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RESEARCH STRATEGIES FOR THE 1980s
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**STRATEGIES FOR PROGRESS IN COCOYAM RESEARCH**

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Although natural flowering and seed setting are rare in the cocoyams — *Colocasia* and *Xanthosoma* — mutual interactions of polyploidization, occasional somatic mutations, and introductions to new and contrasting environments and growing conditions, followed by selection over several centuries in cultivation, have produced an impressive array of variability within the two species. This variability, which has accumulated on account of the vegetative means of propagating the species, if exploited, can benefit the entire African continent through systematic collection, evaluation, and distribution of elite cultivars. Variability can further be increased and superior varieties developed when flowering, seed setting, and methods of hybridization and breeding procedures are worked out. Suggestions are given as to how these can be achieved.

La formation naturelle d’inflorescences et de graines est rare chez les taros *Colocasia* et *Xanthosoma*, l’interaction de la polyploïdie, des mutations somatiques accidentelles, leur introduction dans des nouveaux milieux où les façons culturales sont différentes, facteurs associés à la sélection pratiquée au cours des siècles, ont augmenté la variabilité de ces espèces de façon impressionnante. Le continent africain tout entier pourrait profiter de l’exploitation immédiate de ces caractéristiques dues à la multiplication par voie végétative de ces espèces, et on pourrait procéder à la constitution de collections systématiques, à l’évaluation et la distribution de cultivars supérieurs. La variabilité pourrait être accrue et des variétés encore plus parfaites obtenues par des méthodes de reproduction et d’hybridation au moment de la floraison et de la nouaison. On suggère des moyens pour y parvenir.

The cocoyams — *Colocasia* and *Xanthosoma* — are the two most important genera of the family Araceae. The other three genera *Alocasia*, *Amorphophallus*, and *Cyrtosperma* are important as food plants only in the pacific basin.

Originating in Southeast Asia, probably in India or Malaysia, where wild forms are still found, *Colocasia* spread throughout India and the pacific basin (including New Zealand and Hawaii) in prehistoric times (Burkhill 1938, Porteres 1960). It reached Egypt through the Middle East in 100 AD and later spread westward along the Mediterranean and across Africa to the Guinea Coast (West Africa). By 1500 it was already in cultivation in Gambia and Sao Thome. Madagascar, which is culturally linked with Indonesia, is believed to be another route by which the cultivation of *Colocasia* diffused through Africa. From West Africa, it reached tropical America in the early 1500s, and by 1800 it had spread from the Caribbean to Brazil and, recently, to the south coast of the USA. The cultivation of *Colocasia* is therefore worldwide — throughout the tropics to the borders of the temperate regions.

*Xanthosoma* originated in tropical America and was in cultivation in pre-Colombian times. It occurs from Mexico to Brazil, but its cultivation is concentrated in the Caribbean. It was introduced during the 1840s or probably earlier by West Indian missionaries into West Africa (Wright 1930b), from where it spread to other parts of Africa. It is also cultivated in Oceania and Southeast Asia. Its cultivation, like that of *Colocasia*, is pantropic, but because of its superiority over the latter, in yield, taste, adaptability, and resistance to pests and diseases, *Xanthosoma* is rapidly displacing *Colocasia* in West Africa and probably in other parts of the world also.

**CLASSIFICATION AND VARIABILITY**

There has been considerable controversy about the taxonomy of *Colocasia*. The taro, eddoe, dasheen curcas (Kolkas), or "old" cocoyam, are all forms of a plant originally described as *Arum esculentum* but now referred to as *C. esculenta* or *C. antiquorum*. The name having priority and, therefore, validity, however, is *C. esculenta*. Taro is the paddy form and the others are dryland forms.

Classic Linnean taxonomic concepts are not always rigidly applicable to plants that have been in
cultivation for a long time and especially where vegetative propagation and clonal selection have been practiced over several centuries, giving rise to continuous variation of forms. Hill (1939), therefore, treated the taros as a polymorphic species, C. esculenta. (C. esculenta is taro, and C. esculenta cv. globurifera is dasheen.) This classification is shared by several workers.

There are hundreds of cultivars of C. esculenta differing in corm size, shape, texture, colour, starch, properties, acridity, number of secondary corms, and uses. Cultivars also differ in fertilizer and irrigation requirements, pest and disease resistance.

These variations have probably arisen through somatic mutations, genetic recombinations brought about as a result of chance seed setting, chromosomal aberrations and polyploidization (both euploidy and aneuploidy). Reported chromosome numbers (2n) are: 14, 22, 26, 28, 38, and 42; 2n = 28 predominantly occurs in India, Japan, and Polynesia and 2n = 42, in India, New Zealand, and the Philippines (Yen and Wheeler 1968).

Thus, because of the predominantly vegetative mode of propagation of Colocasia and its long history as a cultivated crop, it has been possible to select and preserve over the ages types of variation found useful to humans. The accumulation of these different types has made it possible for suitable cultivars to be found in different areas and in various growing conditions of soil, water, altitude, temperature, management, planting practices, etc.

This large store of variation is immediately available for utilization in its raw state and in all future combinations and recombinations, if conditions for flowering, hybridization, seed setting, and raising of seedlings are discovered.

Like Colocasia, variability within Xanthosoma is fairly large. The genus includes crops popularly known as Yautia, Tannia, Macabo, Mafaffa, or new cocoyam. Agriculturalists usually refer to the edible corm-producing representatives of Xanthosoma simply as X. sagittifolium. However, a number of species have been identified based mainly on vegetative characteristics (Haudricourt 1941) from the multiplicity of cultivated forms. These include X. sagittifolium; X. jacquini; X. caracu; X. mafaffa (three cultivars); X. atrovirens (five cultivars); X. beloplyum (four cultivars); and X. brasiliense.

Detailed descriptions of these are available in the literature (Gooding and Campbell 1961a; Karikari 1971). As was indicated for Colocasia, it is doubtful whether all these taxa can stand any rigorous Linnean taxonomic classification. Variability in Xanthosoma, however, appears less than in Colocasia, and the literature on the crop is also comparatively sparse. Chromosome numbers are not available, although for X. sagittifolium, 2n = 26 has been reported, suggesting that it is a diploid (Wilson 1974). However, variability parallel to that found in Colocasia regarding maturity period, corm texture, taste, colour, size, utilization of leaves, etc., also occurs in the Xanthosoma species and cultivars that have been identified.

NATIONAL RESEARCH PROGRAMS

Of the root crops cultivated in Africa, cocoyams have received the least research attention. Research on cocoyams, which started as far back as the early 1930s, has not been sustained; more attention has been given to yams and cassava. For example, in Ghana in 1925 there were attempts to find the causal organism and control measures for a disease described as root rot (Wright 1930a). Posnette (1945) of cocoa swollen-shoot fame continued the investigation and came out with far-reaching recommendations. So far as I am aware that is where the matter has rested. Posnette (1945) also made several introductions including X. violaceum and attempted induction of flowering, hand pollinations, and raising of seedlings in a bid to produce disease-free material for distribution. This work was not pursued. The example of Ghana is parallel to that in several African countries. The priority rating of crops was and is still cash or export crops (cocoa, oil palm, rubber, etc.), food grains (cereals and legumes), and root crops under which cocoyams have had the lowest priority.

STRATEGY FOR PROGRESS

Any strategy must be well-planned and the various steps involved, well-coordinated if good progress is to be made. The planning should be done from an institution like IITA or the National Root Crops Research Institute, Umudike, which should coordinate the work of cooperating institutions throughout Africa. A two-phased program is suggested:

- Phase I (short-term) would be an interim phase during which identification, evaluation, and rapid distribution of elite cultivars among those already available should be made;
- Phase II (long-term) would start as soon as possible but not until all accessions have been properly identified, classified, and screened. Eventually, programs under this phase would supersede those in phase I and would be the
main programs to be pursued. Research at this stage would be multidisciplinary with physiology, pathology, and entomology as major disciplines providing basic information for breeding and agronomy for the long-term improvement of cultivars, their cultivation, and utilization.

**PHASE I**

The circumstances surrounding the earlier introductions could not have ensured that the most suitable or appropriate cultivars have always reached desired locations. If they have, it has been merely fortuitous. Poor flowering and seed setting have meant that clonal selection could only be carried on within the limited material available, i.e., the original introductions and perhaps new types produced by the very rare occurrences of somatic mutations and chance seed setting. At best, selection would have been short-lived because variability would have been quickly exhausted. Our “best” cultivars of today, therefore, may have been much different if the earlier introduction had been of a different mixture.

There is, therefore, the need for a systematic collection program aimed at obtaining both wild and cultivated material from all parts of the world where cocoyams are important and especially where collections already exist. For *Colocasia* these are Hawaii, the Pacific basin, India, and New Zealand; for *Xanthosoma*, the Caribbean islands and other parts of Latin America. There is no comprehensive collection of *Xanthosoma* anywhere, and such a collection exercise is long overdue. The ISTRC — AB should, with the appropriate support, i.e., funds, equipment, etc., assign the job of collection and maintenance to an African institution or institutions, such as IITA, that have the capacity and the expertise.

Problems of collection and maintenance are many, and the few attempts in the past had to be abandoned for want of continuing funds. The problems include:

- Bulky and highly perishable planting materials that are expensive to store and transport;
- Maintenance of living collections by continuous planting, which is laborious and expensive and leads to accumulation of pests and diseases, particularly viruses, in the planting material, resulting in complete deterioration and ultimate loss of the material; and
- Lack of effective means of disinfection or disinfestation of vegetative planting material in many parts of the world, hindering exchange of material between countries.

New methods of long-term germ-plasm storage of vegetative organs therefore are urgently needed. In the interim, current “seed” production practices, such as the use of small corms (cormels) saved from previous harvests, could be improved. Cormels can be stored for as long as 6 months without sprouting, especially if stored at temperatures between 10–15°C with adequate ventilation (Martin 1975).

Identification of all material collected is of primary importance, especially when there is continuous variation of forms, and the need to distinguish cultivars is urgent. Descriptors for *Colocasia* have already been compiled by the International Board for Plant Genetic Resources (AGP, IBPGR/179/52, 1980). This should go a long way in the identification of species and cultivars. Descriptors for Xanthosoma are also urgently required. The ISTRC — AB should request IBPGR to undertake this assignment and to enlist the same experts who compiled the descriptors for *Colocasia*.

Evaluation of elite materials should be carried out at different stages, starting at the museum where, until other methods are found, living collections will be maintained from year to year, and moving to the field trials stage involving, for example, studies on water, soil, and nutrient requirements, plant populations, etc. Evaluation should bring out information on maturation time; yield and quality of corms and leaves; palatability of corms, leaves, and petioles and their suitability for local food preparations, etc.; texture, starch, and dry-matter content, etc. of corms; resistance or tolerance to pests and diseases — insects, fungi, bacteria, viruses, and nematodes; and storage life (i.e., how long corms can be stored without sprouting or deterioration). An intensive search should be made for early-maturing (9 months) types that yield well under severe defoliation.

At this stage, it should be possible to identify other institutions willing to cooperate in further evaluations of selected material for suitability to local conditions (i.e., the well-known and tested cooperative trials that IITA carries out with other crops). Local tests should lead to identification and multiplication of the most suitable clones for distribution within the locality. Distribution should include a package of proven agronomic practices — fertilizer, water, etc. — determined during earlier stages and confirmed in the cooperative trials.

**PHASE II**

A strong physiology program is needed to identify and provide information on important physiologic characters to be used by breeders and agronomists in developing a package of high-yielding varieties and their growing conditions.
Colocasia and Xanthosoma show the least capacity for flowering and setting of fertile seed. Breeding and genetic research cannot proceed unless flowering and fruiting occur. There is, therefore, an urgent need to determine the conditions for flowering, fruiting, and seed setting. Techniques for self-pollination and hybridization as well as techniques of seed germination and seedling establishment also have to be worked out.

Work on flowering has been reported by McDavid and Alanu (1976) and on seeds and seedling propagation by Kikuta et al. (1937), Volin and Zettler (1975), and Jackson et al. (1977). Promising results with respect to flowering, pollination, and seed setting of both Colocasia and Xanthosoma obtained recently at IITA (Annual Report 1978) treating plants with the potassium salt of gibberellic acid (GA3) indicate that flowering can definitely be induced in plants. Manipulations of such environmental variables as day length and temperature, as well as degrees of shading and defoliation imposed alone and in conjunction with chemical treatment, should also be investigated in attempts to promote flowering and seed setting.

Plantlets or mericlones developed from tissue culture can be used as a means of storing germ plasm as substitutes for living collections, which are rather expensive to maintain. Furthermore, the use of plantlets will greatly facilitate distribution of disease-free material in large quantities throughout the continent. There is a need, therefore, to intensify research in this field. Tissue culture has been used in the propagation of several horticultural species; there are therefore several methods that can be investigated. The earlier work reported by Mapes and Cable (1973) on Colocasia should also be investigated and adopted for large-scale multiplication not only for Colocasia but also for Xanthosoma.

Poor utilization of solar energy by root crops has been the concern of many physiologists. Calculations based on more efficient utilization of available radiation by ideal root crops, i.e., in respect of early groundcover, improved light interception and distribution within the canopy, and improved distribution of dry matter in yield organs, indicate a potential dry-matter production of 550 × 10^6 cal/ha-day or one-half of gross potential production (de Vries et al. 1967). Under improved growing conditions, production levels by superior cultivars should result in the production of 140 t/ha-year of cassava and 400 t/ha-year sweet potatoes, i.e., an increase of two to three times in the yields of the current high yielders (Wilson 1974).

Theoretically, these yield targets are possible for cocoyams. However, they can only be realized through basic research in crop physiology and especially the utilization of growth analysis techniques to discover, inter alia, cultivars with superior characters in light interception and distribution and, in dry-matter production, distribution, and accumulation in corms early in the growing period. Varieties with these characteristics will have smaller leaves, smaller leaf-area indices, their energy going to initiate corm bulking early. Their corms will attain maximum size early, i.e., they will be early maturing.

Because cocoyams are grown under shade, there is a rapid turnover of leaves, which is confounded by deliberate but unsystematic defoliation for food. There is, therefore, the need to determine the optimum leaf area and the relationships between leaf area duration and yield, i.e., how often and at what stages of growth should defoliation be made. All these determinations should be made under different shading, moisture, and nutrient regimens. If possible two types should be identified — one type grown for corm yield and one for leaf yield.

There is also the need to determine the best corm conformation. Corm size ranges from one large central corm with a few small side cormels to a medium—small central corm with large numbers of side cormels. Which of these combinations gives higher yields under different growing conditions is uncertain.

In the final analysis it should be possible from such physiologic studies to suggest a basic ideotype to guide selection in breeding programs.

Cocoyams appear to be relatively free from pests and diseases. However, because of the low priority given to these crops in national programs, even those few fungal corm rots and virus diseases have hardly been touched. With large-scale cultivation, pests and diseases will assume greater importance. All accessions should, therefore, be screened for pest and disease resistance.

The research activities by workers from different disciplines should yield results that breeders should digest before embarking upon hybridization programs to combine the useful characters and to develop superior varieties. The development of superior varieties should not lag too far behind the distribution of elite clones from the original germ plasm collection. It should dovetail with it so that any enthusiasm generated by the initial program will be maintained.

After the correct choice of parents has been made, hybridization carried out, and seedlings raised, all that will be required is to select promising lines for testing. Testing should involve national institutions throughout the subregions.