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Long-term Effects of Radioactive Fallout on Plants?

by

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# Long-term Effects of Radioactive Fallout on Plants?<sup>1/</sup>

by

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A number of fallout surveys have been carried out since the widely publicized Castle Bravo bomb test on Bikini Atoll on March 1, 1954. Three of these were under the auspices of the U. S. Naval Radiological Defense Laboratory (NRDL). Among the results of the first of these surveys was the establishment of a series of stations in the Northern Marshall Islands in which the amount of fallout varied, with radiation doses ranging from almost none to doses dangerous to human and animal life. A series of stations selected for subsequent resurvey are listed in order of increasing dose received expressed as total dose to infinity. This figure was obtained from the intensities in roentgens per hour on the day after the shot was fired. These rates were calculated from the earliest actual readings available and are given by Dunning (1957) on a map on page 2. The formula  $5 \times 24 \times 4/\text{hr}$  at  $D \div 1$ , where  $D \div 1$  is assumed to be  $D \div 24$  hours, is used to calculate total dose to infinity. The time of arrival at Rongelap Islet was about 7 hours after the shot. The time to the other stations can safely be assumed to have been about the same or longer, which would give a maximum error of 22 percent.<sup>2/</sup>

## List of stations:

Likiep Atoll, Likiep Islet	.....	scarcely any
Utirik Atoll, Utirik Islet	.....	33.r
Ailinginae Atoll, Sifo Islet	.....	125.r
Rongelap Atoll, Rongelap Islet	.....	336.r
Rongerik Atoll, Eniwetak Islet	.....	365.r
Rongelap Atoll, Eniaetok Islet	.....	816.r
" " , Kabelle Islet	.....	1824.r
" " , Gegen Islet	.....	3360.r

These figures, of course, say nothing of the proportions of particular isotopes present, except that since 7 hours elapsed before this fallout was deposited, the longer-lived ones will have been relatively abundant, which is a very important fact, physiologically, as it is these which will be responsible for any cumulative effects.

During the first two NRDL surveys no visible effects on plants were recorded, though some of the food plants tested showed considerable accumulation of radioactivity in their tissues.

The author of this note accompanied the resurvey of these islands in February, 1956, in the capacity of coral atoll ecologist, but most of his time was required in helping with the collecting of samples for

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<sup>1/</sup> Publication authorized by the Director, U. S. Geological Survey.

<sup>2/</sup> Information supplied by Mr. Sam Rainey.

analysis. Because no gross effects on plants were observed on the earlier surveys and since radiation damage to plants was not known at the radiation intensities existing on these islands no provision was made in the planning of the work for time to observe such phenomena. Time was not available for careful study even after it became evident that the vegetation on some of the islets visited was not normal.

Casual observations were recorded, mostly of a general ecological and descriptive nature, in the course of sample collecting. However, until members of the party recognized that the poor condition of the vegetation on Gegen I. had not been evident the previous year, no serious attention was paid to these abnormal phenomena. By this time it was too late to make any systematic study.

Subsequent study of notes and photographs made on the 1956 survey has indicated that suspicion of cumulative effects of radioactivity is justified and that further field study should be directed specifically at this problem. Until specific studies can be made, it seems best to publish the available data, even though they are inadequate either to establish or to disprove any cumulative radioactive effects. Perhaps if attention is thus called to the problem, someone in position to make further observations may be induced to collect data that will settle the matter before so much time has elapsed that all effects are masked.

In a report to the Atomic Energy Commission in 1950 St. John and Biddulph described visible abnormalities of various sorts observed in August 1949 in plants growing within a mile of the site of the 1948 atomic explosions on Eniwetok Atoll. Some of these were interpreted as persistent physiological effects, others as "phenotypic mutants". The plants affected were the following:

Boerhavia diffusa Forst. f.  
Cenchrus echinatus L.  
Chloris inflata Link  
Cocos nucifera L.  
Fleurya ruderalis (Forst. f.) Gaud.  
Ipomoea pes-caprae (L.) Roth  
Ipomoea tuba (Schlecht.) Don  
Morinda citrifolia L.  
Portulaca oleracea L.  
Scaevola sericea Vahl (as S. frutescens (Mill.) Kr.)

The environments studied on the 1956 survey were very similar to those in which the plants studied by St. John and Buddulph grew, but the intensities of radioactivity were many times less.

On the 1956 survey, attention was first attracted by Suriana maritima L., a small-leaved bright green shrub, which showed dead branches or completely dead bushes wherever observed (condition not recorded on Rongelap Islet, as attention had not been drawn to it at the time Rongelap was visited).

Until Eniwetak Islet, on Rongerik Atoll, was visited only casual attention was paid to this phenomenon. Here, however, the Cordia forest

which covers a large part of the islet appeared a dark gray color from the air. This was found to be due to a dying back of the twigs over the entire tops of the Cordia trees for as much as 30 cm. or even more and a complete loss of leaves from the upper parts of the trees. The Pisonia grandis associated with the Cordia was defoliated but flowering, a condition which could be normal in a severe dry season.

On Gegen Islet, Rongelap Atoll, subjected to the most severe fallout, almost the entire vegetation was observed to be in very poor condition. Cordia and Guettarda, two of the most important shrubs, were dead or apparently dying. Pisonia trees were entirely defoliated except for mistletoe-like clumps of abnormally dark green leaves of an appearance not previously seen in this common species. Lepturus repens, the commonest herb, was completely dead except for a few tiny seedling tufts on the beach ridges. All Fleurya ruderalis plants observed were almost dead. Some coconut trees were dead. The other species present, with the exception of Scaevola sericea and Tournefortia argentea, were in unhealthy condition. The latter two species were in generally good shape wherever observed.

The following two lists present the complete observations, so arranged as to bring out any correlation with fallout intensity.

1. Plant species in which abnormal appearances were observed, occurrences by islets in order of increasing fallout intensity.

Suriana maritima L.

Utirik I. - abundant, very few dead or partly dead plants seen.

Rongelap I. - no specific observations recorded.

Sifo I. - mostly healthy but some bushes dead.

Eniaetok I. - mostly dead.

Kabelle I. - many dead bushes, no live ones seen.

Gegen I. - none seen.

(Similar partially dead Suriana was observed in 1956 on Enyu I., Bikini Atoll by Mr. Sam Rainey (personal communication).)

Pisonia grandis R. Br.

Sifo I. - somewhat defoliated but not strikingly so.

Kabelle I. - almost leafless.

Eniwetak I. - leafless and mostly in flower.

Gegen I. - nearly to entirely leafless and flowering, but with compact clumps of abnormally dark green leaves that somewhat resemble mistletoe from a distance.

Cordia subcordata Lam.

Eniwetak I. - appeared dark gray from above, tops bare of leaves, upper twigs dead to 30 cm. or

more from tips, trees generally rather defoliated, more so in west than east half of islet; a few of the bare terminal branches putting out weak sprouts.

Gegen I. - mostly dead or almost so.

On other islets, normal so far as observed.

Cocos nucifera L.

Uterik I. - normal.

Rongelap I. - normal.

Eniaetok I. - normal.

Kabelle I. - very yellow.

Eniwetak I. - no record of condition.

Gegen I. - some trees dead.

Guettarda speciosa L.

Gegen I. - dead at tips in open scrub; in forest largely dead or severely dying back from tips.

On other islands, apparently normal so far as observed.

Fleurya ruderalis (Forst. f.) Gaud.

Gegen I. - almost dead.

On other islands, apparently normal so far as observed.

Lepturus repens (Forst. f.) R. Br.

Gegen I. - common but completely dead except for a few tiny seedling tufts on beach ridges.

Elsewhere apparently normal so far as observed.

Boerhavia diffusa L., B. tetrandra Forst. f., Achyranthes canescens R. Br., Pandanus tectorius Park., Portulaca lutea Sol., Cassytha filiformis L., Ipomoea tuba (Schlecht.) Don, Tacca leontopetaloides (L.) O. Kize., and Terminalia samoensis Rech. all in poor condition on Gegen I. but nature of damage not recorded. All apparently normal elsewhere so far as observed.

2. Islets visited, in decreasing order of fallout intensity, with plants in which abnormal appearances were observed.

Gegen I.

Achyranthes canescens

Boerhavia diffusa

Boerhavia tetrandra

Cocos nucifera

Cordia subcordata

Fleurya ruderalis

Guettarda speciosa

Lepturus repens

Pandanus tectorius  
Pisonia grandis  
Portulaca lutea  
Suriana maritima  
Terminalia samoensis

Kabelle I.

Suriana maritima  
Cocos nucifera  
Pisonia grandis

Eniaetok I.

Suriana maritima

Eniwetak I.

Cordia subcordata  
Pisonia grandis

Sifo I.

Pisonia grandis (only slightly defoliated, probably  
normal)  
Suriana maritima

Rongelap I.

No species noticed in abnormal condition, but this was  
first islet visited and perhaps damage was unnoticed  
as attention had not been directed toward it.

Utirik Islet

Suriana maritima (not strongly damaged)

These data are inadequate and are therefore only suggestive. It is by no means claimed that there is any causal connection between fallout and the phenomena observed. However, the clear observation that the poor condition of the vegetation was more intense on the islets where the fallout was more concentrated suggests a relationship. This seems to be of sufficient interest to warrant a careful study. Such a study should determine, first, whether these effects are still observable, and, if so, what the actual nature of the damage is, whether there are significant concentrations of radioactive substances in the tissues, whether there are any notable abnormalities in recovered plants, and whether any young seedlings show abnormalities.

For quick reference all records of plants from the three atolls most seriously affected by the 1954 fallout (except Bikini itself), Rongelap, Rongerik, and Ailinginae, as well as all available records of Marshall Island plants affected or putatively affected by fallout

or other radioactivity have been assembled in the following table. Records indicated by T and by Fc are substantiated by specimens deposited in the U. S. National Herbarium. Many additional species were seen on the NRDL survey but not collected because of lack of time and on the assumption that the species would have been picked up by Taylor at least on the same atoll. This did not always turn out to be the case, but the Taylor and Fosberg collections complement each other fairly well. Important extensions of distribution are reported in a separate paper (see Atoll Res. Bull. no. 68) with citation of specimens.

Legend of symbols used in the table:

Habit of plant:

- h -- herb
- v -- creeper or vine
- s -- shrub
- t -- tree

Abnormalities or reported effects of radioactivity:

- Sp -- St. John, 1950, report of persisting (physiological?) effects.
- Sm -- St. John, 1950, report of mutation.
- Bp -- Biddulph, 1950, report of physiological effects.
- \* -- abnormality recorded by Fosberg, 1956.
- U -- abnormality recorded by Fosberg from Utirik, 1956.
- R -- abnormality observed by Sam Rainey on Bikini, 1956.

Miscellaneous data on flora and collections:

- T -- Occurrence reported by Taylor, 1950.
- F -- Occurrence recorded by Fosberg, 1956.
- c -- Herbarium collection by Fosberg, 1956.
- n -- Material collected by Fosberg for radioanalysis at NRDL, 1956.
- e -- Material collected by Evan C. Evans, III, for radioanalysis at NRDL, 1956.

Name of Plant	habit of growth	abnormalities or rad. effects	Rongelap Atoll				Rongerik Atoll		Ailinginae Atoll	
			Gegen I.	Kabelle I.	Eniaetok I.	Rongelap I.	Other	Eniwetak I.	Other	Sifo I.
<i>Polypodium scolopendria</i>	h								Fc	
<i>Pandanus tectorius</i>	t	*	Fec*	Fe	Fec	T Fec		Fec	Fec	
<i>Chloris inflata</i>	h	Sp								
<i>Eragrostis amabilis</i>	h					T		Fc		
<i>Digitaria pruriens</i> var. <i>microbachne</i>	h				Fnc	T Fnc	T		Fnc	
<i>Lepturus repens</i> var. <i>septentrionalis</i>	h	*	Fn*	Fnc	T Fnc	T Fnc		Fn	T	Fnc
<i>Eleusine indica</i>	h					T				
<i>Cenchrus echinata</i>	h	SpSm				T				
<i>Thuarea involuta</i>	h				T	Fnc		Fnc	Fnc	
<i>Fimbristylis cymosa</i>	h			F	T	T				
<i>Cocos nucifera</i>	t	Bp*	Fe*	Fe*	Fe	T Fe		Fe	Fe	
<i>Crinum asiaticum</i>	h				T	T Fc				



Name of Plant	Rongelap Atoll								Rongerik Atoll	Ailinginae Atoll
	habit of growth	abnormalities or rad. effects	Gegen I.	Kabelle I.	Eniaetok I.	Rongelap I.	Other	Eniwetak I.	Other	Sifo I.
<i>Tacca leontopetaloides</i>	h		Fe*	Fe	T Fe	T Fe	T	T Fe	T	Fec
<i>Artocarpus altilis</i>	t					Fe				
<i>Fleurya ruderalis</i>	h	Sm*	Fe*	Fe						Fe
<i>Achyranthes canescens</i>	h	*	Fe*							
<i>Boerhavia diffusa</i>	v	Sm*	Fnc*	Fe				T Fe		
<i>Boerhavia tetrandra</i>	v	*	Fnc*	Fnc		Fnc	T	Fn	T	Fnc
<i>Pisonia grandis</i>	t	*	Fnc*	Fnc*	T Fn	Fnc		Fnc*	T	Fnc*
<i>Portulaca lutea</i>	h	*	Fnc*	Fn	T Fnc			Fe		Fnc
<i>Portulaca oleracea</i>	h	SpSmBp								
<i>Portulaca samoensis</i>	h					Fnc		T		
<i>Cassytha filiformis</i>	v	*	F*		T	F			T	Fe
<i>Caesalpinia</i> sp.	s						T			
<i>Canavalia microcarpa</i>	v				T	T				

Name of Plant	Rongelap Atoll					Rongerik Atoll		Ailinginae Atoll		
	habit of growth	abnormalities or red. effects	Gegen I.	Kabelle I.	Eniaetok I.	Rongelap I.	Other	Eniwetak I.	Other	Sifo I.
<i>Suriana maritima</i>	s	RU*		F*	F F*				F	Fc*
<i>Soulamea amara</i>	t							Fc		
<i>Allophylus timornsis</i>	s						F			Fc
<i>Triumfetta procumbens</i>	v			F	F	F			F	Fc
<i>Sida fallax</i>	s			F	F	F F		Fc		
<i>Calophyllum inophyllum</i>	t						F			
<i>Carica papaya</i>	t					F Fc				
<i>Cucurbita maxima</i>	v					Fec				
<i>Pemphis acidula</i>	ts						F			
<i>Bruguiera conjugata</i>	t						F			
<i>Terminalia samoensis</i>	ts		Fc*		F		F	F		Fc
<i>Ochrosia oppositifolia</i>	t					F				
<i>Ipomoea pes-caprae</i>	v	Sm								

Name of Plant			Rongelap Atoll					Rongerik Atoll		Ailinginae Atoll
	habit of growth	abnormalities or rad. effects	Gegen I.	Kabelle I.	Eniaetok I.	Rongelap I.	Other	Enivetak I.	Other	Sifo I.
<i>Ipomoea tuba</i>	v	SmBp*	F*		F	Fe		Fe	T	Fc
<i>Cordia subcordata</i>	t	*	F*		F		T	T Fc*		Fc
<i>Tournefortia argentea</i>	t		Fe	Fe	T Fe	Fe	T	Fe	T	Fec
<i>Clerodendrum inerme</i>	s				T	T F	T			Fc
<i>Pseuderanthemum car-ruthersii</i>	s				T	T				
<i>Guettarda speciosa</i>		Sm*	Fn*	Fn	T Fn	Fnc		Fn	T	Fnc
<i>Morinda citrifolia</i>		Sm			T Fe	Fe			T	Fec
<i>Scaevola sericea</i>		Sm	Fe	Fe	Fe	Fe	T	Fe	T	Fec
<i>Wedelia biflora</i>	v					T				Fc

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