365 mμ, and 404 mμ. A general classification of these and numbers produced are given. Average approximate dose and percentage germinating spores and those continuing to grow to form adult colonies are tabulated. Control figures are also shown.

		265 mμ	280 mμ	365 mμ	404 mμ
Total colonies plated	Experimental	914	487	616	775
	Control	403	225	303	302
K saltants	Experimental	236	136	1	1
	Control	0	0	0	1
Growth modification saltants	Experimental	34	17	5	9
	Control	0	0	0	2
Mycelial saltants	Experimental	21	14	6	10
	Control	1	1	0	0
Perithecial saltants	Experimental	19	9	13	7
	Control	2	2	1	0
Total saltants other than K	Experimental	74	40	24	26
	Control	3	3	1	2
Percentage K saltants	Experimental	25.8	27.9	0.16	0.1
	Control	0	0	0	0.3
Percentage other saltants	Experimental	8.1	8.2	3.9	3.4
	Control	0.7	1.0	0.3	0.6
Average dose, *joules/cm.*^{2}		0.52	0.24	900	1800
Average percentage germinating spores and ratio of percentage irradiated and control germinating spores	Experimental	53 83	57 70	45 63	29 57
	Control	64	81	71	51
Average percentage germinating spores forming adult colonies	Experimental	42.6	29	30	83
	Control	99	100	100	98

TABLE II

Comparison of numbers of saltants produced by the two short wave lengths of monochromatic ultraviolet light, 265 mμ and 280 mμ, and the two long wave lengths 365 mμ and 404 mμ, the latter being a violet line in the visible region. Control figures are also shown.

		Total colonies plated	Total *K* saltants	Total other saltants
Short wave lengths 265 mμ and 280 mμ	Experimental	**1,401**	**372**	**114**
	Control	628	0	6
Long wave lengths 365 mμ and 404 mμ	Experimental	**1,391**	**2**	**50**
	Control	605	1	2

1,401 experimental colonies, and the number produced by the two long wave lengths was 50 in 1,391 experimental colonies. In the control series of short wave lengths there were 6 saltants in 628 colonies and in the control series of long wave lengths there were 2 saltants (other than 1 *K*) in 605 colonies.

DISCUSSION OF RESULTS

There are two features of significance which stand out from others in this work on the production of saltants by monochromatic ultraviolet and visible wave lengths. The first feature is the production of saltants by the long ultraviolet wave length 365 mμ and by the visible violet wave length 404 mμ. Many of these saltants look similar to those produced by short ultraviolet monochromatic wave lengths. An earlier paper from this laboratory (McAulay, Plomley, and Ford (1945)) tested wave lengths as long as 334 mμ. McAulay (1938) tested 365 mμ for saltants but did not find any. Refinement of technique has enabled saltants to be discovered at this wave length. The second striking feature is the almost complete absence of the *K* saltant at the long wave lengths 365 mμ and 404 mμ. The one or two *K* saltants present are almost certainly due to contamination of long wave lengths by short wave lengths, especially as in one long wave length experiment a *K* saltant appeared in a control colony. Large numbers of *K* saltants are produced by the two short wave lengths of monochromatic ultraviolet light.

It is possible that the big group of growth modification saltants will include some other saltants which are selectively produced. This group has not been carefully analyzed as yet and contains many saltants which have a different growth rate and structure from the normal. The selectively produced *K* saltation would be included in growth modification saltants as its growth and structure differ from the normal. It has been described in detail by Ford (1946). All the *K* saltants can be reproduced from mycelial inoculation and some (8 up to date) can be reproduced from single spore inoculations, so that all *K* saltants are mycelial saltants and some are also spore saltants, yet all have similar structural features. A detailed analysis of other growth modification saltants may reveal the same peculiarity of reproduction. Preliminary tests have suggested that this is so.

The ratio of percentage irradiated and unirradiated spores germinating declines with increasing long wave lengths. If the ratio does not drop too much at visible wave lengths longer than 404 mμ, *i.e.* if the spores are not killed due to length of exposure, saltants may be produced right through the visible spectrum. The dose required for maximum saltant production by 404 mμ is about 9,000 times that required by 280 mμ. So, with even longer wave lengths of visible light, the dose may go up to 100,000 times that required by 280 mμ.

Sincere thanks are expressed to Professor McAulay for helpful assistance during the progress of this work. The funds for the work came from a Commonwealth Grant to the University.

SUMMARY

1. Saltants have been produced in the fungus *Chaetomium globosum* by longer wave lengths than previously reported—by 365 mμ and by a visible line 404 mμ.

2. Absence at these wave lengths of the *K* saltant, which is so abundant at short wave lengths, is marked.

3. Ratio of percentage irradiated spores germinating to control spores germinating decreases from 83 per cent at 265 mμ, a short ultraviolet wave length, to 57 per cent at 404 mμ, a visible violet wave length.

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EXPLANATION OF PLATES

Examples of colonies of *Chaetomium globosum* Fld grown from single spores and grown in Petri dishes approximately 9 cm. in diameter, on 2 per cent malt agar medium.

PLATE 4

FIG. 1. A normal colony of *Chaetomium globosum* Fld grown from a single spore. $\times \frac{4}{5}$.

FIG. 2. An example of a *K* saltation colony, which is produced in large numbers by short wave lengths of ultraviolet irradiation. Four *K* sectors alternate with four normal sectors. The former show the typical arrested edge (*A*), brown pigment in the larger sectors (*B*), and late forming flares (*C*) characteristic of *K* sectors and colonies (Ford (1946)). $\times \frac{3}{5}$.

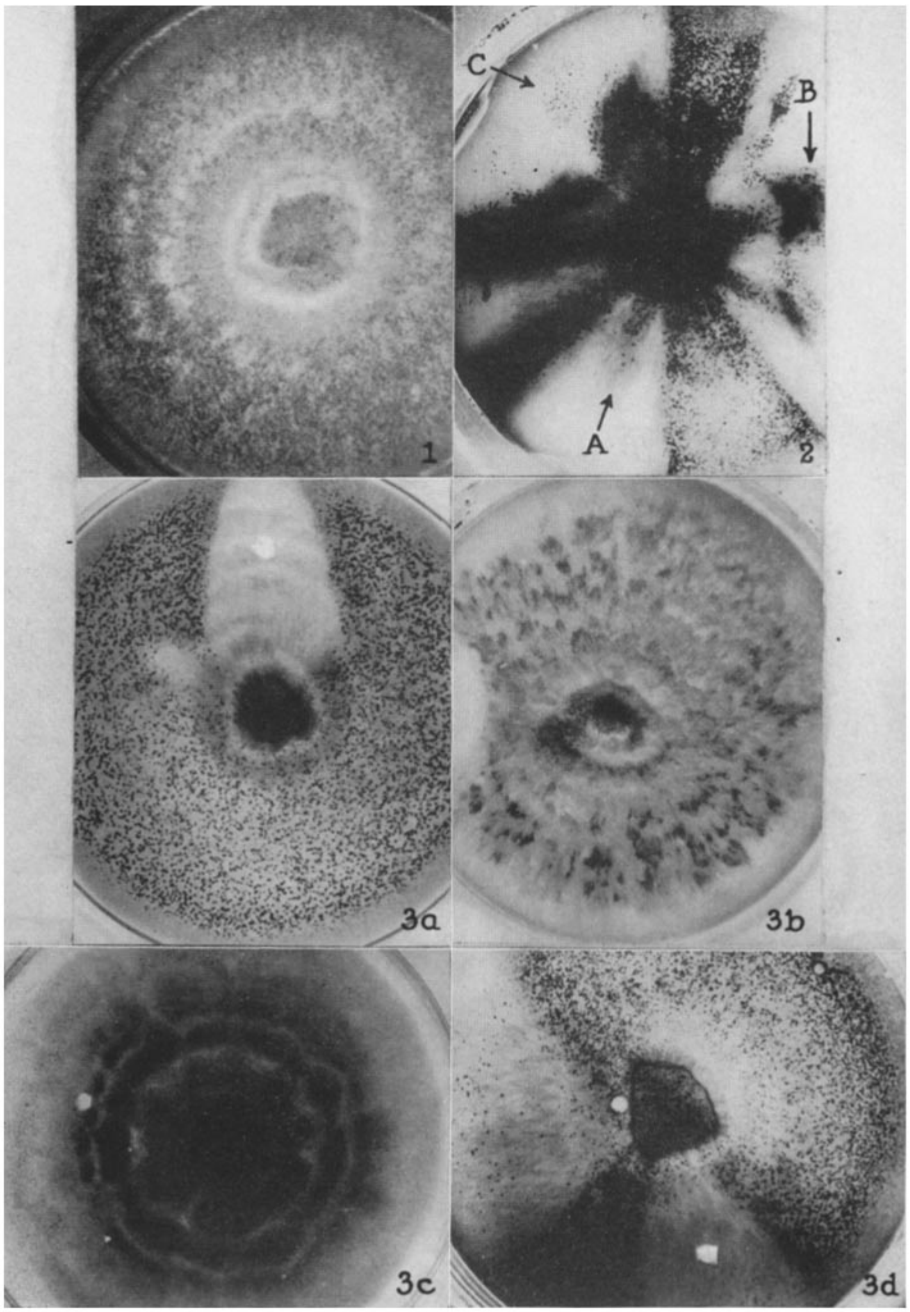
FIG. 3. Examples of saltant colonies, other than the *K*, produced by the short wave lengths, 265 mμ and 280 mμ, of monochromatic ultraviolet radiation. $\times \frac{3}{5}$.

(*a*) Growth modification saltant sectors, 1 small and 1 larger, of a slow growing scalloped mycelium with few or no perithecia, elsewhere colony normal.

(*b*) A growth modification saltant with pigmented scallops and few or no perithecia.

(*c*) A total growth modification saltant showing radiating flares and perithecia smaller than normal.

(*d*) A perithecial saltant showing two sectors with normal mycelium but with few scattered perithecia, between two normal sectors.



(Ford: Saltant production in *Chaetomium globosum*)

PLATE 5

FIG. 4. Examples of saltants produced by 365 mμ, a long wave length of monochromatic ultraviolet light, and by 404 mμ, a visible violet wave length. $\times \frac{3}{5}$.

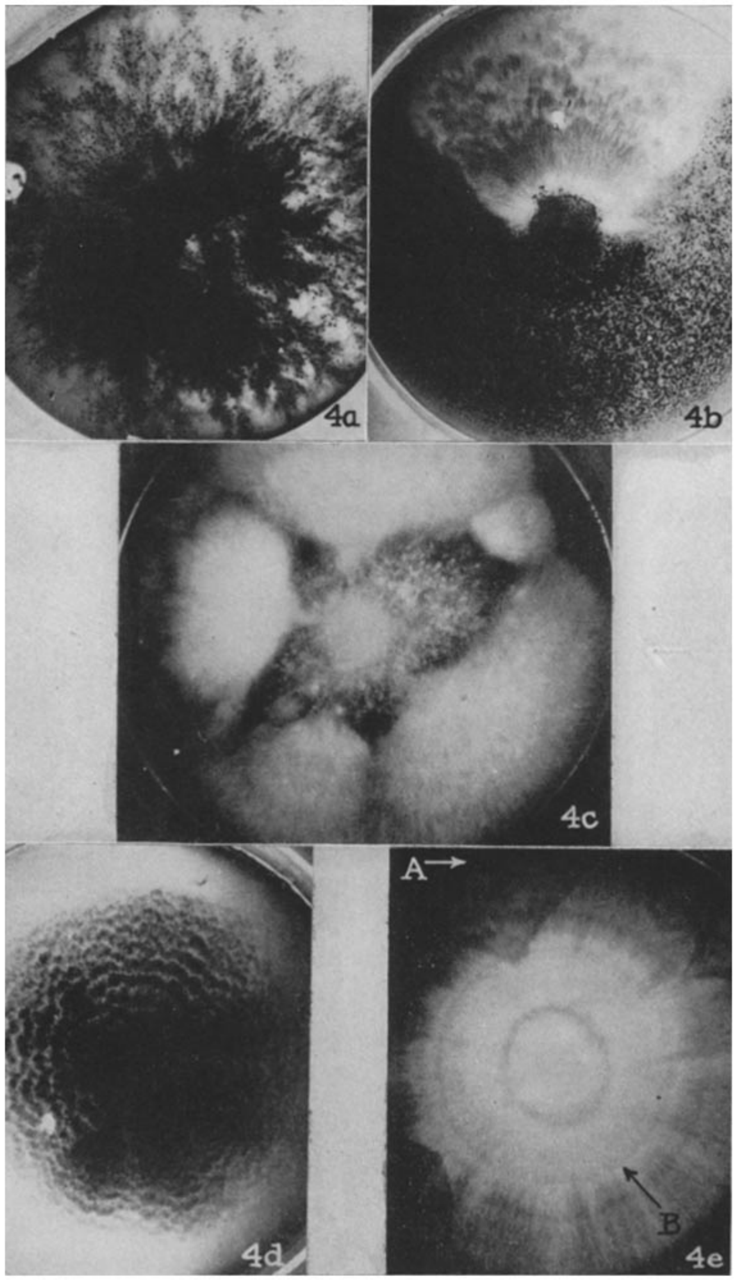
(*a*) A growth modification saltant showing red algal-like flares and fewer perithecia than normal.

(*b*) A growth modification saltant sector showing scalloped structure of mycelium. Remainder of colony normal.

(*c*) A growth modification saltant showing sectors of fast growing normal mycelium and slow growing nobbly mycelium. Perithecia few or absent.

(*d*) A growth modification saltant showing a total scallop structure and slow growth. Perithecia fewer than normal.

(*e*) A colony showing flares of different growth, faster growing scallops at edge (*A*) and denser slow growing mycelium (*B*) over most of the colony. Perithecia absent. Figs. 4 *a*, *b*, and *d* produced by 365 mμ and Figs. 4 *c* and 4 *e* produced by the visible wave length 404 mμ.



(Ford: Saltant production in *Chaetomium globosum*)