

FACTORS AFFECTING RADIOSENSIVITY AND DETERMINATION OF
WORKING DOSES OF MUTAGENS FOR SOME CROP AND FRUIT SPECIES

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Radiation sensitivity of crop plants are dependent on:

Biological, environmental and chemical factors

Biological Factors:

- Between species
- Within same species
- Between varieties
- Seed size
- Chromosome number
- Chromosome size
- Nuclear volume (NV)
- Interphase chromosome volume (ICV)
- DNA content

There is an inverse relationship between radio-sensitivity and ICV and to a lesser degree between Radiosensitivity and DNA content.

N.V. determination:

- (1) Select 10 nuclei of apical shoot meristem cells in interphase
- (2) Calculate mean diameter of the major and minor axes of the individual cells
- (3) Apply formula used in determining volume of a sphere.

Estimation of I C V:

1. Determine NV as above
2. Divide NV by the chromosomes number characteristic of the species.

LD-50 (50% lethal dose) can be predicted from these relationships.

Determination of working doses of mutagens:

Mutagenic treatments result in three types of effects.

- 1 - Physiological damage (primary plant injury)
- 2 - Factor mutations (point mutations, "gene mutations")
- 3 - Chromosome mutations (chromosomal aberrations)

M₁ plant injury may be measured quantitatively as follows:

- (1) Germination under lab./emergence under field conditions.
- (2) Root length, determined soon after germination in the lab
- (3) Seedling height, determined at a particular stage soon after germination/emergence in the lab/field.
- (4) Survival under field/lab. conditions.
- (5) No. spikes (inflorescences)/pl.
- (6) No. florets/spike (inflorescence)
- (7) No. seeds/spike (inflorescence)
- (8) Fruits and/or seeds/pl.

However, for practical mutation breeding programs, working dose range of a mutagen for a crop variety may be obtained from growth reduction and death.

In general, a dose/dose range at which

- a 30% reduction in seedling ht. at a particular stage, and

- a 50% survival of the plants at maturity occurs

is considered to be the working dose at which

- a low plant injury, and

- a high genetic effect

will be obtained.

The working dose ranges of gamma-rays and fast neutrons for some crop species.

Table 1. : For field crops*; Handout.

Table 2. : For Fruits and other crops

Table : Suitable radiation doses and plant materials used for the induction of somatic mutations in vegetatively propagated plants*

	<u>Plant material</u>	<u>Dose</u>
<u>Fruit crops</u>		
Apple	Grafts	3-4 KR 4-7 x 10 ¹² n (th)/cm ²
Banana	Corms	2.5 - 5.0 KR
Grape	Dormant buds	1-3 KR
Lemon tree	Cuttings	2-7 KR
Orange	Dormant Scions	5 KR

<u>Other crop plants</u>	<u>Plant material</u>	<u>Dose</u>
Cocoa	Buds	1-2 KR
Cassava	Nodes	3 KR
Hevea (Rubber)	Dormant green buds	0.5-2.0 KR
Potato	Dormant tuber parts	2-3 KR
Sugar Cane	Buds	2-6 KR
Sweet potato	Detached leaves	3-4 KR
Tea	Rooted cuttings	4-6 KR

*After ; Mut. Breed Manual. 1977. IAEA.

RADIOSENSITIVITY OF CROP SPECIES TO GAMMA AND FAST NEUTRON RADIATION

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GENUS OR FAMILY	SPECIES (TRIVIAL NAME)	NO OF CULTIVARS TESTED	RANGE OF GR50** (DOSE IN Gy)		USEFUL DOSE FOR MUTATION BREEDING (DOSE IN Gy)	
			γ	Nf	γ	Nf
GRAMINEAE						
	AVENA SATIVA (OATS) 2n	12	300-450	8-13	100-250	3-6
	HORDEUM VULGARE (BARLEY)	48	300-450	8-12	100-250	3-6
	ORYZA SATIVA (RICE)					
	a.) JAPONICA	42	250-400	23-38	100-280	10-20
	b.) INDICA	34	350-500	33-47	150-350	15-25
	ORYZA GLABERRIMA (RICE)	14	300-400	26-36	150-300	12-22
	TRITICUM AESTIVUM (BREAD WHEAT)	62	450-600	16-24	150-350	3-7
	TRITICUM DURUM (DURUM WHEAT)	21	350-500	12-17	150-300	3-6
	SECALE CEREALE (RYE)	12	300-500	-	100-300	-
	TRITICALE	16	300-450	-	100-300	-
	SORGHUM VULGARE (SORGHUM)	14	450-600	18-25	150-350	4-10
	PENNISETUM TYPHOIDES (PEARL MILLET)	8	400-550	12-18	150-350	4-8
	PANICUM MILIACEUM (BROODCORN MILLET)	4	450-600	-	150-350	-
	ZEA MAYS (MAIZE)	34	200-400	8-19	100-300	3-8
	ELEUSIANA CORACAWA (AFRICAN MILLET)	5	300-500	-	150-300	-
	ERAGROSTIS TEFF (TEFF)	8	1400-1800	-	600-1200	-
	FESTUCA ARUNDINACEA (FESCUE)	3	100-230	8-10	60-140	2-5
	PHALARIS CANARIENSIS (CANARY GRASS)	2	250-300	-	120-160	-
	LOLIUM PERENNE	3	250-400	-	150-300	-

* GR50 = 50% SEEDLING HEIGHT (OR EPICOTYL HEIGHT) REDUCTION AFTER IRRADIATION OF DORMANT SEEDS EQUILIBRATED TO 12-14% MOISTURE WITH ^{60}Co γ RADIATION (DOSE RATE VARIED BETWEEN 60 AND 700 Gy MIN^{-1}) OR WITH FAST NEUTRONS DERIVED FROM THE SNIF (STANDARD NEUTRON IRRADIATION FACILITY).
PRECISION OF THE APPLIED DOSES: $\pm 5\%$ IRRADIATION OF GR, DORMANT SEEDS WITH 12-14% MOISTURE.

GENUS OR FAMILY	SPECIES (TRIVIAL NAME)	NO OF CULTIVARS TESTED	RANGE OF GR 50 (DOSE IN GY)		USEFUL DOSE FOR MUTATION BREEDING (DOSE IN GY)	
			\bar{x}	N _f	\bar{x}	N _f
LEGUMINOSAE						
PEANUT	ARACHIS HYPOGAEA	14	300-450	18-28	100-350	8-18
PIGEON PEA	CAJANUS CAJAN	6	150-240	25-35	80-150	10-20
CHICK PEA	CICER ARIETINUM	9	180-300	28-45	100-200	18-28
LENTIL	LENS ESCULENTA	7	160-250	9-14	80-200	5-10
LUPINS	LUPINUS ALBUS	3	300-400	15-28	100-250	8-14
	LUTEUS	2	300-450	—	100-250	—
	ANGUSTIFOLIUS	2	300-500	18-28	100-300	10-15
	MUTABILIS	4	250-400	—	100-250	—
					100-200	—
HYACINTH BEAN	BOLICHOS LABLAB	3	250-350	—	300-600	—
ALFALFA	MEDICAGO SATIVA	4	750-900	—	400-700	—
SWEET CLOVER	MELILOTUS ALBUS	3	800-1000	—	60-200	6-12
COMMON BEAN	PHASEOLUS VULGARIS	26	80-300	10-24	50-120 (200)	7-14
LIMA BEAN	PHASEOLUS LUNATUS	8	90-180 (300)	16-27	400-700	25-40
MUNG GRAM	PHASEOLUS AUREUS	6	60-1000	50-70	40-180	3-7
PEA	PISUM SATIVUM	34	60-270	5-12	20-40	0.5-1.0
HORSE BEAN	VICIA FABA MAJOR	4	40-60	1.2-1.8	40-70	1.5-3.0
	VICIA FABA MINOR	9	80-140	3-4	100-250	—
	VICIA SATIVA	3	300-400	—	120-280	—
VETCH	VICIA VILLOSA	3	300-450	—	100-250	15-30
COWPEA	VIGNA UNGUICULATA	8	200-400	25-45	200-500	20-40
MUNG BEAN	VIGNA RADIATA	4	400-900	50-75	200-500	—
CASTOR BEAN	RHIZINUS COMMUNIS	3	450-700	—	100-250	10-18
SOY BEAN	GLYCINE MAX.	28	150-400	20-40	500-900	—
INCARNATE CLOVER	TRIFOLIUM INCARNATUM	4	1200-1700	—	—	—

GENUS OR FAMILY	SPECIES (TRIVIAL NAME)	No OF CULTIVARS TESTED	RANGE OF GRSD (DOSE IN Gy)		USEFUL DOSE FOR MUTATION BREEDING (DOSE IN Gy)	
			γ	Nf	γ	Nf
CRUCIFERAE						
WHITE MUSTARD	SINAPIS ARBA	4	900-1500	—	500-1000	—
WILD TURNIP	BRASSICA CAMPESTRIS OLLIFERA	3	800-1600	—	500-1000	—
INDIAN MUSTARD	BRASSICA JUNCEA	8	1600-2000	—	1000-1500	—
BLACK MUSTARD	BRASSICA NIGRA	3	1300-1800	—	800-1400	—
SWEDE	BRASSICA NAPUS RAPIFERA	9	1200-1600	—	800-1100	—
CHIN. CABBAGE	BRASSICA PEKINENSIS	2	1300-1700	—	700-1200	—
RADISH	RAPHANUS SATIVUS	12	700-1300	60-80	400-800	20-45
ARABIDOPSIS	ARABIDOPSIS THALIANA	6	700-1200	55-75	400-800	20-40
RAPE	BRASSICA NAPUS OLEIFERA	4	600-1100	—	400-700	—
SOLANACEAE						
RED PEPPER (CHILI)	CAPSICUM ANNUUM	8	250-500	—	100-350	—
TOMATO	LYCOPERSICON ESCULENTUM	12	450-600	—	200-400	—
LILIACEAE						
ONION	ALLIUM CEPA	8	160-280	7-12	80-180	—
LEEK	ALLIUM SCORODOPRASMUM	2	200-250	8-11	80-140	—
ASPARAGUS	ASPARAGUS OFFICINALIS	3	300-400	—	150-250	—
UMBELLIFERAE						
CARROT	DAUCUS CAROTA	4	550-700	—	250-400	—
CHEENOPODIACEAE						
SPINACH	SPINACEA OLERACEA	3	300-500	—	150-300	—
QUINOA	CHEENOPODIUM QUINOA	4	300-500	—	150-300	—

GENUS OR FAMILY	SPECIES (TRIVIAL NAME)	NO OF CULTIVARS TESTED	RANGE OF GRSD (DOSE IN Gy)		USEFUL DOSE FOR MUTATION BREEDING (DOSE IN Gy)		
			γ	N_f	γ	N_f	
MALVACEAE							
COTTON	GOSYPIUM ARBORETRUM	3	140-250	4-7	80-150	2-4	
COTTON	GOSYPIUM HIRSATUM	18	300-500	8-12	150-300	3-7	
OKRA	HIBISCUS ESCULENTUS	2	600-850	-	300-500	-	
COMPOSITAE							
SUNFLOWER	HELIANTHUS ANNUUS	8	250-500	-	100-300	-	
SAFFLOWER	CARTHAMUS TINCTORIUS	4	600-700	45-55	200-450	15-30	
NIGER	QUITOTA ABYSSINICA	3	200-260	14-17	80-160	5-8	
LETTUCE	LACTUCA SATIVA	5	350-500	10-15	150-300	4-7	
TILIACEAE							
JUTE	CORCHORUS OLITORIUS	2n	3	700-850	38-45	300-550	15-27
		4n	3	550-700	34-42	250-450	15-25
CUCURBITACEAE							
SQUASH	CUCURBITA MAXIMA	4	500-700	-	250-450	-	
CUCUMBER	CUCUMIS SATIVUS	8	450-600	-	200-400	-	
MELON	CUCUMIS MELO	2	350-500	-	200-350	-	
PEDALIACEAE							
SESAME	SESAMUM INDICUM	11	400-600	-	200-400	-	
LINACEAE							
FLAX	LINUM USITATISSIMUM	5	600-1000	-	300-600	-	
POLYGONACEAE							
BUCKWHEAT	FAGOPYRUM ESCULENTUM	3	300-500	-	150-300	-	