Coconut Research, Development and Dissemination of Technologies - Growers Perception

A Diagnostic Survey Report

Coconut Research Institute
Lunuwila 61150
Sri Lanka

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CONTENTS

EXECUTIVE SUMMARY

The density of palms (including seedlings, non-bearing palms, weak palms etc) per acre varied from 90 in Galle region to 55 in Kalutara region with a mean of 67. Irrespective of region and extent of coconut lands, the mean density of bearing palms alone was 50 per acre and the mean age of bearing palms was 44 years. The mean age of bearing palms of 13% of coconut lands was over 60 years and that was represented by 7% of total extent.

The growers' awareness and practice of traditional technologies such as use of mulch on the manure circle and fertilizer use has improved from 1993 (the year of which last diagnostic survey was carried by the CRI) to 2005. There was no improvement in the awareness and practice of husk pits from 1993 to 2005. The awareness for new technologies recommended after 1993 such as fertilizer recommendation for different soil conditions and different agro-ecological zones, new size and method of husk pits (8'x4'x3' pits and between palms within coconut row), special fertilizer for king coconut, use of ethrel for toddy tapping, use of gliricidia as organic manure, land suitability classes (LSC) for coconut and differential fertilizer recommendation (DFR) was not in satisfactory level (<25%). More than 50% growers were aware of all control measures recommended (prior to 1993 and after 1993) for Black Beetle damage and Red Weevil damage, but the use of integrated pest management was very low (< 20%) for both pest damage except by large extent holders. The awareness of all kernel products was extremely low (< 5%) except 14% for virgin coconut oil and 9% for coconut paste.

The rate of awareness of all technologies significantly increased ($p<0.005$) linearly with the increase of land sizes. This could be either due to improper planning of technology transfer to small holders or large extent holders had more interest to acquire the knowledge than small holders. There was a considerable gap between the percentage of awareness and percentage of use of all technologies indicating that the technologies were not accepted by the growers or the growers were not convinced about benefits of technologies. The gap between awareness and practice is varied among Coconut Cultivation Board Regions (CCBRR). This could be due to the fact that the average number of coconut holdings to be served varied from 1978 in Polonnaruwa region to 6885 in Kegalle region with a mean of 4993. It is a very difficult task to serve all these growers individually by a Coconut Development Officer (CDO) and consequently all coconut growers can't meet the CDO even if the CDO works 240 days per year. It is suggested that CDOO to be given more intensives based on the number of growers in the CDO range and distance from the office of CDOO to estates. The offices of CDOO to be kept open during the working hours of the week. More publicity about the new kernel products is urgently needed and technologies on such products to be given to any entrepreneur.

Black Beetle damage (BBD) is a more serious problem in coconut cultivation than Red Weevil damage (RWD). No control measures were 100% effective for both BBD and RWD. Of the four control methods recommended for BBD, extraction of beetles using a hook was ranked the best followed by addition of naphthalene balls/carbofuran. Issuing a beetle hook along with seedling can make compulsory as a measure to popularize this technique and to reduce the BBD. Use of monocrotophos was ranked as the best control method for RWD by the growers. However, growers (irrespective of land size and CCBR) complained the difficulties to obtain monocrotophos. The use of traps and pheromone was ranked as less effective method for RWD by the growers. However, the use of traps and pheromone will be more effective and efficient if mass trapping system can be implemented in community level. It is recommended to conduct such programs at regular intervals in selected areas. An efficient method has to be implemented to obtain both

red weevil traps and pheromone whenever the need arises. A sustainable control method is urgently needed for control of coconut mite. The growers' awareness on other coconut pests such as coconut caterpillar, coconut scale and plesispa beetle was good, but their knowledge on the control measures was poor.

Majority of growers were unable to apply fertilizer at correct time due to change of climate and weather pattern. The lack of knowledge of the type of soil conditions, amount of fertilizer, method and time of application of fertilizer were some factors which reduce the efficiency of fertilizer use. Both scientists and extension officers have to play a major role to educate the growers on those aspects of fertilizer application. As DFR is a more economical system, it should be popularized among small holders as well. A simple systematic sampling method can be used for small holdings. The DFR program has to be improved by integrating LSC for coconut and past yield achieved to make it more location specific. There is a knowledge gap on various aspects on the effect of irrigation on coconut and no method has been recommended by the CRI, consequently coconut growers have lot of doubts.

Twenty five percent of under plantations were established before the old palms reached 35 years. The time taken to bear in seedlings was significantly higher in under plantations than those in re-plantations. Technology transfer system to be geared to motivate growers not to practice pre-mature under planting and to popularize re- planting. The mortality rate of seedlings significantly varied between CCBRR and the mean mortality was 15%. The three main reasons for casualties of seedling (irrespective of CCBRR) was no rain > black beetle damage > weak seedlings. Growers to be convinced to practice recommended technologies at the time of transplanting seedlings and to purchase seedlings from CCB, CRI or registered nurseries only.

Animal husbandry was practiced by 42% of the growers but only 26% had used it as Integrated Production System (that is use of residual of animal as a fertilizer). The stocking rates of cattles and goats (irrespective of land extent) were significantly higher than recommended stocking rates and it leads to land degradation. The common constraints for intercrops and animal husbandry were difficulty to maintain and lack of market for the products. The technology transfer service should be geared to popularize the concept of Integrated Production System (IPS) and identifying marketing channels to the growers.

There were various short comings in research, development and technical transfer activities. It is necessary to re-think and re-shape the direction of coconut research and development and technology transfer on coconut cultivation. More location specific technologies are required. High priory is to be given to implement coconut land/soil policy and thus most of technologies can be based on the land/soil policy. The present communication system between Technology Transfer Division (TTD) in CRI and CDOO in CCB is formal and vertical and so less effective. A direct linkage between TTD of CRI and Regional Managers of CCB has to be implemented ('horizontal communication system') to have a more efficient system of information dissemination.

Training programs conducted by CRI was popular mostly among the growers in the coconut triangle, but all growers interviewed were very enthusiastic to participate such programs. It is recommended to have such programs outside the coconut triangle and include more programs on pest and disease management and fertilizer application aspects.

Researchers in CRI and Extension Officers in CCB should work more collaboratively to motivate growers to use the recommended technologies

Chapter 1

INTRODUCTION

The Coconut Research Institute (CRI) of Sri Lanka used to deliver various recommendations to improve the coconut cultivation and coconut processing in Sri Lanka. The assessment of the efficiency of such recommendation is generally done using regular diagnostic surveys in addition to the normal field days with growers and extension officers. The CRI conducted the first such survey in 1987 (Ranatunga *et al*, 1988) only in the Puttlam district. In 1993 the second diagnostic survey was conducted in the districts of Gampaha, Kurunegala, Puttlam, Kalutara, Galle, Matara and Hambantota (Somasiri *et al*, 1993). In the second diagnostic survey, small holders whose coconut extent was less than two acres had not been considered.

The main recommendations from the second diagnostic survey were:

- Small holders do not adequately receive know-how in coconut cultivation.
- Many growers raise seedlings using seed nuts from their own lands but they were not aware of the method of selection of seed nuts.
- Growers complained that the recommended planting hole (2x2x2 & 3x3x3) is not practicable.
- Farmers were not aware of the benefits of poly-bagged seedlings.
- Use of organic fertilizer was very low (15%). They were not aware of the need of supplementation of organic manure with inorganic fertilizers.
- Use of mulch, husk pits, cover crops was very low. Main constraints for not using mulch, husk pits and cover crops were root formation due to continuous mulch, difficulty to establish and expensive respectively.
- Not having a long-term policy on subsidy so that growers will have an assured system which relied upon.

However, no diagnostic survey was carried out due since 1993 to find the growers response on various technologies although new technologies on cultural cultivations were introduced by the CRI during the last 12 years. In 1998 a new research division namely Coconut Processing Research Division (CPRD) was established by the CRI to develop technologies on various kernel products. Further, Extension Division of the CRI was reorganized and named as Technology Transfer Division (TTD). The TTD has been conducting series of one day training programs including field demonstrations on all aspects of coconut cultivation in order to enhance and improve the knowledge of the coconut growers.

Further, in spite of the all research and development and technology transfer activities on coconut cultivation, the annual national coconut production (ANCP) in Sri Lanka did not reach to the expected target of 3000 million nuts during 1993 to 2004 except in 2000 (3096 million nuts). During this period the mean ANCP was 2794 million nuts with a median of 2564 million nuts (Peiris *et al*, 2005).

Therefore, this survey was carried out from March to July, 2005 covering eleven Coconut Cultivation Board Regions (CCBRR): Anurahdapura, Galle, Gampaha, Hambantota, Kalutara, Kegalle, Kuliyapitiya, Kurunegala, Marawila, Monaragala and Ratnapura. Though it was planned to cover the CCBRR of Ampara and Jaffna, those areas were not conductive for a survey operation at that time. Unlike the previous survey in 1993, the small coconut holdings between 0.5- 2.0 ac were included in this survey.

The sampling method was two stage stratified probability sampling and the sample size was 545.

1.1 Objective

The specific objectives of the survey were:

- To identify the growers awareness on recommended technologies on coconut cultivation.
- To identify the growers awareness on kernel products of coconut.
- To identify the gap between awareness and practice of recommended technologies by the growers.
- To identify strategies of the coconut research and development.
- To identify the strategies of the technology transfer of coconut cultivation.
- To recommend some policies for the Ministry of Coconut Development.

Chapter 2

SURVEY METHODOLOGY AND DATA ANALYSIS

2.1 Survey Methodology

2.1.1 Sampling procedure

The sampling procedure was a two stage stratified probability random sample representative of the entire coconut growing main areas in the country excluding areas in Ampara and Jaffna. As most of the recommended cultural practices depend on the climatic condition, particularly rainfall distribution, the main ecological regions (AERR) in the main coconut growing areas were taken as the primary sampling units (PSU). The mean, maximum and minimum values of annual rainfall based on past rainfall data from 1932 to 2001 in each AER is given in Table 1.

Table 1. Useful statistical indicators for the selected agro-ecological regions

Agro-ecological region (AER)	Annual rainfall indicator (mm)		
	Mean	Minimum	Maximum
IL_1	1700	1130 (1986)	2250 (1963)
IL_3	1485	897 (1986)	2370 (1933)
WL_1	2260	1475 (1983)	3660 (1963)
WL_2	2480	1600 (1983)	4038 (1963)
WL_3	2420	1214 (1983)	3610 (1975)
DL_1	1150	717 (1949)	2150 (1984)
DL_3	1015	600 (1992)	1815 (1961)

(*Source:* Peiris *et al*, 2004, the year of which corresponding maximum and minimum occurred is shown in parentheses)

As the use of recommended practices depends on the size of land as well, four different land size classes within each AER were taken as the secondary sampling units (SSU). Four land extent classes were: 0.5-2, 2-5, 5-10 and above 10 acres. Thus a sampling unit was a coconut holding above 0.5 acre. There is a greater homogeneity within each stratum so that each stratum can be represented by fewer number of sampling units.

2.1.2 Sample size

In deciding sample size it was taken that maximum possible margin of error for a given factor was 0.2 with 95% confidence (Cochran, 1967). Considering above assumption and based on the various constraints such as manpower, time, money etc. the sample size decided as 545 coconut holdings. This is about 0.7% of the total number of coconut holdings in Sri Lanka (MPI, 2005).

2.1.3 Allocation of sampling units

Allocation of the number of sampling units within primary and secondary sampling units was done based on the proportion to the land extend of coconut. The sample units were randomly selected within selected coconut development ranges (CDOO) belongs to primary sampling units by consulting the respective Regional Managers of the Coconut Cultivation Board (Fig. 1).

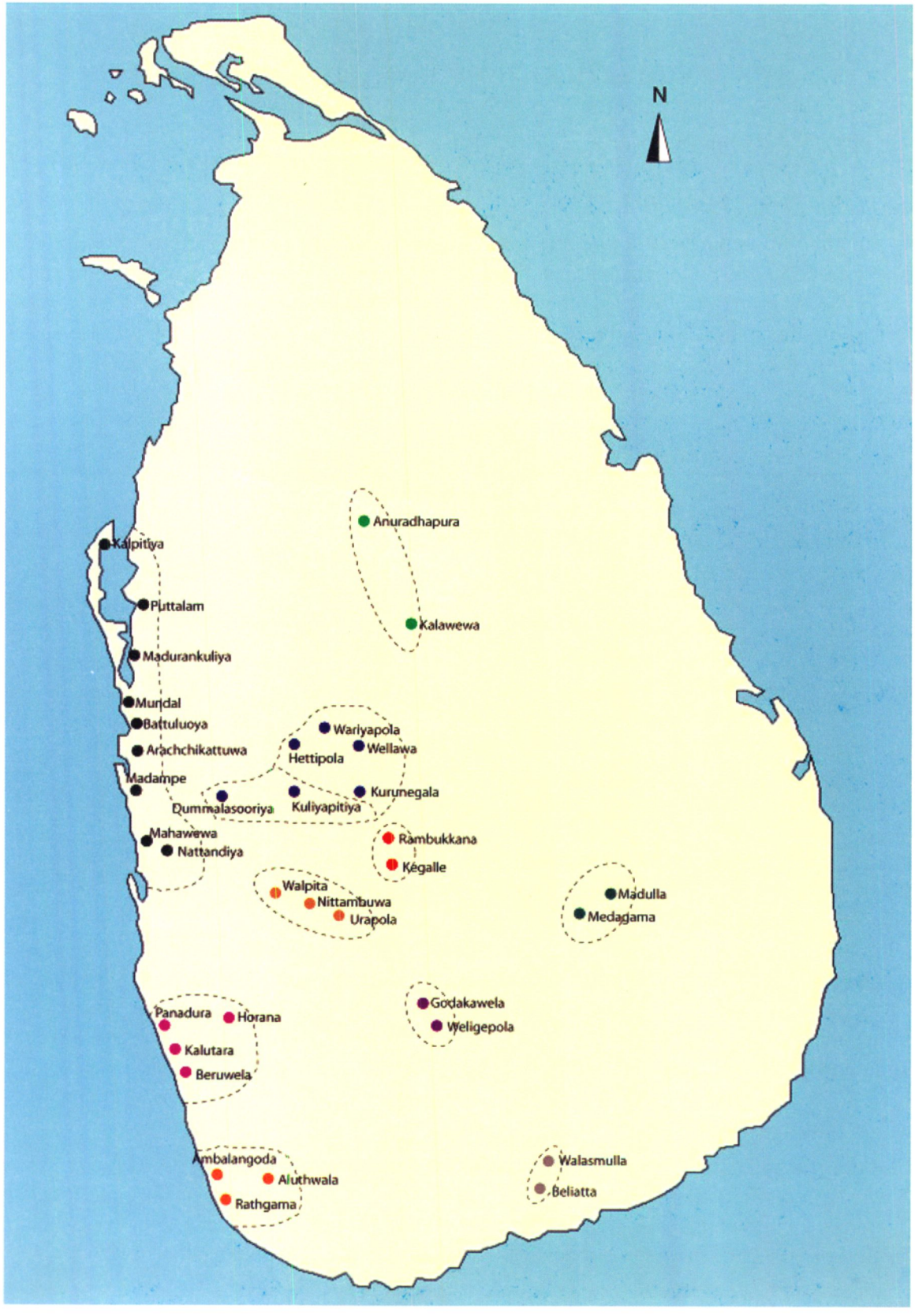


Figure 1. Selected coconut development ranges (CDOO) for the survey

The allocation of sampling units among PSU and SSU is shown in Table 2. Out of the total sample size of 545, only 543 was considered for the data analysis.

Table 2. Allocation of sample size for the survey by primary sampling units (PSU): AERR and the secondary sampling units (SSU): land extent classes

AER	Size of land extent classes in acres (x)				Total
	0.5 < x d" 2	2< x d" 5	5< x d" 10	10 < x	
IL1	71	60	39	62	232 (42.6%)
IL3	11	10	10	11	40 (7.7%)
WL1	14	7	9	11	41 (7.5%)
WL2	21	12	9	18	60 (11.0%)
WL3	19	21	16	18	74 (13.6%)
DL1	6	6	2	6	20 (3.7%)
DL3	18	24	17	17	76 (13.9%)
Total	160 (29.4%)	140 (25.7%)	102 (18.7%)	143 (26.2%)	545

Percentages of the total sample size within each PSU and SSU are shown in parentheses.

2.2 Data Acquiring

2.2.1 Structured questionnaire

A detailed questionnaire consists of about 400 questions was prepared to acquire necessary information from the growers. It was done in consultation with the Heads of all research divisions of the CRI. Questionnaire was divided into ten sections related to recommended technologies and technology transfer, namely general information of estates, use of mulch, husk pits, planting materials, under and new planting, use of fertilizer, pest control measures, integrated production systems, kernel products of coconuts and technology transfer.

The questionnaire was pre-tested and the enumerators were trained to collect information for each question. Growers were interviewed through rapid appraisal approach and the enumerators inspected lands as far as possible depending on time. In most occasions enumerators had to consult the coconut growers during the interview or after the interview (Plate 1). Except in a special circumstance answers were obtained from the owner of the land as owners were informed to stay in the land with a specified time in advance. Average time spend to fill one questionnaire was 40 minutes.

Plate 1. Enumerators are explaining some problems to growers during the survey: (a) Madulla CDO range in Monaragala and (b) Bibile CDO range in Monaragala

2.2.2 Data mining

Data were quality controlled and entered into an Excel worksheet and analysed using statistical software, SAS. Distribution of sample size among CCBRR and LSC for coconut is given in Table 3 and Table 4 respectively. Two questionnaires were not included for the analysis due to obvious reasons. The CCBRR and land suitability classes (LSC) for coconut (Somasiri *et al*, 1996) were taken as the post strata for data analysis. During the survey the classification of coconut holding into LSC for coconut was done by visual observation of soil in the estate and soil variability within estate was ignored.

Table 3. Distribution of sample size among the Coconut Cultivation Board Regions (CCBRR)

Coconut Cultivation BoardRegion (CCBRR)	Frequency	Percentage with respect total sample
Anuradhapura	20	3.68
Galle	20	3.68
Gampaha	74	13.63
Hambantota	20	3.68
Kalutara	35	6.45
Kegalle	26	4.79
Kuliyapitiya	70	16.57
Kurunegala	61	11.23
Marawila	165	30.39
Monaragala	11	2.03
Ratnapura	21	3.87
Total	543	100

Table 4. Distribution of sample size between LSC for coconut

Land suitability classes (LSC) for coconut	Land extent (in acre)				Total
	$0.5 < x \leq 2$	$2 < x \leq 5$	$5 < x \leq 10$	$x > 10$	
S_1	13	18	10	10	51 (9.4%)
S_2	43	40	25	38	146 (26.9%)
S_3	78	59	56	76	269 (48.5%)
S_4	24	23	11	19	77 (14.2%)
Total	158	140	102	143	543

2.3 Statistical Analyses

2.3.1 Data analysis

As most of the responses are qualitative variables either dichotomous (binary) or nominal scale data analysis was carried out using categorical data analysis techniques such as 2-way and multi-way contingency tables. The association in 2-way contingency tables was tested using maximum likelihood chi-square test. The association in multi-way contingency tables was carried out by fitting linear logistic models and validity of models was done using likelihood ratio test (Collet, 1992). Comparison between levels within explanatory variable was done using odd ratios. A trend of a response variable with land extent classes was tested by fitting simple linear regression model. All analyses were carried out using SAS software (SAS, 2001).

2.4 Assessment of Technology Transfer System

If the percentage of awareness with respect to number of growers, for a given technology is high then it was assumed that technology transfer for the particular technology is effective. If the percentage of practice of that technology is high then it is assumed that acceptability of that technology by the growers is effective. The gap of a given technology was defined as the difference between the percentage of awareness and percentage of use. Thus it was assumed that the main objective of the dissemination of technology is to reduce the gap provided that the percentage of awareness is high.

Chapter 3

GENERAL BACKGROUND OF THE ESTATES AND GROWERS

3.1 Details of Sampling Units

3.1.1 Extent covered

Table 5. Basic details of coconut holdings selected for the survey across the selected Coconut Cultivation Board Regions (CCBRR)

CCBR	Bearing extent covered in the survey (ac)	Mean age of the bearing palms (years)	Mean number of bearing palms ac	Mean number of palms* ac
Anuradhapura	211	24	46	76
Galle	553	44	65	91
Gampaha	838	48	52	62
Hambantota	167	45	49	58
Kalutara	260	42	46	55
Kegalle	340	36	47	62
Kuliyapitiya	863	48	52	74
Kurunegala	855	45	49	66
Marawila	2828	40	50	66
Monaragala	72	33	48	70
Ratnapura	162	34	51	65
Total	7149	42	50	67

* Sum of bearing, young, and seedling and disease palms.

Total extent covered in the survey was 7149 acres (Table 5) and it represented 0.7% of the total coconut extent of 975600 acres in Sri Lanka (MPI, 2005). The average size of a sampling unit was 13.3 acres.

3.1.2 Age of bearing palms

The mean age of bearing palms irrespective of the type of plantation was 42 years (Table 5) with a minimum of 6 years and maximum of 110 years. The distribution of age of the bearing palms is shown in Figure 2.

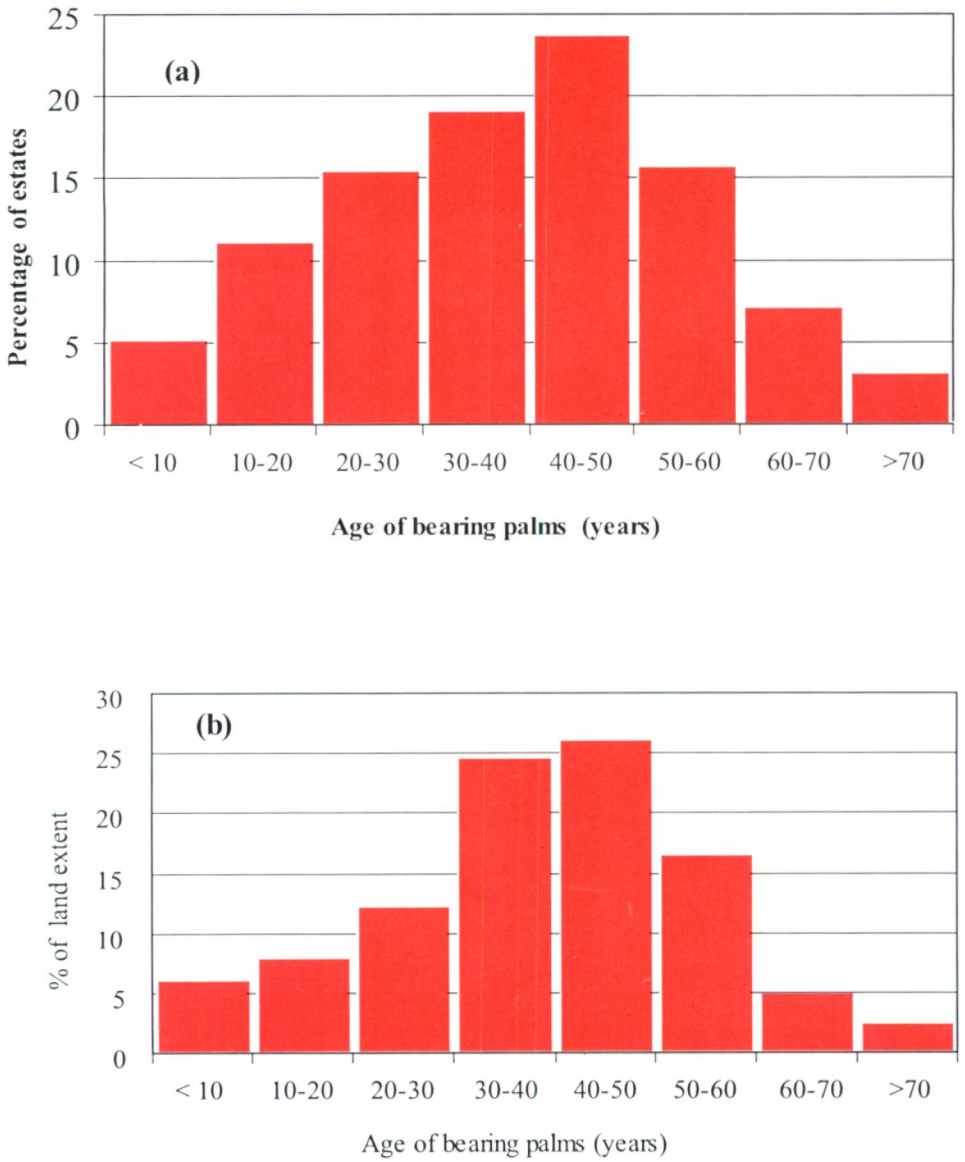


Figure 2 Distribution of age of bearing palms in the coconut lands with respect to (a) number of estates and (b) total extent

The age of bearing palms of about 30% of lands was below 30 years (Fig. 2.a) and it is represented by 26% of the total extent (Fig. 2.b). The age of bearing palms of 60% of estates were between 30 and 60 years and it is represented by 67% of the total extent. The age of bearing palms in about 10% of lands was above 60 years and that in about 3% of lands was above 70 years (Fig.2.a). The extent of bearing palms of age greater than 60 years was 7% (Fig. 2.b). In fact, according to latest Agriculture Census in 2002 total extend over 60 years was also 7% (DCS, 2004).

The variation of the mean age of bearing palms among AERR and among LSC for coconut is shown in Table 6.a and Table 6.b respectively. The mean age of bearing palms was significantly different between AERR. It was generally lower in dry regions (Table 6.a) and higher in the WL3 region. There was no difference of the age of bearing palms among land size classes (Table 6.b).

Table 6. Distribution of age and density of palms of the lands selected for the survey

(a) by AERR

AER	Age of bearing palms (yrs) (mean ± se)	Mean number of bearing palms/ac	Mean number of palms/ac
IL1	44 ± 2	49	64
IL3	45 ± 3	54	75
WL1	39 ± 3	45	56
WL2	38 ± 2	55	73
WL3	48 ± 2	52	62
DL1	24 ± 5	46	76
DL3	32 ± 2	55	74

(se = standard error of the mean)

(b) by land extent class

Extent (ac)	Age of bearing palms (Yrs(mean ± se)	Mean number of bearing palms/ac	Mean number of palms/ac
0.5 – 2.0	42 ± 2	51	71
2.0 – 5.0	40 ± 3	49	63
5.0 – 10.0	44 ± 3	51	71
> 10	38 ± 2	45	54

(se = standard error of the mean)

3.1.3 Density of plantation

Results in Table 4 indicate that the mean number of bearing palms per acre was 50 and the mean density in most of coconut lands in almost all CCBRR with respect to bearing palms was below the recommended density of 64 palms per acre by the CRI. However, by considering all types of palms including non bearing palms, diseased palms and seedlings the mean density was 67 palms per acre. It concludes that the planting density of the coconut lands in all CCBRR, except in the Galle region was almost closer to the recommended density. The mean density of the coconut lands in the Galle region (91 palms per acre) was exceptionally high and it does not provide enough solar radiation for the growth of the palms.

3.1.4 Type of plantation

The estates were grouped into (i) under (mature plantation with under plantation), (ii) re/new (new or replanting) (iii) mix (combination of mature, senile or re/new plantation), (iv) mature (only mature plantation without under plantation) and (v) senile plantation (over 60 years and yield was < 1000 nuts/palm/year) as depicted in Figure 3. This classification was totally based on the inspection of the land at the time of survey and sometime classification of senile was difficult to judge.

Figure 3 indicates that about 5% of lands were senile. That is average yield of those palms was less than 20 nuts per year. The percentage of senile plantation was higher among small holders (0.5-2ac) category than that in larger estate category (>10 ac). The majority of lands covered in the survey were mature plantation followed by mix plantation (Fig. 3.a). With respect to land extent majority of land extent (45.7%) was under mix plantation followed by mature plantation which was 28.4% of land extent covered. The percentage of land extent under senile plantation was 3.1%.

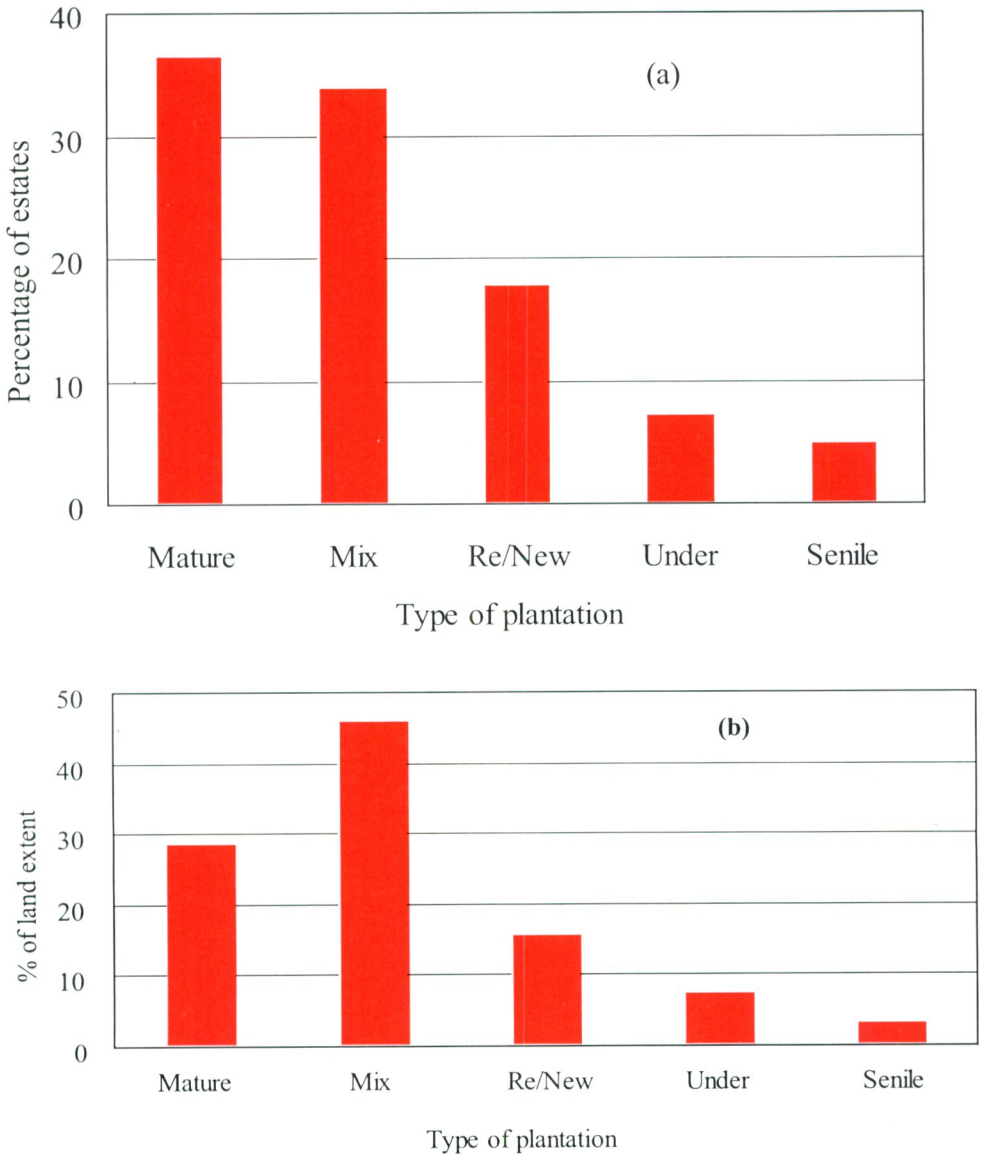


Figure 3. Distribution of type of plantation of the selected estates for the survey with respect to (a) number of holdings and (b) total extent

In order to get some idea about age of palms within each plantation type, mean and coefficient of variation (cv) were computed for each type. The mean and variability of the age of bearing palms of the five types of plantations were: (a) mature plantation (43 years with a cv of 30%), (b) mix plantation (45 years with a cv of 40%), (c) re/new plantation (25 years with a cv of 50%), (d) under plantation (42 years with a cv of 45%) and (e) senile plantation (60 years with a cv of 18%). The senile plantation had the lowest variability of age indicating majority of senile palms had reached the age of about 60 years.

3.2 Estate Owners

3.2.1 Main source of income of the growers

Coconut cultivation was the main source of income of only 38% of the growers irrespective of land extent. The main source of income of other growers was either from their main occupation (56%) or other types of occupation (6%). About 30% of the estate owners received their main income from the coconut land indicating 70% of the estate owners had alternative source of income other than the income from the estate and thus they give less attention to the coconut lands.

3.2.2 Absentee landowners

The data indicated that 70% of growers reside at their coconut holdings and the balance 30% was absent land owners. The percentage of absentee land owners were significantly different ($p<0.001$) among CCBRR. The highest percentage of absentee land owners was reported in Kegalle (62%) while the lowest (14%) was from Ratnapura. Of the four CCBRR in the traditional coconut triangle (Kurunegala, Marawila, Kuliyapitiya and Gampaha) the highest percentage of absentee land owners was reported in Gampaha (35%) followed by in Marawila (30%).

The percentage of absentee land owners significantly increased with the increase of land extent. It varied from 14% among small holders to 58% among large holders. Based on the percentage of absentee land owners among large extent holders the CCBRR can be ranked as Kurunegala (72%) > Gampaha (72%) > Marawila (65%) > Kuliyapitiya (54%) > Anuradhapura (48%) > Ratnapura (33%)> Kalutara (30%) > Galle (28%). The absentee land owners were higher in the coconut triangle. This is a typical problem in large coconut holdings in Sri Lanka which may had a greater impact on the national coconut production.

However, such a study had not been reported. It is important to convince those land owners that the yield obtain is significantly lower than the average yield from non absentee lands.

Chapter 4

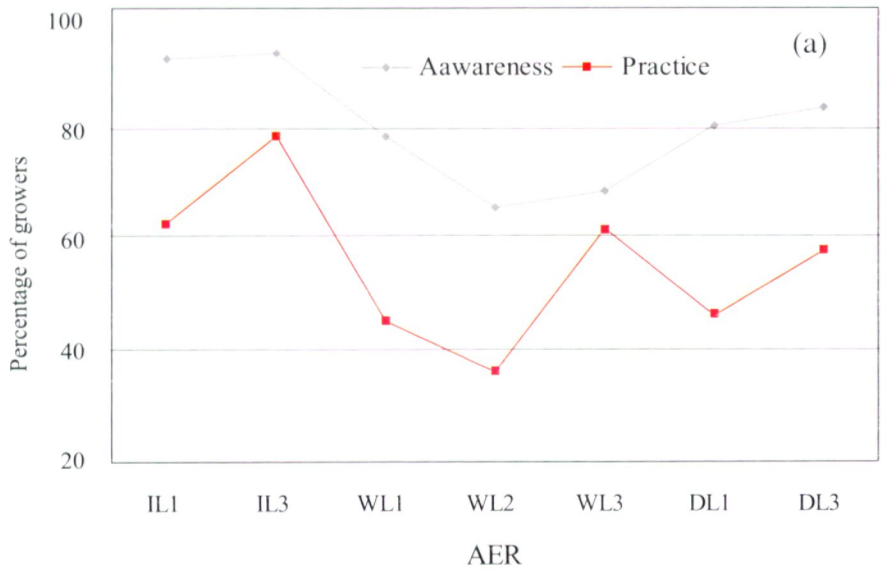
TECHNOLOGIES ON AGRONOMIC PRACTICES (MULCH, GLIRICIDIA, HUSK PITS, IRRIGATION)

4.1 Use of Mulch

4.1.1 Awareness and use of mulching

CRI has recommended in maintaining mulch throughout the year in the entire manure circle (radius of 6') of the coconut palm to conserve moisture in the soil, to reduce fertilizer loss and to suppress the weed growth. However, the optimum benefits with respect to palm water status can be obtained when the whole land in covered with a thick layer of coir dust (Ranasinghe, *et al.*, 2003).

Majority of the growers in the sample (82%) was aware of the benefits of keeping mulch but only 56% were practiced. The percentage of awareness significantly increased ($p < 0.001$) with the increase of land extent. The percentage of awareness was 74, 82, 86 and 91 for the four land extent classes respectively. The percentages of awareness and practice of mulch by AERR and CCBRR are shown in Figure 4.a and Figure 4.b respectively.



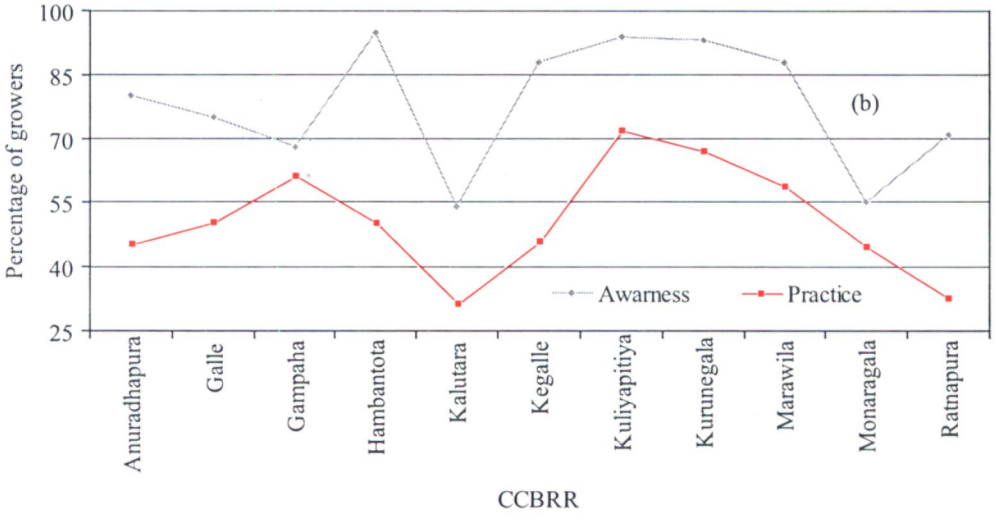


Figure 4. The percentages of awareness and practice of mulching around the manure circle of the palm by (a) AERR and (b) CCBRR

The growers' awareness on mulch was significantly different between AERS ($p< 0001$). It was the lowest in WL_2 and WL_3 and the corresponding values were 65% and 68% (Fig. 4). The growers in Monaragala and Kalutara showed significantly lower percentage of awareness (Fig. 4) than the growers in other regions. The percentage of growers who practiced mulching was significantly influenced ($p<0.0001$) by the interaction between AERR land extent classes (Table 7).

Table 7. Percentage of growers who practiced mulch among AER and land extent size

AERs	Land extent size (ac)				Mean
	0.5 - 2	2-5	5-10	>10	
IL1	62	52	49	81	62
IL3	67	80	60	100	78
WL1	50	14	44	55	44
WL2	24	33	56	39	35
WL3	42	67	56	78	61
DL1	33	33	50	83	45
DL3	56	71	29	71	58
Mean	52	55	47	73	56

According to Table 7 the percentage of growers who practice mulch was very low among the medium size land holders (2-5 ac) in WL1. Of the AERR the highest percentage of growers had practiced mulch in IL1 and IL3 irrespective of land extent size. The percentage of growers who had mulch was substantially high among large coconut extent holders (73%). This was a good improvement compared with corresponding percentage of 45% according to last diagnostic survey in 1993 (Appendix A). Similar improvement was found among all land extent classes (Appendix A).

4.1.2 Gap on the practice of mulch

The 'gap on the practice of a recommended practice' was defined as the difference between the percentage of awareness of that recommendation and the percentage of practice of that recommendation. That is,

Gap on the use of mulch = (percentage of growers who were aware of mulch – percentage of growers who practiced mulch.)

Based on the above definition it was found that the overall gap on the use of mulch was 26%. The gap on the use of mulch was significantly different between AERR and also between CCBRR ($p<0.001$). The gap on mulch was lowest among the growers in WL3 and highest in DL1 (Fig. 4). Figure 4 also indicated that gap on the use of mulch was higher in dry regions although mulch had been strictly recommended for dry regions. The gap on mulch was significantly higher in Hambantota and Kegalle than that in Gampaha or Monaragela (Fig. 4).

4.1.3 Frequency of mulching

Only 31% of growers maintained mulch throughout the year. About 17% maintained mulch at irregular intervals and 9% maintained mulch during drought period or after application of fertilizer (Fig. 5).

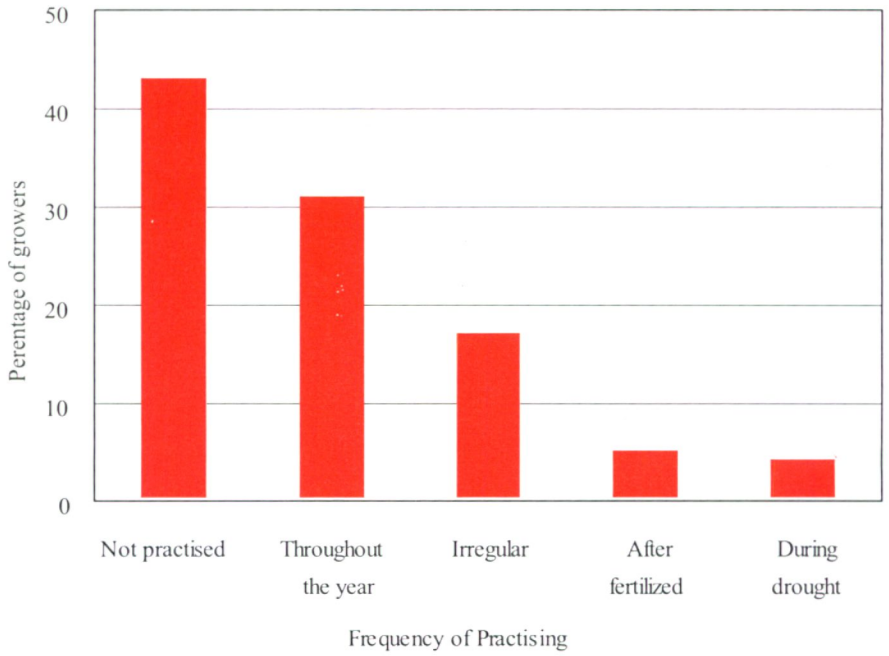


Figure 5. Frequency of practicing mulch by the growers

4.1.4 Material used for mulching

Majority of the growers (25%) used coconut fronds as a material for mulch followed by coconut husk (18%) and weed trash (15%). The material used for mulch had the same trend for each of the land extent class. However, the pattern of material used was significantly different among CCBRR. Majority of growers in Anuradhapura, Kurunegala and Kuliyapitiya used weed trash. Coconut fronds were heavily used by the growers in Gampaha, Kegalle and Marawila.

4.1.5 Constraints for mulching

The views of the growers about the constraints for not practicing mulch as recommended were classified into three major reasons as depicted in Figure 6.

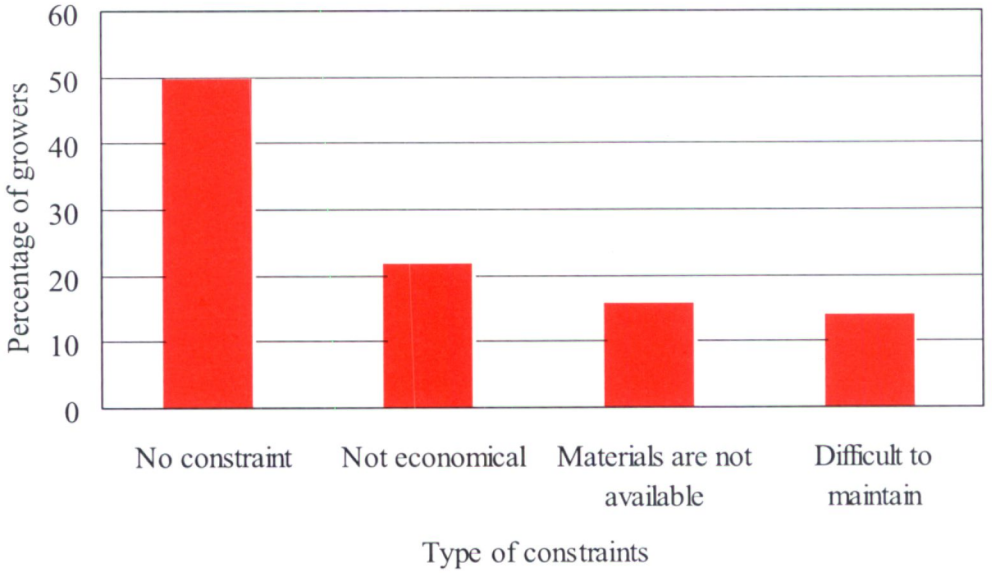


Figure 6. Reasons for not practicing mulch around the coconut palm

Fifty percent expressed that they did not have constraints to maintain mulch. The two main constraints were not economical followed by non availability of material. The type of constraints was not significantly different among AERR and land extent classes. The reasons for not economical may be due to the fact that growers were not aware of additional benefit with respect to number of nuts due to mulch. Finding coconut fronds had been difficult for growers in many parts of the coconut growing areas as coconut fronts were used for other purposes. Further, the impact of yield with respect to nut and copra yield had not been quantified by the CRI.

4.2 Use of Gliricidia

4.2.1 Growing gliricidia

CRI has recommended growing Gliricidia in all coconut lands due to various reasons. Gliricidia has also been recommended as a source of energy recently. Among the growers in the sample only 46% had grown Gliricidia in their coconut lands. As for the use of mulch, the percentage of growers who had grown Gliricidia in their coconut lands was significantly lower ($p<0.005$) in DL1 (15%) and DL3 (28%) than other AERR. The highest percentage was observed in IL3 (70%) followed in IL1 (54%).

The corresponding percentages increased linearity ($p<0.001$) with the increase of land extent class. The percentages of growers who had grown gliricidia was significantly different between CCBRR ($p<0.0001$) and it varied from 15% in Anuradhapura to 81% in Kegalle (Fig. 7).

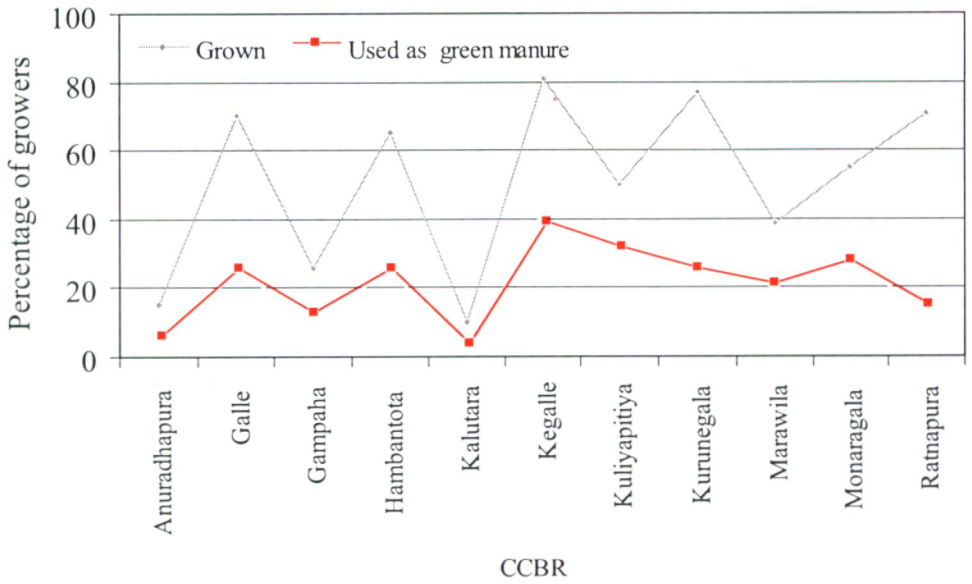


Figure 7. Use of gliricidia in their coconut lands as green manure

Though gliricidia can easily be grown in Kalutara gliricidia trees was found only in 10% of the coconut lands in Kalutara. In contrast although gliricidia has grown in most of the coconut lands in Kegalle, Ratnapura, but most of the growers were not aware of the benefits of gliricidia (Fig. 7).

4.2.2 System of planting of gliricidia

The majority of growers (27%) used to grow Gliricidia along the fence. Gliricidia was grown as recommended in between palms by 9% of growers. This system is the best and efficient method to grow gliricidia for the benefit of coconut palms.

4.2.3 Benefits of gliricidia

About 20% growers had grown gliricidia for the purpose of green manure for their coconut palms. Nearly 5% had grown for the use of live support for intercrops. Rest of the growers had grown gliricidia for the use of fencing. Among the growers interviewed only one grower in Kurunegala had used gliricidia for fuel wood and no grower was found using gliricidia for gas fires which has been popularizing.

These results indicated that growers were not fully aware the potential benefit of gliricidia. This could be due to that CRI has not given sufficient awareness programs to popularize the importance of gliricidia for coconut lands as a source of fertilizer, as a source gas fires and as a source of wood. This further confirmed from finding that of the coconut lands where gliricidia was grown in Ratnapura and Galle (wet region), the use of gliricidia for the benefits of coconut palm was very unsatisfactory level.

4.3 Use of Husk Pits

4.3.1 Awareness of current recommendation

Burying of husks in coconut lands is an old cultural practice recommended by the CRI to increase yield. Coconut husks buried in soil absorb considerable quantity of water during the rainy season. Much of this absorbed water becomes available to coconut palms during the dry season. The use of husk pits in lateritic gravel and sandy soils increased nut yield by 15% and 20% respectively (Liyanage *et al.*, 1993). From time to time different methods and different dimensions of the husk pits had been recommended. The current recommendation is the use of 8'x 4'x 3' pits between palms within coconut rows which was introduced in 2001. In the survey it was noted that 70% of the growers were not aware of the current method and 74% were not aware of the current size of the husk pits, resulting 80% of the growers irrespective of AERR, land extent classes and CCBRR were not aware both the current method and size of the husk pit. The corresponding percentages were significantly different among land extend classes (Table 8.a) as well as among CCBRR (Table 8.b).

Table 8. Assessment of awareness of the current recommendation on husk pits (8'x 4'x 3' pits between palms within coconut rows) with respect to percentage of growers who were aware

(a) by land extent classes

Activity	Land extent class (ac)				mean
	0.5-2	2-5	5-10	>10	
Method of burying husk	10	23.	39	50	30
Size of husk pits	12	21	37	40	26
Method & size	8	14	28	34	20

(b) by CCBRR

CCBR	Percentage of growers aware of the activity		
	Method of burying husk	Size of husk pits	Both (method & size)
Anuradhapura	15	25	15
Galle	20	20	20
Gampaha	34	23	19
Hambantota	25	25	20
Kalutara	20	15	14
Kegalle	27	35	26
Kuliyapitiya	34	28	23
Kurunegala	31	34	21
Marawila	35	28	33
Monaragala	15	20	10
Ratnapura	15	20	15
Mean	30	26	20

It can be seen even among large extent holders, only 34% were aware of both method and size of the current recommendation on husk pit. Of the CCBRR the percentages of growers who were aware of both method and size of husk pit were just above the present national mean (20%) only in Marawila, Kegalle, Kuliyapitiya and Kurunegala. This clearly indicates that new recommendation on husk pits had not gone to most of the coconut growers irrespective of area and land extent size and rate of awareness was very low even among the growers in the coconut triangle.

4.3.2 Awareness of the benefits of husk pits

Irrespective of land extent classes 85% of the growers were aware (Table 9) that husk burying was useful to conserve moisture in coconut lands and to improve the coconut yield.

Table 9. Percentage of growers who were aware of the benefits of burying husks in coconut lands by CCBRR x land extent classes

CCBR	Land extent class (ac)				Total
	0.5-2	2-5	5-10	>10	
Anuradhapura	83	67	95	67	75
Galle	20	60	95	71	55
Gampaha	89	85	94	83	88
Hambantota	95	95	67	95	90
Kalutara	77	95	80	95	85
Kegalle	83	95	60	95	88
Kuliyapitiya	90	85	88	95	93
Kurunegala	88	86	91	95	90
Marawila	87	81	77	90	84
Monaragala	70	50	0	100	64
Ratnapura	37	33	75	100	62
Total	82	83	81	92	85

The corresponding percentages were almost same among land extent classes. Among CCBRR it was lower in the regions of Galle(55%), Ratnapura(62%) and Monaragala(64%) compared with that in other regions. The percentage of awareness was significantly different by the interaction of CCBRR and land extent classes. The lowest awareness was found among small holders in Galle (20%) followed by the smaller holders in Ratnapura region.

4.3.3 Practice of husk pits

The use of husk pits was significantly influenced ($p< 0.05$) by the interactions between land extent classes with CCBRR (Table 10.a) and LSC for coconut (Table 10.b).

Table 10. Percentage of growers practiced any type of husk pit (irrespective of size and method)

(a) by CCBR x land extent class

CCBR	Land extent class (ac)				Total
	0.5 - 2	2-5	5-10	>10	
Anuradhapura	0	0	50	67	30
Galle	10	50	50	71	45
Gampaha	6	33	44	83	41
Hambantota	0	0	33	83	30
Kalutara	6	14	40	33	17
Kegalle	50	40	0	30	31
Kuliyapitiya	37	38	56	71	50
Kurunegala	24	36	45	63	43
Marawila	26	29	51	72	44
Monaragala	0	0	20	0	10
Ratnapura	12	33	25	17	19
Total	20	29	46	66	40

(b) by LSC for coconut x land extent class

LSC	Land extent class (ac)				Total
	0.5 - 2	2-5	5-10	>10	
S_1	0	28	40	70	20
S_2	28	32	56	66	44
S_3	17	31	45	66	40
S_4	25	28	36	60	34
Total	20	22	41	58	40

According to Table 10.a it can be confirmed that small holders, particularly (0.5 -2ac) did not practice husk pits in almost all CCBRR with an exception in Kegalle. The percentage users of husk pits in the medium land extent class (2-5 ac) in Gampaha, Kegalle, Galle and Kuliyapitya was significantly higher than that of the users in large extent class in Monaragala and Ratnapura. According to the diagnostic survey in 1993 the percentages of growers who used husk pits in the lands between 2-5 ac, 5-10 ac and > 10 ac were 26, 45 and 61% respectively. Comparison with the results in the present finding (Table 10), it can be confirmed that the use of husk pits had not improved from 1993 to 2005 as the use of mulch (Appendix A).

As for awareness for husk pits, the percentage of practice of husk pits was not significantly different among LSC for coconut. Results in Table 10.b indicated that percentage of practice was not significantly different among LSC for coconut within land extent classes except for small land extent holders. The percentage of husk pit users among medium land extent group (<5 ac) in the LSC for coconut S2, S_3 and S_4 were below the corresponding national mean percentage.

4.3.4 Gap on the use of husk pits

The gap between the percentages of awareness and practice by CCBRR is shown in Figure 8. The gap on the use of husk pits was the lowest in Galle as both the awareness and practice were low and almost similar. The gap on the use of husk pits was the highest in Kalutara (68%) as the awareness was high and practice was low. The CCBRR: Hambantota (65%), Kegalle (57%) and Monaragala (54%) also showed a considerable gap for the use of husk pits (Fig.8).

4.3.5 Constraints on the use of husk pits

The constraints for not burying husk in pits were classified as (a) not economical, (b) materials were not available, (c) no man power/no machines and (d) others (various reasons other than above) as depicted in Figure 9. As there had been demand for husk by various stake holders in the coconut industry such as coir industry, export of coir pith etc, coconut growers found difficult to use husk for burying in their lands. Also due to prevailing economic situation in the country, the cost of opening pits, transport and burying husk for each pit had been gone up.

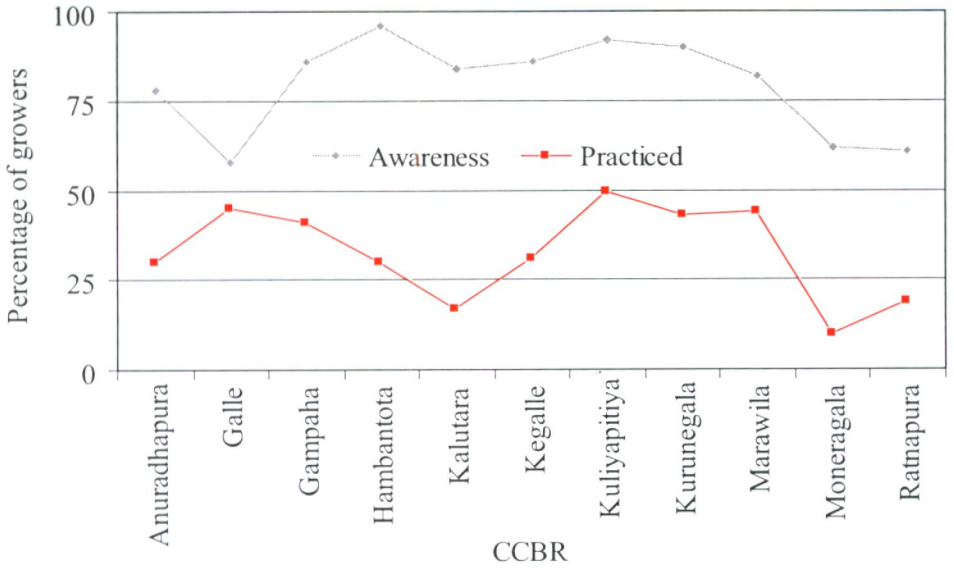


Figure 8. The percentages of awareness and practiced of husk pits by the growers

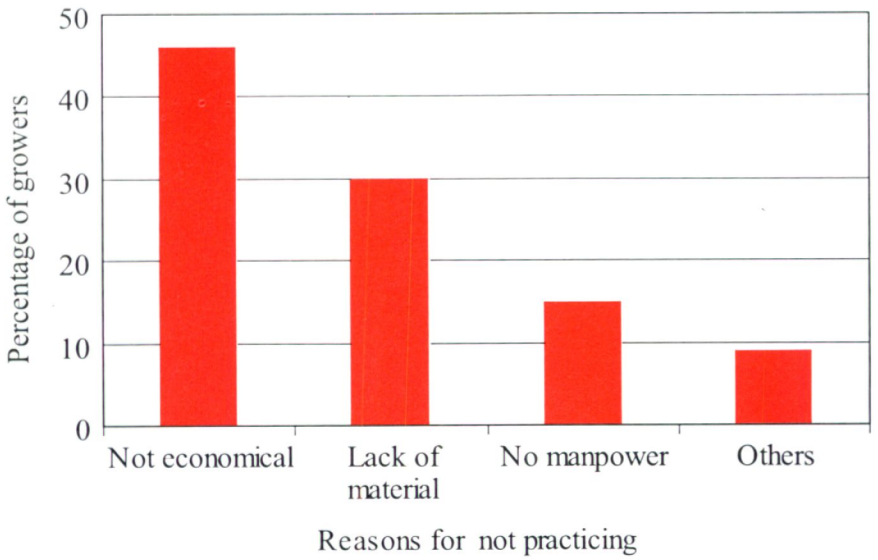


Figure 9. Reasons expressed by the growers for not practicing husk pits in their coconut lands

4.3.6 Type of husk pit (method, size and material) used

Of the 40% growers who had husk pits in their lands, it was noted that most of growers had done only for a part of land or they were very old and not rehabilitated for a long period. Only 10% of the growers had used pits in between palms with rows (Fig. 10.a) while 17% had practiced husk pits either middle of coconut square or around each palm. Another 13% had used pits in irregular way (no systematic method).

As the CRI had recommended various sizes of husk pits the growers had used different sizes of husk pits. However, the sizes of husk pits were categorized into four sizes as depicted in Figure 10.b. Only 10% had used latest recommendation size of 8' x 4' x3' pits. Jumbo pits were very large pits recommended by the CRI during 1995. Except very few percentages of growers (4%) almost all others had used husk alone for pits (Fig 10.c).

4.4 Practice of Irrigation

The analysis found that systematic irrigation such as drip and sprinkler irrigation was practiced by 1% and 5% of the growers respectively (Table 11).

Table 11. Percentage of growers who irrigated coconut palms by land extent class and type of irrigation

Land extent class	Type of irrigation			
	Drip irrigation	Sprinkler irrigation	Hose/ Bucket	None
<2	0.6	3.2	17.3	78.9
2-5	0.7	4.3	16.4	78.6
5-10	2.3	6.8	19.6	71.3
>10	4.2	2.8	16.8	76.2
Total	1	5	16	78

The corresponding percentages among large extent holders were 4.2 and 2.8 indicating that large extent holders preferred drip irrigation than sprinkler irrigation. The percentage of growers who practiced irrigation using hose or bucket system was 16% and the corresponding percentage for large extent holders was 16.8%. Results confirmed that majority of coconut growers including large extent holders preferred hose or bucket system (Table 11).

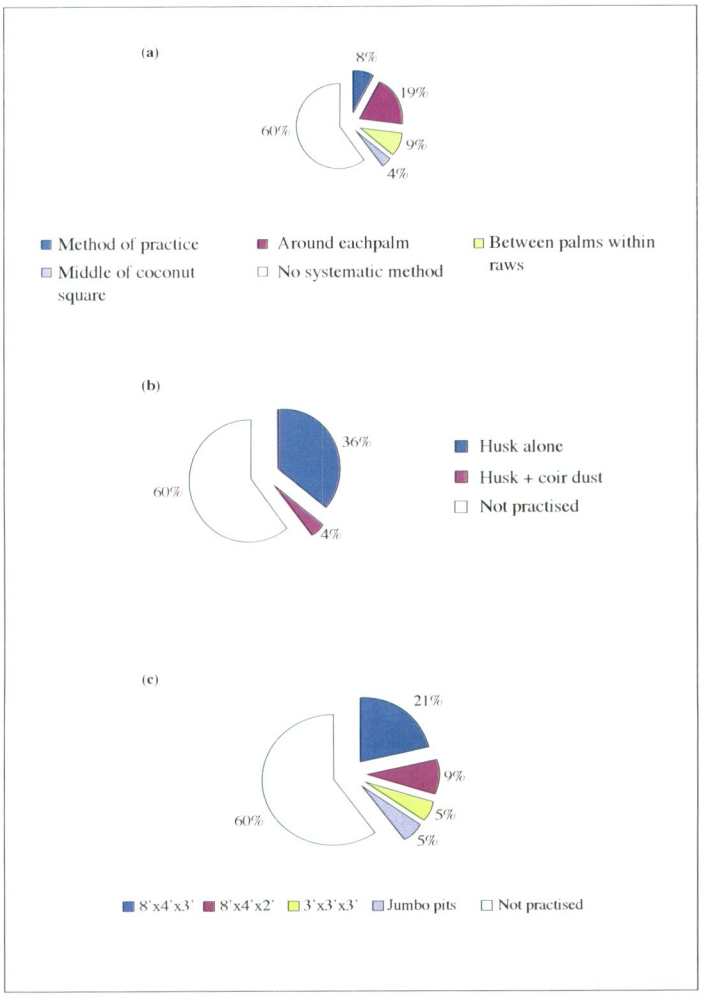


Figure 10. Different types of husk pits used in coconut lands by (a) methods, (b) materials and (c) sizes

Abeywardena (1979) had shown that nut and copra yield can be increased by 30% and 40% respectively due to hose irrigation. Irrigation was done only during dry periods when moisture deficit can occur. It was monitored by measuring rainfall. About 375 liters per palm per year was applied and watering was done an average of 20 times per year.

However, CRI has not recommended particular irrigation system for coconut cultivation and percentage of yield increase due to drip or sprinkler was also not known. There is a big knowledge gap on various aspects on the effect of irrigation on coconut. Nevertheless in any system of irrigation it is necessary to convince the growers to maintain rain gauge in their estates to reduce the waste of water. This is the only way where grower can monitor the amount of water to be applied based on the wetness of the soil. It is urgently necessary to identify an efficient and effective method of irrigation.

4.5 Land Suitability Class (LSC) for Coconut

Coconut Research Institute introduced five land suitability classes for coconut namely S1, S2, S3, S4 and S5 based soil physical and biological properties of the coconut lands and identified the potential yield output in 1995. S5 is generally considered as lands not suitable for coconut cultivation. The potential yield per palm per year in the four LSC for coconut S1, S2, S3 and S4 was 95, 80, 63 and 47 respectively based on 158 palms/ha.

4.5.1 Awareness of LSC for coconut

The survey found that 95% of the growers were not aware of the LSC for coconut. The percentage of non awareness was not significantly different among land extent classes and CCBRR. The percentage of small holders (0.5-2 ac) who were not aware of LSC for coconut was 99%. The corresponding percentage among large estate holders (> 10 ac) was 76%. It was further found that the percentage of non awareness of LSC for coconut among the growers having extent more than 30 acres was 81%.

Thus, immediate action has to be taken to educate the growers about the LSC for coconut. The non-awareness of the potential yield of their coconut lands would prevent the use of recommended practices to increase the yield in most suitable LSC for coconut such as S1 and S2. Similarly some growers may tend to practice unsuitable technologies for marginally suitable lands..

4.6 Climate Change

The percentage of growers who expressed that they noticed change of rainfall pattern and increase of temperature during recent years was 71% and 67% respectively (Table 12). The awareness of changes of both rainfall and temperature were significantly different between land extent classes. The percentage of awareness by small holders was significantly higher than that of among large extent holders. Only 54% of the growers indicated that climate change had affected to their cultural practices of the estates.

Table 12. Response of the grower's towards climate change with respect to rainfall and temperature (% awareness)

AER	Noticed a		Percentage of growers whose work had been affected due to climate change
	change in rainfall pattern (%)	increase in temperature (%)	
IL1	82	78	64
IL3	95	90	72
WL1	29	20	27
WL2	10	10	12
WL3	68	76	58
DL1	80	86	45
DL3	97	82	59
Mean	71	67	54

The results in Table 12 confirmed that climate change would impact more on the coconut cultivation in the IL_1 and IL_3 regions than that in other regions. The coconut extent in these two regions is about 40% of the coconut extent in Sri Lanka and has the highest extent of most suitable coconut lands such as S1 and S2 of LSC for coconut.

Chapter 5

PLANTING MATERIAL AND RELATED PROBLEMS

5.1 Planting Material

5.1.1 Availability of coconut seedlings

Thirty six percent (36%) of the growers expressed that coconut seedlings were not available for planting whenever they need, particularly during two rainy seasons. This is a substantial improvement compared to the corresponding percentage (70%) reported in the second diagnostic survey in 1993 (Appendix A). The percentage of non availability of seedlings was significantly different among the land extent classes ($p< 0.005$) and the corresponding percentages were 35, 28, 40 and 22 for the four land extent classes: 0.5-2.0, 2.0-5.0, 5.0-10.0 and > 10 ac respectively.

Peiris (2006) showed that the amount of seedling issued by the Coconut Cultivation Board (CCB) alone during past years was higher than the requirement for national planting program based on the assumptions of 25% seedling mortality, 2% under replanting rate and 2% new planting rate. In this study land extent under coconut was taken as 416,253 ha, though the extent under coconut according to recent agricultural census in 2002 was 394,836 ha (DCS, 2005). The 2% new planting rate is equivalent to 7900 ha/year (» 20000 acres per year) which is a more conservative figure.

However, in reality there had been a shortage for coconut seedlings in particularly during October and November. Therefore producing coconut seedlings should be targeted according to a plan and distributing seedlings also to be properly planned to make the national planting program more effective and efficient manner. The newly formed Seed Nut Selection Unit under the preview of Genetics and Plant Breeding Division of CRI has to play significance role to minimize this national disaster and supply the good quality seedlings to the grower.

5.1.2 Source of planting material

Figure 11 indicates the ranking order of the growers used to obtain seedlings.

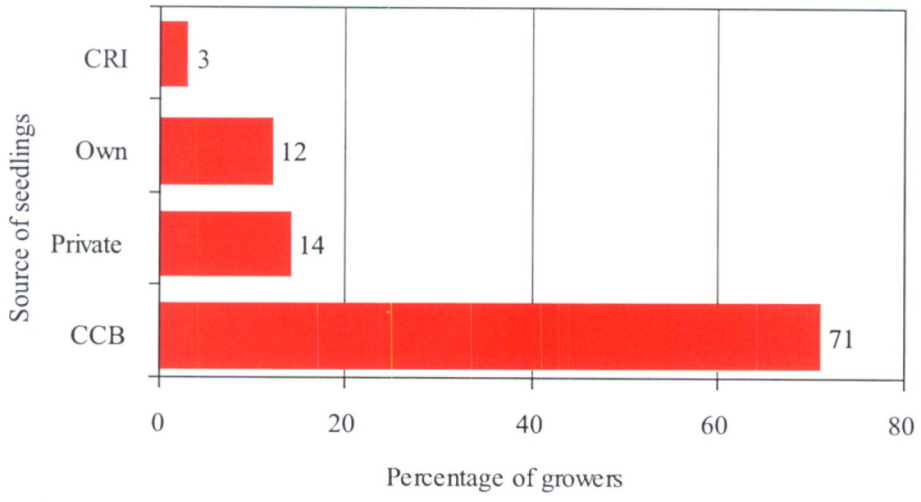


Figure 11. Ranking order of the sources of which growers used to obtain coconut seedlings

It is obvious that the main source of the seedling distributor is CCB. About 25% used to obtain/ purchase their own/private seedlings. This means that nearly one out of four growers had used either own seedlings or seedlings from private owners. According to the 1993 survey this was about 30%. The higher percentage of own seedlings were used by the small holders. It is a common practice that some growers maintain coconut nurseries and sell seedlings without any proper instruction from CRI or CCB.

The percentage of seedlings issued by the CRI was very low due to the fact that CRI do not sell seedlings on commercial scale, but CRI supplies seed nuts from the improved varieties to CCB for them to raise seedlings in their coconut nurseries distributed in many locations in Sri Lanka. Of the growers who obtained seedlings either from CCB or CRI, about 20% raised seedlings by themselves in their estates or purchased seedlings by other growers when seedlings were not available in CCB or CRI.

5.1.3 Selection of seed nuts

In addition to the seed nuts issues to the CCB by the CRI, a very low percentage of seed nuts are issued to private coconut nurseries. Further, some private growers maintain coconut nurseries using seed nuts selected from their own estates. The CRI has to monitor the activities of private nurseries and those growers have to renew their permit regularly. However, due to various reasons this system had not been practiced and private growers used to issue coconut seedlings. Therefore, the method of seed nut selection was investigated during the survey from those who raised seedlings. The type of nut selection was classified into four methods as shown in Figure 11.

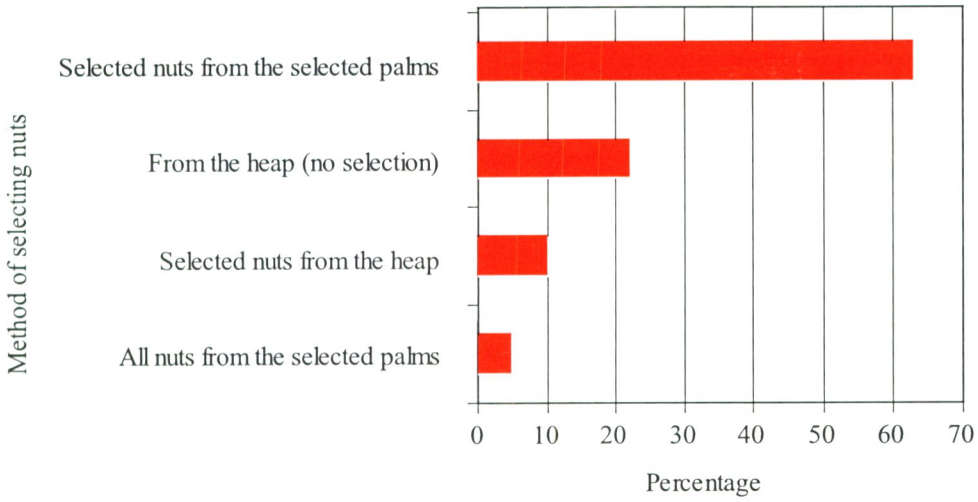


Figure 12. Growers approach in selecting nuts for seed nuts to raise seedlings

Figure 12 indicates that majority of growers (62%) practiced the correct procedure in selecting nuts (that is, selected nuts from the selected palms). This means that 38% of the growers who produced coconut seedlings were not knowledgeable to identify correct seed nuts. According to Figure 12, 10% of the growers had used selected nuts from the heap of nuts and 23% of the growers had selected all nuts from the heap. Another 5% of the growers had used all nuts from the selected palms. The incorrect method of nut selection certainly has an impact for the poor performance of seedlings.

5.1.4 Management of the coconut nurseries

It was found that 112 out of 543 (21% of the growers) maintained their own coconut nurseries. All the growers who maintained their own coconut nurseries were asked whether they followed the guidelines for coconut nurseries recommended by the CRI (Table 13).

Table 13. Assessment of growers practice towards the CRI recommended guidelines for coconut nurseries

Recommended guidelines	Percentage of growers who practiced the guidelines	
	correctly	incorrectly
(a) Site of the seed bed	35	65
(b) Selection of nuts	38	62
(c) Placement of seed nuts	31	69
(d) Rejection of non-germination after 5 months	28	72
(e) Selecting of seedlings after 7 months	27	73
All five steps	14	86

Results in Table 13 confirmed that each step of nursery management was not correctly practiced by at least 65% of the growers who raised their own seedlings. The percentage of incorrect use was higher for selecting of seedlings at 5 months and 7 months which are very important steps

in providing high quality coconut seedlings. The analysis further confirmed that the all five steps were correctly practiced by 14% of the growers who maintain nurseries. That is, 86% of the private nurseries were incorrectly managed.

5.1.5 Size of planting hole

The present recommendation on planting holes is: (i) 3'x3'x3' for sandy soils and (ii) 4'x4'x4' for gravel and clayey soils. A very high percentage of growers (76%) were not aware of the recommended size of planting hole for gravel and clayey soils (Table 14). 'Similarly 38% of the growers were not aware of the recommended size of planting hole for sandy soils.

Table 14. Assessment of growers' awareness of the sizes of planting holes and the feasibility for the use

Percentage of	Size of the planting hole	
	3'x3'x3' (sandy)	4'x4'x 4' (gravel & clayey)
Awareness	62%	24%
Feasibility for the use	56%	23%

The analysis found that the percentage of growers who were not aware of the size of planting hole for gravel and clay was significantly higher ($p<0.001$) than that for sandy soil. Further 77% of growers expressed that planting hole of size 4'x4'x4' for gravel and clayey soils was not feasible to practice.

5.1.6 Coconut varieties

Majority of the seedlings raised by the CCB are from the nuts selected from high yielding palms selected from high yielding blocks with consultation from the CRI staff. Those selected palms are known as plus palms which was introduced by the CRI. The seedlings raised from those nuts are commonly popular among growers as ordinary tall.

In addition to the above, the two improved coconut varieties CRIC60 (TxT) and CRIC65 (DxT) have been promoted by the CRI since 1960 and these varieties were available in all CCB nurseries. The seed nuts for these two varieties are supplied to CCB by the CRI. In average about 180,000 nuts from TxT and DxT are supplied annually to CCB.

CRI recently introduced two new cultivars namely CRISL98 (Tall x San Ramon), Kapruwana (Drawf Green x San Raman). Moorock tall which is suitable for wet zone was also recommended during 2003. The response of the grower's about the awareness of each coconut variety and availability of such coconut varieties in their properties are shown in Figure 13.

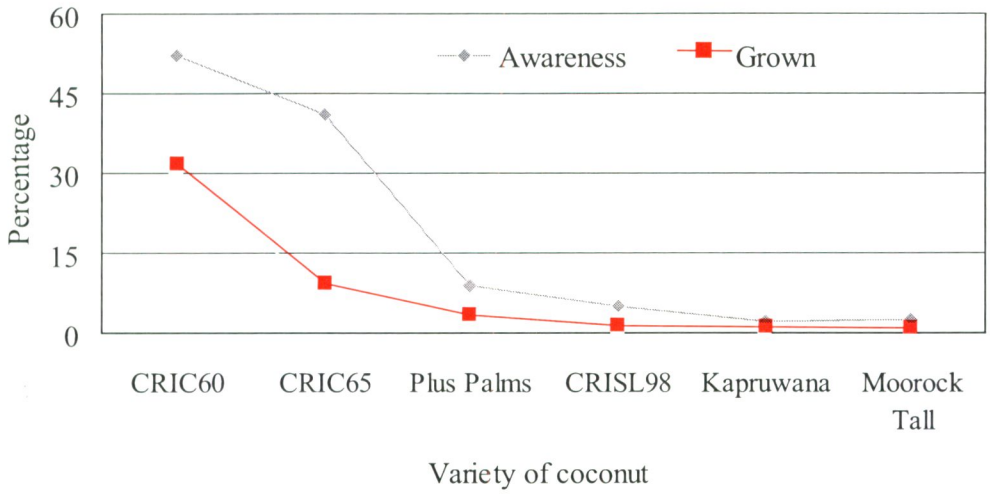


Figure 13. Percentage of awareness of different coconut varieties

Figure 13 clearly indicates that 52% of the growers (irrespective of area and the land extent) were aware of CRIC60. CRIC65 was not yet popular among growers as it was known by 37% and was grown by 8% of the growers. Nine percent of the growers were aware of plus palms. This may due to the fact that it is popular as ordinary tall. However, these findings justified that either the growers were not educated on the varieties of coconut they purchased or they were not keen to know type of variety they planted.

The percentage of awareness of CRIC60 and CRIC65 was highly significantly different among land extend classes ($p<0.005$) and among CCBRR ($p<0.005$) but there was no significant interaction between the two variables (Table 15). The above results confirmed that most of growers were not aware of CRIC60 and CRIC65. The percentage of non-awareness of these two types were higher among the growers in regions of the coconut triangle (Gampaha, Marawila, Kurunegela and Kuliyapitiya) than that in the regions Anuradhpura, Galle and Kurunrgela.

Table 15. Growers' awareness of CRIC 65 and CRIC0

(a) by CCBRR

CCBR	Percentage of growers who were aware of		
	CRIC60	CRIC65	Both
Anuradhapura	75	75	75
Galle	90	85	85
Gampaha	90	29	28
Hambantota	40	40	40
Kalutara	51	54	49
Kegalle	92	77	77
Kuliyapitiya	39	33	30
Kurunegala	41	39	34
Marawila	39	36	36
Monaragala	36	9	9
Ratnapura	33	28	29
Total	52	41	39

(b) by land extent classes

Land extent	Percentage of growers who were aware of		
	CRIC60	CRIC65	Both
0.5 - 2	40	30	28
2-5	48	36	35
5-10	52	39	38
>10	69	58	56
Total	52	41	39

5.1.7 Transplanting seedlings

CRI has recommended various steps to follow when transplanting seedlings. During the survey the growers were asked whether they adhere to those practices (Table 16). Results in Table 16 indicated that more than 75% of growers had placed the seedling correctly (6" above soil) and used two layers of husk at the bottom of planting hole. However, the application of fertilizer and use of organic manure had been practiced by extremely few percentages of growers.

Table 16. Percentage of growers who adhere to the recommended steps when transplanting seedlings

Recommended steps at the time of transplanting	Percentage of growers practiced	
	2005	1993
Use of two layers of husks at the bottom of the planting hole	83	75
Basal NPK fertilizer dressing	32	20
Mix soil with organic manure	18	n/a
Keep the seedlings a little above soil (6")	78	75
Treat for termites	32	19
Place a mulch after planting	60	n/a

(n/a - has not been included in the 1993 survey)

Further, use of termite treatment prior to transplant was low (32%). Not practicing these recommendations may increase rate of casualties of seedlings in the field. The percentages of fertilizer application were significantly different among land extent classes, CCBRR and AERR ($p<0.005$) and out of these three factors land extent was the most influential factor on the use of various practices. Results also indicated that there was a slight improvement in all steps of recommendations at the time of transplanting of seedlings. Results in Table 17 indicated the fertilizer usage was the lowest at the time of transplanting, in all land extent classes.

Table 17. Use of fertilizer for coconut seedlings by land extent classes (percentage of growers' who used)

Use of fertilizer	Percentage of growers in the land extent class (ac)				
	0.5-2	2-5	5-10	>10	Mean
At the time of transplanting	18	28	30	52	32
After six month	37	47	53	62	50
After one year	41	64	73	76	62
Regularly (after one year)	32	41	59	67	50

The percentage at fertilizer usage for seedlings was higher during six months and one year after transplanting. After one year the corresponding percentages had dropped in all land extent classes. In all stages of fertilizer the percentage of growers who applied fertilizer increased with the increase of land extent classes. The analysis also found that watering of seedling during dry period was done by 50% of the growers in all land extent classes. The above results indicated that lack of proper management would effect the poor growth of seedlings and delaying of bearing stage

5.1.8 Reasons for casualties of seedlings

Of the 543 growers interviewed in the survey, only 19% expressed that no casualties of seedlings due to any reasons. The ranking order of various reasons for casualties is shown in Figure 14.

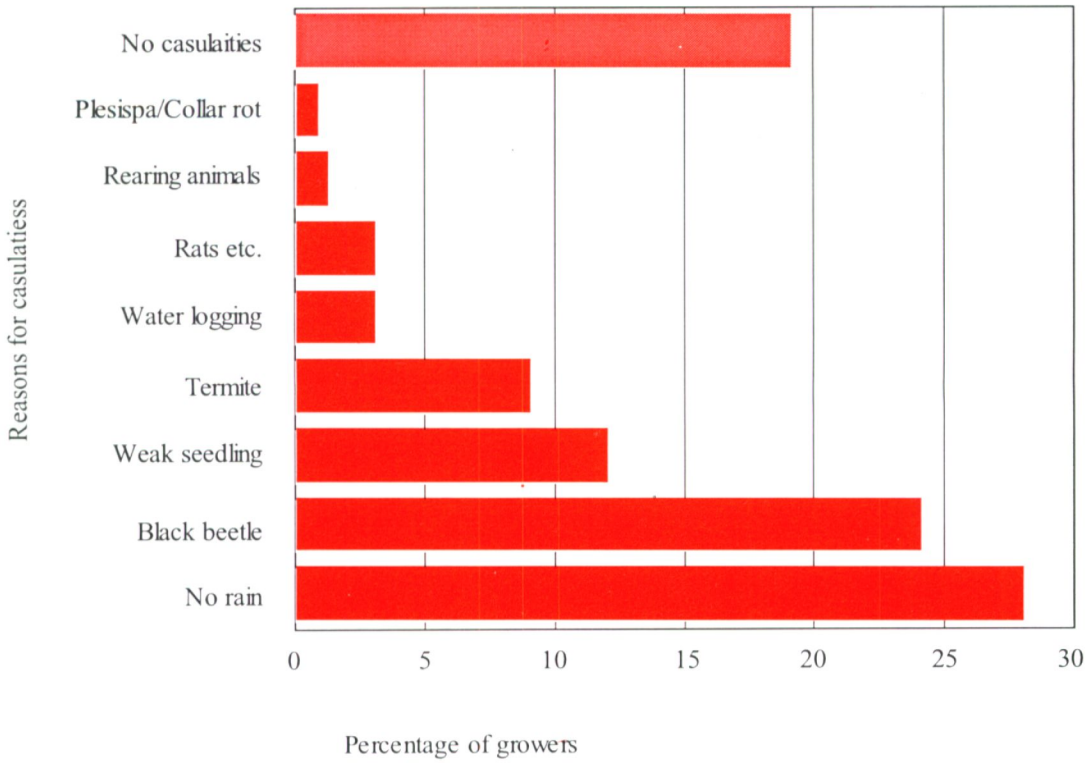


Figure 14. Ranking order of the reasons for casualties of seedling

Results indicated that the major reasons for casualties of seedlings were lack of water and black beetle followed by weak seedlings and termite problem. The problems due to rats, hedge-hog etc was slightly higher than the problem due to rearing animals. Such problems were location specific (Table 18). These results suggest that growers should be educated to control black beetle to reduce seedling mortality. Nevertheless it was observed that the growers were reluctant to go around in their holdings regularly to check the seedlings. The reason for weak seedling would be due to lack of proper care at the time of transplanting or due to planting of poor quality seedling raised incorrectly.

Table 18. Major reasons for seedling mortality in different CCBRR

CCBR	Main reason	% of Mortality
Anuradhapura	Black beetle	50
Galle	Black beetle	50
Gampaha	Weak seedling	13
Hambantota	Weak seedling	45
Kalutara	Black beetle	32
Kegalle	Rats/porcupines	32
Kuliyapitiya	Black beetle	38
Kurunegala	No rain	30
Marawila	No rain	44
Monaragala	No rain	37
Ratnapura	Weak seedling	43

5.1.9 Rate of seedling mortality

The percentage of seedling mortality was highly varied (cv = 70%) within a CCBR and between regions. Ignoring all factors such as AERR, LSC for coconut, soil type, CCBRR and land extent classes the mean percentage of mortality was (11.4±1.4) %. Of these four factors, the mortality rate was significantly influenced by the CCBRR.. The highest mortality percentage was recorded in Hambantota (19.7±6.4) and lowest was in Anuradhapura (4.6±1.5) as depicted in Figure. 15.

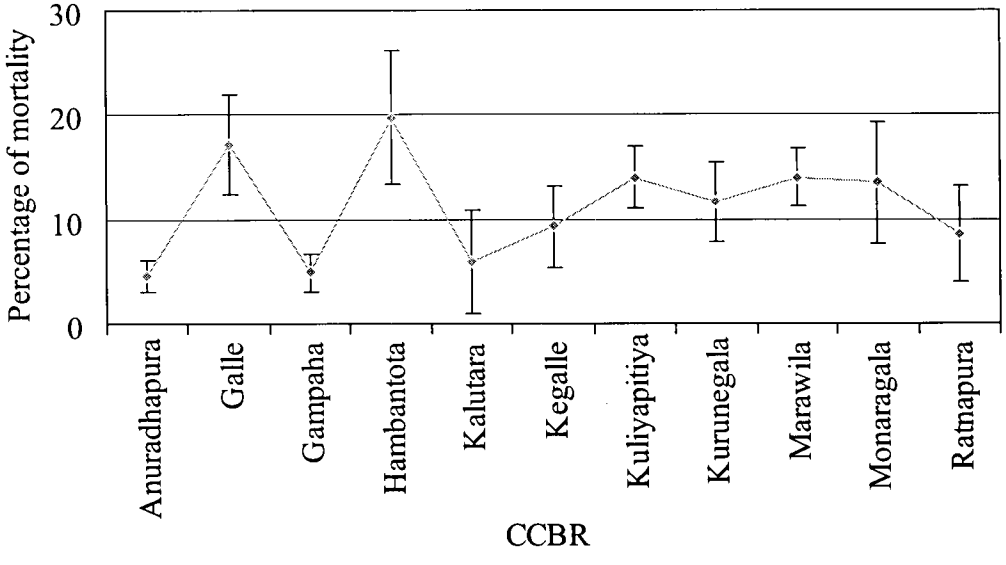


Figure 15. Percentage of seedling mortality (mean ± se) by CCBRR

Chapter 6

USE OF FERTILIZER

6.1 Fertilizer Mixtures

6.1.1 Awareness of new fertilizer recommendations

During 2002 the CRI recommended two separate fertilizer mixtures for the bearing palms in Dry zone and Wet and Intermediate (Wet Int) zones namely APM_D and APM_W respectively. Similarly two fertilizer mixtures for young palms in Dry zone (YPM_D) and Wet and Intermediate zones (YPM_W) were recommended. The main reason in recommending different mixtures was the two different sources of phosphate to different agro-ecological zones. Eppawala rock phosphate (ERP) and imported rock phosphate (IRP) had been recommended as a source of phosphate for coconut lands in Wet Int zone and Dry zone respectively. The introduction of ERP as a P source was able to save the cost of fertilizer and save the foreign exchange.

The application of dolomite had been recommended few days after application of normal NPK fertilizer mixture as it was not recommended to mix dolomite and urea together. However, according to new fertilizer recommendations described above dolomite can be applied along with NPK mixtures as no significance loss of nitrogen was found when it is mixed with urea based mixtures

The growers' awareness of the above aspects of new fertilizer mixtures were evaluated in the survey. The analysis showed that only 14% and 13% of growers were aware of new adult palms and young palm mixtures respectively. The percentage of awareness was significantly different among land extent classes, AERR, and CCBRR ($p< 0.005$), but none of the interactions was significant. The corresponding results by land extent class, by AERR and by CCBRR are given in Tables 19, 20 and 21 respectively.

Table 19. Percentage of growers aware of the new fertilizer recommendation for adult and young palms, different sources of P and mixing of urea with dolomite by land extent classes

Land extent group	Fertilizer mixtures of		P source is from		Urea can be mixed with dolomite at the time of application
	young palms YPM_D /YP_M	adult palms APM_D /APM_W	ERP for Wet/Int zone	IRP for Dry zone	
0.5 - 2	8	8	4	4	11
2-5	9	9	4	4	11
5-10	13	11	6	6	28
>10	25	24	22	22	38
Total	14	13	9	9	21

Table 20. Percentage of growers aware of the new fertilizer recommendation for adult and young palms, different sources of P and mixing of urea with dolomite by AERR

AER	Fertilizer mixtures of		P source is from		Urea can be mixed with dolomite at the time of application
	young palms YPM_D /YP_M	adult palms APM_D /APM_W	ERP for Wet zone	IRP for Dry zone	
IL_1	12	11	9	9	23
IL_3	22	23	13	12	28
WL_1	17	17	5	5	15
WL2	28	27	23	23	40
WL_3	5	3	1	1	15
DL_1	0	0	0	0	5
DL3	14	14	8	8	12
Total	14	13	9	9	21

Table 21. Percentage of growers aware of the new fertilizer recommendation for adult and young palms, different sources of P and mixing of urea with dolomite by CCBRR

CCBRR	Fertilizer mixtures of		P source is from		Urea can be mixed with dolomite at the time of application
	young palms YPM_D /YP_M	adult palms APM_D /APM_W	ERP for Wet zone	IRP for Dry zone	
Anuradhapura	0	0	0	5	5
Galle	30	30	25	25	20
Gampaha	5	3	1	1	15
Hambantota	20	20	15	15	15
Kalutara	17	17	9	9	32
Kegalle	39	35	31	31	58
Kuliyapitiya	14	13	10	10	28
Kurunegala	13	13	7	7	25
Marawila	13	13	9	9	18
Moneragala	9	9	9	9	9
Ratnapura	10	10	0	0	0
Total	14	13	9	9	21

Results clearly indicate that the knowledge of fertilizer mixtures was in a very unsatisfactory level indicating that the most important aspect of coconut cultivation had not gone to growers. The growers in Kegalle showed the highest awareness rate. The growers in Anuradhapura were not aware of all five aspects described above (Table 21). Trend of the awareness for new young palm mixture and adult palm mixture are the same. The percentage of awareness among large extent holders was significantly higher than that among other growers. Based on the rate of awareness for new fertilizer mixtures for adult and young palms the ranking order of the selected CCBRR was: Anuradhapura < Gampaha < Monaragela < Ratanapura < Marawila < Kurunegela < Kuliyapitiaya < Kalutara < Hambantota < Galle < Kegalle.

6.1.2 Awareness of different P sources

Results of the above tables clearly indicate that almost all the growers were not aware of the two different P sources in the mixtures. Irrespective of land size of the growers only 9% of the growers were aware of the phosphate source for fertilizer mixture for wet and intermediate zones from ERP and that for dry zone from IRP. However, 22% of large extent holders were aware of different P sources. No growers in Ratnapura region were aware of different P sources in the fertilizer mixtures. The awareness was significantly different among CCB regions.

6.1.3 Awareness of mixing urea with dolomite

The application of dolomite had been recommended few days after application of normal NPK fertilizer mixture as it was not recommended to mix dolomite and urea together. However, according to new fertilizer recommendations described above dolomite can be applied along with NPK mixtures a no significance loss of nitrogen was found when it is mixed with urea based mixtures. The results shown above indicated that 80% of the growers were not aware of the use of dolomite along with urea base mixtures. This percentages were extremely high (»90%) among the growers in the CCBRR of Anuradhapura, Ratnapura and Monaragela.

6.2 Awareness on Special Recommendation

Table 22. Growers' awareness on special technologies on fertilizers recommended by the CRI

Awareness of	Percentage of growers
Special fertilizer for king coconut	4
DFR based on leaf nutrients	20
Organic fertilizer mixtures	19
Straight fertilizer	46
Application of fertilizer via fertigation	18
Use of ethrel for toddy tapping	3

Results in Table 22 clearly indicate that awareness of the above technologies except use of straight fertilizer was very low. Results further showed that awareness of all the above technologies increased with the increase of land extent (Fig. 16).

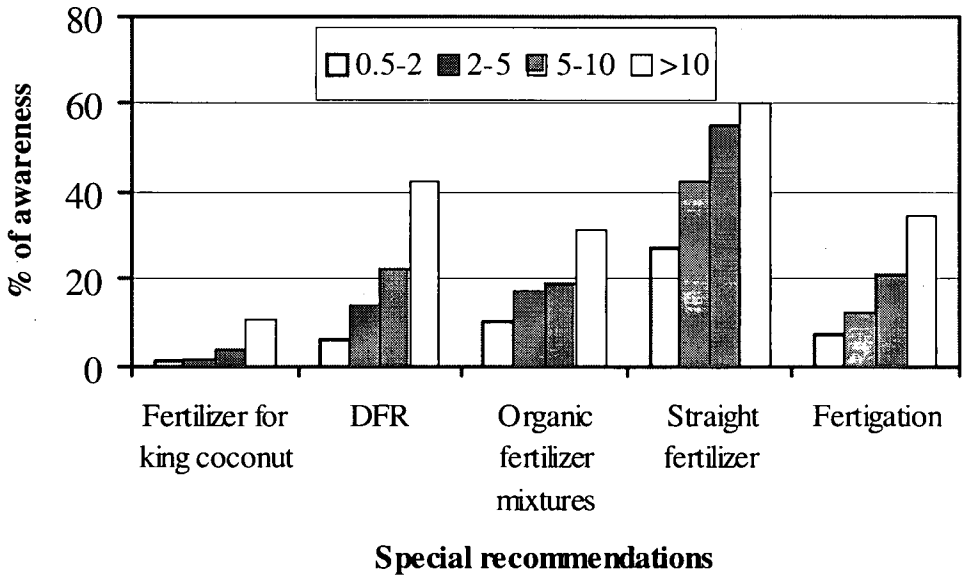


Figure 16. Growers' awareness of different fertilizer technologies by land extent classes

6.2.1 Fertilizer for king coconut

Results in Table 22 confirmed that the fertilizer recommendation for king coconut had not gone to the growers as it was aware of by 4% of the growers. The percentage of awareness of fertilizer for king coconut was highly significant among land size class ($p<0.001$) and it was below 1% among the small holders (0.5-2 ac) as against 10% among holders (>10 ac) as depicted in Figure 16.

6.2.2 Differential fertilizer recommendation (DFR)

The CRI has recommended fertilizers based on the nutrients status of palms, known as differential fertilizer recommendation (DFR) in 1988. This procedure allows early rectification of nutrient deficiency and avoids excessive use of fertilizer. The overall percentage of awareness was 20%. Of the CCBRR, the percentage of awareness of DFR was higher than the overall mean in Kurunegala(30%), Marawila (28%) and Kuliyapitiya(27%) indicating DFR was popular within the traditonal coconut triangle. The percentages of growers who aware of DFR in Hambantota, Ratnapura and Monaragala were zero. Of the growers having property of greater than 30 ac, 52% was aware of DFR indicating it is very popular among large extent holders.

This service was started free of charge. After 2001 a nominal fee was charged by the CRI for the analysis and the growers have to provide transport to take leaf samples. This service was later expanded to Coconut Cultivation Board as well. Thus, the use of DFR can be expected low when the estates are far away from the CRI as cost of transport would be high. However, awareness of DFR should be same among the growers irrespective of locations under an effective technology transfer system. About 20% of the growers were aware of DFR. This percentage of awareness of DFR showed an increasing trend with the increase of land size (Fig. 16).

The percentage of awareness among small holders (0.5-2.0 ac) was 5% as against 41% among large extent holders (> 10ac). As DFR identifies best dosage for the given coconut lands the

extension program of the CRI should be geared to popularize the DFR system to small holders as well. Because of the existence of DFR it is necessary to reconsider a common mixture rather mixtures based on soil conditions and agro-ecological regions. Further, it is necessary to incorporate LSC of coconut or any soil class policy as fertilizer absorption depends on the soil physical and chemical properties.

6.2.3 Organic fertilizer mixtures

In addition to inorganic fertilizer mixtures organic fertilizer mixtures were also recommended by the CRI to improve the soil fertility in coconut lands. Organic fertilizer mixtures were aware of by 19% of the growers. This percentage of awareness among the large extent holders (>10 ac) was 32% (Fig. 16) as against 3% among small holders. As organic fertilizers are readily available in small holdings the use of organic fertilizer should be highly popularized among small holders.

6.2.4 Straight fertilizer

CRI has been popularizing the use of straight fertilizers (inorganic) to avoid the use of poor quality inorganic fertilizer mixtures available in the market as well as to prevent the adulteration of fertilizers. The awareness of straight fertilizer was exceptionally high (60%) among the large extent holders (Fig. 16). Among small holders the awareness was nearly 30%. However, analysis found that a large gap between the awareness and use of straight inorganic fertilizer. The gap had been widening when the extent of land increased (Fig. 17) indicating that the large extent holders prefer to normal fertilizer mixtures than straight fertilizers.

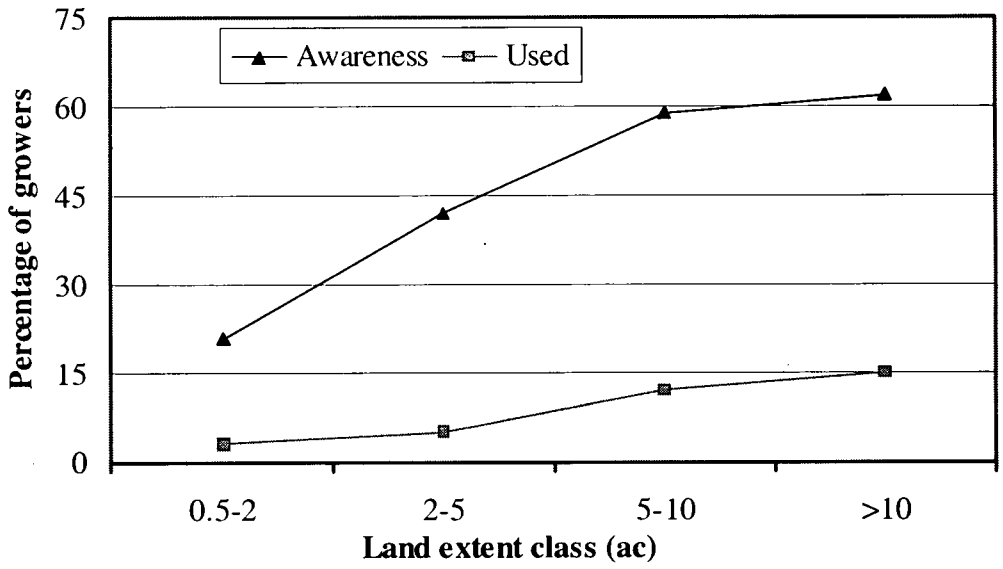


Figure 17. Gap between awareness and use of straight inorganic fertilizers

6.2.5 Fertigation

Fertigation is a method of application of fertilizer in a small quantity along with water. The advantages are this does not involve much labour cost, fertilizer can be supplied in a small quantity at different times throughout the year and increase efficiency of the rate of absorption. Only 18% were aware of this method. This system also popular among large extent holders

(34%) compared with 8% among small holders (Fig. 16). However, the efficiency of fertigation has not been compared with normal fertilizer application.

6.2.6 Use of ethrel

CRI recommended to use ethrel to increase toddy yield. Toddy tapping was practiced by 4% of the growers in the sample of which majority was from the CCBRR of Kalutara and Marawila. Of these two regions Kalutara is the most popular for toddy tapping and it is practiced mainly in the CDO ranges of Panadura, Kalutara and Beruwala. Of the growers who practice today tapping, 92% were not aware of the use of ethrel to increase the toddy yield. However, they used to apply malathene to increase the yield. The main constraint of the toddy tapers was low price offered for toddy. It was found that toddy tapping palms are fertilized with high dosage of fertilizer.

6.3 K and Mg Deficiency

K and Mg deficiencies are two common problems in coconut plantation due to insufficient and incorrect application of fertilizer. Generally these two deficiencies can be easily detected by visual observation of the colour of coconut fronds. However, K and Mg deficiencies were able to identify by 21% and 41% of the growers irrespectively land extent class (Table 23).

Table 23. Percentage of growers who aware of the identification of K and Mg deficiency by CCBRR

CCBRR	Percentage of growers aware of	
	K deficiency	Mg deficiency
Anuradhapura	15	30
Galle	25	55
Gampaha	26	77
Hambantota	20	20
Kalutara	6	29
Kegalle	45	69
Kuliyapitiya	19	40
Kurunegala	15	40
Marawila	25	30
Monaragala	9	9
Ratnapura	10	33
Total	21	41

According to the results in Table 23 the growers in the CCBRR of Kalutara, Monaragala and Ratnapura had the lowest awareness of K deficiency of coconut palms. The percentage of awareness in other region varied from 15% to 25%. The type of the treatment used for K deficiency was not included in the survey. As for other cases the rate of awareness of K and Mg deficiencies increased linearity from 8% to 41% and from 22% to 62% respectively with the increase of land extent class indicating that the small extent holders had less knowledge in identification such deficiencies in the coconut palms than the large extent holders.

The rate of awareness for the identification of Mg deficiency was significantly higher than that of K deficiency in all CCBRR except in the regions of Hambantota and Monaragala. Most of the growers in all CCBRR except Monaragala and Hambantota were able to identify Mg deficiency of the coconut palms and the awareness rate varied from 30% to 77%.

6.3.1 Treatment for Mg deficiency

Dolamite and Kieserite had been recommended to apply for Mg deficiency depending on the intensity of deficiency. Dolamite and Kieserite were applied for Mg deficiency by 41% and 11% of the growers respectively. The distribution of dolomite and kieserite application by land extent classes is shown in Figure 18. Nearly 45% of the growers had done nothing for Mg deficiency. A very high percentage of growers (65%) among small holders had not applied either Dolamite or Kiesarite (Fig. 18) indicating Mg deficiency can be seen more in palms in small holdings than in large holdings. Figure 18 clearly indicates that the application of dolomite has increased linearity with the increase of land extent.

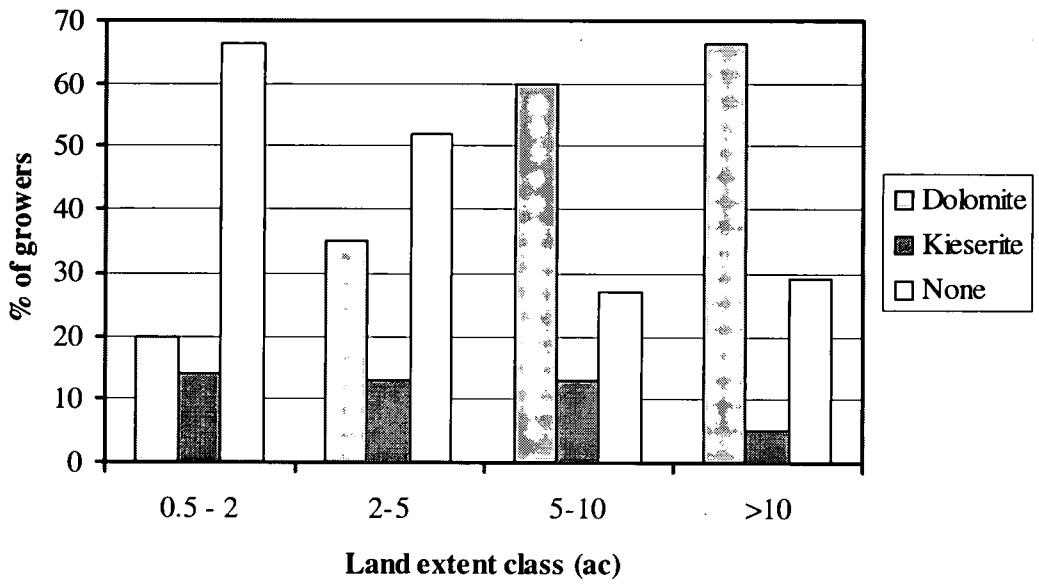


Figure. 18. Use of dolomite and kieserite for Mg deficiency by land extent classes

6.4 Manuring Adult (Bearing) and Young (Non-Bearing) Palms

The status of fertilizer application was studied separately for adult palms (bearing palms) and young palms (not yet bearing). In the survey it was found that growers did not avoid in fertilizing weak, diseases or senile palms even though the growers knew it was unproductive.

6.4.1 Frequency of applications

It was found that 43% had manured adult palms regularly (once a year) and 26% had manured at irregular intervals irrespectively of type of fertilizer (organic vs inorganic), amount of dosage per palm and the number of palms fertilized. The percentage of regular application of fertilizer significantly increased ($p < 0.05$) with the increase of land extent classes. The percentage of growers who had never applied fertilizer for adult palm was 31% (Fig. 19). The corresponding percentages for young palms were 35 (regular), 25 (irregular) and 45 (never).

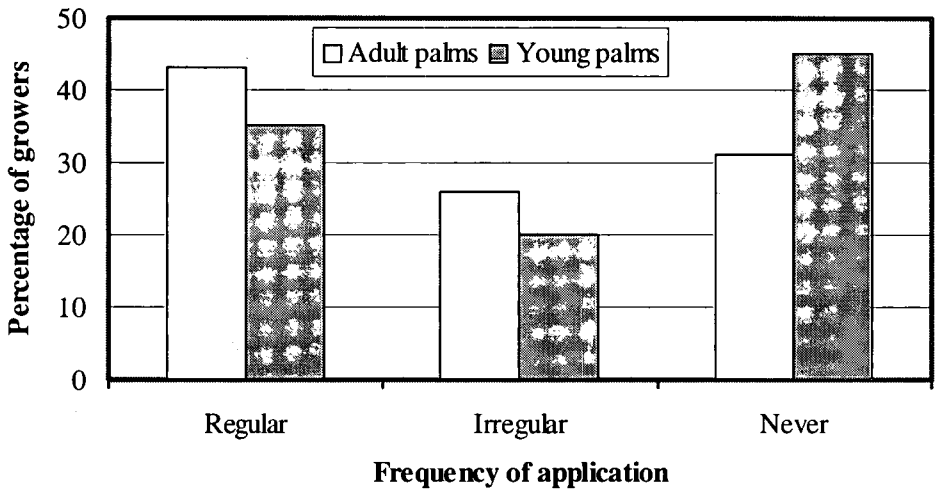


Figure 19. Frequency of fertilizer application for adult and young palms (irrespective of type, amount and fertilized extent)

Results in Figure 19 indicate that the tendency of applying fertilizer was generally higher for adult palms than young palms irrespective of AERR, CCBRR and land extent classes. Ignoring manuring at the pre-bearing stage would result poorly grown low yielding palms at early stage. The frequency of fertilizer application for adult palms and young palms was significantly different among land extent classes and CCBRR (Table 24).

Table 24. Percentage of fertilizer application for adult and young palms

(a) by CCBRR

CCBR	Adult palms			Young palms		
	R	IR	NF	R	IR	NF
Anuradhapura	50	10	40	40	20	40
Galle50	20	20	35	20	45	
Gampaha	57	12	31	45	2	53
Hambantota	20	5	75	20	0	80
Kalutara	45	20	35	28	14	58
Kegalle	33	20	47	45	20	35
Kuliyapitiya	40	28	32	35	28	37
Kurunegala	40	13	47	23	23	54
Marawila	50	26	24	40	20	40
Moneragala	9	0	91	20	9	71
Ratnapura	23	4	73	14	9	77
Total	43	26	31	35	25	45

(R- regular; IR- irregular; NF- not fertilized)

(b) by land extent classes

Land extent	Adult palms			Young palms		
class (ac)	R	IR	NF	R	IR	NF
0.5 – 2	31	22	46	19	18	63
2-5	40	26	34	31	20	49
5-10	60	16	24	46	13	41
> 10	65	16	19	49	23	28
Total	43	26	31	35	19	45

(R- regular; IR- irregular; NF - not fertilized)

Results indicated that the use of fertilizer for young palms was less compared to the use of adult palms in all land extent classes as well as in all CCBRR indicating that the tendency of applying fertilizer by the growers was high when palms were producing nuts. Inadequate manuring at the pre-bearing stage would result poorly grown low yielding palms.

The application of regular fertilizer showed an increasing trend for both adult and young palms when the increase of land extent classes. The percentage of coconut growers (>10ac) who applied fertilizer regularly for adult and young palm were 65% and 49% respectively (Table 24.b). The application of regular fertilizer for adult palms was lowest amount the growers in Monaragela region (9%) followed by Hambantota (20%) and Ratnapura (20%) regions. The rate of application of fertilizer for young palms was also lowest in the CCBRR of Monaragela, Hambantota and Ratnapura. Application of regular fertilizer for both adult and young palms was highest in Gampaha and Marawila.

Compared with frequency of application during 1993 the results suggested that the use of fertilizer during 2005 had been increased (Appendix A). According to the diagnostic survey conducted in 1993 the percentage of growers used fertilizer regular, irregular and never was 31, 21 and 48 respectively.

6.4.2 Effect of fertilizer on soil type and agro-ecological zones

The use of fertilizer used was significantly influenced (p=0.004) by the interactions of soil type (sandy/sandy loamy vs gravel/clayey) with agro-ecological zones (Wet/Intermediate vs Dry). The results are summarized in Table 25.

Table 25. Percentage of growers who applied fertilizer for adult palms by agro-ecological zones x soil types

Agro-ecological	Soil type						Overall total (%)		
	sandy/sandy loamy			gravel/clayey					
zone	R	IR	NF	R	IR	NF	R	IR	NF
Dry	65	26	9	42	24	34	57	26	17
Wet/Int	48	20	32	44	15	41	46	19	25
Total	50	23	27	46	16	38	43	26	31

(R-regular; IR- irregular; NF- not fertilized)

Results indicate that regular application of fertilizer in coconut lands in sandy/sandy loamy soils was significantly higher in dry zone than those in wet/intermediate zones. The regular application of fertilizer in coconut lands in gravel/clayey was not significantly different between two agro-ecological zones. The percentages of not fertilized lands were significantly higher in gravel/clayey soil than those in sandy/sandy loamy soils.

6.4.3 Type of fertilizer

The type of fertilizers used by the growers was categorized into four groups as shown in Figure 20. The majority of coconut growers used inorganic fertilizer (mixture) for both adult and young palms (Fig. 20). The use of inorganic (straight) fertilizers was very low in spite of continuous popularizations of straight fertilizer by the CRI and with the high percentage of awareness of straight fertilizer by the growers. This indicates that growers still prefer to use the available mixtures in the market. Results indicated that all types of fertilizer use were higher for adult palms than young palms.

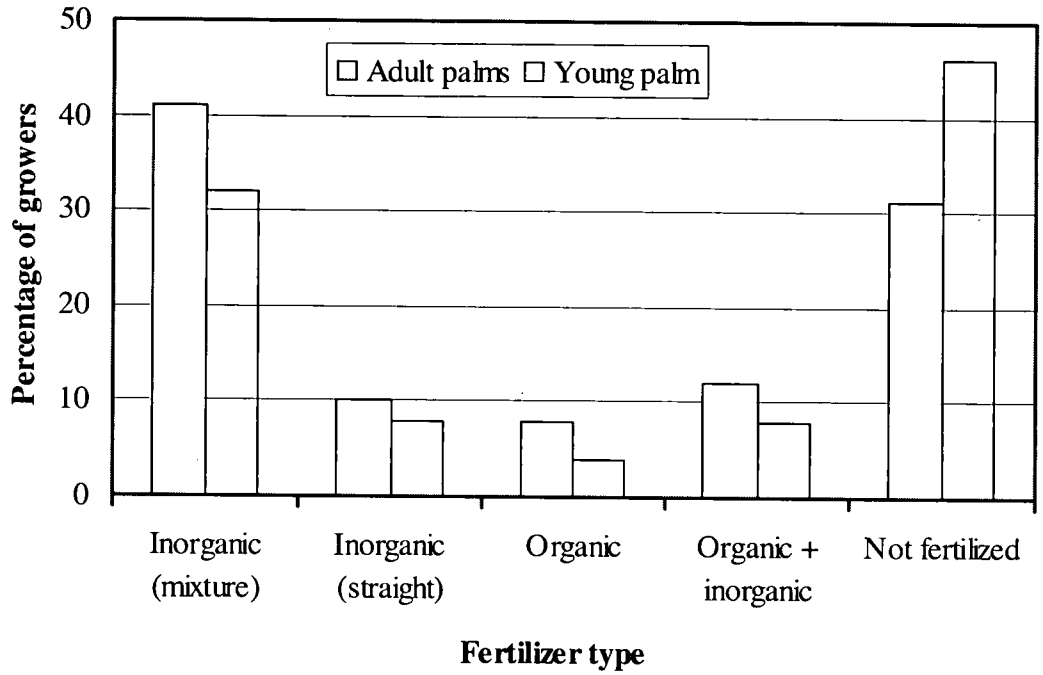


Figure 20. Percentage distribution of type of fertilizer used for adult and young palms by the growers (irrespective of frequency of application)

6.4.4 Type of organic fertilizers

The most popular organic fertilizer among the coconut growers who used organic fertilizer alone or organic fertilizer with inorganic fertilizer was cow dung followed by poultry dung (Fig. 21) for both adult and young palms.

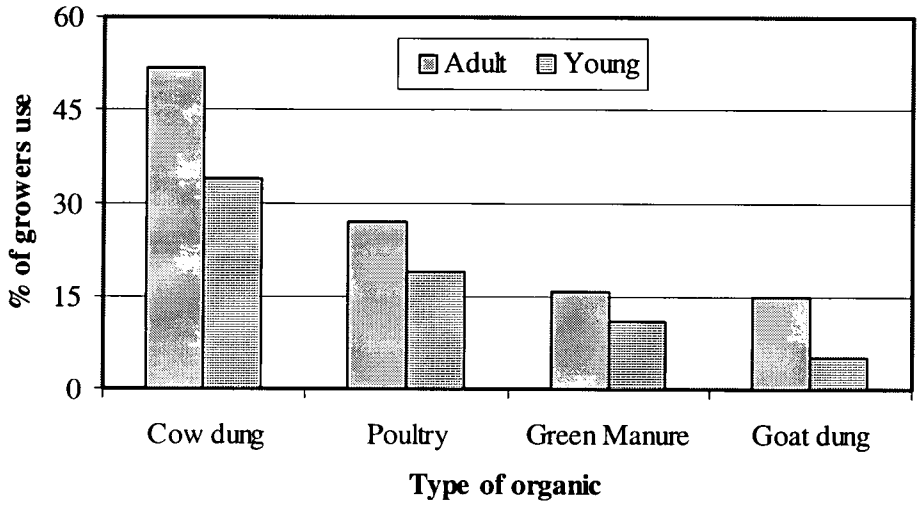


Figure 21. Percentage distribution of the type of organic fertilizers used for adults palms and young palms among the users of organic fertilizers

The percentage of goat dung application was higher for the adult palms than that for young palms.The percentage of green manure application was almost same for both adult and young palms. Thus irrespective of type of palms (adult or young) the preference order of organic fertilizers was: cow dung > poultry dung > green manure > goat dung. The application of goat manure with chemical fertilizer to CRI65 variety showed an increase of 35% nut yield and 40% copra yield (Tennakoon, 1990). However, this information has not gone to growers.

6.4.5 Method of fertilizer application

CRI has recommended different types of fertilizer applications from time to time. The present recommendations are: (a) surface dressing and mulch and (b) trench system (Fig. 22). Both methods have advantages and disadvantages. However, few growers had used digging system as well (Fig. 22).

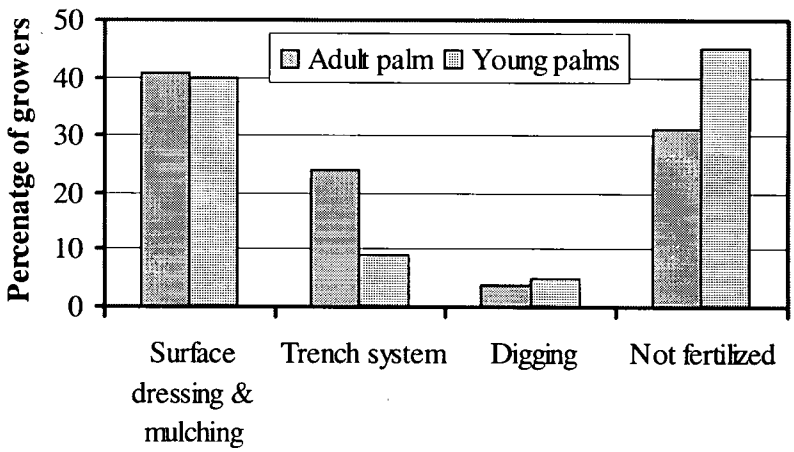


Figure 22. Distribution of fertilizer application methods used for adult and young palms

Results in Figure 22 indicated that popular method of fertilizer application was surface dressing and mulching for both adults and young palms irrespective of soil type and AER. In fact this system is the most efficient method. Surface dressing and mulching system was highly popular (>90%) among the growers in the CCBRR of Ratnapura, Moneragala, Hambantota, Kegalle, Gampaha and Galle (Table 26). It was found that some growers used to apply fertilizer very close to bole of the palms (within 3') which may reduce the full benefit. It indicated some growers were not aware of the correct way of fertilizer application. Further, it was found this technique can not be practiced in coconut lands where tea is grown, particularly coconut estates in Ratnapura and Galle.

About 25% of the growers had used trench system for adult palms while it was 10% for young palms. Both surface dressing and mulching and trench system had been practiced by the growers in main coconut triangle (Marawila, Kuliyapitiya, Kurunegala and Kalutara). Digging fertilizer in small holes around palms had also practiced by extremely few growers in the above four CCBRR, though this method has not been recommended by the CRI. Thus it is worth to find the impact of this system of fertilizing.

Table 26. Use of different methods of fertilizer application for adult palm by CCBRR (percentage of growers practiced)

CCBR	Method of fertilizing		
	Surface dressing and mulching	Trench system	Digging
Anuradhapura	66	34	0
Galle	94	6	0
Gampaha	92	8	0
Hambantota	100	0	0
Kalutara	57	29	14
Kegalle	91	9	0
Kuliyapitiya	50	36	14
Kurunegala	61	24	15
Marawila	42	55	3
Moneragala	100	0	0
Ratnapura	100	0	0

The surface dressing and mulching in gravel/clayey soils was significantly higher ($p< 0.05$) than that in sandy/sandy loamy soils (Table 27) indicating surface dressing was popular in gravel soils than sandy soils.

Table 27. Association between soil type and method of fertilizer application for adult palm (percentage of growers practiced)

Soil type	Method of fertilizing		
	Surface dressing and mulching	Trench system	Digging
Sandy/sandy loamy	55%	39%	6%
Gravel/clayey	68%	27%	5%

The practice of trench system in sandy/sandy loamy soils was also significantly higher ($p<$ 0.05) than that in gravel/clayey soils indicating trench system was popular in sandy/sandy loamy soils. Similar trend was observed for young palm as well.

6.4.6 Grower's view on fertilizer application

Irrespective of the use of fertilizer 22% of the growers believed that use of fertilizer has no guarantee to increase yield (Table 28). Even among fertilizer users, 10% of the growers mentioned that fertilizer has no guarantee to increase yield.

Table 28. Association between fertilizer use and yield increase (% of growers)

Fertilizer use	Yield increase due to fertilizer	
	yes	No
yes	90%	10%
no	41%	59%
Total	78%	22%

Further, about 30% among small holders (< 5 ac) and 12% among large extent holders (> 5 ac) also believe that the use of fertilizer has no beneficial effect. Such a thing could happen if the fertilizer was applied at incorrect time. However, of the fertilizer users 90% expressed that use of fertilizer does tend to increase yield (Table 28).

6.5 Amount of Fertilizer Used

CRI has recommended four separate inorganic fertilizer mixtures for adult palms based on two soil conditions (soil condition 1 and soil condition 2) and two agro-ecological zones (wet/ intermediate and dry) as shown in Table 29. The two soil conditions were: (a) soil condition 1 (lateritic or quartizitic gravelly loams) and (b) soil condition 2 (deep reddish or yellowish loams in coastal areas). Generally soil condition 1 belongs to S3 and S4 LSC for coconut and soil condition 2 to S1 and S2 LSC for coconut (Table 29).

Table 29. Amount of the recommended inorganic fertilizer (NPK) per palm per year by the CRI (each dosage requires 1 kg of dolomite)

Agro-ecological zone(AEZ)	Soil condition 1 (lateritic or quartizitic gravelly loams)	Soil condition 2 (deep reddish or yellowish loams in coastal areas)
Wet/Int.	4.30 kg	3.35 kg
Dry	4.00 kg	3.15 kg

(*Source*: CRI Advisory circular A5)

It clearly indicates that amount recommend for lands in S1 and S2 LSC was lower than that for lands in S3 and S4 LSC, though the potential yield per palm is much higher in S1 and S2 lands than that in S3 and S4 lands.

6.5.1 Inorganic fertilizer received per palm (based on the total sample)

Irrespective of the status of fertilizer application the survey revealed that the mean dosage of inorganic fertilizer received to an adult palm per year was 1.88 ± 0.12 (mean ± SE) with cv =90% indicating the average amount received was well below the recommended amount and also it had a greater variability. The cumulative distribution of fertilizer received by an adult palm per year based on the total survey is shown in Figure 23.

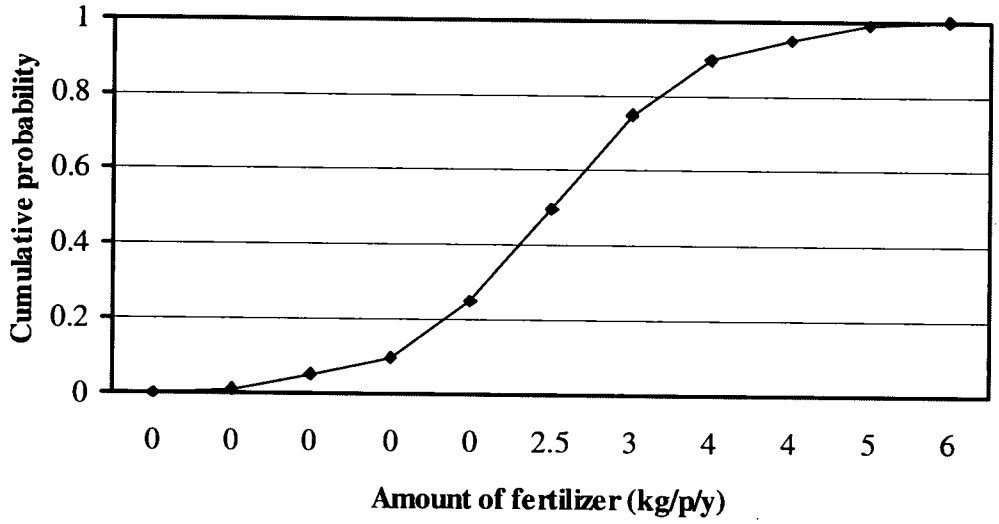


Figure 23. Cumulative distribution of fertilizer dosage received by an adult palm (based on total sample)

According to Figure 23, 22% of the growers in the survey had applied more than 3.0 kg/palm/ yr and 5% of the growers had applied more than 4.0 kg/palm/year.

The amount of fertilizer received by a palm per year based on the above classification for adult palm and young palm are shown in Table 30.a and Table 30.b respectively.

Table 30. Amount of NPK fertilizer received by a coconut palm per year (kg) by Agro-ecological zone (AEZ) x soil conditions based on the total sample (n=543)

(a) For adult palms

AEZ	Soil condition 1	Soil condition 2	Mean
Wet/Int	(1.61 ± 0.20)	(2.13 ± 0.28)	(1.80 ±0 .16)
Dry	(2.23 ± 0.62)	(2.26 ± 0.42)	(2.25 ± 0.34)
Mean	(1.67 ± 1.80)	(2.18 ± 0.22)	(1.88 ± 0.12)

(b) For young palms

AEZ	Soil condition 1	Soil condition 2	Mean
Wet/Int	(0.78 ± 0.14)	(1.02 ± 0.20)	(0.87 ± 0.12)
Dry	(0.88 ± 0.38)	(0.45 ± 0.14)	(0.59 ± 0.16)
Mean	(0.79 ± 0.12)	(0.85 ± 0.16)	(0.82 ± 0.16)

Results clearly indicate that amount of fertilizer received by both adult and young palms of the lands in the above four groups were significantly lower than the recommended dosage. The dosage of fertilizer received per palm per year increased with the increase of land extent in each group, but the difference was not statistically significant. This situation would lead depletion of essential plant nutrients in the soils and consequently yields reduction and high immature nut fall.

6.5.2 Amount of inorganic fertilizer applied for adult palms based on fertilizer users (n=374)

Based on growers who applied fertilizer for adult palm (irrespective of frequency) the amount of fertilizer applied for adult palms by soil conditions and AEZ is shown in Table 31.

Table 31. The amount of fertilizer received by a adult palm (kg/p/y) based on the growers who applied fertilizer irrespective of frequency (n = 374)

AEZ	Soil condition 1	Soil condition 2	Mean
Wet/Intermediate	2.67 ± 0.20 (38%)	2.79 ± 0.26 (17%)	2.75 ± 0.16
Dry	3.05 ± 0.50(24%)	2.57 ± 0.42(18%)	2.70 ± 0.34
Mean	2.77 ± 0.18	2.72 ± 0.22	2.73± 0.17

(Percentage of reduction with respect to recommended dosage according to Table 29 is shown in parathesis)

Results in Table 31 indicate that the amount of NPK fertilizer applied to an adult palm per year was about 40% less than the recommended dosage in the coconut lands of soil condition 1 in wet and intermediate zones. The corresponding amount in the coconut lands in soil condition 1 in Dry zone was 24%. The percentage reduction in coconut lands in soil condition 1 in both AEZ was below 18%. The distribution of the amount of fertilizer (per palm per year) received by fertilized palms irrespective of frequency is shown in Figure 24.

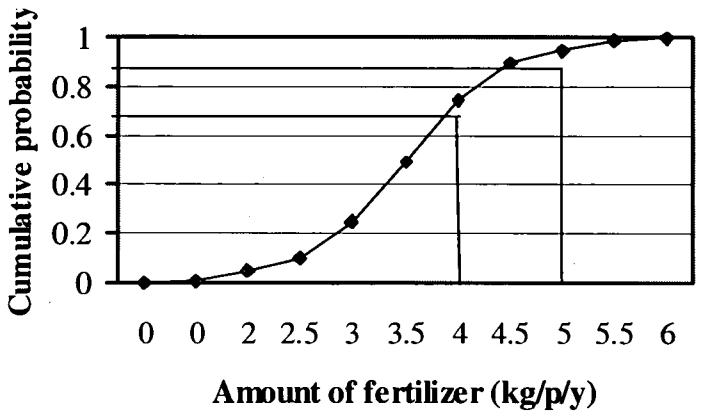


Figure. 24. Cumulative distribution of fertilizer dosage for adult palm per year (based on the growers who used fertilizer)

More than 50% of the palms in the coconut lands of which fertilizer was applied received at least 3 kg per year per palm. At least 5% of palms in the coconut lands of which fertilizer was applied received more than 5 kg per palm per year.

6.5.3 Amount of inorganic fertilizer received per adult palm based on regular fertilizer users (n=233)

Table 32. The amount of fertilizer received by a adult palm (kg/p/y) based on the growers who applied fertilizer regularly (n = 233)

AEZ	Soil condition 1	Soil condition 2	Mean
Wet/Int	(3.10 ± .14) (27.9%)	(3.33 ± 0.20) (0.6%)	3.20 ± 0.12
Dry	3.33 ± 0.40 (16.8%)	3.21 ± 0.38 (-1.9%)	3.24 ± .28
Mean	3.13 ± 0.14	3.29 ± 0.18	3.30 ± 0. 21

(Percentage of reduction with respect to recommended dosage according to Table 29 is shown in parathesis)

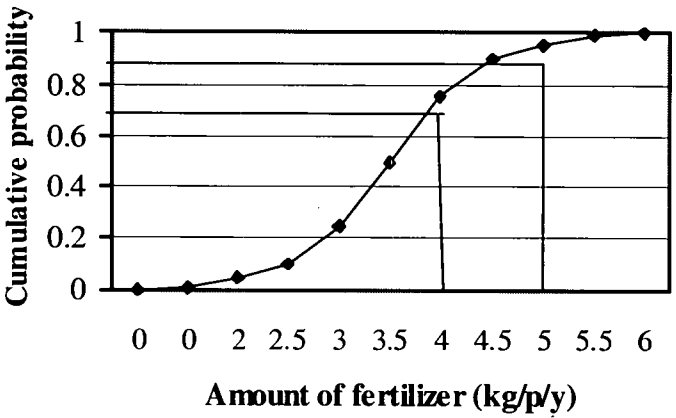


Figure 25. Cumulative probability distribution of fertilizer dosage for adult palm by regular users of fertilizer

Figure 24 indicates that among the regular inorganic fertilizer users, 10% of growers had applied more than 4.0 kg/p/y and 5% had applied more than 5.0 kg/p/y.

6.5.4 Amount of organic fertilizers used

Continuous application of organic manure improves the humus content in soil, water holding capacity, microbiological activities and nutrient retention of soils and consequently increases the yield. Unlike inorganic fertilizer dosage, the recommended organic dosage depends only on the soil conditions, but not based on agro-ecological zones (Table 33 a).

Table 33 a. Organic fertilizer dosage from different sources (kg/palm/year) recommended by the CRI

Type of organic	Soil condition	
	1 (lateritic or quartizitic gravelly loams)	2 (deep reddish or yellowishloams in coastal areas)
Cattle manure	30 Kg	20 Kg
Goat manure	25 Kg	20 Kg
Poultry manure	30 Kg	20 Kg
Gliricidia	30Kg	20 Kg

(*Source*: CRI Advisory circular A5)

According to Figure 18 only 20% in the sample had used organic fertilizer (organic alone by 8% and organic with inorganic by 12%) to adult palms. The amount of organic fertilizer used by those growers is shown in Table 33 b.

Table 33 b. Amount of organic fertilizer applied (kg/p/y) based on organic fertilizer users in the sample (n=108)

Type of organic	Soil condition		Mean
	1	2	
Cattle manure	15.9 ± 6.1 (47%)	11.6 ± 3.4 (42%)	13.1 ± 3.0
Goat manure	12.5 ± 9.0 (50%)	15.5 ± 6.2 (23%)	14.7 ± 2.5
Poultry manure	20.6 ± 4.4 (31%)	19.9 ± 6.2 (0.5%)	20.3 ± 3.6
Green manure	11.9 ± 6.5 (60%)	13.9 ± 10.4 (31%)	12.9 ± 7.6
Mean	16.4 ± 3.6	14.0 ± 2.8	15.1 ± 1.1

(Percentage of reduction with respect to recommended dosage in shown in paramethesis)

Irrespective of the type of organic the mean amount of organic fertilizer applied per palm per year was 15 ± 1.1 kg. Comparison of Table 33 a. and 33 b. indicate that mean amount of fertilizer received in all types of lands was below the recommended dosage. However, it was found that 10% of the organic fertilizer users (that is, 2% of the total sample) had used more than 30 kg/palm/year and 5% of them (that is, 1% of the total) had used more than 35 kg/p/year. The difference between the recommended level and the amount applied was higher in the lands in soil condition I than in the lands in soil condition II. The amount of green manure used for the lands in soil condition I and soil condition II was below 60% and 31% respectively.

6.5.5 Amount of organic fertilizers applied based on regular organic fertilizer users

The analysis confirmed that the growers who used green manure regularly for the lands in soil condition I were applied the recommended amount of green manure of 30 kg (Fig. 26). Similarly the lands in soil condition 2 were received more than the recommended amount of green manure of 20 kg. However, the correct amount of green manure alone does not sufficient to fulfill the fertilizer requirement as it provides only N requirement and so other fertilizer should be supplemented from different sources.

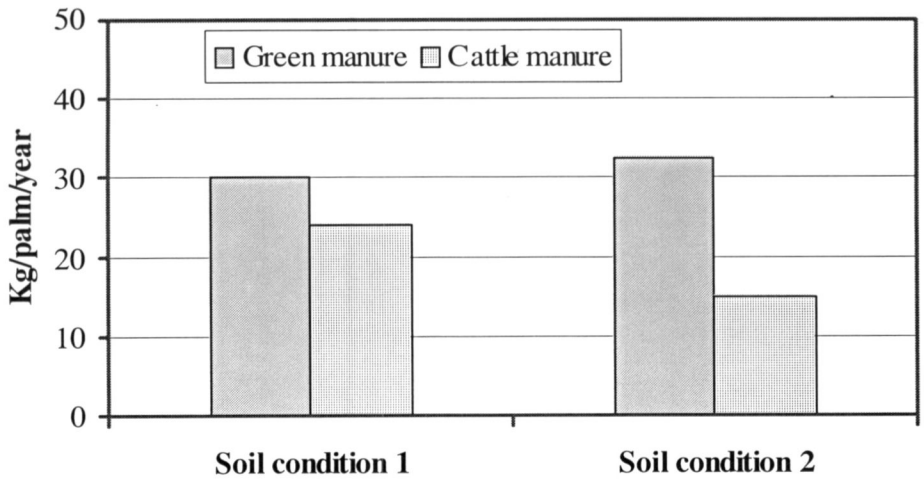


Figure. 26. Amount of green manure and cow dung applied for coconut palms (kg/p/y)

The analysis confirmed that all the growers in the sample who used organic fertilizer had not applied the correct fertilizer recommendation.

6.5.6 Alternative use of inorganic and organic fertilizer

Although organic manure and inorganic supplement had been recommended to apply annually for both young and adult coconut palm, alternative application of organic manure had been recommended for at least once in 3-4 years in order to improve the quality of the soil. Of the fertilizer users irrespective of the frequency and type of fertilizer only 11% had used alternative application of organic with inorganic. This percentage too increased with the increase of land extent class from 6% among small holders to 15% among large estate holders. However, data gathered is not sufficient to analyze further details.

6.5.7 Amount of fertilizer applied young palms

CRI recommended two types of fertilizers to young palms (non-bearing) namely YPM_W (fertilizer dosage for lands in Wet/Int zone) and YPM_D (fertilizer dosage for lands in Dry zone) irrespective of soil type. The frequency of application was six monthly intervals for wet/ intermediate zones from 0.64 kg/palm (at the age of six months) to 1.53 kg/palm (at the age of 4 years) and for dry zone from 0.525 kg/palm (at the age of six months) to 1.260 kg/palm (at the age of 4 years) along with 500 g. of dolomite at each six monthly intervals irrespective of agro ecological zone.

According to Figure 19 the frequency of fertilizer application for young palm was 35% (annually), 20% (irregular) and 45% (not fertilized). However, it was found that no growers applied fertilizer at six monthly intervals up to four years for young palms. As for adult palms, the amount of fertilizer applied for young palms was also computed under three scenarios (Table 34).

Table 34. Useful statistical indicators of the amount of fertilizer received for young palms (kg/p/y)

Statistical indicator	Based on thetotal sample	Based on thos who used inorganic fertilizer	Based on those who used inorganic fertilizer regularly
Mean	0.82	1.49	1.71
Median (50% level)	0.00	1.50	1.50
3rd quartile (75% level)	1.50	2.00	2.50

Result in Table 34 indicate that the mean amount of fertilizer received by a young palm was lower than the recommended dosage in each scenario. However, analysis found that 25% of the growers who used inorganic fertilizer had applied more 2.0 kg per palm. Similarly 25% of the growers who used inorganic fertilizer regularly had applied more 2.5 kg per palm

6.5.8 Constraints for fertilizing

The main reason for not applying fertilizer or not using the recommended dosage was that the use of fertilizer was not economical (Figure 27). This was due to the fact the nut price did not increase linearity as the cost of other inputs increase linearly. The economic analysis of fertilizer was not known on a dynamic nature which varies with time.

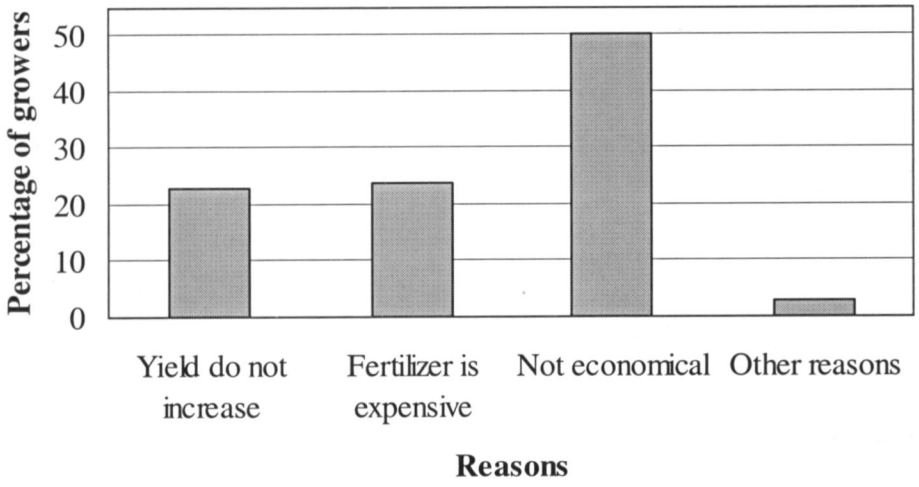


Figure 27. Reasons for not using fertilizer as recommended

Chapter 7

ANALYSIS OF UNDER PLANTATIONS

7.1 Percentage of Estates Having Under, New and Re Planting

In order to find some properties of under planting the growers were asked to specify whether their estate had at least one under, new or replanting block. The enumerator inspected that block to see the status of plantation. If there were more than one block, only one block having highest extent was taken in to consideration. Similarly if there were more than one system only one system was considered for the analysis. If the enumerators were unable to include any block into the above three groups then it was put into other group.

The analysis found that in the survey sample of 543, only 201 estates had a block of under plantation, 170 estates had a block of new plantation and 10 estates had a block of replanting. The corresponding percentages were 37%, 31% and 19% respectively. Results indicate that higher percentage of under plantations had taken place in the CCBRR of Kurunegala, Kuliyapitiya, Gampaha, Hambantota and Marawila. Majority of soils in the under planting lands of those regions was generally poor due to fertility degrading as old palms were either from third or forth generation plantation. More percentage of new plantings was taken place in Anuradhapura, Monaragala, Kegalle and Marawila. These lands can be considered as first generation for coconuts. The highest percentage of replanting (8%) was also taken place in Marawila followed by Kurunegala (6%). However, the extent of such block was not taken in this survey.

As the number of replanting estates was very low compared with the number of under planting or new planting estates, replanting estates were not considered for further analysis in this Chapter. The percentage distribution of under planting and new planting estates with a CCBR among the identified under and new planting estates is shown in Figure 28.

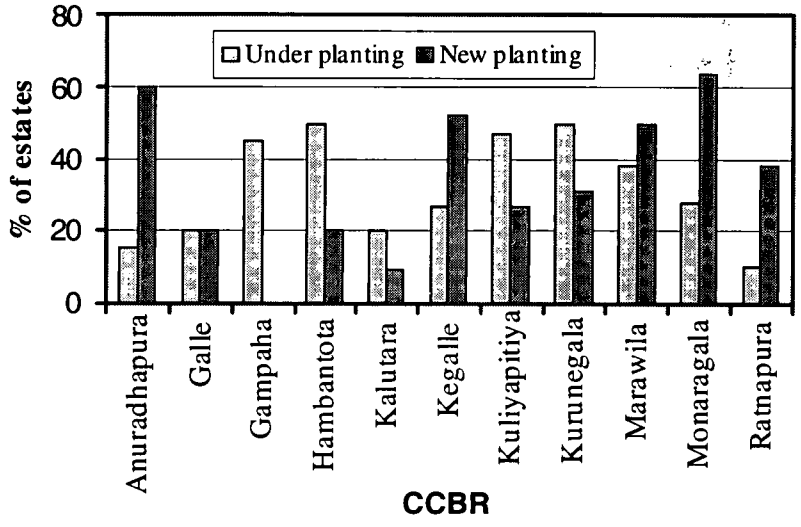


Figure 28. Percentage distribution of the number of estates having under planting and new planting

7.2 Status of Under Plantation

7.2.1 Age of the old and young palms

In the survey the age of old and young plantation in the under plantation block was obtained. The age of the young palms in the under plantation block varied from three months to 40 years with a mean of 14.5 years and CV of 81% (Table 35).

Table 35. Variability of the age of young and old palms in the identified under plantation blocks by CCBBR

CCBR	Age of young palms (mean ± se)	Age of old palms (mean ± se)
Galle	15 ± 7	50 ± 10
Gampaha	21 ± 3	64 ± 3
Hambantota	17 ± 6	55 ± 6
Kalutara	15 ± 5	56 ± 9
Kegalle	14 ± 4	54 ± 6
Kuliyapitiya	12 ± 2	60 ± 2
Kurunegala	12 ± 2	63 ± 2
Marawila	15 ± 1	60 ± 3
Monaragala	8 ± 5	55 ± 4
Ratnapura	6 ± 3	45 ± 3
Mean	14.5 ± 0.9	65 ± 6

Among the CCBRR the highest mean age of the young palms in the under plantation was in Gampaha (21 years) which varied from 3 to 40 years. The next highest was in Hambantota (17 years) which also varied from 4 months to 40 years. The mean age of the old palms in the under plantation was 65 years (CV=24%) with a minimum of 25 years and maximum of 100 years. The mean age of the old palms in the under plantation was also higher in the four CCB regions in the coconut triangle namely Kurunegala, Marawila, Kuliyapitiya and Gampaha. During the survey it was found that in almost all under planting blocks old palms were not yet removed.

7.2.2 Distribution of age of old plantation at the time of under planting

The age of old plantation at the time of under planting was taken as the difference between the age of old plantation at the time of survey and age of young plantation at the time of survey. The distribution age of the palms of the old generation at the time of replanting is shown in Figure 29.

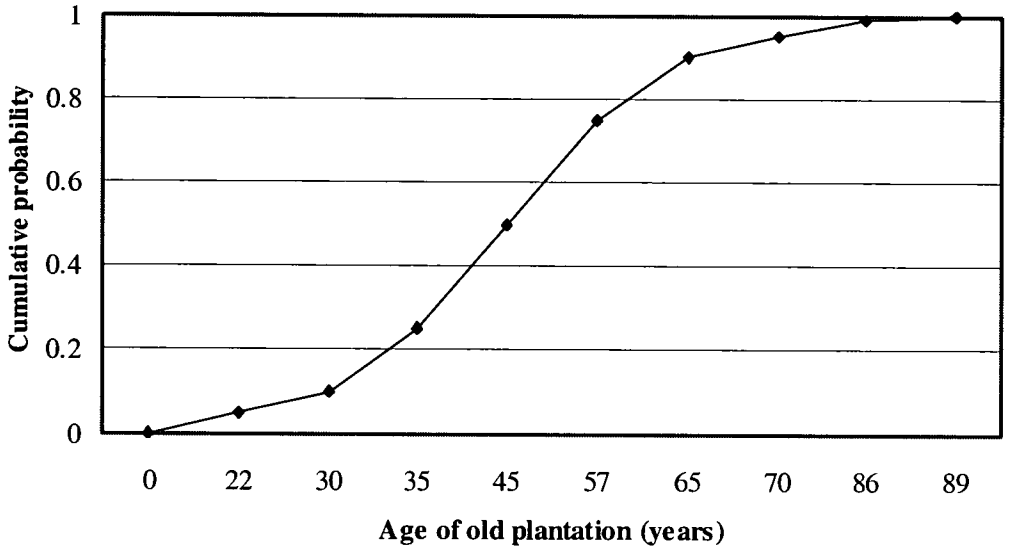


Figure 29. Distribution of age of the old palms in the under plantation

According to the results in Figure 29 it indicates that 50% of the under plantations were done before the age of old palms reached 45 years. About 25% of under plantations were done prior to the age of old palms reached 35 years. Thus it can be confirmed that most of under plantation had been done before the old plantation became maturity with respect to age. The productivity of those palms at the time of under planting was not aware by the growers and also such information can not be acquired.

7.2.3 Present status of under planting block

According to visual observation by the enumerators, out of under planting blocks only 35% of the blocks had established under planting correctly (Fig. 30). The old plantation had not been removed totally in 19% of the under planting blocks. Old plantation had been partially removed in 26% of the under planting blocks.

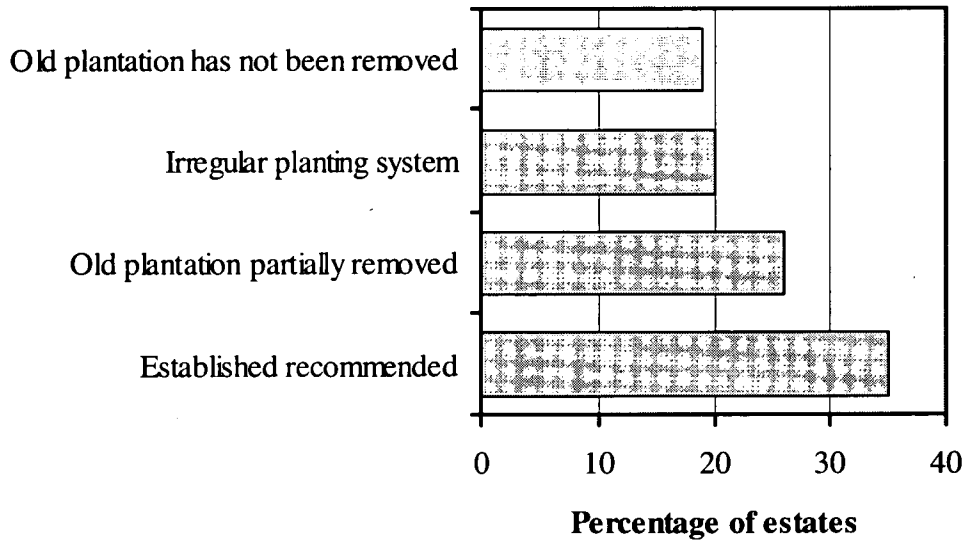


Figure 30. Enumerators' assessment of the under planting block

7.3 Comparison of Bearing Time

7.3.1 Mean time of young palms to bear

In order to compare performances of under planting and new planting with respect to bearing time the growers were asked to specify the time taken to bear 25%, 50% and 75% of the young palms (Fig. 31).

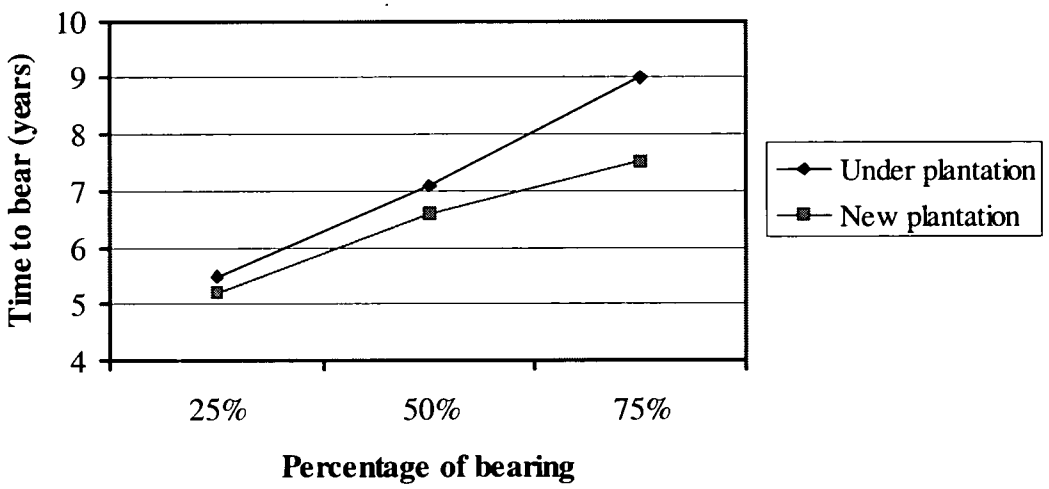


Figure 31. Comparison of mean time taken to bear in the three different planting systems

Results indicate that new replanting was more superior to under plantation with respect to early bearing. Time taken to bear 75% of palms in under planting system was significantly higher ($p < 0.005$) than the corresponding period for new planting system. The number of re-planting estates was low compared to the number of new or under planting estates. However, it was found that there was no significantly different on time to bear between new and re planting system.

In addition to the response from the growers the general performance of the growth of young palms in those blocks was assessed through visual observations by the survey team (Fig. 32.). The above results confirmed that both new planting and re-plantings were more superior to under planting.

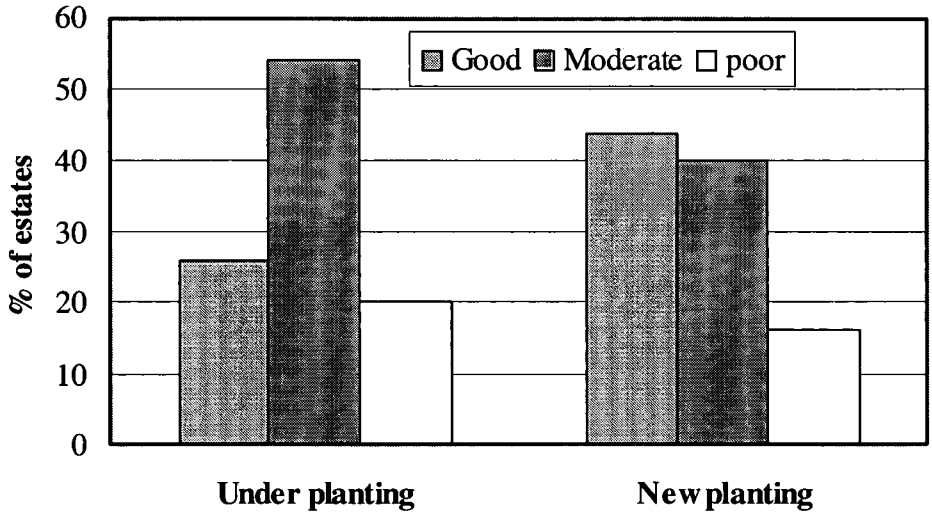


Figure 32. Assessment of the performance of young palms by the survey team.

Chapter 8

CONTROL MEASURES OF COCONUT PESTS

Pest and diseases is one of the major problems in coconut cultivation. However, in this survey major pests such as black beetle, red weevil, coconut mite, coconut caterpillar, and coconut scale and minor pests such as plesispa beetle and termites were considered. A separate survey was carried out parallel to this to find more details on coconut diseases. (Ranasinghe *et al*, 2006)

8.1 Status of Black Beetle

8.1.1 Lands having black beetle damage (BBD)

The damage of coconut seedlings due to black beetle is a very serious problem in coconut cultivation. In the survey 72% of the growers claimed that the black beetle damage had existed in their lands, but only 52% were aware that it was a serious problem in coconut cultivation (Table 36). Both types of the percentages were significantly different among land extent classes and among CCBRR, but the interaction was not significant.

As similar for the use of recommended cultural practices the percentage of coconut lands with black beetle damage too significantly increased with the increase of land extent class. About 80% of large estates (>10 ac) had black beetle damage, at least for one seedling. As explained in Chapter 6 it was difficult to acquire the information on the intensity of damage with respect to the number of seedlings for each estate in such survey.

Table 36. Percentage of coconut lands having black beetle damage (BBD) and percentage of coconut lands claimed that BBB is a serious problem

(a) by land extent class

Land extent class	% of coconut lands having BBD	% of growers claimed BBD was a serious problem
0.5 – 2.0	64	44
2.0 – 5.0	74	54
5.0 – 10.0	72	58
> 10	81	54
Mean	72	52

(b) by CCBR

CCBR	% of coconut lands having BBD	% of growers claimed BBD was a serious problem
Anuradhapura	75	55
Galle	85	75
Gampaha	58	50
Hambantota	45	40
Kalutara	60	38
Kegalle	50	50
Kuliyapitiya	84	62
Kurunegala	77	44
Marawila	79	49
Monaragala	82	45
Ratnapura	67	14
Mean	72	52

Results in Table 36.b indicated that the percentage of estates having black beetle damage in the regions within the coconut triangle and in the regions of Monaragela and Anuradhapura was higher than the corresponding national average of 52%. Among the CCBRR the overall percentage was lowest in Hambantota. Analysis also found that in almost all CCBRR black beetle damage was higher among large estates (>10ac). Small holdings (0.5-2 ac) in Gampaha showed significantly law percentage of black beetle.

8.1.2 Identification of black beetle damage

The four methods to identify black beetle damage are (i) geometric cuts in the leaf (ii) breaking of flag leaves and (iii) holes on petioler bases. The analysis found that 18% of the growers were not aware of any method of identification of BBD (Fig. 33). Majority of the growers (46%) were aware of more than one method of identifying BBD. The geometric cuts in the leaf were the most common method followed by holes in petioler bases to identify the damage.

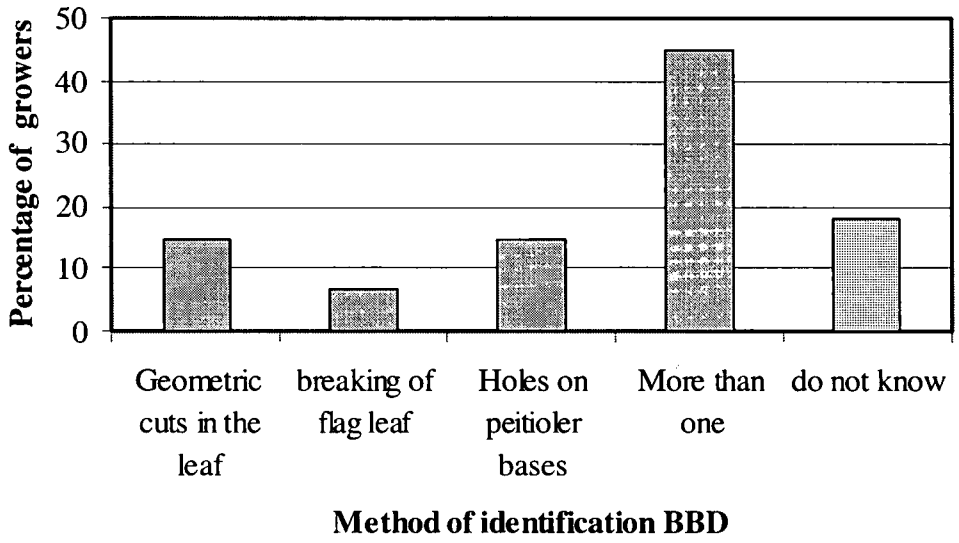


Figure 33. The method of identification of the black beetle damage in the coconut seedlings

8.1.3 Awareness of controlling black beetle damage

CRI has recommended various control measures to beetle damage and during the survey those recommendations were accessed based on the growers' experience. The main four are: (a) destruction of breeding ground, (b) extract beetle using a hook, (c) application of used engine oil/coal tar and (d) use of naphthalene ball/carbofurun. It was found that each of the controlling method except extract beetle using a hook was not aware by more than 50% of growers (Table 37). The awareness for each method of control significantly increased with the increase of land extent class.

The percentages of non-awareness of all four recommendations were significantly varied among the CCBRR ($p < 0.0001$). It is interesting to note that majority of growers (53%) were not aware of the use of naphthalene balls or carbofuran which was one of the oldest method among the four recommendations (Table 37). However, this percentage was exceptionally low in Anuradhapura region. More than 75% of the growers in Ratnapura region were not aware any of the recommendation. Also 60% of the growers in Hambantota were also not aware any of the recommendation.

Table 37. Percentage of non awareness of different methods to control of black beetle

CCBR	Percentage of non-awareness (%)			
	Destruction of breeding ground	Extract beetle using a hook	Application of used engine oil/coal tar	Use naphthalene balls or carbofuran
Anuradhapura	55	20	30	25
Galle	55	45	40	30
Gampaha	53	68	58	76
Hambantota	55	60	75	80
Kalutara	49	57	69	66
Kegalle	39	50	31	42
Kuliyapitiya	39	35	30	39
Kurunegala	42	49	43	44
Marawila	47	22	30	51
Monaragala	68	55	55	64
Ratnapura	80	90	76	85
Mean	50	43	52	53

8.1.4 Gap between awareness and practice of controlling methods

Among the growers had BBD the percentages of awareness for the above four control methods were 58%, 67%, 68% and 55% respectively. According to Figure 34 the use of controlling methods was very low (50%) for all recommendations. Among the four methods the highest percentage of growers (67%) had used a hook to extract the beetle. In fact it was the best method for small holders as it takes more time to cover a large area. The highest gap was observed for the application of used engine oil or coal tar. Though such materials were readily available and easy to apply growers had not used very much. In fact the highest awareness rate was observed for this recommendation.

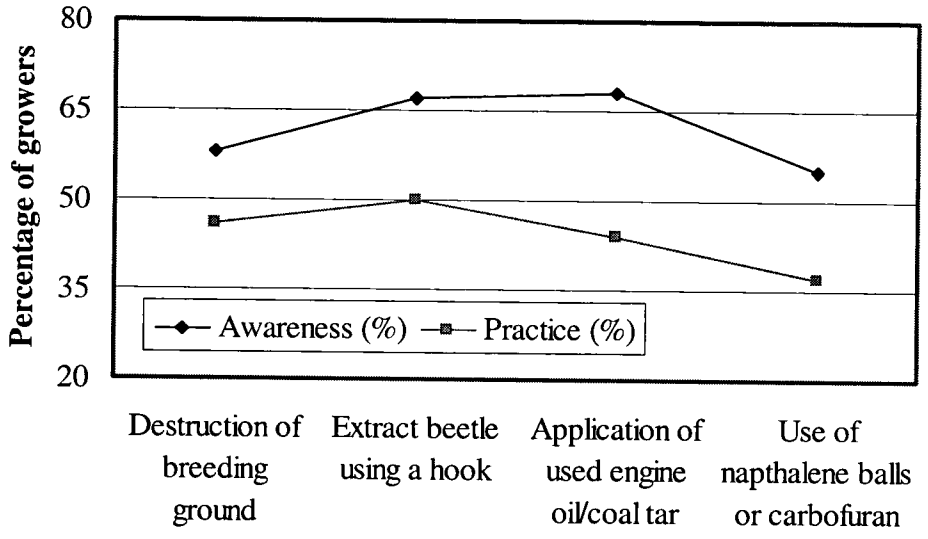


Figure 34. Gap between awareness and practice of the recommended methods to control black beetle

8.1.5 Integrated pest management (IPM) of black beetle control

The awareness in IPM of black beetle was defined as the percentage of growers who were aware of at least three of the above four recommendations (L. C. P. Fernando, *Pers Comm.*). That is, Pr(awareness of at least three methods out of four methods) = Pr(awareness of three methods) + Pr(awareness of all four methods).

Analysis found that only 44% of the growers were aware of IPM of black beetle (Table 38). The highest percentage of awareness in IPM of black beetle was reported in the regions of Kuliyapitiya and Marawila and the lowest was in Ratnapura region. As for other cultural practices the knowledge on IPM of back beetle too increased with the increase of land extent class. It varied from 28% among small holders to 65% among estate owners. Analysis found that 27% of growers were aware of all four control measures irrespective of land extent classes. Of the growers in the estate sector (> 10 ac) nearly 50% were aware of all four control measures.

Table 38. Percentage of growers who were aware of integrated pest management (IPM) of different pests in coconut cultivation

(a) by land extent class

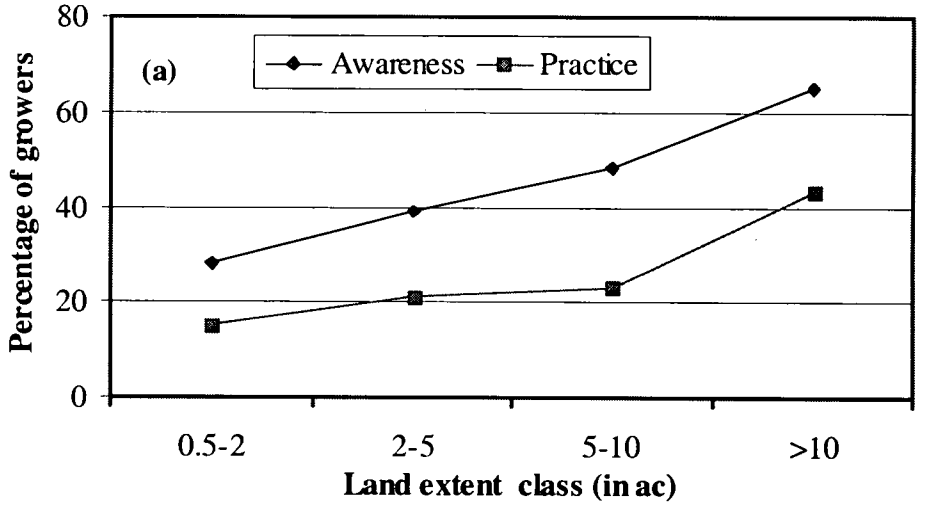
Land extent(ac)	Percentage of growers aware of IPM of		
	Black beetle	Red weevil	Coconut mite
0.5-5	28	31	14
2-5	39	46	25
5-10	48	62	35
>10	65	70	51
Mean	44	51	31

(b) by CCBR

CCBRR	Percentage of growers aware of IPM of		
	Black beetle	Red weevil	Coconut mite
Anuradhapura	55	85	45
Galle	50	60	5
Gampaha	23	24	11
Hambantota	20	30	10
Kalutara	31	54	11
Kegalle	54	61	38
Kuliyapitiya	58	57	38
Kurunegala	43	59	43
Marawila	56	53	44
Monaragala	18	64	0
Ratnapura	0	29	0
Mean	44	51	31

8.1.6 Gap on IPM of black beetle

The gap between awareness and practice of IPM of black beetle is shown in Figure 35. The overall gap was 18% as out of the 44% of the growers who were aware of IPM, only 26% practiced IPM system. Unlike for other practices the gap on IPM system did not show an upward trend with the increase of land extent class (Fig. 35.a). The highest gap (25%) was found among the growers having coconut lands of 5-10 acres.



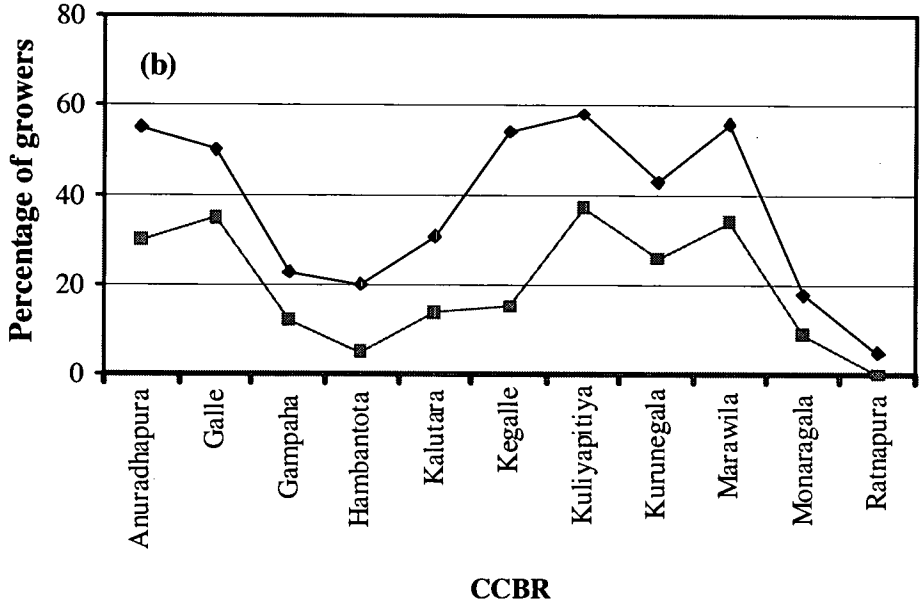


Figure 35. Gap between awareness and practice of IPM of black beetle (a) by land extent and (b) by CCBR

8.1.7 Growers' assessment on the control measures of black beetle

Among those who practiced the controlling methods were asked to rank each recommendation into (a) good control, (b) moderate control and (c) no control. Figure 36 indicates that about 60% of the growers claimed that each method moderately controls the black beetle. Based on the percentage of good control for each method, the methods can be ranked as: Extract beetle using a hook > use of napthalene balls/carbofuran > destruction of breeding ground > application of used engine oil/coal tar.

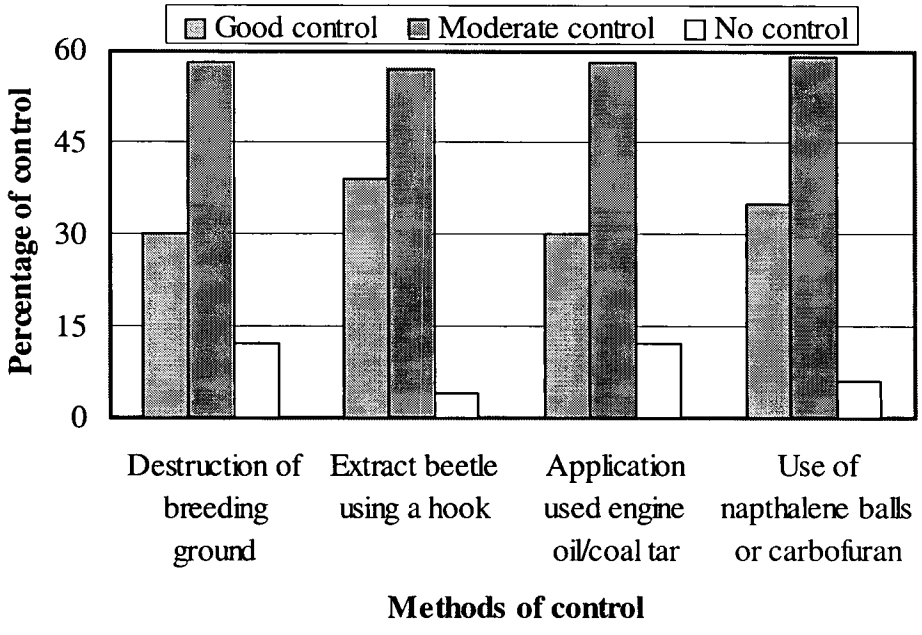


Figure 36. Comparison of growers' assessment for different recommendation to control BBD

These results confirm that it is necessary to promote use of IPM on BBD and develop more control measures for BBD. As the use of beetle hook was more popular among growers and most effective control measures it can be recommended to issue a beetle hook along with seedlings or make it available at the CCB nurseries.

8.2 Status of Red Weevil Damage (RWD)

8.2.1 Percentage of lands having RWD

Red weevil damage was reported only 56% of the coconut lands irrespective of land extent classes confirming that the percentage of red weevil damage was less than that of black beetle. It was also found that 84% of the estates having RWD had BBD indicating there was strong relationship between the existence of BBD and RWD. However, of the estates having BBD only 65% had RWD. The highest percentage of lands having red weevil was observed in large extent holders (Table 39). The percentage damage of red weevil was significantly lower (p = 0.05) among small holdings (0.5 -2 ac) than that in large extent holdings (>10 ac). In fact recent survey conducted in Kuliyapitiya area (Herath, *et a*l, 2004) reported that percentage of RDW was 65% among the holders (< 10 ac) and the age category of 5-10 years were identified as the most susceptible to RWD.

Table 39. Percentage of estates having red weevil damage

(a) by land extent class

Land extent (ac)	Percentage of lands
0.5 – 2.0	45
2.0 – 5.0	53
5.0 – 10.0	60
> 10.0	68
Mean	56

(b) by CCBR

CCBR	Percentage of lands
Anuradhapura	75
Galle	90
Gampaha	45
Hambantota	30
Kalutara	60
Kegalle	54
Kuliyapitiya	50
Kurunegala	67
Marawila	55
Monaragala	73
Ratnapura	48
Mean	56

The percentage of lands having red weevil damage (RWD) was also significantly different among CCBR and the highest percentage was reported in Galle followed by Anuradhapura. The percentage of RWD was the lowest (30%) in Hambantota and it was below the national average. Almost all growers expressed that RWD was a serious problem. It confirmed that the RWD had significantly higher impact on coconut cultivation than BBD.

8.2.2 Identification of red weevil damage

The majority of the growers were aware of more than one method in identification of RWD (Fig. 37). Only 26% was not aware of any method to identify red weevil damage, but little percentage of those estates (20%) had red weevil damage.

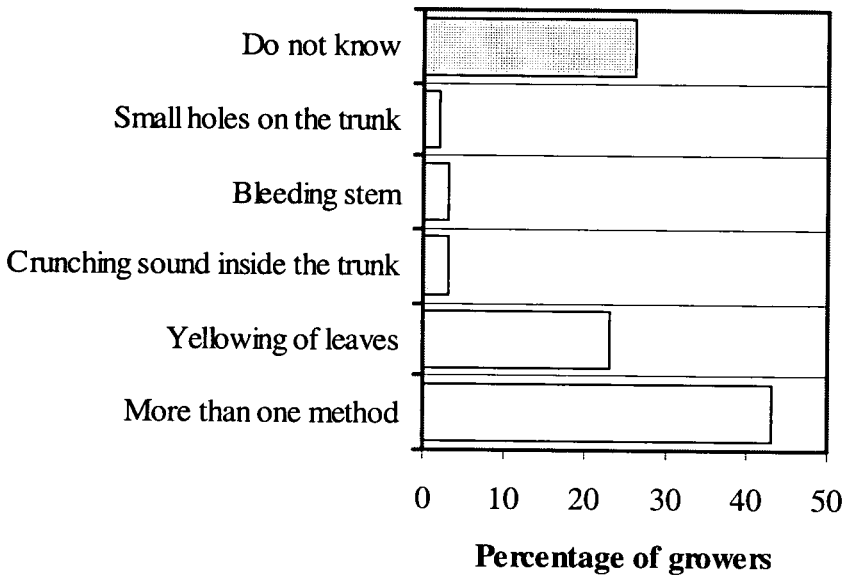


Figure 37. Growers' awareness for different methods of identification of RWD

8.2.3 Controlling measures for RWD

The rate of awareness for each of the above five control methods is shown in Table 40. Of the five control methods of red weevil recommend by the CRI, the majority of the growers (52%) were aware of proper disposal of dead palms infested by red weevil followed by regular checking of young palms.

Table 40. Percentage of growers aware of each recommended method of RWD

(a) by land extent

Land extent	Method of controlling RWD				
(ac)	I	II	III	IV	V
0.5 – 2.0	40	54	22	30	20
2.0- 5.0	42	61	36	50	36
5.0 – 10.0	61	74	50	50	44
> 10	72	88	55	65	64
Mean	52	68	40	48	40

(I - regular checking, II – disposal of dead palms, III – treatment of fresh wound, IV – use of monocrotophos, V- use of pheromone traps)

(b) by CCBR

CCBR	Method of controlling RWD				
	I	II	III	IV	V
Anuradhapura	75	80	25	95	75
Galle	65	75	35	60	55
Gampaha	27	42	19	30	26
Hambantota	30	45	20	30	20
Kalutara	66	74	31	54	40
Kegalle	84	88	38	46	46
Kuliyapitiya	52	72	48	52	50
Kurunegala	48	75	59	54	43
Marawila	56	72	45	49	40
Monaragala	82	100	55	36	36
Ratnapura	43	38	24	29	14
Mean	52	68	40	48	40

(I - regular checking, II – disposal of dead palms, III – treatment of fresh wound, IV – use of monocrotophos, V- use of pheromone traps)

8.2.4 Gap on red weevil control

Of the growers who had RWD in their lands the awareness of the above five control methods were 67%, 85%, 54%, 66% and 57% respectively. Among those who practiced any of the control method the highest gap was observed for use of pheromone traps and use monocrotophos (Fig. 38). It should be noted that about 80% of growers were aware of proper disposal of dead palms infested by red weevil and practiced the same in order to reduce the black beetle damage resulting very low gap.

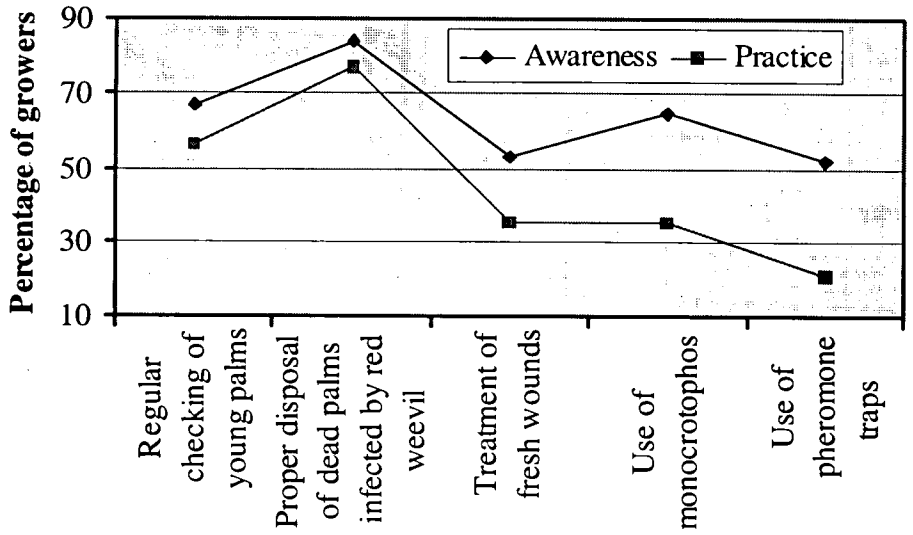


Figure 38. Gap between the percentage of awareness and percentage of practice for different recommendations on red weevil damage

8.2.5 Availability of pheromone and traps

Among these who were aware of the use of pheromone for red weevil control, 45% of the growers claimed that pheromones were not available. Further, 25% claimed that traps were not available to purchase. The results confirmed that both pheromone and traps had not been available together at the same time. Availability of pheromone was not significantly different either among CCBRR or land extent classes indicating that the above problem was almost same in all coconut growing regions as well as among coconut growers irrespective of land size. .

8.2.6 Availability of monocrotophos

Monocrotophos was also not available in the open market and it can be obtained only from CRI or from the CCBRR, once the recommendation was given by the Coconut Development Officer after inspecting the land. Monocrotophos is a restricted insecticide to import and it is presently recommended only for coconut. In the survey 70% of growers expressed that monocrotophos was not available to obtain (or to purchase) whenever they required resulting that the control of red weevil damage was ignored. The non availability of monocrotophos was significantly different among CCBRR (p=0.0037) and it was serious (>75%) in Hambantota and Marawila. However, the RWD was extremely low in Hambantota region compared with other regions (Table 39). The percentage of non availability was below 50% in Anuradhapura, Galle, and Kegalle regions. The non availability of monocrotophos was also significantly different among land extent classes (p=0.0007). It was very high (83%) among small extent holders as against 50% among large estates holders. This confirmed that access for monocrotophos was more difficult to small holders.

The time to obtain monocrotophos was varied from less than a week to eight weeks with a mean of 5.4 weeks. Thus it is necessary to make arrangements to access the coconut growers irrespective of the location and size of land for both traps/pheromone and monocrotopos if those recommendations to be followed.

8.2.7 Growers' assessment of the recommendations of RWD

The growers were asked to assess the effectiveness of each control method according to good control, moderate control and no control based on their experience. Based on the percentage of good control the five controlling methods can be ranked as: use of monocrotophos > regular checking of palms > treatment of fresh wound > proper disposal of dead palms > use of pheromone traps (Fig. 39).

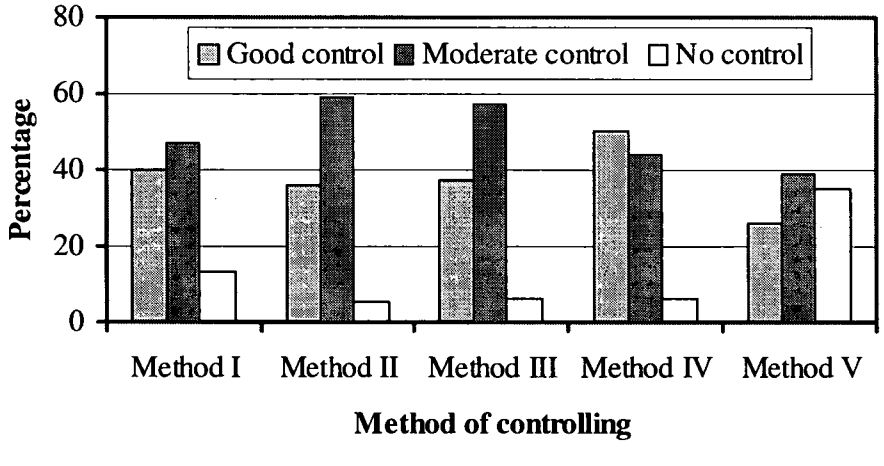


Figure 39. Growers' assessment of five recommended methods to control the red weevil (I - regular checking, II – disposal of dead palms, III – treatment of fresh wound, IV – use of monocrotophos, V- use of pheromone traps)

Of the five treatments the latest recommendation was the use of pheromone, but the highest percentage of growers ranked the use of pheromone as least effective method (Fig. 39). In fact among the growers having RWD both percentage of awareness and practice were the lowest for the use of pheromone traps. Similar trend had been identified in Kuliyapitiya area (Herath *et al.* 2004).

8.2.8 Gap on integrated pest management (IPM) of red weevil

As for black beetle, the awareness of at least three controlling methods out of five was defined as the awareness of integrated pest management system for red weevil (L. C. P. Fernando, *Pers Comm.*).

That is, Pr (awareness of integrated controlling method)

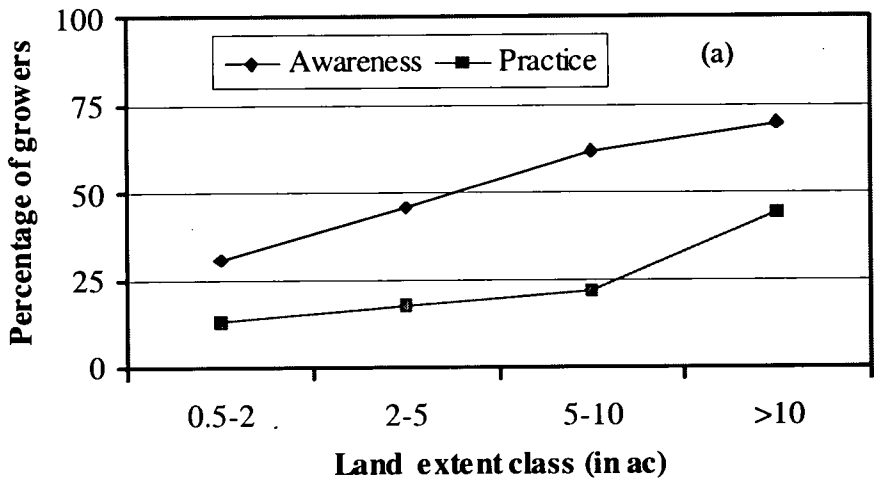
= Pr (awareness of at least three methods out of five)

= Pr (three methods were aware) + Pr (four methods were aware) + Pr (all five methods were aware).

Results found that 51% of the growers (irrespective of land extent size and CCBR) were aware of IPM of red weevil (Table 36), but only 25% of the growers had practiced IPM of RWD. The distribution of growers who were aware of IPM of RW by CCBRR and land extent classes is shown in Table 38. It can be seen that awareness of IPM of red weevil was higher than that of black beetle.

It is worth to mention that the aware of IPM of red weevil was the lowest in Gampaha region (24%) followed by the growers in Ratnapura region (29%) and Hambantota region (30%). The highest awareness rate on IPM of RWD was found in Anuradhapura. The gap between the awareness and practice of IPM of red weevil is shown in Figure 40.

All five methods of controlling of RWD were aware of by 21%. This percentage was highly significant among the land extent classes ($p<0.001$). The percentage of awareness of all five controlling methods varied from 6% among the small extent holders to 41% of the large extent holders.



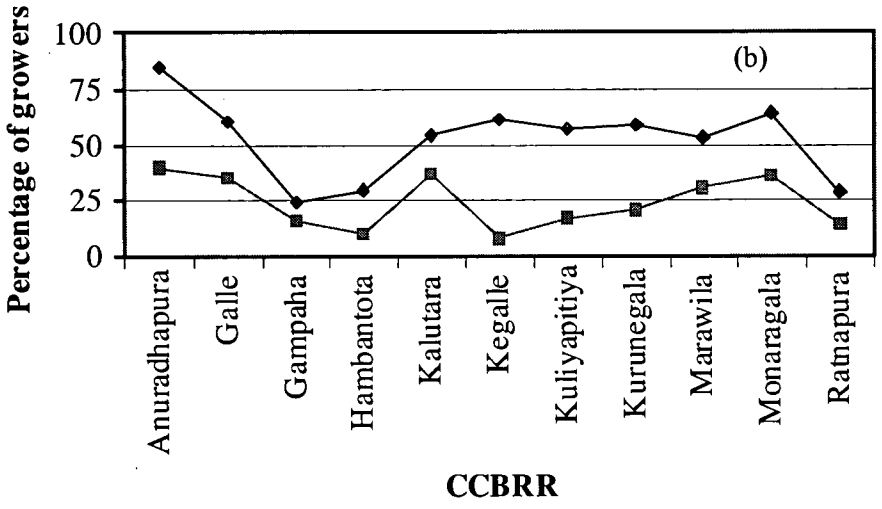


Figure 40. Gap on the use of IPM of red weevil (a) by land extent classes and (b) by CCBRR

Based on the above findings it can be confirmed that it is necessary to promote IPM system to control RWD. Further, it is necessary to implement a very efficient system to issue both traps/ pheromone and monochrotophos to growers. Implementation of farmer participation community programs at various locations for mass trapping is also recommended.

8.3 Coconut Mite

8.3.1 Distribution of lands having coconut mite

In the survey the growers were asked to specify whether they got at least few mite infested palms in their lands, but the number of mite infested palms were not taken due to obvious reasons. Sixty one percent (61%) of the growers expressed that they had mite infestation in their lands. Nine percent (9%) were not aware about mite infestation and 30% had no mite infestation.

The percentage of estates having mite infestation was highly significantly different among the CCBRR ($p< 0.0001$). The estates in Galle, Kalutara, Kegalle, Ratnapura, Moneragala and Hambantota had hardly mite infestation, but more than 90% of estates in Kurunegala, Marawila, Kuliyapitiya and Anuradhapura had mite infestation (Figure 41).

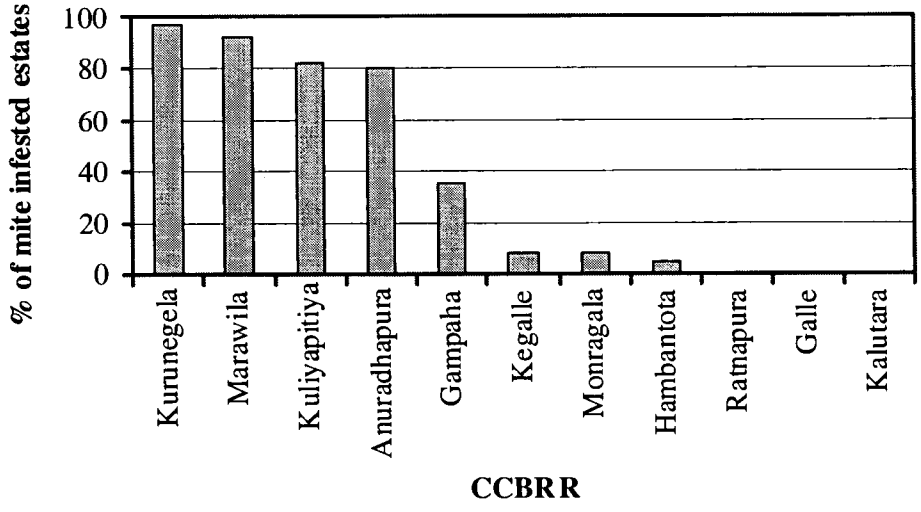


Figure 41. Distribution of the estates having mite infestation by CCBR

Of the five CCBRR having reasonable percentage of mite (Kurunegala, Marawila, Kuliyapitiya, Anuradhapura and Gampaha), it was found that the percentage of lands having mite infestation was significantly lower among small holders (0.5-2 ac) than medium or large extent holders (2-5, 5-10 & > 10 ac), but no significant difference was found between three large land extent groups (Fig. 42).

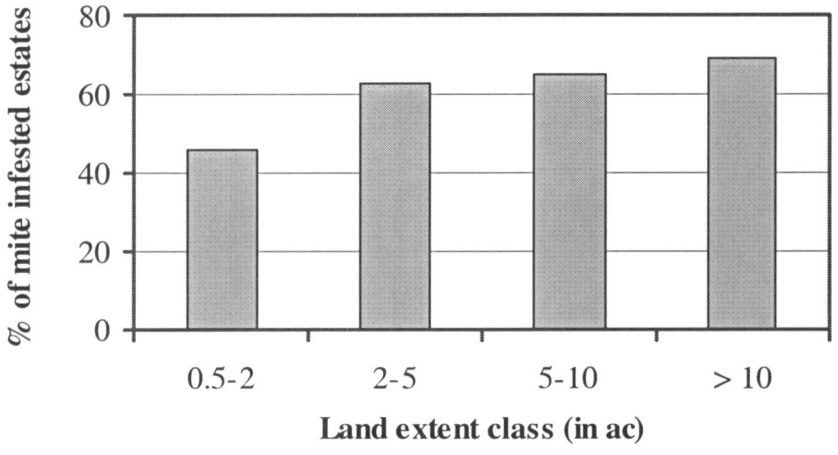


Figure 42. Distribution of the mite infested lands in CCBR of Kurunegala, Marawila, Kuliyapitiya, Anuradhapura and Gampaha by land extent classes

8.3.2 Identification of mite damage

It was found that more than 90% of the growers in the CCBRR of Hambantota, Ratnapura, Galle and Kalutara were not aware of to identify the mite infestation palms. This could be due to an obvious reason as mite infestation had not yet spread in those regions as in other regions. However, it would be necessary to educate those growers to identify coconut mite damage. In contrast almost all the growers in the CCBRR (Kurunegala, Monaragala, Kuliyapitiya and Anuradhapura) were aware of the identification of mite infestation.

8.3.3 Effect of cultural practices on mite infestation

In the CCBRR of Kurunegala, Marawila, Kuliyapitiya, Anuradhapura and Gampaha, the percentage of mite infested lands was not significantly different between status of the use of cultural practices such as mulching, husk pits and fertilizer (Fig. 43). These results confirm that there was no significant impact of recommended technologies such as use of mulch, husk pits and fertilizers on the percentage of mite infestation lands. However, it is worth to compare the impact of these technologies on the intensity of mite infestation palms.

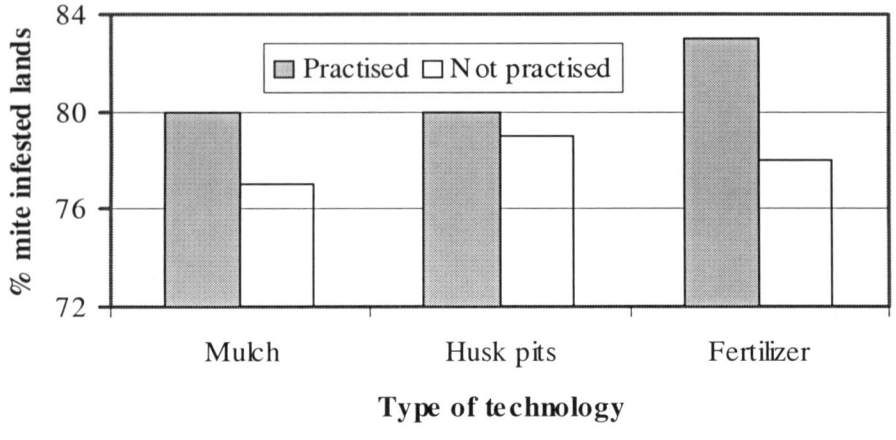


Figure 43. Distribution of mite infested lands under different cultural practices

8.3.4 Control measures for mite

Four recommendations to control coconut mite were released by the CRI since coconut mite was identified first time in Sri Lanka during late 1977. The percentage of awareness for each recommendation is shown in Table 41.

Table 41. Growers' awareness of different recommendations to control coconut mite

(a) by CCBRR

CCBR	Percentage of growers aware of		
	Use of engine oil	Bagging with sulphur	Use of margosamixture
Anuradhapura	95	25	60
Galle	5	5	5
Gampaha	70	12	8
Hambantota	15	10	10
Kalutara	25	20	14
Kegalle	50	27	46
Kuliyapitiya	65	33	47
Kurunegala	80	33	72
Marawila	62	42	55
Monaragala	0	0	9
Ratnapura	5	0	21
Mean	56	28	40

(b) by land extent classes

Land extent (ac)	Percentage of growers aware of		
	Use of engine oil	Bagging with sulphur	Use of margosa mixture
0.5-2	36	11	23
2-5	56	23	34
5-10	65	32	46
>10	72	48	59
Total	56	28	40

Results suggest that the use of engine oil was aware by many growers in all land size classes and in all CCBRs except Monaragala, Ratnapura, Galle, Hambantota and Kalutara where percentage of lands having mite infestation was very low (Fig. 42). Similarly as mite infestation was low in small coconut lands it can be confirmed that, though the use of engine oil can easily be practiced in small lands the awareness of this method was lower among small holders.

8.3.5 Gap on the use of mite control

The mite infestation was not reported in the CCBRR of Kegalle, Monaragala, Hambantota, Ratnapura, Galle and Kalutara. Therefore for the analysis of gap between awareness and practice

of each recommendation and the growers' assessment of each recommendation the above six regions were excluded. Further, as the recommendation on use of monocrotophos has been withdrawn it was also not included. The result on the analyses of gap between awareness and practice for the remaining recommendations is shown in Tables 42-44.

Both the percentages of awareness and gap were the highest for the use of engine oil in all the regions (Table 42) indicating that the use of engine oil was not accepted by many growers. The highest percentage of growers in Kurunegala region had used margosa mixture.

TTable 42. Gap between the awareness and practiced of used engine oil to control mite infestation by the selected CCBRR

CCBR	Percentage of growers		Gap (%)
	Aware of	Practiced	
Anurdhapura	94	31	63
Gampaha	88	31	47
Kuliyapitiya	74	13	61
Kurunegala	83	22	61
Marawila	62	7	55
Total	72	13	59

Table 43. Gap between the awareness and practiced of bagging with sulphur to control mite infestation by the selected CCBRR

CCBR	Percentage of growers		Gap (%)
	Aware of	Practiced	
Anurdhapura	31	0	31
Gampaha	23	0	23
Kuliyapitiya	42	3	39
Kurunegala	34	5	29
Marawila	42	4	38
Total	39	3	36

Table 44. Gap between the awareness and practiced in the use of margosa mixture to control mite infestation by the selected CCBRR

CCBR	Percentage of growers		Gap (%)
	Aware of	Practiced	
Anurdhapura	56	27	29
Gampaha	11	4	7
Kuliyapitiya	60	2	58
Kurunegala	75	28	47
Marawila	57	10	47
Total	57	11	46

8.3.6 Growers' assessment on the controlling methods of coconut mite

Based on the growers' assessment for each method, the application of used engine oil was ranked as the most effective treatment to control coconut mite, but only 32% of the growers expressed that it was a good control. According to studies in CRI application of used engine oil was found to be the best method which control mite totally. According to the CRI recommendation engine oil has to be applied every three months for the newly opened bunch for one year. Thus it can be hypothesized that 26% of the growers who expressed that it did not control mite (Fig. 44) had not followed the CRI instructions. No growers had mentioned that bagging with sulphur was a good control method to coconut mite.

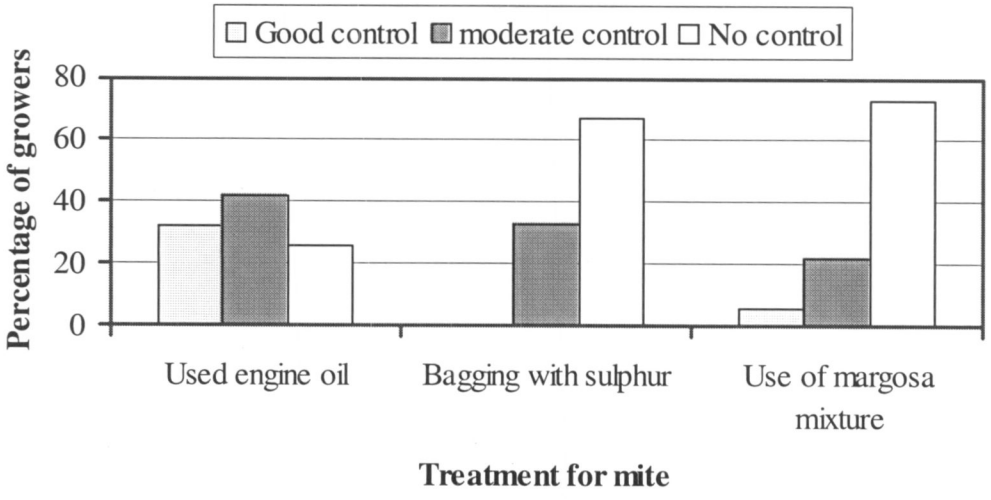


Figure 44. Growers' assessment for the different methods to control coconut mite

8.4 Plesispa Beetle

8.4.1 Estates having plesispa beetle

Coconut seedlings are generally damaged by plesispa beetle. Only 10% was mentioned that they had this problem while 43% was not aware such a problem (Fig. 45).

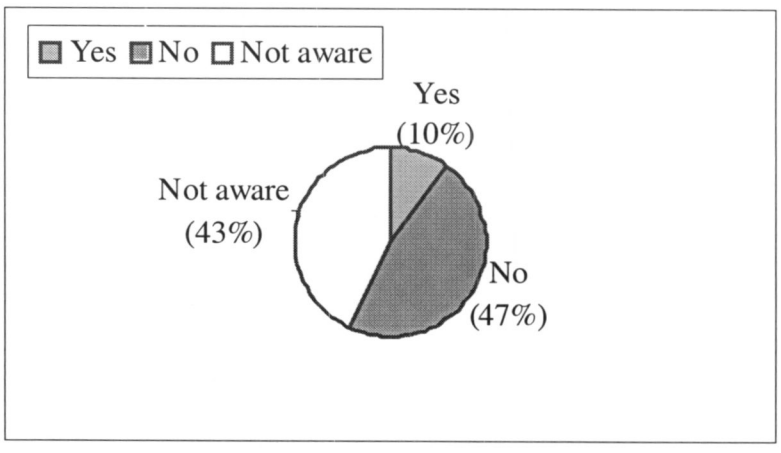


Figure 45. Percentage of estates having plesispa beetle damage

The low percentage estates with plesispa beetle could be due to high percentage (43%) of non awareness to identify the damage of plesispa. This further justifies as 40% the large extent holders were also not aware of identification the plesispa damage (Table 45).

Table 45. Distribution of estates having seedling damaged by plesispa beetle within land extent classes

Land extent (ac)	Percentage of estate with plesispa beetle		
	Yes	No	Not known
0.5 - 2	4	45	51
2-5	9	52	39
5-10	15	46	39
>10	14	48	38
Total	10	48	42

The percentage of estates having this pest was significantly higher in CCBRR of Gampaha and Kuliyapitiya (Table 46).

Table 46. Distribution of estates having damaged seedlings/palms due to different pests by CCBRR

CCBR	Percentage of estates having damaged due to			
	Plesispa beetle	Coconut caterpillar	Coconut scale	Termites
Anuradhapura	0	5	0	30
Galle	0	0	0	35
Gampaha	26	8	5	26
Hambantota	0	10	0	35
Kalutara	0	0	3	9
Kegalle	0	4	0	42
Kuliyapitiya	16	2	3	44
Kurunegala	7	2	2	62
Marawila	9	16	5	31
Monaragala	9	0	0	63
Ratnapura	5	5	0	38
Total	10	7	3	36

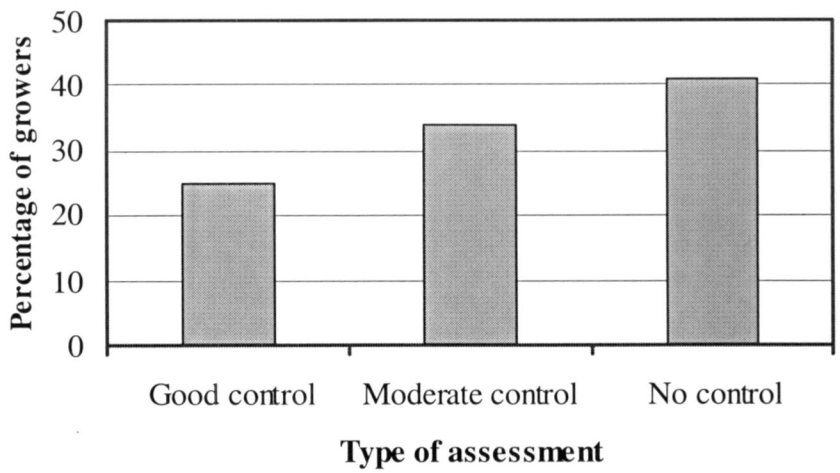


Figure 46. Growers' assessment of the use of chlopyriphos/marshall for control of plesispa beetle

8.5 Coconut Caterpillar

8.5.1 Distribution estates having coconut caterpillar

As for plesispa beetle damage for seedling, damage of coconut leaves due to coconut caterpillar was also reported only by 7% of growers (Fig. 47).

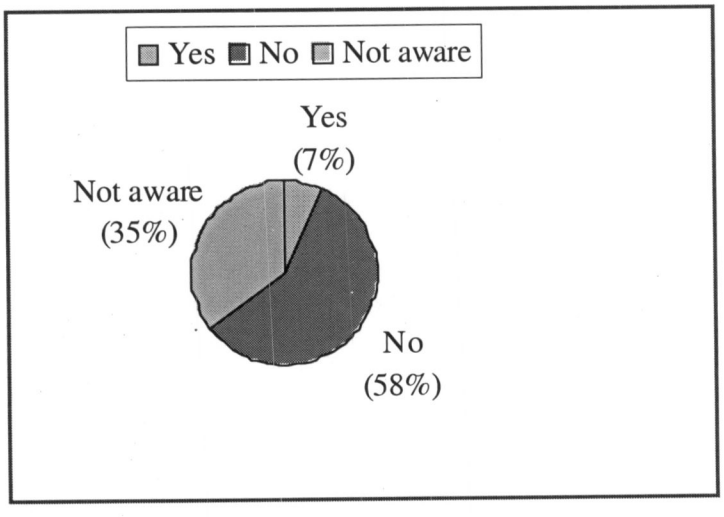


Figure 47. Distribution of estates having coconut caterpillar damage

Although damage due to coconut caterpillar has been known since 1970, it was surprised to note that 35% of the growers (irrespective of land extent class) were not aware of coconut caterpillar damage (Fig. 47). The percentage of non-awareness among the small holders (47%) was almost double as that for the large extent holders (Table 47). Of the CCBRR the highest percentage of coconut caterpillar damaged was reported in Marawila region followed by Hambantota region (Table 46).

Table 47. Distribution of estates having coconut caterpillar damage by land extent classes

Land extent (ac)	Percentage of estates having coconut caterpillar damaged		
	Present	Not present	Not aware
0.5 - 2	2	51	47
2-5	9	55	36
5-10	9	63	28
>10	11	65	24
Total	7	58	35

8.5.2 Controlling coconut caterpillar

Of the growers reported coconut caterpillar damage, parasitoids were used to control coconut caterpillar by 15% of the growers while monocrotophos were used by 10% of the growers (Fig. 48). Majority of growers claimed that they were unable to get parasitoids whenever they need.

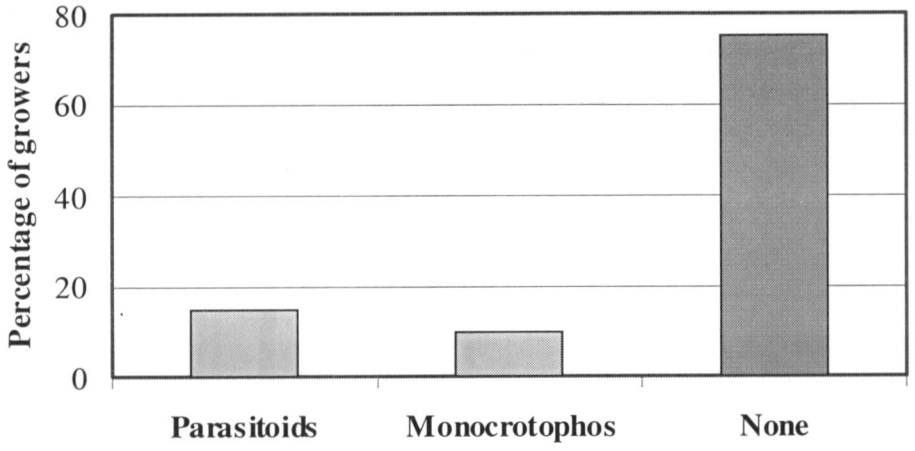


Figure 48. Use of recommended chemicals to control coconut caterpillar

8.5.3 Growers' assessment

According to the assessment of growers on the use of parasites was not a successful controlling measure for coconut caterpillar (Fig. 49). Only 30% indicated that it was a good controlling method.

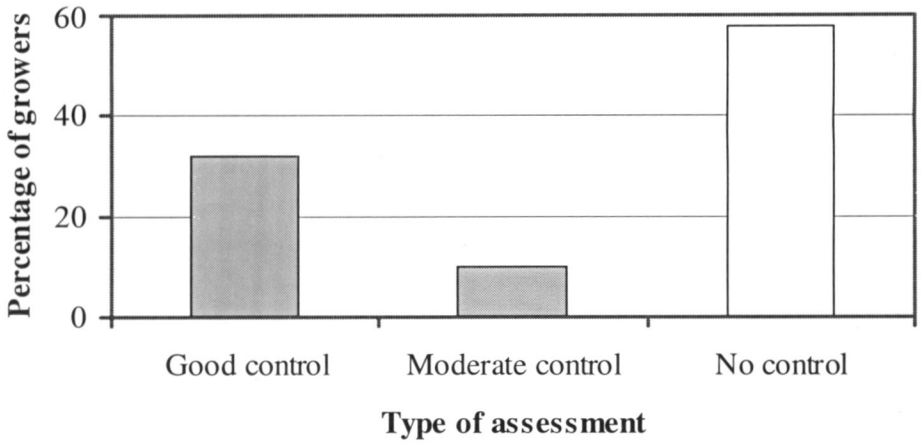


Figure 49. Growers' assessment on the use of parasitoids to control coconut caterpillar

8.6 Coconut Scale Damage

Scale damage was reported only in 3% of estates while 54% were not aware. The percentages of estates reported scale damage was extremely low in all land extent classes (Table 48). Of the CCBRR scale damages was reported only in the four regions namely Marawila, Gampaha, Kuliyapitiya and Kurunegela as shown in Table 46.

Table 48. Distribution of estate having scale damage by land extent

Land extent(ac)	Percentage of estates having scale damaged		
	Present	Not present	Not aware
0.5 - 2	1	46	52
2-5	3	56	41
5-10	5	55	40
>10	3	58	37
Total	3	54	43

8.7 Termite Damage

8.7.1 Distribution of termite damage

Termite damage was common in most of the estates and it was reported by 36% of the growers. The percentage of estates having termite damages was not significantly different among land extent classes but it was the highest among the estates of 2-5 acre size (Table 49).

Table 49. Distribution of estates having termite damage environment by land extent

Land extent (ac)	Percentage of estates of termite damage	
	Yes	No
0.5 - 2	29	71
2-5	38	62
5-10	43	57
>10	38	62
Total	36	64

According to Table 46 termite damage was reported by considerable percentage of growers in almost all the regions with exceptionally high in Kurunegela and Monaragela and exceptionally low in Kalutara region. The termite damage was significantly lower in sandy/sandy loamy soils (32%) than that in gravel/clayey soils (43%).

8.7.2 Use of recommended methods

Different insecticides were recommended from time to time to control termite. The most commonly used insecticide by the growers was cholopyriphos and the percentage was 23 (Fig. 50). Admire was used by 8% of growers.

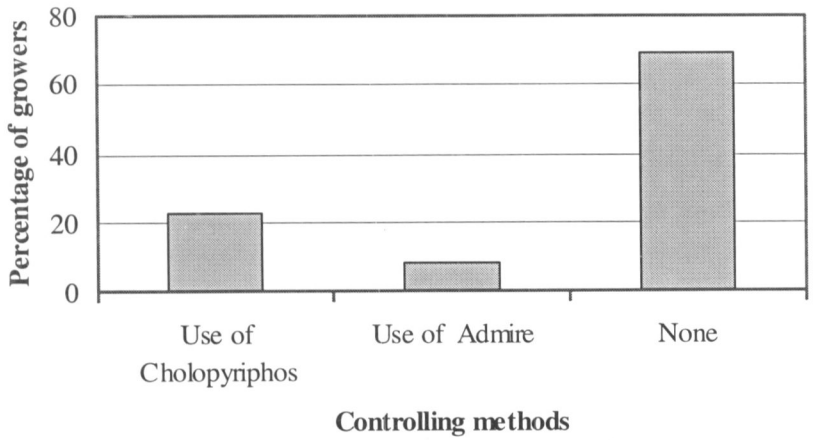


Figure 50. Type of insecticides used to control termites

8.7.3 Assessment of control methods

The use of chlopyriphos was the best insecticide to control termite which had 63% of good control and 36% of moderate control. About 65% growers claimed that the use of admire or other insecticides were not successful to control termites (Fig. 51).

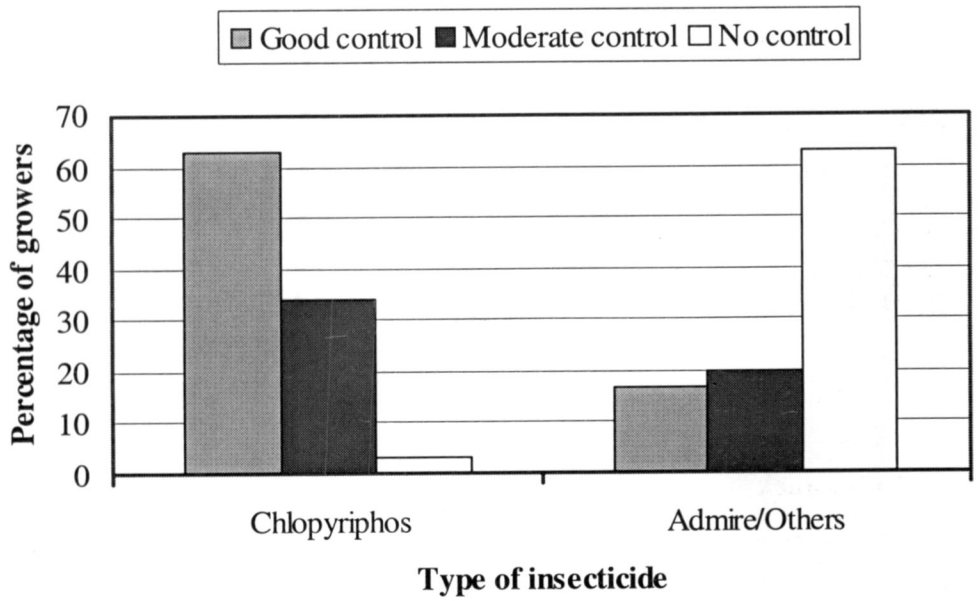


Figure 51. Growers' assessment of the use of insecticides to control termite

Chapter 9

INTEGRATED PRODUCTION SYSTEM

9.1 Practice of Livestock

The practice of various types of livestock to increase income of the growers and the use of residual of the livestock system to reduce the cost of fertilizer and improve the soil fertility had been recommended by the CRI. The analysis found that any type of livestock production system was practiced by 42% of the growers. The residual of the livestock system was used to reduce the cost of fertilizer and improve the soil condition by 26% of the growers. The distribution of growers who practiced of any livestock system and those who used its residual for the benefit of the plantation among CCBRR is shown in Figure 52.

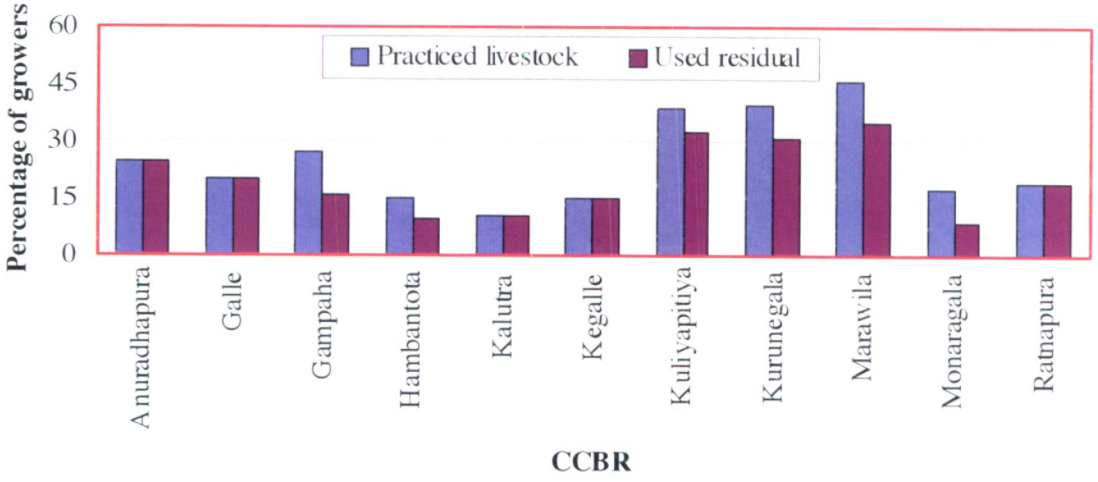


Figure 52. The pattern of practice live stock system and use of its residuals for benefit of the coconut palms by CCBRs.

Figure 52 suggest that all the growers who practiced livestock system in CCBRR of Anurdhapura, Galle, Kalutara, Ratnapura and Kegalle utilized full benefits of the residual of the system to reduce the cost of fertilizer and to improve soil condition. The highest percentage of livestock system was practiced by the growers in Kuliyapitiya, Kurunegala and Marawila, but all those growers did not practice integrated livestock system. Results in Figure 52 confirmed that

integrated system of livestock was practiced by all the growers who had livestock in all regions of Anuradhapura, Galle, Kalutara, Kegalle and Ratnapura as there was no difference between the percentage of practice and percentage of use of livestock. Of the AERs, the highest percentage of livestock system was practiced in DL3 followed by IL3 and IL1 (Fig. 53). The corresponding percentages were lower in wet regions than in other regions.

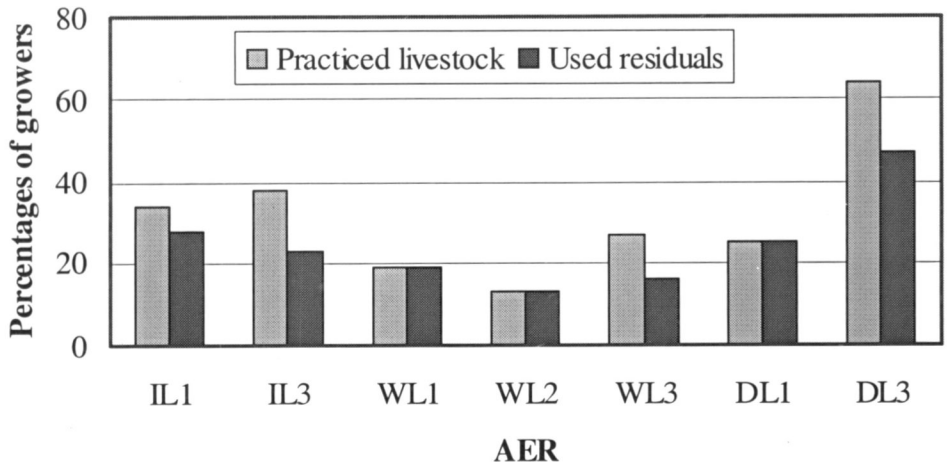


Figure 53. The pattern of practice live stock system and use of its residuals for benefit of the coconut palms by AERR

The major constraints for livestock system (irrespective of animals) was difficulties in maintain animals followed by unavailability of animals (Fig.54). The ranking order of the constraints was not significantly different among AERR.

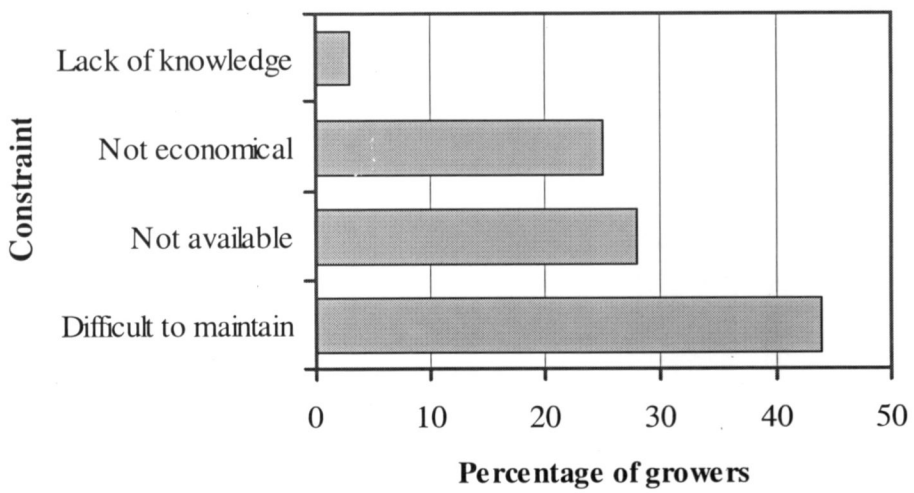


Figure 54. Constraints for the use of livestock system

9.1.1 Type of animals and stocking rate

The majority of growers practiced cattle (27%) followed by poultry (10%) as depicted in Figure 55.

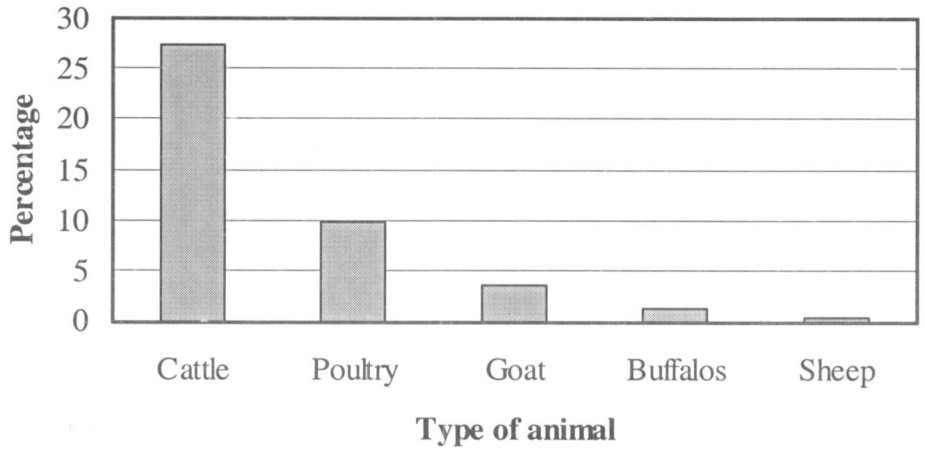


Figure 55. Distribution of type of animals used for livestock system by the growers

The stocking rate (number of animals per hectare) was computed to find the efficiency of livestock system of cattle and goat. The mean stocking rate for cattle (irrespective of land extent) was 3 and it varied from 8 among small holders to one among large extent holders (Table 50).

Table 50. Stocking rate of cattle and goat by land extent classes

Land extent (ac)	Stocking rate	
	Cattle	Goat
0.5-2	8 (19)	13 (4)
2-5	5 (36)	5 (4)
5-10	1 (34)	11 (5)
>10	1 (59)	1 (6)
Mean	3(148)	7 (19)

(The number of growers practiced is shown in the parentheses)

The recommended stocking rates for cattle and goats were 1 cattle for 4 hectares and 1 goat for one hectare. According to Table 50 it confirmed that the stocking rate for cattle was exceptionally higher in small extent estates (<5 ac) and it was almost the same as recommended among the large extent estates (> 5 ac). Similarly the stocking rate for goat was higher than the recommended stocking rate except among large extent holders (> 10 ac). The mean number of poultry per hectare by land extent is given in Table 51.

Table 51. Mean number of populate by land extent

Land extent (ac)	Mean
0.5-2	342 (12)
2-5	215 (18)
5-10	208 (8)
>10	179 (53)
Mean	232 (53)

(The number of growers practiced is shown in the parentheses)

9.1.2 Use of integrated production system

If the growers use both livestock with grown pastures and use residuals of livestock for the coconut palms then that system is defined as 'integrated production system'. The analysis found that only 3% of the growers in the sample (that is, 14 out of 543) or 8% (14 out of 183) of the growers who has livestock practiced 'integrated production system'.

9.2 Intercrops

The most common intercrops recommended to grow in coconut lands can be classified into three types namely (a) perennials (over 10 years) such as cocoa, coffee, pepper, clove, cinnamon, rambuton, tea, avocado, lime, cashew and mango (b) semi- perennials (2-5 years) such as banana, pineapple, passion fruit, papaya, sugar cane and betel and (c) seasonal/annual crops (less than one year) such as pulses and cereals , tubers and yams, ginger, turmeric, chilies and vegetables.

9.2.1 Distribution of intercrop lands and type of intercrops

Intercrops were grown by 50% of the growers. The percentage of growers having intercrops in their lands was not significantly different (Fig. 56).

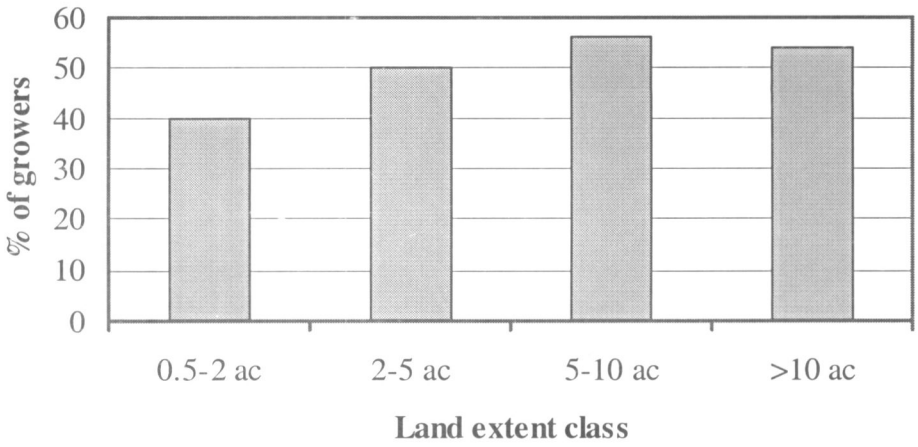


Figure 57. Percentage of lands having at least one intercrops within land extent classes.

The main intercrops grown by growers (irrespective of land extent) within CCBRR are shown in Table 52. Results indicated that some of the intercrops were not the recommended intercrops for that area. The highest percentage of intercrops (81%) was found in the Ratnapura region followed by Kegalle and Galle regions. Tea was grown as a intercrop in majority of lands in Galle. Tea and cinnamon were grown as intercrops in majority of lands in Galle and Kegalle. The percentage of estates with intercrops was significantly influenced ($p< 0.005$) by the interaction between two major soil types (sandy/sandy loamy vs gravel/clayey loamy) and CCBRR (Table 53).

Table 52. List of major intercrops grown in coconut lands in different CCBRR

CCBRR	Major intercrops
Anuradhapura	Banana, papaya, betel,
Galle	Cinnamon, tea, Banana
Gampaha	Banana, pineapple, rambutan
Hambantota	Banana, cashew, pepper
Kalutara	Pepper, ginger, banana
Kegalle	Banana, pepper, cinnamon
Kuliyapitiya	Banana, pineapple, betel
Kurunegala	Banana, pepper, cashew
Marawila	Banana, cashew, pineapple
Monaragala	Banana, pepper, lemon
Ratnapura	Tea, Banana, pepper,

Table 53. Percentage of intercrop growers by CCBR and soil type

CCBR	Soil type		Total
	Sandy/sandy loamy	Gravel/clayey loamy	
Anuradhapura	33	58	55
Galle	85	45	70
Gampaha	65	58	61
Hambantota	75	56	60
Kalutara	30	75	46
Kegalle	63	80	73
Kuliyapitiya	36	58	45
Kurunegala	36	64	49
Marawila	30	53	33
Monaragala	55	48	54
Ratnapura	67	91	80
Total	57	43	50

The percentages of intercropped coconut lands in the regions of Galle and Hambantota were significantly higher among the lands in sandy/sandy loamy soils than in gravel/clayey soils. Similarly the percentages of intercropped coconut lands in the regions of Kalutara, Kurunegela and Ratnapura were significantly higher among the lands in gravel/clayey than that in sandy/sandy loamy soils.

9.2.2 Constraints for intercrops

The constraints specified by the growers can be ranked as shown in Figure 58.

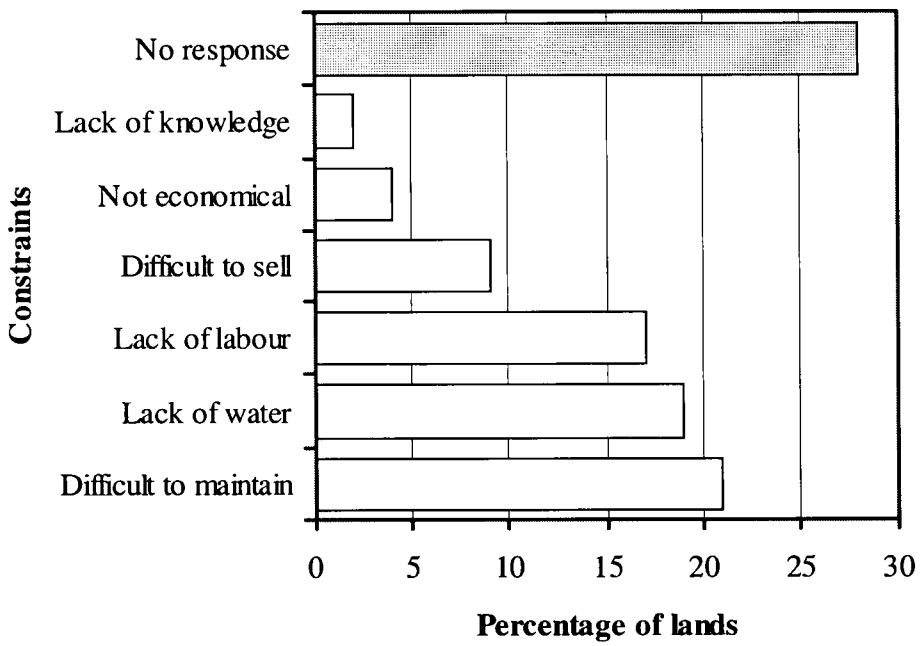


Figure 58. Growers' constraints in practicing intercrops in coconut lands

Both livestock production system and intercrop system were practiced by 17% of the growers and the majority of such growers were from Marawila, Kuliyapitiya, Kurunegala and Gampaha.

Chapter 10

KERNEL PRODUCTS OF COCONUT

The traditional kernel products of coconut in Sri Lanka are desiccated coconut (DC), copra, coconut oil, coconut milk power and coconut milk cream. As it is necessary to conduct research on different kernel products apart from the above traditional products Coconut Processing Research Division (CPRD) was established by CRI during 1997. During a short period CRI was able to produce nine kernel products namely virgin coconut oil, coconut paste, coconut jam, skim milk beverages, sports drink, coconut water beverages, coconut wine, spread cheese, and salad dressing. As the major input for those products obtained from the coconut, it would be useful to know the awareness of these products by the coconut growers. All these products are displayed in most of field days organized to the coconut growers by the CRI or CCB.

10.1 Growers' Awareness of the Kernel Products

The growers were asked whether they were aware of each of the above mentioned kernel product and their awareness by CCBRR is shown Table 54. Results in Table 54 clearly indicated that the coconut growers were not aware of all those products developed by CRI with exceptions to virgin coconut oil and coconut paste. Nevertheless the percentage of awareness for virgin coconut oil and coconut paste was very low. It should be noted that the percentage of awareness for almost all products was limited to the regions of Kalutara, Marawila, Kuliyapitiya and Gampaha.

Based on the above results it revealed the necessity in conducting awareness programs on all kernel products to growers. As most of these products are not readily available in the market, it is necessary to promote all technologies to entrepreneurs and to identify consumer demand for each product.

Table 54. Growers' awareness of various coconut products (% growers) by CCBRR

CCBR	Type of product								
	i	ii	iii	iv	v	vi	vii	viii	ix
Anuradhapura	10	10	10	0	5	0	0	0	0
Galle	0	0	0	0	0	0	0	0	0
Gampaha	16	7	5	3	4	4	10	3	3
Hambantota	0	0	0	0	0	0	0	0	0
Kalutara	17	17	9	6	6	5	11	6	6
Kegalle	23	15	0	0	0	0	0	0	0
Kuliyapitiya	16	10	20	2	2	4	4	4	2
Kurunegala	13	7	2	0	2	2	0	0	0
Marawila	14	10	4	3	2	2	4	2	2
Monaragala	9	9	0	0	9	0	9	0	0
Ratnapura	14	9	0	0	0	0	0	0	0
Total	14	9	4	2	2	2	5	2	2

(i=virgin coconut oil, ii = coconut paste, iii = coconut jam, iv = skim milk beverages, v = sports drink, vi= coconut water beverages, vii= coconut wine, viii = spread cheese, ix = salad dressing)

Chapter 11

TECHNOLOGY TRANSFER

In addition to the extension service carried out by the Coconut Development Officers (CDOO) of the Coconut Cultivation Board (CCB) certain amount of extension is also carried out by the CRI as technology transfer is one of the major activities of the Coconut Research Institute. The main strategies of the technology transfer activities of the Institute are:

- Transfer of coconut cultivation and processing technologies and information to extension personnel, growers, commercial enterprises and the general public.
- Acquiring information about technology needs and production problems of the coconut cultivation and processing sectors.
- Evaluate the relevance and effectiveness of technologies at the field level

The Institute conducts several programmes to update the technical knowledge of Coconut Development Officers of CCB, field extension officers of related institutions, coconut growers, processors and the general public. The Institute conducts seminars, field days, training and educational programmes, crop clinics, farmer field schools and several mass media programmes. The one day training program series conducted by the Institute is famous among the coconut growers. The programme was designed and conducted in CRI substations to fulfill technology needs of coconut growers. Based on the evaluation in each year, the content and the methodology of the programmes are revised. This educational programme series has the highest participation of coconut growers because it has direct interaction with scientists in the sector and more practical events.

11.1 Awareness of One Day Training Program

During the survey growers were asked whether they are aware of such programmes. The awareness of the growers by CCBRR and by land extent classes are shown in Figure 59.

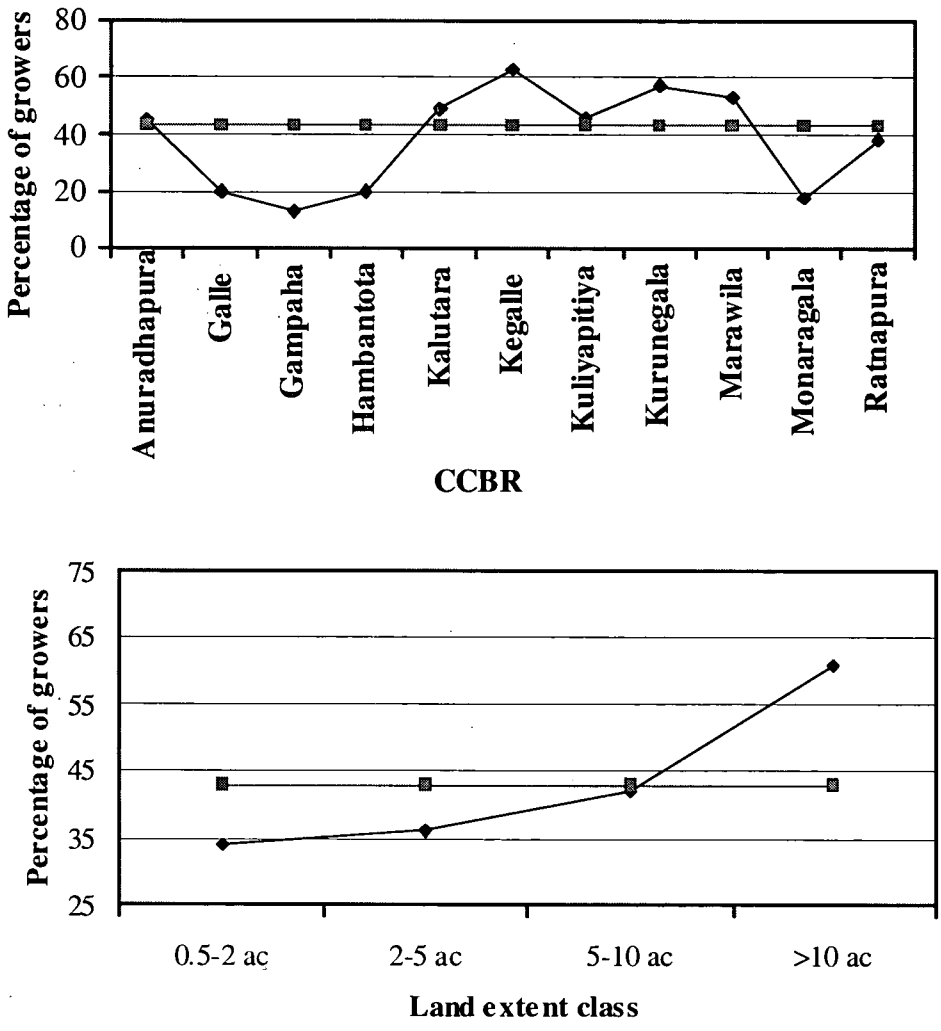


Figure 59. Percentage of growers who know about the one day training programs on coconut cultivation conducted by the CRI by (a) CCBRR and (b) land extent classes (horizontal line indicates national average)

Results indicate that 43% of the coconut growers (irrespective of CCBRR and land extent classes) were aware of the training programmes conducted by the CRI. The percentage awareness was the lowest among the growers in Gampaha and it was well below the national average. The percentage of awareness in the regions of Monaragala, Hambantota, Galle and Ratnapura were also below the national average. The highest percentage of awareness (63%) was reported in Kegalle region followed by Kurunegala region (57%).

The percentage of awareness by the growers among large extent holders was significantly higher ($p<0.0001$) that by the growers in each of other three land extent group. The rate of awareness of training programs increased linearity with the increase of land extent classes (Fig. 59.b) as for other technologies confirming that the dissemination of information had gone faster to large extent holders than small extent holders.

11.2 Participation for the Training Programs

The one-day training program series covers seven important areas in coconut cultivation namely (i) replanting, (ii) soil and moisture conservations, (iii) fertilizer applications, (iv) productivity

improvement with intercrops, (v) pest and disease management, (vi) rehabilitation of low yielding coconut plantation and (vii) estate management. Generally seven programmes are conducted in a year. The participants have the option to select the programmes based on their needs.

Based on the sample, none of the growers in Ratnapura, Monaragala, Hambantota participated any of the one day program (Table 55). The lowest percentage had participated for rehabilitation, estate management and intercropping modules. The highest percentage had participated for the program on replanting followed by fertilizer application. Results in Table 55 suggest that the participation by the large extent holders for each module was higher than national average. The series of one day training program is specially arranged for the growers who have easy access to CRI. Thus the percentage of participants is not a good indicator to evaluate the awareness of such programs, but it gives some idea that the many growers have no opportunity to participate these one day training modules. Thus it suggests that such training programs have to be extended to other coconut growing areas as well.

Table 55. Percentage of growers who participated for each module

(a) by CCBR.

CCBR	Type of module of the training program (% of growers)						
	RP	SM	FA	I	PD	R	EM
Anuradhapura	15	5	5	0	5	0	0
Galle	5	0	0	0	0	0	0
Gampaha	9	7	9	8	7	4	7
Hambantota	0	0	0	0	0	0	0
Kalutara	3	3	0	0	0	0	0
Kegalle	19	15	8	4	4	4	4
Kuliyapitiya	10	8	9	6	5	5	7
Kurunegala	8	8	10	8	11	8	10
Marawila	8	7	9	7	9	6	6
Monaragala	0	0	0	0	0	0	0
Ratnapura	0	0	0	0	0	0	0
Total	8	6	7	5	6	4	5

(RP-Replanting; SM- Soil moisture; FA- Fertilizer; I- Intercrops; PD – Pest & Disease; R – Rehabilitation; EM – Estate Management)

(b) by land extent classes

Land extent	Type of module of the training program (% of growers)						
(ac)	RP	SM	FA	I	PD	R	EM
0.5-2	2	1	2	1	2	0	0
2-5	7	5	5	4	4	3	4
5-10	7	6	7	5	6	5	5
>10	15	13	15	11	14	11	13
Total	8	6	7	5	6	4	5

(RP-Replanting, SM- Soil Moisture, FA- Fertilizer application, I- Intercrops, PD – Pest & Disease, R – Rehabilitation; EM – Estate Management)

11.3 Knowledge on Coconut Cultivation

Growers were asked whether they have an adequate knowledge on coconut cultivation. Only 28% of the growers mentioned that they have adequate knowledge in coconut cultivation. That is, 72% of the growers did not have an adequate knowledge on coconut cultivation. The corresponding values were 80%, 72%, 68% and 63% among the four land extent classes 0.5-2 ac, 2-5 ac, 5-10 ac and > 10 ac respectively. The percentage of growers not having adequate knowledge in coconut cultivation was significant different ($p<0.0001$) among CCBRR (Fig. 60).

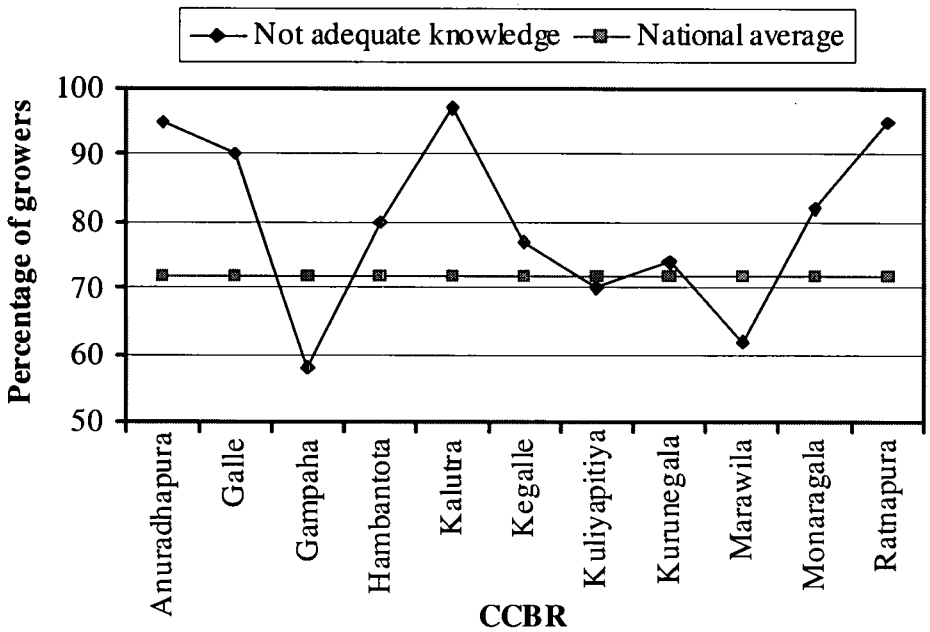


Figure 60. Percentages of growers not having adequate knowledge on coconut cultivation by CCBR

11.3.1 Effect of one day training program on knowledge improvement

About 5% (that is 28 out of 543) had participated for all seven modules of the training. Majority of those growers were from Marawila, Kurunegala and Kuliyapitiya regions.Relationship between the participation for all seven modulus and adequate knowledge on coconut cultivation was significantly associated ($p<0.005$) indicating participation of all modulus significantly influenced to improve the knowledge of the coconut growers (Table 56). Among the growers who participated all seven modulus, 29% of them still believe that they did not have adequate knowledge on coconut cultivation (Table 56). Further, 26% of the growers who did not participated for all seven modulus also had adequate knowledge on coconut cultivation.

Table 56. Relationship between the participation for seven modulus and adequate knowledge on coconut cultivation

Participated for all seven modulus	Have an adequate knowledge on coconut cultivation	
	Yes	No
Yes	71%	29%
No	26%	74%

11.4 Dissemination of Technology via Mass Communication

CRI used to disseminate information through various mass media such as newspapers, radio, television (TV), publications, website (www.cri.lk) etc. Fifteen percent (15%) of the growers informed that they listened to the CRI radio program such as 'Kapruka Pamula' (Table 57). TV programmes of the CRI were watched by 51% of the growers. The newspaper articles on coconut cultivation and related aspects were read by 42% of the growers (Table 57). These results confirmed that television was the most popular mass communication as a source of dissemination of information followed by news paper articles. Similar trend was also found among the growers in each region as well (Table 57). Results indicated that radio programs were less effective to disseminate technology.

Table 57. Percentage of growers who had received CRI programs communicated through radio, television and newspaper articles

CCBRR	Type of media		
	radio	television	newspaper articles
Anuradhapura	10	85	70
Galle	20	40	45
Gampaha	22	57	45
Hambantota	40	45	40
Kalutara	3	57	49
Kegalle	31	65	69
Kuliyapitiya	12	49	38
Kurunegala	20	57	43
Marawila	11	46	34
Monaragala	19	45	36
Ratnapura	5	24	33
Mean	15	51	42

11.4.1 Growers' view about knowledge improvement

Growers were asked to specify two types of sources out of seven listed below (Fig. 61) for knowledge improvement based on their preference.

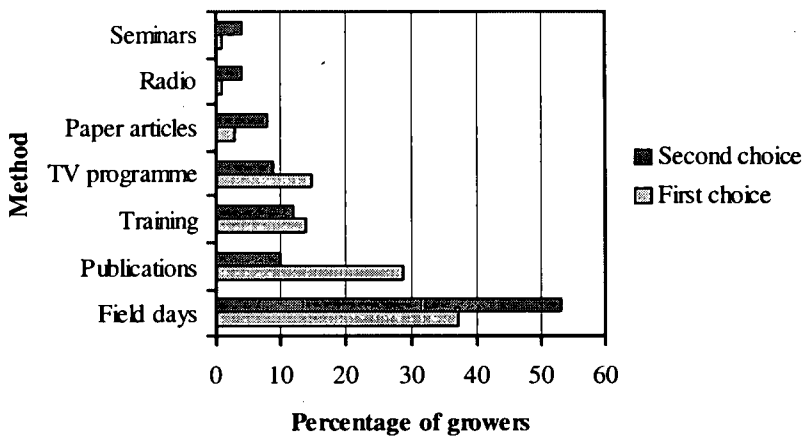


Figure 61. Growers' choice on the types of media to be used to disseminate the technology by CRI

According to the growers' response shown in Figure 61 the best method to transfer the technology and to update the knowledge of coconut growers is conducting field days.

11.4.2 Technical areas where coconut growers need knowledge and experience

The two useful areas specified by the growers in which they need more knowledge and experience on coconut cultivation and management is shown in Figure 62.

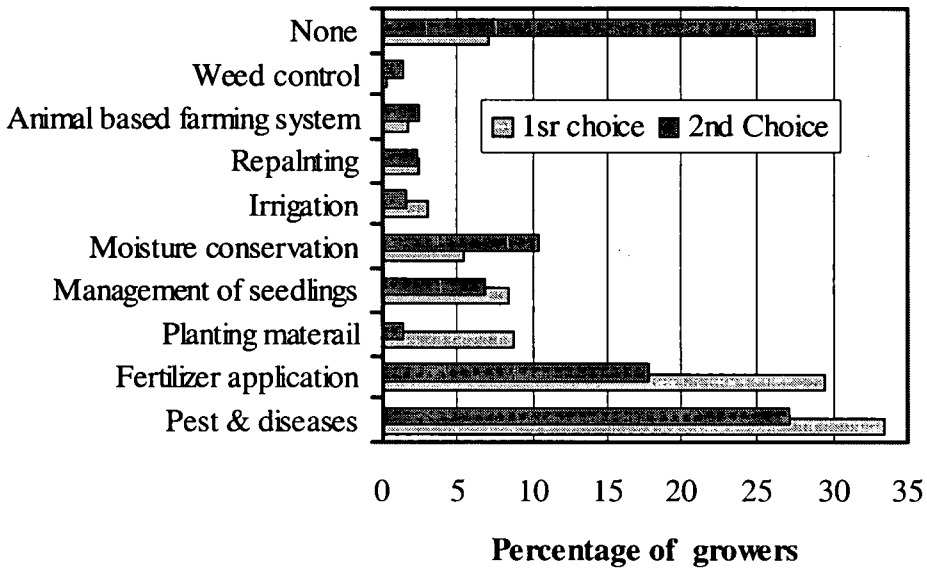


Figure 62. Growers' choice of the areas they need more knowledge and experience

According to Figure 62 it is clear that the two important technical areas that the growers expected to have a training from the CRI were pest and diseases followed by fertilizer application. The demand from the growers for these two areas was significantly higher than that for other areas. The demand for irrigation, replanting and animal based farming system was very low. Results suggested that in future more modulus can be organized on fertilizer application and pest and disease management along with the normal training programs. In addition field days particularly on the above technical areas would be very useful.

11.5 Growers' Assessment on Various Services

Growers were asked to assess the general services such as advisory service, availability of seedlings, finance support, training and education and other inputs like fertilizer, insecticide etc. available in Sri Lanka to improve coconut cultivation based on three levels namely good, average and below average (Figure 63).

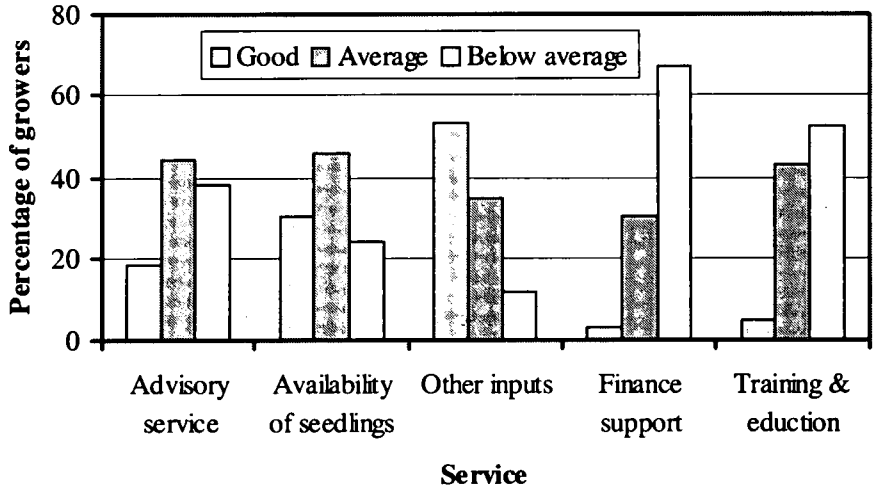


Figure 63. Growers' assessment on various serviced available for coconut cultivation

Results show that growers do not happy with the financial support available for coconut cultivation. Apart from that advisory services and training & education program had been ranked as below average indicating that the coconut growers do not satisfy on technology transfer aspects on coconut cultivation. Thus it is recommended to have farmer educational programmes based on their area specific needs in the form of field days and seminars.

11.6 Work Load of Coconut Development Officers (CDO)

The extension service for coconut growers in Sri Lanka is provided through 17 CCB regions namely Polonnaruwa, Amparai, Annuradapura, Monaragala, Matale, Kalutara, Kuliyapitiya, Galle, Marawila, Hambantota, Kurunegela, Ratnapura, Gampaha, Matara and Kegalle. Each CCB region has different numbers of Coconut Development Officers (CDOO) who are supposed to assist all coconut holders in his CDO range within the CCB region.

11.6.1 Average coconut extent per CDO

In this analysis the comparison between CCB regions (excluding Jaffana and Trincomalee) is carried out without considering the total extent in each CDO range within CCB region. The extent under each region was taken according to 2002 agriculture census report. The total extent of the 15 CCB regions shown in Figure 64 represents about 95% of the total coconut extent in Sri Lanka. The national average of extent to be covered by a CDO is 3000 ha (Fig. 64).

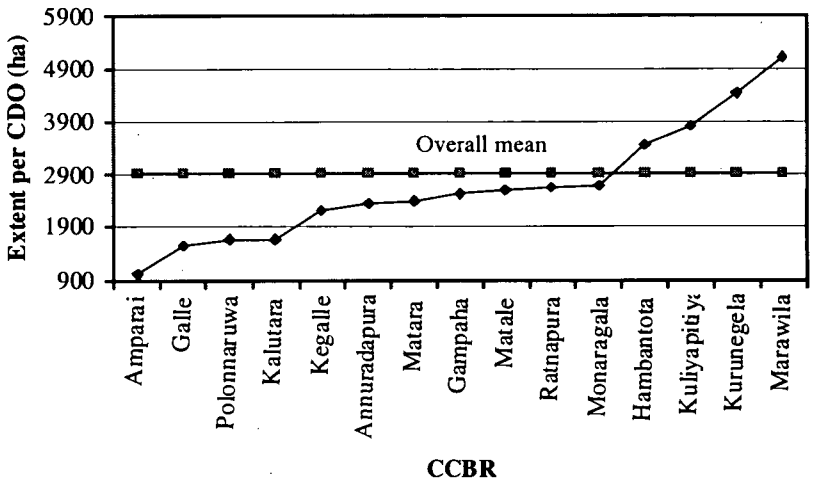


Figure 64. Spatial variability of the mean coconut extent to be covered per CDO among CCB regions (horizontal line represents overall mean)

According to Figure 64 it indicates that the area to be covered per CDO has large variability between CCB regions (cv=41%) and it varies from 1017 hectares in Amparai to 5121 hectares in Marawila. The extent to be covered per CDO in the regions of Hambantota, Kuliyapitiya, Kurunegela and Marawila was higher than the national average of 2930 hectares per CDO.

11.6.2 Average number of coconut holdings per CDO

The total number of coconut holdings in each district except North and Eastern provinces has been complied by the Department of Census and Statistics (DCS) based on data of 2002 Agricultural Census (W. M. U. Dissanayake, *Pers Comm.*). The total number of coconut holdings has increased from 372,790 in 1982 to 1,336,671 in 2002. The number of holding in the districts of Colombo, Nuwara-Eliya and Kandy and Badulla were allocated to CCB regions of Kalutara, Matale and Monragala, respectively. The holdings in Kurunegala were divided 2:3 ratio between Kuliyapitiya and Kurunegala regions. Figure 64 indicates that the number of holdings to be served by a CDO varied from 5012 (Gampaha) to 19,490 (Anuradhapura) with a mean of 10362. Thus, to serve all the growers individually, CDO has to meet 43 growers per day, if he/she works 240 days per year (20 days/month). This is an impossible task.This figure also varied among CCB regions. In would be more difficult in regions like Anuradhapura, Monaragala, Ratnapura and Matale. In fact, extent of coconut lands in these regions had increased compared to 1982 figures (www.cri.lk).

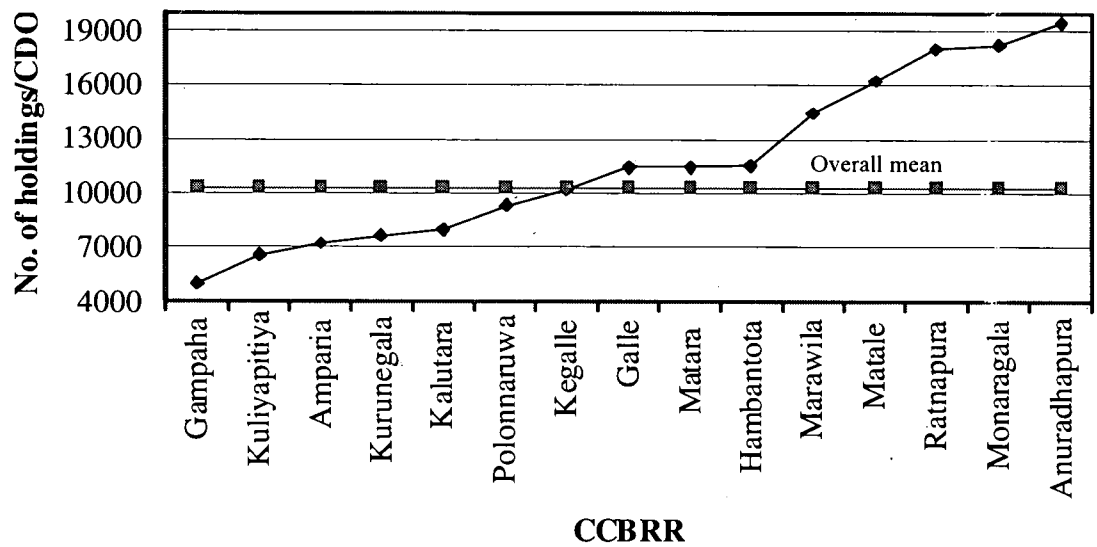


Figure 65. Spatial variability of the mean number of coconut holdings to be served per CDO among CCB regions (horizontal line represents overall mean)

The above results suggest that facilities to CDOO to be improved based on location or number of CDOO has to be increased. CDOO are available in their office only on Wednesdays to provide the technical advices and support services to growers who visit the office. As the number of growers who are served by each CDOO is very large, the office can be kept opened in other four days for the benefit of growers, particularly for the benefit of small holders who has less awareness on recommended technologies than large holders, with another officer who could attend the needs of coconut growers. In fact the best way to analyze this problem is to consider the distance to each coconut holder from the office of CDO using GIS technology and it will be a complicated optimizing problem.

Chapter 12

CONCLUSIONS AND RECOMMENDATIONS

In this Chapter the major observations **(O)** and the corresponding recommendations **(R)** are given below.

Absentee Land Owners

O: The absentee landowners were about 30% of coconut lands irrespective of land size and location. This percentage was the highest (58%) among large extent holders (>10 ac). Among them, it was exceptionally high in the regions of Kurunegala (74%), Gampaha (72%) and Marawila (65%).

R: Carry out a survey on the absentee land owners in the above three regions to compare the yield of such lands with control (non absentee landowners).

Age of Bearing Palms

O: The mean age of bearing palms in a coconut land was 42 years. The age of bearing palms was distributed symmetrically between 10 and 70 years. The age of bearing palms of about 30% of lands was below 30 years and it is represented by 26% of the total extent. The age of bearing palms of 60% of estates was between 30 and 60 years and it is represented by 67% of the total extent. About 10% of lands, the age of bearing palms was above 60 years and it is represented by 7% of the total extent.

R: Implementation of an effective under planting program based on age distribution of palms within each CCB region is required. Thus a suitable survey is suggested in each region to identify age distribution of bearing palms. Further, it would be better if the yield of such lands can also be obtained.

Density of Plantation

O: The mean number of bearing palms per acre varied from 67 in Galle region to 45 in Kalutara region with a mean of 54. However, the mean density of coconut lands (including non-bearing, young, seedlings and weak/disease palms) was 67 palms per acre with a maximum of 91 palms per acre (in Galle region) and a minimum of 55 palms/acre (in Kalutara region).

R: Growers to be motivated to remove non-bearing palms and diseased palms and to maintain a density of 64 palms per acre.

Type of Plantation

O: Majority of lands (70%) were either mature plantations (mature plantation alone or mix plantation) and plantation with new/re plantation. About 5% of lands were senile and the percentage of land extent under senile plantation was 3%.

R: Maintain a list of estates having senile plantations by each region so that priority can be given to such lands in re-planting or new planting programs.

Climate Change

O: Majority of growers (70%) noticed the change in the pattern of rainfall between years and increase in the air temperature in all coconut growing areas. About 55% of the growers expressed that the climate change has affected the timing of their cultural practices.

R: Implement a Climate Information Center to carry out climate prediction studies in all coconut growing areas and provide updated information on climate to the growers and educate growers about the impact of climate on coconut plantations.

Land Suitability Classes (LSC) for Coconut

O: Irrespective of the CCBRR and land extent, 95% of the growers were not aware of the land suitability classes for coconut. This percentage was 89% even among the estate holders (>10 ac).

R: Land suitability class map in a finer scale to be prepared and distributed among Coconut Development Officers (DCOO) so that they can train and educate coconut growers to identify LSC for coconut and its benefits.

Practice of Mulch:

O: Although the majority of growers were aware of the beneficial effects on mulching in coconut lands, there was a substantial difference between the percentage of awareness (82%) and the percentage of practice (56%). This technology was correctly practiced only by 30%. Lack of coconut fronds and weed trash are the major constraints for mulching.

R: Growers have to be motivated about the benefits of keeping mulch around each palm and their economic benefits with respect to the number of nuts. This should be an essential cultivation practice particularly in coconut lands in Agro-ecological regions in Dry and Intermediate zones.

Use of Gliricidia

O: Gliricidia was grown by 46% of the growers and it was used a green manure by 26% of growers. The corresponding percentages of the coconut lands in Galle, Kegalle and Ratnapura (potential areas for gliricidia) were 70% and 15% respectively. Lack of knowledge on potential benefits of gliricida (green manure, fuel wood, gas fires) is a main constraint among growers.

R: Initiate a program to popularize to grow gliricidia in coconut lands to be used as a multi purpose user. Special attention has to be given for the regions like Ratnapura, Kegalle and Galle.

Practice of Husk Pits

O: Different dimensions and methods of husk pits have been recommended during past. The benefits of burying husks in pits were aware by 85% of growers irrespective land size, but any type of husk pits was practiced only by 40% of the growers. The latest recommendation of husk pit (8' x 4' x 3' - between palm within coconut raw) was aware only by 20%. This size is not suitable for small holdings particularly for land extent less than 2 ac. Also it is not suitable for lands where the planting system is irregular and where tea is intercropped with coconut (Ratnapura). The main constraints for the practice of husk pits were cost for material and labour followed by non availability of husks. Most of the existing husk pits were not rehabilitated though it is recommended to rehabilitate once in five years. Growers are not aware of the potential economic benefits of establishing husk pits.

R: Not to change size and method of husk pits from time to time, however size of husk pits can depend on LSC of coconut as the distribution of coconut roots vary among the soil type. An alternative method for husk pits for coconut lands intercropped with tea, small holder (< 2 ac) having irregular planting system and uneven and sloapy lands to be investigated.

Availability of Coconut Seedlings

O: Based on land extent under coconut in 1982 (442,402 ha), 2% re-planting rate, 2% new planting rate and 25% seedling mortality the amount of seedling required per year, was 1,800,000. The number of seedlings issued by the CCB alone during past years was higher than the requirement for national planting program. Issuing more seedlings than the above requirement would be a national loss.

R: Plan and implement an efficient system of issuing coconut seedlings to avoid such national loss.

Use of Own Seedlings

O: About 25% of the growers use either their own seedlings or from private nurseries. Among them, seed nuts were incorrectly selected by 38% growers. The recommended technologies in maintaining a nursery are not followed by the private nursery owners. Seed nuts are correctly done by 60% of growers who maintain a coconut nursery. Rejection of non germinators after 5 months was done only by 28%. Rejection of weak seedlings after 7 months was done only by 26%.

R: Encourage growers to plant seedlings raised from CCB, CRI or registered nurseries only and give enough publicity through media to convince coconut growers about poor quality seedlings produced by private owners.

Manage of Seedling

O: The use of fertilizer at the time of transplanting and regular application thereafter was low. Growers do not follow the instructions recommended by CRI at the time of transplanting and thereafter. The mean mortality rate of seedlings was 15%. The major causes for causalities of seedlings were lack of watering, black beetle attack and poor quality of seedlings.

R: Convince growers to pay more care and attention, to follow recommended practices at the time of transplanting, to monitor growth of seedlings and to irrigate seedling during dry periods.

Size of Planting Hole

O: About 75% and 40% of the growers were not aware of the recommended size of planting hole for gravel (4'x4'x4') and sandy (3'x3'x3') respectively. Also many growers complained that the recommended size for planting hole for gravel soil was not feasible.

R: A mechanism to be implemented for small holders to organize themselves through their societies to rent a backhoe machines to make seedling holes.

Awareness of Planting Material

O: A large percentage of growers in all CCBRR were not aware of the new cultivars introduced by CRI such as CRISL98 (Tall x San Ramon), and Kapruwana (Drawf green x San Ramon). Also 52% and 41% of the growers were aware of CRIC60 (T X T) and CRIC65 (DxT), respectively. The non awareness of CRIC60 and CRIC65 was very high in Monaragala and Ratnapura regions.

R: Growers to be educated about different types of varieties they purchase/plant in their lands, and the source of purchase and its importance for various claims they complain on the seedlings.

Practice of Irrigation

O: Drip irrigation was not popular among the growers and it was practiced only by the large extent holders (> 10 ac) and the percentage of adoption was 4%. The classical horse/bucket system was popular among all growers and the percentage of adoption was 15% in all four land extent classes.

R: More efficient, effective and economical irrigation method to be identified. Further, growers who use any irrigation system should be encouraged to use a rain gauge in their estate.

Under Planting

O: 45% of the under plantations were established before the old palms reach 45 years and 25% of under plantations were established before the old palms reach 35 years. Under planting is less superior to new planting with respect to time to bear.

R: Growers to be discouraged to carry out under planting prematurely and should be promoted new planting as far as possible.

New Inorganic Fertilizer (NIF) Recommendation

O: Present fertilizer recommendation is complicated. Moreover, about 85% of the growers (irrespective of land extent) and 75% of the large extent (>10 ac) holders too were not aware of new fertilizer recommendations. Further, less amount of fertilizer had been recommended for soil condition 2 (deep reddish or yellowish loams in coastal areas deep loams at foot hills, alluvial loams in flood plains) than soil condition 1 (lateritic or quartizitic gravelly loams- deep sands in coastal & river flood plains) under both climatic conditions (Wet/Intermediate and Dry). Also the amount of fertilizer recommended for soil condition 2 is higher than the amount of fertilizer required for potential output from the corresponding soil condition.

R: It is necessary to modify the present fertilizer dosage recommended to different soil conditions and agro-ecological zones by incorporating nutrient removal from each land suitability class.

Fertilizer Use for Adult vs Young Palms

O: The growers' interest in manuring young (not-bearing) palms was lower than that in adult (bearing) palms. The amount of fertilizer received by both adult and young palms was significantly lower than the recommended dosage. Inadequate manuring at the pre-bearing stage would result in poorly grown low yielding palms. The percentages of growers regularly manured (irrespectively amount of fertilizer) for adult and young palms were 43% and 35%, respectively. About 25% of the regular fertilizer users (that is, 10% of total) had applied more than 4.0 kg/palm/year and 5% of the regular users (that is, 2% of the total) applied more than 5.0 kg/palm/year.

R: Motivate the growers about the importance of applying fertilizer for young palms than for adult palms to make the coconut palms more sustainable. Also educate the growers to use correct amount of inorganic fertilizer irrespective of the stage of growth to minimize cost.

Method of Fertilizer Application

O: Though the recommended method is surface dressing and mulch, growers also practiced trench system and digging system. In addition to incorrect amount and incorrect time of application, fertilizer use efficiency is low due to incorrect method too.

R: Develop and disseminate area specific fertilizer application method.

Differential Fertilizer Recommendation (DFR)

O: DFR is not popular among small holders. Only 5% of the small holders (0.5-2 ac) were aware of DFR. The overall awareness rate, irrespective of land extent and CCBRRs was 20%. The percentage of awareness of DFR by large extent holders (> 30 ac) was 50%.

R: It is necessary to popularize DFR even among small holders as DFR is the efficient fertilizer recommendation than blanket dosage. Further, it is necessary to incorporate more parameters such as LSC for coconut (or soil type) and past yield achieved into the DFR methodology to make the recommendation more location specific.

Straight Fertilizer

O: Considerable percentage of growers (50%) was aware of straight fertilizer. However, such fertilizers were used for adult palms by only 10% of growers. Large extent holders do not prefer very much due to additional cost involve in mixing.

R: Studying the benefits of straight fertilizer in terms of nuts and cost-benefit is necessary.

Special Fertilizer for King Coconut

O: Only 4% of the growers were aware of the new fertilizer recommendation for king coconut.

R: Maintain a database of king coconut growers and disseminate this information to king coconut growers directly through CDOO.

Use of Ethrel

O: Growers in toddy tapping areas such as Beruwela, Panadura and Kalutara were not aware of the use of ethrel to increase the toddy yield.

R: Disseminate this technology to toddy tappers by organizing special filed days.

Use of Organic Manure

O: Twenty percent (20%) of the growers were aware of different types of organic fertilizers, but the corresponding percentage was extremely low (10%) among small holders (<2.0 ac). Rates of organic fertilizer dosage (kg/palm/year) applied was less than the recommended dosage irrespective of soil condition and type of organic.

R: Motivate growers to apply the correct amount of organic fertilizer along with recommended amount of muriate of potash depending on the soil condition and type of organic manure.

Black Beetle Damage (BBD)

O: About 20% were not aware of identification of BBD. The gap between the awareness of different control methods and their application was about 20% for all four control methods. According to growers' assessment, the most effective method was to extract beetle using a hook. Only 44% of the growers were aware of IPM of BBD and it was practiced by 26%.

R: Issue a beetle hook along with seedlings. More control measures to be developed and use of IPM of BBD to be promoted.

Red Weevil Damage (RWD)

O: The damage of coconut seedlings due to red weevil was not much (56%) compared to BBD. Of the five control methods recommended for RWD, the highest awareness rate was found for disposal of dead palms infected by red weevil followed by regular checking. About 70% of growers expressed that monocrotophos was not available to obtain/purchase whenever they are required. Also, both pheromone and traps had not been available together at the same time. Implement a very efficient system to issue both traps/pheromone and monochrotophos to growers.

R: Implement farmer participatory community programs at various locations for mass trapping. Organize a very efficient system to issue both traps/pheromone and monocrotophos to growers.

Coconut Mite

O: Of the three recommended methods to control coconut mite, the application of used engine oil was ranked as the most effective treatment to control coconut mite by the growers but only 32% of the growers expressed that it was a good control. Further, almost all growers complain that the use of engine oil is not practically feasible.

R: Identifying a sustainable biological control method is urgently needed.

Intercrops/Animal Husbandry

O: The main constraint in intercrops and animal husbandry are difficulties in maintaining, lack of water, difficulties in selling. Majority were not aware the integrated production system (practicing both intercrops and animal husbandry and use residual of animals as fertilizer).

R: Promote integrated production system, particular among small holders, to search marketing channels for intercrops to the growers, to implement loan/intensive scheme to start small sales outlets in their lands to sell animal products, intercrops etc.

Kernel Products

O: Out of nine kernel products developed by the CRI only 14% and 9% of growers were aware of virgin oil and coconut paste, respectively.

R: Organize awareness programs to the coconut growers and disseminate the technologies to the respective entrepreneurs. Conduct surveys on marketing aspects on these products and search for foreign investors to start large scale industries through BOI or Export Development Board.

Awareness of Recommended Technologies

O: The percentage of awareness of all technologies increased with the increase of land extent.

R: Encourage group approach in technology transfer by establishing more field demonstrations.

Technology Transfer

O: Training programs conducted by the CRI were highly appreciated by many growers. Of the growers, who participated for all seven modules, 71% expressed that they acquired good knowledge about coconut cultivation. However, demand for all modules was not the same.

R: Conduct such one day training programs outside the coconut triangle and include more modules on pest and diseases management and fertilizer application. Address area specific problems through field days in consultation with respective CDOO.

Update and Enhance Knowledge of CDOO

O: The present system of technology transfer from CRI to CDOO is a vertical communication system which is more formal and less effective.

R: Implement a system of horizontal communication with less formal and more effective between Technology Transfer Division and CDOO (or with RMM of CCB). Conduct regular technology updating programs (two times a year) to all CDOO and continue CCB-CRI dialogue to cover all regions annually. Participation of at least one scientist from CRI (rotational basis) to monthly CDOO conference at the regional level is required.

Status of CDOO

O: The number of growers to be served by a CDO is highly varied from region to region and one CDO can't serve to all the growers even s/he works 20 days per month.

R: Provide additional fuel allowance (based on location they serve and number of growers to be served) and support staff to the CDOO. The office of CDO should be kept opened during all working days.

REFERENCES

Abeygunawardena, P., Abeyratne, F., and Fernando, M. T. N. (1999). Economics of soil moisture conservation in coconut lands using coconut husks and coir dust. *Cocos*. (10), 35-45.

Abeywardena, V., (1979) Influence of watering on the yield of coconut. *Ceylon Coconut Quarterly* (30), 4, 90-100.

Collet, R (1992) *Modeling binary data.* Chapman and Hall, London.

DCS (2004). *Sri Lanka Census of Agriculture 2002 – Report on Estate Sector*, Department of Census and Statistics, P O Box 563, Colombo.

Herath, H. C, Jayawardena, J. K. M. P., and Henry Nimal, P. A. (2004). Assessment of knowledge level and factors affecting adoption of Red Weewil Control measures of the small holding sector in Kuliyapitiya region. *Proceedings of the International Conference of the CRISL.* 346-353 (Eds: T. S. G. Peiris and C. S. Ranasinghe)

Liyanage, M. De. S., Jayasekera, K. S., and Fernandupulle, M. N., (1993). Effects of application of coconut husk and coir dust on the yield of coconut. *Cocos* (9), 15-21.

MPI (2005). *Coconut Statistics*, Ministry of Plantation Industry, Colombo 2, Sri Lanka

Peiris, T. S. G., Ranasinghe, C. S., Fernando, M. T. N. and Ratnasiri, J. (2004). Progress report on the project on, "Assessment of the Impacts and adaptations to climate change in the Plantation sector with particular reference to coconut and tea in Sri Lanka (Project no. AS-12).

Peiris, T. S. G. (2006). Is there is a real shortage of seedling? *Polwiththi*, The News letter of CCB, Vol. (4), January.

Peiris, T. S. G., Hansen, J. W. and Lareef, Zubair (2005). Use Of Seasonal Climate Information To Predict Coconut Production In Sri Lanka, Accepted for publication *International Journal of Climatology.*

Peiris, T. S. G., and Samarajeewa, S., (1997). *A report on evaluation of coconut subsidy programmes.* An interim report submitted to the Coconut Research Board and Coconut Cultivation Board.

Ranasinghe, C. S, Premasiri, R. D. N. and Silva, L. R. S. (2003). Effect of mulches and cover crops on water status and gas exchange of coconut. *Cocos* (15), 01-11.

Ranasinghe, C. S., Peiris, T. S. G., Jayawardena, J., Perera, L., Fernando, M. T. N. and Wickramananda, I. (2006). Coconut palm decline: Assessment of the prevalence and probable causes. A CRI Publication (in preparation).

Ranatunga, A. S., Liyanage, L. V. K., Mathes, D. T, Somasiri, L. L. W. and Perera, R. A. J. R. (1988). *Some technical issues arising from cultural practices currently adopted in coconut holdings under rehabilitation subsidy program in the Puttalam District.* A report by the Diagnostic survey team submitted to the CRISL, Lunuwila, Sri Lanka.

SAS (2001). SAS/STAT *User Guide* Version of 4th edition, Volume 2, SAS Institute, INC Cary, NC, USA.

Somasiri, L. L.W, Peiris, T. S. G., Gunatilaka, H. A. J., Fernnaod, M. T. N. and Pinto, J. L. J. G. (1993). *An appraisal of coconut growers' reactions and observations on CRI recommended cultural practices and other related issues.* A report by the Diagnostic survey team submitted to the CRISL, Lunuwila, Sri Lanka.

Somasiri, L. L. W., Nadarajah, N., Amarasinghe, L. and Gunathilake, H. A. J. (1994). Land suitability assessment of coconut growing area in the coconut triangle. *Occasional Publication Series 3,* CRI, Lunuwila.

Tennakoon, N. A. (1990). Goat manure as a soil ameliorant and yield stimulant in coconut. *Cocos* (8), 26-32.

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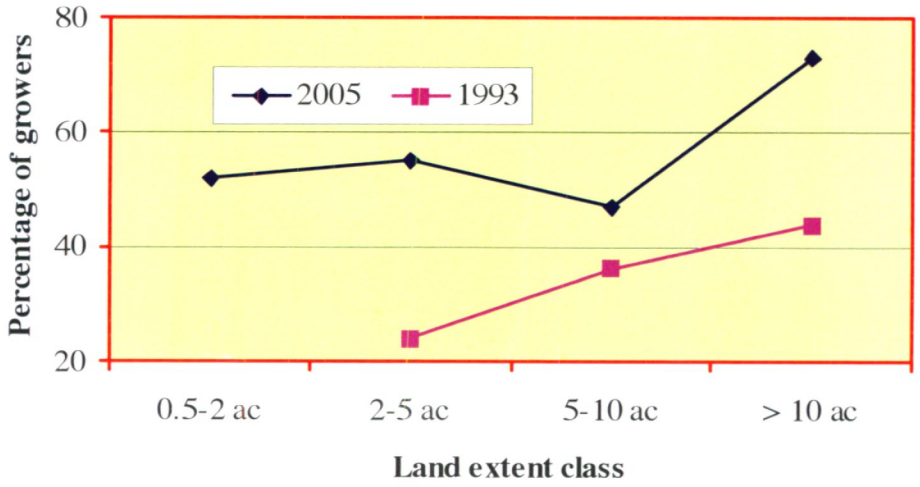
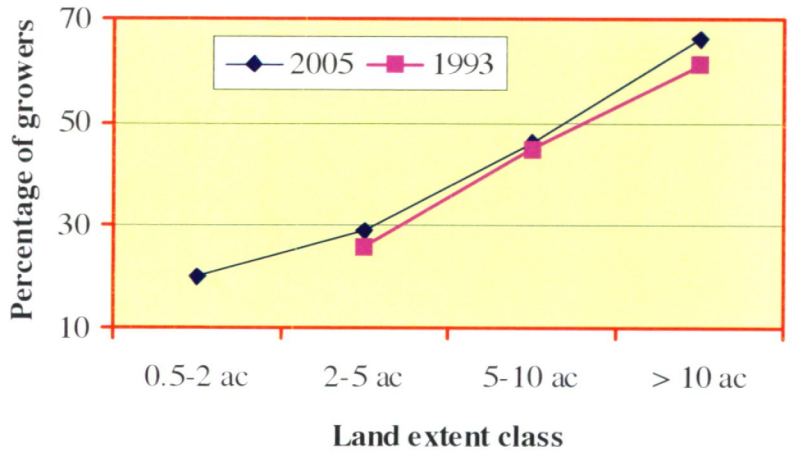
Appendix A

Comparison of the practice of recommended technologies during 1993 and 2005

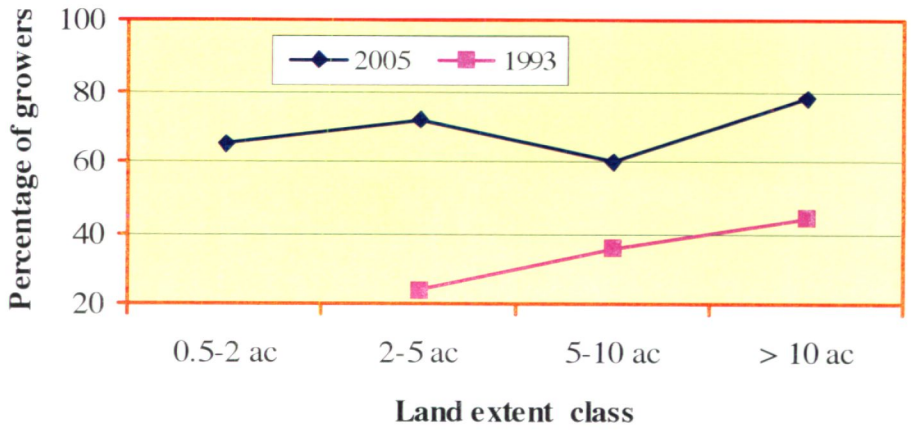
(a) Practice of mulch



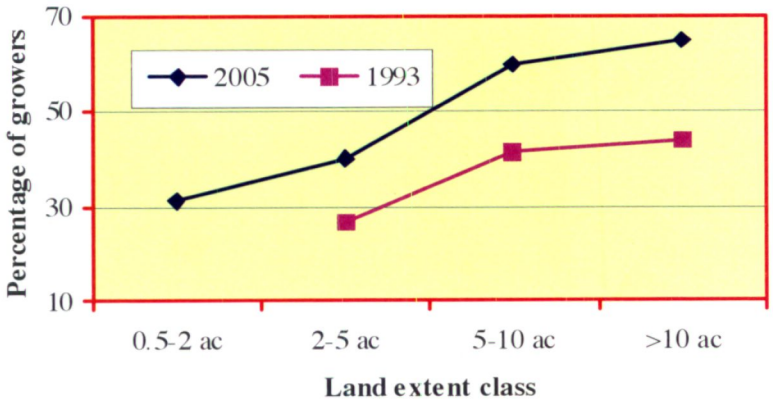
(b) Practice of husk pits



(c) Availability of seedlings



(d) Use of fertilizer for adult palm



(e) Use of fertilizer for young palms