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IMPROVEMENT OF CROPS IN AFRICA THROUGH THE USE OF INDUCED MUTATIONS

REPORT OF A REGIONAL SEMINAR
JOINTLY ORGANIZED BY THE
INTERNATIONAL ATOMIC ENERGY AGENCY
AND THE
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
AND HELD IN LUSAKA, ZAMBIA, 20-24 JUNE 1988

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FOREWORD

Tropical root and tuber crops such as cassava, yam and sweet potato, bananas and plantains, grain legumes like cowpea, pigeon pea, peanut and beans and among the cereals primarily sorghum, millet and maize are the staple foods for most African people. However, there is a chronic shortage of food in the region and the risk of starvation on a wide scale is always present among the population of about 500 million.

There is an urgent need to improve the generally low yielding indigenous crop varieties in order to raise production levels and reduce the food gap. Exploitation of available genetic resources combined with the use of induced mutations can result in the much needed development of better varieties. For several of the crops mentioned, induced mutations offer a unique chance of achieving progress in breeding, while for others the method is a valuable supplement to conventional plant breeding.

IAEA and FAO have been engaged for many years in co-ordinating research projects aimed at developing more efficient methods for the induction and selection of mutations for various crop plant species. The methodology is available but has to be adapted to local objectives and conditions. It was desirable to review the status of the genetic improvement of crops by induced mutations in other parts of the world and compare this with work in Africa. This would form the basis to promote technology transfer and to encourage African plant breeders to make use of the best methods available. It was felt that these objectives could be achieved through a regional seminar which would bring together plant breeders from developing countries in Africa and experts from developing and developed countries in other regions.

The Seminar took place 20 - 24 June at the Mulungushi Conference Hall, Lusaka (Zambia). It was hosted by the Ministry of Agriculture and Water Development and the National Council for Scientific Research (NCSR).

33 plant breeders from 14 countries followed the invitation and during 4 days discussed their particular breeding tasks, problems and achievements among themselves and with invited experts. This opportunity was much appreciated and led even to the idea of organizing a regional African plant breeders association like EUCARPIA in Europe or SABRAO in South-East Asia.

One day was devoted to visiting the Nuclear Analytical Laboratory of the NCSR and the Mount Makulu Central Agricultural Research Station.

A similar Seminar had been held 23 - 27 October 1978 at Ibadan (Nigeria), hosted by the International Institute of Tropical Agriculture. The report was published by IAEA as Technical Document No. 222 (1979).

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PROGRAMME OF THE SEMINAR

Monday 20 June 1988

9.30 Opening by Hon. Minister of Agriculture and Water Development.

A. Micke (FAO)/IAEA)
Introductory Lecture: The role of induced mutations for crop improvement.

C.R. Bhatia (India)
Mutation breeding for crop improvement in India

B. Donini (Italy)
Mutation breeding in Italy

Mutation breeding of rice
Reports by J. Pedro (Benin)
M.S. Mansaray (Sierra Leone)
H.M. Ching'ang'a (Tanzania)
A.O. Abifarin (WARDA)

Discussion

19.00 Reception hosted by FAO/IAEA and the Ministry of Agriculture.

Tuesday 21 June 1988

9.00 - 18.00 Mutation breeding of grain legumes
Reports by J. Uzo (Nigeria)
P. Omanga (Kenya)
G. Gumisiriza (Uganda)
P. Safo-Kantanka (Ghana)
P. Nyabyenda (Rwanda)
T.M. Amet (Liberia)
M.E. Abdelrahman (Sudan)
D.M. Lungu (Zambia)

Discussion

Mutation breeding of oilseeds crops
Reports by P. Nyabyenda (Rwanda)
M.E. Abdelrahman (Sudan)
M.S. Mwala (Zambia)
X.T. Muunga (Zambia)

Discussion

Mutation breeding of maize and sorghum
Reports by C. Mwambula (Zambia)
J. Pedro (Benin)
M.E. Abdelrahman (Sudan)
A. Bretaudeau (Mali)

Discussion

Wednesday 21 June 1988

9 - 18.00 Mutation breeding of tomato
Reports by P.R. Rubaihayo (Uganda)
A. Diallo (Guinee)

Discussion

Mutation breeding of root and tuber crops
Reports by J.O. Uzo (Nigeria)
O. Safo-Kantanka (Ghana)
P. Omanga (Kenya)
T. Amet (Liberia)

Discussion

Mutation breeding of fruit trees

Reports by C.K. Mwamba (Zambia)
W.K. Chishimba (Zambia)

Discussion

Thursday 22 June 1988

Excursion (a) National Council for Scientific Research: Nuclear Analytical Laboratory, Lusaka.

(b) Ministry of Agriculture and Water Development: Mount Makulu Central Agricultural Research Station at Chilanga.

(c) Botanical Garden and Zoo.

Friday 23 June 1988

9.00 - 18.00 F. Novak (IAEA Laboratory):
Mutation breeding using in-vitro culture techniques.

N. Murata (FAO/IAEA):
Mutation breeding for disease ressistance.

Discussion

A. Micke (FAO/IAEA):
- Information about assistance by FAO/IAEA for mutation breeding.
- Summary and closing remarks.

SUMMARIES OF LECTURES AND REPORTS

THE ROLE OF INDUCED MUTATIONS FOR CROP IMPROVEMENT

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The tool to induce mutations and thus to supplement genetic variation is available to plant breeders since more than 60 years, but only slowly breeders have learned to make use of this possibility. The first mutant cultivars were released around 1950 and during the following 20 years worldwide only about 80 more cultivars of different species derived from induced mutants (Sigurbjörnsson and Micke, 1969, 1974). Since then, however, many plant breeders seem to have recognized the value of induced mutations.

The Joint FAO/IAEA Division collects information on the use of induced mutations in plant breeding and publishes such information in the "Mutation Breeding Newsletter". Up to March 1988, our records contain 1093 cultivars derived directly from induced mutants or from the use of such mutants in cross breeding (Table 1).

Table 1.

Mutant derived cultivars (till March 1988)

group of plant species	number of cultivars		
	from direct use of induced mutant	from mutant crosses	Total
cereals	285	165	450
grain legumes	84	33	117
oilseed crops	21	5	26
industrial crops	36	8	44
forage crops, grasses	11	1	11
fruits, vegetables	64	3	67
ornamentals	373	4	377
			1,093

Some of the first mutant cultivars were more or less by-products of radiobiological or genetic research carried out in developed countries, but the success since the seventies appears to come from plant breeding programmes. Thus it is also not surprising to see that the developing countries benefit more and more from the additional possibilities. Table 2 illustrates the trend: By 1987 almost 50% of the known "mutant cultivars" were from developing countries but mainly from Asia. This is the reason why we felt it would be timely to organize a Seminar for African plant breeders to make them more aware of recent developments.

Table 2. Mutant cultivars developed in certain groups of countries in percent of total number according to reviews published in 1969, 1974 and 1987 (Sigurbjörnsson and Micke, 1969, 1974; Micke et al. 1987.)

	1969	1974	1987
Number of cultivars	77	147	844
<u>Groups of countries</u>			
(A) <u>according to geographical regions</u>			
Europe (incl. USSR)	59.7	54.8	38.5
North America	20.8	16.7	8.6
Asia and Oceanea	16.9	27.1	51.5
Latin America	2.6	1.4	0.8
Africa	0	0	0.6
(B) <u>according to economic categories</u>			
developed countries	84.4	80.5	51.0
developing countries	15.6	19.5	49.0

The Manual on Mutation Breeding, published by IAEA in 1977 is still the standard text book used, e.g in FAO/IAEA Training Courses. It provides a bulk of useful information on when and how to use induced mutations for plant improvement. But there are also a number of good reviews published in recent years, such as by Broertjes and van Harten (1988), Konzak (1984) Micke et al. (1987). Crop specific monographs are being published by FAO/IAEA in the series "Mutation Breeding Review", available issues deal with sorghum and millets, pea, <u>Capsicum</u>. To keep abreast with new developments, the FAO/IAEA Mutation Breeding Newsletter is published twice a year and distributed costfree to interested plant breeders.

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MUTATION BREEDING FOR CROP IMPROVEMENT IN INDIA

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Sustained efforts to evaluate the potential of induced mutations in crop improvement programmes were initiated at the Indian Agricultural Research Institute, New Delhi, and the then Atomic Energy Establishment at Trombay, during the latter half of the nineteen fifties. At that time, there were several groups in the country, specializing in chromosomal studies. With easy access to radiation sources and availability of chemical mutagens, many such groups exposed seeds and other plant parts, mainly to investigate the cytogenetic effects of different radiations and chemical mutagens. The early efforts of others were aimed to enhance the frequency or enlarge the spectrum of mutations. Different types of radiations, chemical mutagens and their physical and chemical modifiers singly or in combinations were used. This exploratory phase continued till the end of the sixties and part of the early seventies. Development of fully awned mutant cultivars in awnless wheats, amber grain types in red grain 'Mexican' wheats, dwarf mutants in rice and early maturity mutants in castor established the utility of induced mutations in crop breeding programmes and its acceptance as an additional tool in plant breeding.

Currently, mutation research is carried out in three types of laboratories:

i) National laboratories having a strong commitment to plant breeding programmes;
ii) Departments of genetics or plant breeding in the agricultural universities;
iii) Botany and genetics departments in other universities.

The new mutant cultivars have largely come from the national laboratories or the plant breeding departments. For all the major crops, there are national and regional breeding programmes carried out in co-operation by the national research institutes and the state agricultural universities. These programmes also have strong linkages with the international crop research institutes like IRRI, CIMMYT, ICRISAT etc. Project Directorates for a crop or a group of crops, co-ordinate the testing of all new entries. A three-year system of testing is generally followed. Finally the available data are scrutinized by the State or National Varietal Release Committee, which recommends the release of new varieties for commercial cultivation. Once a variety is released and notified, the National or State Seed Corporation or a private seed company can take up the certified seed production programme. In most countries this type of testing with some variations is required before a new crop variety can be approved for commercial cultivation.

New cultivars from mutation breeding

Using radiation and chemical mutagens followed by selection for phenotypic changes in plants, a large number of improved cultivars have been developed in various crop and ornamental plants (Micke et al. 1985, 1987). In India, at least 150 such cultivars have been developed using the mutation technique, including 70 in ornamental plants (Anonymous 1979).

At the Bhabha Atomic Research Centre, nine cultivars - three of groundnut (TG-1, TG-3, TG-17); two of pigeon pea (Trombay Vishakha-1, TAT-10) and one each of rice (Hari), mungbean (TAP-7), blackgram (TAU-1) and jute (TKJ-40 Mahadev) developed by our group have been released and notified by the Government. A number of other improved stocks are at different stages of testing. Some of the mutants isolated in mustard, groundnut and jute have been used extensively in hybridization at different breeding centres in the country. In addition, mutations at physiological, anatomical, cellular, biochemical and molecular level have been isolated. Large kernel size and high oil groundnuts, mustard with yellow seed coat colour, photoperiod insensitive jute, profusely branching mungbean, seed storage protein and enzyme variants are some of the interesting mutants.

Increasing yield potential

Mutants superior to the parent cultivar in one or two components of yield, can be isolated in mutagenized populations with reasonable probability. Similarly, early flowering and maturity mutants are obtained easily. Using such mutants in cross breeding, we are attempting to increase the yield potential, keeping the crop duration constant or trying to reduce the duration while maintaining yield.

Those embarking upon new mutation breeding programmes should realize that it requires sustained efforts over a period of 10-12 crop seasons before a new variety is accepted for cultivation. Plant breeding is highly competitive. The new mutant strain should not only be superior to the parent cultivar but also effectively compete with other new entries from national and international institutes and private breeders. The results obtained in India as well as other countries clearly show that mutation breeding has greater chances of success when carried out as a part of plant breeding programmes. Strong linkages with the national plant breeding programmes are necessary.

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CONTRIBUTION OF MUTAGENESIS TO THE DEVELOPMENT OF IMPROVED VARIETIES IN ITALY

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An experimental mutagenesis programme was started in Italy in 1958 at the Agriculture Laboratories, Casaccia Nuclear Research Centre, ENEA, Rome, Italy, for both genetic research and applied mutation breeding. Efforts concerned cereals, vegetables and fruit trees and a lot of knowledge was gained on doses of treatment both with physical and chemical mutagens, methodology of handling the material, mutant selection and evaluation. New mutant varieties in the different species have been released to the farmers and substantially contribute to the economy of the country. This review describes the contribution of mutagenesis to the development of improved varieties in Italy in the past 25 years.

Cereals

In view of the economic importance of durum wheat in Italy and in the Mediterranean and Near East Area, and because the yield of durum wheat was substantially lower than bread wheat, the programme initially focused on this crop. Later on, bread wheat, triticale and barley were included in the studies.

Several varieties have been treated both with chemical and physical mutagens. Several methods of irradiation (acute, chronic, recurrent) at different ontogenic stages of the plant (seed, growing and heading stage, pollen, both gametes, zygote) have been applied. We studied the effect upon the frequency of mutations and the development of chimeras. The efficiency of the mutagens was assessed. The appropriate methods of treatment and the methodology of handling plants in the first and subsequent generations have been established.

The selection of mutated plants has been carried out by applying screening methods based on visual inspection and other appropriate techniques for the identification of the desired changes. Mutations affecting characters such as culm length, stiff straw, number and length of internodes, heading time, disease resistance, kernel weight, protein content of the seeds have been recorded.

Useful mutations were selected particularly for lodging resistance. The lodging susceptibility and straw weakness of the original durum wheat varieties was a serious problem affecting the yield. No natural genetic sources for culm shortening were available for breeders in durum wheat. The plant height reduction of the selected mutants ranged from 10 to 40% of the parental variety height. The genetics of short and stiff culm mutants was clarified, being monogenic and recessive or dominant.

A programme for the agronomical evaluation of durum wheat mutant lines aimed at ascertaining the concrete possibility of direct use as a new variety of the best mutants. In order to evaluate the new mutant lines in different agronomic environments, trials were carried out in different regions of Central and Southern Italy and in the Mediterranean North Africa and Near East countries, in co-operation with FAO and IAEA. From all the agronomic data gathered, it was clearly demonstrated that certain mutant lines, compared with the original parents, gave a consistent improvement in yield and grain quality or in other cases outyielded the local varieties.

Mutant varieties were registered and released to the farmers under the names Castelfusano (1969), Castelporziano (1969), Casteldelmonte (1969), Castelnuovo (1974), Icaro (1988). A new variety Ulisse is in the process of registration.

The utilization of the mutants, particularly the new short straw lines, in a hybridization programme for incorporation of better rust and mildew resistance was determinant in the rapid genetic improvement of the Italian _durum_ wheat varieties. As results of these crosses several new varieties have been obtained: Creso (1974), Tito (1976), Augusto (1982), Febo (1982), Giano (1982), Peleo is under registration. Mutant varieties, particularly Creso, are now the leading varieties of _durum_ wheat in Italy contributing to over 50% of Italian _durum_ production.

In bread wheat the mutant variety Spinnaker, released in 1988, has been obtained through mutation breeding by fast neutron seeds treatment of the variety Anza. The variety characteristics are: lodging resistance, high yield and good grain quality.

A mutant variety of barley Dueplù is under registration. It possesses early maturity, lodging resistance and high yield. The variety has been obtained by crossing an early mutant line "Leonessa precoce" with the variety Horpacs-Ketzores.

Vegetable crops

Tomato, pepper, pea and potato and other legumes (lentil, chickpea, bean, etc.) are widely cultivated in Italy. They are essential components of the human diet in the Mediterranean as well as in other world countries.

A mutation breeding programme has been carried out at the ENEA Agriculture Laboratories aimed at the improvement of these crops. The desired characteristics were yield improvement, determinate type (tomato, pea), contemporary fruit ripening (tomato), suitability for mechanical harvest (tomato, pepper), good quality for fresh consumption (tomato), resistance to disease, virus and nematodes (tomato, pepper, chickpea).

Knowledge has been accumulated on the more efficient doses or concentrations of physical or chemical mutagens to be applied on seed, pollen, or _in-vitro_ cultured material. The procedures of handling treated material, mutant selection and screening either under laboratory, greenhouse or field conditions were also established. Mutant varieties coming directly from mutants or from the crosses of mutant lines have been agronomically evaluated, registered and released to the farmers.

The mutant varieties of pea Esedra (1980), Navona (980) and Trevi (1985) are commercially popular due to their better performance in yield, adaptability for mechanical harvest and better technological characteristics for canning. Trevi was derived from crossing a Sprinter line with a mutant line of Parvus. New mutant pea varieties recently obtained and under registration are Paride, Pirro, Priamo.Among several mutants obtained in pepper, which are now under evaluation, the mutant line A 704 is resistant to Phytophtora capsici and it will be used in crosses as a new source of resistance to control the root rot disease which plagues the pepper growing area in Italy. A new technology has been set up in potato by combining mutation breeding and in-vitro culture micropropagation. The method has the advantage of speeding up the recovery of induced mutations and as a result a new potato variety Desital (under registration) has been obtained.

Fruit trees

The possibility of using applied mutagenesis for improving desirable characteristics in fruit trees has been intensively studied at ENEA's Agriculture Laboratories. The research carried out deals with better techniques of mutagenic treatments, the understanding of the mechanism of mutation induction and the set up of more efficient methodology of somatic mutation isolation in the different crops considered. The results obtained generally show that radiations enhance the frequency of somatic mutations and produce minor changes without deeply altering the genotype of the cultivar. Experiments have been performed in several fruit species: apple, almond, apricot, citrus, grape, loquat, olive, peach, sweet cherry and useful mutations have been recorded.

Among desired changes of selected mutants are: less vigorously growing trees (dwarf type) to facilitate the fruit harvest in sweet cherry and olive; change in fruit colour and size of apple; reduced number of seed in the fruit of Citrus; late flowering to escape the spring frost in almond. Mutant varieties have been registered up to now in olive (Briscola, 1982), in sweet cherry (Durone compatto di Vignola and Burlat Cl, 1988) and in almond (Supernova, 1988).

The contribution of applied mutagenesis to the development of improved varieties in Italy has been remarkable. The knowledge of mutation breeding technologies which has been achieved by scientists of ENEA's Agriculture Laboratories in cereals, vegetable and fruit tree crops is now available to be shared with developing countries.

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FACTORS LIMITING PRODUCTION OF RICE IN THE PEOPLE'S REPUBLIC OF BENIN

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Rice is a rather recent crop in Benin. Its cultivation developed between 1960 and 1975 in connection with the improvement of irrigation water supply. Rice development schemes benefit from co-operation with Togo, China and Korea. The consummation is rapidly increasing and production lags seriously behind, nearly 80% are imported. Last year, around 7000 ha were under rice cultivation with average yields of 1,4t/ha. In 1976, there were more than 10,000 ha of rice, and 12,000 t of production, but in certain provinces rice cultivation was abandoned in favour of more profitable crops.

Lack of good rice varieties is one major factor limiting production. For a long time, IR 442 and IR8 have been used for irrigated upland rice and the Congolese variety R66 for the lowland. As water supply is rather irregular, drought tolerance is needed for upland rice besides better resistance to *Pyricularia* and *Helminthosporium*. Research co-operation with FAO, IITA, IRRI, WARDA and IRAT allowed identification of interesting varieties for Benin. These are for upland rice: IET 2885, BW 196, ITA 212, ADNY 11, IR 2042-178-1, IR 327 P339-2 and IR 1529-380-3. ADNY 11 and COL 38 were released for cultivation in 1984, ITA 212 is expected to be released. But sofar only 3,6% of the rice area is planted with improved cultivars. Other production constraints are in the rather archaic production system, the irregular supply and high costs of irrigation water, low level of fertilizer application and in particular diseases like blast (*Pyricularia*), which may cause a total crop failure. Pesticides are becoming too costly.

Mutation breeding has not been used so far, but some of the introduced cultivars (like IRAT 13) were derived from mutation breeding.

RICE VARIETAL IMPROVEMENT IN SIERRA LEONE: AN EXPERIENCE WITH THE USE OF INDUCED MUTATIONS

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In Sierra Leone, rice is grown in distinct ecologies: Rainfed Uplands (RU), Mangrove Swamps (MS), Inland Valley Swamps (IVS), Bolilands (B), and Riverain Grasslands (RG). There is considerable variation in the methods of cultivation, soil type and fertility. Breeding since 1934 tailored varieties that have adaptation to these ecologies.

Rice was probably introduced to Sierra Leone some 4,000 years ago. At the national Rice Research Station, Rokupr, scientists have exploited indigenous germplasm for high yielding varieties. The selections ROK 3 and ROK 16 were released in 1974 and 1978, respectively, for upland cultivation, while ROK 27 and ROK 30 were released in 1988 for use in the IVS and Bolilands, respectively. Introducing rices from international agricultural research centres and other foreign breeding programmes is a short term strategy. 21 introduced varieties have been released since 1961 for cultivation (Table 1).

Table 1: Rice varieties released from introductions into Sierra Leone.

Cultivar	Original Name	Origin	Ecology	Year of Release
Tikiri Samba	Tikiri Samba	Ceylon	Upland	1961
Anethoda	Anethoda	"	"	"
Gantang	Gantang	North Borneo	IVS	1963
Faya	Faya	Nyasaland	IVS	1963
SR26	SR26	India via Ceylon	IVS	1963
Indochine Blanc	Indochine Blanc	Guinea	RG	1963
ROK 6	IR 5-178	IRRI	Irrigated low-lands	1974
ROK 11	ADNY 2	Columbia via IRRI	Irrigated low-lands	1978
ROK 12	ADNY 11	" " "	" "	1978
ROK 14	Mange 2	Taiwan	" "	1978
ROK 17	Lac 23	Liberia	Upland	1988
ROK 18	IDSA 6	Ivory Coast	"	1988
ROK 19	Farox 299	Nigeria (NCRI)	"	1988
ROK 20	IRAT 161	France via IITA	"	1988
ROK 23	ADNY 301	IRRI	IVS	1988
ROK 24	Suakoko 8	Liberia	IVS	1988
ROK 25	Mashuri	IRRI	IVS	1988
ROK 28	BG 90-2	Sri Lanka via IRRI	IVS	1988
ROK 31	BG 400-1	Sri Lanka via IRRI	IVS	1988
ROK 32	ITA 235	IITA	IVS	1988
ROK 33	IR 58	IRRI	IVS	1988

Some varieties possessing genes for tolerance to adverse soils or resistance to pests and diseases have been included in hybridization and tremendous successes were made in developing varieties for the different ecologies. Two sets of crosses have resulted in the release of some 15 rice varieties. The first hybridization programme, between 1963 and 1965 resulted in the release of ROK 1 to ROK 5 and ROK 7 in 1974 and ROK 8 to ROK 10, ROK 13 and ROK 15 in 1978. A second set of crosses made between 1974 and 1978 led to the release of the varieties ROK 21, ROK 22, ROK 26 and ROK 29 in 1988.

Major breeding objectives today are improvement of disease resistance and reduction of lodging blast disease caused by Pyricularia orzyae, is the most destructive widespread fungal disease in Sierra Leone, brown spot, caused by Helminthosporum oryzae and leaf scald, caused by Rhynchosporium oryzae are likewise dangerous. Germplasm with resistance include varieties OS6, LAC 23, Dourado Precoce, and Moroberekan. Loss of grain due to lodging may vary from 12 to 60%. Among recommended varieties with only moderate lodging are ROK 1, ROK 2, ROK 6, ROK 11, ROK 12 and ROK 14. In 1977, several local and improved rice varieties were irradiated at Fourah Bay College, the University of Sierra Leone, using Germanium and Polonium as neutron sources. Plant height was reduced by induced mutations. Grain yield was affected, but not the maturation date.

In West Africa, the mutant IRAT 13 has been used profusely by IITA in Nigeria and IDESSA in Ivory Coast to produce several of the advanced lines popularly used today. (See table below).

Cultivar/Line	Parentage
IRAT 104	IRAT 13/Moroberekan
IRAT 111	IRAT 13/IRAT 10
IRAT 112	IRAT 13/Dourado Precoce
IRAT 101	Mutant of 63-83

In Sierra Leone, through the use of induced mutations, well adapted varieties could be further improved by:

(a) reducing the plant height, thus improving loding resistance
(b) increasing disease resistance, and
(c) producing mutants that are tolerant to soil problems such as iron toxicity, salinity and acidity.

For example:

(i) ROK 4, ROK 5, ROK 8 and ROK 9 are high yielding and well adapted to the mangrove ecology of Sierra Leone. They have good grain (slender, long), good cooking and keeping qualities. However, they lodge miserably. Induced semi-dwarf mutants keeping all the good features would be of great value.

(ii) ROK 3, ROK 16 and ROK 17 are popular upland rice varieties. They are high tillering, with heavy (large) panicles and high yield. With the exception of ROK 3, these varieties are resistant to leaf and neck blast and brown spot diseases. ROK 3 is moderately susceptible to brown spot disease (Helminthosporium oryzae). All three varieties lodge under fertile soil conditions. Semidwarf mutants of these varieties with resistance to brown spot (for ROK 3) can be most valuable.

(iii) ROK 10, ROK 23 and CP 4 are popular IVS varieties grown widely in all the IVS in the country. They are high yielding with good grain qualities., but lodge. Induced semidwarf mutants could boost IVS rice production.

NATIONAL CROP PROBLEMS AND POTENTIAL SOLUTIONS BY PLANT BREEDING WITH REFERENCE TO RICE

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Tanzania has experienced a major food deficit for some time, the seriousness of which increased in recent years. Although rice is traditionally a minor component of food, it is becoming more popular especially in the urban areas and is now widely grown, either as an upland crop (usually interplanted with maize), or as a wetland crop in naturally swampy areas, river valleys and basins.

Rice production in the country totals now 547,000 metric tons from 316,000 hectares. The average farm yields are far below the level demonstrated to be possible on experiment stations. Instead of reaching the experimental levels of 6-8 t/ha, good farmers get 3-4 t/ha but a majority of farmers gets as little as 0.5 t/ha. The wide range of agroclimatic conditions under which rice is grown, the broad array of natural enemies of the rice plant, the adverse growing conditions combine to reduce the yield of rice.

There is a great need to intensify and strengthen our research efforts to meet the increasing demand for rice arising from population increase and increased urbanization. The primary strategy is to remove production constraints through genetic improvement. Rice varieties tailored for specific conditions, locations and cropping systems are needed. These varieties must have a higher yield potential than the cultivars traditionally grown.

Since 1935, attempts have been made to produce varieties with greater yield potential, resistant to diseases and insect pests for Tanzania's varied agro-ecological zones. The present Rice Improvement Programme was initiated at Ilonga in 1966 and since then rice breeding has concentrated on hybridization and mutation breeding of indigenous long season varieties. A number of varieties suitable for lowland cultivation such as Faya Theresa, Gamti, Afaa Nwanza and Kihogo red (Morogoro) and three upland varieties namely Dunduli ya milimani, Salama and Africa have been developed through pure line selection. One variety developed in India, IET 2397 was released as Katrin in Tanzania. Selemwa, a product of hybridization between local and introduced varieties was released and is being cultivated widely under lowland rice culture.

Outstanding lines with higher grain yield, improved lodging resistance, better protein quality and content than their parents were obtained by mutation breeding since 1972 and the mutant germplasm will be used for cross-breeding. Induced mutations could be useful for the solution of specific problems, where more conventional breeding methods are insufficient. Some promising results already apparent with rice suggest that induced mutation can offer a unique additional approach to improve rice production as a supplement to and in combination with conventional cross-breeding.

THE USE OF INDUCED MUTATION IN BREEDING RICE FOR IRON TOXICITY TOLERANCE

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Iron toxicity is an important soil problem for rice production in many parts of West Africa and other parts of the world. In solving this problem, conventional breeding methods have been tried by many breeders. Often the results were not satisfactory because many of the parents are not good combiners. In view of this, two rice cultivars Suakoko 8 and ITA 249 were irradiated by the IAEA Laboratory in Vienna with 20-30 krad ^{60}Co gamma rays. One objective was whether shorter and more tillering plants can be obtained from Suakoko 8 which is an iron toxicity tolerant variety. The other objective was to obtain from the moderately tolerant long duration semi-dwarf variety ITA 249, taller plants with higher level of tolerance to iron toxicity, maturing 110-120 days after sowing and with more productive tillers per plant. Increased height is desirable for our conditions as ITA 249 is only about 90 cm tall.

The M3 population five weeks after transplanting contained desirable plants that may meet some of the objectives. Many M3 plants from irradiated ITA 249 were more tolerant to iron toxicity than the mother variety. Some of these mutants were more vigorous and taller than the short culm mother variety. On the other hand, the results of Suakoko 8 irradiation were not very promising. Most of the mutants were not enough different from the mother variety. Some were increased in height which is undesirable as mature height of Suakoko 8 is already about 150 cm. If the present preliminary observations are confirmed, induced mutations in ITA 249 will produce desirable plants within a shorter time than conventional breeding would have taken.

PROBLEMS OF INCREASING THE YIELD OF FIELD AND VEGETABLE COWPEAS AND SUGGESTIONS FOR A BREEDING STRATEGY

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Food in many parts of Africa means cereals and tubers, but leguminous grain and vegetable crops could fill the large gap in protein intake. Their improvement needs more emphasis.

Two types of Vigna unguiculata L. (Walp.) are cultivated in Nigeria, the field cowpea for dry grain which is extensively grown in the semi-arid belt and the vegetable cowpea cultivated in the savannah and the rain forest belt. Production problems of course are primarily in soil fertility, drought, insect pests, etc.

Plant breeding should help to achieve better environmental adaptation and grain yield. For vegetable cowpeas, the problems are somewhat different. They are fairly well adapted to acid soils, but have a too shallow root system. They are climbing or decumbents. There is no evidence, that field and vegetable cowpeas have been crossed. Flower color of vegetable cowpeas may lead to a higher degree of resistance to the cowpea moth. There are also noticeable differences between field cowpeas and vegetable cowpeas with respect to nodule formation in response to indigenous rhizobia. Vegetable cowpea might be improved in drought avoidance by transferring the deep root system from field cowpea through crossing. Field cowpea has been subject to mutation breeding in several countries but no such attempt is known for vegetable cowpea.

GRAIN LEGUMES PRODUCTION PROBLEMS IN KENYA

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In Kenya, where animal protein and chemical fertilizers are relatively expensive, grain legumes are the major source of protein and subsidise commercial fertilizer application in marginal areas to sustain soil fertility. Beans, pigeon peas, cowpeas, mungbeans and lablab beans are grown. Over 70% of the production area is scattered in the semi-arid and arid areas characterized by bimodal and low rainfall. The major yield reducing factors are frequent drought, poor soil fertility, diseases and insect pests. Over 60% losses in yield can be caused by a combination of insect pests and diseases. During some years drought can lead to total crop failure. Improved cultivars should be capable to alleviate some of these production constraints.

Recent research efforts have already resulted in the identification of drought escaping lines of pigeon pea, mungbean and lablab bean. Research work on breeding for insect pest and disease tolerance is in progress through conventional breeding methods. In this way, we aim at improving the well adapted local cultivars for semi-arid areas in Kenya for yield, drought tolerance, disease and insect pest resistance. There might also be a potential to use induced mutations.

SOYBEAN IMPROVEMENT RESEARCH STRATEGIES IN UGANDA

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Soybean was introduced into Uganda around 1910, but there was only modest production until the mid 1940's. During World War II approximately 15,000 ha were cultivated.

Since 1960, many breeding lines and varieties from all over the world have been evaluated. Six introduced varieties (S-38, Congo 72, Clark 63, Bukalasa 4, No. 7 and Kabanyolo I) have been released. Yields from 400 to over 2000 kg/ha have been reported. Through 1981 to 1983, approximately 5000 ha of soybean were grown. Currently, Kabanyolo I, released in 1975 is the recommended variety.

The long term strategy involves the acquisition of germplasm from all over the world to be screened for desirable agronomic traits followed by hybridization and selection for adapted high yielding recombinants.

The short term strategy has fo far taken advantage of soybean materials brought into Uganda through INTSOY as part of the International Soybean Variety Experiment and through the USAID programme from I.I.T.A., Nigeria. In field trials, the local check Kabanyolo I yielded better than most of the INTSOY materials and equal to the I.I.T.A. materials. The problem seems to be lack of adaptation, since the management was optimal. Eventhough Kabanyolo I and No. 7 competed favourably with the entries from INTSOY and IITA in terms of seed yield, they are far more shattering and susceptible to bacterial pustule (Xanthomonas campestris).

There is a need to improve the adaptation of the introduced high potential yielding materials and the disease and shattering resistance of the adapted material. No improvement is possible unless genetic variability is created. It is in this regard that mutation breeding is seriously considered.

There is a history of mutation breeding for soybean improvement in Uganda in the mid 1970's. Gamma rays and EMS were used. The characters studied included (a) the vegetative period (b) days to maturity (c) number of branches (d) main stem node number and (e) seed yield. The results were very interesting considering the fact that the treatments improved the adaptation of Clark 63, an American variety, to our growing conditions, ultimately resulting in significant increase in seed yield. Valuable macro-mutants were identified with relative ease in only two generations. Several of the introduced varieties have their origin in semi-temperate regions of America. Such materials are bound to suffer from the short days and tend to flower too early (30-40 days after planting). Mutants insensitive to photoperiod have been induced.

Reduction of shattering in our local Kabanyolo I and No.7 could more than double our average national yields. Mutation breeding has not been used very much to develop non-shattering soybean strains, but such types were found in other populations. Shattering resistant materials are already available to us especially among accessions from I.I.T.A., but those are not adapted to our conditions. The most serious diseases are bacterial pustule (Xanthomonas campestris pv. phaseoli) and a range of viruses. The most serious potential pest is the green stink bug (Nazara viridula L.). Mutation breeding has been used frequently to produce disease resistance, but not so much against pests. Fortunately, INTSOY and IITA materials appear to be free from bacterial pustule, but some of them suffer seriously from virus attack.

BREEDING SOYBEANS FOR IMPROVED SEED VIABILITY AND PROMISCUOUS NODULATION

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According to an FAO report of 1982, African nations harvested just over 900 kg/ha of soybeans on 300,000 ha of land while importing 440,000 t of soybean oil and 259,000 t of soybean cake or meal.

A 1987 survey of 15 feed mills in Ghana revealed that each mill imports 100-500 t of soybean cake per annum, giving a total of 7,500 t/annum. Large quantities of soybean oil also continue to be imported into the country.

The crop has been known in the country since 1909 but it is still not cultivated on any scale mainly due to the loss of seed viability which leads to spotty field emergence - a problem which occurs in all the humid tropics.

Since 1982, the breeding program at U.S.T. has concentrated on screening lines received from IITA for seed viability. This involves selecting lines resistant to field weathering and using the hot water and methanol stress tests to select for lines with good storability. Although a few promising lines such as TGX 342-356D, TGX 306-036C, TGX 713-09D and TGX 539 5E have been identified, none of these consistently stores well for a very long time under ambient environmental conditions. Black seeded varieties have generally been found to be more resistant to field weathering, and seed quality is better when produced in the minor than in the major rainy season.

Another objective is to breed for soybeans that nodulate readily with the indigenous rhizobia - i.e. promiscuous nodulation. A few of such lines so far identified include TGX 713-011, TGX 342-356D, and TGX 306-036C. A mutation breeding program to solve these problems has been initiated.

PRODUCTION OF FOOD LEGUMES IN RWANDA: PROBLEMS AND POSSIBLE SOLUTIONS

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Food legumes are very important in Rwanda as a source of protein. In 1985, they occupied 34% of the crop land and contributed more than 50% of the protein consumed by the people. The more important species are common bean, pea, peanut and soybean. Through increase in acreage total production of all of them except peas increased during the past 10 years. Major problems hindering further production increases are (a) marginal conditions (poor and acid soils, cold temperature and high humidity at higher elevations), (b) fungal pathogens of bean and pea at highland medium elevations, viral diseases of climbing bean and peanut, bacterial diseases of bean and soybean, and a number of insect pests (bean fly, aphids, Bruchus), (c) inoculation with specific rhizobia for soybean and pea is practiced, but nodulation of common bean is still a problem, (d) legume cultivation in mixtures presents problems with fertilization and pesticides, (e) problems of soybean technology and use in kitchen limits further extension, (f) most of the farms are suburban farms of less than 1 ha., improved cultivars and improved technologies are not much used, which causes a large gap between potential and actual production.

For certain of these problems, the solutions are known, e.g.

- development of productive, resistant and locally well adapted cultivars.
- promotion of the higher yielding winding beans.
- intensified research on symbiotic nitrogen fixation, particularly with common bean.
- transfer of improved production technologies .
- production and distribution of high quality seeds.

Large collections of germplasm have been introduced, were evaluated and are being used in cross breeding. No attempt has yet been made to use induced mutations.

GRAIN LEGUMES RESEARCH PROGRAMME AT SUAKOKO, LIBERIA - A REVIEW

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The Central Agricultural Research Institute (CARI) was created in 1979 and charged with the responsibility of making significant advances with respect to numerous problems afflicting grain legumes in Liberia. Earlier research lacked programs and continuity. To solve the problems, new approaches and programs were initiated.

Linkages between CARI and the International Institute of Tropical Agriculture (I.I.T.A.), Asian Vegetable Research Development Center (AVRDC), INTSOY, U.S.A. and FAO Seed Service in Rome were strengthened. A large number of advanced lines of cowpea, mungbean, peanut and soybean with some accessions of winged bean, limabean, and pigeon pea were screened under local conditions for desirable traits. Elite varieties of cowpea with disease and pests resistance were identified and incorporated into national programs. Some varieties of mungbean with high yielding potential have been accepted and integrated in the cropping systems of some parts of the country. Results of peanut yield maximization trials are available. Through International Soybean Trials some varieties with high yielding potential were identified, but the search for soybean varieties with promiscuous nodulation is a priority. Induced mutations may offer additional desired genetic variation.

CROP IMPROVEMENT PROGRAMMES AT SHAMBAT, SUDAN

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Crop improvement at the Faculty of Agriculture, University of Khartoum involves three major crops: sorghum, sesame and faba bean (*Vicia faba* L.).

Sorghum and sesame are cultivated in rainfed areas by small farmers outside the government schemes. The main factors limiting increased production are low yield potential of the existing cultivars, scarcity and unreliability of rains, crop pests and diseases and the high labour demand for harvest. Sorghum provides 75% of the national cereal production. Breeding aims at high and stable yielding varieties, resistance to water stress and resistance to *Striga*. Stemborers cause much trouble too. Breeding objectives in sesame include higher yield, resistance to water stress and suitability for mechanical harvest (even maturity, determinate growth, delayed shattering or nonshattering.

Faba bean is the top food legume in Sudan. The crop is confined to irrigated areas in the northern half of the country. The major problems under investigation are hardseededness (up to 20%), tannin content, flower drop and susceptibility to powdery mildew. Desired genetic variation could be produced by mutagenesis.

APPLICATION OF INDUCED MUTATION TECHNIQUES IN THE IMPROVEMENT OF YIELD OF BAMBARA GROUNDNUT (*Voandzeia subterranea* (L.) Thou)

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Bambara groundnut (Voandzeia subterranea (L) Thou) is an important food crop in Africa. The yield of this crop could be improved from the reported average of 750kg/ha to over 3000 kg/ha. The application of nuclear techniques to induce mutations offers an opportunity for improving yield in new varieties.

Selection for yield *per se* is difficult. Indirect selection criteria for yield based on yield components and yield related components would be a realistic approach. Induced mutation techniques could then be directed at improving these attributes individually and thereby improving overall yield. However, these attributes have to be identified in character association studies in this crop.

One such study was conducted at the University of Zambia field station in the 1985/86 growing season. Twenty six bambara groundnut accessions obtained from Zambia and Zimbabwe were planted in single rows to determine associations between yield components and other yield related attributes. Number of pods per plant, number of seeds per pod, number of seeds per plant, grain yield per plant, 100 grain weight, harvest index, number of petioles, number of branches per plant, number of nodes per plant, length of petiole and number of leaflets per petiole were determined from a sample of 10 plants in a plot.

Significant correlations were observed between grain yield per plant and the following traits: number of branches per plant, number of nodes per plant, number of pods per plant, harvest index, number of seeds per plant and 100 grain weight.

A stepwise multiple regression analysis showed that only three traits, namely number of seeds per plant, 100 grain weight and harvest index were the important variables determining grain yield per plant in bambara groundnut. There were no significant intercomponent correlations. These results indicated that the three traits should be used in selection for higher yield. Since there were no significant negative intercomponent correlations among these traits, we expect that improvement of any one would not lead to a reduction in the expression of the others.

A PLACE FOR MUTAGENESIS IN SUNFLOWER FOR THE SUBTROPICAL AFRICA

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Natural genetic variation is the major source for selection in breeding of sunflower (Helianthus annuus L.). The continuous extraction of superior material and the discarding of the remainder, however, results in the gradual reduction of this variation for some characteristics/traits of importance. Gene-recombination from crosspollination or natural outcrossing may not create sufficient desired variation. In this case gain from selection will be negligible. To enhance variation for certain traits, mutagenesis offers an alternative to introgression, the latter requiring long periods to recover the original genotype which one intended to have improved.

DISEASE PROBLEMS IN SUNFLOWER (*Helianthus annus* L.) AND POTENTIAL SOLUTIONS BY PLANT BREEDING THROUGH NUCLEAR TECHNIQUES

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The most important diseases of sunflower (Helianthus annuus) in Zambia are leaf spots (Alternaria helianthi), leaf blotch (Septoria helianthi), white mold (Sclerotinia sclerotiorum) and yellowing spot virus. Tolerance/resistance to these diseases may be obtained through plant breeding. However, this requires a large natural variability, as is the case in sunflower - a cross-pollinated crop. Conventional plant breeding for disease tolerance/resistance stands to play a major role as a long term solution in stabilising yield against losses from diseases, but induced mutations could offer additional possibilities for disease resistant mutants if facilities and enough trained manpower for screening were available.

In Zambia breeding approaches to disease resistance commence with yield loss assessment on exotic as well as local inbreds to ascertain the importance of a disease through an appropriate scoring system developed for each disease. Superior inbreds are crossed with their respective testers for hybrid production which undergo further screening in the primary trials, preliminary variety trials and finally the National Variety Trials.

MAIZE RESEARCH ACTIVITIES IN ZAMBIA

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Maize is the most important crop in terms of production, number of farms and cropped area; it accounts for over 70% of the total value of marketed agricultural products; it is a national staple food. The goal of the maize research program is to increase the production of maize in order to help Zambia to achieve food self-sufficiency and eventually an exportable surplus of maize grain.

Systematic work on maize improvement, which began in 1978 has achieved noteworthy success. The release of MM 752, a purified version of SR 52 and six other hybrids, 3 single crosses and 3 three-way crosses as well as 2 open pollinated varieties, has provided an opportunity for farmers to choose a variety suited to specific agro-ecological situations. These hybrids and varieties offer earlier maturity, improved disease resistance and some drought tolerance. Recently a double cross involving two commercially released hybrids has been pre-released. This hybrid would be most economical in grain production, suitable to high rainfall areas and resistant to maize streak virus, which is the major limiting factor for increased maize production in the country. Several new combinations of hybrids and open pollinated varieties are in the process of development for future release. Research efforts are on-going to improve the quality of released hybrids and varieties, relative to pest and disease resistance, drought tolerance and adaptability. Increased attention is being directed towards development of production packages affordable by small scale farmers.

MAIZE BREEDING IN THE PEOPLE'S REPUBLIC OF BENIN

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Benin is essentially an agricultural country. The main crops are maize, sorghum, rice, millet, yam, cassava and peanut. Maize is cultivated on about 450,000 ha with an average yield around 750 kg/ha primarily in the North and the Centre of Benin.

Maize research is carried out at two stations at I.N.A. for the two Northern provinces, at the Niaouli Station for the Southern provinces. INA has produced by selection from local populations 3 varieties: "Jaune d'INA" (J.I) "Composite Jaune d'INA" (C.J.I.) and "INA Hybrid". The best most recent variety "TZB" (resistant to streak) reached in multilocation trials a yield of 2.7t/ha, under experimental conditions (10ha) even 4t/ha. At Niaouli in co-operation with IRAT hybrids NH1 and NH2 were produced, the latter resistant to Puccinia polysora but susceptible to streak, yielding about 3.5 t/ha. It is popular because of food technological and organoleptic qualities, which make it suitable for traditional dishes. NCP80, an early composite was released but withdrawn again because of susceptibility to streak. From co-operation with CIMMYT/IITA stems the variety "Poza-Rica 7843 SR". It is resistant to streak, yields potentially 6t/ha of white grain in 120 days. Another CIMMYT/IITA variety is the white grain composite "Pirsabak 7930 SR", yielding potentially 4t/ha in 90 days. "Poza-Rica 7843 SR" has a number of bad characters e.g. the poor coverage of the cob facilitating grain infestation, and inacceptable grain quality for certain local dishes. Varieties tested in farmers field in the South are:

early	late
E.V.8430 SR (Control)	Poza Rica 7843 SR-W (Control)
DMRE-SR-W	E.V.8322 S.R.-W
MAYO GALKE 82 TZE SR-W	SEKOU 81 TZSR-W
	E.V. 8443-SR-W
	IKENNE 83 TZSR-W

Two varieties exceeding NCP-80 in yield at Sekou are SAFITA 2 (3.8 t) and SYNTH.C (4.4t)

In the North, varieties tested in farmers fields include:

very early	early	intermediate
KITTO	Pirsabak 7930 SR	Across 83 TZUT-W
Pop 31 SR Early	SAFITA-2 (RE)	Kamboinse (2) TZVT-W
Pop CSP	Pop 30 SR Early	Safita 102-RE
	MG 82 TZESR-W	EV 8422-SR-W
	Early 84 TZSR-W	EV 8443-SR-W
		EV-8449-SR-W

Production constraints are very divers. A general problem is adaptation to the rainfall pattern in the different regions of the country. Biological constraints are susceptibility to streak, Striga, rust, Helminthosporium, termites, stemborers. Drought tolerance is likewise important. Poor soil fertility and suboptimal cultivation practices likewise reduce production.

GENETIC ANALYSIS OF M_2 PROGENIES DERIVED FROM DIFFERENT DOSES OF GAMMA IRRADIATION OF MALIAN SORGHUM STRAINS AND AN AMERICAN VARIETY

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The variety improvement of sorghum faces the problem of low genetic variation which appears to be imposed by the autogamous reproduction system. To act against this constraint numerous crosses are made each year in Mali between local cultivars (tall, well adpated, lax panicle, low production, good grain quality, etc.) and American cultivars (compact and productive panicles, short culm, high tillering, relative susceptible to pathogens and pests, poor grain quality, etc.). The main objective is to transfer short culm and productivity to the local varieties. The majority of these crosses gave progenies characterized by the prescence of a brown layer giving poor digestibility to sorghum.

In addition, for enlarging genetic variation, we have begun with mutagenesis in sorghum. For this, seeds of three local varieties and one dwarf American variety were irradiated with 20-30 kR. We have observed physiological effects in M_1, and analyzed the M_2 progenies for interesting genetic variation, dependent upon variety and dose. The variation induced in the local varieties includes productivity factors, vigor, tiller number, plant height, panicle type (bending or upright, compact), colour and and size of glumes, colour and size of grains, etc.

THE MAKERERE TOMATO IMPROVEMENT PROGRAMME

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The tomato (Lycopersicon esculentum Mill) is gaining popularity in Uganda but the use of unadapted varieties is a major constraint to production. The tomato is susceptable to various diseases. Bacterial wilt Pseudomonas solanacearum),late blight (Phytophtora infestans) early blight (Alternaria solani) are particularly devastating as they often reach epiphytotic levels in some locations. The root knot nematodes (Meloidogyne spp.) are also a very serious pest. Efforts are being made to introduce resistance genes from outside the country and to create more genetic variability in the germplasm by local collection and induced mutations. An interdisciplinary improvement programme for the crop is being mounted.

STUDY ON TOLERANCE/RESISTANCE OF TOMATO TO ATTACK BY *Pseudomonas solanacearum* E.F. Smith

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The necessary increase in food production can only be achieved by increased productivity, since the land is limited. Among the constraints are poor soil fertility, old fashioned production systems, poorly performing cultivars. A particular problem are insects and pathogens, which have the constant capability for genetic variation. Varieties in order to withstand their enemies have to make use of the immense genetic variation available and by favourable recombination improve crop production. In Guinea it is common practice to introduce germ plasm from all over the world and to test it in comparison with local forms. In this context, we tested 30 varieties of tomato for their tolerance/resistance to attack by Pseudomonas solanacearum. The pathogen may cause 40-60% crop loss or more.

The plants were not artificially inoculated, since there is sufficient pathogen inoculum in the field. The best varieties (all introduced) had 25-50% infection, but are poorly adapted to local conditions (they stem mainly from Asia). It is hoped, that other introductions can be found that are more resistant. Induced mutations might be an alternative. A study on the composition of this pathogen is to be undertaken.

BREEDING FOR A-CYANOGENESIS IN CASSAVA BY MUTATION TECHNIQUES

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Cassava clones are vegetatively propagated and most of them contain a high amount of HCN that may lead to death upon ingestion, if the food is improperly prepared. There are certain cassava materials that are cooked without fermentation or other treatments like pressing out the liquid, suggesting that they have a low cyanide content. But they are not important as cultivars for some reasons.

There is a similar occurrence of cyanide in white clover which has been very well studied. The work on cyanide in clover shows two genes to control two enzymes whose complementary actions result in cyanide formation. Biochemists and plant physiologists working on cyanogenesis in cassava have used tonoplast vesicles to reveal that aldoxine is formed as an intermediate.

It is suggested here that using radiation genetic techniques it might be possible to induce changes on the loci controlling cyanide synthesis to permit selection for a-cyanogenesis in commercial clones of cassava.

Mutagen treated materials will be subjected to laboratory tests for selection of hydrocyanic-acid-less types which may be propagated or used in further breeding for commercial application.

ROOT AND TUBER CROP IMPROVEMENT AT THE UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

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The root and tuber crops are major starchy staples in Ghana. According to FAO projections per capita demand for these crops in 1990 whould be 314.3 kg/head as compared to 70.9 kg/head for cereals.

In 1983/84, the national deficit for these crops were 557,000 t., 843,000 t, 131,000 t for cassava, cocoyam and yam respectively. During the same period the respective average yields of these crops were 4.1, 3.9 and 6.1 t/ha. The low yields are attributable to many factors including diseases, pests and unavailability of high yielding varieties.

The breeding program at U.S.T. has concentrated on cassava improvement. For over five years now, improved varieties from the International Institute of Tropical Agriculture (IITA), Nigeria, have been tested and found to be high yielding and resistant to the common cassava diseases and pests.

In the 1987 trial for example Ims 518 and Tms 4(2) 1425-w gave yields of 40.5 and 37.8 t/ha respectively which were 62% and 51% higher than the best local check. The high yielding lines from IITA are however, unsuitable for traditional local food preparations since they do not have the desired mealy texture when cooked. Preliminary analyses have shown that the local varieties which have the desired mealy texture do not have significantly higher starch contents than the IITA varieties. Whether the amylose/amylopectin ratio affects the cooking quality is being investigated. It is planned to improve the cooking quality of the IITA lines by altering the quantity and, or composition of the starch through mutation breeding.

Characterization of different white yam accessions based on cooking quality has been initiated, studies on physiological basis of yield in the cocoyams and varietal screening in sweet potatoes are being undertaken.

CASSAVA AND SWEET POTATO PRODUCTION CONSTRAINTS IN KENYA

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Cassava and sweet potato constitute 42.5% of the total world root and tuber crops production. About 28% of cassava and sweet potato is produced in Africa. In Kenya cassava and sweet potato are grown on 80,000 ha with a production of 85 million t, the main areas under these crops lie in the Coast, Nyanza and Western Provinces. About 80% of Kenya is semi-arid and arid. Cassava and sweet potato are believed to be fairly drought resistant, but unfortunately these crops are only grown on subsistence level in the more arid provinces. The production of cassava and sweet potatoes has not shown an appreciable increase in this country, largely because of lack of suitable varieties, inavailability of disease-free planting material as well as inappropriate production technology.

(1) Cassava (Manihot esculenta Crantz) was first introduced to the Coast region of East Africa at the end of the eighteenth century by the Portuguese and got established as one of the staple foods throughout the region. The use of cassava varies widely with different ethnic groups in various parts of the country. Locally developed cultivars are distinguished by methods of preparation and utilization. Most of them are of long duration, have low yield potential, and are susceptible to diseases and insect pests. The cassava improvement programme at the National Dryland Farming Research Centre Katumani was initiated during 1982 with local and exotic germplasm.

The screening of germplasm resulted in two varieties Muceri-ceri and KME1 which show improvement in yield and better resistance to diseases and pests. Hybridization intends transfer earliness, desirable tuber placement, resistance to pests and disease into locally well adapted good quality (low hydrocyanic glycoside) varieties. Cassava can survive extreme drought conditions through minimising transpiration by leaf shedding and stomata closure. Breeding aims at varieties capable to survive the long dry spell and efficient in utilization of limited moisture. Early maturity (8-12 months) for an altitude 600-1600 above sea level, to escape prolonged drought is also receiving high priority.

Cassava mosaic virus (CMV) transmitted by whitefly (Bemisia spp.) results in 20-95% reduction of tuber yield. Breeding for resistance to CMV was first initiated by H.H. Storey during 1937 in Tanzania. In absence of effective resistance within Manihot esculenta, he successfully transferred resistance from M. glaviozii. Some of the CMV resistant hybrids were released to farmers in the Coast Province, Kenya. These hybrids did not gain popularity due to unacceptable quality of tubers. But the same source of resistance has been extensively used at IITA. Therefore there is need to look for alternate sources of resistance to CMV either from wild relatives or by mutation induction in the cultivated cassava. Another important disease is cassava bacterial blight (Xanthamonas manihotis). According to IITA, resistant varieties are available.

Cassava as an introduced crop from South America originally did not have any major insect problem in Africa. It is only in the recent past that green cassava mite and mealy bug seriously threaten cassava production.

Biological control developed by IITA is quite effective. IITA has identified sources of resistance, pubescence of the shoot tip is believed to be associated with it. The preferred local land races, good for traditional food preparations, are susceptible to cassava green mite and may be improved through induced mutations. Scale (Pseudaulacaspis pentagona) can cause economic losses during long dry period. Varietal differences for susceptibility have been observed.

Cassava is traditionally grown in mixture with other crops. A wide range of genetic variability ranging from "monoculm" to profuse branching habit is available, but during early stages of establishment there is severe competition from fast growing weeds.

Cassava roots are highly perishable, perhaps it is possible to improve the shelf-life by breeding.

(2) Sweet potato (Ipomea batatas (L.) Lam) is adapted to a wide ecological range and is grown by small scale farmers throughout the country. As a short duration crop it has tremendous potential. Improved varieties can yield upto 40 t/ha without fertilizer in four months. Both tubers and leaves are used as food. Being mainly a source of carbohydrate tubers are also rich in calcium, iron, potassium and vitamins A, B and C. The national average yields (11.7 t/ha) are lower than the world average (14.8 t/ha). 1982 a sweet potato improvement programme was initiated at the National Dryland Farming Research Centre Katumani. Over 150 germplasm accessions both of local and exotic origin are being maintained under field conditions. Cross pollination is the rule due to self incompatibility. Both controlled crossing and open pollination accomplished through insects resulted in wide genetic variation for maturity period, plant type, reaction to diseases and pests, tuber characters and other traits of economic importance.

Sweet potato is relatively drought resistant but it needs adequate moisture at early stages. It can give some yield in a properly managed soil with 50 mm precipitation during the growth period. In the semi-arid areas of Kenya where the effective rainfall comes within 6-8 weeks in a rainy season, early maturing varieties (110 days) can escape dry spell during later stages. The breeding for drought tolerance therefore aims at reduced vegetative mass combined with a fast growth rate at early stages.

Sweet potato virus is widespread throughout Kenya. Losses in tuber yield may reach 50-80%. Resistance is available and improved varieties have been developed at IITA. No other sweet potato disease of economic importance has been reported so far. However, root knot nematode (Meloidogyne spp) occurs. The tubers affected by nematodes may rot in the soil. Varieties differ in susceptibility.

A large number of insect species attack sweet potato in Kenya. However, sweet potato weevil (Cylas puncticollis and Cylas formicarius) are the single most devastating pest prevalent throughout semi-arid areas of Kenya which can cause yield loss upto 90%. The weevils damage leaves and vines, but it is most serious when the main stem is damaged at the base or when the adults and larvae tunnel through the tubers. The damaged tubers develop a bitter taste and are unfit for human consumption. Many tubers rot in the soil because of subsequent infection by bacteria and fungi. IITA has identified resistant sources. Sweet potato butterfly (Acraea acerata) is an occasional pest. The caterpillars can completely defoliate the plants. During dry spell the young growing shoots can be attacked by Aceria spp.

In Kenya, sweet potato is consumed as a snack or part of the meal after boiling or roasting. Sweet potato varieties with dry flesh of white or yellow colour are preferred over moist flesh with orange colour. The potential of sweet potato as a staple food would largely depend on development of less sweet varieties. Recently less sweet clones have been developed through conventional breeding methods. Mutation breeding could perhaps be effective in changing genes responsible for amylase activity which breaks down starch into sugar.

ROOT AND TUBER CROPS PRODUCTION AND RESEARCH IN LIBERIA

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The root and tuber crops cassava, sweet potato, cocoyam, and yam are widely grown in Liberia. They supply the population with more than 30% of their daily caloric intake. Root and tuber crops development is of major concern to the Ministry of Agriculture. Cassava and sweet potato are given top priority because cassava is second to rice as a staple food crop and sweet potato is next in line.

Although root and tuber crops have been under cultivation for a long time, production is low due to several factors. Among these are: unavailable good planting materials of varieties that are high yielding and of good cooking quality, poor stand establishment due to drought and termite damage at time of planting, high susceptibility to diseases and pests, frequent defoliation of leaves or breaking of apex for consumption as vegetable, poor cultural practices and also socio-economic factors (low economic return and poor consumer acceptance).

Realizing the problems, the potential, and the importance of root and tuber crops in the Liberian diet and farming system, the Government of Liberia in 1979, initiated the Root and Tuber Crops Program with the aim of varietal improvement for yield, pest and disease resistance, good nutritional quality, etc. and to provide good quality planting materials to farmers.

The Central Agriculture Research Institute (CARI), the research arm of the Ministry of Agriculture, has released three cassava varieties (CARICASS 1, 2 and 3) which are high yielding and resistant to major cassava pests and diseases found in Liberia. Four new cassava clones have been introduced in 1987 into multilocational trials.

Significant progress has been made in developing sweet potato materials (TIS 2532, TIS 2544 and TIB 1) that show greater resistance, higher yield and consumer acceptance. Cocoyam and yam research is at an initial stage only.

WILD FRUIT TREE CROPS IN ZAMBIA

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Zambia has numerous forest tree species. About twenty genera, belonging to nearly fifteen families, are known to yield edible fruits. These fruits are relatively popular due to their local abundance, country-wide distribution and quality. Although man has utilized wild fruit tree crops since time immemorial, improvement of these tree crops to increase yield has received very little attention. Varieties which are high yielding and capable of responding to fertilizers are presently unknown. There is a real need to develop improved varieties.

PRELIMINARY RESULTS OF RADIOSENSITIVITY TESTS WITH *Ricinodendron rautanenii* Shinz. AND *Uapaca kirkiana* (Mull.) Arg. FRUIT TREES

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Ricinodendron rautanenii and Uapaca kirkiana are important indigenous wild fruit trees. The economic potential of R. rautanenii lies in the high-oil yielding stone and easy-to-carve wood. Reports regarding oil content show that it ranges from 38 to 60%. The U. kirkiana fruit is an extremely popular fruit among the local population serving as a rich source of vitamin C. Sugar content in the fruit is 8.5% and it is being utilized in the production of local wine.

Apart from ecological, soil, physiological, silvicultural and pathological studies, research has focused so far on the genetic improvement using hybridization. However, little headway has been made because both R. rautanenii and U. kirkiana are dioecious, making it difficult to self-pollinate or backcross. Furthermore, being perennial plants they have very long reproduction cycles. It has been found logical to attempt the use of induced mutations in improving some important characters of both R. rautanenii and U. kirkiana.

The aim of the first studies was to determine the optimum dose which would subsequently be used in inducing the dwarf types suitable for high yield density planting.

Small-sized branches of both R. rautanenii (about 3 cm in diameter) and U. kirkiana (about 2 cm in diameter), from evenly aged plants were air layered prior to irradiation in order to induce rooting. After roots had formed the cuttings were detached from the mother plant and exposed to irradiation by gamma rays from a caesium 137 source. In each cutting 3 buds were exposed to radiation while the rooted basal end was protected.

The treatment range in 1978 was 2, 4 and 5 kR for R. rautanenii and 2 and 4 kR for U. kirkiana. After 60 days in the greenhouse the cuttings were assessed for sprouting and shoot length. The following parameters were calculated: percent of cuttings sprouted, percent of buds sprouted, mean shoot length and percent of treated mean shoot length in relation to control. It was concluded that 4 kR would be a suitable dose for R. rautanenii and 3 kR for U. kirkiana. However, there were striking differences in radiosensitivity of cuttings dependent upon the months during which branches were cut from the trees.

MUTATION BREEDING USING IN VITRO CULTURE TECHNIQUES

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Plant tissue culture became a useful supplementary tool which can be used in various steps of mutation breeding. The development of _in vitro_ mutation breeding technology has been reviewed at several FAO/IAEA symposia and research co-ordination meetings [1-5]. Methods include shoot-meristem culture, adventive organogenesis and somatic embryogenesis, haploidy, _in vitro_ selection and embryo rescue. Shoot-meristem culture and adventive organogenesis are employed in rapid clonal propagation of superior plants, especially in horticultural and perennial crops. Meristematic tissues multiplied _in vitro_ are used as suitable material for mutagenic treatment, especially in vegetatively propagated plants. Mutagen treatment applied to shoot-meristem tips will usually give rise to chimera. Periclinal chimera and/or solid mutant shoots can be obtained by repeated _in vitro_ subculture and by induction of axillary buds after mutagenic treatment. Development of adventitious shoots on explants cultured _in vitro_ is an extremely important process since they usually originate from a single cell. Mutagenic treatment of unicellular systems avoids chimera formation. Explants (leaf, petiole, peduncle, etc.) are normally irradiated before _in vitro_ culture and then adventive shoots arise directly from the explant tissue in favourable _in vitro_ conditions. After rooting of shoots the plants are transferred to soil and observed for mutations during their further development. By using micropropagation techniques the mutated branches are multiplied and desirable characters are retained. A good example of the above system is mutation breeding of ornamental plants.

Cell culture techniques allow to grow very large populations of plant cells for mutagenesis and _in vitro_ selection. However, such a system is available only for a limited number of crop species. The development of morphologically competent cell suspensions and plant regeneration via somatic embryogenesis would be an essential step for the application of biotechnology in crop improvement. _In vitro_ mutagenesis and cell selection are particularly important for apomictic crops where there is no sexual reproduction that could generate genetic variation. Bananas and plantains are examples for such crops. _In vitro_ mutation breeding systems are being developed in the IAEA Seibersdorf Laboratories.

Anther culture as well as ovary culture can lead to haploid plants. When mutations are induced before or during _in vitro_ culture, haploid individuals provide an opportunity for direct selection of recessive mutations. After chromosome doubling, homozygous mutant plants become available (doubled haploid line). This method accelerates the mutation breeding process.

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MUTATION BREEDING FOR DISEASE RESISTANCE

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1. Types of disease resistance expected from mutation breeding

Among mutants with improved disease resistance a number of virus resistances induced by gamma irradiation have been reported. They are generally stable and useful. There are many reports showing that pathotype-specific resistance of fungal diseases have been induced. However, whether this type of resistance should be aimed at in breeding is an unsettled problem, which should be decided in each case. Sources for this type of resistance can often be found in available germplasm. However, non-specific resistance has been induced as well. Proof for usefulness of induced mutations for disease resistance is available in literature (IAEA 1977, 1983). In Japanese pear, resistance to Alternaria alternata was induced by chronic gamma-irradiation. The resistant clone turned out to be resistant also to the AK-toxin produced by the fungus, an interesting type of resistance.

Physiological and environmental factors often affect the expression of resistance of plants to pathogen infection. Brown spot of rice, e.g. is influenced by the root vigor and minerals in soils. Upland cultivation makes paddy rice more sensitive to blast. High temperature renders Brassica spp. weak to soft rot caused by Erwinia spp. Phytophthora infestans can only be rampant at maturity of potato. Improvement of morphological and physiological traits by mutation breeding may contribute to improvement of disease resistance or tolerance.

2. In-vitro screening of disease resistance

Use of pathotoxins

In-vitro screening for disease resistance has the advantage of easy handling almost unlimited populations. However, the technique has serious limitations (IAEA, 1985). One possible approache is the selection for tolerance to pathotoxins, where such substances are among the causes for the host plant's disease.

Plant pathogenic fungi and bacteria produce various metabolites in culture media. Products depend on the composition of the media. Among them "host specific toxins" have been identified in some pathogens.

Definition of Host-Specific Toxins: Microorganism X (but not others) produces substance Y which damages plant or plant group A but not others, and only A is parasitized" (R.K.S. Wood 1973, referred by S. Nishimura - Ann.Rev. Phytopath. 1983, 21:87-116).

Agents that fit to this definition are found in Alternaria spp. Most of their toxins are produced during the germination of spores. Some of Helminthosporium toxins are also regarded as host specific. They can be isolated from rather aged cultures. Attempts to use these toxins in screening have been successful.

Phaseolo-toxin produced by Pseudomonas syringe pv. phaseolicola is generally regarded as host-non-specific. But it acts specifically on legume species. Plant produced after meristem culture selection with this toxin showed "reduced symptoms" rather than the expected resistance to infection.

Many metabolites, acids, growth substances, etc. can disturb the selection when crude preparation is used carelessly. Citrus callus cells screened by Phytophthora citrophthora culture filtrate turned out to be "dependent on the auxins" produced by the fungus and contained in the culture filtrate rather than be resistant to some specific toxins. In fact, the order of tolerance of four cultivars to the culture filtrate was the reverse of the order of their resistance to the disease.

Pathotoxins therefore should only be used in screening after they have been characterized biochemically and phytopathologically.

Expression of resistance genes in-vitro culture

Plant characters expressed in the single cell or callus state are rather limited. Among them are: 1) resistance to antibiotics or amino acid analogues, 2) metabolite synthesis in response to PCP, 4CA and polycyclic aromatic hydrocarbons, 3) induced synthesis of pathogenesis-related proteins, 4) immunity (but not hypersensitivity type of resistance) to viruses and 5) synthesis of alkaloids.

For the future, it is expected that the DNA probe method, which can identify the genes residing in dedifferentiated as well as differentiated tissues, can be used for screening particular mutant cells in culture.

3. Virus elimination by in-vitro techniques and the problem of re-infection.

Producing virus-free planting material through in-vitro culture is a very important and economic measure for preventing crop losses. Attempts are now going on in Citrus, and other species to prevent the re-infection of clones by their artificial inoculation with only mildly virulent related viruses. Attempts are not successful yet, but interesting results exist.

Papaya ring spot: Mutated virus with mild virulence was effective in protecting papaya from this destructive disease in Hawaii. However, it is not so effective in Taiwan and Thailand. (Papaya is usually seed grown and the papaya ring spot virus is not transmitted through seeds).

Potato: Inoculation with a mildly virulent virus is said to be effective only for one vegetative growth cycle.

Tomato mosaic virus: Attenuated viruses sprayed on tomato seedlings can protect the plant effectively through the harvest. One does not need to fear a mutation of the virus to restore its virulence. The entire nucleotide sequence has been analysed showing that the attenuated virus harbours several nucleotide changes.

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EXCERPTS FROM DISCUSSIONS

A. MICKE
Scientific Secretary

In his opening remarks, the Zambian Minister of Agriculture, Mr. Chuula, stressed the need to strengthen agriculture, agreed that plant breeding receives highest priority in the country and underlined the important role that nuclear techniques can play in agricultural research. The following lectures by Drs. Micke, Bhatia and Donini explained the potential of using induced mutations as a supplementary tool in plant breeding and illustrated the remarkable achievements in developed and developing countries outside Africa.

The first topic to be discussed among the participants was rice improvement. Speakers from Benin, Sierra Leone, Tanzania and Liberia mentioned the rising demand for rice as human food (at the expense of other more traditional food items) which countries try to satisfy by huge imports. There are many constraints to increasing local rice production. Soil and climatic conditions restrict the areas where rice can be grown either as flooded or as upland rice. In addition, a rice crop faces weeds, pests and pathogens. Many rice cultivars introduced from overseas did not have the required adaptation and grain quality. Mutation breeding for rice improvement had already some success in West Africa, e.g IRAT 13 is a famous mutant variety released in Cote d'Ivoire, which was widely used in cross breeding and led to many other improved cultivars. There were also earlier attempts for rice mutation breeding in Eastern Africa and in Egypt, but no mutant variety was released. The problems are diverse and more genetic variation is required. Short culm mutants of local cultivars should be easy to obtain for improving the fertilizer responsiveness through improved lodging resistance and higher tillering. Early maturing mutants could escape drought. Resistance to blast needs to be improved and mutation induction could help. Particular attention might be paid to Oryza glaberrima, which is adapted to particular West African conditions and could be genetically improved following mutation induction. A concerted effort on rice mutation breeding would seem timely.

Grain legumes were the second group of crops discussed. Their role in supplying valuable protein to the human diet was recognized already by the UN Protein Advisory Group 15 years ago. The various species grown have local consumer preference as well as particular adaptation to agro-ecological conditions. Many legumes are grown under marginal conditions where yields are poor but production has little competition from other crops. Under better conditions, grain legume yields at prevailing market prices are generally not competitive to other crops. Here, yields have to be increased drastically (up to 3-4 t/ha) which is difficult due to insufficient soil fertility (low phosphate, low pH), insufficient symbiotic nitrogen fixation, attack by pests and numerous diseases caused by fungi, bacteria and virus. Although international agricultural research centres like IITA, ICRISAT and ICARDA, and other international programmes like INTSOY work on genetic improvement of their mandate legume crops like cowpea, chickpea, lentil, soybean and provide improved germplasm, the results are not overwhelming due to the need for local adaptation. Lack of clear definition of breeding objectives on one side and absence of suitable genetic variation on the other side are the main obstacles for the needed diversified improvement of grain legume cultivars. Good results with mutation breeding, mainly in Asia and Europe give justification to expectations that stronger regional efforts in grain legume breeding including the appropriate use of induced mutation techniques would be rewarding. More emphasis should be given to use of locally well adapted germplasm of species that are more or less indigenous to Africa and for which there is demand on local markets. More attention should also be paid to the need of improved cultivars suited for mixed cropping and intercropping. An important asset of improved legume cultivars would be, if the required amounts of nitrogen would be fixed by symbiosis with indigenous rhizobia, avoiding the requirement for artificial inoculation.

Among the cereals, sorghum and millet are indigenous to Africa, but maize has gradually become the staple food cereal in many communities. Plant breeding of maize has reached high standards, probably mainly due to the influence by CIMMYT but also by co-operation with other foreign breeding programmes. Among seminar participants, there was little interest in supplementing ongoing maize breeding by induced mutations, but for sorghum and millet there seems to be desire for more genetic variation (e.g. to combat Striga and stem borers, or to improve grain quality).

In general, there is shortage of cooking oil supply in many African countries. Therefore, interest in sesame and sunflower breeding (besides groundnut and soybean) is rather widespread. Sunflower's oil quality is not particularly suited for tropical conditions, perhaps by mutation induction a reduction of the unsaturated fatty acids for better keeping quality can be achieved. In sesame, non-shattering remains the primary objective, since there is no suitable germplasm for this anywhere. A worldwide co-operation among sesame breeders as fostered by FAO and IDRC would be highly recommendable. The good prospects of peanut mutation breeding have been well exemplified in India.

Root and tuber crops still form the staple food for a majority of African people outside the bigger cities. These crops appear adapted to good as well as bad agro-climatic conditions and therefore deserve more attention by plant breeders. The development of in-vitro technology allows a relatively easy supply of disease free planting material. This alone should drastically increase the production potential. The same technology, however, can give faster advances in creation and selection of genetic variants that would be required for improved cultivars. Resistance to pathogens and pests would be certainly the predominating aim. Quality aspects are also important as many of the more recently developed higher yielding cultivars are not readily accepted by the consumer. Genetic variation can be produced by in-vitro mutation breeding, however, advances in breeding require the application of effective selection using criteria that are in line with well defined breeding objectives. Here, international co-ordination, research and training would be highly desirable. In cassava as well as sweet potato requirements for export and industrial processing are different from local consumer's preferences.

There were several other crops discussed at the seminar, which may be misleadingly called minor crops, such as vegetable cowpea and bean, tomato, fruit trees, pea and faba bean, yam, banana. In all of these, genetic variation can be created by mutagenesis when needed. However, the establishment of sound breeding programmes (not merely testing of introductions) would be a pre-requisite for success.

In more general discussions, principles of mutation breeding were raised such as choice of parent, choice of mutagen, population size. In relation to breeding objectives the matter was raised how yield, being dependent upon many genes, can be improved by mutagenesis, changing only individual genes. It was stressed that the definition of a trait or character is made by man. Each gene has a certain effect which may be dramatic and easily recognizable (easy to select) or minute and hardly recognizable (detectable only in replicated trials or under controlled environment conditions). There are many examples that yield has been improved by single gene mutations, which altered photoperiodic response, tillering or branching, flowering time or duration, fruit or seed size etc.

By using the "doubled haploid technique" selection of mutations in "quantitative characters" will become easier and more reliable, as there would be no heterozygous component in the population from which mutants are to be selected. Unfortunately, this technique is not yet generally applicable.

In disease resistance, another objective of major concern, we actually face a comparable situation, in the sense that one can recognize major and minor gene effects. But there is no justification for separating host plant genes into two distinct classes, one with major and the other with minor effects, because the "intermediates" may be numerous. One may also be sceptical whether in nature there is a clear cut difference between genes leading to "vertical" and genes leading to "horizontal" resistance. The complications derive from the fact that many pathogens possess their own evolutionary capacity. It makes them capable of adaptive genetic reactions to man-made artefacts in the genetic composition of the host species, as they result from the widespreading use of a "disease resistant" cultivar. Therefore, it is important for the breeder to co-operate with the plant pathologists in monitoring the compositions and development of pathogen populations and in establishing stabilizing patterns of released cultivars. Breeders should also be aware that recently introduced crop species may carry a particular risk, due to the fact that compatible pathogens and pests may be initially absent but could build up extremely fast, once a new crop (variety) gains popularity.

Many specific questions raised are thoroughly treated in the FAO/IAEA Mutation Breeding Training Courses and in the "Manual on Mutation Breeding" available from IAEA. Seminar participants were advised about possibilities of assistance by FAO and IAEA, e.g by mutagen treatment, through research co-peration and through training.

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