CYTOGENETICAL STUDIES ON SOME CEREAL AND TUBER CROPS OF NORTH-EASTERN HILLS

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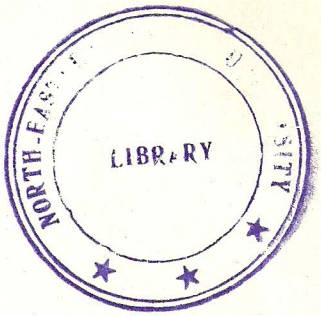

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I certify that the thesis entitled "Cytogenetical studies on some cereal and tuber crops of North-Eastern Hills" submitted by Mr. K.M. Kuruvilla for the degree of Doctor of Philosophy of the North-Eastern Hill University, Shillong embodies the record of original investigation carried out by him under the supervision of Late Dr. Avtar Singh. He has been duly registered and the thesis presented is worthy of being considered for the award of the Ph.D. degree. This work has not been submitted for any Degree of any other University.

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Signature of the Supervisor.

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RESPECTFULLY DEDICATED

TO

MY SUPERVISOR, LATE DR. AVTAR SINGH

C O N T E N T S

A C K N O W L E D G E M E N T S

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INTRODUCTION

The Indian sub-continent is unique in that its North-Western parts from Punjab, North-Western Province in Pakistan, Kashmir and Afghanistan upto Central Asia happen to be one of the most important centres of origin of a large number of important crop plants, the most important being the wheats. Similarly, the North-Eastern part of India extending from Assam, Sikkim and Meghalaya to Burma and Malayasia is another important centre where several cultivated plants including rice, orange, mango, banana and some tuber crops originated. Meghalaya State falls within this region. It has a wide range of altitudes from 100 metres to approx. 2000 metres and is covered by variable climatic conditions and soil types. Hills are also isolated from one another geographically giving rise to important ecological niches. It is exceptionally rich in germplasm of a large number of plants, viz., cereals, fruits, tubers, etc. The Agricultural Scientists and Institutes quite often organise collections of wild relatives of rice, oranges, bananas, dioscorea, etc. from time to time as these accessions are essential for their studies/improvement programme, but even then inestimable stock of the great variability remains to be explored. It may be stated that Vavilov (1931) while describing Chinese centre of origin of plants mentioned -

"If we take into account the enormous number of wild plants besides the cultivated ones used for food in China, we may better understand how hundreds of millions of people manage to exist on its soil." Similarly, in the North-Eastern region where organised agriculture and cultivation is a recent feature, the original inhabitants sustained themselves on the natural tubers, fruits, cereals and other crops. As an illustration one has to see to believe how hillsides after hillsides in the Assam region wild bananas grow from which through clonal selection or natural hybridisation and polyploidy cultivated varieties could have evolved.

While sustained efforts are being made for the collection, conservation and assessment of the germplasm of major crops like rice, Cicer, Phaseolus, Cucumis, sugarcane, mango, cotton, orange, etc., no worthwhile attention is being paid to spot out and assess the existing variability of lesser known tuberous plants. As mentioned above the role of these tuberous plants in the food chain of the local population cannot be underestimated. It would, therefore, be very useful and rewarding if the locally cultivated tuber crops and their wild relatives be extensively collected and suitably assessed. Such efforts can be of considerable importance for their improvement and wider cultivation so as to contribute substantially to the food granary of the country.

Tuber crops in fact constitute the major staple food for the people in the tropics. Most of these tuber crops are aroids which grow both in plains and hills, and show an array of variable habits. It is with this aim that a number of species of the tuberous crops have been selected which commonly grow in Meghalaya regions. Their cytogenetical aspects and food value need to be properly determined.

A cursary glance at the literature reveals that some attention has been paid to the cytogenetics of tubers growing in other parts of this country as well as in other parts of the world, but there is complete lack of information on the tuberous plants that are found in North-Eastern hills of India.

The whole range of variability with respect to cyto-types, clones, polyploids, natural hybrids, etc. may be expected which could be utilised later in a meaningful manner.

There are a large number of tuberous crops, but for an indepth and fruitful informations the investigation will be restricted to some of the common and cultivated aroids and their wild relatives. The aroids - a monocotyledonous group of plants, comprise of 1400-1500 species belonging to 105 genera (Lawrence, 1951). Vegetative propagation is the primary mode of reproduction in this family,

even if a few of them may be sexually fertile. The genera Colocasia, Gonatanthus, Xanthosoma, Arisaema, Steudnera and Amorphophallus are common in the hills and plains of Meghalaya. Of these, the first three genera belong to the tribe Colocasieae and the remaining three to the tribe Areae, Diffenbachieae and Pythionieae respectively (Hutchinson, 1944).

The genus Colocasia, commonly known as 'Taro' and in West Africa as 'Cocoyam', grows luxuriantly in Meghalaya. The corms and cormels are economically important as they have store of carbohydrate and starch. The starch is amylase and amylopectin and is readily digestible, hence, they are greatly priced as food. Even in protein content it is better than sweet potato or Cassava (Mannihot). The plants propagate vegetatively, hence, there is continuous gradation of characters. The taxonomy of Taro, therefore, presents complications. According to Plucknett (1976) there may be more than 1000 cultivars of Taro. C. esculenta is considered as the most widely cultivated taxon. Mookerjea (1955) studied a number of taxa of the Araceae including Colocasia and reported 2n = 28. However, a great number of morphological strains/types growing in the plains and hills of Meghalaya were not covered in this study. Similarly, the taxon Gonatanthus sarmentosus which showed 2n = 32

by the same author, was not collected from Meghalaya.

Sharma and Sircar (1963) reported various cytotypes with different chromosome numbers in North Indian species (not Meghalaya) of Colocasia antiquorum. Another mitotic studies in C. antiquorum and C. esculenta were carried out by Magoon et al. (1971) with a view to bring out the nature and trend of chromosomal variations in Colocasia. These cytological reports on materials collected from another area than Meghalaya confirm that the various species of Colocasia growing in North-East Hill region have not been touched and, therefore, need critical cytological investigation from both basic and applied standpoints to bring out the mechanism of variations and thus may be helpful in selecting suitable clones and cytotypes for multiplication and cultivation.

Similarly, the other genus Amorphophallus comprising of about 90 species of which 14 are reported in India (Wealth of India, 1948) has not been collected to any extent from Meghalaya. Two species, A. campanulatus and A. riveri, are cultivated and greatly valued for their edible corms. Two species of Amorphophallus, A. bulbifer and A. titanum were reported to possess $2n = 36$ and $2n = 26$ respectively by Chandler (1943).

Magoon et al. (1970) and

Krishnan et al. (1970) studied the pachytene chromosomes in Amorphophallus. But in recent years Ramachandran (1977) prepared the karyotypes of the 4 South Indian species of Amorphophallus, namely, A. bohenackeri, A. companulatum, A. bulbifer and A. dubius. The reported 2n numbers in these are 26, 28, 39 and 28 respectively. These studies and reports indicate the variation in chromosome numbers, existence of cytotypes, polyploids, etc. within the genus. It is, therefore, worthwhile to explore the materials growing in Meghalaya to determine the extent of variability in them.

The other important aroid genus Xanthosoma is commonly known as 'Tannia' or 'Cocoyam'. It is generally considered a tropical American genus and was brought in use by the American-Indian of the Carribean Islands (Plucknett, 1976). During the middle and late 19th and early 20th centuries 'Tannia' spread throughout the Pacific and Indo-Asia where it achieved the status of minor crops because of its high resistance to diseases and pests (Massel and Barrow, 1955). Superficially Xanthosoma resembles Colocasia, but as detailed later they differ from each other in important morphological features. Nutritionally it is similar to Colocasia. In fact, the corm of 'Tannia' is composed of 77-86% edible materials. It is

also richer than 'Taro' in mineral elements. Onwueme (1978) reported that between 1965 and 1974 'Tannia' was grown on 6,89,000 hectares of land in the world. Even in Asia 61,000 hectares of land was under 'Tannia' cultivation during this period. The most common cultivated form is X. sagittifolium which appears to have numerous morphological forms (Onwueme, 1978). The species, therefore, is polymorphic. The other species of the genus like X. atrovirens, X. carcau and X. violaceum are grown in West Indies and Philippines. Uptill now the improvement of the group has been limited to the genetic variability present in small numbers of cultivars (Warrid, 1970). It is evident that there is vast scope for collections from the various regions and ecological habitats so as to fully and suitably assess them for selection and cultivation.

The studies in the other genera like Arisaema and Steudnera are equally sketchy.

Thus the importance of these tuberous crops which are used as food can be better and properly appreciated only when it would be recalled that large part of the North-Eastern regions, full of mountains and forests and inhabiting various tribes of local populations whose assured means of food supply through cultivation is of recent introduction. The tubers seen in this light assume special importance. Therefore, from the point of view of the food

values of these tuberous crops and also to explore the range of variations in them in this region of the centre of their origin where most of the dominant genes are expected to be present, form the basis of their inclusion in the present investigation.

The other common cereal, besides rice, which form the favourite crop of the hill tribes, is maize. So much work on maize, both of fundamental and applied nature, has been done throughout the world that even to review them will form a solid book. Why was then maize selected for the present investigation, is the consideration that there is a strong school of thought that the secondary centre of origin (even primary centre) of maize is the North-Eastern India. The relationship of Zea with Tripsacum and Euchlaena may be reviewed and also its relationship with Coix and Sorghum as mentioned by Anderson (1945) and Mangelsdorf (1947) need to be investigated. What is surprising is that some of the primitive types of maize grow in the hills of Sikkim and Meghalaya. These strains still bear 5-6 cobs per plant, the character commonly inherited from Tripsacum. A number of composites and hybrid maize varieties have been evolved in the plains and been exported to the hills for higher yield that many of these primitive varieties are gradually being replaced. It would be a

misfortune if the primitive maize germplasms which could provide important clues to the Asian origin of maize and its relationship with Coix and Sorghum vis-a-vis Tripsacum, are totally replaced by modern hybrid composits. An attempt has, therefore, been made to collect some of the yellow and white kernnel maize types grown in remote areas of Meghalaya and to study their inheritance with a view to know if they throw 'off-types'/'recessive genotypes' which may provide valuable evidence about the origin and development of these primitive hill strains. It is also to stress that more intensive effort is needed to collect on large scale all the available strains of the primitive maize grown in various inaccessible hill areas where improved varieties of maize from the plains have not yet invaded.

In view of this some of the maize varieties grown in the hills were selected for investigation of their inheritance behaviour, growth pattern and cytogenetics so as to utilise these informations to discuss their importance in evolution and breeding.

In addition to the cytogenetical aspect of the tuberous crops and the primitive varieties of maize, another approach, namely, electrophoresis, has been employed to study the carbohydrate and protein profiles in some accessions collected from various regions. Electrophoretic

studies which are greatly helpful in cases where taxa/varieties which have same chromosome number and behaviour, and very similar morphological traits, would reveal different types of protein and carbohydrate profiles. The difference of bands in electrophoretic studies thus bring out the cryptic structural differences in the genetic make-up of the taxa which are otherwise non-detectable in cytological preparations.

Coupling of morphological, cytological, genetical amd electrophoretic studies are thus expected to provide very useful information on the variability pattern and phylogenetic relationship in these groups of plants.