Cadbury - KAU Co-operative Cocoa Research Project

Proposal for Extension of
RESEARCH COLLABORATION BEYOND 2002

Submitted to

M/s. CADBURY INDIA LTD.

COLLEGE OF HORTICULTURE
ERALA AGRICULTURAL UNIVERSITY
KAU P.O, THRISSUR, KERALA

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CONTENTS

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PROPOSAL FOR

EXTENSION OF RESEARCH COLLABORATION FOR A THIRD TERM (2002- 2007)

1. INTRODUCTION

Cocoa was introduced into India in the early 20th century; but its cultivation was limited to a few Government farms. Cocoa cultivation was resumed in a big way in the 1960's. Starting from a few hundred hectares during 1960's, the area under the crop increased to 1927 hectares by 1970-71 and to 29,000 hectares by 1980-81. From this peak in area, there was a drastic decline to about 22,600 hectares by 1982-83 and then a steady decrease to 9,800 hectares by 1994-95. A slight increase followed to take the area to 12,400 hectares in 1996-97 and 14193 hectares in 1998-99. The decline in price of the produce was the reason for such a lack of interest in this crop and the consequent decrease in area. Production, on the contrary, registered a steady increase over the years to reach a peak of 7715 tonnes of dry beans by 1985-86, after which it decreased to the lowest level of 6000 tonnes by 1998-99. At the present average productivity of 30 pods per plant annually; the production would have been around 14,500 tonnes if the area of 29,000 hectares of 1970-71 existed. It is estimated that consumption of cocoa beans in the country by the processing industries by the turn of 2005 would be about 27700 tonnes. With the economic liberalisation policies of the Govt. of India and due to increased marketing investments, the demand for cocoa based products in the country has been registering a rapid rate of about 15- 20 per cent from 1994 onwards. The production of cocoa hardly meets 30% of the demand projected by the processing companies in India. In order to make the country self sufficient with respect to its requirement, technology for increasing yield from unit area has to be standardised. Development of clones with high yield, disease resistance and acceptable bean quality are essential to step up productivity.

2. AGRONOMIC FEASIBILITY

Agronomically, cultivation of cocoa in the interspaces of coconut and arecanut is feasible especially as shade tolerance of cocoa is high. Also, when managed well with irrigation and adequate fertilizer application, the yield of the main crop, coconut increases, the extent of increase as noted in the experiments at the Central Plantation Crops Research Institute, Kasaragod, being around 50 per cent. It is however to be noted that when cocoa is under neglect, the yield of coconut comes down. The introduction of irrigation consequent to introduction of cocoa as mixed crop of coconut; when done, can further increase productivity of coconut.

It is estimated that the total area under coconut in Kerala is about 9 lakh hectares. It is also logical to assume that practically all the area under this crop in Kerala will also be suitable for cocoa

cultivation. If about 10 per cent of the area in Kerala is brought under cocoa intercropping, the total annual dry cocoa bean production would be about 45,000 tonnes at the current level of productivity of 30 pods/plant. This is well above our requirement. At the current price of Rs 50 per kg. of dry beans, this level of production will be worth about Rs 225 crores annually. It also relevant that this much of national wealth will be added with no additional allocation of land.

The quality of Indian cocoas is about the same level as that of other South East Asian cocoa and as such there is very high potential for export. The demand for cocoa-based products in the country has been registering a rapid rate of about 15- 20 per cent from 1994 onwards. Considering the above large potential of this crop, it is necessary that production in the country is stepped up substantially.

3. PROGRESS OF RESEARCH ON COCOA AT THE KERALA AGRICULTURAL UNIVERSITY

Research on cocoa was initiated at the Kerala Agricultural University with the field planting of a feasibility trial on cocoa cultivation in coconut interspaces at the Regional Agricultural Research Station, Pilicode in July 1970. Barring this, and a study on survey of the pest complex associated with this crop started in 1976 at the College of Horticulture, all other experiments were started since 1978, most of them under the erstwhile world bank aided Kerala Agricultural Development Project, which operated from 1977 to March 1986. The important findings from these experiments are furnished below:

1. Cocoa was found to be compatible with coconut as an intercrop and it could be planted either as a single hedge or as double hedge in between two rows of coconut. When spacing is more than 9 m between coconut palms, double hedge will be a suitable system whereas in plantations upto this spacing, single hedge will be better.
2. Cultivation of cocoa along with coconut will result in no decrease in yield of coconut as long as cocoa is irrigated and fertilized adequately.
3. Vegetative propagation in cocoa is possible through budding, grafting and rooting of cuttings. Among these budding is most viable.
4. For raising cocoa seedlings, the shade optimum will be in the range from 50 to 75 per cent; the shade level being around 75 per cent in the early stages and around 50 per cent at later stages.
5. For grown up cocoa, yield was found to increase progressively with increasing levels of illumination, the highest being in the open. Intense shading resulted in substantial yield decline.
6. The micronutrient; zinc was found to be deficient in some situations and typical deficiency symptoms on foliage is found to occur. Application of 0.5 % Zinc sulphate through foliage was found to correct this deficiency.

7. A germplasm collection involving all the available variability in the country was established at Vellanikkara since 1979. This collection included some of the best combiners and some clones with distinct tolerance to diseases.
8. A total of twenty six clones from among the germplasm collections were identified as superior. These had high yield and acceptable bean size.
9. Using the available self incompatible parental clones, hybridization work was started since 1984 and one set of hybrids was field established during 1986.
10. Cocoa bean size was found to vary widely in Indian cocoa, the beans being smaller in the case of rainy season crop which has developed through the rainfree period. Providing irrigation during rainfree months did not completely correct this smallness of beans. Malaysian beans, on the contrary, were uniform in size throughout the year.
11. Cocoa bean pH was found to be around 5 in Indian cocoa with about 30 % of the samples showing values less than 5. Storing harvested mature pods prior to fermentation up to four days was found to improve the quality of fermented beans, the quality deteriorating with further increase in the period of storage.
12. Small scale fermentation methods were evolved for fermenting as small quantities as 2 kg.
13. Among the diseases of the crop, black pod caused by *Phytophthora palmivora* was found to be the most serious, some other diseases being pink disease caused by *Phytophthora* sp. and die back caused by *Diplodia* sp. Application of Bordeaux paste at the fork region and cut ends of the stem and spray of 1% Bordeaux mixture before the onset of monsoon was found to give absolute protection against pink disease.
14. Survey of pest complex associated with cocoa showed that there are about 14 insectan and three non- insectan pests associated with this crop. The important non-insectan pests were rats and squirrels. Tentative recommendations on containing the damage by the pests were given.

4. Cadbury – KAU CO-OPERATIVE COCOA RESEARCH PROJECT (CCRP)

The Cadbury - KAU Co-operative Cocoa Research Project (CCRP) was started with effect from April 1987. The experimental area and other infrastructure available with the University were utilised for the project. There was provision for three scientists, two farm assistants, two office assistants and one driver for this project. The project duration was ten years. Funding from the collaborators was total for the first six years and was limited to Rs. 6 lakhs year during the last four years. During the ten-year tenure of the first phase of this project, there was a substantial strengthening of research on crop improvement and crop protection including regular introduction of clonal material from the Quarantine Station of University of Reading, identification of superior clones for breeding and cloning, production of four sets of hybrids and their field planting and evaluation and initiation of resistance breeding against vascular streak dieback.

A project for standardisation of protocol for micropropagation in this crop was sanctioned by the Department of Biotechnology during 1990 for a three-year period. Following two extensions, it came to a close during 1995. Based on the work under this project, tissue culture research on cocoa had progressed to the forefront on the aspects of micropropagation and somatic embryogenesis. A few micropropagated plants could be planted out after hardening. There are, however, some problems in commercialisation of this protocol.

In addition to the above Cadbury-funded research programme, a Central Sector Scheme for production and distribution of vegetatively propagated high yielding clones was also sanctioned during 1993. This scheme had an annual budget of about Rs 20 lakhs and a target for distribution of 1.5 lakh budded plants annually.

Following the cessation of the ten-year tenure of Cadbury - KAU Co-operative Cocoa Research Project (CCRP), technical assessment of the research work was undertaken by M/s Cadbury India. Based on this, the project was extended for a further period of five years. During the extended period sanction was given for creation of one additional position of Associate Professor (Hort./ P.Breed.). Out of the total budget estimate of the project for five years, the collaborators' share was fixed as Rs. 55 lakhs. During this extended period, cocoa research was further strengthened. An ICAR Ad-hoc project on "Genetic analysis of cocoa (*Theobroma cacao* L.) hybrids" was sanctioned for three years with a total financial outlay of 6.25 lakhs and it started functioning from 17.11.1999.

The period of collaboration of Cadbury - KAU Co-operative Cocoa Research Project (CCRP) is to end by March 2002

4.1 OBJECTIVES

The broad objectives of the collaborative project were

1. To continue and strengthen breeding investigations
2. To continue ongoing field experiments of long term nature on crop management
3. To take up studies on diseases of the crop and
4. To take up ancillary studies of short term nature like rooting of cutting, tissue culture and top working

4.2 EXPERIMENTS IN PROGRESS AND SALIENT RESULTS

4.2.1. CROP IMPROVEMENT

The crop improvement work taken up were the following:

1. Germplasm collection, screening and selection of superior clones, testing the performance of these clones in comparative yield trials and large scale production of clonal material from elite clones.

2. Production of first generation hybrids of self incompatible high yielders, assessment of their performance and selection of superior hybrids. This programme was taken up in four stages starting from 1984.

3. Production of homozygous plants through selfing

4. Breeding for resistance to VSD which involved selection of resistant parents, utilising them to produce hybrid pods, raising hybrid seedlings, screening the seedlings for resistance to VSD by keeping them in isolated humid net houses surrounded on all sides with infected seedlings and field planting of tolerant hybrids. This programme has been in progress since 1994.

1. Germplasm collection, screening and evaluation

i. Germplasm

The collection located at the main campus of the Kerala Agricultural University at Vellanikkara has six sets of plants. Four were from seeds and the last two, cloned material. Germplasm I consists of plants arising from open pollinated pods of 15 plants introduced from the Cocoa Research Institute of Ghana. These included nine Amazonians, one Trinitario, one Amelonado, one Criollo and three hybrids. Germplasm II to IV were from pods of promising plants from the bulk populations from all over the country and Germplasm V and VI, clonal material from the different types available in the various research stations and those directly introduced from the University of Reading, UK.

The germplasm VI is a collection of vegetatively propagated types was originally field established in 1983 with 126 types collected from CPCRI Regional Station, Vittal; Cadbury Farm, Thamarassery; RARS, Pilicode and CPCRI Substation, Kannara. The collection was expected to include nearly all the cocoa types introduced into the Country till then from time to time. Collection of budwood for addition to this germplasm was continued mainly with plants from farmers' fields with reported superiority in field performance. In addition, a total of 24 clones were introduced as bud wood from the Quarantine Station of the University of Reading during December 1990. Budded plants from these were field planted in June 1991 after quarantine. Nineteen more consignments of bud wood were received from Reading in January 92; June 92; January 93; July 93; January 94; May 95; November 95; April 96; July 96; November 96; May 97; August 97; November 97; November 98, April 99; August 99, February 2000 and September 2000 and February 2001. Out of the total of 374 clones introduced, only 140 could be successfully field established. All the clones from the first introduction which were planted in 1991 started yielding and some of them were found to be very promising. The collections of 1992-93 included 91 clones from farmer's field also - 38 from Wynad District and 53 from Calicut District - the basis of which was reported to be superiority.

Collections of 1993-94 included 30 clones from the University of Reading, 15 VSD tolerant

clones from farmers' fields from Kottayam District and three from the CPCRI, Regional Station, Vittal. All these were field planted during June 1994.

Some of the important clones are IMC 67, Na 31, MUG 413, SIAL 93, IMC 10, EET 272, ICS 6 and SCA 6. The newly added clones are regularly being evaluated for yield, pod and bean characters, and self- incompatibility. The accessions showed wide range of variability in yield as well as pod and bean characters. Very high yield up to 154 pod /tree/year was recorded in clone like PA 7 x Na32(s).

ii. Screening and selection

From the different germplasm collections, 26 self- incompatible plants were identified for inclusion in the first stage of breeding for producing the F_1 hybrids. The bases of selection were pod yield, reported combining ability and oven dry kernel weight of more than 0.8g. A replicated field trial involving these 26 parental clones was field planted in 1989 for comparative assessment of performance. The first set of 26 self incompatible plants selected for hybridisation programme was planted as a replicated field trial for comparative assessment of their performance (CYT 1). They came to bearing in 1991-92. The results suggested that the highest yielding six clones based on yield of the last ten years were M 9.16, G IV 18.5, M 16.9, GI 15.5, G II 20.4 and GVI 68.

A further selection of high yielding clones was done in 1991 based on the yield for five to six years. The total number of such clones identified comes to 44. Twenty four of these were found to be self incompatible and were included in the stage II breeding programme for producing F_1 hybrids. The self-compatible parents were used for the production of inbreds starting with the first generation selfed pods. The second set of 44 plants selected from each different set of germplasm had more than double the average yield of the set. Their self- compatibility reactions were tested by controlled hand pollination. The data on pod yield of these plants, dry bean weight and self compatibility reactions were recorded. These 44 clones were field planted as a comparative yield trial (CYT II) in 1993. Highest yielding three clones based on the mean yield for the last five years are G IV 1. 2, G VI 17 and G VI 33. Of these good clones, G VI 33 and GIV 1.2 are self compatible

The third round of selection of parents was made in 1993 and this time more importance was given to VSD tolerance rather than yield since this disease was found to assume significance in all cocoa growing tracts of Kerala. Clones already available in the germplasm having reported tolerance to VSD as well as a few hybrids of Progeny Trial I (PT I) which were expected to have genes for resistance were selected. Only self incompatible parents with acceptable pod and bean characters were selected . The 39 clones thus selected (31 from Germplasm VI, 7 from PT I and 1 from GI) were field established in 1994 as CYT III for comparing their performance. These 39 clones field planted during 1994 have started yielding. When the mean yield of last four years was considered, G VI 142 was found to give the maximum yield (21.4).

The first generation hybrids produced during 1986, 1987 and 1988 have started steady bearing by 1994-95 and selection was made from these also. Based on their yield and pod and bean characters coupled with self incompatibility, 44 parents (hybrids) were selected including five from Series I, 12 from Series II, three from Series III and 25 from Progeny Trial. These 44 parents were also planted during 1998 as a replicated field trial (CYT IV) for assessing their performance.

2. Production of first generation hybrids and selection of superior hybrids

This work started since 1984 was taken up in four stages

i. Stage I

Series I, Series II & Series III hybrids and Progeny Trial I

This involved production of 119 crosses utilising a total of 26 incompatible parents, screening them based on seedling vigour using HD^2 as the criterion (H- height, D- diameter of the stem) and final selection of superior hybrids based on field performance. These hybrids were produced over a four - year period from 1984 and those screened in from crosses of 1984, 1985 and 1986 were field planted in an unreplicated observational trial with a maximum population of 15 each along with a set of open pollinated bulk seedlings and budded plants of all the parents. These were planted during 1986, 1987 and 1988, respectively and these are designated as Series 1, Series II and Series III hybrids. The Series I and II hybrids and their parents started yielding from 1989 and their yield data were collected. All these hybrids initially selected based on seedling vigour were produced again during 1988-90 and these were planted as a replicated progeny trial starting from 1988-89. The total number of hybrids included was 29. A set of open pollinated bulk seedlings were also included thus making the total number of treatments 30. The design was RBD, the number of replications, five and the number of plants per plot, six. These plants have attained steady bearing.

The pod and bean characters of the hybrids of Series I and II and those of Progeny Trial I were studied starting from the first year of bearing. The data on these showed impressive increases over the years in the case of pod width, pod length, pod weight, wet bean weight, bean length, bean thickness and dry bean weight.

In Series I, an overall mean pod yield for the last twelve years also showed G I 5.9 x G VI 68 to be the best. In Series II, the overall mean values of yield for the last twelve years indicated that, the H6 hybrid G I 5.9 x G VI 61 was the best with 42.6 pods/ tree/year. The comparison of the data for the last eight years in Series III suggested the superiority of H1 (M9.16 x GVI 53). These trials are to be continued to get confirmatory results.

In Progeny Trial I, the maximum yield over the last ten years was obtained from the hybrid H4 (G I 10.3 x G VI 54) with 35.7 pods.

Ten top yielding plants each from the above four trials were selected from the entire population based on cumulative yield and bean characters, which will be screened for resistance to VSD during the coming year.

ii. Stage II

Series IV hybrids

This programme started in 1990 had self incompatible high yielders for the first stage breeding, the new high yielders selected during 1990 based on the cumulative yield of plants of germplasm collections I to IV and local population of the shade trial from 1984 to 1990.

This breeding programme is slightly different from stage I in that there was to be initial selection of better combiners through the assessment of general combining ability using a common tester parent (G I 5.9), the assessment being made mainly through seedling vigour. Out of 59 crosses made 29 crosses were selected based on seedling vigor and the most vigorous hybrid seedlings from these 29 crosses were planted during 1992 in an unreplicated trial with 15 plants/ cross along with G I 5.9. These hybrids are designated as Series IV hybrids. When the overall mean value of pod yield for the last six years was analysed, the H13 hybrid GI 5.9 x GI 4.8 was ranked first (45.6).

Progeny Trial II

The ten best combiners selected from GCA crosses based on seedling vigour, were crossed in diallel combinations including the reciprocals. These parents include the tester parent G I 5.9 along with M 9.16, M 13.12, G II 19.5, G VI 24, G VI 51, G VI 59, G VI 60, G VI 64 and S 28.3. Out of the 45 expected crosses, many failed due to cross-incompatibility. The hybrid seeds developed from these crosses were sown. The seedlings were screened for vigour and 25 hybrids were field established in June 1994 along with one bulk for comparison. This trial designated as Progeny trial II, was laid out in RBD with three replications and six plants per plot. Layout of this trial as well as analysis of the data in a true diallel was not possible since many of the crosses could not be produced due to cross incompatibility. A comparison of yield of the hybrids for the last four years revealed that H 15 hybrid (GII 19.5 x G VI 60) was ranked first.

iii. Stage III

Progeny Trial III & IV

In this programme started in 1992, parents were selected from high yielding first generation hybrids of Series I and Series II. One plant each from the crosses which was self incompatible was selected. All possible crosses were made excluding those with any common original parent. Eighteen hybrids were selected for the programme and 115 cross combinations were expected. Many crosses failed due to cross-incompatibility of the selected parents. Forty eight of these crosses were made in 1992-93 and the rest during 1993-94. The hybrid seedlings were screened in the nursery and the

vigorous hybrids from each cross were field planted in 1994 as Progeny Trial III. The trial was laid out in RBD with three replications, 23 treatments (22+1 bulk) and six plants per plot. These plants are in the bearing stage. The data on mean yield over the last four years suggested the superiority of H3.

Rest of the 67 crosses of this programme were attempted during 1993-94 and in these also, many crosses failed due to cross incompatibility. After completing the seedling observations, 29 hybrids were field established in Progeny trial IV in 1995 along with one bulk and two inbred (S_1) crosses for comparison. The trial was laid out in RBD with 32 treatments, three replications and six plants per plot. In this trial the highest yield was the observed in the hybrid H 5.4 x H 1.10.

Comparison of hybrids in the different Progeny Trials

The wet bean yield /tree during 1998-99 was compared in different hybrids of the progeny trials II, III and IV. The results revealed that the highest percentage recovery of better hybrids was in progeny trial II. The percentage of hybrids with a wet weight of above 4001 g /tree/year was 10.3, 8.1 and 3.8 respectively in the trials II, III and IV respectively.

The data on pod and bean characters were also compared for the recovery of hybrids with maximum desirable values (pod weight > 300 g; wet bean weight >80 g; number of beans/ pod > 35 and oven dry weight of a single peeled bean > 0.8 g). The results revealed that the highest number of desirable hybrids were obtained from P II

The average yield of pods in hybrids and clones of different trials (Series I, Series II, Progeny Trial I and CYT I) field planted from 1986 to 1989 were compared for ten years. The data showed a definite superiority of hybrids over parents during the early years.

iv. Stage IV

Breeding for resistance to Vascular streak die back disease (VSD)

Vascular streak die back disease (VSD) caused by *Oncobasidium theobromae* became a serious disease of cocoa in the early 1990's and hence attention was focused on breeding for resistance to VSD. Observations on the incidence of the disease in farmers' fields in Kottayam and Idukki districts indicated that the severity of the disease varied with the genotype and some of the clones expressed tolerance to the disease.

The clones assembled in the germplasm and the hybrids, which have attained steady yield, were screened using 0-9 scale prepared based on percentage of twigs infected in a tree.

The high yielding and resistant types were selfed to assess self-incompatibility and only self-incompatible types were selected as parents. Screening, selection of parents and hand pollination to produce resistant hybrids were done during the six consecutive years from 1995-96. The number of pods set was recorded at monthly intervals. Based on the data, the crosses were classified as compatible and incompatible. The pods were harvested when they were ripe, beans extracted, counted

and seeds sown in poly bags filled with potting mixture in the nursery situated 2 km away from the mother plants and other cocoa plants.

The field method of screening for resistance to Vascular Streak Die Back was done by exposing the seedlings to natural inoculum from surrounding infected seedlings. The seedlings were raised in a net house, individually labelled and kept in rows. Inside the net house the relative humidity was raised manually to the highest attainable level during the rainy season by covering the structures on all sides. Misting was done at regular intervals. After emergence of the seedlings, they were surrounded by VSD infected seedlings. At frequent intervals the percentage seedlings infected with VSD was noted. The disease escapes were field planted after two years during the first year and after one year in subsequent years, for observing the performance. The hybrid seedlings obtained up to 1999 could be field planted. The rest are undergoing nursery screening.

The data up to 1999 indicated that out of the hybrid seedlings (19,505) derived from 238 crosses, only 2,042 were resistant arising from 171 crosses. Hybrids from most of the crosses did not show total immunity to the disease and the percentage of infection varied from cross to cross. The results obtained during the four- year- period suggested the superiority of G VI 55 (IMC-10), G IV 18.5(local selection) and G VI 126 (SCA-6) for transferring disease tolerance to the progeny. Among the crosses compared for recovery of healthy seedlings, it was found that the parents used during the first year were comparatively capable of yielding higher number of tolerant hybrids. The crosses M 9.16 x G VI 55, M 13.12 x G VI 55, G VI 126 x G IV 18.5, G VI 126 x G VI 55, G VI 137 x G IV 18.5, G VI 142 x G VI 55, G VI 146 x G IV 18.5, G VI 147 x G IV 18.5, G VI 167 x G VI 55 and G VI 169 x G VI 55 gave more than fifty per cent recovery of resistant seedlings after two years in the nursery. However, during the second year none of the crosses recorded more than 50 per cent recovery. During the third year, G IV 18.5 x H 12.4 (87), G IV 18.5 x H 5.4 (86), G VI 55 x H 9.15 (87), G VI 55x H 5.4 (86) and G VI 55 x H 12.4 (87) recorded above 50 per cent recovery. Only G VI 23 x G VI 14 gave more than fifty per cent disease escapes during the fourth year. These crosses could therefore be suggested as effective for producing higher number of resistant seedlings. Among the parents identified as better for transferring resistance to the progeny, SCA-6 is characterised by small bean size, which is also heritable. Hence this could not be directly utilised for seed production. The other parents could be multiplied clonally and raised in a biclonal seed garden for direct production of resistant hybrids.

The selected resistant hybrids are being evaluated in the field. The study indicated that tolerance to VSD is heritable and the degree of tolerance varied from hybrid to hybrid. There is scope for production of large number of resistant seedlings by selection of parents and using them for hybridization.

Symptomatological and anatomical studies:

The LS of the infected stem showed fungal hyphae of *O. theobromae* growing in the xylem vessels. Leaf scars resulting from the fallen leaves showed white diffused growth emerging from the vascular traces. Smooth, hyaline and thin walled, broad, ovate basidiospores of the fungus could also be identified. The infected seedlings also could be identified by the above symptoms. Further confirmation of the disease was made by splitting the infected stem, which showed brown streaks in the xylem.

3. Biclonal seed garden

In order to produce quality hybrid seeds, a biclonal seed garden was established in 1996. Six high yielding clones were selected based on their yield as well as combining ability based on their performance in the stage I breeding programme. Along with yield, VSD tolerance was also given importance while selecting the parents. The six self incompatible parents selected were M 13.12 (P1), G I 5.9 (P2), G VI 55 (P3), G VI 56 (P4) G II 19.5 (P5) and M 16.9 (P6). This selection was based on the promising yield of the hybrids M 13.12 X G I 5.9 (P1 X P2), G I 5.9 X G VI 55 (P2 X P3); G I 5.9 X G VI 56 (P2 X P4) and G II 19.5 X M 16.9 (P5 X P6) in earlier crosses. These self incompatible parents were planted in such an order that the four different crosses are produced. Eight rows of each parent were left as border to prevent unwanted cross pollination. This seed garden was established in the interspaces of coconut. The six parents were planted in 220 rows and the total number of plants in this trial comes to 1621.

4. Production of homozygous plants through selfing

The objective of this programme is to produce fully homozygous plants for utilization in the breeding programme. The high yielding plants that were self compatible were used for the production of selfed progeny. The first set of selfed pods of four different genotypes was produced during 1987 and the seedlings of these field planted in 1988. These plants came to flowering during 1991 and again selfing was attempted. Second generation selfed pods could be produced from three genotypes and the S_1 progeny of one parent was completely self incompatible. Selfed progeny were raised during every year from self compatible parents identified as well as from the already established S_1 and S_2 progeny.

Inbreeding depression in the selfs was very high compared to that in hybrids of the same age. The extent of inbreeding depression varied among the parents indicating substantial differences in the levels of heterozygosity of the parents. In the percentage of self compatible progeny produced, there were again differences between the four parents, the values being 0, 10, 20 and 60. Hence, only from three parents, S_2 progeny could be raised. Selfing was continued and inbreds of different generations were raised whenever the selfed plants attained the flowering age. Because of self incompatibility in the selfed progeny, many plants could not be included in the continued selfing programme. At

present, the programme has reached up to field planted S4 generation in one genotype, S3 generation in two genotypes, S2 in 6 genotypes and S1 in 25 genotypes. All these were field established starting from 1991 to 1998 and their growth observation as well as yield were regularly recorded.

The high yielding self incompatible S_1 progeny were also utilized for the production of inbred crosses, (S_1 x S_1). The objective was to produce comparatively uniform hybrid population. The S_1 crosses made were S_1 M 12.21 x S_1 M 18.7 and S_1 G II 7.4 x S1 M 18.7. These hybrids were also included in Progeny Trial IV for comparison of their performance along with hybrids of the same age.

Crosses between S1 genotypes and between S2 genotypes were taken up during 2000-01. The inbred crosses are being maintained in the nursery for taking up field planting in the coming season.

The seedlings produced from inbreds were found to be highly susceptible to VSD since many seedlings died in the nursery due to VSD. Inbreds also show forking of the stem. Another observation was that a high percentage of the inbreds showed forking of main stem. The number of stems produced by the inbreds also tended to increase with generation. In the S4 inbreds, main stem forked in to 3-4.

5. Establishment and maintenance of scion orchards I, II, III and IV

The first scion orchard was established in 1992, with 70 selected high yielding clones, for the supply of bud wood for further rapid multiplication.

The scion orchards II, III and IV were established during 1994 using plants budded with chupon buds. These were field planted at a closer spacing of 1.5 m x 1.5 m with fifteen most promising clones.

6. Release of high yielding clones

Seventy high yielding clones were identified from the germplasm collections so far and these were planted as a scion orchard and multiplied in large numbers for distribution. With the incidence of VSD in the cocoa growing tracts of Kerala, attention was diverted to disease tolerance. Seven high yielding clones were identified as tolerant to this disease. These were M 16.9, M 13.12, G I 5.9, G II 19.5, G IV 18.5, G VI 55 and G VI 56. The maximum pod yield so far obtained from these clones was 72.0, 90.7, 80.5, 93.5, 55.0, 180.3 and 94.8 respectively. These varieties were presented before the State Seed Sub Committee and were approved for release. They were designated as CCRP 1- 7.

4.2.2 CROP MANAGEMENT

i. Studies to determine the response of cocoa to shade and irrigation

This trial was planted under rubber trees in 1979 to assess the growth and yield of cocoa at

various shade levels. Shade manipulation was done by graded thinning of the rubber trees. The shade levels tried were 0, 25, 50 and 75 per cent. The trial was continued for ten years and the results indicated that there is increase in the growth of the plants and yield with increasing levels of illumination. More than five times increase in yield was observed in the open compared to the highest shade level tried. During 1988, the experimental plot was subdivided and one sub plot under each shade level was continued without irrigation and the other sub plot brought under sprinkler irrigation. Compared to intense shade level, the yield levels in the open were 2.4 times under irrigated conditions and 6.8 times when left non- irrigated.

This experiment was discontinued and replanted with CYT III. The plants in the de-shaded area, however are maintained for continued observations. There are many plants giving consistently very high pod yield over the last six years. The highest yielder of this group recorded a mean pod yield of 271.4/ tree /year with a range in pod yield of 187- 474 pods per tree per year. Twenty six plants in this trial consistently produced an average of more than 100 pods over the last six years.

ii. Trials on training and pruning of cocoa.

This experiment started in 1981 had a total of seven treatments with the first tier formed at 1.0 - 1.5 ; 1.5 - 2.0 m; and 2.0 - 2.5 m with one or two tiers of branches along with an unpruned control. The data on pod yield were collected up to ten years. In the early years, up to 1987-88, unpruned control recorded higher yield than all pruned plants. Since 1988-89, the treatment differences ceased to be statistically significant. However, in 1992-93 and 1993-94, one treatment receiving pruning (training the stem to a height of 1.5 - 2.0 m and having the second tier at 1.0 - 1.5 m) was the best treatment. The conclusions are that when properly done, pruning will not decrease yield of cocoa and that this operation may increase productivity as compared to unpruned control.

This trial was also discontinued in 1995 as sufficient data were already collected.

iii. NPK fertilizer experiment on budded plants.

This field experiment started in 1983 had a total of 27 treatment combinations of three levels each of N, P_2O_5 and K_2O. The design was partially confounded factorial RBD with three replications. Clonal material was used for the study in order to eliminate plant to plant variability.

As the results appeared to be vitiated by the overlapping root zones of experimental plants and by nutrient sharing through fallen leaves, the experiment was discontinued.

iv. Top working

This technique has been standardized to rejuvenate old and unproductive cocoa plants and also to convert genetically poor yielders to high yielders. Among the different treatment viz. cutting at jorquette height, cutting at ground level and cutting half way below jorquette height and snapping

back, better results were obtained under the third treatment. Cutting half way below the jorquette height induced a large number of chupons to develop from below this region due to breakage of apical dominance. Patch budding was done on three to four vigorous and healthy shoots using scions from high yielding, disease resistant clones and the rest were removed. The polythene tape was removed three weeks after budding and the stock portion above the bud union was snapped back. The snapped portion was removed after two hardened leaves develop from the bud. When sufficient shoots were hardened, the canopy of the mother tree could be completely removed. The continued connection of the root with the snapped canopy was found to be essential as this will ensure supply of photosynthates to the root system . Because of the presence of an established root system and the trunk with reserved food, the top worked trees grow much faster and give prolific yield one year after the operation. Though this can be done on all seasons, it is preferable to do it in rainfree period in irrigated gardens. For rainfed situations, it may preferably be done after the receipt of pre-monsoon showers.

Top working was done in three stages, the first stage being done to standardize the process in 1988. The second stage was completed in 1993 with fifteen rows of plants top worked. The third set of top worked trees (1994) include 522 plants of Germplasm I, II, III and IV. Fifteen high yielding clones were used for top working. To compare the performance of top worked clones, the trial was laid out in RBD with four replications and six plants per plot. The treatments were allotted randomly to the entire population so that this area may later serve as a polyclonal seed garden. Any desired plant of this germplasm can also be resumed to grow at any time since the main stem part of the stock plant is retained in the process of top working.

The top worked trees started yielding heavily from the second year onwards. About 50 per cent improved yield was obtained in the second year and about 100 per cent increase in the third year. Loss of crop for one year during the operation is compensated by bumper crops in the subsequent years. The main stem will continue to belong to the older plant and the fruits borne in this area belong to the poor yielder. Better yields are however obtained from the fan branches of the high yielding clone used for top working.

4.23. CROP PROTECTION

i. Survey of cocoa diseases in Kerala

This survey was aimed at finding out the occurrence of different diseases of cocoa in various cocoa growing tracts of Kerala. Survey was conducted in major cocoa growing tracts of Kerala. During the survey, a number of diseases were found to occur in cocoa with varying intensities. The diseases noticed are given below:

Sl. No	Name of disease	Causal organism	Occurrence
1	Vascular streak die back	*Oncobasidium theobromae*	Throughout the state
2	Phytophthora pod rot	*Phytophthora palmivora*	Throughout the state
3	Colletotrichum pod rot	*Colletotrichum gloeosporioides*	Throughout the state
4	Seedling blight	*Phytophthora palmivora*	Only in nurseries
5	Phytophthora canker	*Phytophthora palmivora*	Old gardens
6	Pink disease	*Corticium salmonicolor*	Old Gardens
7	White thread blight	*Marasmiellus scandens*	Stray occurrence throughout Kerala
8	Horse hair blight	*Marasmius equicrinis*	Neglected old gardens
9	Leaf blight	*Colletotrichum gloeosporioides*	Throughout the state
10	Chupon blight and twig die back	*Phytophthora palmivora*	Throughout the state
11	Lasiodiploidia pod rot	*Lasiodiploidia theobromae*	Stray occurrence
12	Zinc deficiency	Zinc deficiency	Stray occurrence
13	Phanerogamic parasite		Stray occurrence
14	Cylindrocladium leaf blight	*Cylindrocladium illicicola*	CCRP Farm
15	Grey leaf blight	*Phyllosticta* sp	CCRP Farm

Among the above diseases, Vascular streak die back (VSD), *Phytophthora* pod rot, *Colletotrichum* pod rot, *Colletotrichum* leaf blight, chupon blight and twig die back were found prevalent in cocoa gardens throughout the state with varying intensities. Among them VSD, has now become a serious disease of cocoa throughout Kerala. This disease affects, both seedlings and grown up plants.

During the study, the occurrence of new diseases like Horse hair blight, *Cylindrocladium* leaf blight and *Phyllosticta* leaf blight were recorded for the first time in the country.

Detailed investigations on the symptomatology of important diseases were carried out. Some variations in symptom expression from what has been described elsewhere for the diseases like VSD, *Phytophthora* pod rot and seedling blight were noticed. During the survey, bud wood from high yielding VSD tolerant plants was collected and the plants derived from these were maintained in the

germplasm collection.

ii. Studies on Vascular Streak Die back (VSD)

Oncobasidium theobromae, the causal agent of VSD, is a highly specialized near obligate pathogen. It is the only known wind - borne leaf penetrating basidiomycete vascular pathogen. Occurrence of this disease was first noticed in the early 1980s from Kottayam district. Now the disease has spread in all the cocoa growing tracts of Kerala. The symptomatology of the disease was studied in detail. Seedlings and budded plants maintained in the nursery of the Project showed severe incidence of the disease (Plate 13). This disease could be identified by its characteristic symptoms like yellowing of leaves with green islets (Plate 14), defoliation, lenticel enlargement, axillary bud proliferation, formation of sporophores on fallen leaf scars etc. However, some variations in symptom expression from that already described from elsewhere were also noticed during the study.

The variations in symptom expression noticed were

1. The first diagnostic symptom in seedling was the necrosis of the stipules of the terminal bud without any other symptom.
2. The leaves arising out of such buds will be smaller and chlorotic.
3. In the infected seedling, the area adjacent to the midrib and veins remained green while other portions were yellow.
4. On mature leaves of seedlings / twigs first symptom was the development of pale green colour of the leaf lamina with intermingled normal green areas starting from the proximal end of the leaves.
5. Leaves with such initial symptoms could be seen either on the middle or tip of the twigs.
6. Sometimes only proximal end of the infected leaves showed yellowing with green islets and the distal end remained green.
7. The leaves with the disease symptom did not usually fall off; but remained attached to the twigs with yellow region turning to dark brown and green islets remaining as such.
8. Severe marginal necrosis of the leaves of the infected twig, resembling potassium deficiency was also observed.
9. Lenticel enlargement was not always observed as the usual early symptom.
10. In mild infection, the growth of twigs and axillary buds was noticed; but with marked reduction in the internodal length and leaf size.
11. Chlorosis of entire leaves of infected small twigs.

Standardisation of isolation technique of VSD pathogen

The study was aimed at selection of the best suited medium for isolation of *Oncobasidium theobromae* and also to find out the plant part to be used for getting maximum success in isolation. Of the eleven different media tried, maximum percentage of success of isolation was obtained with Corticium culture medium, closely followed by water - agar and potato - dextrose - agar. Among the different plant parts used for isolation, the maximum success was obtained when infected midrib of leaves and tender stem were used.

Morphological characters of the pathogen

The morphological characters of the isolated VSD pathogen as well as that occurring in the sporophores of the natural infections were studied. The fungus produced slightly yellowish or whitish fluffy aerial mycelia on Corticium culture medium and potato - dextrose - agar medium. But on water - agar, it produced sparse mycelium. The mycelium was branched, hyaline and septate. Hyphal cells measured 3-6 µm in breadth and 36-186 µm in length. Some hyphae differentiated into swollen monilioid cells of 6-9 µm breadth and 24-48 µm length. No basidiospore formation was noticed in culture. Monilioid hyphae found in the sporophores of the leaf scars of infected plants were comparatively larger than that seen in culture and measured 6-12 µm in breadth and 30-120 µm in length. The basidia measured 3-6 µm in basal width and 7-10 µm in apical width with straight or curved sterigmata. Basidiospores were hyaline and ellipsoid with one side flattened.

Histopathological studies

Comparison of anatomy of infected and healthy stem of cocoa revealed noticeable difference. Longitudinal cross sections of infected stems revealed the presence of fungal hyphae in many of the xylem vessels. Xylem vessels were found to be clogged and the cells and tissues adjacent to the infection were deeply stained. The secondary xylem were found to be disorganized and were damaged.

Transmission of VSD through grafting and budding

Two types of grafting and five types of budding were carried out to know whether VSD is transmitted by these methods. VSD infected twigs were used as scion and bud wood. Six month- old seedlings served as a root stocks. There was no establishment of grafts or buds. However, vascular streaking was observed in root stocks grafted or budded by different methods indicating transmission of the disease.

Chemical control of VSD

a. Effect of fungicides

This experiment was conducted in a farmer's plot to locate an effective fungicide to check the

severity of the disease. The experiment consisted of six treatments with three systemic and two contact fungicides. The treatments were given at monthly intervals, starting from the onset of monsoon and observations of the disease intensity were taken. The results indicated that none of the fungicides were effective in checking the severity of VSD.

b. Effect of fungicides in preventing the incidence of VSD in cocoa seedlings

In this study, the comparative efficacy of three systemic and two contact fungicides was evaluated. The results indicated that spraying Calixin (0.1%) is effective in reducing the severity of the disease in seedlings.

iii. Screening of cocoa types for resistance to VSD

Screening of cocoa types in seed gardens

This study was conducted to know whether any of the promising cocoa types planted in the seed gardens in the farmers' field at Vazhithala, Muttom and Kalaketty possesses any resistance against VSD. The reaction of cocoa types to VSD was assessed on a 0-9 scale based on the percentage of twigs infected. The results of the study indicated that all the cocoa types were infected by the disease with varying intensities. Cocoa types G VI 55, G VI 54, M 13.12, and G IV 18.5 recorded comparatively minimum disease score. Maximum disease score was observed in types G I 15.5 , G I 10.3 and G I 4.8

Incidence of VSD in Germplasm VI

The incidence and severity of VSD in Germplasm VI of the project were periodically recorded. The study indicated that about 36 clones did not take up infection while others showed varying percentages of disease incidence and severity.

Similarly the observations on the incidence of VSD in CYT I and CYT II of parental clones revealed varying percentages of incidence and severity.

Reaction of cocoa hybrids to VSD

Cocoa hybrids derived from promising and high yielding VSD tolerant clones were evaluated for their resistance to VSD. The hybrids were kept in rows in a net house provided with mist. Sufficient inoculum was provided by placing infected cocoa seedlings all around the hybrid seedlings. The results of the study obtained so far indicated that all the hybrids showed varying percentages of disease incidence and some of the hybrids were comparatively tolerant to the disease. The hybrids which did not show the symptoms of VSD were field planted for assessing their yield potential as well as VSD resistance.

iv. Studies on seedling blight of cocoa

Detailed investigations on the symptomatology, etiology and management of seedling blight of cocoa were conducted. The causal agent of this disease was identified as *Phytophthora palmivora*. It causes various symptoms on leaf and stem (Plate 15). Budded plants were more prone to the disease. Results on screening of budded plants of 62 high yielding cocoa plants against the pathogen revealed that all cocoa types except two took up infection with varying intensities. Four experiments on the chemical control of seedling blight were carried out. The result indicated that the fungicides like Foltaf, Acomin, Fytolan and Bordeaux Mixture were effective in checking the incidence.

v. Sensitivity of isolates of *Phytophthora palmivora* and *Marasmiellus scandens* to fungicides

This study was conducted to select a suitable fungicide against four isolates of *Phytophthora palmivora* causing pod rot, seedling blight, seedling canker and twig blight of cocoa and an isolate of *Marasmiellus scandens*. Bordeaux Mixture, Fytolan, Acomin and Contaf were very effective against all isolates of *P. palmivora* while Bordeaux Mixture and Fytolan were effective against *Marasmiellus scandens*.

vi. Screening of cocoa types against resistance to *Phytophthora* pod rot disease

The symptom of the disease is given in Plate 16. Reaction of 69 cocoa types maintained in scion orchard and 166 cocoa types maintained in germplasm VI were evaluated for resistance to pod rot. For screening, detached pods of same age of maturity were artificially inoculated with mycelial disc of *P. palmivora* and were incubated at room temperature in polybags with sufficient humidity. The percentage pod area infected were calculated for assessing the reaction of the cocoa types. Studies revealed that none of the cocoa types were immune to the disease. All the cocoa types showed varying degrees of disease incidence, with five types recording moderately resistant reaction.

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4.2.5 List of theses Completed utilizing facilities developed at the CCRP

Ph.D

1.Standardisation of *in vitro* techniques for rooting, hardening and micrografting in cocoa (*Theobroma cacao.* L)- Bindu, M.R.- 1997

2. Genetic analysis of certain clones, hybrids and inbreds in cocoa- Rose Mary Francis - 1998.

3. Effect of weather on cocoa and improvement of bean size through seasonal crop orientation.- Prameela, K.P - 1997

Masters Degree

1. Organic recycling through cocoa litter- Sreekala- 1997
2. Soil nutrient dynamics in cocoa- Smitha, K.B- 1995
3. Growth and yield analysis of top worked cocoa plants.- Nimmy Jose- 1996
4. Root level interaction in coconut - cocoa system- Vandana Venugopal – 1996
5. Nitrate Reductase Activity in cocoa – Rekha Bhaskar- 1991
6. Weed management in cocoa nursery- Shylaja – 2001
7. 1. Plantlet regeneration through somatic embryogenesis in cocoa (*Theobroma cacao.* L)- Jiji Joseph- 1994
8. Genetic analysis of yield attributes in cocoa (*Theobroma cacao* L.)- Homey Cherian- 1993
9. Anther culture in cocoa (*Theobroma cacao.* L)- Sunil, K.P. 1992
10. Somatic embryogenesis in cocoa- Jolly Antony- 1993
11. Standardisation of selection criteria for cocoa hybrids- Raji Varghese- 1999
12. Estimation of genetic parameters from specific crosses of cocoa (*Theobroma cacao* L.) – 1999
13. Vascular streak dieback of cocoa and its management- Yogi Ajaykumar- 1996
14. Infestation reactions and management of *Helopeltis theivora* in cocoa clones- Beena Nair- 1998
15. Optimum size of plots in cocoa (*Theobroma cacao* L.) - a multivariate case- Sheela, M.A- 1987
16. Optimum stratification for yield estimation in cocoa (*Theobroma cacao* L.) - Sunil Kumar –2000
17. Standardization and acceptability of dairy products with cocoa mass – Sunitha Nair 2001

4.2.6 PRODUCTION AND DISTRIBUTION OF PLANTING MATERIALS

Under the central sector scheme on cocoa financed by the Directorate of Cashew and cocoa development, budded plants of cocoa were produced and distributed through the department of Agriculture, Kerala, Karnataka and Tamil Nadu. Hybrid pods collected from poly clonal and biclonal

seed gardens were distributed to Cadbury India limited and farmers. The details of distribution from 1994-95 are furnished below.

Year	Hybrid pods	Hybrid seedlings	Budded plants
1994-95	1,485	1,315	26,682
1995-96	16,209	2,320	41,925
1996-97	23,347	1,095	56,140
1997-98	24,700	-	75,226
1998-99	23,481	264	88,931
1999-00	37,161	506	1,03,865
2000-01	33,426	915	63,248
2001-02	23, 640	350	15,211
TOTAL	1,83,449	6,765	4,71,228

4.2.7. INFRASTRUCTURE DEVELOPMENT

The total area under experimental cocoa at present is 12 ha. The experimental area was brought under sprinkler irrigation. One electric pumpset (25 hp) was procured under the Central Sector Scheme on cocoa. About 24 shade houses for production of one lakh budded plants/ year were established utilizing the funds from the Directorate of Cashewnut & Cocoa Development, Kochi. A quarantine house was constructed during the second term. Two poly clonal and one biclonal seed gardens have been established which can produce 10 lakh hybrid seeds per year. The Jeep was purchased during the first phase of the programme.

The facilities developed by the project is being utilized for imparting practicals to both UG and PG students of the college. Seventeen M.Sc and three Ph. D students have completed their research programmes utilizing the facilities available at CCRP.

Most of the important visitors to the University were taken to the farm and they were much impressed by the progress of work of the project. Training programmes on breeding, management and crop protection in cocoa are being conducted regularly.

4.2.8. MAN POWER

Sl. No.	Post	Name of incumbent	Date of joining	Date of leaving
a. Scientists				
1	Professor (Agronomy)	Dr.R. Vikraman Nair	01-04-1987	25-2-99
		Dr. C.George Thomas*	16.11.99	Continuing
2.	Associate Professor (Pl. Breed.)	Dr. (Mrs) V.K. Mallika	17-06-87	Continuing
3.	Associate Professor (Hort.)	Dr. S.Prasannakumari Amma	25-02-99	Continuing
4.	Associate Professor (Pl.Path.)	Dr. Koshy Abraham	up to 30.9.2001	
b. Technical staff				
1.	Farm Supervisor (Hr. Grade)	Mr. C.B.Sugathan	06-06-98	Continuing
2.	Farm Assistant (Sr. Grade)	Mrs. R. Jayanthi	13-05-96	Continuing
3	Driver	Mr. K.S.Jayen	1.7. 2001	Continuing
c. Adminstrative & Supporting staff				
1.	Assistant	Smt K.K.Valasa	1.6.2001	Continuing
		Mr.A. Reghu	29-05-99	Continuing

* Associate Professor working against the post

4.2.9 DETAILS OF EXPENDITURE AND RECEIPTS DURING THE SECOND TERM

Source	1st year (1997-98)	2nd year (1998-99)	3rd year (1999-00)	4th year (2000-01)	5th year (2001-02)	Total
Share of Cadbury India Ltd.	8.00	10.00	11.00	12.00	13.00	54.00
Share of KAU	8.00	8.50	9.00	9.50	10.00	45.00
Internal receipt	2.00	2.00	2.00	2.00	2.00	10.00
Total	18.00	20.50	22.50	23.50	25.00	109.00
Actual expenditure	18.51	19.30	25.40	43.73	27.70*	134.64 *
Actual receipts	2.53	3.94	5.53	3.76	6.5*	22.26*

* Up to 31.1.2002

5. PROPOSAL FOR EXTENSION TO THE THIRD TERM

5.1 BACKGROUND

The Cadbury - KAU Co-operative Cocoa Research Project (CCRP) was started with effect from April 1987. The project was sanctioned initially for a period of ten years. On successful completion of the project with substantial improvement in infrastructure and technical know how on cocoa, the project was extended for a further term of five years. The project is to terminate on 31.3.2002. The major areas where the project could make a breakthrough and the need for continued financial support from the collaborators are furnished below:

1. Systematic introduction of germplasm material from the Quarantine Station of University of Reading is in progress and a minimum of two consignments of clones are received through the National Bureau of Plant Genetic Resources. This introduction is very important in the case of cocoa which is a newly introduced crop and in which variability in the country is very limited. This part of the programme is being supported by M/s Cadbury, U K also. The centre has assembled 515 valuable types in the germplasm collection, which is rated as the largest in the country. This work has to continue.

2. Breeding programme at Kerala Agricultural University is one of the strongest in the world and the approximate number of experimental hand pollinations made every year is about 10,000. Thousands of hybrids were so far produced out of which many have been carried forward to the stage of field planting as four progeny trials. In the early years, yield improvement was the only breeding objective. But since 1996, tolerance to VSD was added as yet another objective. These breeding programmes are to be continued utilising the variability introduced through the germplasm collections.

3. A long range programme of inbreeding was started since 1988 and it has progressed upto S4. This unit of KAU is perhaps the only unit in the world which has taken up the programme and this work is to be continued.

4. Systematic work on screening of clones and hybrids for VSD tolerance has been taken up since 1996 and results from this work will have far reaching consequences in controlling the damage due to this disease. This disease is reported to have done substantial damage in countries like Malaysia and Papua New Guinea. But the extent of damage in India is comparatively low because of the reasonable variability available in the cocoa population of the country. The studies could help to identify certain crosses as superior in producing tolerant hybrids. Among the parents identified as better for transferring resistance to the progeny, SCA-6 is characterised by small bean size, which is also heritable. Hence this could

not be directly utilised for seed production. The other parents could be multiplied clonally and raised in a biclonal seed garden for direct production of resistant hybrids. The study indicated that tolerance to VSD is heritable and the degree of tolerance varied from hybrid to hybrid. There is scope for production of large number of resistant seedlings by selection of parents and using them for hybridization.

From this trial, about 1500 VSD tolerant hybrids were field planted starting from 1998 and these have just started yielding. Such a huge collection of VSD tolerant hybrids is not available elsewhere. The evaluation and maintenance of these hybrids and their improvement of pod and bean characters through further back crosses is highly essential since most of the hybrids have SCA 6 as one of the parents.

This part of the work on identification of clones resistant to this disease and evolution of hybrids combining disease tolerance and yielding ability is proposed to be continued.

5. Assessment of performance thousands of hybrids in the field which are at different stages of growth is to be done. Many hybrids are yet to attain steady yield. The observations are to be continued and the data are to be analysed statistically. There are a number of elite hybrids in different trials, which are to be systematically evaluated for yield and other desirable traits.

6. The poly and biclonal gardens established under the project are much valuable and their maintenance seem to be very essential to meet the demands of hybrid pods in the coming years.

7. The maintenance of scion orchards will be highly useful for supply of bud wood to the growers

8. The observations are to be continued in plants under different management trials and top working as these have not given confirmative results.

Hence, the present project is to be continued with the same manpower and infrastructure.

5.2 TECHNICAL PROGRAMME PROPOSED

1. Germplasm collection, evaluation and maintenance: The germplasm will be enriched through

introduction from other cocoa growing countries. These clones will be evaluated for yield, pod and bean characters and resistance to diseases especially Vascular Streak Die back and pod rot. The selected clones will be included in the breeding programme.

2. Hand pollination, screening hybrids for disease resistance, field planting of tolerant hybrids and their evaluation
3. Continuing individual plant observations on yield and other desirable traits in CYT I, II, III, IV; Progeny Trials PI, II, III, & IV ; Series Hybrids SI,SII,SIII and SIV and VSD trial.
4. Attempting back cross breeding in VSD tolerant hybrids with poor bean size
5. Maintenance of scion orchards and supply of bud wood to the growers
6. Maintenance of poly and biclonal seed gardens, production and distribution of hybrid pods
7. Continuing individual plant observations in Top Working trial and
8. Estimation of genetic parameters in different hybrids

5.3 ADDITIONAL INFRASTRUCTURE REQUIRED

The farm house maintained by the unit, needs remodelling for which a lumpsum provision of Rs 0.5 lakhs is proposed. The power tiller of the project is very old necessitating repair at very frequent intervals. Hence provision has been made for the purchase of a new one.

5.4 PERIOD OF COLLABORATION

The proposed period of collaboration is five years.

5.5 SUGGESTED COLLABORATORS

The research programme was funded by Cadbury India Ltd. The funding was total during the first six years and limited to Rs. 6 lakhs for the next four years. The share of the collaborators during the second term was Rs. 55 lakhs. It is suggested that there may be 50% funding by the collaborators during the third phase as per the budget enclosed.

5.6 MONITORING & EVALUATION

These are at present being done by officials of collaborators, M/s Cadbury India Ltd. and the technical committee constituted for the purpose by the University.

Attn: Dr. Kumaran, Director of Research

കേന്ദ്ര ഗവൺമെന്റ് പ്രഖ്യാപിച്ച നാളികേര ടെക്നോളജി മിഷന്റെ ഭാഗമായി ഗവേഷണ പദ്ധതികൾ ഏറ്റെടുത്തു നടപ്പാക്കി കർഷകർക്ക് പ്രയോജനപ്രദമായ നേട്ടങ്ങൾ പ്രചരിപ്പിക്കും.

കുട്ടനാട് പ്രദേശത്തെ നെൽകൃഷിയും മത്സ്യം വളർത്തലും സംയുക്തമായി ഏറ്റെടുക്കാനാവശ്യമായ ഗവേഷണത്തിന്റെ പ്രചാരത്തിനും ഊന്നൽ നല്കും. ചേലവ് കുറഞ്ഞ കളനിയന്ത്രണരീതികൾ ഉരുത്തിരിച്ചെടുക്കാനുള്ള ഗവേഷണം ത്വരിതപ്പെടുത്തും.

കിഴങ്ങുവർഗ്ഗങ്ങൾ ഉയർന്ന വിളവും, ഊർജവും വരുമാനവും പ്രദാനം ചെയ്യുന്ന വിളകളായതിനാൽ, കിഴങ്ങുവർഗ്ഗവിളകളെ നമ്മുടെ ആഹാരരീതിയിലേക്ക് വർധിച്ച പ്രാധാന്യത്തോടെ തിരിച്ചുകൊണ്ടുവരുന്നതിനാവശ്യമായ ഗവേഷണത്തിനും, നടീൽ വസ്തുക്കളുടെ ലഭ്യത വർധിപ്പിക്കുന്നതിനുമുള്ള തീവ്രമായ ശ്രമം നടത്തും.

സംയോജിത കീടനിയന്ത്രണരീതി അവലംബിച്ചാൽ മാത്രമേ സുസ്ഥിരകൃഷിരീതി വിജയത്തിലെത്തിക്കുവാൻ സാധിക്കുകയുള്ളൂ. ഇതിനാവശ്യമായ ഗവേഷണ പ്രവർത്തനങ്ങൾ ത്വരിതപ്പെടുത്തും.

ജൈവകൃഷി സമ്പ്രദായത്തിന് ഇന്ന് പ്രചാരം ഏറിവരികയാണ്. ജൈവകൃഷി ഉല്പന്നങ്ങൾക്ക് കൃഷിരീതി വികസിപ്പിച്ചെടുക്കുന്നതിനും ജൈവകൃഷി ഉല്പന്നങ്ങളുടെ തനിമയും ഉന്നതനിലവാരം ഉറപ്പുവരുത്തുന്നതിനും മാനദണ്ഡങ്ങൾ നിശ്ചയിക്കുന്നതിനുമുള്ള ഗവേഷണത്തിന് പ്രാധാന്യം കൊടുക്കും.

ഐ.ടി. മേഖലയിലെ നേട്ടങ്ങൾ ഉപയോഗപ്പെടുത്തി കാർഷിക ഗവേഷണ കേന്ദ്രങ്ങളെ തമ്മിൽ ബന്ധിപ്പിക്കുകയും അവയുടെ ഗവേഷണ നേട്ടങ്ങൾ എളുപ്പം കർഷകരിലെത്തത്തക്കവിധത്തിൽ സജ്ജീകരണങ്ങൾ ഏർപ്പെടുത്തും.

കാർഷിക വൃത്തിയിൽ സ്ത്രീ പങ്കാളിത്തം വർധിപ്പിക്കുന്നതിനും, കാർഷിക മേഖലയിൽ പ്രവർത്തിക്കുന്ന സ്ത്രീകളുടെ അധ്വാനഭാരം ലഘൂകരിക്കുന്നതിനും, കാര്യക്ഷമത വർധിപ്പിക്കുന്നതിനും ഉതകുന്ന ഗവേഷണ പരിപാടിക്ക് മുൻഗണന നല്കും.

കേരളത്തിലെ കാർഷിക മേഖലയിൽ ലോകവ്യാപാര ഉടമ്പടിയുടെ ഭാഗമായി പരിഷ്കാരങ്ങൾ ഉണ്ടാക്കാനിടയുള്ള പ്രത്യാഘാതങ്ങളെക്കുറിച്ച് പഠിക്കുന്ന ഡബ്ലിയു.ടി.ഒ. കമന്റീഷനുമായി സർവകലാശാല സഹകരിച്ച് പ്രവർത്തിച്ചു വരുന്നു. തുണിവേഴ്സിറ്റിയിൽ നടപ്പു സാമ്പത്തിക വർഷം തുടങ്ങിയ ഡബ്ലിയു.ടി.ഒ. സെൽ ശക്തിപ്പെടുത്തുവാനും ബൌദ്ധികസ്വത്തവകാശം, പേറ്റന്റ് റൈറ്റ് തുടങ്ങിയ മേഖലകൾ ഉൾപ്പെടുത്തി വിപുലീകരിക്കാനും നിർദ്ദേശിക്കുന്നു. വിദ്യാർത്ഥികൾക്കും ഗവേഷകർക്കും ഇക്കാര്യത്തിൽ ആവശ്യമായ സഹായവും നിർദ്ദേശവും നൽകാൻ പര്യാപ്തമായ രീതിയിൽ ഈ സെല്ലിന്റെ പ്രവർത്തനം വിപുലീകരിക്കുന്നതാണ്.

ജൈവസാങ്കേതികവിദ്യ കർഷകമേഖലയിൽ വിപ്ലവകരമായ മാറ്റം ഉണ്ടാക്കാൻ ശക്തമായ ഒരു നേട്ടമായി ഇതിനകം അംഗീകരിക്കപ്പെട്ടിട്ടുണ്ട്. കാർഷിക സർവകലാശാലയിലും ജൈവസാങ്കേതികവിദ്യ അടിസ്ഥാനമാക്കിയുള്ള അനേകം ഗവേഷണ പദ്ധതികൾ ഇപ്പോൾ തന്നെ നടന്നുവരുന്നുണ്ട്. ഇവ വർദ്ധിച്ച പ്രാധാന്യത്തോടെ തുടർന്നും ഏറ്റെടുത്തു നടത്തുന്നതാണ്.

പഴങ്ങൾ, പച്ചക്കറികൾ, പൂവ്വച്ചച്ചെടികൾ എന്നിവയുടെ വാണിജ്യ-പരമായ പ്രാധാന്യം നാൾക്കുനാൾ ഏറിവരികയാണ്. ഈ വിളകളുടെ കൃഷി, ചെറുകിടക്കാർക്കും ലാഭകരമായി ഏറ്റെടുക്കാൻ ആവശ്യമായ ഗവേഷണ പദ്ധതികൾ നടപ്പിലാക്കും.

കശുവണ്ടി, സുഗന്ധദ്രവ്യവിളകൾ എന്നിവ നമ്മുടെ വിദേശനാണ്യവിളകളും ആണല്ലൊ. പ്രധാനമായും കയറ്റുമതി ലാക്കാക്കി കൃഷി ചെയ്യുന്ന ഈ വിളകളിൽ അന്താരാഷ്ട്രനിലവാരത്തിലുള്ള ഗുണമേന്മാഘടകങ്ങളാണ് നിഷ്കർഷിച്ചിട്ടുള്ളത്. ഇതിന് ഉതകുന്ന തരത്തിലുള്ള ഉല്പാദനം സാധ്യമാക്കുന്നതിന്റെ ഗവേഷണം ഊർജിതപ്പെടുത്തും.

ചെലവ് കുറച്ചുകൊണ്ട് ഉല്പാദനവും വരുമാനവും വർധിപ്പിക്കുക എന്നതായിരിക്കും പൊതുവിൽ കാർഷിക സർവകലാശാലയുടെ ഗവേഷണ സമീപനം. നമ്മുടെ കാർഷികോല്പന്നങ്ങൾക്ക് കംപോളിത്തിൽ മത്സരക്ഷമത കൈവരണമെങ്കിൽ ഈ തത്വം പ്രയോഗത്തിൽ വരുത്തിയേ പറ്റൂ. ഉല്പന്നങ്ങളാക്കുന്നതിന്റെയും വിപണനത്തിന്റെയും അതുവഴി പുതിയ തൊഴിലവസരങ്ങൾ സൃഷ്ടിക്കുകയും ചെയ്യുന്ന ഗവേഷണ പദ്ധതികൾക്ക് വരും വർഷത്തിൽ കൂടുതൽ പ്രോൽസാഹനം നല്കും.

ശാസ്ത്രീയ ഔഷധസസ്യ ഗവേഷണം കാർഷിക സർവകലാശാലയിൽ നടന്നുവരുന്നുണ്ട്. ഔഷധവ്യവസായ മേഖലയുടെയും, ചെറുകിട കർഷകരുടെയും നന്മക്ക് ഉതകുന്ന വിധത്തിൽ ഈ ഗവേഷണ മേഖലയെ ശക്തിപ്പെടുത്താൻ സർവകലാശാല ഉദ്ദേശിക്കുന്നുണ്ട്.

വെറ്ററിനറി കോളേജും, അതുമായി ബന്ധപ്പെട്ട കേന്ദ്രങ്ങളുടെ വികസനത്തിനും, മൃഗസംരക്ഷണമേഖലയിലെ ഗവേഷണ പ്രവർത്തനങ്ങൾക്ക് കൂടുതൽ ഊന്നൽ നല്കുവാൻ കാർഷിക സർവകലാശാല ശ്രദ്ധ ചെലുത്തുന്നതാണ്. കന്നുകാലി-സംരക്ഷണവും, പ്രജനനവും, ഉല്പാദനവുമായി ബന്ധപ്പെട്ട ഗവേഷണങ്ങൾവഴി ചെലവ് കുറഞ്ഞ രീതിയിലുള്ള വളർത്തുമൃഗ പരിപാലനമുറകൾ വികസിപ്പിച്ചെടുക്കുന്നതിന് ക്ഷീരമേഖലയിലെ സാംപത്തിക പ്രതിസന്ധി തരണം ചെയ്യുന്നതിനാവശ്യമായ ഗവേഷണങ്ങൾ തുടരുന്നതാണ്. ആട്, പന്നി മുതലായവയുടെ കൃഷി ലാഭകരമായി നടത്തുന്നതിനും അധിക വരുമാനം കർഷകർക്ക് ലഭിക്കുന്നതിനും ആവശ്യമായ ഗവേഷണങ്ങൾ ഏറ്റെടുക്കുന്നതാണ്.

അത്യുൽപാദനശേഷിയുള്ളതും കേരളത്തിലെ കാലാവസ്ഥക്ക് യോജിച്ചതുമായ കോഴി, താറാവ്, കാട എന്നിവയുടെ വികസനത്തിനും പ്രത്യേക ഊന്നൽ നല്കുന്നതാണ്.

മത്സ്യകൃഷി മേഖലയുടെയും, അലങ്കാര മത്സ്യകൃഷിയുടെയും സമഗ്രമായ വികസനത്തിന് സഹായകമാകുന്ന ഗവേഷണ പദ്ധതികൾ പ്രോൽസാഹിപ്പിക്കുകയും ചെയ്യും. സംസ്ഥാന ഗവൺമെൻറ് ഈയിടെ പ്രഖ്യാപിച്ച ഫിഷറീസ് നയത്തിൻെറ ഭാഗമായ ഗവേഷണ പദ്ധതികൾക്ക് സർവകലാശാല പ്രത്യേക പ്രാധാന്യം നല്കും.

സംസ്കരിച്ച മത്സ്യ-മാംസ ഉല്പന്നങ്ങളും ഗുണനിലവാരവും വൈവിധ്യവർക്കരണവുമായി ബന്ധപ്പെട്ട ഗവേഷണ പദ്ധതികൾ സർവകലാശാല നടപ്പുവർഷത്തിൽ ഏറ്റെടുക്കുന്നതാണ്.

ഐ.സി.എ.ആർ. തുടങ്ങി വിവിധ ഏജൻസികളിൽനിന്നും ധനസഹായം ഉദ്ദേശിച്ച് താഴെ പറയുന്ന ഗവേഷണപദ്ധതികൾ പുതുതായി അനുവദിക്കുവാൻ ഉദ്ദേശിക്കുന്നു.

1. All India Co-ordinated Research Project on Post Harvest Technology of Horticultural Crops - Vellanikkara.
2. Centre for Research on Laterite Soils - Pilicode.
3. Agribusiness Consultancy Consortium - Directorate of Research.
4. Elephant Study Centre, Mannuthy.

ഇതിനുപുറമെ സംസ്ഥാന ഗവൺമെൻറ് ധനസഹായം ചെയ്യുന്ന വിവിധ ഗവേഷണ പദ്ധതികളും, ഐ.സി.എ.ആർ./എൻ.എ.ടി.പി. പദ്ധതിയുടെ കീഴിൽ 40 ഗവേഷണ പദ്ധതികളും പുതുതായി അംഗീകരിക്കപ്പെട്ടിട്ടുണ്ട്.

സർവകലാശാലയുടെ വിവിധ ഗവേഷണ കേന്ദ്രങ്ങളുടെയും, കാംപസുകളുടെയും ഉയർന്ന ഉല്പാദനക്ഷമത നേടിയെടുക്കുന്നതിന് ഉതകുന്ന പദ്ധതികൾ പ്രത്യേകം ഏറ്റെടുത്ത് നടപ്പാക്കുന്നതാണ്. ഇതോടൊപ്പം,

Intensive Integrated, irrigated precision farming.

Protected cultivation, Peri-urban Commercial Horticulture.

എന്നീ നവീനങ്ങളായ ഗവേഷണ മേഖലയിൽ സർവകലാശാല പദ്ധതികൾക്ക് രൂപം കൊടുക്കുന്നതാണ്.

ബാഹ്യഏജൻസികൾക്ക ഗവേഷണ പദ്ധതികൾ സമർപ്പിച്ച് അനുമതി നേടി, ഗവേഷണ പദ്ധതികൾ ഒട്ടുമിക്കതും ബാഹ്യ ഏജൻസികളുടെ സഹായത്തോടെ ഏറ്റെടുത്തു നടത്തുന്ന സാഹചര്യം സൃഷ്ടിക്കും. ഗവേഷണ പ്രൊജക്ടുകൾ എഴുതിത്തയ്യാറാക്കി സാംപത്തിക സഹായം നേടുന്ന ശാസ്ത്രജ്ഞർക്ക് പ്രോൽസാഹനം നല്കും.

കാർഷിക സർവകലാശാലാ ശാസ്ത്രജ്ഞൻമാരുടെ വൈദഗ്ധ്യം നേടുന്നതിന് വേണ്ടി കർഷകരിൽനിന്നും മറ് ഏജൻസികളിൽ നിന്നും ഉണ്ടാകുന്ന അഭ്യർത്ഥന വർധിച്ചുവരുന്നുണ്ടു. ഈ ആവശ്യത്തിന് വേഗത്തിൽ പരിഹാരം കണ്ടെത്താൻ അനുയോജ്യമായ ശാസ്ത്രജ്ഞനെ എളുപ്പത്തിൽ തെരഞ്ഞെടുക്കാൻ സഹായിക്കുന്ന വിധത്തിൽ കാർഷിക സർവകലാശാലാ ശാസ്ത്രജ്ഞരുടെ വൈദഗ്ധ്യം വിവരിക്കുന്ന ഒരു ഡയറക്ടറി പ്രസിദ്ധീകരിക്കുന്നതാണ്.

ഡയറക്ടർ ഓഫ് റിസർച്ച്

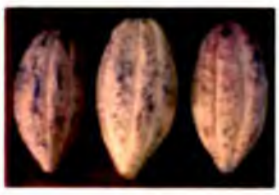
എഫ്.ബി.25.3.

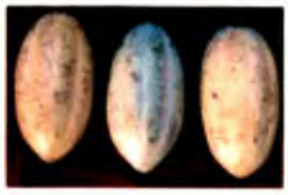
5.7 FINANCIAL STATEMENT

Sl. No	Category	Scale of pay	No. of posts	Period					Total
				I Yr. (2002-03)	II Yr. (2003-04)	III Yr. (2004-05)	IV Yr (2005-06).	V Yr .(2006-07)	
Salaries									
1	Professor(Pl. Breed.)	16400-22400	1	3.20	3.30	3.40	3.50	3.60	17.00
2	Assoc. Prof.(Hort. & Agron.)	12000-18300	2	5.10	5.30	5.50	5.70	5.90	27.50
3	Farm Supervisor Gr.I	7200-11400	1	1.31	1.32	1.33	1.34	1.35	6.65
4	Farm Assistant(Sel Gr.)	5800-9425	1	1.14	1.15	1.17	1.19	1.21	5.86
5	Assistant Sel. Gr	5800-9425	1	1.11	1.13	1.15	1.17	1.19	5.75
6	Asst. Gr.I	4600-7125	1	0.99	1.01	1.03	1.05	1.07	5.15
7	Driver	3350-5275	1	0.63	0.65	0.66	0.68	0.69	3.31
TOTAL(1)			**8**	**13.48**	**13.86**	**14.24**	**14.63**	**15.01**	**71.22**
Travel expenses (2)				**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.50**
Non-recurring contingencies									
Remodelling farm house				0.50					0.50
Power Tiller with trailer				1.00					1.00
Total(3)				**1.50**					**1.50**
Recurring contingencies									
Farm Operations				10.50	10.60	10.70	10.80	10.90	53.50
Research materials				1.00	1.20	1.40	1.60	1.80	7.00
Fuel charges and maintenance of vehicle, power tiller & Diesel pumpset				0.60	0.70	0.80	0.90	1.00	4.00
Miscellaneous expenditure				1.00	1.20	1.40	1.60	1.80	7.00
Total(4)				**13.10**	**13.70**	**14.30**	**14.90**	**15.50**	**71.50**
G. Total(1+2+3+4)				**28.18**	**27.66**	**28.64**	**29.63**	**30.61**	**144.72**
Receipts anticipated				**3.00**	**3.20**	**3.40**	**3.60**	**3.8**	**14.00**

ABSTRACT OF FINANCIAL ESTIMATE (Rs. in lakhs)

Source	1st year (2002-03)	2nd year (2003-04)	3rd year (2004-05)	4th year (2005-06)	5th year (2006-07)	Total
Salaries	13.48	13.86	14.24	14.63	15.01	71.22
TA	0.10	0.10	0.10	0.10	0.10	0.50
Recurring contingencies	1.50					1.50
Recurring contingencies	13.10	13.70	14.30	14.90	15.50	71.50
Total	**28.18**	**27.66**	**28.64**	**29.63**	**30.61**	**144.72**
Receipts anticipated	**3.00**	**3.20**	**3.40**	**3.60**	**3.8**	**14.00**





TREES AND PODS OF SOME
RELEASED CLONES

SOME HIGH YIELDING HYBRIDS

TWO SUPERIOR CLONES
UNDER EVALUATION

STEM FORKING IN S_4 INBREDS

BEAN PIGMENTATION IN INBREDS

SCREENING FOR RESISTANCE TO VSD








Seedling blight


Black pod


Top worked tree