Der Tropenlandwirt, Zeitschrift für die Landwirtschaft in den Tropen und Subtropen
95. Jahrgang, April 1994, S. 99 – 103

Radiation Sensitivity of two Ginger Varieties *(Zingiber officinale Rosc.)* to Gamma Irradiation

Empfindlichkeit von zwei Ingwersorten *(Zingiber officinale Rosc.)* gegenüber Gammastrahlung

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The mutability and radiosensitivity of two local ginger varieties in Nigeria "Tafin Giwa" (UG l) and "Yatsun Biri" (UG 2) were studied using gamma rays from a 60Co gamma source. There was a high frequency of chlorophyll mutations indicating a high mutability in ginger. GR 50 was obtained at 5.0 and 6.0 Gy in UG1, and UG2, respectively, while LD50 was obtained at 8.75 Gy in both varieties. The dose limitation range for ginger was estimated to be 5.0-9.0 Gy.

1 Introduction

Ginger, Zingiber officinale Rosc., was introduced by the Portuguese into West Africa in the 16th century (PURSEGLOVE 1972) and probably into Nigeria within the same period. The cultivation of the crop started vigorously in 1927 (ERINLE 1988) and by 1959, Nigeria exported 1,582.8 tons. Since then, production and importance of the crop as an export commodity has increased. The economic part of ginger is its stem rhizome and the best quality rhizomes that command high prices in the world trade are those that are large, light-coloured, brittle, and possess good aroma and little fibre (PURSEGLOVE 1972). Although several varieties of the crop exist, improvement through conventional hybridization is not practiced, because ginger is a difficult plant from a breeding point of view in that it flowers but does not set fruits and seeds (OKWUOWULU 1988, RAMACHANDRAN 1982). Induced mutation breeding can there-

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fore prove very valuable. Mutation breeding has become an effective way of generating useful genetic variations for crop improvement (MICKE et al. 1987) especially in crop plants which have little variability or are not easily amenable to improvement through conventional breeding. This report covers work on the mutability, determination of radio-sentivity, and the establishment of a dose limitation range for mutation breeding in ginger.

2 Material and Method

The study was carried out in a greenhouse at the National Root Crops Research Institute, Umudike, Umuahia, Nigeria. 2 locally adopted varietlies, yellow ginger ("Tafin Giwa") and black ginger ("Yatsun Biri"), were used. The 2 varieties are coded UG 1 and UG 2, respectively. On the 6th December 1990, batches of planting ginger seeds (rhizomes) of the 2 varieties were exposed to 0 (control), 2.5, 5.O, 7.5, and 10.0 Gray (Gy) gamma rays from a 60Co gamma source at the Center for Energy Research and Development, Obafemi Awolowo University, Ile-Ife, Nigeria. 40 setts, each weighing about 29 g, were prepared from each treated batch and planted singly in black polythene bags filled with sterilized soil mixture of top soil, poultry droppings, and sharp river sand in a 4:2:1 ratio. These were mulched with dry grass to a depth of about 5 cm and watered 3 times a week. The experiment was repeated in late March 1991. However, an additional 12.5 Gy dose treatment was added. The data collected included the frequency of chlorophyll mutations, sprout counts, plant height, number of tillers, leaves, and leaf area. A combined analysis was done to determine % sprout, relative survival, and lethality. The relative survival was calculated as

$$\frac{\text{survivalofdosetreatment}}{\%\ \text{survivalofcontrol}} \times 100$$

Lethality was estimated as 100 - relative survival %.

3 Results and discussion

High doses of gamma rays progressively inhibited sprouting in the 2 ginger varieties used (Table 1). The number of days to sprout initiation in the control was 29 and 25 days UGl and UG2, respectively, and varied from 65 to 116 days in UGl and 31 to 141 days in UG2 in the treated setts. The same trend was evident in the number of days to 50% sprout. The survival percentage decreased with increased doses of gamma rays, while lethality increased with dose. Also the plant heights, number of leaves, and leaf area per stand decreased with dose (Table 2). GR 50 (50 % growth reduction / 50% plant height of control) was abtained at about 5.0Gy and 6.OGy in UGl and UG2, respectively, while LD 50 (50% lethality) was obtained at about 8.75Gy in both varie-

ties (Fig. 1). Mutagen treatment resulted in physiological damage, factor mutations, and chromosome mutations. Physiological damages are more easily measured than factor and chromosome mutations and are used extensively in radio-sensitivity tests (GAUL 1977). The general relationship between dose and response of ginger plants in our study in relation to sprouting potentials, survivability, and growth reduction agreed with the general trend observed in mutation induction (GAUL 1977). BROERTJES (1977) noted a relationship between physiological damage and mutation frequency. Generally, the mutation frequency increases with increasing doses and the survival capacity decreases with increasing doses. Therefore, in establishing the dose limitation range for any crop, one must choose a range between a low dose with high survival but lower mutation frequency and a high dose with higher mutation frequency but lower survival. BRUNNER (1985) made the observation that for a meaningful mutation induction that will increase the chance of obtaining meaningful mutants, the mutagenic dose treatment must allow the survival of 40-60% and / or a retardation in growth of about 50%. Based on the results of the present study, the dose limitation range for ginger is 5.0-9.0. Gy.

One remarkable response of the ginger crop to gamma radiation was the high frequency of chlorophyll mutations noticed which increased with the dose (Table 3), an indication that ginger is highly mutable. Chlorophyll mutations are generally not of any agronomic importance but are rather an indication of gene mutability and sensitivity to mutagens in crop plants.

Tab. 1: Sprout and Establishment Characteristrics of Ginger Setts Exposed to Differents Doses of Gamma Rays

Variety	Dose (Gy)	Time to 1st Sprout (DAP)*	Time to 50 % Sprout (DAP)	No. Survived	% Sprout	Relative Survival %
UG_1	0	29	90	78	97.5	100.0
	2.5	65	120	74	92.5	94.9
	5.0	76	124	66	82.5	84.6
	7.5	111	139	44	55.5	56.9
	10.0	116	—	24	30.0	30.8
	12.5	—	—	0	0.0	0.0
UG_2	0	25	67	80	100.0	100.0
	2.5	311	20	72	90.0	90.0
	5.0	40	140	68	85.0	85.0
	7.5	100	161	46	57.5	57.5
	10.0	113	—	22	27.5	27.5
	12.5	141	—	14	17.5	17.5

* DAP - days after planting

Tab. 2: Effect of Doses of Gamma Radiation on the Mean Plant Height, Number of Tillers, Number of Leaves, and Leaf Area Per Stand Two Ginger Varieties, UG_1 and UG_2

Variety	Dose (Gy)	Plant Height (CM)	Number of Tillers	Number of Leaver	Leaf Area (CM^2)
UG_1	0	67.7	3.1	38.2	1009.6
	2.5	47.3	2.2	26.2	535.1
	5.0	33.0	2.1	21.9	421.9
	7.5	18.5	1.5	13.0	227.1
	10.0	16.8	1.2	13.2	162.7
	12.5	—	—	—	
UG_2	0	72.1	2.9	36.6	951.8
	2.5	60.4	2.5	30.3	666.8
	5.0	42.0	2.3	23.8	497.4
	7.5	31.0	2.3	17.7	346.7
	10.0	21.5	2.3	17.5	337.7
	12.5	12.3	1.6	15.1	274.9

Tab. 3: Frequency (%) of Chlorophyll mutants in Two Varieties of Ginger Setts Exposed to Different Doses of Gamma in adiation

Dose (Gy)	No. of Chlorophyll UG_1	Mutants UG_2
0	0	0
2.5	12	5
5.0	18	9
7.5	20	13
10.0	30	21
12.5	—	6

Zusammenfassung

An den Lokalsorten von Ingwer 'Trafin Giwa' (UG l) und 'Yatsun Biri' (UG 2) wurden Mutabilität und Strahlenempfindlichkeit gegenüber Gammastrahlung auf einer 60Co-Quelle untersucht. Eine hohe Rate an Chlorophyllmutationen verdeutlicht die hohe Mutabilität von Ingwer. UG 1 erreichte die GR 50 bei 5.O Gy und UG 2 bei 6 Gy. Die LD50 trat bei beiden Sorten bei 8.75 Gy ein. Eine für Ingwer geeignete Strahlung sollte im Bereich von 5.0 bis 9.0 Gy liegen.

E. C. NWACHUKWU, L. S. O. ENE et E. N. A. MBANASO: Sur la sensibilité de deux cultivars de gingembre (*Zingiber officinale Rosc.*) aux rayons gamma

Ont été étudiés les cultuvars locaux de gingembre 'Trafin Giwa' (UG l) et 'Yatsun Biri' (UG 2) en vue de leurs mutabilité et sensibilité vis-à-vis de la radiation gamma sur une source 60Co. Un taux élevé de mutations de chlorophylle souligne la haute mutalibilité du gingembre. UG 1 atteignait la GR 50 à 5.O Gy, et UG 2 à 6 Gy. La LD50 s'est produite pour les deux variétés à 8.75 Gy. La radiation propre au gingembre devrait être de 1 ' ordre de 5.O à 9.O Gy .

E. C. NWACHUKWU, L. S. O. ENE y E. N. A. MBANASO: Sensibilidad de dos variedades de jengibre (*Zingiber officinale Rosc.*) ante la radiación gamma

Las variedades locales de jengibre "Trafin Giwa" (UG l) y "Yatsun Biri" (UG 2) fueron investigadas en cuanto a mutabilidad y sensibilidad ante la radiación gamma proveniente de una fuente de Cobalto 60. Una alta cuota de mutaciones de la clorofila demuestra la elevada mutabilidad del jengibre. UG 1 alcanzó la GR 50 con 5,0 Gy y UG 2 con 6 Gy. La dosis letal (DL) de ambas variedades fue alcanzada con 8,75 Gy. La dosis de radiación apropiada para el jengibre debe encontrarse entre 5,0 y 9,0 Gy.

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