

**STUDIES ON INTERVAL AND METHOD OF PLUCKING
ON PRODUCTIVITY AND QUALITY OF CHINA HYBRID
TEA (Camellia sinensis (L) O. Kuntze)**

THESIS

BY

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PALAMPUR — 176 062 (M. P.) INDIA**

IN

Partial fulfilment of the requirements for the degree

OF

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(AGRONOMY)**

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CERTIFICATE I

This is to certify that the thesis entitled "Studies on interval and method of plucking on productivity and quality of China hybrid tea (*Camellia sinensis* (L) O.Kuntze)" submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Agriculture (Agronomy) of Himachal Pradesh Krishi Vishvavidyalaya Palampur, is the bonafide research work carried out by Sh. Rakesh Kumar Sud under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of this investigation have been fully acknowledged.

Palampur
Dated: Jan. 2^o, 1993


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This is to certify that the thesis entitled "Studies on interval and method of plucking on productivity and quality of China hybrid tea (*Camellia sinensis* (L) O. Kuntze)" submitted by Sh. Rakesh Kumar Sud to Himachal Pradesh Krishi Vishvavidyalaya, Ealampur, in partial fulfilment of the requirements of the degree of Doctor of Philosophy in Agriculture (Agronomy) has been approved by the student's Advisory Committee after an oral examination of the same in collaboration with the external examiner.

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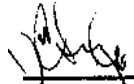
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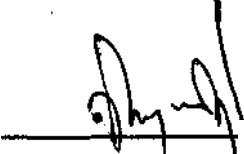

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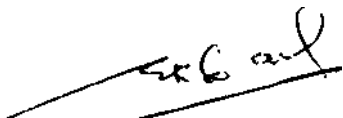
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CONTENTS

Chapter	Title	Page
1.	INTRODUCTION	1 - 5
2.	REVIEW OF LITERATURE	6 -36
	2.1. Tea plant	6 - 8
	2.2. Management of tea plant	8 -11
	2.3. Plucking operation in tea ..	11-15
	2.4. Growth of tea shoot ...	16-22
	2.5. Growth of tea bush	22-24
	2.6. Yield of crop	24-27
	2.7. Physical standard of crop ..	27-28
	2.8. Chemical composition of shoots	28-31
	2.9. Quality of Bade tea ...	31-34
	2.10. Yield vs. quality	34
	2.11. Economics of plucking	34-36
3.	MATERIALS AND METHODS	37-54
	3.1. General	37
	3.2. Experimental details	37-40
	3.3. Field culture ...	40-42
	3.4. Growth studies	42-45
	3.5. Yield	45-47
	3.6. Quality	47-49
	3.7. Economics	49-53
	3.8. Statistical analysis	53-54
4.	EXPERIMENTAL RESULTS	55-185
	4.1. Experiment I: Plucking interval trial	
	4.1.1. Growth studies	55-83
	4.1.1.1. Number of unfolded leaves	55-58
	4.1.1.2. Dormancy index	58-61
	4.1.1.3. Fresh weight of shoot	61-63
	4.1.1.4. Dry weight of shoot	63-66
	4.1.1.5. Dry matter content of shoot	67-70
	4.1.1.6. Shoot weight increment	70-76
	4.1.1.7. Rate of regeneration of shoots	76-78
	4.1.1.8. Number of plucking points	78-81
	4.1.1.9. Bush surface area	81-82
	4.1.1.10. Annual creep	81-83
	4.1.2. Yield	83-90
	4.1.2.1. Green leaf yield	83-86
	4.1.2.2. Made tea yield	87-90

Chapter	Title	Page
	4.1.3. Quality	90-128
	4.1.3.1. Per cent fineness of crop	90-94
	4.1.3.2. Polyphenol content	94-98
	4.1.3.3. Made tea characteristics	98-116
	4.1.3.4. Taster's evaluation	116-128
	4.1.4. Economics	129-135
	4.1.4.1. Planting efficiency	129
	4.1.4.2. Cost of plucking	130-131
	4.1.4.3. Gross return	131-135
	4.2. Experiment I	
	4.2.1. Method of plucking trial	
	4.2.1.1. Growth studies	136-149
	4.2.1.1.1. Number of unfolded leaves	138-137
	4.2.1.1.2. Dormancy index	138-141
	4.2.1.1.3. Fresh weight of shoot	138-142
	4.2.1.1.4. Dry weight of shoot	142-144
	4.2.1.1.5. Dry matter content of shoot	144-146
	4.2.1.1.6. Number of plucking points	146-148
	4.2.1.1.7. Bush surface area	148-149
	4.2.1.1.8. Annual creep	148-149
	4.2.2. Yield	150-155
	4.2.2.1. Green leaf yield	150-153
	4.2.2.2. Made tea yield	153-155
	4.2.3. Quality	155-178
	4.2.3.1. Per cent fineness of crop	155-157
	4.2.3.2. Polyphenol content	157-159
	4.2.3.3. Made tea characteristics	159-169
	4.2.3.4. Taster's evaluation	169-178
	4.2.4. Economics	178-185
	4.2.4.1. Planting efficiency	178-179
	4.2.4.2. Cost of plucking	179-181
	4.2.4.3. Gross return	181-185
5.	DISCUSSION	186-228
	5.1. General	186
	5.1.1. Layout of experiments	186-187
	5.1.2. Performance of unpruned vs pruned bushes	187-193
	5.2. Effect of plucking intervals	194-228
	5.2.1. Growth studies	194-197
	5.2.2. Yield	197-200
	5.2.3. Quality	200-204
	5.3.4. Economics	204-206

Chapter	Title	Page
	5.3.Effect of months of plucking ..	206-214
	5.3.1.Growth studies.	206-211
	5.3.2.Quality.	211-214
	5.4.Interaction effect	214-219
	5.4.1.Growth studies	214-215
	5.4.2.Quality.	215-219
	5.5.Effect of methods of plucking	220-228
	5.5.1.Growth studies.	220-221
	5.5.2.Yield	221-223
	5.5.3.Quality.	223-227
	5.5.4.Economics	227-228
6.	SUMMARY AND CONCLUSIONS.	229-246
	6.1.General.	230-232
	6.2.Effect of plucking intervals ..	232-237
	6.3.Effect of months of plucking ..	237-240
	6.4.Effect of methods of plucking	240-244
	CONCLUSIONS.	244-246
	Future lines of work	247-248
	LITERATURE CITED.	(i)-(xiii)
	APPENDIX.	(1)-(xx)

L I S T O F T A B U E S

Table	Title	Page no.
4.1	Effect of plucking intervals on number of unfolded leaves per shoot in different months of plucking in unpruned and pruned years	56
4.2	Effect of plucking intervals on dormancy index of tea shoots in different months of plucking in unpruned and pruned years	59
4.3	Effect of plucking intervals on fresh weight of plucked shoot (mg) in different months of plucking in unpruned and pruned years	62
4.4	Effect of plucking intervals on dry weight of plucked shoot (mg) in different months of plucking in unpruned and pruned year	64
4.5	Effect of plucking intervals on per cent dry matter content of tea shoots in different months of plucking in unpruned and pruned years	68
4.6	Effect of plucking intervals on rate of fresh weight increment of tea shoot (mg/day) in different months of plucking in unpruned and pruned years	71
4.7	Effect of plucking intervals on rate of dry weight increment of tea shoot (mg/day) in different months of plucking in unpruned and pruned years	74
4.8	Effect of plucking intervals on rate of shoot regeneration in different months on plucking in unpruned and pruned years	77
4.9	Effect of plucking intervals on number of plucking points per unit area and per primary of tea bush in unpruned and pruned years	80
4.10	Effect of plucking intervals on increase in bush surface area of tea in unpruned and pruned years	82

Table	Title	Page no.
4.11	Effect of plucking intervals on annual creep of plucking table of tea bush in unpruned and pruned years	82
4.12	Effect of plucking intervals on green leaf yield of tea (kg/ha) in different flushes and over the season in unpruned and pruned years	84
4.13	Effect of plucking intervals on made tea yield (KMTH) in different flushes and over the season in unpruned and pruned years	88
4.14	Effect of plucking intervals on fineness of crop (%) in different months of plucking in unpruned and pruned years	91
4.15	Effect of plucking intervals on polyphenol content (2) in plucked tea shoots in different months of plucking in unpruned and pruned years	95
4.16	Effect of plucking intervals on caffeine contents (%) in made tea in different months of plucking in unpruned and pruned years	99
4.17	Effect of plucking intervals on theaflavin (TF) content (X) in made tea in different months of plucking on unpruned and pruned years	103
4.18	Effect of plucking intervals on thearubigin (TR) content (%) made in tea in different months of plucking in unpruned and pruned years	106
4.19	Effect of plucking intervals on total colour of made tea in different months of plucking in unpruned and pruned years	110
4.20	Effect of plucking intervals on brightness (%) made tea in different months of plucking in unpruned and pruned years	112
4.21	Taster's report on brightness of made tea as influenced by plucking intervals in different months in unpruned and pruned years	117
4.22	Taster's report on flavour of made tea as influenced by plucking intervals in different months in unpruned and pruned years	120

Table	Title	Page no.
4.23	Taster's report on overall quality of made tea as influenced by plucking intervals in different months in unpruned and pruned years	123
4.24	Taster's report on nominal valuation (Rs/kg) of tea manufactured from the crop of different intervals in different months during unpruned and pruned years	126
4.25	Plucking efficiency (leaf plucked kg/hr) as influenced by plucking intervals in unpruned and pruned years	129
4.26	Cost of tea plucking as influenced by different plucking intervals in unpruned and pruned years	130
4.27	Effect of plucking intervals on average price of leaf plucked, gross income and gross income obtained per rupee invested on plucking	132
4.28	Average number of unfolded leaves per shoot as influenced by different methods of plucking in different months during unpruned and pruned years	137
4.28	Dormancy index as influenced by different methods of plucking in different months during unpruned and pruned years	140
4.30	Average fresh weight of pluckable shoot (mg) on bushes under different methods of plucking in different months during unpruned and pruned years	141
4.31	Average dry weight of pluckable shoot (mg) on bushes under different methods of plucking in different months during unpruned and pruned years	143
4.32	Per cent dry matter content of plucked shoots as influenced by different methods of plucking in different months during unpruned and pruned years	145
4.33	Effect of methods of plucking on number of plucking points per unit area and per primary of tea bush in unpruned and pruned years	147

Table	Title	Page no.
4.34	Increase in bush surface area (X) as influenced by different methods on plucking during unpruned and pruned years	149
4.35	Effect of methods of plucking on annual creep (cm) of plucking table during unpruned and pruned years	149
4.36	Effect of methods of plucking on green leaf yield (kg/ha) of tea in different flushes and over the season during unpruned and pruned years	151
4.37	Effect of methods of plucking on made tea yield (KMTH) of tea and in different flushes and over the season during unpruned and pruned years	154
4.38	Per cent fineness of plucked crop as influenced by different methods of plucking in different months during unpruned and pruned years	156
4.39	Per cent polyphenol content in plucked shoots as influenced by different methods of plucking in different months during unpruned and pruned years	158
4.40	Per cent caffeine content in made tea as influenced by different methods of plucking in different months during unpruned and pruned years	160
4.41	Per cent theaflavin (TF) content in made tea as influenced by different methods of plucked in different months during unpruned and pruned years	162
4.42	Per cent thearubigin (TR) content in made tea as influenced by different methods of plucking in different months during unpruned and pruned years	164
4.43	Total colour of made tea as influenced by different methods of plucking in different months during unpruned and pruned years	166
4.44	Brightness (%) of made tea as influenced by different methods of plucking in different months during unpruned and pruned years	168

Table	Title	Page no.
4.45	Taster's report on brightness of made tea as influenced by different methods of plucking in different months in unpruned and pruned years	170
4.46	Taster's report on colour of made tea as influenced by different methods of plucking in different months in unpruned and pruned years	172
4.47	Taster's report on flavour of made tea as influenced by different methods of plucking in different months in unpruned and pruned years	173
4.48	Taster's report on total quality of made tea as influenced by different methods of plucking in different months in unpruned and pruned years	175
4.49	Taster's report on nominal valuation (Rs/kg) of made tea as influenced by different methods of plucking in different months in unpruned and pruned years	177
4.50	Plucking efficiency (leaf plucked kg/hr) as influenced by different methods of plucking in different in unpruned and pruned years	178
4.51	Cost of tea plucking as influenced by different methods of plucking in unpruned and pruned years	180
4.52	Effect of methods of plucking on price of plucked leaf, gross income per hectare and return per rupee invested on plucking	183

L I S T O F F I G U R E S

Fig.	Title	Between Page No.
2.1.	Primary tea shoot showing pruning and skiffing operations	9 & 10
2.2.	A maintained tea bush	9 & 10
2.3.	A primary tea shoot showing different systems of plucking	10 & 11
2.4.	A primary tea shoot showing development of "crow-feet"	10 & 11
2.5.	Active and <i>Bandhi</i> (dormant) tea shoot	16 & 17
2.6.	A growing tea shoot	16 & 17
3.1.(a)	Mean weekly meteorological data during 1990 (Temperature, Rainfall & Evaporation)	37 & 38
3.1.(b)	Mean weekly meteorological data during 1990 (Relative humidity & Sunshine)	37 & 38
3.2.(a)	Mean weekly meteorological data during 1991 (Temperature, Rainfall & Evaporation)	37 & 38
3.2.(b)	Mean weekly meteorological data during 1991 (Relative humidity & Sunshine)	37 & 38
3.3.	Plan of layout of Experiment I (Studies on plucking interval)	42 & 43
3.4.	Plan of layout of Experiment II (Studies method of plucking)	42 & 43
3.5.	Tea bush showing standard plucking system	43 & 44
3.6.	Tea bush showing black plucking system	43 & 44
5.1.	Effect of plucking intervals on growth of tea shoot.....	194 & 195
5.2.	Effect of plucking intervals on green leaf yield	197 & 198
5.3.	Effect of plucking intervals on quality of tea	201 & 202

Fig.	Title	Between Page No.
5.4.	Effect of plucking intervals on made tea characteristics	203 & 204
5.5.	Effect of plucking intervals on Taster's evaluation of made tea	204 & 205
5.6.	Effect of plucking intervals on cost of plucking	205 & 206
5.7.	Effect of plucking intervals on economics of plucking	205 & 206
5.8.	Effect of months of plucking on growth of tea W11V/V0	207 & 208
5.9.	Effect of months of plucking on quality of t? v? OL	211 & 212
5.10.	Effect of months of plucking on made tea characteristics	213 & 214
5.11.	Effect of months of plucking on Taster's evaluation of made tea	214 & 215
5.12.	Effect of methods of plucking on growth of U6CL S11QQT*	221 & 222
5.13.	Effect of methods of plucking on green leaf JE JL C X U	222 & 223
5.14.	Effect of methods of plucking on quality of Wt? CJL	224 & 225
5.15.	Effect of methods of plucking on made tea characteristics	226 & 227
5.16.	Effect of methods of plucking on Taster's evaluation of made tea	227 & 228
5.17.	Effect of methods of plucking on cost of plucking	228 & 228 b
5.18.	Effect of methods of plucking on economics of plucking	228 & 228 b c

Chapter 1



INTRODUCTION

Chapter I

I N T R O D U C T I O N

Tea, the cheapest beverage, next only to water, is manufactured from the tender shoots of the plant *Camellia sinensis* (L.) O. Kuntze. Globally, its cultivation has spread in about 32 countries located from 45°N in Georgia to 38°S in Brazil. It grows in acidic soils, in regions upto 2460 m above mean sea level with annual rainfall ranging from 125 to 750 cm.

Tea plays an important role in the national economy. Being labour intensive, tea industry employs ten times more mandays than general agriculture and, thus, provides jobs to millions of people both directly and indirectly. It is a major source of foreign exchange to the countries like Sri Lanka, India and China.

With an area of 415 thousand hectares, Indian tea industry leads the world in both production and productivity. In 1990, the world tea production was 2513.6 m kg of which India produced 714.7 m kg (28.4%) followed by China 534.0 m kg (21.2%) and Sri Lanka 233.2 m kg (9.31%), but out of the total national production, India and China exported 199.7 m kg (27.9%) and 192.5 m kg (36.0%), respectively, against 215.6 m kg (92.5%) of Sri Lanka (Dudeja, 1991). The low percentage of export in India and China is due to higher internal consumption. In India, of the total production in 1991, north India produced 75% and rest 25% was by south India. In north India, Assam and West Bengal produced 52.3 and 21.8% (including 1.8% from Darjeeling) of the total national production, respectively, while the production in other northern states including Tripura, Himachal Pradesh and

Uttar Pradesh was quite low (Calcutta Tea Marketing Report, 1991). In south India, Tamil Nadu and Kerala produced 12.9 and 8.1% of the total national production while Karnataka produced only 0.6% (Tea Statistics, 1986).

The tea industry in Kangra Valley of Himachal Pradesh had a glorious history. The tea cultivation commenced in 1849 with the feasibility studies conducted by Dr. Janeson, Superintendent of Botanical Gardens, north-west province. It became world famous for its quality as evidenced by the Gold and Silver medals which it won between 1886 and 1895 at London and Amsterdam tea exhibitions, but this old and fine industry received a serious setback in April 1905 when a great earthquake devastated the plantations and ruined tea factories. Now Kangra tea industry is no more strong. The area under tea has come down to 2063 hectares from 4183 hectares (Jain, 1986), possibly on account of uneconomic returns due to inadequate management.

In 1991, Himachal Pradesh produced 1.20 million kg tea (Tech. Officer Tea, Palampur, 1992) which was only 0.16% of the national production. Its average yield of 582 kilograms made tea per hectare (KMT/H) during the year was much lower than the national average of 1780 KMT/H. The tea industry in Darjeeling, where the climate and germplasm are almost analogous to that of Himachal Pradesh, produces higher yield with far better average price. Amongst various reasons of low yield and quality of tea in Himachal Pradesh, improper bush management, poor standard of plucking and manufacturing and low input use due to lack of technical knowhow are important factors, besides others like

over-century old plants and uneconomical size of holdings.

The tea plant is grown for its young shoots from which different types of teas viz. 'green tea', '*semifemented tea' and 'black tea - CTC or orthodox' are manufactured. Hence, technologies have been developed to encourage young shoot production. These include pruning, tipping, plucking and shade management, besides optimum plant population, fertilizer application, water management, and pest and diseases control.

"Plucking" in tea involves harvesting of shoots usually, consisting of the growing terminal buds and two tender leaves below it, generally referred to as 'two and a bud' or '2+Bud'- the 'standard shoot', growing above the 'plucking table' i.e. the flat top surface of tea bush at a pre-determined height above ground level. It is a very costly operation undertaken in tea plantation. Plucking is important not only for the harvest of crop but also for the development of the next generation of shoots, because it acts as a stimulus for the regeneration of further orders of lateral shoots. The operation is carried out throughout the season at pre-determined intervals.

During a cropping season, the growth of shoots is influenced by factors such as plant types and style of pruning and seasonal agroclimatic variations. Therefore, a generalised recommendation on plucking interval cannot be valid for all seasons, plant types and sections of plantation under different pruning cycles. Variation in growth of shoots call for regulation of plucking interval based on the growth rate of shoot to obtain a desired

composition of crop.

Shoots plucked at longer intervals (rounds) are obviously larger and heavier leading to higher yield per round, but total rounds of plucking in a season will be less. On the other hand, shorter interval, while giving lower yield per round due to smaller size and lighter pluckable shoots, increase the frequencies of pluckings in a season. Such variation in the composition of crop certainly affects the quality profile of the crop. The total mandays required for plucking in a season mostly depends on the interval of plucking. Though longer plucking interval reduces the number of pluckings, the shoots plucked, usually, are coarser. On the other hand, the shoots plucked in shorter interval are tender and easy to pluck. Thus, standard of shoot may affect the plucking efficiency. Hence, study on effect of plucking interval on yield and quality of crop and overall economics would be very important and practical.

Plucked shoots are important for the yield, but the shoots left behind on the plucking table in every plucking round are equally important for sustained productivity, as these are the major sinks. In "Standard Plucking System" small 1+Bud shoots and unopened buds are not plucked while in "Black Plucking System" only unopened buds are left behind. Whether these systems influence the yield and quality of plucked crop and sustained productivity of the plucked tea bush is a matter of investigation.

Plucking operation in tea is highly labour intensive, and therefore, efficient harvesting during the entire cropping season

calls for more labour requirement, particularly in this era of high use of inputs. Paucity of labour especially during the peak flush period, is a serious problem in Himachal Pradesh as plucking season coincides with the sowing/harvesting of other field crops. Besides, in Himachal Pradesh, the feeling of a social stigma of tea plantation labourer keeps away the available labour necessitating mechanisation of tea harvesting. Use of mechanical devices for plucking tea shoots is expected to reduce the labour requirement. However, the effect of mechanical plucking of the China hybrid tea, under Himachal Pradesh conditions, on the yield and quality, and overall economics of tea production is not known and necessitates investigation on this aspect also.

Information available on the above mentioned aspects is either limited to *assamica* type of tea or to other types of agro-climatic conditions. In Himachal Pradesh, where there is a great need to maximise yield without sacrificing the unique quality of the China-hybrid Kangra tea, no such information is available on which ideal plucking programmes can be formulated.

Considering the importance of the above facts, the present studies were planned to meet the following objectives:

1. to standardise interval and method of plucking for maximising tea productivity,
2. to standardise interval and method of plucking for quality of plucked shoots,
3. to study some of the phytotic factors governing the interval and method of plucking, and
4. to assess the economics of different plucking intervals and methods.

Chapter 2

**REVIEW
OF
LITERATURE**

Chapter 2

R E V I E W O F L I T E R A T U R E

The literature relevant to the present investigations have been reviewed under the following broad headings :

- 2.1. Tea plant
- 2.2. Management of tea plant
- 2.3. Plucking operation in tea
- 2.4. Growth of tea shoot
- 2.5. Growth of tea bush
- 2.6. Yield of crop
- 2.7. Physical standard of crop
- 2.8. Chemical composition of shoots
- 2.9. Quality of made tea
- 2.10. Yield vs. quality
- 2.11. Economics of plucking

2.1. Tea plant

Botanically, the tea plant now known as *Camellia sinensis* (L.) O.Kuntze was formerly named *Thea sinensis* (L.). It belongs to the Family Theaceae. It is an evergreen plant and in nature grows to a big shrub or a small tree. It is known only in cultivation and no wild tea has been reported (Kingdom-Ward, 1950). Today, tea is cultivated in all five continents (Bonheure, 1990).

Three basic types of tea, widely differing in their growth

habit and morphological features are generally recognised. These varieties are *sinensis* (the China tea plant), *assamica* (the Assam tea plant) and *canbodiensis* (the 'canbod race' or 'southern form' or Indo-China tea plant) (Roberts *et al.*, 1957; Wight, 1972; Bezbaruah, 1976; Sharna and Venktaranani, 1974).

The China tea plant (Plate 2.1) is a multistemmed shrub, growing 1-3 m tall, with small 3-6 cm long dark green, hard, matt and semi-erect to erect leaves, while the Assam tea plant (Plate 2.2) is a small tree growing upto 9-10 m tall with relatively large 15-20 cm long, light green, supple, glossy, horizontal to droopy leaves. The canbod tea plant is similar to the Assam plant in height and size of leaves but differs from it in seasonal development of blood red pigments on the leaves in winter (Barua, 1986). Wight (1962) proposed the name *Camellia sinensis* (L.) for the China plant, *Camellia assamica* (Masters) for the Assam plant and *Camellia assamica* sub-sp. *lasiocalyx* (Planch MS) for the Canbod plant. The commercial tea populations are hybrids among of these forms of tea with possible introgressions from other related non tea species. The presence of non tea genome like *Camellia irrawadiensis* in cultivated tea was clearly demonstrated by Wight and Barua (1957) and Wood and Barua (1958). A tea population as a whole is assigned to either the China or the Assam type on subjective judgment based on aggregate of vegetative features, while the presence of red pigmentation on the petiole and margins of leaves mark the identity of Canbod plant.

The China tea plants grow well in the cold climate of higher



Plate 2.1. *China hybrid tea bush*



Plate 2.2. *Assam hybrid tea bush*

altitudes and in the warm tropics. The Assam tea plant do not thrive in cold climate where freezing temperature occurs. The plants of Cambod race appear to be somewhat less susceptible to cold than the Assam plants (Barua, 1986). Today, the China tea is cultivated mainly in China and Japan while the Assam and its hybrids in India, Sri Lanka, Indonesia, Africa, South America, Australia and even in Russia and middle east (Bonheure, 1990).

2.2. Management of. tea. plant.

A free growing tea plant has a much larger leaf area (Hadfield, 1974) and accumulates greater dry matter (Magambo and Cannel, 1981) than a well managed and pruned tea bush of same age but no commercial yields are possible in free growing tea plant. To keep it economically productive, the vertical growth of the plant is kept under check by pruning and plucking at regular intervals to maintain it in bush form with a flat top surface.

In the very early years of tea cultivation in China, there was no concept of pruning. The tender shoots which grow in flushes on the freely growing tea plants were harvested with considerable care, and as such this harvesting posed lot of difficulties (Ukers, 1935). The concept of pruning in tea probably came from horticultural practices followed in certain fruit crops for giving shape to the tree to regenerate new branches (Mittra, 1976). No record exists as to when the practice of annual prune started in India.

Pruning in tea is essentially the artificial removal of leaf

bearing branches of the plant, practised to (a) establish plucking table (b) stimulate vigorous shoot growth (c) rationalise wood/shoot ratio and (d) renew maintenance foliage (Jain and Tanang, 1988). In order to achieve the above objectives three types of pruning systems are practised from time to time in the life of a tea bush. These are: 1) formative prune (the first prune, where free growing young tea plant is trained and brought upto form table topped bush) 2) maintenance prune (carried out to maintain the bush vigour by removing 'crows feet' (i.e. multi-prolonged structure formed on first order laterals due to repeated branching consequent to plucking of shoots) and lowering down the table height which occur due to continuous plucking of bush) and 3) corrective prune (resorted to rejuvenate the old bush).

Until recently the bushes were pruned annually. The practice was found to be suitable for production of quality tea but detrimental to the sustained productivity. Presently a series of light forms of cuts, i.e. skiffings, have been introduced extend the gap between two successive pruning operations (pruning cycles) for higher crop productivity. Depending on severity, the skiffing operations have been categorised as "level off skiff, 'light skiff, "medium skiff or "deep skiff (Fig. 2.1). Normally the severity of skiffing increases with the passage of time from the last pruning operation (Kulasegaran *et al.*, 1975; Jain and Tanang, 1988; Barua, 1989).

In the early years, all the shoots growing on the pruned bush were plucked soon after their growth without leaving behind

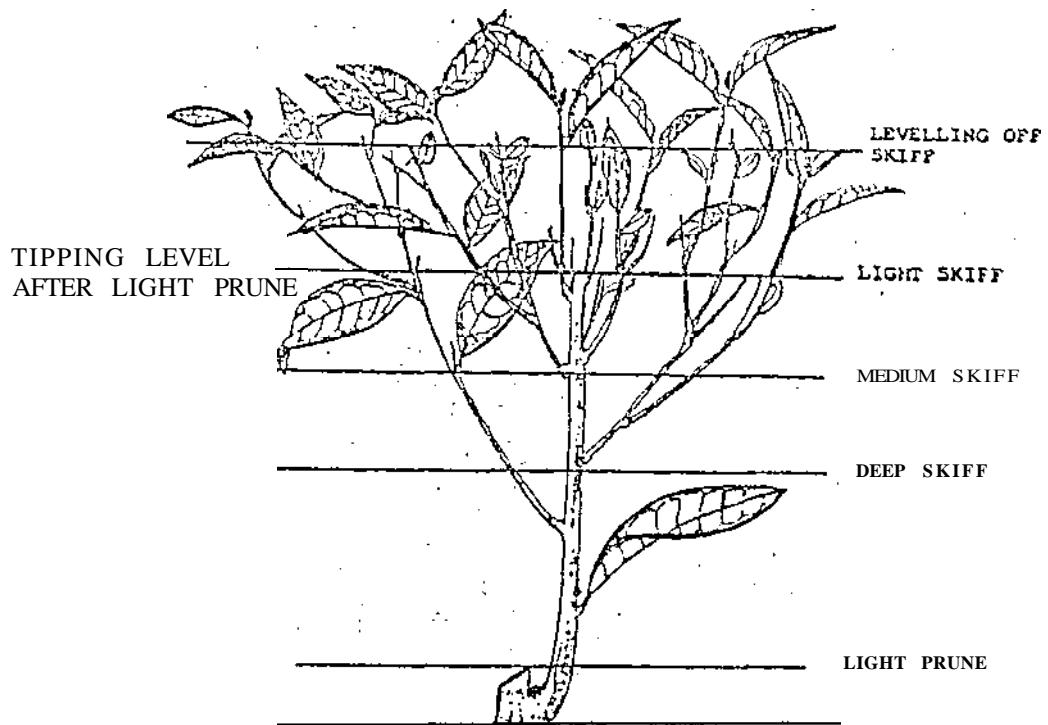


Fig.2.1. *Primary tea shoot showing pruning & skiffing operations*

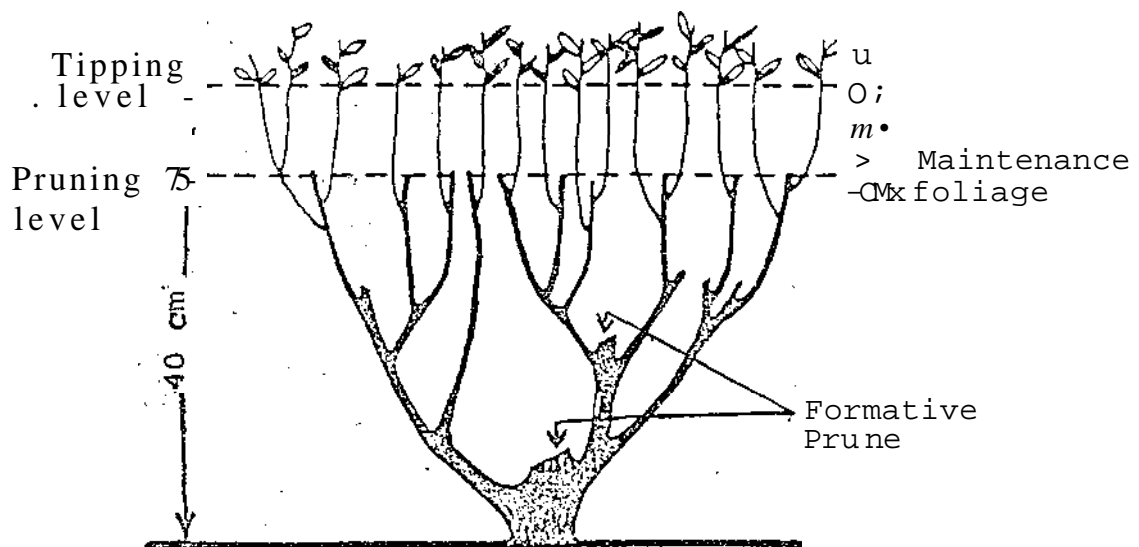


Fig.2.2. *A maintained tea bush*

any leaf, hence devoiding the bush of new growth. In 1953, Williamson showed that plucking the harvestable shoots after leaving a few leaves on the stems below it before plucking away helped in sustaining productivity of the bush in the later season, and thereby, did not lower the total yield (Sarkar, 1988). Thus, the concept of retaining maintenance foliage (Plate 2.3) came into existence. The Maintenance foliage synthesise carbohydrates and supplies these to frame, roots as well as to the growing shoots. During active flush period the direction of movement of carbohydrates is towards flush (actively growing shoots) while during dormancy period, the assimilates are stored in the form of starch in the roots (Manivel and Hussain, 1982).

The cultivated bush has a permanent frame bearing a number of branches called "pruning sticks". When the bushes are pruned, the cut ends of the pruning sticks lie in a horizontal plane. The new shoots that emerge from dormant buds on the sticks are called "primary shoots" or "primaries". These primaries are decapitated ("tipped") when they reach the pre-determined tipping level sufficient maintenance foliage on the bush (Plate 2.4; Fig. 2.2). After a primary shoot has been tipped, new shoots arise from axillary buds (Plate 3.9) and the phenomenon is called 'regeneration'. Thus, tipping stimulates the regeneration of dormant axillary buds on the primary shoots into actively growing lateral shoots which are then plucked as crop when these grow above tipping level. Repeated plucking of successive orders of lateral shoots as crop result in the formation of a complex shoot system on each single primary shoot (Fig 2.3). The depth of

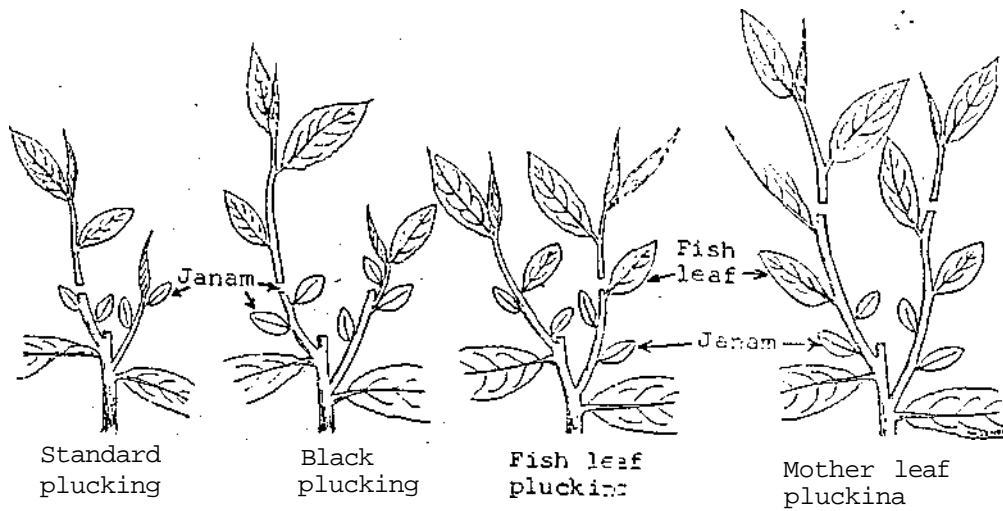


Fig.2.3. A primary tea shoot showing different systems of plucking

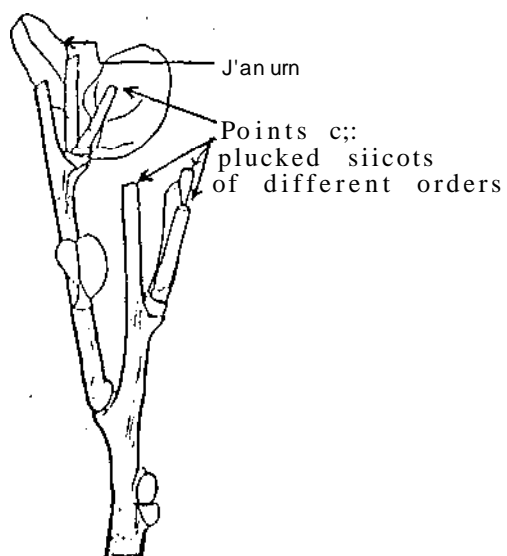


Fig.2.4. A primary tea showing development of 'crowfeet'



Plate 2.3. *Maintenance foliage of tea bush*



Plate 2.4. *'Tipping' of tea bush after pruning*

maintenance foliage is also regulated by the tipping. The role and importance of maintenance foliage has been highlighted by Manivel (1978 & 1980).

As late as 1926, the systems of pruning and plucking as they exist today were almost unknown even in China where the tea culture actually developed. Torgasheff (1926) described the then cultivation method as "primitive" and plucking method as "barbarous". As mentioned earlier, the all tender young tea shoots growing in flushes in naturally growing tea shrubs or trees were plucked as crop. Such plucking involved great care and difficulty particularly in high hills. From inaccessible heights, monkeys were reported to be trained to pluck tea in China (Derek Maitland, 1982) but how far this is true, is a matter of speculation.

With the passage of time, the concepts of pruning, tipping and maintenance foliage came into being as a result of gain in knowledge and experience, and better understanding of physiology of tea bush.

2.3. Effect of plucking operation in tea

Growth, yield and quality of tea as well as the health of tea bush are influenced by the severity of plucking. Wettansinghe *et al.* (1981), Sharma (1983), Gvasaliya (1986), Kulasegaram, 1988) and Sukasman (1989) observed that higher yield was obtained with harder plucking system but at the cost of health of tea bush health. Hence, While the leaf plucked is important for the harvest, the leaf left behind is the foundation of bush health and

sustained productivity (Jain and Tamang, 1988).

Growing buds and 1+Bud shoots are known to be the strongest sink (Tocklai Exptl. Station Ann.Sci.Report 1982-84). Manivel and Hussain (1986) recommended their retention on the plucking table to reap the sink-induced accelerated photosynthesis of maintenance foliage. So, the formulation of plucking programme should be based on source - sink relationship so as to reap higher production without any ill effect on bush health.

2.3.1.Interval of plucking

For harvesting maximum number of 2+Bud growing shoots in north east India, Wight (1932) suggested a plucking round equal to leaf period, *i.e.* the rate of leaf unfolding, since all growing shoots with one unfolded leaf (1+Bud) are usually left behind on the plucking table. But considering the impracticability of shorter round for plucking, he further suggested a generalised round of 7 days, which was, later, found suitable (Dutta, 1961). But Rahman (1977) demonstrated that the suitable round varies from 7 days to 14 days as rate of leaf unfolding varies during the crop season. Besides the leaf period the weight increment by individual shoots are important. According to Tanton (1979), tea is sink limited, with sufficient than adequate foliage leaves producing more photosynthates than the growing shoots could consume. He suggested to enlarge the sink capacity of tea shoots and, hence, productivity by plucking 3+Bud shoots instead of 2+Bud as the photosynthates are imported by shoot upto third leaf stage. But such plucking reduced the

quality of crop (Ullah and Jain, 1980). Therefore, all these aspects require attention while formulating plucking interval.

Sharma and Murty (1989) under south Indian conditions made an attempt to develop a system to predict the optimum interval between plucking rounds in different seasons to enable advanced planning and effective deployment of labour. They compared two systems, one based on the number of days required for axillary buds to reach the 3+Bud stage, accumulated day degrees and the growth hierarchy (number of shoot generation) existing on plucking surface, the other based on day degrees required for unfolding and expansion of the third leaf on shoot comprising 2+Bud. They found that by the use of first system, there was abrupt and marked variation in the interval requiring rapid and frequent changes in labour deployment, though second system was promising.

2.3.2. Systems and methods of plucking

'*Janas* plucking', 'fish leaf plucking', 'mother leaf plucking' and 'single leaf plucking' are the different plucking systems followed in different places (Fig. 2.4). *Janata* plucking (plucking shoot to scale leaf at plucking table) is suitable in situations where rate of growth is fast while fish leaf plucking (plucking shoot to fish leaf at plucking table) is suitable where rate of growth is slow (Sarkar, 1988). The former standard is common in north east India and also in Kangra Valley of Himachal Pradesh. In 'mother leaf' or 'single leaf plucking' one leaf is left on the plucking table on alternate plucking to nourish the coming generation of shoot.

Hand plucking and mechanical plucking are the different methods of plucking which can be opted depending on the need and convenience.

2.3.2.1. Hand plucking

Hand plucking entails manual removal of tender shoots on the bush. It is a selective method of plucking where desired standard of shoot can be plucked or left behind on the bush.

Two systems of plucking are generally followed in *janan* plucking. The more popular one is "Standard", a somewhat lenient system where buds and small 1+Bud shoots are left unplucked. The other system is "Black" where only unopened buds are left behind and all other shoots are plucked (Fig. 2.4). Observations on *assamica* of bushes show that when Black plucking is carried out throughout the plucking season, the yield is reduced compared to that under standard plucking (Tocklai Exptl. Station, Ann.Sci.Report 1982-83). However, Black plucking system is recommended as a short term measure during periods of severe pests (jassids and thrips) infestations, attack of Blister blight disease, and tendency for higher dormancy state of the plucked bush towards the end of early and end flushes in unpruned tea (Tamang, 1987a, 1987b and 1988).

2.3.2.2. Mechanical plucking

To overcome the shortage of labour or to cut down the high cost of plucking, mechanical plucking aids have been tried in many countries. In most cases, trials have been confined to the

use of hand operated or motorised shears. In north east India, mechanical plucking have been tried in the forties (Indian Tea Association, Annual Report 1949).

Summarising the history of hand operated shear, Dharanraj (1980) mentioned that in south India, the first shear introduced in 1962 was a pair of cutting scissors fitted with a receptacle to collect leaf. Although higher plucker output was obtained with this shear, the crop quality and bush yield suffered as operation resembled hedge clipping resulting in harvesting of coarse maintenance leaf, red wood and immature shoots. Basically the operation was against the principles of bush physiology, so the exercise was discontinued in 1969. The practice was reintroduced in 1979 with some modifications in the size and shape of shear. The modified shear also prevents the cutting of immature shoots.

Self propelled, selective plucking machines have been developed in Georgia where only 10% of crop was plucked by machine in early seventies (Dey, 1972) and rest being plucked manually.

In Japan, where tea is plucked only three to four times in year, motorised shears are generally used for harvesting the leaf shoots which are then sorted into different grades and manufactured separately for making green tea of different qualities (Barua, 1889). Various types of motorised shears ranging from snail knapsack to tractor mounted have been developed in Japan. These types of plucking machines are also in use

Georgia.

2.4.growth *QL* tea. shoots

Tea shoots exhibit the characteristic 'phasic growth'; the shoot extends in alternating phases of growth and dormancy. Hence, morphologically, the shoots are categorised as either "active" when the terminal bud is found to almost as long as the subtending leaf, "dormant (*banjhi*)" when the terminal bud becomes diminutive in size (Fig. 2.5).

A tea shoot commences its growth phase by swelling and elongation of the dormant terminal bud and then unfolding of usually two cataphylls or scale leaves (also called "*Janajas*"), and a snail, comparatively thicker and unserrated or senescent transition leaf ('fish leaf or '*golpat*') in quick succession, and subsequent foliage leaves (Fig. 2.6). Pluckable shoots on the plucking table arise from the axillary buds remaining on the stems of previously plucked shoots or from the regrowth of dormant shoots lying below the plucking table (Sarkar, 1988). The growth of young shoots has been expressed in terms of time required for its development, number of leaves unfolded, gain in weight and its density in the bush, proportion of dormant to active shoots, dry matter content, etc. The factors which are known to affect tea growth are the genotype (Stuart, 1930; Tubbs, 1932; Hadfield, 1966; Maganbo and Onolo, 1982; Hyirenda and Ridpath, 1984), the environment (Barua, 1969; Laycock, 1969; Herd and Squire, 1976; Carr, 1977; Fordhan and Palmer-Jones, 1977; Squire, 1978; Barua and Das, 1979; Tanton, 1981 & 1982a&b), the management (Barua, 1961; Templer, 1978; Squire, 1979; Othieno,

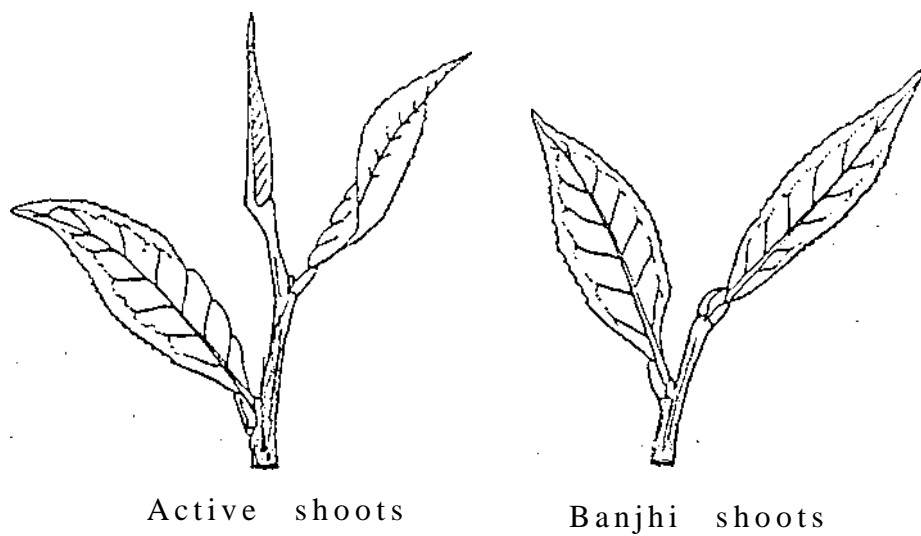


Fig.2.5. Active and Banjhi (Dormant) tea shoots

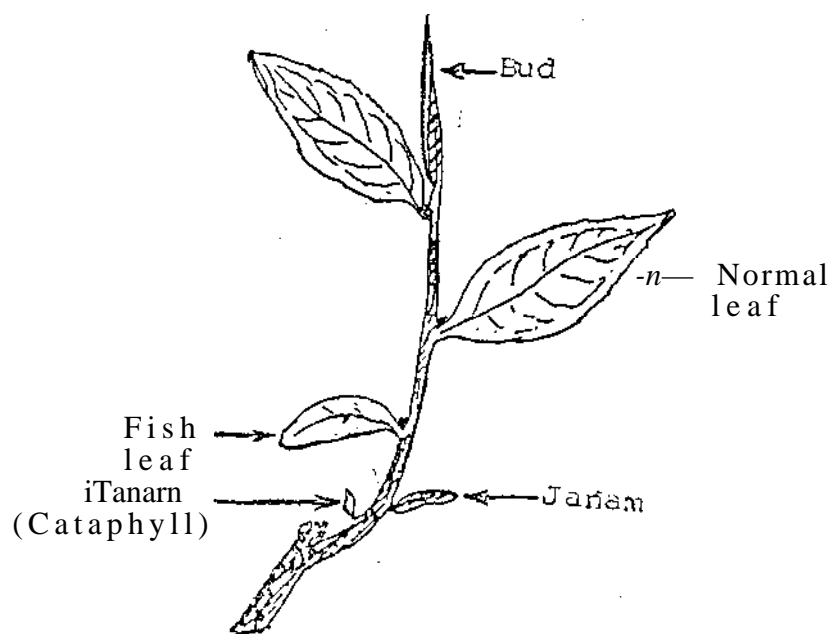


Fig.2.6. A growing tea shoot

1980; Mwakha and Anyuka, 1982), dormancy, and growth regulators (Kulasegaram, 1969 & 1971; Kulasegaram and Kathiravetpillai, 1972 & 1974).

2.4.1. Shoot density

Number of shoots per unit area of bush surface area is one of the very important yield-attributing characters of tea bush. Plucking practices encouraging the density would result in higher yields.

2.4.1.1. Effect of plucking interval

Shorter rounds result in more number of plucking points per unit area than extended ones (Ranganathan *et al.*, 1983; Nathaniel *et al.*, 1986). Cloves (1989a) and Othiambo (1989) observed that while shoot density per harvest showed increasing trend but cumulative shoots harvested showed reducing trend with increase in plucking interval.

2.4.1.2. Effect of method of plucking

No published evidence was found indicating the effect of method of plucking on shoot density.

2.4.2. Shoot weight

Measurement of the growth of several thousand shoots by Tanton (1981) indicated that an individual shoot grows exponentially to harvestable size but if they are left unplucked, they grow to the typical sigmoidal mode. Pruning practice also affects the shoot weight. During pruned year, pluckable shoot is usually twice as heavy as similar standard shoot in the unpruned

year (Mwakha, 1988).

2.4.2.1. Effect of plucking interval

Following plucking **from 6 to 22 days interval**, Odhiambo (1989) found increase in fresh weight **from 0.65 to 0.89 g/shoot**. Mwakha (1991) observed that all shoot grades - **1+Bud, 2+Bud and 3+Bud** were significantly affected **by plucking interval**, whereby Bean shoot weight increased with increase in coarseness of plucking.

2.4.2.2. Effect of method of plucking

Machine harvesting resulted in production of **smaller** shoots as shown by the lower weight of both 2+Bud and 3+Bud shoots in comparison to hand plucking (Watson *et al.*, 1982).

2.4.3. Shoot density vs. weight

In pruned year, shoots per unit area are **minimum** and have maximum unit weight but in unpruned year they tend to increase in number and decrease in unit weight (Rahman, 1988). The decrease in weight has been explained by Tubbs (1936) to be due to internal competition among increased number of shoots while Portsmouth (1957) considered it to be due to increased complexity of branching at plucking surface resulting in interference with movement of water and nutrients to the growing apices, but Bight (1955) attributed this to the loss of vigour of apical meristems due to ageing.

Due to nature of growth curve, there was 55% increase in dry matter in a 3+Bud shoot than in a 2+Bud shoot which occurred over a period of 3-5 days (Cloves, 1989b). Under Rangra condi-

tions the dry weight of a 2+Bud shoot more than doubled after 4 days of its formation (Annual Report, CSIR Complex Palampur, 1988-89).

A hard plucking system encourages shoot number and has a negative effect on unit weight of shoots while on the other hand, a lenient system has an opposite effect because many shoots become dormant below the plucking surface (Rahman, 1988).

2.4.4. Regeneration rate

"Regeneration rate" denotes the time (days) taken by an axillary bud on a plucked shoot to grow into a pluckable standard shoot following plucking. It has been reported to be influenced by the type of bush and climatic conditions. It was also influenced by altitude (Mwakha, 1985a).

The time required for a dormant bud to grow into a pluckable size was 76-95 days in Kenya (Mwakha, 1985b), 81 days in Sri Lanka, 42-49 days in Malawi and 36-42 days in Assam, India (Rahman, 1988). However, the influence of plucking practices on regeneration rate is not known though it is an important phenomenon for formulating plucking programme (Cloves, 1989b).

2.4.5. Leaf period

The time interval between the unfolding of two successive appendages in a growing shoot is called "leaf period" or "phyllochron". Wight as early as 1932, suggested the consideration of leaf period for formulating plucking programme. Leaf period is not constant as it changes with climatic conditions, and is also

affected by the types of plant in a given climate (Das, 1984). Reports from various places reveal that leaf period is 9 days in Sri Lanka (Portsmouth and Rajiah, 1957), 9-10 days in Java (Harler, 1964), 3-7 days in north east India (Rahman, 1977; Das, 1984, Tamang, 1985), 6-7 days in east Africa (Magambo, 1975) and 3-6 days in Kangra Himachal Pradesh (Annual Report, CSIR Complex Palampur, 1986-87).

Leaf period has shown an inverse relationship with the yield of crop throughout the cropping season (Annual Report, CSIR Complex Palampur 1987-88). However, no information is available on the influence of plucking practices on leaf period.

2.4.6. Dormancy index

The ratio of number of *banjhi* shoots (the terminal bud is less than half the length of the subtending leaf) to active shoots is known as "dormancy index" (Wight and Barua, 1955). In a tea bush, at a given time during growing season not all the terminal buds are either active or dormant, there being certain number of each type (Pethiyagoda, 1964). Regular fluctuations in crop production are thought to be caused by regular changes in dormancy index (Tanton, 1981). During crop season, active flush and cessation of flush can be judged by relative narrowing or broadening of dormancy index value in pluckable bush. Factors like nutritional constraint, moisture stress, hormonal imbalance, environmental conditions have been implicated for changes in the ratio. Restricted supply of nitrogen or inadequate availability of water and other nutrients will contribute for the buds going *banJhi*. as reported by de Haan (1941) and Bond (1945). This was

further corroborated by anatomical studies where it was observed that the vascular tissues, especially the xylem of **sten**, immediately below the apices of *banjhi* shoots are ill developed (Bond, 1945; Wight and Barua, 1955; Barua and Das, 1979). From economic and practical point of view, commercial tea cultivation is aimed at producing more active shoots or decreasing the *banjhi* proportion because higher level of dormant shoots are reported to adversely affect both productivity as well as quality of tea (Ranganathan *et al.*, 1983).

2.4.6.1. Effect of plucking interval

The percentage of active shoots was significantly reduced in a 7 days plucking round than shorter rounds (Nathaniel *et al.*, 1986). Therefore widening of plucking interval is expected to increase the dormancy index.

2.4.6.2. Effect of method of plucking

The style of plucking *e.g.* too light or too hard are reported to affect the *banjhi* level in the yield (de Haan, 1949). Watson *et al.* 1982 did not find any difference in the proportion of active shoots in machine and hand plucked bushes. Though the proportion of *soft-banjhi* shoots (shoots with dormant bud and one or two soft leaves below it) was not much affected by mechanical plucking or hand plucking the proportion of hard *banjhi* shoot was much higher in the former and was not existing at all in the latter (Mwakha, 1990).

2.4.7. Dry matter content

Dry matter content, which is the ratio of dry shoot weight

to the fresh weight, expresses the recovery percentage of made tea from the raw material. Generally, dry matter is considered to be one-fourth of the fresh weight of crop. In south India average conversion of 23 per cent from fresh leaf to made tea yield is accepted (Haridas, 1978), but Satyanarayana (1984) observed wide variations (16 to 27%) in dry matter content due to seasonal changes and clonal factor. Significant difference in dry matter content between clones has been reported by Bezbaruah and Hussain (1975), and Tamang (1985).

2.4.7.1. Effect of plucking interval

Ranganathan *et al.* (1983) observed slightly higher moisture percentage in tea shoots plucked at shorter rounds than at extended ones.

2.4.7.2. Effect of method of plucking

Mechanically plucked leaf contains some proportion of overgrown shoots and cut mature leaves. However, there is no published report available on the dry matter content of shoots under this circumstances.

2.5. *QL tsa. hush*

The management factors which affect the crop productivity do so through their effects on frame development and canopy depth of maintenance foliage both of which are essential prerequisites for sustained high production (Kulasegaram *et al.*, 1975). Bush surface area and annual rise in plucking table have been reported to be affected by plucking practices (Barua, 1969; Watson, *et al.*, 1982).

2.5.1. **Bush** spread

Total bush surface area has been reported to be one of the yield attributing characters (Barua, 1969).

2.5.1.1. Effect of plucking **interval**

Though no published information could be located during survey of literature but, it is expected that shorter round will restrict the spread due to frequent plucking .

2.5.1.2. Effect **of aethod of plucking**

In Sri Lanka Watson *et al.*, (1982) observed the spread of machine plucked tea bushes at two locations to be 117.3 and 89.5 en against 137.0 and 101.7 en in hand plucked ones, respectively. The average of these figures indicates that spread of machine plucked tea bush is United to 0.87 tine the hand plucked one.

2.5.2. **Annual** creep

A bush under continuous plucking nanifests 'creep' of plucking table (Jain and Tanang, 1988). In other words, there is continuous rise in plucking level of bush with plucking operation. Sarkar (1988) suggested that the creep should not exceed beyond 5.6 en in pruned year and 4.0 en in unpruned year otherwise it results in loss of crop

2.5.2.1. Effect of plucking interval

Ranganathan *et al.* (1983) and Mwakha (1987) observed low creep due to shorter intervals as compared to longer ones. Similarly, consistent rise in plucking table with widening plucking interval have been reported by Odhianbo (1989).

2.5.2.2.Effect of method of plucking

Expressing the results in terms of total height instead of creep, Watson *et al.* (1982) reported that the increase in height was much lower in machine plucked bushes resulting in an average height of 85.2 cm after two years compared with 100.2 cm for hand plucked bushes in Sri Lanka.

2.6.Yield.

The yield of tea bush depends on number of factors namely: the number of plucking points per unit area of bush, the proportion of active to dormant shoots at a time, the frequency and duration of flushing (Herd and Squire, 1976) and surface area of tea bush (Barua, 1969). According to Rahman (1977), the yield of tea is the product of weight of shoots and their **number** per unit area and these are generally complementary to each other. Length of plucking interval and method of plucking have been reported to influence the component of crops and, hence, the total yield.

2.6.1.Effect of plucking interval

It has been reported from Sri Lanka that though the average weight of shoot plucked on fortnightly round was distinctly higher than that of weekly round, the latter gave higher yield (Tubbs, 1938 & 1949; Pethiyagoda, 1967). Another report of Nathaniel *et al.* (1986) revealed that the shorter round of 4 days gave 16% more crop over the standard round of 6 days. Similarly, Palmer-Jones (1977) in Central Africa, Dunur and Naidu (1985) in Mauritius and Mwakha (1987) in western Kenya observed the

superiority of shorter rounds in respect of crop productivity.

The increase in yield in the shorter round is mainly due to formation of more number of plucking points per unit area because the plucking act as a stimulus for further shoot production by temporarily destroying the apical dominance (Portsmouth and Rajiah, 1957). Besides, the higher mean weight of individual shoot plucked in longer rounds is not sufficient enough to compensate for reduction in total number of shoots, resulting in net loss of crop (Portsmouth, 1957). However, the findings of experiments carried out in India contradict the above results. In north east India plucking was carried out in four types of clones at an interval of 3 to 14 days. The results indicated the differential behaviour of clones in respect of gross weight of harvest, however, it increased with increase in the length of plucking interval with some fluctuations in all clones (Tocklai Exptl. Station Ann.Sci.Report, 1970-71). Sarkar (1988) reported a linear relationship between plucking interval from 5 to 13 days and yield of tea both in pruned as well as in unpruned tea sections. Recent report on long-term trial on plucking round from 1978-85 at Tocklai Experimental Station (Assam) showed that the longer round of 13 days brought the highest yield while shorter round of 5 days, the lowest, however, the general trend in field production was in the order of 13 > 9 > 11 > 7 > 5 days interval (Barbora and Saikia, 1989). The report further showed that the pruning/skiffing operation interact significantly with the length of plucking interval. Under south Indian conditions, Verghese (1977) observed longer interval of 15

and 25 days producing higher biomass of shoots. Similarly, Ranganathan *et al.* (1983), too reported highest total yield for three cycles with longer plucking interval.

Outside India, Grice (1984) in Central Africa has also found higher yield with longer intervals. Early work of Tenpler (1971) revealed that plucking twice a week as compared to once a week gave significantly more yield but later in 1977 he reported that longer plucking intervals were more productive due to greater shoot weight owing to extra time available for growing in longer plucking interval. Interestingly, recent report from Central Africa (Malawi) showed that increasing interval from 7 days to 10/11 days brought higher yield which remained constant when interval was increased to 14 days but declined significantly when the plucking interval was further broadened to 21 days and there was no significant difference either between 7 and 21 days round or 10/11 and 14 days plucking intervals (Cloves, 1989a).

2.6.2. Effect of method of plucking

More frequent and hard plucking has been reported to increase tea yield (Tubbs, 1932; Portsmouth, 1953; Tenpler, 1978; Cloughley *et al.*, 1983; Mwakha, 1985a&b), but such increase diminishes after first year due to deterioration of bush health as a result of ageing of maintenance leaves (Visser, 1960).

Mechanical plucking has been reported to give higher yield than hand plucking. Reports from Taiwan (Shin *et al.* 1974), Central Africa (Hdanugoba, 1977), South Africa (Rooster, 1975) and Georgia (Tkeshelashvili and Khukhunaishvili, 1975) showed an

increase in yield in the range of 12-13% due to machine plucking. According to a report from India, machine plucking done at a fixed height of 95 cm did not increase yield (Tocklai Lixpti. Station 1911-1991, 1992). Shear plucking also showed an increase in green leaf yield to the tune of 5-12% over hand plucking in Taiwan (Shin *et al.*, 1974) and south India (Mathias, 1983 and Reddy, 1983).

Watson *et al.* (1982) in Sri Lanka found that the leaf harvested by machine included mature leaves and pieces of stalk and overgrown shoots all of which contribute to 35% of the weight of leaf harvested. Their data reveal that the output of acceptable leaf was 51% and 74% for the two types of machines used.

2.7. Physical standard of crop

In tea plantations a shoot of 'two-leaves-and-a-bud' (2+Bud) is considered as Standard shoot with respect to yield and quality. When the harvested crop contains shoots of 2+Bud or smaller sizes *i.e.* 1+Bud and *1+banjhi* (one soft-leaf-and-a dormant terminal bud), it is graded as 100% fine and the quality of such crop is considered very good. As the proportion of shoots larger than 2+Bud and *1+banjhi* increases in the plucked crop, the fineness of the crop decreases proportionately.

2.7.1. Effect of plucking interval

Longer plucking round (or, delay in plucking) reduces fineness of crop because of inclusion of coarse and overgrown shoots bigger than two leaves, and because of higher amount of

dormant shoots (Sarkar, 1988; Barbora and Saikia, 1989). According to Basu (1989), in coarse plucking the percentage of bud, first leaf and second leaf cones down to 43 from 83 (in case of fine plucking), which brings down the chemical composition and, hence, quality of made tea. Another report from Malawi indicated that the proportion of 3+Bud size shoots increased while 2+Bud decreased as round length increased (Cloves, 1990b).

2.7.2. Effect of **aethod** of plucking

Mechanical plucking improves the yield at the cost of quality of crop. The proportions of soft pieces, hard pieces and rubbish are higher with mechanical plucking (Ndamugoba, 1977; Watson *et al.* 1982. Mwakha. 1990), which is unsuitable for manufacturing tea. Moreover, the plucked shoots in it are fibrous (Mwakha, 1986) which again is not good for quality tea. However, the standard of mechanically plucked tea can be improved if leaf quality control is achieved through manipulation of harvesting round length and judicious adjustments of the height of plucking table in consecutive harvesting round (Mwakha, 1990; Tocklai Exptl. Station 1911-1991, 1992).

2.8. **Cheai**cal **OQB**osition of **tea. shoot**

The presence of large quantities of polyphenols (17-30%), caffeine (2-4%) and some other constituents like amino acids particularly theanine (N-ethylglutamine) makes tea bush different from other plant species (Millin and Rustige, 1967). The concentration of polyphenol and caffeine in tea shoots give an idea of potential quality horizon in the made tea.

2.8.1. Polyphenol (Catechins)

Polyphenols or catechins are the major constituents of tea shoots which are responsible for liquor characteristics. These are mainly astringent. Although tea leaf contains thirty different phenolic substances (Roberts, 1958 & 1962), only three of these (-)-epigallocatechin (EGC), (-)-epigallocatechin gallate (EGCG) and (-)-epicatechin gallate (ECG), can be ranked as major constituents and generally referred to as primary catechins. According to Yaminiishi (1990), the catechin content differs considerably between *assamica* and *sinensis* groups, may be as high as 30% in the former and only around 10% in the latter.

2.8.1.1. Effect of plucking interval

Bhatia and Ullah (1968) found a progressive decline in phenolic content from tender parts to the older parts of a shoot system. In a 3+Bud shoot, concentration of polyphenol decreased from bud to third leaf, stem of the shoot containing the lowest concentration of polyphenol (Bhatia, 1961; Ann. Sci. Report, TRA 1977-78; Ullah and Jain, 1980). Therefore, longer interval of plucking which increases the proportion of coarser shoots in plucked crop is appears to lower down the polyphenols concentration compared to shorter intervals.

2.8.1.2. Effect of method of plucking

Though no published information could be traced out regarding the effect of different methods of plucking on polyphenol content, it has been seen that any method which increases the fine shoot proportion in the harvested crop would

improve the overall polyphenol content in the harvested crop.

2.8.2.Caffeine

It plays an important part in the taste and 'briskness' of the tea beverage. High levels of caffeine enhance the creaming property of black tea. The ability of black tea infusion to cream and the colour of the cream formed are important yardsticks employed for evaluating the quality of tea (Dev Chaudhary, 1980). In tea beverage, caffeine concentration range from 2-4% (Blauch and Tarka, 1983). Cloughley (1982) reported that the caffeine content of made tea is affected by seasonal, genetic, agronomic and cultural factors. The highest levels are produced during peak harvesting period when shoot growth is most rapid. Tea produced in off-season contains about 50% less caffeine. Generally, tea shoots from *assaiatica* types were richer in caffeine than *sinensis* type (Yaminishi, 1990). During manufacturing process of black tea, the content of caffeine increases partly due to release from complex molecules which contain caffeine molecule as a part of its make up (Yaminishi, 1990).

2.8.2.1.Effect of **plucking interval**

Work done at Tocklai Experimental Station (Tea Research Association), Assam, revealed that bud contains highest amount of caffeine which gradually goes on declining in lower leaves while stem of the shoot contains lowest content of it (Bhatia, 1961; Ann. Sci. Report, TRA, 1977-78; Ullah and Jain, 1980). The tender younger shoot which is the consequence of shorter plucking intervals, was found to contain higher content of caffeine (Owuor and Chavanji, 1986).

2.8.2.2. Effect of method of plucking

Owuor *et al.* (1991) reported that mechanically plucked tea produced inferior quality tea which is measured by volatile flavour compounds (theaflavin and caffeine). **They** further found that raising the mechanical plucking by 2 cm **from previous height** resulted in less quality deterioration.

2.9. Quality of *made tea*.

The term 'quality' in tea has not been very well defined. In general sense, it is the collection of desirable attributes of made tea and used particularly when characters of tea liquors are expressed organoleptically. Apart from appearance of tea and colour of leaf after infusion, it is the taster's palate which assesses the quality of brewed tea (Dev Chaudhary, 1980).

Good quality raw material (i.e. plucked tea shoots) is a basic need for a high quality made tea. But evidences show that the standard of plucked leaf, handling of the leaf and variation in any step of manufacturing (*viz.*, withering, rolling, fermentation and drying) brings large differences in the chemical components of made tea (Dev Choudhary, 1980; Owuor and Othieno, 1988).

Among the various components of made tea, theaflavin, thearubigin, and caffeine are of great significance and are responsible for various attributes of tea infusion. Role of caffeine and its concentration in crop plucked at different intervals and by different methods has already been described in

section 2.8.2.

2.9.1. Made tea parameters

A joint study by Tocklai Experimental Station and Butler Wharf Laboratory showed that polyphenols of tea shoot **which** were colourless were first oxidized to O-quinone **with the help** of polyphenol oxidase/peroxidase and subsequently condensed to a class of golden yellow compounds - theaflavins (TF) and a class of reddish brown compounds - thearubigins (TR). TF were found responsible for colour, briskness and quality and TR for strength, colour and body of liquor (Tocklai Exptl. Station 1911-1991, 1992). Roberts (1958) reported that the high values of tea could be related with large levels of TF and adequate levels of TR. By and large, theaflavins were considered to be important parameters for determining quality of made tea (Roberts and Smith, 1961; Nakagawa, 1970; Wickermasinghe and Perera, 1973).

The formation of TF, TR and other components of **made** tea are dependent on temperature, humidity, degree of cell damage, degree of withering, besides polyphenol and enzyme levels of tea leaves (Tocklai Exptl. Station 1911-1991, 1992).

2.9.1.1. Effect of plucking interval

Tender shoots contained more theaflavin (Lelyveld, 1986), hence shorter rounds ensure higher content of TF in **made** tea. With widening plucking interval, quantities of TF in 2+Bud shoots increased (Baruah *et al.*, 1980).

2.9.1.2. Effect of method of plucking

Lelyveld (1986) observed higher amount of theaflavin in hand

plucked tea than mechanically harvested one. This was particularly due to shorter plucking interval and higher proportion of tender shoots in the former than latter. Lelyveld *et. si.* (1989) observed clonal variation in respect to TF content. In some clones TF content was not affected, while in other it was improved. Due to mechanical plucking low quantity of TF in made tea, has also been reported recently by Owuor *et al.* (1991), which was improved by raising plucking height of bush by 2 cm.

2.9.2.Taster's evaluation

The made tea is assessed and evaluated by the tea tasters who are often guided by economic considerations, liking of consumers and their own liking and disliking. The assessment based on organoleptic tasting is severely restricted by human limitations, the same tea tasted by different tasters does not necessarily receive the same valuation and marks for liquor characteristics (Sharma, 1987).

2.9.2.1.Effect of plucking interval

Information available on the effects of plucking interval on quality of made tea reveal that the relative values given to samples by tea tasters decreased in a linear fashion as the plucking interval increased (Barbora and Saikia, 1989; Mitini-Nkhoma, 1989).

2.9.2.2.Effect of method of plucking

Tea manufactured from machine plucked crop received lower valuation both in seed grown as well as in clonal tea (De Silva,

1968). Mwakha (1990) reported better tasters' evaluation in machine plucked crop compared to hand plucked crop when plucking was followed with 2 en rise of plucking height of bush on consecutive harvesting rounds.

2.10. Yield vs_ quality

Increase in yield associated with the declining plucking standard, as influenced by plucking interval, was subjected to marked loss of quality (Basu, 1988; Baruah *et al.*, 1986; Sarkar, 1988; Barbora and Saikia, 1989), which means the yield may increase at the cost of quality or *vice versa*.

Palmer-Jones (1974), who determined the coefficient of regression together with the best estimate of expected future regression on theaflavin content at London Auction Price, indicated that the effect of plucking standard on quality is much less than its effect on yield. But later in 1977 he considered unwise to transfer such research findings to commercial practice due to the reason that the commercial producers who employ coarse plucking may also have other practices which exacerbate the effect of coarse standard on quality. Cloves (1989) too reported considerable loss in yield following quality shoot plucking of 2+Bud size and advocated the selection of clones based on the quality of 3+Bud size shoot rather than 2+Bud particularly with regard to fiber content.

2.11. Economics

Low cost, higher return, and maximum profits are the basic objectives of all entrepreneurs, whether it is agricultural

or industrial. In tea, plucking operation is a major input which absorbs around 60-85% of labour cost and accounts for 25% of cost of cultivation (Awasthi and Sarkar, 1983; Mitini **Nkhoma**, 1989; Rawlley and Beig, 1990).

2.11.1. Effect of **plucking interval**

The plucker's productivity expressed as amount of leaf plucked per man per day increased significantly with prolongation of plucking rounds from shorter (7 days) to longer (14 days) (Mwakha, 1991). Shorter plucking round calls for overall higher labour force due to higher frequencies. Jones (1985) estimated the plucking cost in 14 days round to be 64% of that of 7 days round, but gross revenue was higher in latter.

Tea of high quality was obtained from smaller shoots (Owuer *et al.* 1987) but they expressed doubt regarding economics of such tea. Sharma and Murty (1989) under south Indian conditions found higher net profitability with 3+Bud particularly with flexible intervals depending on growth of shoots instead of following 7 days flat round. According to them, the increase in profitability was largely due to reduced labour requirements.

2.11.2. Effect of **method of plucking**

Varying degrees of efficiency of mechanical plucking have been reported by different workers at different places. It ranged from 6 times in Sri Lanka (Watson *et al.*, 1982) to 13 times in South Africa and even to more than 50 times in Kenya (Mwakha, 1986 & 1990). This wide difference in efficiency could be due to the different types of machines with varying capacities of

plucking.

In India, average increase in plucker's productivity ranged between 38-50% with shear plucking at 9-11 days interval **and** 438% with machine at 14 days interval (Barbora *et al.*, 1992).

Though efficiency of plucking is improved by machine harvesting, cost of manufacture increased due to extra labour requirement for sorting out undesirable leaf, hard pieces and rubbish (Watson *et al.*, 1982). So there is need to compare increased labour cost of hard plucking with the loss in quality and lower payment for machine plucked tea.

Chapter 3

**MATERIALS
AND
METHODS**

Chapter 3

M A T E R I A L S A N D M E T H O D S

The field investigations were carried out at Banuri Tea Experimental Farm of Council of Scientific and Industrial Research (CSIR) Complex Palampur during 1990 and 1991. The details of materials used and methods employed during the course of investigations are presented in this chapter.

3.1.1.general

3.1.1-Location

The research farm is located at an elevation of 1290.8 m above mean sea level at 32°6' N latitude and 76°3' E longitude. The area falls in the mid hills of Shivalik ranges of Himalayas.

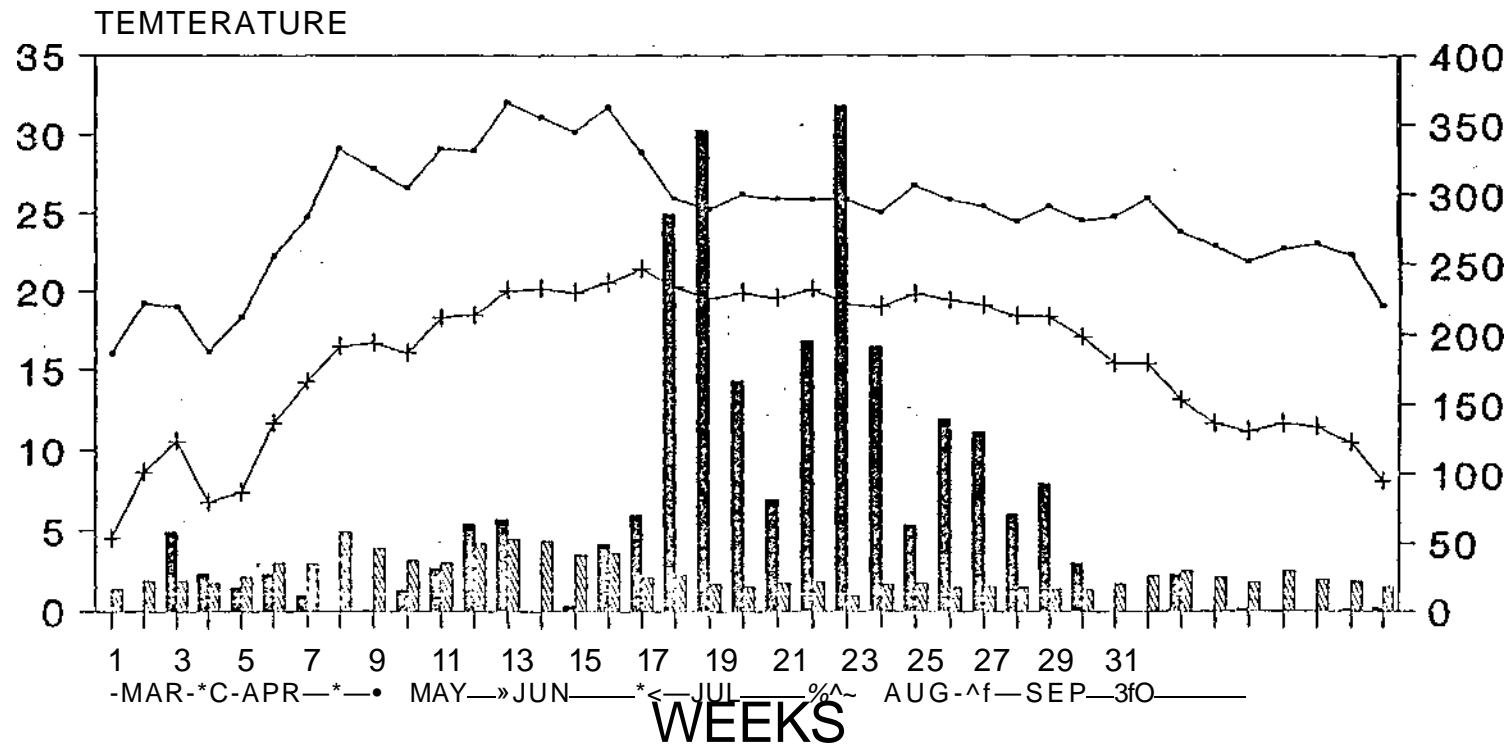
3.1.2.Climate

Agro-climatically, the region has been classified as Hid Hills Temperate Wet (Zone II) with severe winter and mild summer. The annual rainfall is more than 2500 mm, out of which about 75 per cent is received during June to September, whereas May, October and November are mostly the months of least rainfall.

Mean weekly meteorological data for the years 1990 and 1991 recorded at the Agrometeorological Observatory of the Department of Agronomy, Himachal Pradesh Krishi Vishvavidyalaya, Palamper have been depicted in Figs. 3.1(a), 3.1(b), 3.2(a) & 3.2(b) and appended in Appendix I. Besides, the mean monthly meteorological data for the crop duration during the years 1990 and 1991 have also been presented in Table 3.1.

MEAN WEEKLY METEOROLOGIC YEAR 1990

MAX. & MIN.



MAX. TEMP.(Deg.Cent)

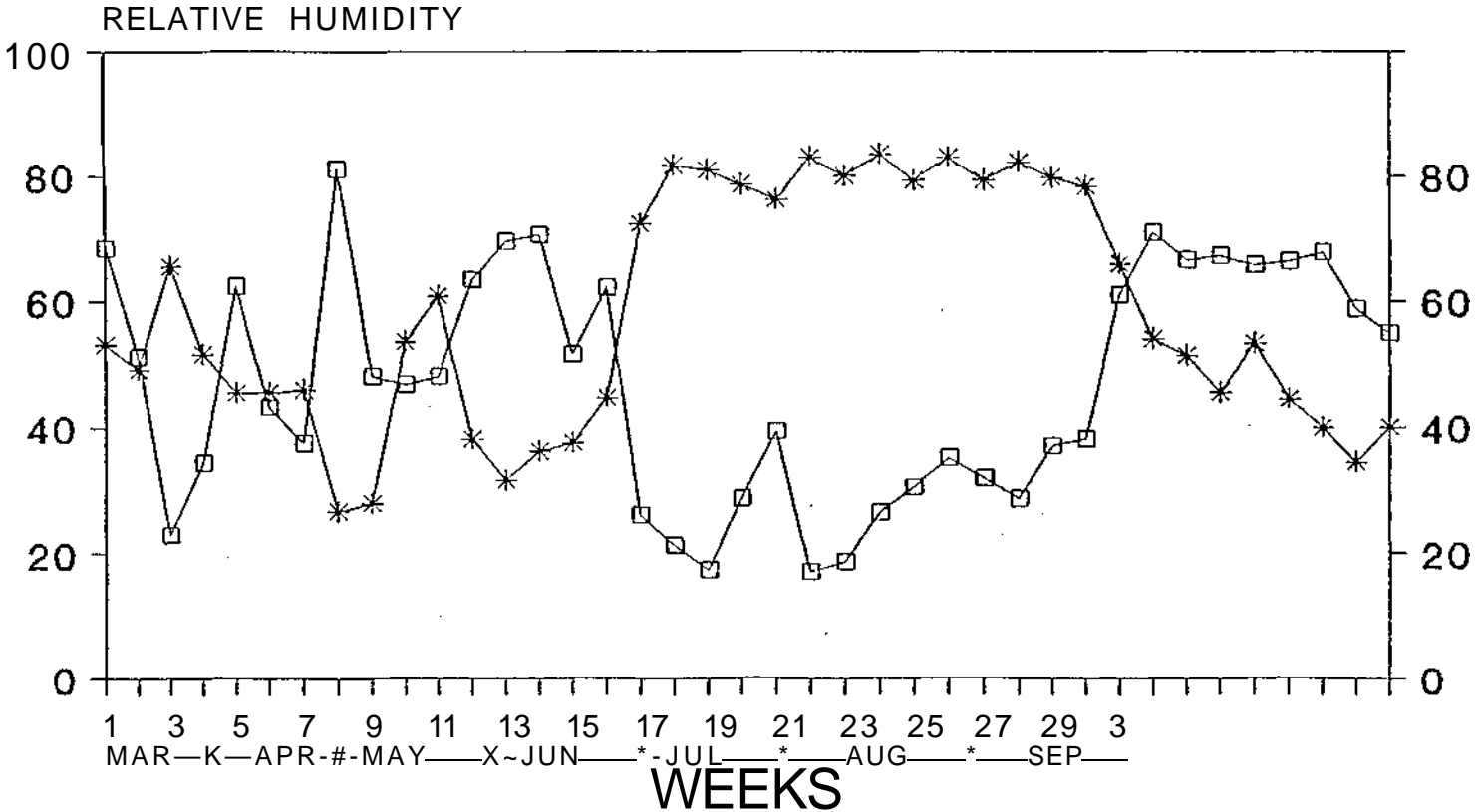
MIN. TEMP.(Deg.C

TOTAL RAINFALL (mm)

TOTAL EVAPORN.

Fig.3.1.(a) Mean weekly meteorological data dur
(Temperature, Rainfall & Evapora

MEAN WEEKLY METEOROLOGIC YEAR 1990

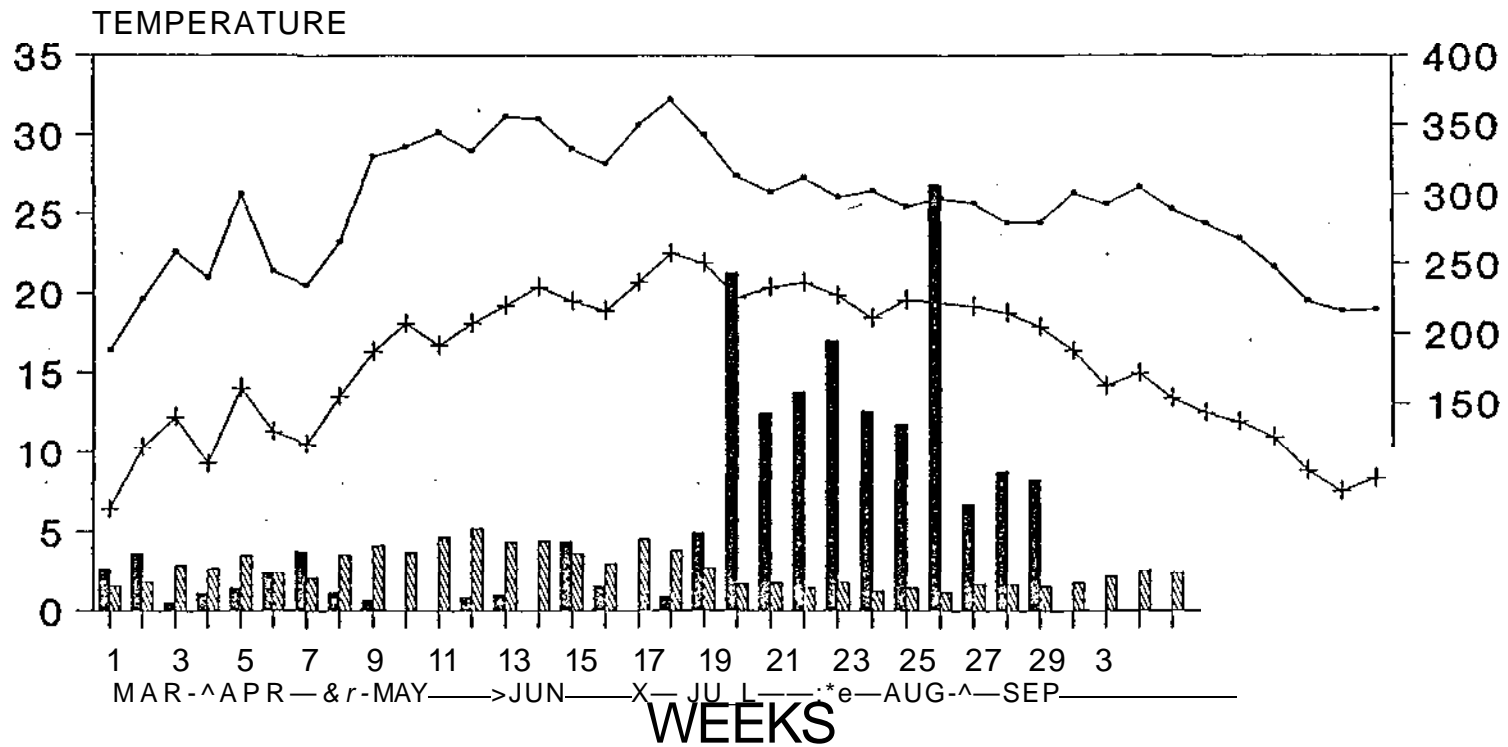


R. H. (%) SUN SHINE (Hrs.)

Fig.3.1.(b) Mean v/weekly meteorological data d {Relative Humidity & Sunshine}

MEAN WEEKLY METEOROLOGICAL DATA YEAR 1991

MAX. & MIN.



MAX.TEMP.(Deg.Cent.)

MIN.TEMP.(Deg.

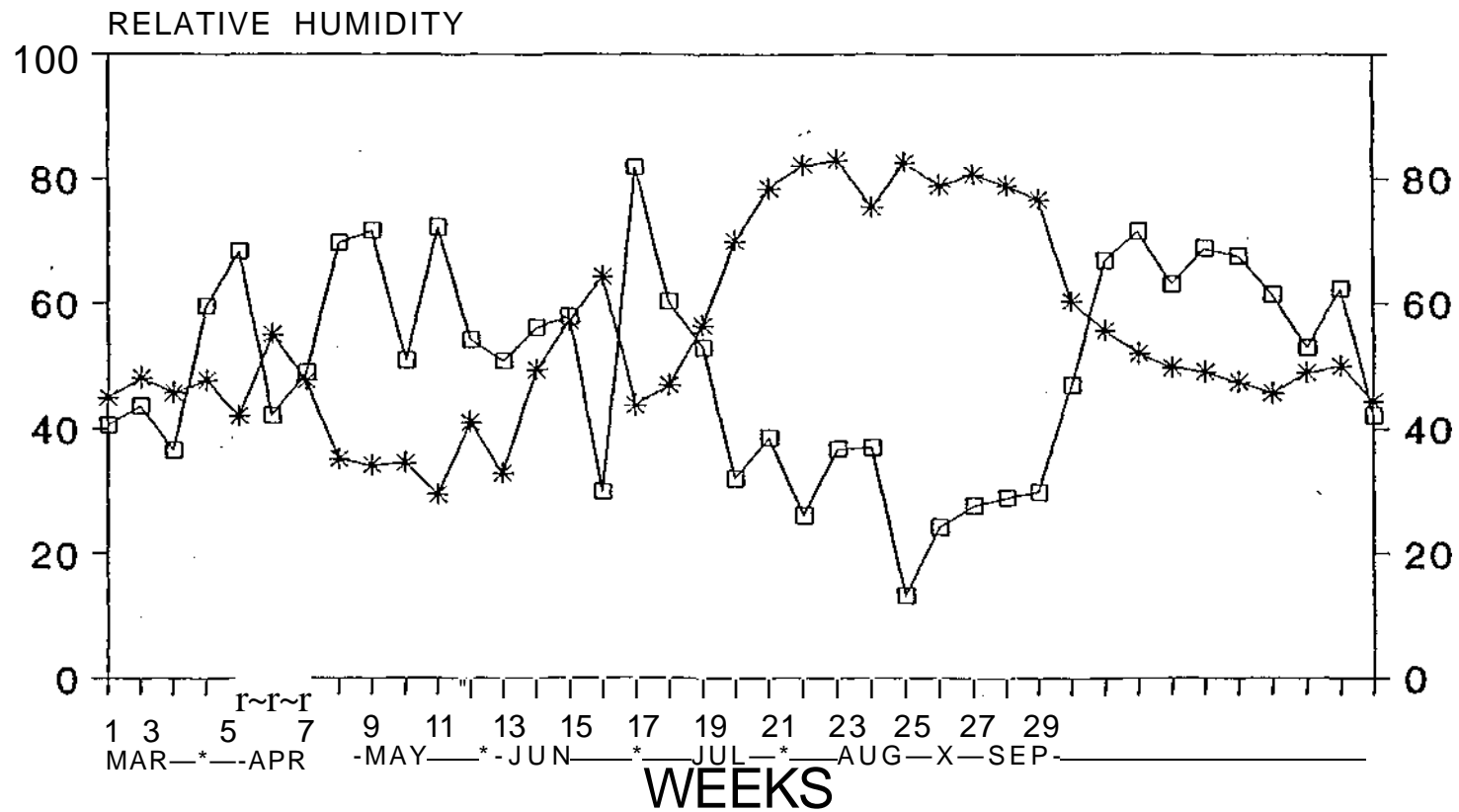
TOTAL RAINFALL (mm)

TOTAL EVAPON.

Fig.3.2.(a) Mean weekly meteorological data d
(Temperature, Rainfall & Evapo

MEAN WEEKLY METEOROLOG

YEAR 1991



- * - R.H. (%) SUN SHINE (H)

Fig.3.2.(b) Mean weekly meteorological data
(Relative Humidity & Sunshi)

Table 3.1 Mean monthly Meteorological data for the period of crop season during the years 1990 and 1991

Month	Max. Temp. (m)		Min. Temp. (fC)		R.H.(%)		Sun shine (hrs)		Rainfall (mm)		Evaporation (mm)	
	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
March	11.4	28.6	7.5	18.1	59	48	199.3	257.7	283.6	98.3	83.6	111.4
April	24.9	24.1	13.7	12.6	38	44	245.4	245.7	39.2	98.8	171.2	146.3
May	29.2	29.9	18.2	17.9	45	34	252.6	258.7	178.8	27.7	182.9	213.9
June	31.4	33.2	23.7	23.4	51	52	218.7	253.3	288.0	83.3	160.2	195.4
July	25.7	28.3	19.8	22.5	80	69	113.1	174.3	857.9	556.8	78.7	107.8
August	26.8	26.1	19.5	19.5	82	80	117.4	119.2	797.7	842.2	69.5	71.1
September	22.8	25.8	17.8	17.6	79	72	156.9	186.1	329.5	265.8	69.8	84.1
October	23.8	25.0	13.2	13.2	52	50	381.1	352.3	27.5	8.0	106.3	115.7
November	21.8	19.8	15.3	8.7	70	46	101.7	234.6	3.4	3.8	86.6	72.0

A perusal of the Table 3.1 reveals that June was the hottest month during both the years with peak of mean maximum temperature above 30°C. Mean minimum temperature, recorded in the months of March and November - the border months of the cropping season was the lowest falling below 10.3°C during both the years. July and August were the wettest months, receiving 857.9 and 797.7 mm rainfall in 1990 and 556.8 and 842.2 mm in 1991, respectively. There was no rainfall in October, 1991. It was quite low (3.8 mm or below) in November during both the years. The loss of moisture through evaporation was highest in May. The values were 182.9 and 213.9 mm in 1990 and 1991, respectively. Mean relative humidity ranged between 38 to 82% and 34 to 80% during first and second year, respectively. The highest total sun shine hours, above 300, was recorded in the month of October during both the years.

3.1.3. Soil

Composite samples of soil from 0-15 cm depth were collected from the experimental area before initiation of the experiments. Physico-chemical properties of the soil of experimental field have been given in Table 3.2.

A perusal of the Table 3.2 reveals that soil of experimental field was sandy clay loam in texture and acidic in reaction with medium availability of nitrogen and phosphorus and high of potassium.

Table 3.2 Physio-chemical properties of the soil of experimental area

Soil characteristics	Content	Method employed
1. Physical (Mechanical)		
Sand (%)	54.8	International pipette method (Pipper, 1966)
Silt (%)	16.8	
Clay (%)	26.9	
2. Chemical		
pH (1:2.5 soil water suspension)	5.57	Glass electrode pH meter (Jackson, 1967)
Organic carbon (%)	2.01	Walkley and Black's rapid titration method (Piper, 1966)
Available nutrients (kg/ha)		
Nitrogen (N)	333	Walkley and Black's rapid titration method (Piper, 1966)
Phosphorus (P)	32	Olsen's method (Jackson 1967)
Potash (K)	343	Ammonium acetate method using flame photometer (Jackson, 1967)

3.1.4. Cropping history

The present studies were conducted on over 130 years old China hybrid tea plantation devoid of shade trees (Plate 3.1(a&b)). The old tea bushes of the experimental area were rejuvenated by pruning at ground level in 1984. The bushes were cut-back (the first light prune following rejuvenation pruning) at 40 cm above ground in cold weather of 1987. Pre-treatment yield of plots of Experiment I (Plucking Interval Trial) was recorded in 1987. The present study was initiated in the second unpruned year (1990). The experimental area has been receiving recommended levels of management including of fertilizer, insect-pests, disease and weed control.

3.2. Experimental details

Two separate field experiments (as per section 3.2.1 & 3.2.2) were initiated in 1990, in a unpruned tea section (second unpruned year). After the scheduled operations and observation throughout cropping season, bushes of the experimental area were pruned (Plate 3.2) during winter (December, 1990) for the next year's (1991) observations.

Details of treatments imposed, methods employed and observations recorded were as follows :

3.2.1. Experiment I: Studies on plucking interval

Plucking interval was varied from 3 to 17 days, as detailed below:



Plate 3.1. *General view of tea plantation*



<u>Treatment</u>	<u>Plucking interval</u>
T ₁	3 days
T ₂	5 days
T ₃	7 days
T ₄	9 days
T ₅	11 days
T ₆	13 days
T ₇	15 days
T ₈	17 days

Design : Randomised Complete Block (R.B.D.)
Replications : Three
Net plot size : 6 x 4 bushes
Spacing : 1.00 m x 1.20 m
Planting material : Existing old China hybrid tea bushes

3.2.2. Experiment II : Studies on method of plucking

Four methods were studied as described below :

<u>Treatment</u>	Method of plucking
M ₁	Hand plucking -Standard system
M ₂	Hand plucking -Black system
M ₃	Shear plucking
M ₄	Machine plucking

Design : Latin square (L.S.D.)
Replications : Four
Net plot area : 6 x 4 bushes
Spacing : 1.00 m x 1.20 m
Planting material : Existing old China-hybrid tea bushes

3.3.field, culture

3.3.1.Layout of experiments

In Experiment I, blocking of plots was done on the basis of pre-treatment yield of the plots with the objective of minimising the variability amongst the plots in a block. The **low** yielding plots formed one block, medium yielding plots the second block, and high yielding plots the third block. Experiment II, where the pre-treatment yield was not recorded was laid out in Latin Square Design. The plans of layout of the experiments are shown in Figs. 3.3 & 3.4.

3.3.2.General skiffing/pruning operations

In both the experimental tea bushes were light skiffed in January 1990. The plucking commenced in last week of March in both the experiments. All border bushes (bushes around the plots) were regularly trimmed in order to maintain the plot demarcations. In December 1990, the bushes were pruned at 45 cm above ground level. The pruning litter was evenly spread around bushes in the respective plots. In May 1991, tipping was done at 55 cm above ground surface.

PLAN OF LAYOUT OF EXPERIMENT PLUCKING INTERVAL TRIAL

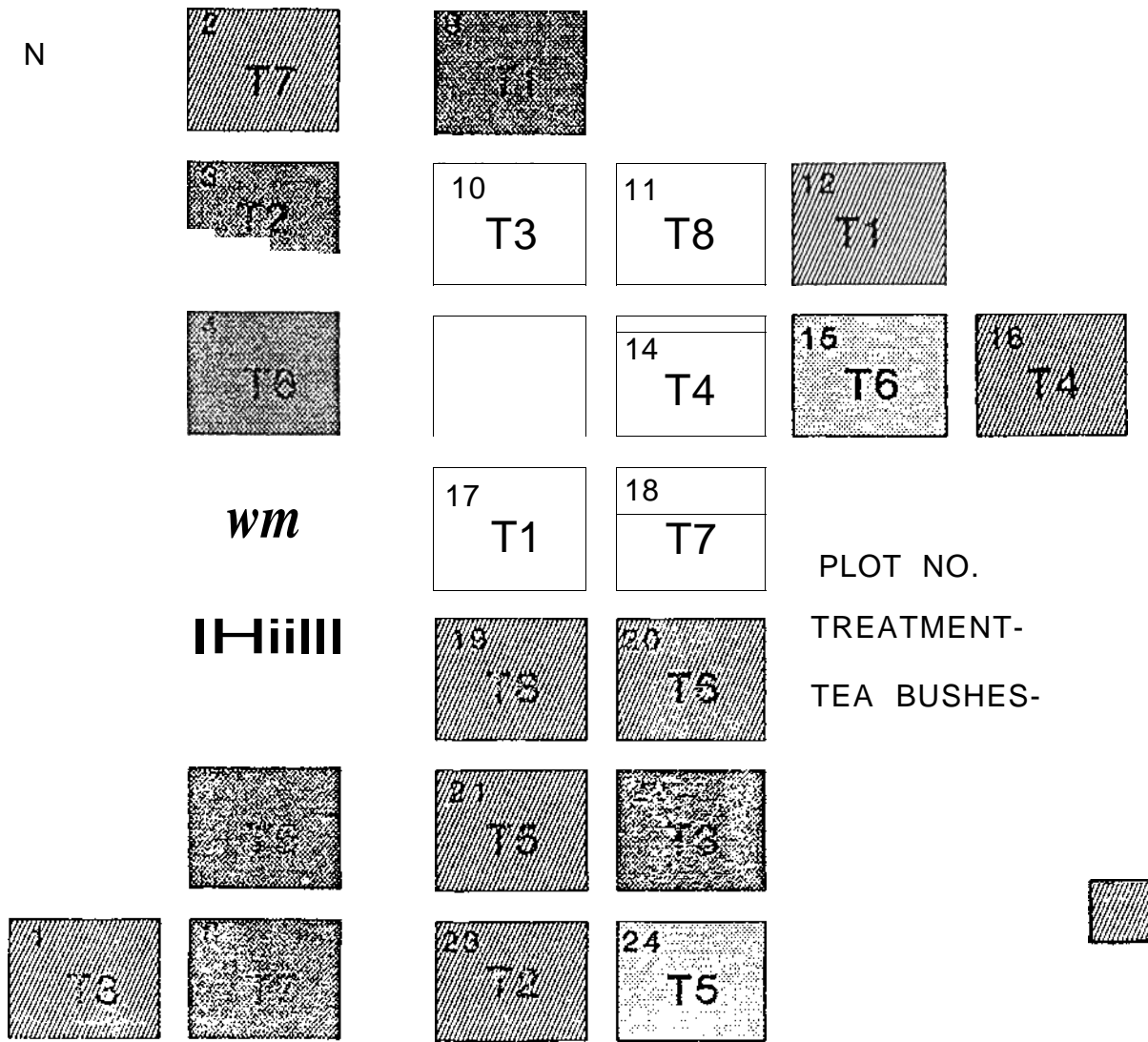
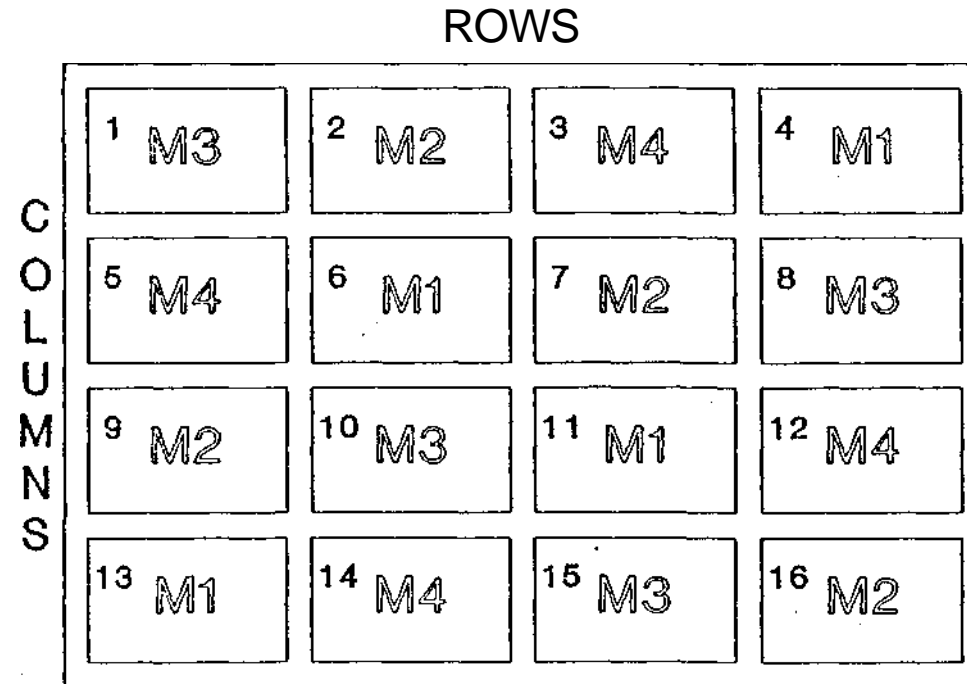


Fig.3.3. Plan of layout of Experiment I (Studies on p

PLAN OF LAYOUT OF EXPERIM METHOD OF PLUCKING TRIAL



K	PLOT NO,	o . o o o o o	
	TREATMENT	•>1 o o o o o o o	
	TEA BUSHES	-ff- o H «ii 01 >o o o o o o o	1.2 A
DESIGN : L.S.D.			1.0 M

Fig.3.4. Plan of layout of Experiment II (Studies on m

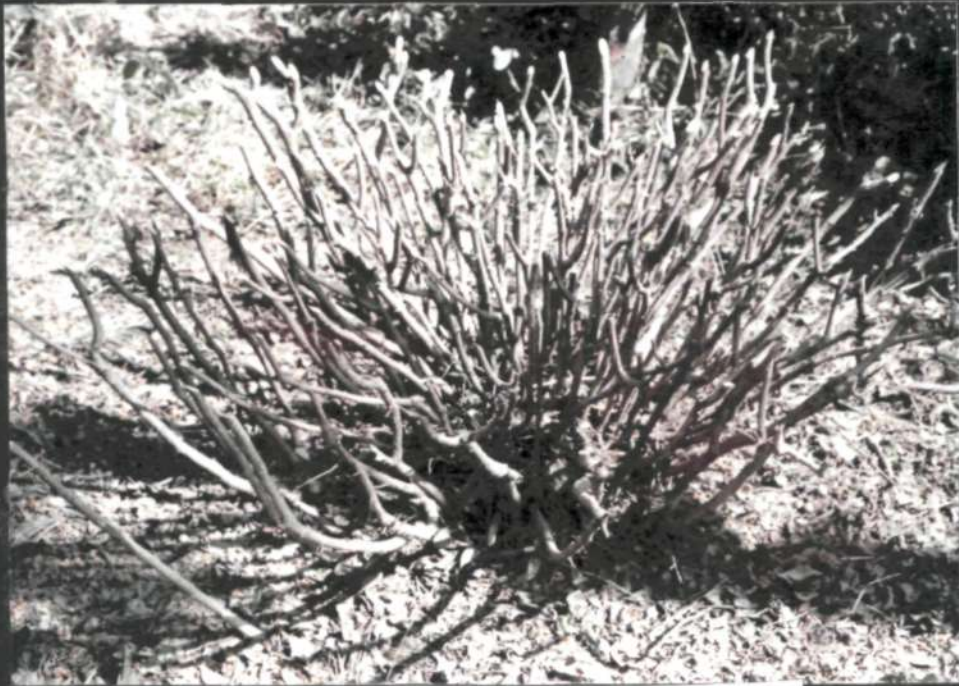


Plate 3.2. *Pruned tea bush*



Plate 3.3. *Hand plucking*

3.3.3.Plucking

3.3.3.1.Experiment I: Plucking Interval Trial

'Pluck to *janam*' (*janam* plucking) system was followed where shoots protruding above plucking table were plucked to the level of scale leaves at plucking table (Plate 3.3). The interval length between two successive pluckings was as per treatment schedule.

3.3.3.2.Experiment II: Method of Plucking trial

The plucking carried out in different methods was as described below:

M¹ - Standard Plucking

All shoots, excepting active buds with small single leaf (1+Bud) and only growing buds, growing above plucking table were plucked as crop following *janam* plucking system (Fig. 3.5)

M₂ - BlacJL Plucking

All shoots, including one leaf and bud (1+Bud), with the exception of only growing buds without subtending open leaves, above plucking table, were plucked as crop (Fig. 3.6).

M₃ - Shear Plucking

Hand operated shear (Plate 3.4) was used to pluck the crop. All shoots above the plucking table were plucked (trimmed) with the shear (Plate 3.5).

Shear is a modified pair of scissors resembling hedge clipper consisting of 22.5 cm long cutting blades and a handle of 30 cm. A receptacle of dimensions 22.5 cm x 20.5 cm x 7.0 cm,

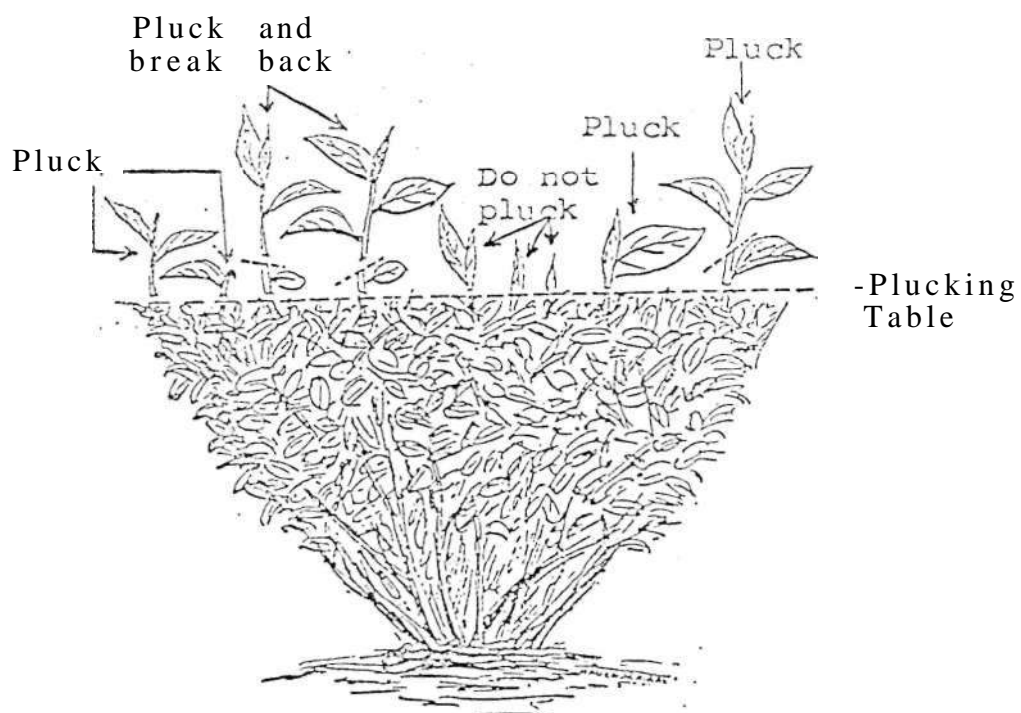


Fig.3.5. Tea bush showing standard plucking system

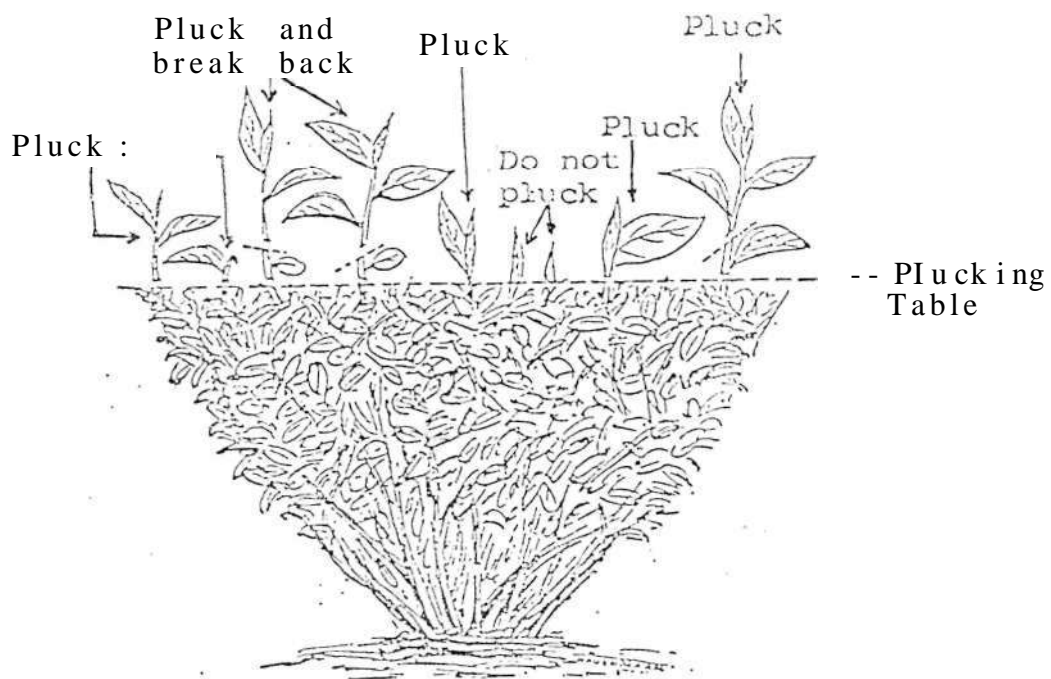


Fig.3.6. Tea bush showing black plucking system



Plate 3.4. *Shear*



Plate 3.5. *Shear plucking*

made of light weight material like fiber glass, is fitted on the right or left blade. The movement of blades cuts the shoot; and throws them in the receptacle. The cut shoots are frequently transferred into the collection basket.

M₄ - Machine Plucking

Manually operated Japanese plucking machine (Plate 3.6) was used to harvest the crop. All shoots growing above the plucking table were usually cut (Plate 3.7).

Kawasakis' Model PJ-35E with engine model SE-16 (knapsack type engine) was used. The machine was essentially a motor operated shear consisting of two major parts -(1) motor and (2) blade assembly (Plate 3.6). Motor supplies mechanical movement to the blades through a cable (driving flexible shaft). The moving speed of blade can be regulated through a throttle. A fan is fitted with the blade assembly which blows the cut shoots into the collection bag attached behind the blade assembly.

The machine plucking needs two persons. The motor is loaded on the back of operator who also handles the blade assembly and harvests the crop at desirable level. Another person handles the other end of collection bag and moves with the operator. The collection bag, when full, is emptied by transferring the cut shoots into a plucking basket.

3.3.4. Manuring

Recommended dose of N, P₂O₅ and K₂O @ 90, 90 and 90 kg/ha was applied in a single dose during March, 1990 and April, 1991

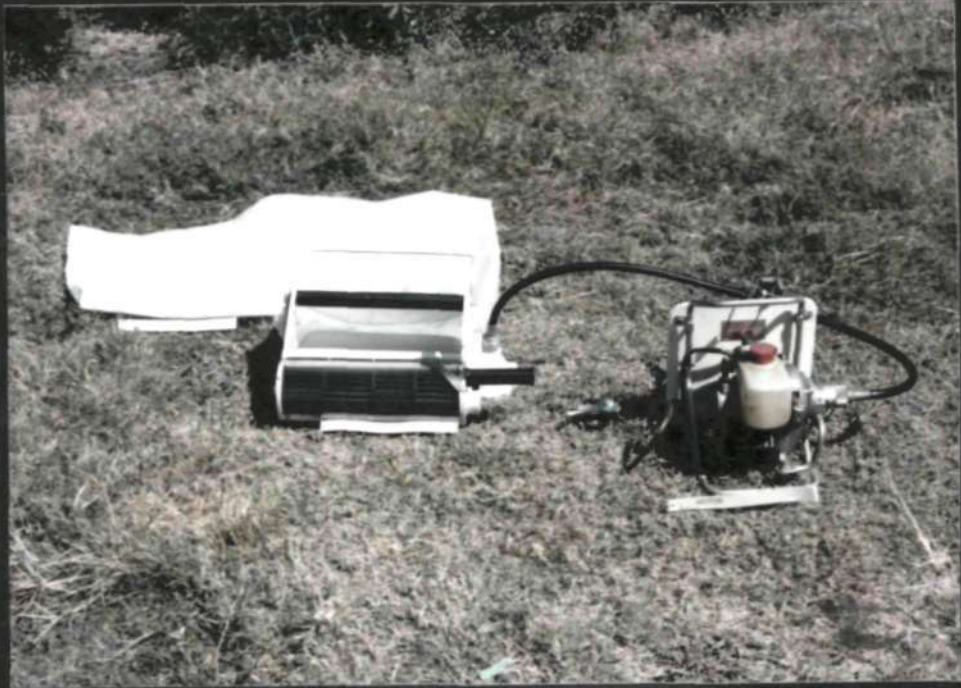


Plate 3.6. Machine



Plate 3.7. Machine plucking

in both the experiments.

3.3.5. Plant protection

For control of weeds, a mixture of 2,4-D and paraquat @ 2.5 g and 2.5 ml, respectively per liter of water was applied in end March with hand operated backpack "herbi" sprayer. The application was followed by a round of glyphosate application @ 5 ml/liter with the same sprayer in rainy season. In unpruned year (1990), an application of paraquat was also given in September. In the pruned year (1991), following pruning the plots were *cheeled* in January-February and treated with pre-emergence application of atrazine @ 2 kg/ha. During rainy season, a round of glyphosate @ 5 ml/liter was also applied.

A general spray of 1:400 dilution of endosulfan was undertaken for the control of thrips every year. There was no severe attack of any disease during the experimental period.

3.4. Shoot growth studies

For shoot growth studies, 10 bushes were selected in each plot along the central two rows. In each bush, 2 shoots with just unfolded first leaf were tagged immediately after the plucking. As such, a total of 20 shoots were tagged in each plot. These shoots were plucked on the day of corresponding next plucking round for observations. The results have been expressed month-wise. The observations recorded in intervals overlapping in two months were pooled in the month to which major part of the interval belonged.

3.4.1. Humber of unfolded leaves

All the twenty tagged shoots were plucked on the day of plucking of a particular interval or method. The number of leaves unfolded including the tagged ones on these plucked shoots were counted and average number was calculated.

3.4.2. Dormancy Index

The plucked twenty shoots were classified into two categories on the basis of size of apical bud. When the size of the terminal bud was equal to or greater than half the length of the subtending leaf, it was regarded as "active shoot", otherwise the shoot was considered "*banjhi*" or "dormant shoot" (Plate 3.8).

The dormancy index was expressed as the ratio of number of *banjhi* shoots to active shoots (Wight and Barua, 1955) and was worked out by the following equation:

$$\text{Dormancy Index} = \frac{\text{No. of } \textit{banjhi} \text{ shoots}}{\text{No. of active shoots}}$$

3.4.3. Fresh weight

After removing the surface moisture of the shoots with blotting paper, the fresh weight of the shoots was noted and average fresh weight was worked out and expressed as mg/shoot.

3.4.4. Dry weight

The shoots were dried in hot air oven at 80°C for 48 hours, and dry weight was recorded and average dry weight in terms of mg/shoot was computed.

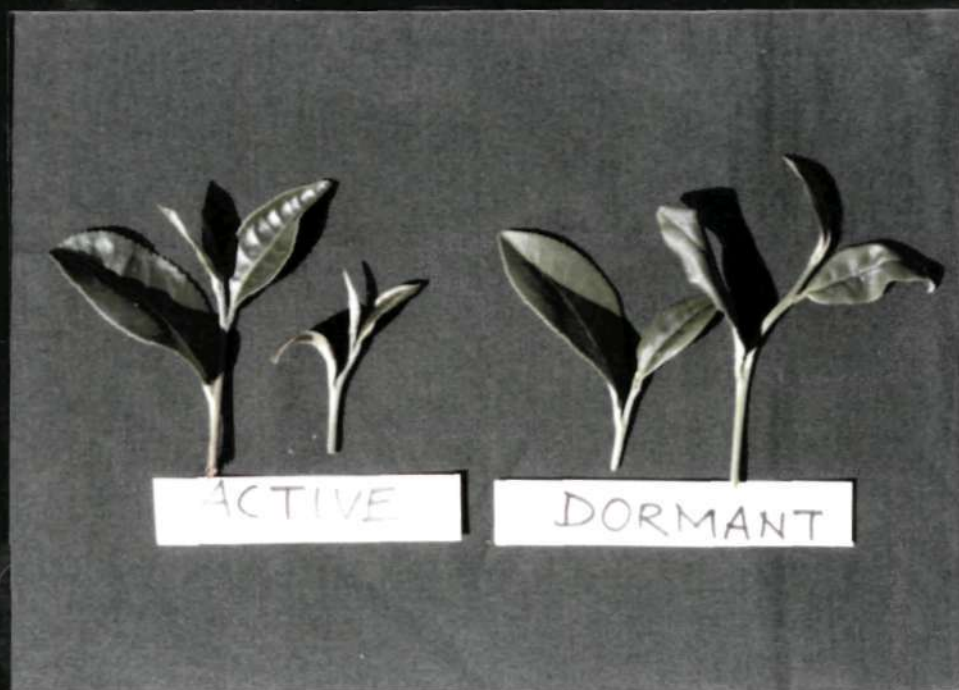


Plate 3.8. Active and Dormant (Banjhi) shoots



Plate 3.9. Regeneration of shoot

3.4.5. Shoot weight increments

The average fresh and dry weights per shoot recorded at the time of tagging and after the plucking at a particular interval were used to work out the increment in terms of fresh or dry weight gain per day using the following relationship and expressed as mg/day.

$$\text{Increment (mg/day)} = \frac{\text{Final weight of the shoot at a particular plucking interval (mg)} - \text{Initial weight of shoot at the time of tagging (mg)}}{\text{Plucking interval (days)}}$$

3.4.6. Dry matter content

The dry matter of the shoots in plucking interval trial (Experiment I) was calculated as per following equation :

$$\% \text{ Dry matter} = \frac{\text{Dry weight (g)}}{\text{Fresh weight (g)}} \times 100$$

In the method of plucking trial (Experiment II) 50 g composite sample was drawn from the harvested crop. After recording its fresh weight, it was dried in hot air oven for 48 hours at 80°C and dry matter content was computed by the above equation.

3.4.7. Regeneration rate

On first day of each month, 20 shoots in 10 bushes (2 shoots per bush) were plucked and the stubs of these plucked shoots on the plucking table were tagged. Time (days) taken by the top axillary bud on the tagged stub to develop into a pluckable 2+Bud (two-leaves-and-a-bud) shoot was recorded (Plate 3.9), watching

the growing buds on alternate days. The time interval (days) required for the development of 2+Bud shoot from the top axillary bud represented the regeneration rate.

In plucking interval trial (Experiment I), the plucking was done at intervals as per the treatments. In method of plucking trial (Experiment II), the plucking was carried out when plots under treatments were visually ready for plucking. " *J an am* plucking", which is the standard practice in this region, was followed. The harvested crop was classified into three flushes as under:

Early Flush : Crop obtained upto June, 15

Main Flush : Crop obtained between June, 16 to September, 15

Back-end Flush : Crop obtained after September, 16

The sum total of the yield of these three flushes represented the total season's yield.

3.5.1.Green leaf yield

The green leaf yield (g/bush) obtained per plot was computed to that for kilogram per hectare (kg/ha), by multiplying it with a factor 8.333 which was worked out on the basis of bush spacing.

3.5.2.Made tea yield

The made tea output was determined by multiplying green leaf yield with the corresponding average dry matter content and expressed as KMTH (kilogram made tea per hectare):

$$\text{Made tea yield (KMTH)} = \frac{\text{Green leaf yield (kg/ha)}}{\text{Dry matter content (\%)}} \times \frac{1}{100}$$

3.6. Quality

3.6.1. Fineness of crop

At each plucking, a well mixed sample of 50 g/plot was drawn. The shoots in the unit samples were separated into three categories - (a) fine shoots *i.e.* one-leaf-and-a-bud (1+Bud), two-leaves-and-a-bud (2+Bud), and one-leaf-and-a-dormant-bud (*1+banjhi*); (b) coarse shoots *i.e.* shoots greater than 2+bud size in case of active and *1+banjhi* in case of dormant shoots; and (c) loose and/or cut leaves. The fine part of shoots of category (b) *i.e.* 2+Bud in case of active shoots and *1+banjhi* in case of dormant shoots was separated and pooled in category (a). The category (b) and (c), representing non fine part were also pooled together. The fresh weights of category (a) and (b+c) were recorded and the per cent fineness of the crop was calculated by the following relationship:

$$\% \text{ Fineness} = \frac{\text{Fine shoot weight (g)}}{\text{Total weight of sample (g)}} \times 100$$

3.6.2. Total polyphenol content in tea shoots

The composite green tea leaf samples from each experimental plot was obtained at monthly interval during second to third week of each month. These samples were steamed for two minutes to inactivate the enzymes responsible for further changes in chemical composition of the harvested shoots. The samples then

were dried in hot air oven at 80°C for 48 hours. The dried samples were found to be Tino powder and packed in air tight polythene bags for the further analysis. The polyphenol content in those samples was determined in November and December each year by the method described by Swain and Hillis(1959).

3.6.3.Made tea parameters

3.6.3.1.Processing of orthodox black tea

For manufacturing Orthodox black tea, green leaf samples were drawn from each plot during second to third week of each month during cropping season in both the years. These samples were processed in a pizey roller consisting of 5 miniature hoods mounted on a single table (Plate 3.10) as per instructions in T.D.Sr. No. (102/2;1980). The steps followed for the processing of black tea were as under (Plate **3.12**):

3.6.3.1.A.Withering

Freshly plucked shoots weighing 200 g were kept **for** withering on Hessian cloth mounted on wooden frame. A wither around 60 per cent was maintained.

3.6.3.1.B.Rolling

Withered samples weighing 120 g were loaded into each roller cup. The movable pressure cap was considered equivalent to no pressure; the cap + 225 g equivalent to light pressure, and the cap + 450 g equivalent to heavy pressure. The rolling was done for 60 minutes with following sequence (Tea Encyclopedia, 1969):

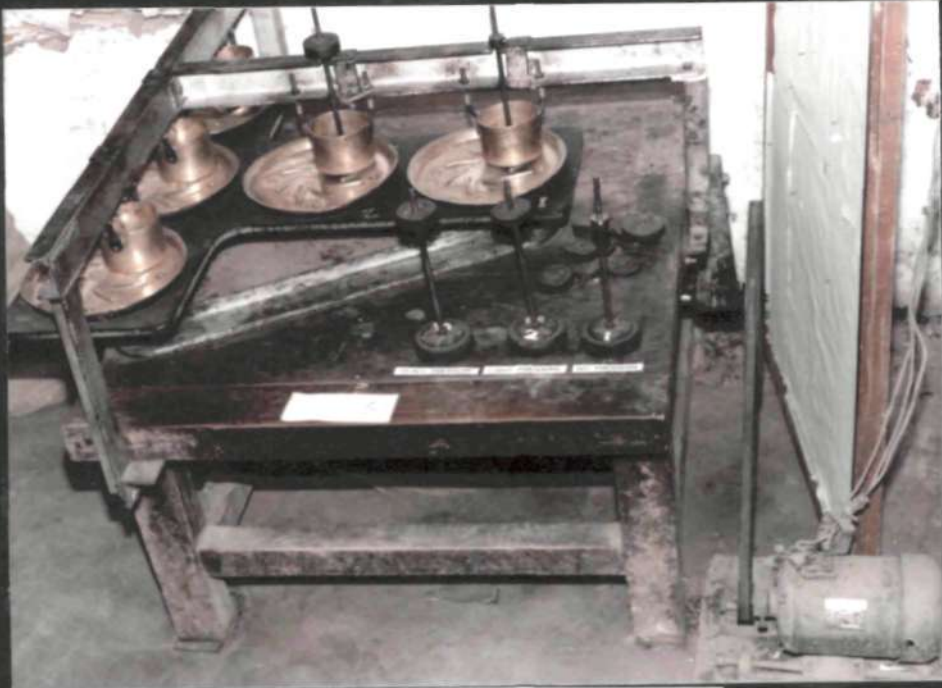


Plate 3.10. *Pizey roller*

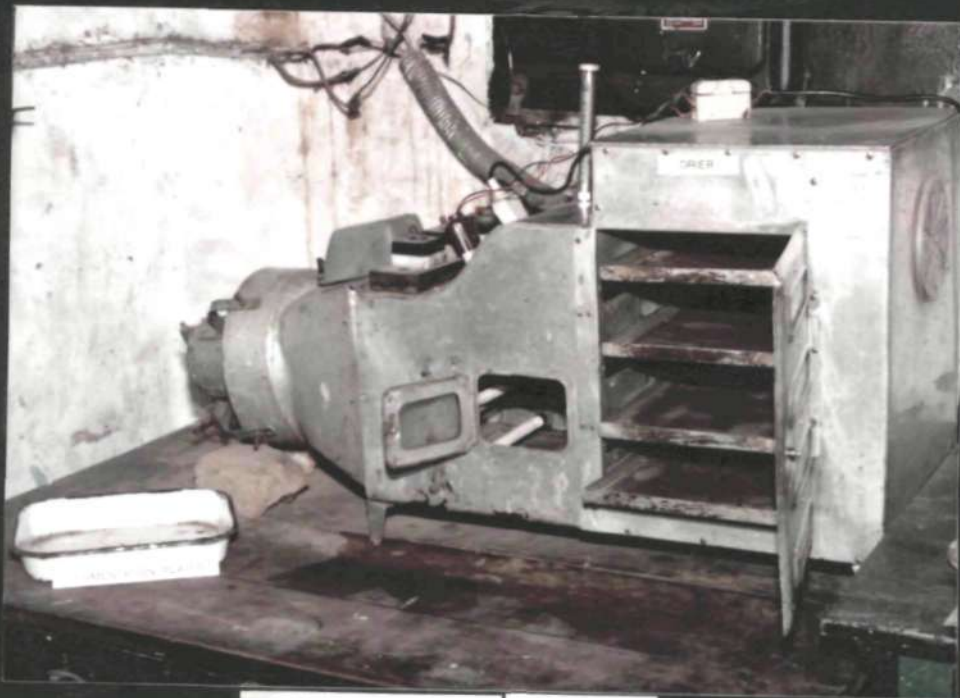


Plate 3.11. *Drier*

Time (min)	Pressure
5	No pressure
10	Heavy pressure
5	No pressure + ball breaking
5 x 3 cycles	Light pressure
5	Heavy pressure

3.6.3.1.C.Oxidation (Fermentation)

After rolling, the samples were spread separately in small aluminum trays to a depth of 2 cm for fermentation. Total fermentation time, inclusive of rolling time (one hour) was varied between 2 hr 15 min to 3 hr 15 min depending upon temperature (Ravindaranath and Dev Chaudhary, 1981) as per the following table:

Temperature (°F)	Fermentation Period (inclusive of rolling time)	
	hr	min
70-72	3	10
73-74	3	05
75-76	3	00
77-78	2	55
79	2	45
80	2	35
81	7.	25
82-85	2	15
86-88	2	10
89	2	05
90-92	2	00

3.6.3.1.D.Drying (Firing)

The fermented samples were fired at a temperature of 90-95°C for the first 15-20 minutes and then at 75-80°C for next 25-30



Plate 3.12. *Different steps of tea manufacturing*



Plate 4.1. *Made tea samples of the leaf plucked by different methods of plucking*

minutes. During this period regular shifting of trays (Plate 3.11) and material was carried out.

3.6.3.I.E.Packing

The drier mouth samples were packed in transparent polythene bags without crushing the bags and were sealed air tight.

3.6.3.2.Estimation of chemical constituents in made tea

3.6.3.2.A.Preparation of tea infusion

As described by Ullah (1972 & 1986), the infusion was made in a thermos-flask taking 3 g made tea with 125 ml boiling distilled water and filtering after 10 minutes. The filtered infusion was cooled and used for the estimation of different parameters of made tea viz., caffeine, theaflavin, thearubigin, total colour and brightness.

3.6.3.2.B.Determination of caffeine

The caffeine content in made tea samples was estimated as per the procedure described by Ullah *et al.* (1987).

3.6.3.2.C.Determination of theaflavin (TF), thearubigin (TR), total colour and brightness

The determination was made following the procedure of Ullah, (1986).

3.6.4-Taster's evaluation

At the end of crop season, 20 g made tea from each sample was packed separately in polythene bags and sent to the Chairman, Tea Brokers Private Limited, Calcutta for organoleptic evaluation.

The taster evaluated the samples for brightness, colour, flavour and valuation. The first three attributes were expressed semiquantitatively such as - poor, fair, good, very good and excellent. For statistical analysis, these attributes were assigned the number value of 1,2,3,4 and 5, respectively. The valuation was done quantitatively giving score ranging from 25 to 50.

3.7. Economics

3.7.1. Plucking efficiency

Time involved for plucking in a particular treatment was recorded throughout the season. The efficiency was expressed in terms of quantity of leaf plucked (kg) per hour.

3.7.2. Value of plucked crop

The value of fresh leaf (crop) based on its average fineness, was assessed on the basis of rates paid by The Palampur Cooperative Tea Factory Ltd. (Appendix III).

3.7.3. Gross Income per hectare

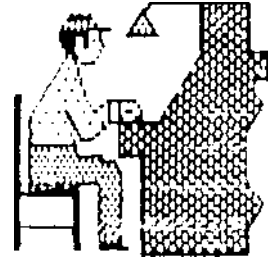
Gross income was worked out by multiplying the green leaf yield with the value of crop.

$$\begin{array}{l} \text{Gross income} \\ \text{(Rs/ha)} \end{array} = \begin{array}{l} \text{[Total green leaf yield]} \\ \text{(kg/ha)} \end{array} \times \begin{array}{l} \text{fValue of crop]} \\ \text{(Rs/kg)} \end{array}$$

3.7.4. Gross Income per rupee invested on plucking

It was obtained by dividing gross income per hectare by the

Chapter 4



EXPERIMENTAL RESULTS

Chapter 4

EXPERIMENTAL RESULTS

The results obtained from the field Experiment I (Studies on plucking intervals) and Experiment II (Studies on methods of plucking), conducted at Banuri Tea experimental farm of Council of Scientific and Industrial Research Complex Palampur, Himachal Pradesh, during the years 1990 and 1991, have been presented in this chapter with the help of data tables.

4.1 Experiment I - Plucking Interval Trial

4.1.1. Growth studies

4.1.1.1. Number of unfolded leaves

The effect of plucking intervals on number of unfolded leaves per shoot in different months during unpruned and pruned years have been shown in Table 4.1 and corresponding analyses of variance in Appendix IV. Results reveal that there was significant difference in the number of unfolded leaves as affected by intervals of plucking, months of plucking as well as their interaction during unpruned (1990) as well as pruned (1991) years.

It is evident from the table that the number of unfolded leaves per shoot was higher in pruned year than in unpruned year.

(a) Effect of plucking intervals

In both the years, the number of unfolded leaves significantly increased with increase in the interval of plucking from 3 to 17 days except in unpruned year when 15 and 17 days interval showed similar number.

Table 4.1 Effect of plucking intervals on number of unfolded Koirth.3 of plucking in unpruned and pruned years

Plucking intervals	Months of plucking					
	April	May	June	July	August	Septe
Unpruned year (1990)						
3 Days	1.33	1.08	1.08	1.20	1.14	1.0
5 Days	1.87	1.77	1.72	1.89	1.97	1.7
7 Days	2.21	2.03	2.03	2.22	2.15	2.0
9 Days	2.59	2.32	2.35	2.45	2.53	2.4
11 Days	3.14	2.61	2.45	2.97	2.85	2.9
13 Days	3.63	2.91	2.84	3.25	3.78	3.1
15 Days	3.92	3.04	3.21	3.73	3.49	3.5
17 Days	4.00	3.28	3.41	3.49	3.57	3.5
Mean	2.84	2.38	2.39	2.65	2.68	2.5
Pruned year (1991)						
3 Days		1.16	1.20	1.47	1.47	1.3
5 Days		1.88	1.95	2.15	2.06	1.9
7 Days		2.34	2.39	2.52	2.60	2.3
9 Days		2.39	2.44	2.94	3.06	3.0
11 Days		3.44	3.46	3.29	3.74	3.1
13 Days		3.63	3.59	3.60	4.06	3.8
15 Days		4.14	3.95	4.27	4.56	4.3
17 Days		4.33	4.30	4.12	5.37	4.4
Mean		2.91	2.91	3.55	3.36	3.0
Unpruned year (1990)						
	SEm+Z ¹	LTSTDT	CV %	Pruned		
				SEm+7-		
Interval	0.04	0.13		0.05		
Month	0.04	0.12		0.04		
I X M	0.12	0.33	8.11	0.12		

(b) Effect of months of plucking

During unpruned year, number of unfolded leaves was significantly highest in April. The number declined in May and remained constant till June. It significantly increased in July and again remained similar till September. Thereafter, it again declined significantly in October. During pruned year, the number of leaves was highest in August followed by July and September. The number was same and significantly lowest in May and June followed by that in October. The number of unfolded leaves was also same in July and September.

(c) Interaction effect

The interaction between interval and month of plucking regarding the number of unfolded leaves per shoot during both unpruned and pruned years was significant (Table 4.1).

During unpruned year the effect of plucking interval on number of unfolded leaves during different months remained more or less similar excepting in July and August months. In July, the highest number was under 15 days interval whereas in August the highest number was under 13 days interval. Like other months, 15 days interval in July was statistically at par with 17 days interval in this respect. Similarly, 13 days interval in August did not differ significantly from 15 and 17 days. Besides, the 13 days interval was also found to be at par with 15 days interval in May, July, September and October. It also did not differ significantly from the lower interval of 11 days in May, July, September and October. Similarly, 9 and 11 days intervals in May, June, and August; 7 and 11 days intervals in May, June, July and

October; and 5 and 7 days intervals in May and September exhibited statistically similar number of unfolded leaves per shoot.

During pruned year, in all the months of observation, the effect of plucking interval on number of unfolded leaves followed similar trend. A close perusal of the data reveals that 17 days interval did not differ significantly from 15 days interval in May, July and September. Similarly, plucking intervals of 15 and 13 days in October; 13 and 11 days in May to July and in October; 11 and 9 days as well as 7 and 5 days in September and October; and 9 and 7 days in May and June showed statistically same number of unfolded leaves per shoot.

4.1.1.2. **Dormancy** index

Significant influence was observed on dormancy index due to interval and month of plucking and their interaction (Appendix IV). Table 4.2 embodies the data in this respect.

It is evident from the table that the dormancy index was higher in unpruned year than that of pruned year.

(a) Effect of plucking intervals

The data reported in Table 4.2 reveal that in unpruned year dormancy index increased with increase in plucking interval but the differences between each consecutive intervals were not significant. Similarly, in pruned year differences between plucking intervals from 5 to 11 or 13 to 17 days with regard to dormancy index were not significant.

Table 4.2 Effect, of plucking intervals on dormancy index of
of plucking in unpruned and pruned years

Plucking intervals	Months of plucking					
	April	May	June	July	August	September
Unpruned year (1990)						
3 Days	0.000	0.000	0.017	0.006	0.000	0.00
5 Days	0.052	0.057	0.154	0.048	0.098	0.21
7 Days	0.060	0.071	0.194	0.115	0.105	0.17
9 Days	0.073	0.100	0.217	0.153	0.212	0.47
11 Days	0.099	0.204	0.349	0.218	0.275	0.86
13 Days	0.128	0.173	0.711	0.210	0.250	1.04
15 Days	0.169	0.200	0.978	0.234	0.287	0.93
17 Days	0.317	0.264	1.021	0.273	0.300	1.11
Mean	0.112	0.134	0.455	0.157	0.191	0.60
Pruned year (1991)						
3 Days	-	0.000	0.000	0.000	0.000	0.00
5 Days	-	0.000	0.000	0.021	0.031	0.02
7 Days	-	0.000	0.000	0.044	0.029	0.03
9 Days	-	0.000	0.000	0.063	0.012	0.07
11 Days	-	0.000	0.000	0.037	0.047	0.10
13 Days	-	0.000	0.000	0.102	0.118	0.15
15 Days	-	0.000	0.000	0.100	0.074	0.13
17 Days	-	0.035	0.067	0.166	0.150	0.10
Mean	-	0.004	0.008	0.067	0.058	0.08

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Interval	Unpruned year (1990)			Pruned
	SEm+/-	L.S.D.	FV %	SEm±Zz
Month	0.038	0.107		0.008
I X M	0.036	0.100		0.007
	0.173	0.282	53.47	0.018

(b) Effect of months of plucking

In general, dormancy index increased with increase in the age of shoot from April to October. During unpruned year, the highest dormancy index was recorded in October which, however, was comparable with that of September. In June, dormancy index was significantly lower than September but more than April, May, July and August. The latter months were at par in this respect. In pruned year also, October month demonstrated highest index followed by September, July and August. The differences in dormancy index recorded in the month of July, August and September were not significant. In pruned year the index was lowest in May and June.

(c) Interaction effect

Interaction effect of plucking intervals and months of plucking was significant in respect of dormancy index during both unpruned and pruned years (Table 4.2).

In general, the trend of dormancy index was similar in all the months during both the years *i.e.* increase in dormancy index with plucking interval, with few exceptions. In unpruned year, dormancy index due to plucking intervals from 3 to 15 days was zero in May and June months. Besides, 15 days interval in September, October in unpruned year, and **July, August and September** in pruned year resulted in lower indices than 13 days interval, however, the differences between these **two intervals** were statistically not significant. In addition, 15 **days interval** brought higher dormancy index than 17 days **interval** in **September**

Table 4.3 Effect of plucking intervals on fresh weight of pl months of plucking in unpruned and pruned years

Plucking intervals	Months of plucking					
	April	May	June	July	August	September
Unpruned year (1990)						
3 Days	95	76	65	65	57	5
5 Days	153	135	115	104	108	8
7 Days	201	201	161	171	147	12
9 Days	328	311	240	223	227	20
11 Days	394	426	298	381	305	28
13 Days	508	538	363	425	429	27
15 Days	794	594	420	573	458	43
17 Days	903	739	591	664	593	57
Mean	422	378	282	326	290	25
Pruned year (1991)						
3 Days		211	159	177	145	11
5 Days		373	291	332	243	17
7 Days		519	377	443	374	25
9 Days		781	547	595	628	44
11 Days		954	854	743	845	54
13 Days		1176	989	931	1054	82
15 Days		1562	1303	1146	1193	104
17 Days		1743	1369	1409	1685	136
Mean		915	736	722	771	59

	Unpruned year (1990)			Pruned	
	SK _{m±} /::	L. 45. D.	cy %	SK _{m+Z} :	L
Interval	11	30		23	
Mean	10	28		20	
I X M	28	79	16.1	58	

(c) Interaction effect

During unpruned year, the interaction between plucking intervals and months of plucking with respect to fresh weight of shoot was significant (Table 4.3). The table reveals that though shoot weight increased with increase in plucking interval, but the intervals of 3 and 5 days as well as 5 and 7 days were on par with each other during all the months of observation,. Plucking intervals of 7 and 9 days, and 11 and 13 days resulted in similar weight of shoot in the months of July, September and October. Differences in shoot weight in April, July, August and October in plucking intervals of 9 and 11 days were also not significant. Plucking intervals of 13 and 15 days in May, June and August, and 15 and 17 days in October were also at par in this respect.

The interaction between plucking intervals and months of plucking with respect to fresh weight of shoot was also significant in pruned year (Table 4.3). Increase in plucking interval increased the shoot weight consistently during all months of observation. However, significant increase was not observed in intervals between 3 to 5 days in June to August; 5 to 7 days in May to August; 7 to 9 days in July; 9 to 11 days in July and September; 11 to 13 days in June; 13 to 15 days in September; and 15 to 17 days in June. Shoot weight from 3 to 7 days interval was similar in September. In October, plucking intervals from 3 to 9 days, 7 to 11 days, 9 to 15 days and 11 to 17 days also resulted in similar shoot weight.

4.1.1.4. Dry weight of shoot

The dry weight of shoot was significantly influenced by

Table 4.4 Effect of plucking intervals on dry weight Of p] months of plucking in unpruned and pruned years

Plucking intervals	Months of plucking						
	April	May	June	July	August	Sept	
Unpruned year (1990)							
3 Days	25	20	17	16	14		
5 Days	38	34	29	25	25		
7 Days	57	57	39	40	33		
9 Days	80	74	58	52	51		
11 Days	85	102	71	86	64		
13 Days	127	124	87	103	96		
15 Days	187	140	102	135	104		
17 Days	188	174	144	139	147		
Mean	98	90	68	74	67		
Pruned year (1991)							
3 Days	-	49	36	45	33		
5 Days	-	84	69	82	60		
7 Days	-	113	82	103	80		
9 Days	-	170	116	142	123		
11 Days	-	205	182	205	172		
13 Days	-	257	190	197	220		
15 Days	-	329	282	292	287		
17 Days	-	396	310	309	376		
Mean	-	200	158	172	169	1	
>runed year (1990)							
	SEm ⁺ ± L			h		S.D.	cv %
Interval	3			7			4
Month	3			7			3
1 X M	7			20		16.92	10
Pru							
	SEm+ /						

plucking intervals, nonths of plucking and their interaction during both unpruned (1990) as well as pruned (1991) year (Appendix IV). The results have been presented in Table 4.4

(a) Effect of plucking intervals

The Table 4.4 shows that like fresh weight, dry weight of shoot also increased consistently and significantly with each successive increase in plucking interval during both the years of study.

(b) Effect of nonths of plucking

In unpruned year, dry weight of shoot was significantly highest in April. It reduced significantly till June. From June to August it remained constant and then declined rapidly till October. In pruned year, maxinum dry weight of shoot was recorded in May. The weight reduced distinctly in June, later improved somewhat in July, but started declining rapidly after July till October. The shoot weight was comparable in July and August as well as in June and August.

(c) Interaction effect

The dry weight of plucked shoot was significantly influenced due to interaction between plucking intervals and nonths of plucking during both the years of study (Appendix IV). The general trend of increase in shoot weight as a result of increase in plucking interval was sinilar in all the nonths during both the years of study but the significance between plucking intervals varied (Table 4.4) as described below

During unpruned year, in general, the shoot dry weight in-

creased consistently and significantly with increase in duration of plucking interval with few exceptions. The lowest dry weight was recorded in the shoot plucked at 3 days interval, which did not differ significantly with the shoot of 5 days interval in months from April to July; with shoots of 5 and 7 days in August and September and; with the shoots of 5 and 9 days in October. The difference in the dry weight of shoots plucked at 5 and 7 days in all the months was also non-significant. On the other side the dry weight of shoot plucked at 17 days interval was significantly highest in all the months except in April and July, where it was at par with the shoot of 15 days interval.

During pruned year also there was significant increase in the dry weight of plucked shoot with each successive increase in plucking interval from 3 to 17 days in all the months though the differences were more pronounced in May. The dry weight of shoot plucked at 5 and 7 days and 11 and 13 days in June; 5 and 7 days, 11 and 13 days and 15 and 17 days in July; 3 and 5 days, and 5 and 7 days and 9 and 11 days in September did not differ significantly. In October, where shoot weight reduced considerably in all plucking intervals in comparison to other months, did not result into significant difference in the shoot dry weight due to different plucking intervals. In this month, the highest weight recorded in the shoot of 17 days interval remained statistically similar to shoot of 15 and 13 days intervals while the shoot of lowest weight plucked at 3 days interval did not differ significantly with shoot of 5 to 9 days intervals.

4.1.1.5. Dry matter content of shoot

There was significant difference in the dry matter content of shoot as influenced by intervals and months of plucking as well as their interaction (Appendix IV), both during unpruned (1990) as well as pruned (1991) years. The results have been presented in Table 4.5.

It is evident from the table that the dry matter content was little more in unpruned year as compared to pruned year.

(a) Effect of plucking intervals

The data presented in Table 4.5 reveal that during both the years of study, dry matter content decreased with increase in plucking interval from 3 days to 11 days, thereafter it increased with plucking interval. However, the increase was not significant in plucking intervals from 11 to 17 days in unpruned year. In pruned year, dry matter content was significantly higher due to 13 to 17 days intervals, compared with 11 days. In both the years of study, plucking interval of 7 and 9 days exhibited similar dry matter content, which was comparable to that of 13 days interval in the pruned year. Dry matter content in plucking intervals of 15 and 17 days were also statistically alike.

(b) Effect of months of plucking

In unpruned year, the highest dry matter content was observed in October followed by May. April, July and September had similar dry matter content, which was significantly more than that in August but less than May. August month recorded the lowest dry matter content. In pruned year also, highest dry matter content was observed in October which was followed by

Table 4.5 Effect of plucking intervals on per cent dry ma
different months of plucking in unpruned and pr

Plucking intervals	Months of plucking					
	April	May	June	July	August	Sep
Unpruned year (1990)						
3 Days	25.4	26.4	25.4	24.8	24.4	
5 Days	25.4	25.8	25.4	23.9	23.6	
7 Days	24.8	25.3	24.1	23.3	22.9	
9 Days	23.6	24.5	24.3	23.6	22.6	
11 Days	23.9	24.7	24.0	21.9	21.1	
13 Days	22.3	23.9	23.4	24.3	22.4	
15 Days	22.0	24.7	24.8	23.2	22.7	
17 Days	22.1	25.0	24.3	22.9	23.1	
Mean	23.7	25.0	24.5	23.5	22.9	
Pruned year (1991)						
3 Days	-	23.3	24.2	25.8	22.9	
5 Days	-	22.4	23.7	24.6	22.2	
7 Days	-	22.7	22.4	23.8	21.5	
9 Days	-	21.8	21.4	23.9	19.6	
11 Days	-	21.4	22.0	21.8	20.4	
13 Days	-	21.8	22.6	23.1	20.8	
15 Days	-	22.1	23.1	25.5	21.1	
17 Days	-	22.7	24.1	23.2	21.3	
Mean		22.3	22.9	24.0	21.2	

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Interval	Unpruned year (1990)			Pr
	SEM+/-	L. . o » D.	CV %	SEM+ ,
Month	0.1	0.4		0.1
1 X M	0.1	0.4		0.1
	0.4	1.1	2.77	0.4

July, June, May and September in order. The dry matter content was statistically similar in May and September. August month recorded lowest content in this year also.

(c) Interaction effect

Interaction between plucking intervals and months of plucking significantly influenced the dry matter content of shoot during both years of the study (Table 4.5).

During unpruned year, the dry matter content, in general, was highest in the shoots of shortest interval of three days and it decreased continuously with increase in plucking interval upto 15 days in April, 13 days in May and June and 11 days in July to October months but further increase in plucking interval upto 17 days resulted in slight but inconsistent increase in the content. The range of variation in dry matter content due to variation in plucking interval was between 22.0 to 25.4 per cent in April, 23.9 to 26.4 per cent in May, 23.4 to 25.4 per cent in June, 21.8 to 24.8 per cent in July, 21.1 to 24.4 per cent in August, 21.9 to 24.7 per cent in September and 25.3 to 26.8 per cent in October. The highest content during the season (26.8 per cent) recorded in October was in the shoots of 3 days plucking interval which, however, did not differ significantly with that of 5, 7 and 15 days intervals in the same month as well as 5 and 7 days intervals in May. Similarly, the lowest content of dry matter during the season (21.1 per cent) observed in August month was in the shoots of 11 days interval and statistically it was at par with the dry matter content of shoots of 15 and 17 days intervals

in April and 11 days in July and September.

During pruned year, the shoot dry matter content, in general, was highest in the shortest interval of 3 days and it decreased continuously with increase in plucking interval upto 9 days in June & August, 11 days in May, July and October or 13 days in September but further increase in the interval upto 17 days resulted in inconsistent increase in the content. During this year the range of variation in dry matter content of shoot as a result of variation in plucking interval was between 21.4 to 23.3 per cent in May, 21.4 to 24.2 per cent in June, 21.8 to 25.8 per cent in July, 19.6 to 22.9 per cent in August, 20.2 to 23.5 per cent in September and 24.8 to 27.4 per cent in October. In this year also the shoots of 3 days intervals in October had significantly highest dry matter content (27.4 per cent) over the season. The next highest content was in the shoots of 15 days interval (26.3 per cent) in the same month which, however, did not differ significantly with the dry matter of 3 to 17 days excepting 11 days interval in the month (October) as well as with 3 and 15 days plucking intervals in July. The lowest content during the season (19.6 per cent) recorded in August was in the shoots of 9 days interval which was statistically at par with that of 11 days interval of the month as well as of September.

4.1.1.6. Shoot weight increment

Rate of increment of fresh and dry weights of shoots were significantly affected by plucking intervals, months of plucking and their interaction during both unpruned (1990) and pruned (1991) years (Appendix IV). The data in this respect have been

Table 4.6 Effect of plucking intervals on rate of fresh we (mg/day) in different months of plucking in unpru

Plucking intervals	Months of plucking					
	April	May	June	July	August	Sept
Unpruned year (1990)						
3 Days	12.5	10.0	8.5	8.6	7.5	
5 Days	19.1	17.8	15.1	12.9	14.7	1
7 Days	20.5	22.1	17.5	18.7	16.0	1
9 Days	30.0	29.4	22.4	20.4	21.4	1
11 Days	30.6	34.5	23.5	31.1	24.5	1
13 Days	34.7	37.9	24.9	29.6	30.3	2
15 Days	42.7	38.0	25.4	35.6	28.3	2
17 Days	49.7	40.7	32.5	36.7	32.8	3
Mean		~2878~	21.2	24.2	21.9	1
Pruned year (1991)						
3 Days		27.7	20.9	23.2	19.1	1
5 Days		49.0	38.9	45.0	31.0	2
7 Days		55.9	40.0	48.0	40.8	2
9 Days		72.5	50.0	54.2	60.0	4
11 Days		75.1	68.8	57.8	68.8	4
13 Days		80.7	68.7	63.4	74.3	5
15 Days		95.6	80.4	69.3	73.6	6
17 Days		95.0	90.9	76.6	84.6	5
Mean		68.9	57.3	54.7	56.5	41

Interval	Unpruned year (1990)			Prune
	SEm+Z	L.S.D.	CV %	SEm+Z ³
Month	0.8	2.2		1.9
I X M	0.7	2.1		1.6
	2.1	5.8	16.03	4.5

presented in Table 4.6 and Table 4.7. Both the tables reveal that rate of shoot weight increment (fresh as well as **dry**) was almost double in pruned year as compared to unpruned year.

4.1.1.6.A.Rate of fresh weight increment

(a) Effect of plucking intervals

It is evident from the Table 4.6 that rate of fresh weight increment in unpruned year (1990) increased consistently and significantly with each increase in plucking interval. The trend was similar in pruned year (1991) also excepting that the rate of increment was statistically same in 5 and 7 days, 11 and 13 days as well as in 15 and 17 days intervals.

(b) Effect of months of plucking

During unpruned year, rate of fresh weight increment was higher in April and May followed by July. The rate of fresh weight increment in June and August was significantly lower than July but higher than September. It was lowest in October.

During pruned year, May recorded the highest rate of fresh weight increment, followed by June, July and August. The rate reduced significantly upto October.

(c) Interaction effect

During unpruned year, increase in plucking interval in all the months of observation from 3 to 17 days resulted in increased rate of fresh weight increment, except in July where 9 days interval showed the rate comparable with that in all the higher intervals. The rate of fresh weight increment in 17 days interval

was also at par with that in plucking intervals upto 15 days in July and September, upto 13 days in May and August and upto 11 days in October. In July, September and October, plucking intervals of 3 and 5 days did not differ significantly between them in this respect. Plucking intervals of 5 and 7 days in all months had similar rate of increment. From June to October, rate of fresh weight increment in plucking intervals of 7 and 8 days was similar. The plucking interval of 9 days was also statistically similar with 11 days in May and August; 11 and 13 days in April, September and October; and 11 to 15 days in May and August.

During pruned year differences between plucking intervals of 15 and 17 days in all months of observation were not significant. Plucking intervals of 3 and 5 days in August; and 3 to 7 days in September resulted in similar rate of shoot weight increment. Further, plucking intervals from 5 to 7 days in May and August, and 5 to 9 days in June and July also showed similar rate of shoot weight increment. The interval of 7 days or shorter differed significantly with that of 9 days or longer in all months except in July where plucking interval from 7 to 11 days did not differ significantly. In May and July, plucking intervals of 9 to 13 days recorded similar rates of shoot weight increment but in August and September 13 days interval recorded higher rate than 9 or 11 days interval. In October ' increase in plucking interval did not bring significant change in rate of shoot weight increment.

4.1.1.6.B. Rate of dry weight increment

The effects of plucking interval, month of plucking and

Table 4.7 Effect of plucking intervals on rate of dry (mg/day) in different months of plucking in unp

Plucking intervals	Months of plucking					
	April	May	June	July	August	September
Unpruned year (1990)						
3 Days	3.2	2.6	2.2	2.1	1.8	
5 Days	4.6	4.3	3.8	3.0	3.4	
7 Days	6.0	5.5	4.1	4.3	3.5	
9 Days	7.2	6.9	5.	4.7	4.7	
11 Days	6.4	8.2	5.	7.0	5.0	
13 Days	8.7	8.6	5.	7.2	6.7	
15 Days	11.5	8.5	6.	8.4	6.4	
17 Days	10.2	9.5	7.9	7.6	8.2	
Mean	7.2	6.8	5.1	5.5	5.0	
Pruned year (1991)						
3 Days		6.4	4.7	5.9	4.4	
5 Days		10.8	9.4	10.9	7.9	
7 Days		13.9	8.5	10.9	8.5	
9 Days		15.6	10.4	12.8	11.4	
11 Days		15.9	14.6	16.2	13.8	
13 Days		17.5	12.9	13.1	15.4	
15 Days		20.0	17.3	17.7	17.8	
17 Days		21.5	16.9	16.6	20.9	
Mean		15.2	TO	13.0	12.5	
Unpruned year (1990)						
	<u>SEm+/-</u>	L.S.D.	CV %	<u>SEm+/-</u>		
Interval	0.2	0.6		0.3		
Month	0.2	0.5		0.3		
I X M	0.5	1.5	17.03	0.8		

their interaction on rate of dry weight increment have been shown in Table 4.7.

(a) Effect of plucking **intervals**

It is evident from Table 4.7 that the rate of dry weight increment increased significantly with increase in plucking interval from 3 to 17 days during both the years of study. However, the increases due to plucking intervals of 13 and 17 days as compared to 11 and 15 days, respectively, were not significant. Similarly, the difference between 7 and 5 days intervals was non-significant in this respect during pruned year.

(b) Effect **of months of plucking**

During unpruned year, rate of shoot dry weight increment was highest in April, which remained statistically at par to that in May, after which it declined significantly till October.

During pruned year, the highest rate of dry shoot weight increment was recorded in May followed by July, August and June. The rate further decreased from September until October. The differences between July and August as well as between August and June were not significant in this respect.

(c) Interaction effect

Table 4.7 embodies the data pertaining to the interaction effect of months and intervals of plucking on rate of shoot dry weight increment. It is clear from the table that the trend of effect of different plucking intervals in all the months was similar to their main effects with few exceptions in the significance among them in different months as described below:

In all the months during unpruned year, 17 days plucking interval resulted in highest rate of shoot dry weight increment but was at par with 15 days interval in April, September and October. It was also at par with intervals upto 11 days in May and July, and with 13 days in August. On the other hand, 3 days interval showed lowest rate of dry weight increment, but its differences with intervals upto 5 days in July, upto 7 days in September and upto 9 days in October were not significant.

During pruned year, 17 days interval recorded highest rate of shoot dry weight increment, however, it did not differ significantly with 15 days interval in all months of observation excepting August. In October, the 17 days interval was at par with plucking intervals upto 5 days, though 15 days interval showed numerically higher rate of shoot dry weight increment. The lowest rate of increment of dry shoot weight was recorded in case of 3 days interval and this had non-significant differences in this respect with plucking intervals upto 7 days in September and upto 11 days in October.

4.1.1.7. Rate of regeneration of shoots

The data pertaining to rate of regeneration of shoots expressed as days taken by top axillary bud to grow to 2+Bud size following plucking as influenced by intervals and months of plucking as well as their interaction have been given in Table 4.8 and corresponding analyses of variance in Appendix IV.

The data embodied in Table 4.8 reveal that the main effects

Table 4.8 Effect of plucking intervals on rate of shoot re months of plucking in unpruned and pruned years

Plucking intervals	Months of plucking					
	April	May	June	July	August	Sep
Unpruned year (1990)						
3 Days	22.5	41.4	41.2	30.2	34.3	3
5 Days	22.5	41.6	41.2	30.5	34.3	3
7 Days	23.7	42.3	38.2	32.0	35.5	3
9 Days	24.0	40.6	41.4	32.5	34.7	3
11 Days	23.6	41.2	42.1	32.0	36.0	3
13 Days	25.8	40.1	40.6	31.9	35.7	3
15 Days	25.8	43.9	41.8	30.5	36.6	3
17 Days	26.0	43.0	39.0	30.9	35.8	3
Mean	24.2	41.8	40.7	31.3	35.4	3
Pruned year (1991)						
3 Days	-	29.3	30.9	31.2	29.5	
5 Days	-	28.1	29.7	30.2	27.4	
7 Days	-	29.3	30.1	29.4	28.0	
9 Days	-	27.1	28.9	31.5	27.5	
11 Days	-	28.1	28.6	29.0	27.1	
13 Days	-	28.5	28.9	30.9	26.5	
15 Days	-	28.1	28.9	29.6	28.1	
17 Days	-	28.7	30.6	30.3	29.4	2
Mean	-	28.4	29.6	30.3	27.9	

Interval	Unpruned year (1990)			Pruned
	SEm+/-	L.S.D.	CV%	SEm+/-
Month	0.4	-NS-		0.3
1 X M	0.4	1.2		0.3
	1.2	-NS-	5.90	0.8

of plucking interval as well as its interaction with different months of plucking during both years in respect of regeneration rate of shoot were non-significant. However, the effect of months of plucking was significant during both the years.

During unpruned year, rate of regeneration was significantly highest in April followed by July, August and September. All these months differed significantly from each other in this respect. The regenerative rate is slowest in May and June.

During pruned year, the regeneration rate was faster in September followed by April, May, June and July. But the differences between former two as well as latter two months were not significant.

During both the years, shoots plucked in October could not regenerate to 'two leaves and a bud' (2 + Bud) stage. On an average, pruned year showed faster rate of regeneration than unpruned year.

4.1.1.8. Number of plucking points

The influence of plucking interval on number of plucking points per 100 cm² and per primary shoot was found significant during both the years of study (Appendix IV). The data are given in Table 4.8.

The plucking point density per 100 cm² and per primary shoot decreased with increase in plucking interval during both the years of investigation. Plucking points were, in general, more in unpruned year than in pruned year.

4.1.1.8.A.Plucking points per unit area

The shortest plucking interval of 3 days resulted in the highest plucking points per unit area during both the years. In unpruned year, 5 and 7 days intervals, remaining at par resulted in significantly higher plucking points than 9 days or longer intervals. Plucking interval of 9 days also showed significantly higher plucking points than longer intervals. Similarly, 11 days interval exhibited higher plucking points than the intervals **more** than 15 days. The differences between 11 and 13 days, 13 and 15 days, and 15 and 17 days plucking intervals were not significant in this respect.

During pruned year, 5 days plucking interval resulted in higher plucking points than the longer intervals. Plucking intervals of 7 and 9 days, and 9 and 11 days did not differ with each other in this respect but 7 days interval showed significantly higher plucking points than 11 days or wider intervals. Similarly, 9 days interval produced significantly higher plucking points than that of 13 days or wider intervals.

4.1.1.8.B.Plucking points per primary

Number of plucking points per primary shoot declined in pruned year (19.1) compared to that in unpruned year (51.9). During unpruned year, plucking intervals of 3,5 and 7 days resulted in significantly higher plucking points than 5,9 and 15 days intervals, respectively. The differences between 3 to 5 days, 5 to 9 days, 7 to 15 days, and 11 to 17 days plucking intervals were not significant- The trend during pruned year was

Table 4.9 Effect of plucking intervals on number of area and per primary of tea bush in unprun

Plucking intervals	Mo.of plucking points/100 cm		No.o U
	Unpruned year (1990)	Pruned year (1991)	
3 Days	112.7	86.0	
5 Days	86.3	66.3	
7 Days	75.3	49.3	
9 Days	60.0	46.3	
11 Days	48.0	36.7	
13 Days	39.0	34.3	
15 Days	30.3	29.0	
17 Days	26.7	27.3	
Mean	59.8	46.9	
SEm+/~	3.7	3.8	
L.S.D	11.0	11.5	
CV %	10.70	14.02	

also similar to that of unpruned year. In pruned year, plucking intervals of 3, 5 and 7 days resulted in significantly higher plucking points than higher intervals. Plucking intervals of 3 to 7 days, 5 to 11 days, 5 to 15 days, and 9 to 17 days did not differ significantly with each other in this respect.

4.1.1.9. Bush surface area

Table 4.10 embodies the data on effect of different plucking intervals on per cent increase in bush surface area in unpruned (1990) and pruned (1991) years. Though during both the years there was gradual increase in bush surface area with widening of plucking interval from 3 to 17 days but their effect was significant during unpruned year only (Appendix IV). During unpruned year also, the increase in bush surface area was significant only due to the longest interval of 17 days compared with the shortest interval of 3 days (Table 4.10).

4.1.1.10. Annual creep

The effect of plucking interval on annual creep in unpruned and pruned tea bushes (Table 4.11) reveals that the creep increased with increase in plucking interval. The average creep was more in unpruned year than that in pruned year particularly in longer intervals. The effect of plucking interval on annual creep was significant only in unpruned year (Appendix IV), where plucking intervals of 9 to 17 days showed statistically similar creep but significantly more than that due to 5 days and shorter intervals. Plucking interval of 7 days also resulted in higher creep than intervals below 5 days but lower than that due to over 15 days intervals and was at par with intervals from 9 to 13

Table 4.10 Effect of plucking intervals on increase in bush surface area of tea in unpruned and pruned years

Plucking intervals	% Increase in bush surface area *			
	Unpruned year (1990)		Pruned year (1991)	
3 Days	2.41	(5.8)	2.75	(7.6)
5 Days	2.50	(6.4)	3.13	(9.9)
7 Days	2.51	(6.3)	3.10	(9-7)
9 Days	2.88	(8.4)	3.40	(12.1)
11 Days	3.19	(10.4)	2.78	(7.7)
13 Days	3.16	(9-9)	3.11	(10.9)
15 Days	3.46	(12.0)	3.95	(16.7)
17 Days	3.59	(12.9)	4.05	(18.8)
Mean	2.96	(9.0)	3.28	(11.7)
SEm+/-	0.38	-	0.47	-
L.S.D	1.13	-	-N.S.-	-
CV %	22.02	-	24.88	-

* Data subjected to square root transformation
Original values are given parentheses

Table 4.11 Effect of plucking intervals on annual creep of plucking table of tea bush in unpruned and pruned years

Plucking intervals	Annual creep (cm)	
	Unpruned year (1990)	Pruned year (1991)
3 Days	2.80	2.80
5 Days	3.63	3.77
7 Days	4.73	4.07
9 Days	5.57	4.10
11 Days	5.87	4.67
13 Days	5.87	4.68
15 Days	6.63	4.87
17 Days	6.70	4.83
Mean	5.23	4.23
Sfm+/-	0.42	0.41
L. S. D	1.27	-NS-
CV %	13.88	16.75

days. Plucking interval of D days showed significantly lower creep than 5 days interval.

4.1.2.Yield

4.1.2.1.Green leaf yield

The effect of plucking interval on green leaf yield in different flushes as well as total of the season during both the years - unpruned (1990) and pruned (1991) has been presented in Table 4.12. The corresponding analyses of variance have been appended in Appendix V.

A perusal of the table indicates that increase in plucking interval was associated with increases in yield. The details of the effect of plucking interval on green leaf yield are given here under:

4.1.2.1.A.Early flush

Early flush contributed 39.6 per cent of the total yield of the season in unpruned year, whereas in pruned year its contribution was only 7.6 per cent. In pruned year, the yield in early flush was only 13.2 per cent of that in unpruned year.

The plucking intervals did not Manifest significant effect (yield of early flush in unpruned year. However, in pruned year, crop plucked at 13 days interval recorded significantly higher yield than that of shorter intervals but it did not differ significantly with the yield of higher intervals of 15 and 17 days. The yield due to latter intervals was also statistically similar to that of 5 and 7 days. Crop harvested at 5 to 11 days intervals

Table 4.12 Effect of plucking intervals on green le
different flushes a:vi over the season in

Plucking intervals	Early flush	Main flush	Backend	
Unpruned year (1990)				
3 Days	3911	4526	1255	
5 Days	4471	5524	1231	
7 Days	4748	5839	1584	
9 Days	4731	6431	1212	
11 Days	5180	6610	1547	
13 Days	5723	6295	1298	
15 Days	5662	7185	1045	
17 Days	5498	8104	1088	
Mean	4991	6314	1283	
Pruned year (1991)				
3 Days	424	4082	1765	
5 Days	571	4922	1439	
7 Days	623	5388	1971	
9 Days	500	6041	1763	
11 Days	504	6691	1306	
13 Days	983	7519	1496	
15 Days	838	6985	2483	
17 Days	821	7571	2945	
Mean	658	6150	1896	
Unpruned year (1990)				
	SEm+/-	L.S.D.	CV %	SEm
Early flush	524	-N.S. -	18.17	10
Main flush	250	759	7.00	46
Backend flush	75	226	9.80	15
Total season	707	2145	9.73	55

did not bring significant change in yield. The lowest yield was recorded at 5 days interval which, however, did not differ significantly with 17 days interval.

4.1.2.1.B.Main flush

Mean green leaf yield of main flush was almost similar in both the years (6314 kg/ha in pruned and 6150 in unpruned). The main flush yield during unpruned year contributed 50.2 per cent to the total seasonal yield whereas it was 70.6 per cent during pruned year.

During unpruned year, the longest plucking interval of 17 days brought significantly highest green leaf yield of main flush followed by 15 days interval which did not differ significantly with 9 and 17 days intervals. Significantly lowest yield was obtained with shortest plucking interval of 3 days followed by 5 days. The yields recorded in 5 and 7 days intervals were statistically similar.

During pruned year also, the green leaf yield was highest in case of 17 days plucking interval, though did not differ significantly with 15 days plucking interval. The green leaf yield was significantly lowest with plucking interval of 3 days which remained at par with 5 and 7 days intervals.

4.1.2.1.C.Backend flush

The contribution of backend flush to the total season's yield was 10.2 per cent in unpruned year and 21.8 per cent in pruned year. Compared with unpruned year this flush in pruned year had 47.8 per cent more yield.

During unpruned year, the green leaf yield of the crop plucked at 7 and 11 days intervals was statistically similar and significantly higher than other plucking intervals. The yield differences in case of remaining intervals were not significant among them.

During pruned year, plucking intervals of 17 days resulted in significantly highest green leaf yield followed by 15 days plucking interval. The yield differences due to 3,5,9,11 & 13 days intervals were not significant amount them during this year.

4.1.2.1.D.Total season

The data in Table 4.12 show that, in general, the total green leaf yield obtained from all flushes in pruned year was 69.1 per cent of that in unpruned year.

During both the years, plucking intervals of more than 5 days recorded significantly higher yield over 3 days interval. In unpruned year, green leaf yields in plucking intervals of 15 and 17 days were significantly higher over plucking intervals of less than 7 days. The interval of 17 days resulted in significantly higher yield than that obtained with 9 days.

In pruned year, plucking interval of 13 days or longer resulted in significantly higher total yield over 9 days or shorter intervals. In this year, 15 and 17 days intervals had significantly higher yield over 11 days or shorter intervals. The plucking intervals from 5 to 13 days in unpruned and from 5 to 11 days in pruned year showed statistically similar total leaf yield

over the season.

4.1.2.2. Made tea yield

Table 4.13 embodies the effect of different plucking intervals on made tea yield of different flushes as well as of total season. The corresponding analyses of variance have been given in Appendix V.

4.1.2.2.A. Early flush

Early flush yield of made tea contributed 39.7 per cent in unpruned and only 7.6 per cent in pruned year towards total season's made tea yield. The made tea yield in pruned year was only 12.7 per cent of that obtained in unpruned year.

The effect of plucking intervals on made tea yield of early flush during unpruned year was not significant (Appendix V).

During pruned year, 13 days interval recorded significantly higher yield than shorter intervals and was non-significant with that due to 15 and 17 days intervals. Plucking intervals of 15, 17, 5 and 7 days in the order were statistically at par in terms of made tea yield. Similarly, there were no significant differences in the yields obtained from pluckings at intervals of less than 13 days.

4.1.2.2.B. Main flush

The contribution of main flush towards total season's yield in unpruned and pruned years was 50.1 and 70.5 per cent, respectively. Made tea yield in pruned year was 83.4 per cent of that in unpruned year.

Table 4.13. Effect of plucking intervals on made t flushes and over the season in unprun

Plucking intervals	Early flush	Main flush	Backen	
Unpruned year (1990)				
3 Days	994	1150	3	
5 Days	1105	1365	3	
7 Days	1152	1417	3	
9 Days	1134	1540	2	
11 Days	1200	1531	3	
13 Days	1343	1478	3	
15 Days	1368	1732	2	
17 Days	1290	1900	2	
Mean	1198	1514	3	
Pruned year (1991)				
3 Days	103	997	4	
5 Days	135	1160	3	
7 Days	140	1215	4	
9 Days	112	1364	3	
11 Days	110	1455	2	
13 Days	222	1697	3	
15 Days	200	1653	5	
17 Days	192	1769	6	
Mean	152	1414	4	
Onpruned year (1990) Prune				
	SE _{ro+V-}	L. S. D	CV %	SE _{m+/-}
Early flush	128	NS-	18.54	25
Main flush	62	187	7 18	113
Backend flush	19	57	9 60	38
Total season	176	535	10 12	138

Made tea yield from main flush increased with increase in plucking interval during both the years. In unpruned year, plucking intervals from 5 to 13 days expressed statistically similar yield, but significantly higher than that of 3 days but lower than 15 and 17 days. Made tea yield obtained due to 15 and 17 days intervals was similar and significantly highest, while the yield due to 3 days interval was significantly lowest during this year.

During pruned year, plucking interval of 9 days or below resulted in significantly lower yield than that of 17 days. In this year, intervals from 9 to 15 days, 5 to 11, and 3 to 7 days produced statistically similar yields of made tea.

4.1.2.2.C.Backend flush

This flush contributed 10.2 and 21.9 per cent made tea yield of the total season in unpruned and pruned years, respectively. The mean yield of the flush in pruned year was 42.1 per cent more than that of unpruned year.

In unpruned year, made tea yield obtained from 7 days interval was significantly higher than other intervals excepting 11 days which was on par. Plucking interval of 11 days produced the yield statistically similar to that of 3,5 and 13 days intervals, but significantly higher than 9,17 and 15 days intervals. The yield in latter intervals was similar and lowest during the flush. The yield obtained with 3 days interval was significantly higher than that of 15 and 17 days intervals.

In pruned year, contrary to unpruned year, the made tea yield due to 15 and 17 days intervals was similar and significantly highest and this was statistically similar to 13 days interval. Plucking interval of 11 days had the lowest yield and remained non-significant with 9 and 13 days intervals. The intervals from 3 to 9 days as well as 13 days also recorded statistically similar yields of made tea.

4.1.2.2.D.Total season

Hade tea yield of total season obtained in pruned year was 66.4 per cent of that in unpruned year.

In general during both the years, there was increase in yield with increase in plucking interval. In unpruned year, plucking interval of 11 days or more produced significantly higher yield than that of 3 or 5 days interval. Differences in made tea yield from 3 to 9 days and from 7 to 17 days were not significant. In pruned year, 15 and 17 days intervals exhibited significantly higher yield over that of 11 days or shorter. The plucking interval of 13 days also registered significantly higher yield than below the 9 days. The made tea yields in plucking intervals from 3 to 11 days, 9 to 13 days as well as from 13 to 17 days were statistically similar.

4.1.3.Quality

Effect of different plucking intervals on quality of tea was evaluated in respect of physical standard of crop (i.e. fineness of crop); polyphenol content (total) in the tea shoot, (which is an indication to the potential tea quality);

Table 4.14 Effect of plucking intervals on fineness of wool plucking in unpruned and pruned years

Plucking intervals	Months of plucking																																		
	April	May	June	July	August																														
Unpruned year (1990)																																			
3 Days	86.2	79.1	74.9	74.8	76.2																														
5 Days	77.6	72.6	68.2	70.3	67.6																														
7 Days	73.3	65.6	65.2	64.5	63.3																														
9 Days	69.6	66.7	63.6	61.9	57.9																														
11 Days	67.0	64.1	60.8	47.6	48.3																														
13 Days	63.1	67.2	53.8	57.2	45.2																														
15 Days	59.9	56.2	47.3	45.3	46.2																														
17 Days	58.6	62.1	43.6	40.7	52.8																														
Mean	69.4	66.7	59.7	57.8	57.2																														
Pruned year (1991)																																			
3 Days		88.5	93.6	87.2	85.0																														
5 Days		71.7	71.7	69.5	69.3																														
7 Days		72.0	60.5	57.3	59.2																														
9 Days		60.9	49.2	46.8	42.5																														
11 Days		50.0	45.6	44.9	34.5																														
13 Days		43.4	36.9	34.2	30.2																														
15 Days		45.8	34.3	33.3	25.1																														
17 Days		47.8	29.6	43.4	21.3																														
Mean		60.0	52.7	52.1	45.9																														
<table border="0" style="width: 100%;"> <tr> <td></td> <td colspan="3" style="text-align: center;">Unpruned year (1990)</td> <td colspan="2" style="text-align: center;">Pruned</td> </tr> <tr> <td></td> <td style="text-align: center;"><u>SEm+/-</u></td> <td style="text-align: center;"><u>L.S.D.</u></td> <td style="text-align: center;">CV %</td> <td colspan="2" style="text-align: center;"><u>SEm+Z-</u></td> </tr> <tr> <td>Interval</td> <td style="text-align: center;">0.8</td> <td style="text-align: center;">2.1</td> <td></td> <td colspan="2" style="text-align: center;">0.8</td> </tr> <tr> <td>Month</td> <td style="text-align: center;">0-7</td> <td style="text-align: center;">2.0</td> <td></td> <td colspan="2" style="text-align: center;">0.7</td> </tr> <tr> <td>I X M</td> <td style="text-align: center;">2.1</td> <td style="text-align: center;">5.7</td> <td style="text-align: center;">5.79</td> <td colspan="2" style="text-align: center;">2.0</td> </tr> </table>							Unpruned year (1990)			Pruned			<u>SEm+/-</u>	<u>L.S.D.</u>	CV %	<u>SEm+Z-</u>		Interval	0.8	2.1		0.8		Month	0-7	2.0		0.7		I X M	2.1	5.7	5.79	2.0	
	Unpruned year (1990)			Pruned																															
	<u>SEm+/-</u>	<u>L.S.D.</u>	CV %	<u>SEm+Z-</u>																															
Interval	0.8	2.1		0.8																															
Month	0-7	2.0		0.7																															
I X M	2.1	5.7	5.79	2.0																															

CD

made tea parameters viz., caffeine, theaflavin (TF), thearubigin (TR) contents as well as brightness and total colour of tea and taster's report on brightness colour, total quality and valuation of tea.

4.1.3.1. **Per cent fineness of cr**

The fineness of crop was significantly affected by plucking intervals, Months of plucking as well as their interaction (Appendix VI). The results have been given in Table 4.14.

In general, the average fineness of the crop in unpruned year (1990) was more than in pruned year (1991).

(a) **Effect of plucking intervals**

During both the years, the fineness decreased significantly with increase in plucking interval. However, the decrease was not statistically significant in respect of plucking intervals of 15 and 17 days in both years; 11 and 13 days in unpruned year; and 13 and 15 days in pruned year.

(b) **Effect of months of plucking**

During unpruned year, the fineness of crop in April was highest which decreased in later months till September and thereafter showed an increase in October. June and July as well as July, August and September recorded statistically similar fineness and also did not differ significantly with October in this respect. In pruned year, the highest fineness of the crop was recorded in May and it showed decreasing trend till August. Thereafter, it increased till October. June, July and September

harvested crops showed similar fineness which, however, was significantly lower than that of October.

(c) Interaction effect

The fineness of crop was significantly influenced due to the interaction between intervals and months of plucking during both unpruned and pruned years (Table 4.14).

During unpruned year, the fineness of crop was significantly highest when it was harvested at 3 days interval in all the months from April to October except that in July, the fineness of the crop plucked at 5 days interval was statistically at par with that of 3 days interval. The fineness decreased in each month significantly with increase in the plucking interval with few exceptions in each month when some intervals were at **par** with others. In April, June, July and October, the longest interval of 17 days resulted in lowest value for fineness and this interval did not differ significantly with 15 and 13 days intervals in April and with 15 days interval in June and July. In **May** and September, plucking interval of 15 days recorded lowest fineness but its difference with 11 and 13 days plucking intervals in September was not significant.

During pruned year also the shortest plucking interval of 3 days produced crop with significantly highest fineness in all the months. The fineness decreased significantly with increase in plucking intervals in all the months though the differences between some intervals in different months were not significant. In May, the lowest fineness was recorded due to 13 days plucking

interval, but it did not differ significantly **from longer** intervals of 15 and 17 days. In July, the fineness of crop due to 13 and 15 days plucking intervals was similar and significantly lowest. In regaining months (i.e. June, August, September and October), crop plucked at 17 days interval had lowest fineness, which, however, did not differ significantly with 15 days interval in June and August, and 13 and 17 days intervals in September.

4.1.3.2. Polyphenol content

The effect of plucking interval, month of plucking and their interaction on polyphenol content of tea shoot in unpruned and pruned years have been presented in Table 4.15 and corresponding analyses of variance given in Appendix VI.

(a) Effect of plucking intervals

The data in Table 4.15 reveal that there was significant decrease in polyphenol content of the shoots with increasing plucking interval from 3 to 17 days during both the years. In unpruned year, plucking intervals of 9 and 11 days, 13 and 15 days as well as 15 and 17 days did not differ significantly with each other. Similarly in pruned year, the difference between 3 and 5 days, 7 and 9 days and 15 and 17 days plucking intervals also remained non-significant.

(b) Effect of months of plucking

In unpruned year, the content of polyphenol was more in May than in April and June, the latter two remaining at par. The polyphenol content decreased significantly from June to October.

Table 4.15 Effect of plucking intervals on polyphenol cont
different months of plucking in unpruned and pr

Plucking intervals	Months of plucking					
	April	May	June	July	August	Septe
Unpruned year (1990)						
3 Days	22.10	23.40	21.03	20.47	19.47	16
5 Days	21.17	21.37	21.33	18.83	18.50	17
7 Days	19.63	19.23	18.17	18.33	17.83	16
9 Days	17.43	19.20	17.53	16.63	16.37	16
11 Days	18.23	19.47	17.47	15.83	15.13	14
13 Days	12.07	16.23	15.93	13.70	13.77	13
15 Days	13.43	18.37	13.50	12.83	12.43	12
17 Days	14.63	16.30	12.43	12.40	11.60	11
Mean	17.34	19.20	17.18	16.13	15.64	15

∞	Pruned year (1991)					
	3 Days	18.45	18.50	19.10	18.95	20
	5 Days	18.55	18.00	19.35	19.00	19
	7 Days	15.80	17.85	17.85	17.95	17
	9 Days	17.15	18.00	18.90	16.95	18
	11 Days	13.55	16.55	17.60	16.20	17
	13 Days	12.85	13.95	15.05	17.25	16
	15 Days	11.20	14.85	14.60	15.05	15
	17 Days	11.70	14.20	13.85	13.65	14
Mean	14.91	16.49	17.04	16.88	17	

	Unpruned year (1990)			Prune
	<u>SEm+/-</u>	<u>L.S.D.</u>	CV %	<u>SEm+/-</u>
Interval	0.28	0.78		0.21
Month	0.26	0.73		0.18
I X M	0.74	2.07	7.79	0.51

The contents in July and August, August and September as well as September and October were statistically sane. The trend of variation of polyphenol content in tea shoots in different months in pruned year was different to that of unpruned year. In pruned year, the content was lowest in May, which increased significantly till July and again declined in August but not to significant level. The content again showed significant increase till October. The content observed in the month of August was similar to that of June in pruned year.

(c) Interaction effect

The interaction between intervals and months of plucking significantly influenced the polyphenol content of tea shoots during both the years of investigation (Table 4.15).

During unpruned year, the highest content of polyphenol was recorded at 3 days plucking interval in April to August, and October but it did not differ significantly with 5 days interval in April to July, 5 and 7 days intervals in August and 5 to 11 days intervals in October. In September, the crop of 5 days interval had significantly higher content than others, but did not differ significantly with 3, 7 and 9 days intervals. The difference of 3 and 9 days plucking intervals with the 11 days interval regarding polyphenol content in this month was also not significant. The lowest polyphenol content in April was recorded at 13 days interval which was statistically similar to that of 15 days. The content due to 17 days plucking interval in this month was significantly higher than that due to 13 and 15 days inter-

vals. As in April, an May also the crop of 13 days plucking interval resulted in Iciest polyphenol content but this interval was at par with 17 days. In this month the difference between 15 and 17 days plucking intervals was also non-significant in this respect. In remaining months, the lowest polyphenol content in tea was noted in case of the produce obtained from 17 days plucking interval. In June and August the differences due to 15 and 17 days intervals were not significant. In July, September and October, the lowest content was noticed in case of 17 days interval which was statistically sinilar to that of 13 and 15 days intervals. Overall comparison shows that tea harvested at 3 and 5 days intervals in April and May and at 5 days interval in June recorded highest polyphenol content. On the other side, tea plucked at an interval of 13 days in April; 17 days in June; 15 and 17 days in July and August; and 13 to 17 days in September and October not differing significantly amongst themselves contained lowest polyphenol.

The interaction between plucking intervals and months of plucking in pruned year also showed the similar trend as that in unpruned year with few exceptions. In September and October, significantly highest polyphenol content was obtained in 3 & 5, and 5 days plucking intervals, respectively. The lowest content was noted in the pluckings of May month at intervals of 15 and 17 days. The shortest plucking interval of 3 days resulted in highest polyphenol content in the shoots throughout the year but this interval did not differ significantly with 5 and 7 days in May and July; 5 to 9 days in June; 5 and 7 days in August and 5

days in September. In October, the content due to 3 days interval was significantly highest. In all the months of plucking, the longer intervals of 15 and 17 days, remaining at par, had significantly lower polyphenol content than other intervals. It was found that 15 days interval did not differ significantly with 13 days in May; 15 days interval did not differ significantly with 11 days in August and 13 days in September; and both 15 and 17 days intervals did not differ significantly with 13 days interval in June, July and October in this respect.

4.1.3.3. Made tea characters

The made tea samples were analyzed for the five important characters of black tea, viz., caffeine content, theaflavin content, thearubigin content, total colour and brightness. The results have been presented in Tables 4.16 to 4.20. The corresponding analyses of variance have been compiled in Appendix VII.

4.1.3.3.1. Caffeine content

The effects of plucking intervals, months of plucking and their interaction on caffeine content of made tea in unpruned (1990) and pruned (1991) years were significant (Appendix VII) and have been presented in Table 4.16.

(a) Effect of plucking intervals

There was significant decrease in caffeine content with increase in plucking intervals during both unpruned (1990) and pruned (1991) years. However, the decrease was not significant between the intervals of 11 and 13 days as well as between 15 and 17 days during both the years, besides 3 and 5 days in unpruned

Table 4.16 Effect of plucking intervals on caffeine content at different months of plucking in unpruned and pruned tea bushes

Plucking intervals	Months of plucking				
	May	June	July	August	September
Unpruned year (1990)					
3 Days	3.498	2.883	2.742	2.677	2.329
5 Days	3.302	2.902	2.841	2.392	2.049
7 Days	2.715	2.461	2.394	2.296	2.045
9 Days	2.841	2.244	2.141	2.163	1.950
11 Days	2.870	2.204	2.003	1.937	1.923
13 Days	2.725	2.141	2.211	1.843	1.887
15 Days	2.301	1.920	1.870	1.921	1.662
17 Days	2.010	1.972	1.821	1.892	1.787
Mean	2.783	2.341	2.253	2.140	1.954
Pruned year (1991)					
3 Days	2.663	2.914	3.239	2.852	3.033
5 Days	2.477	2.924	3.023	2.647	2.612
7 Days	2.289	2.733	2.737	2.723	2.480
9 Days	2.157	2.461	2.647	2.449	2.261
11 Days	2.096	2.267	2.463	2.149	2.088
13 Days	2.156	2.351	2.269	1.967	2.279
15 Days	2.067	2.180	2.285	2.000	1.713
17 Days	1.908	1.938	2.360	1.920	1.816
Mean	2.227	2.471	2.628	2.338	2.285

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	Unpruned year (1990)			P
	SEm+/-	L.£»D.	CV %	SEm
Interval	0.037	0.103		0.
Month	0.035	0.097		0.
I X M	0.098	0.273	7 21	0.

year.

(b) Effect of months of plucking

In unpruned year, the caffeine content of made tea decreased from April to September and improved a little later in October but not significantly. The caffeine content in June and July;... In September and October months were statistically similar. The trend of variation in caffeine content in pruned year was different. During this year, the content was significantly higher in July and October months than others. The content increased significantly from May to July and then declined until September; May and September or August and September as well as July and October had comparable caffeine contents in made tea.

(c) Interaction effect

The interaction between plucking intervals and months of plucking in respect of caffeine content of made tea was significant during both the years of study (Table 4.16).

During unpruned year, the caffeine content in tea plucked in May, June and July was significantly higher in case of plucking intervals of 3 and 5 days but in August and September, tea of 3 days interval had significantly higher caffeine content than that of 5 days interval. In October, 3 and 5 days intervals did not differ significantly with 7 days interval in this respect. Significantly lowest caffeine content was recorded due to 17 days plucking interval in May. In July and October also, tea obtained from plucking interval of 17 days contained lowest caffeine content but similar to that of 15 and 11 days intervals. In June

and September, tea plucked at 15 days interval had the lowest caffeine content and did not differ significantly with plucking intervals of 17 and 13 days. In September also, plucking interval of 15 days resulted in tea with lowest caffeine content which, however, was at par with 13 and 17 days intervals. The caffeine content of tea plucked at 13 and 17 days intervals, did not differ significantly from that of 5 to 11 days intervals in this month. In overall assessment, the highest caffeine content was observed in tea of May month plucked at the intervals of 3 and 5 days whereas the lowest content was recorded in tea of September month plucked at 15 days interval, which, however, did not differ significantly with the content of 9 to 13 as well as 17 days intervals in the same month; 15 days interval in June; 15 and 17 days intervals in July; 13 to 17 days intervals in August; and 11 to 17 days intervals in October.

During pruned year also plucking intervals of 3 days in all the months resulted in tea with significantly higher caffeine content. This interval did not differ significantly with 5 days in May and July; 5 and 7 days in June and August, and 5, 7 and 9 days in October. In June and October, tea obtained from the plucking interval of 17 days had significantly lowest caffeine content. In May and August also the lowest caffeine content was observed in the tea harvested at 17 days interval and this content did not differ significantly with that of 15 and, 11 days intervals in May and 15, 13 and 11 days intervals in August. In July, the lowest content was recorded in tea of 13 days interval which was at par with that of 15, 17 and 11 days intervals. The

tea obtained at 15 days interval contained lowest caffeine percentage in September, though it did not differ significantly with that of 17 days interval. Tea made from the harvest of 3 and 5 days intervals in July and 3 days interval in September had the highest caffeine content in the season. On the other hand, tea of 15 and 17 days intervals harvested in May, June and August contained significantly lowest caffeine.

4.1.3.3.2. Theaflavin content

The theaflavin (TF) content in made tea was significantly influenced due to plucking intervals, months of plucking and their interaction during both unpruned (1990) and pruned (1991) years (Appendix VII). The results have been presented in Table 4.17.

(a) Effect of plucking intervals

The different plucking intervals had significant influence on TF content of made tea. Increase in plucking interval from 3 to 17 days resulted in significant decrease in TF content of made tea during both the years of study. In unpruned year, however, 11 days interval did not differ significantly with 9 and 13 days intervals in this regard. Similarly the TF content of tea from 15 and 17 days intervals remained similar during pruned year.

(b) Effect of months of plucking

The data presented in Table 4.17 reveal that in unpruned year, the TF content decreased significantly from May to August and thereafter increased till October. The TF content was similar in the tea obtained during months from May and October

Table 4.17 Effect of plucking intervals on theaflavins in tea in different months of plucking in unpruned year (1990)

Plucking intervals	Months of plucking				
	May	June	July	August	September
Unpruned year (1990)					
3 Days	0.530	0.365	0.310	0.295	0.369
5 Days	0.501	0.380	0.299	0.272	0.309
7 Days	0.460	0.315	0.283	0.291	0.312
9 Days	0.366	0.263	0.242	0.267	0.271
11 Days	0.351	0.265	0.260	0.222	0.268
13 Days	0.320	0.211	0.216	0.241	0.301
15 Days	0.246	0.208	0.202	0.227	0.290
17 Days	0.262	0.175	0.255	0.194	0.220
Mean	0.380	0.273	0.258	0.251	0.293
Pruned year (1991)					
3 Days	0.297	0.467	0.505	0.338	0.393
5 Days	0.282	0.425	0.478	0.288	0.295
7 Days	0.277	0.396	0.441	0.245	0.297
9 Days	0.266	0.393	0.408	0.183	0.315
11 Days	0.250	0.318	0.355	0.152	0.310
13 Days	0.232	0.325	0.261	0.200	0.218
15 Days	0.230	0.244	0.270	0.123	0.187
17 Days	0.235	0.246	0.285	0.136	0.183
Mean	0.259	0.352	0.375	0.208	0.275

Unpruned year (1990)				
	SEm+/-	L, S.D.	CV %	SEm
Interval	0.005	0.013		0.0
Month	0.004	0.011		0.0
I X M	0.011	0.031	6.34	0.0

as well as July and August. In pruned year, the content increased significantly from May to July and then declined to the lowest level in August. It improved later in September and October. June and October recorded similar TF contents, which, however, were significantly higher than that of September month.

(c) Interaction effect

The theaflavin content of made tea was significantly influenced by the interaction between plucking intervals and months of plucking during unpruned and pruned years (Table 4.17)

During unpruned year, wider variations in TF content due to plucking intervals were recorded in May and October when TF content was higher than other months (Table 4.17). The TF content in the tea made from the crop of 3 and 5 days plucking intervals in May was not only highest in this month but also during other months. However, in September and October, plucking interval of 3 days had significantly higher TF content in made tea. The tea of this interval in each respective month also resulted in highest TF content but its difference with 5 days interval in June; 5 and 7 days in July; and 5 to 9 days in August were not significant in this respect. On the other side, the lowest TF content was noted in tea made from the crop of 15 and 17 days intervals in May; 17 days interval in June, September and October; 15 days interval in July; and 17 and 11 days intervals in August. Overall, the tea made from the crop of 17 days plucking interval in June while remaining at par with that of 15 days interval in July and 17 days interval in August, had the lowest content of TF in the season.

During pruned year, the wider variations in TF content of made tea due to different plucking intervals were noted in July (Table 4.17). Like unpruned year, tea Manufactured from the crop of 3 days plucking interval resulted in the highest TF content in all the months, however, its differences with that of 5 and 7 days in May; 5 days in July; and 5 to 9 days in October were not significant. Tea of July month made from 3 days plucking interval while remaining at par with 5 days interval recorded significantly higher TF content than the remaining intervals. The next highest content of TF was in the tea of 3 days interval harvested in June which also remained statistically similar to the content of tea of July month plucked at 5 days interval. On the other hand, tea of 15 days plucking, not differing significantly with that of 13 and 17 days plucking intervals in May; 17 days plucking interval in June and October; and 11 and 17 days plucking intervals in August had lowest TF content. In July, though the lowest content was recorded in the tea obtained from 13 days plucking interval, its difference with the content of the crop of 15 and 17 days intervals was not significant. In September also, tea of 15 and 17 days crop without differing significantly contained lowest TF content. Overall, the lowest TF content was recorded in the tea of 11, 15 and 17 days plucking intervals in August in the pruned crop.

4.1.3.3.3. Thearubigin content

Thearubigin (TR) content of made tea was significantly influenced due to plucking interval, month of plucking as well as

Table 4.18 Effect of plucking intervals on thearubi tea in different months of plucking in un

Plucking intervals	Months of plucking				
	May	June	July	August	Septemb
Unpruned year (199					
3 Days	11.342	10.971	9.871	9.408	7.74
5 Days	11.542	10.906	8.974	9.288	7.45
7 Days	9.971	10.841	8.799	8.963	6.61
9 Days	10.132	9.637	8.315	7.961	6.81
11 Days	9.938	9.984	7.371	7.378	6.95
13 Days	10.042	7.834	8.015	7.233	6.75
15 Days	8.591	7.141	7.910	7.230	6.22
17 Days	7.928	8.142	6.977	7.251	6.62
Mean	9.936	9.432	8.279	8.089	6.89
Pruned year (1991					
3 Days	6.872	7.671	8.401	7.832	8.38
5 Days	6.901	6.775	7.152	7.614	8.29
7 Days	6.531	5.603	7.420	7.874	6.52
9 Days	5.932	6.010	7.206	6.979	7.82
11 Days	5.740	5.962	5.320	5.186	5.99
13 Days	6.361	5.990	4.614	6.149	6.16
15 Days	6.501	5.117	5.001	4.694	5.01
17 Days	6.199	5.400	5.099	5.121	5.15
Mean	6.380	6.066	6.277	6.431	6.66
Unpruned year (1990)					
	SEm+/-	L.E>.D	CV %	S	
Interval	0.223	0.624			
Month	0.193	0.540			
1 X M	0.545	1.527	11.34		

their interaction during both unpruned (1990) as well as pruned (1991) years (Appendix VII). The results have been presented in Table 4.18.

(a) Effect of plucking intervals

Like caffeine, polyphenol and TF, there was decrease in TR content due to increase in plucking interval **from** 3 to 17 days. In unpruned year, significant decrease in TR content was observed when plucking interval was increased **from** 3 to 7 days or longer, 5 to 9 days or longer, 7 to 11 days or longer, 9 to 15 days or longer and 11 to 17 days. In pruned year, plucking intervals longer than 7 days resulted in significantly lower TR content in nade tea than the shortest interval of 3 days. Plucking intervals of 15 and 17 days, remaining at par, resulted in significantly lower content of TR than 13 days interval in this year which was non-significant with TR content at 11 days interval.

(b) Effect of months of plucking

The trend in TR content during different months of plucking in unpruned and pruned years was different (Table 4.18). In unpruned year, TR content of nade tea decreased continuously from May to September but increased in October. The TR contents in May and June, July and August, and September and October were statistically alike. In pruned year, lowest TR content was recorded in June month which increased till October; however, the contents were statistically similar during the months from May to August. Besides, the TR contents of nade tea in the months

of May, July and August were also similar to that in September month.

(c) Interaction effect

Interaction between different intervals and months of plucking significantly influenced the TR content during both the years of study. The effect of different plucking intervals reveals that, in general, TR content decreased with increase in plucking interval in each month but in August during unpruned year and in May during pruned year the effect was not significant (Table 4.18).

During unpruned year, the TR contents of tea prepared from the crop of 3,5,9 and 13 days plucking intervals in **May**; 3 to 13 days in June; 3 to 7 days in July and August; and 3 to 7 and 9 days in October were statistically similar and significantly higher than remaining intervals in respective months. Plucking intervals of 15 and 17 days in May; 13 to 17 days in June; 11 to 17 days in July and August; and 11,15 and 17 days in October while not differing among them respective months had lowest TR content. The TR content in tea of 15 days plucking interval in June was statistically as high as that in 9 days interval. Similarly, the TR contents in tea of 13 and 15 days intervals were at par with that in tea of 5 to 9 days intervals.

During pruned year, TR contents observed in tea of crops plucked at 3 and 5 days in June and September; 3 to 9 days in July and August; and 3 to 13 days in October were statistically similar and significantly higher than remaining intervals. Pluck-

ing intervals from 7 to 17 days in June; 11 to 17 days in July, September and October and 11, 15 and 17 days in August recorded statistically similar content, which was significantly lower than other intervals.

4.1.3.3.4. Total colour

Table 4.19 contains the data on the effect of plucking intervals, months of plucking and their interaction on total colour of nade tea both in unpruned (1990) as well as in pruned (1991) years. The corresponding analyses of variance have been appended in Appendix VII.

(a) Effect of plucking intervals

The tea manufactured from the harvest of 3 to 17 days plucking intervals had significant decrease in colour of nade tea with increase in length of plucking interval during both years. However, the reductions in total colour by extending plucking intervals from 3 to 5 days, 5 to 7 days and 7 to 15 days in unpruned year were not significant. In the similar way, in pruned year plucking intervals of 7 and 9 days, 9 and 11 days and 15 and 17 days recorded statistically same total colour of nade tea.

(b) Effect of months of plucking

During unpruned year, total colour of tea, nade from the harvests obtained in the months of May, June, July and September was statistically alike and significantly superior to that of August. The colour of tea in August month was still better than that of October that resulted in tea with poorest colour. In pruned year, the poorest colour of nade tea was noted in the tea

plucked in May. The tea of September and July had similar and significantly better total colour than that of August, October and June. The differences among August, October and June were not significant in respect of total colour of made tea in this year.

(c) Interaction effect

Total colour of made tea was significantly affected by the interaction between different plucking intervals and months of plucking during both the years. Though the general trend of total colour was decreasing with increase in plucking interval in all the months of observation but the decrease was not consistent particularly during unpruned year (Table 4.19).

During unpruned year, the plucking intervals of 3, 5 and 9 days in May; 3 to 11 except 9 days in June; 3 to 15 except 11 days in July; 3 to 9 days in August; 3, 7, 11 & 17 days in September; and 5 & 11 to 15 days in October resulted in statistically similar and higher total colour than remaining intervals.

During pruned year, the total colour of made tea obtained from the crop of May remain unaffected due to variation in plucking interval. In remaining months, the tea made from the pluckings of 3 and 9 days in June; 3 to 9 days in July; 3 & 5 days in August; and 3 to 13 days in October had statistically similar total colour which was higher than remaining intervals.

4.1.3.3.5. Brightness

The brightness of made tea expressed in percentage as influenced by interval and month of plucking as well as their inter-

Table 4.20 Effect of plucking intervals on brightne months of plucliing in unpruned and prune

Plucking intervals	Months of pluckin				
	May	June	July	August	Septemb
Unpruned year (19					
3 Days	19.877	18.917	13.791	8.057	10.63
5 Days	19.151	20.019	12.178	11.946	9.85
7 Days	18.071	14.412	13.317	10.153	9.97
9 Days	13.311	11.774	8.715	7.824	9.67
11 Days	14.121	11.856	10.515	8.697	8.65
13 Days	13.353	11.079	9.933	8.331	10.05
15 Days	11.471	13.216	9.404	7.824	8.90
17 Days	12.341	10.743	7.221	8.053	7.28
Mean	15.212	14.002	10.634	8.861	9.380
Pruned year (199					
3 Days	10.570	17.452	17.647	11.136	10.70
5 Days	11.960	15.315	17.889	12.519	9.55
7 Days	10.574	13.953	16.504	11.163	10.15
9 Days	11.409	11.655	16.057	6.128	9.06
11 Days	10.778	11.382	16.088	7.530	11.81
13 Days	10.375	12.979	17.204	7.924	8.41
15 Days	9.722	10.126	14.479	7.166	7.25
17 Days	9.375	11.202	14.470	4.885	7.70
Mean	10.595	13.008	16.292	8.556	9.331

ND

Unpruned year (1990)

	SEm+/-	L.S.D.	CV %
Interval	0.367	1.026	
Month	0.317	0.889	
I X M	0.898	2.514	12.88

action in unpruned (1990) and pruned (1991) years has been given in Table 4.20. The corresponding analyses of variance have been appended in Appendix VII.

(a) Effect of plucking intervals

The tea obtained from the harvest of 3 to 17 days resulted in significant decrease in the brightness as a result of increase in the plucking interval during both years of the investigation. However, the brightness of tea made from the crops of 3 and 5 days as well 15 or 17 days plucking intervals was similar during both the years. In unpruned year, plucking interval of 7 days resulted in the brightness similar to that of 5 days interval. The tea obtained from intervals of 9 to 15 days in unpruned year and 9 to 13 days in pruned year had statistically similar brightness.

(b) Effect of months of plucking

In unpruned year, higher brightness was observed in tea manufactured from May plucking. The brightness decreased afterwards till August and it showed increasing trend thereafter till end of the season. The brightness of made tea from plucking of May and October, June and October as well as August and September was statistically similar. In pruned year, the brightness increased from May to July and thereafter decreased markedly in August and improved later till October. Statistically, tea manufactured from the crop of July had the highest brightness followed by October while August plucked tea contained the lowest brightness in made tea.

(e) Interaction effect

The brightness of tea was significantly influenced due to interaction between different intervals and months of plucking (Table 4.20) during both the years of investigation.

During unpruned year, tea with higher brightness was obtained when it was prepared from the harvest of 3, 5 and 7 days intervals in May, difference among these intervals being non-significant. The tea with lowest brightness in this month was obtained when made from the crop of 15 days plucking interval which, however, did not differ significantly from the tea of 17, 13 and 9 days plucking intervals. In June, tea of 5 days interval remaining at par with that of 3 days interval recorded higher brightness than other intervals; while plucking interval of 17 days not differing significantly with other intervals ranging from 9 to 15 days, resulted in tea of lowest brightness. Like May, plucking intervals of 3 to 7 days in July also resulted in tea with significantly higher brightness, but in this month, the differences in tea of 5 days interval with that of 11 and 13 days intervals were not significant. The tea of significantly lowest brightness in this month was received when made from the plucking of longer intervals of 15 and 17 days. In August and September, all plucking intervals excepting 5 days in August and 17 days in September resulted in tea with statistically similar brightness. Tea of 5 days interval in August while not differing significantly with that of 7 days interval, had highest brightness while tea of 17 days interval made in September contained lowest brightness. In October, tea made from the pluckings of 3 days

interval had significantly heighest brightness. It was also heighest during the season. Tea nade fron the crop of 13 to 17 days interval in October nonth resulted in lowest brightness. The tea nade fron the crop which was plucked at 3,5 and 7 days intervals in May, and 5 and 7 days intervals in June were statistically as brighter as the tea of 3 days interval in October . On the other hand, the poorest tea in respect of brightness was obtained when it was prepared fron the harvest of 15 and 17 days intervals in July, 9 to 17 days intervals in August and 9 to 17 days excepting 13 days intervals in September.

During pruned year, the brightness of tea of all intervals excepting 5 days in May was statistically alike. The tea of 5 days interval in this nonth, though, had highest brightness but differed significantly only with the tea of 15 and 17 days intervals. In June, tea obtained fron the pluckings of 3 days interval recorded significantly highest brightness followed by that of 5 and 7 days intervals. The lowest brightness was observed in the tea nade fron the crop of 11 to 17 days interval. In July, tea prepared fron the crops of 3 to 7 days of plucking intervals while not differing with each other and with that of 9, 11 and 13 days, recorded significantly higher brightness than tea of 15 and 17 days intervals. Plucking intervals of 3 to 7 days remaining at par, resulted in tea with highest brightness in August while 17 days interval not differing significantly with 9 days produced tea of lowest brightness. In Septenber, the tea of 11 days interval not differing significantly with that of 3 and 7 days intervals had higher brightness then other intervals. In October,

tea with significantly highest brightness was obtained when manufactured from the harvest of 5 days plucking interval, however, it did not differ significantly with the tea of 3 days plucking interval. Overall comparison of tea made during the season reveals that tea of July plucked at 3 to 13 days intervals and of October plucked at 5 days interval had significantly higher brightness while tea obtained in August from the harvest of 9 days and longer, and in September obtained from 13 days or longer intervals contained lower brightness.

4.1.3.4.Taster's evaluation

Taster's evaluation of made tea in respect of brightness, colour, flavour, total quality, and comparative valuation in different months of plucking during unpruned and pruned years (excepting April in 1990 where tea was not manufactured) has been presented in Table 4.21 to 4.24. The analyses of variance of above observations have been appended in Appendix VIII.

4.1.3.4.1.Brightness

The effect of plucking intervals, months of plucking and their interaction on brightness of made tea in unpruned (1990) and pruned (1991) years as evaluated by tea taster has been given in Table 4.21. The corresponding analyses of variance have been appended in Appendix VIII.

(a) Effect of plucking intervals

Increase in plucking interval from 3 to 17 days resulted in significant decrease in brightness of made tea during both the

Table 4.21 Taster's report on brightness' of raade tea intervals in different months in unpruned

Plucking intervals	Months of plucking				
	May	June	July	August	September
Unpruned year (1990)					
3 Days	4.33	4.00	3.00	2.00	2.50
5 Days	4.00	3.33	2.00	1.00	2.50
7 Days	3.00	1.33	2.00	1.00	1.50
9 Days	2.00	3.50	2.00	2.00	1.00
11 Days	1.67	2.33	1.33	2.00	2.50
13 Days	2.50	2.67	1.00	1.00	1.33
15 Days	1.00	1.33	1.00	1.00	2.00
17 Days	1.67	1.00	1.00	1.33	1.50
Mean	2.52	2.44	1.67	1.42	1.85
Pruned year (1991)					
3 Days	2.50	3.00	3.33	2.67	3.00
5 Days	2.50	2.00	2.00	2.00	2.00
7 Days	3.00	3.00	2.00	2.00	2.00
9 Days	1.00	1.00	1.00	2.00	1.50
11 Days	1.50	1.00	2.00	2.00	1.50
13 Days	2.33	2.00	1.50	2.00	2.00
15 Days	1.67	2.33	3.00	1.00	1.33
17 Days	1.33	2.00	1.00	1.00	2.00
Mean	1.98	2.04	1.98	1.83	1.92

Unpruned year (1990)

	SEm+/-	E..S.D.	CV	SE
Interval	0.08	0.23		0
Month	0.07	0.20		0
I X M	0.20	0.56	15	0

* Ratings : 3=Poor; 2=Fair; 3=Good; 4=Very good; 5=Exc

years. In unpruned year, tea made from shoots plucked at plucking interval of 9 days showed same brightness as that of 7 and 11 days intervals. The made tea of shoots plucked at 13 to 17 days intervals also had similar brightness.

In pruned year, the brightness of tea made from plucking intervals of 5 and 7 days was alike. The tea made from harvest of 13 days interval showed brightness as good as that of 5 days interval, but lower than that of 7 days interval. The brightness of made tea of 15 days interval was statistically similar to that of 11 and 13 days intervals. The lowest brightness was noted in tea from 9 days plucking interval, which, however, did not differ from that of 17 days interval.

(b) Effect of months of plucking

In unpruned year, tea manufactured from October plucked shoots expressed highest brightness followed by that of May, June, September, July and August in the order. The brightness of made tea of May, June, July and September crop was statistically similar. In pruned year also, tea prepared from October secured highest marks for brightness and was followed by the tea made from June, May, July, September and August pluckings in the order. In this year, brightness of tea in case of June, May, July and September as well as May, July, September and August plucked shoots was statistically similar.

(c) Interaction effect

In taster's opinion, tea manufactured from the crop plucked at different intervals in different months varied significantly

in respect of its brightness during both the years of investigation (Table 4.21).

During unpruned year, tea made from the harvest of 3 days interval had highest brightness in all months except October. In May, the brightness of tea obtained from 3 days interval did not differ significantly from 5 days plucking interval. Similarly in September tea made from pluckings of 5 and 15 days intervals had same score for brightness as that of 3 days interval. In October, tea of 5 days interval was rated higher for brightness than 3 days interval. The differences among 3, 7 and 15 days intervals in respect of brightness were non-significant. The tea of 15 days plucking interval in May had significantly lowest rating for brightness followed by the tea of 11, 17 and 9 days intervals. The plucking intervals of 13 to 17 days in July; 5, 7 and 13 to 17 days in August; 9 and 17 days in September; and 13 days in October secured similar and lowest ratings for brightness.

4.1.3.4.2. Colour

In taster's view, the tea made from plucking intervals from 3 to 17 days in different months of plucking from May to October during both unpruned (1990) as well as pruned (1991) years had same colour. A numerical value 2 in 5 point scale was given to all tea samples.

4.1.3.4.3. Flavour

The effects of plucking intervals, months of plucking as well as their interaction on flavour of made tea in unpruned (1990) and pruned (1991) years as judged organoleptically by

Table 4.22 Taster's report on flavour[#] of made tea intervals in different months in unpruned

Plucking intervals	Months of plucking				
	May	June	July	August	September
Unpruned year (1990)					
3 Days	3.00	3.00	2.67	2.00	2.00
5 Days	2.67	1.00	1.50	2.00	2.00
7 Days	2.00	2.00	1.00	1.00	1.00
9 Days	2.33	2.00	1.33	1.00	1.00
11 Days	1.33	1.00	1.00	1.50	1.50
13 Days	1.50	1.33	1.00	1.00	1.00
15 Days	1.00	1.00	1.00	1.00	1.00
17 Days	1.00	1.00	1.00	1.00	1.00
Mean	1.85	1.54	1.31	1.31	1.31
Pruned year (1991)					
3 Days	2.00	2.00	2.00	2.00	2.00
5 Days	2.00	2.00	2.00	2.00	2.00
7 Days	1.00	1.00	1.00	1.00	1.00
9 Days	1.00	1.00	1.00	1.00	1.00
11 Days	1.00	1.00	1.50	1.00	1.00
13 Days	1.33	1.00	1.00	1.00	1.00
15 Days	1.00	1.00	1.00	1.00	1.00
17 Days	1.00	1.00	1.00	1.00	1.00
Mean	1.29	1.25	1.31	1.25	1.25

	Unpruned year (1990)			Pruned year (1991)
	SEm+/-	L.S.D.	CV %	SEm+
Interval	0.06	0.16		0.0
Month	0.05	0.14		0.0
1 X M	0.14	0.40	15.29	0.0

* Ratings 1=Poor; 2=Fair; 3=Good; 4=Very good; 5=Exc

Tasters have been shown in Table 4.22. The corresponding analyses of variance have been put in Appendix VIII. In general, the flavour of made tea was better in unpruned year compared to that of pruned year.

(a) Effect of **plucking intervals**

Variation in plucking interval from 3 to 17 days recorded significant effect on flavour of made tea during both the years. The effect was more pronounced in unpruned year than pruned one. In general, increase in plucking interval resulted in decrease in flavour of made tea. In unpruned year, the flavour of **made** tea due to 15 days plucking interval was significantly higher than 13 days and was at par with 9 days. In pruned year, the effect was not very distinct. Tea made from shoots plucked at 3 and 5 days intervals recorded similar flavour that was better than other intervals. The differences in plucking intervals from 7 to 17 days were non-significant in this respect.

(b) Effect of **months of plucking**

The effect of month of plucking on flavour of made tea was significant during unpruned year (Appendix VIII). During this year, the highest flavour was recorded in tea made from the crop of October month followed by May and June. The flavour in July, August and September plucked tea was similar but lower than other months.

(c) Interaction effect

The interaction between plucking intervals and months of plucking significantly influenced the flavour of made tea during

unpruned year as evaluated by Tasters (Table 4.22). Tea Manufactured from the crop of 3 days plucking interval in all months excepting October received the highest score for flavour. The flavour of tea made from the harvest of 5 days interval in May, August and September was also good and statistically at par with that of 3 days interval in these months. In October, tea prepared from the pluckings of 15 days interval while remaining at par with that of 5 and 7 days intervals exhibited highest flavour on Taster's scale. The lowest score for flavour was secured by the tea made from the crop of 17, 15 and 11 days intervals in May; 11 to 17 days intervals in June; 7 to 17 days intervals in July; 7 to 17 days intervals excepting 11 days in August and September; and 9 to 17 days intervals excepting 15 days in October.

4.1.3.4.4.Total quality

Effect of plucking intervals, months of plucking and their interaction on total quality of made tea on 15 point scale in unpruned (1990) and pruned (1991) years as evaluated by tea Tasters has been presented in Table 4.23. The corresponding analyses of variance have been shown in Appendix VIII.

(a) Effect of plucking intervals

The total quality of made tea declined significantly during both years as a result of increasing plucking interval from 3 to 11 days. The quality due to 15 days interval was better than that of 13 days interval in unpruned year and 9 days interval in pruned year. A close perusal of the data reveal that the differences in quality between 7 and 9 days, and 9 and 11 days in

Table 4.23 Taster's report on overall quality plucking intervals in different months i

Plucking intervals	Months of plucking				
	May	June	July	August	Septem
Unpruned year (199					
3 Days	9.33	9.00	7.67	6.00	6.5
5 Days	8.67	6.33	5.50	5.00	6.5
7 Days	7.00	5.33	5.00	4.00	4.5
9 Days	6.33	7.50	5.33	5.00	4.0
11 Days	5.00	5.33	4.33	5.50	6.0
13 Days	6.00	6.00	4.00	4.00	4.3
15 Days	4.00	4.33	4.00	4.00	5.0
17 Days	4.67	4.00	4.00	4.33	4.5
Mean	6.38	5.98	4.98	4.73	5.17
Pruned year (1991					
3 Days	6.50	7.00	7.33	6.67	7.0
5 Days	6.50	6.00	6.00	6.00	6.0
7 Days	6.00	6.00	5.00	5.00	5.0
9 Days	4.00	4.00	4.00	5.00	4.5
11 Days	4.50	4.00	5.50	5.00	4.5
13 Days	5.67	5.00	4.50	5.00	5.0
15 Days	4.67	5.33	6.00	4.00	4.3
17 Days	4.33	5.00	4.00	4.00	5.0
Mean	5.27	5.29	5.29	5.08	5.17

Dnpruned year (1990)

	<u>SEm+/-</u>	<u>L.S.D.</u>	CV %
Interval	0.10	0.28	
Month	0.09	0.25	
I X M	0.25	0.70	7.34

* Score in 15 point-scale
(Sum total of scores assigned to brightness, colou

unpruned year; 11 and 13 days, and 13 and 15 days plucking intervals in pruned year were not significant.

(b) Effect of **Konths** of plucking

The tea made from the pluckings of October month had better score for quality followed by May, June, September, July and August during unpruned year. The differences of quality of tea made from September and July, as well as July and August pluckings were not significant. In pruned year also, tea made from October plucking was better than that of other months and was followed by June, July, May, September and August pluckings. Tea made from the crop of June, May, July and September had similar quality. The last three months were also at par with August which had the lowest score for quality.

(c) Interaction effect

The total quality of tea (based on Taster's score) obtained from the pluckings of 3 to 17 days interval got significantly different ratings in different months of plucking during both the years of investigation (Table 4.23).

Data on total quality of made tea (Table 4.23) reveal that the tea manufactured from the harvest of 3 days plucking interval in all the months except October, got highest rating but its differences with 5 days interval in May and September were not significant. In October, tea of 5 days plucking interval received highest score for quality followed by 15 days and these two intervals remained at par. The quality of tea made from pluckings of 7 days interval in this month also did not differ signifi-

cantly with that of 15 and 3 days intervals, but tea of 3 days interval got significantly lower rating than that 7 and 5 days intervals. The data further reveal that the tea manufactured from the pluckings of 15 and 17 days interval in May and June; 11 to 17 days in July; 7, 13, 15 and 17 days in August; 9, 13 and 17 days in September, and 13 days intervals in October scored lowest rating for total quality.

During pruned year, the tea prepared from the crops plucked from 3 and 5 days intervals in May; 3 days in June, July, August and September; and 5 days in October scored significantly highest rating for quality. The quality of the crop made from 3 days plucking interval in October remaining significantly lower than that of 5 days interval was better than the tea of all other intervals, excepting 11 days. On the other hand, tea manufactured from the harvest of 9 and 17 days intervals in May and July; 9 and 11 days intervals in June; 9, 11 and 15 days intervals in September and 15 and 17 days intervals in August and October received lowest rating. In overall comparison, the tea of 15 and 17 days interval in October was of poorest quality but recorded significantly better score than the poorest quality teas of other months; while the tea of 3 days interval made in the months from June to September and of 5 days interval in October were rated the best teas from total quality point of view.

4.1.3.4.5.Valuation

The effects of plucking intervals, months of plucking and their interaction on valuation of made tea as evaluated by

Table 4.24 Taster's report on nominal valuation (Rs/ the crop of different intervals in differ and pruned years

Plucking intervals	Month3 of plucking				
	May	June	July	August	Septemb
Unpruned year (199					
3 Days	35.00	35.00	33.33	30.00	30.00
5 Days	33.33	25.00	27.50	30.00	30.00
7 Days	30.00	30.00	25.00	25.00	25.00
9 Days	31.67	30.00	26.67	25.00	25.00
11 Days	28.33	25.00	25.00	27.50	25.00
13 Days	26.67	26.67	25.00	25.00	25.00
15 Days	25.00	25.00	25.00	25.00	25.00
17 Days	25.00	25.00	25.00	25.00	25.00
Mean	29.38	27.71	26.56	26.56	26.25
Pruned year (1991					
3 Days	30.00	30.00	30.00	30.00	30.00
5 Days	30.00	30.00	30.00	30.00	25.00
7 Days	25.00	25.00	25.00	25.00	25.00
9 Days	25.00	25.00	25.00	25.00	25.00
11 Days	25.00	25.00	27.50	25.00	25.00
13 Days	30.00	25.00	25.00	25.00	25.00
15 Days	25.00	25.00	25.00	25.00	25.00
17 Days	25.00	25.00	25.00	25.00	25.00
Mean	26.88	26.25	26.56	26.25	25.63

Dnpruned year (1990)

	SEm+/-	L.S.D.	CV %	S
Interval	0.29	0.82		
Month	0.25	0.71		
I X M	0.72	2.01	4.39	

Tasters during unpruned (1990) and pruned (1991) years have been presented in Table 4.24. The corresponding analyses of variance have been appended in Appendix VIII. In general, the value of made tea was more in unpruned year compared to produce of pruned year

(a) Effect of plucking intervals

In general, the value of tea showed decreasing trend with increase in plucking interval during both years with few exceptions. In unpruned year, made tea obtained from 15 days plucking interval was valued as high as that of 7 days interval. Besides, the difference in valuation of made tea due to plucking intervals of 11 and 13 days was not significant. In pruned year, 13 days interval resulted in better value of tea than 11 days but remained at par with 7 days interval. During this year the valuation of made tea obtained from 9 days plucking interval was as low as that of 15 and 17 days intervals.

(b) Effect of **months** of plucking

During unpruned year, the valuation of made tea was significantly higher in October plucked shoots followed by May and June. Made tea from July and August months of plucking got the lowest valuation. In pruned year, the tea of May and July months remaining at par fetched significantly higher value followed by August and October. The tea made from the pluckings of June, July and August fetched statistically similar valuation. The lowest value was assigned to the tea of September plucking.

(c) Interaction effect

The interaction between plucking intervals and months of

plucking in respect of valuation of Bade tea was significant during both the years. In general, increase in plucking interval in all months of plucking resulted in reduction in valuation of tea (Table 4.24).

During unpruned year, tea made from the pluckings of 3 days interval in May, June and July got significantly highest valuation. In August and September also this interval not differing significantly with 5 days, resulted in significantly higher valuation than remaining intervals. Deviating **from** the general trend, the tea of 15 days interval in October got significantly highest valuation followed by 5, 7 and 3 days intervals. Plucking intervals of 17 days, not differing statistically with shorter intervals upto 13 days in May; 5 days except 7 and 9 days in June; 7 days in July, August and September except 11 days in August; and 9 days except 15 days in October received the lowest valuation during the season.

During pruned year the tea Manufactured from the crop of 3, 5 and 13 days in May; 3 and 5 days in June, July and August; and 3 and 7 days in October got same and significantly higher valuation than remaining intervals. Plucking intervals from 7 to 17 days in May, June, July and August except 13 days in May; and 11 days in July; and 5 to 17 days in September and October except 7 days in October fetched similar and lowest valuation.

4.1.4.Economics

4.1.4.1.Plucking efficiency

The variation in plucking interval significantly affected the plucking efficiency of plucker, expressed in terms of quantity of leaf plucked per hour during both unpruned (1990) and pruned (1991) years. The results have been given in Table 4.25. The corresponding analyses of variance have been presented in Appendix IX.

The data in Table 4.25 clearly show the consistent and significant increase in plucking efficiency with increase in plucking interval from 3 to 17 days during both the years of study. However, the intervals of 11 and 13 days as well as 13,15 and 17 days in unpruned year, and 13 and 17 days in pruned year did not differ significantly with each other in respect of plucking efficiency.

Table 4.25. Plucking efficiency (leaf plucked kg/hr) as influenced by plucking intervals in unpruned and pruned years

Plucking interval	Unpruned year (1990)	Pruned year (1991)
3 Days	0.582	0.852
5 Days	0.963	3.245
7 Days	1.285	1.702
9 Days	1.601	2.066
11 Days	1.910	2.370
13 Days	2.140	2.984
15 Days	2.364	3.021
17 Days	2.372	3.382
Mean	1.652	2.203
SEm+-	0.099	0.097
L.S.D	0.300	0.294
CV %	10.37	7.63

4.1.4.2. Cost of **plucking**

The data in Table 4.26 show the number of plucking rounds, average number of Handdays involved per plucking, total (cumulative) mandays throughout the plucking season and cost of plucking as influenced by different plucking intervals. The pertinent analyses of variance have been shown in Appendix IX.

4.1.4.2.1. **Number of plucking rounds**

The number of plucking rounds decreased with increase in plucking interval during both years. The plucking frequencies varied from 13 to 73 with corresponding intervals of 17 and 3 days, respectively, in unpruned year. The corresponding frequencies in pruned year were 11 and 60, respectively.

4.1.4.2.2. **Number of mandays per plucking**

The average number of Bandays required for plucking per round for one hectare showed an increasing trend with increase in plucking interval during both years of the study. The number of mandays varied from 28.5 to 59.6 with pluckings at 3 to 17 days intervals during unpruned year, and from 15.3 to 38.2 in pruned year, respectively. On an average, mandays employed for plucking in unpruned year were 1.58 times the mandays in pruned year.

4.1.4.2.3. **Total number of mandays per hectare**

Mandays required for one hectare plucking throughout the season were worked out by summing up the mandays requirement of each plucking interval during the season. Data in Table 4.26 show that contrary to average mandays required per plucking, the cumulative mandays used for plucking throughout the season

Table 4.26 Cost of tea plucking as influenced by diff
unpruned and pruned years

Plucking intervals	No. of plucking intervals		Av. mandays/ha per interval		Total per he 1990
	1990	1991	1990	1991	
3 Days	73	60	28.5	15.3	2081.4
5 Days	44	36	33.2	19.3	1461.0
7 Days	32	25	37.1	23.3	1188.1
9 Days	25	20	38.8	25.1	970.9
11 Days	20	17	43.6	26.4	871.7
13 Days	17	14	45.7	29.8	777.1
15 Days	15	12	49.0	35.4	734.3
17 Days	13	11	59.6	38.2	774.2
Mean	29.9	24.4	41.9	26.6	1107.3
SEm+/-			2.1	1.2	41.5
L.S.D			6.3	3.7	125.9
CV %			8.53	7.86	6.49

* @Rs 22/- per manday

decreased with increase in plucking interval. The range of variation in number of nandays requirement was 774.2 to 2081.4 during unpruned year and from 420.0 to 920.8 during pruned year with corresponding decrease in plucking interval **from** 17 to 3 days. The data also reveal that during unpruned year, plucking interval of 9 and 11 days, 11 and 13 days and 13 to 17 days required similar number of nandays. Similarly, in pruned year, plucking intervals of 9 and 11 days and from 11 to 17 days needed same number of nandays for plucking throughout the season.

4.1.4.2.4. Cost of **plucking**

In general, cost of plucking in pruned year was one-half to that of unpruned year.

Increase in plucking interval resulted in significant decrease in cost of plucking during both the years of study. However, the increase was statistically non-significant after 13 days interval in unpruned year, and after 11 days in pruned year. The differences in cost of plucking between 11 and 13 days intervals in unpruned year and 9 to 11 days intervals in pruned year were also not significant.

4.1.4.3. **Gross return**

Table 4.27 embodies the effect of plucking intervals on average price of leaf plucked, gross income per hectare and gross income per rupee invested on plucking during unpruned (1990) and pruned (1991) years. The corresponding analyses of variance have been appended in Appendix IX.

Table 4.27 Effect of plucking intervals on average price of leaf plucked and gross income obtained per rupee invested

Plucking intervals	Av. price of leaf plucked* (Rs./kg)		Gross income (Rs./ha)		Gr ru
	1990	1991	1990	1991	
3 Days	10.02	11.61	97154	72836	
5 Days	8.88	8.90	99707	61598	
7 Days	8.18	7.53	99593	60099	
9 Days	7.83	5.98	96915	49469	
11 Days	6.67	5.10	89099	43441	
13 Days	6.62	3.87	87825	38740	
15 Days	5.74	3.73	79414	38591	
17 Days	5.54	3.56	81423	40406	
Mean	7.44	6.28	91391	50648	
SEm+/-	0.12	0.13	4097	3225	
L.S.D.	0.36	0.40	12427	9784	
CV %	2.77	3.67	7.76	11.03	

* Price as paid by The Palampur Cooperative Tea Factory

4.1.4.3.1. Average price of leaf

Average price of leaf during pruned year (Rs 6.28/kg) was, in general, less than that during unpruned year (Rs 7.44/kg).

Differences in average price of leaf plucked on different intervals were significant during both the years of investigation. The average price of leaf decreased significantly with increase in length of plucking interval during both the years. However, the difference was not significant with increase in the interval from 7 to 9 days, 11 to 13 days, and 15 to 17 days in unpruned year; and from 13 to 17 days in pruned year.

4.1.4.3.2. Gross income per hectare

The gross income per hectare obtained in unpruned year was Rs 91,391 and in pruned year it was Rs 50,648. Thus, the gross income obtained in pruned year was just 55.4 per cent of the unpruned year. The variation in the gross income with variation in plucking interval from 3 to 17 days ranged between Rs 74,414 to Rs 99,707 in unpruned and Rs 38,591 to Rs 72,836 in pruned year.

During unpruned year, gross income, in general, increased with increase in plucking interval from 3 to 5 days but further increase in plucking interval from 5 to 17 days continuously lowered the income upto 15 days while improved slightly at 17 days interval. Plucking interval of 5 days resulted in highest gross income but did not differ significantly with intervals of 3,7,11 and 13 days in this respect. The lowest gross income was obtained with plucking interval of 15 days which, however, was

statistically at par with 11,13 and 17 days intervals. Overall, plucking intervals of 3 to 9 days brought significantly higher income than that of 15 and 17 days intervals.

During pruned year, there was continuous and significant decrease in gross income with increase in plucking interval from 3 to 15 days but further increase in plucking interval to 17 days brought slight but non-significant improvement in the gross income. The gross income was significantly highest when plucking interval was 3 days. The intervals of 5 and 7 days resulted in similar gross income which was significantly higher than that of 9 days or longer intervals. The gross income obtained by following plucking intervals of 9 and 11 days were statistically similar, more than that of 13 and 15 days intervals, but did not differ with the gross income of 17 days interval. The difference in gross income obtained with plucking interval of 15 days was lowest but statistically at par with that of 13 and 17 days intervals.

4.1.4.3.3. Return per rupee invested on plucking

Return obtained per rupee invested on plucking was higher in pruned year (Rs 4.23) than in unpruned year (Rs 4.14). The variation in plucking intervals from 3 to 17 days resulted in wider variation in the return per rupee during unpruned year ranging between Rs 2.12 to Rs 5.14 than that of pruned year where the range was between Rs 3.59 to Rs 4.66.

During unpruned year, there was, in general, increase in return with increase in plucking interval from 3 to 13 days but it decreased thereafter upto 17 days. Though the highest return per rupee (Rs 4.14) was obtained by following plucking interval of 13 days but statistically all intervals between 9 to 17 days had similar return. Significantly lowest return per rupee invested on plucking was recorded due to 3 days interval and was followed by 5 and 7 days intervals. The difference in the return per rupee obtained with 5 and 7 days intervals was also significant.

During pruned year, in general, the return per rupee invested on plucking increased with increase in plucking interval from 3 to 7 days and also from 15 to 17 days but it showed decreasing trend when plucking interval was increased from 7 to 15 days. The highest return per rupee (Rs 4.66) was obtained with plucking interval of 7 days but statistically it was not different to those obtained with all longer intervals. The lowest return per rupee recorded at 3 days interval was also at par with that of 5 days interval. The returns obtained with 5 and 15 days intervals were also statistically similar.

4.2. Experiment. IX j_ Methods oX plucking trial

4.2.1. Growth studies

4.2.1.1. Number of unfolded leaves per shoot

The number of unfolded leaves differed significantly in plots under different methods of plucking in both the years viz. unpruned (1990) and pruned (1991) (Appendix X). The results have been summarised in Table 4.28.

During all months of observation, the number of unfolded leaves were higher in plots where mechanical plucking (shear and machine) was exercised compared with that in hand plucked (standard and black) ones in both the years. Plots where plucking was done by machine, number of unfolded leaves was significantly higher than those under shear plucking in May month in unpruned year, and in May, September and October months in pruned year. Whereas, in June in unpruned year, and in August in pruned year, the plots with shear plucking resulted in higher number of unfolded leaves than those with machine plucking. In the remaining months of both years, the number of unfolded leaves were statistically similar in plots plucked with these mechanical methods. In hand plucking method, plots of black plucking recorded significantly higher number of leaves than standard plucking in the months from June to August in unpruned year, and in July, August and October in pruned year. In other months, the differences were non significant. In black and shear plucked plots, the number of unfolded leaves were statistically at par from May to July in unpruned year and in September and October in

Table 4.28 Average number of unfolded leaves
different methods of plucking i
unpruned and pruned years

Methods of plucking	April	May	June	Mont July
Unpruned yea				
Standard	2.24	2.01	2.00	1.94
Black	2.21	2.09	2.16	2.13
Shear	2.30	2.33	2.34	2.10
Machine	2.39	2.63	2.15	2.18
Mean	2.28	2.26	2.16	2.09
SEm+/-	0.05	0.09	0.05	0.05
L.S.D.	N.S.	0.32	0.18	0.16
C.V. %	4.71	8.25	4.79	4.44
Pruned year				
Standard	-	1.69	1.70	1.89
Black	-	1.71	1.78	2.32
Shear	-	2.12	2.40	2.94
Machine	-	2.24	2.52	2.91
Mean	-	1.94	2.10	2.51
SEm+/-	-	0.03	0.04	0.04
L.S.D.	-	0.00	0.14	0.15
C.V. %	-	3.20	3.72	3.38

pruned year. The number unfolded leaves were also comparable in plots of machine and black plucking in June in unpruned year.

4.2.1.2.Dormancy index

The dormancy index *i.e.* ratio of dormant (*banj'hi*) shoots to active shoots was unaffected by the different methods of plucking during April, June and July in unpruned year (1990) and in all the months of observation in pruned year (1991) (Appendix X). Table 4.29 embodies the effect of method of plucking on dormancy index.

In general, the dormancy index was higher in mechanically plucked bushes during both the years. In unpruned year, machine harvesting resulted in significantly higher dormancy index than standard, black and shear plucking. The differences among the latter methods were not significant in this regard. In August and September months of the unpruned year, the leaf harvested by machine and shear resulted in significantly higher dormancy index than standard and black plucked crop. The dormancy index in both the methods of mechanical harvesting or hand plucking did not differ significantly between them in this respect during these months.

4.2.1.3.Fresh weight of shoot

The fresh weight per shoot differed significantly in plots under different methods of plucking, in all months during both the years of study excepting April and June in unpruned year (Table 4.30, Appendix X). In general, mechanically plucked crop showed higher fresh weight. The weight was significantly highest

Table 4.29 Dormancy index as influenced by d
in different months during unprun

Methods of plucking	April	May	June	Month July
Dnpruned yea				
Standard	0.027	0.081	0.175	0.087
Black	0.036	0.100	0.304	0.114
Shear	0.068	0.103	0.238	0.144
Machine	0.040	0.339	0.137	0.119
Mean	0.043	0.156	0.213	0.116
SEm+/-	0.016	0.042	0.085	0.036
L.S.D.	N.S.	0.121	N.S.	N.S.
C.V. %	104.00	44.81	45.09	58.80
Pruned year				
Standard	-	0.003	0.004	0.023
Black	-	0.002	0.024	0.026
Shear	-	0.006	0.020	0.021
Machine	-	0.006	0.024	0.046
Mean	-	0.004	0.018	0.029
SEm+/-	-	0.000	0.013	0.013
L.S.D.	-	0.000	0.044	0.045
C.V. %		0.000	140.86	89.97

in machine plucked plots in September in unpruned year; but in remaining months, the fresh weight was statistically similar in machine and shear plucking methods. The fresh weight of crop in plots of these mechanical methods was also non-significant with that in black plucking plots in July, August and October in unpruned year. In hand plucking plots, fresh weight of shoot under black plucking, in general, was higher than that in standard plucking in both the years, but the significant difference was found only in August and October in unpruned year and in all months excepting May in pruned year.

4.2.1.4. Dry weight of shoot

Monthwise dry weight of shoot in plots under different methods of plucking has been presented in Table 4.31. The dry weight differed significantly due to methods of plucking in all the months during both the years, excepting in April and June in unpruned year (Appendix X).

In general, the dry weight was higher in mechanically plucked plots compared with hand plucked, in both the years. A comparison of dry weight in plots under shear and machine harvesting reveals that the weight was statistically similar in both the methods in all plucking months of unpruned year, and in May, July and August in pruned year. However, plots under machine plucking recorded higher weight than that in shear plucking in June, September and October in pruned year. The plots under black plucking produced the shoot weight statistically similar to that of shear plucking in May and July in unpruned year, and in Sep-

tember in pruned year. Besides, during unpruned year the dry weight of shoot in plots under black plucking was similar to those of shear and machine plots in August and October. The dry weight of shoot in plots under standard plucking was lowest in all months during both the years but their differences with plot under black plucking in all months excepting October in unpruned year and May in pruned year were not significant.

4.2.1.5-Dry matter content

Crop harvested by different methods had significant variation in its dry matter content in April, July and August during unpruned year (1990); and in May, September and October during pruned year (1991) (Appendix X). The results have been summarised in Table 4.32.

It is evident from the table that in unpruned year, dry matter content during April and August was significantly lower in black plucked crop as compared to that of standard, shear and machine plucked ones. The crop obtained by plucking with latter methods had statistically similar dry matter content in these months.

During pruned year, crop obtained with hand plucking (standard or black system) exhibited significantly higher dry matter content than that of mechanical (shear and machine) methods in May. But the differences in dry matter content in the harvest obtained from standard and black systems as well as in shear and machine methods were not significant in this month. In July, crop obtained from standard and machine plucking contained

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statistically similar dry matter content which was significantly higher than that of shear plucking; while the shoot plucked by black system had content which did not differ significantly with any of the methods. Similar was the trend in September month but in this month the shoot of shear plucking recorded significantly highest dry matter. In October crop, plucked by standard, shear and machine methods had statistically similar dry matter content which was significantly higher than that of black plucking.

4.2.1.6. Number of plucking points

The data embodied in Table 4.33 show the effect of different plucking methods on number of plucking points per 100^A cm as well as per primary in unpruned (1990) and pruned (1991) years.

4.2.1.6.1. Number of plucking points per unit area

The density of plucking points per 100 eir" was higher in unpruned year as compared to that of pruned year. In the latter year, the differences among the different plucking methods were non-significant (Appendix X). In unpruned year, shear and machine plucking remaining at par recorded significantly higher plucking point density than standard or black plucking systems. The black plucking exhibited significantly higher plucking points than standard plucking.

4.2.1.6.2. Number of plucking points per primary

The data in Table 4.33 show that the different methods did not differ significantly regarding number of plucking points per primary in both years of study (Appendix X). However, it is interesting to note that during unpruned year the mechanical

Table 4.33 Effect of methods of p
unit area and per prim
years

Methods of plucking	Plucking points/1	
	Unpruned year (1990)	Prun (1
Standard	65.25	6
Black	80.00	6
Shear	95.75	6
Machine	96.50	6
Mean	84.38	6
SKm+/-	4.52	
L.S.D.	15.65	1
C.V. %	10.72	1

Methods (shear and Machine) resulted in higher density than that of hand pluckings (standard and black) but the trend reversed during pruned year. The average density of plucking points per primary in pruned year was only one-third to that of unpruned year.

4.2.1.7. Bush surface area

The different methods of plucking did not have significant effect on per cent increase in bush surface area during any of the years (Appendix X). However, Table 4.34 shows that the increase in bush surface area was more due to black and machine plucking than standard and shear pluckings during both the years of study.

4.2.1.8. Annual creep

The methods of plucking significantly influenced the annual creep of tea bushes during both years of the study (Appendix X).

Annual creep was more in unpruned year (1990) than that in pruned year (1991) (Table 4.35). In both the years, the creep was significantly higher in mechanically (shear or machine) plucked bushes compared with hand plucked (standard or black) ones. In unpruned year, the creep in shear and machine plucked bushes were statistically alike but in pruned year, shear plucking exhibited higher creep than machine plucking. Regarding hand pluckings, standard plucking system resulted in significantly higher creep in unpruned year than black plucking, but in pruned year, both these methods showed similar creep which was also on par with that of shear harvesting.

Table 4.34 Increase in bush surface area (%) as influenced by different methods of plucking during unpruned and pruned years

Methods of plucking	% Increase in bush surface area *	
	Unpruned year (1990)	Pruned year (1991)
Standard	2.52 (6.53)	3.54 (12.80)
Black	3.14 (10.05)	4.35 (19.44)
Shear	2.21 (5.13)	2.04 (4.78)
Machine	3.12 (10.14)	4.49 (22.04)
Mean	2.75 (7.96)	3.61 (14.64)
SEra + -	0.35	0.63
L.S.D.	N.S.	N.S.
C.V. %	25.35	34.69

* Data subjected to square root transformation
Original values are given parentheses

Table 4.35 Effect of methods of plucking on annual creep of plucking table during unpruned and pruned years

Methods of plucking	Annual creep (cm)	
	Unpruned year (1990)	Pruned year (1991)
Standard	5.05	2.89
Black	3.93	2.67
Shear	3.23	2.88
Machine	3.05	0.83
Mean	3.81	2.32
SEm+/-	0.11	0.11
L.S.D.	0.39	0.38
C.V. %	5.87	9.40

4.2.2. Yield

4.2.2.1. Green leaf yield

The green leaf yield as influenced by different methods of plucking during unpruned (1990) and pruned (1991) years has been shown in Table 4.36 and corresponding analyses of variance in Appendix XI.

In unpruned year, the contribution of early, main and backend flushes towards total season's yield was 39.9, 47.4 and 12.7 per cent, respectively. The corresponding figures in pruned year were 13.5, 64.0 and 22.5 per cent. In pruned year, the green leaf yield was 27.4 per cent less than that in unpruned year. The loss occurred in early flush (30.1 per cent). There was marginal recovery of 3.6 per cent by backend flush. The loss in yield in main flush was negligible (0.9 per cent).

The different methods of plucking affected the green leaf yield significantly in early and backend flushes during both the years, while the total season's yield was influenced only in unpruned year (Appendix XI).

4.2.2.A. Early flush

During both the years, the differences in yield obtained in standard and black plucking systems was not significant in unpruned year, the yield of green leaf plucked with shear was significantly highest while the leaf plucked with machine did not differ significantly with that of shear and black plucking. The differences in yield of machine and shear harvesting during pruned year were not significant but these mechanical methods

Table 4.36 Effect of methods of plucking on gr tea in different flushes and over th and pruned years

Methods of plucking	Early Flush	Main Flush
		Unpruned yea
Standard	3527	4597
Black	3764	4652
Shear	4771	4939
Machine	3797	4650
Mean	3965	4710
SEm+/~	178	149
L.S.D.	616	N.S.
C.V. %	8.98	6.35
		Pruned year
Standard	819	4458
Black	787	4602
Shear	1155	4848
Machine	1122	4574
Mean	971	4620
SEm+/-	76	106
L.S.D.	262	N.S.
C.V. %	15.62	4.58

resulted in significantly higher yield than that obtained in both hand pluckings (standard and black).

4.2.2.B. Main flush

As mentioned, the leaf yield was not influenced significantly due to different methods during both the years of study. However, the crop harvested with shear showed a trend of higher yield than other methods during both the years.

4.2.2.C. Backend flush

During unpruned year, the difference between both hand plucking systems (i.e. standard and black plucking) as well as between both methods of mechanical harvesting (i. e. shear and machine plucking) regarding green leaf yield were not significant, but yield obtained in mechanical methods was significantly higher than that of hand plucking methods. During pruned year also the yield obtained in both systems of hand plucking was statistically similar but in this year leaf yield harvested with machine was significantly higher than that of shear plucking. The differences of both hand plucking systems with shear or machine harvesting regarding green leaf yield were not significant during this year.

4.2.2.D. Total season

The total season's yield in unpruned year was significantly higher due to shear plucking than hand (standard or black) plucking and machine harvesting. The latter methods resulted in statistically similar green leaf yield in this year. Though non significant, green leaf yield due to machine plucking was 9.0 %

higher than hand plucking.

4.2.2.2. Made tea yield

The effect of different methods of plucking on made tea yield in unpruned (1990) and pruned (1991) years have been given in Table 4.37 and corresponding analyses of variance in Appendix XI.

The distribution of yield in early, main and backend flushes during unpruned and pruned year was 40.6, 46.4 and 13.0 per cent, and 12.9, 63.7 and 23.4 per cent, respectively. It can be computed from the table that pruning resulted in 29.7 per cent loss in terms of made tea yield. The loss mainly occurred in early flush (31.5 per cent) but was increased by 1.6 per cent by the end of main flush. However, the gain in made tea yield by 3.4 per cent by the end of backend flush reduced the overall loss to 29.7 per cent.

4.2.3.A. Early flush

The trend and significance of made tea yield obtained in different methods of plucking was exactly similar to that recorded in case of green leaf yield, i.e. during unpruned year, the shear plucking resulted in significantly highest yield and the yield in other methods was statistically similar; and during pruned year, both mechanical methods while not differing statistically, resulted in significantly higher made tea yield than that of both the hand plucking methods which were also at par.

Table 4.37 Effect of methods of plucking on m
and in different flushes and over t
pruned years

Methods of plucking	Early Flush	Main Flush	B
			Unpruned year
Standard	878	1114	
Black	917	1087	
Shear	1192	1185	
Machine	949	1115	
Mean	984	1125	
SEm+/-	44	35	
L.S.D.	152	N.S.	
C.V. %	8.95	6.16	
			Pruned year
Standard	189	1064	
Black	180	1066	
Shear	256	1128	
Machine	253	1080	
Mean	220	1084	
S'Em+/-	22	27	
L.S.D.	59	N.S.	
C.V. %	15.60	5.02	

4.2.3.B. Main flash

Like green leaf yield, the made tea yield also did not differ significantly due to different methods of plucking during both the years (Appendix XI). Following the pattern of green leaf yield, the made tea yield from shear plucking resulted in a marginal increase over other methods during both the years.

4.2.3.C. Backend flush

During unpruned year, the pattern of yield due to different methods and their significance in this flush was also similar to that of green leaf yield, i.e. significantly higher yield due to mechanical methods over hand pluckings. But during pruned year, there was some change in the significance. In this year shear plucking recorded significantly lowest yield, while the yield in other methods was statistically similar.

4.2.3-D. Total season

The significance of made tea yield recorded with different methods of plucking during both years of study was exactly similar to that of green leaf yield. To repeat, the yield obtained during unpruned year due to shear plucking was significantly highest while other methods resulted in similar yield. During unpruned year, higher yields were recorded due to mechanical methods than hand plucking, but statistically non-significant.

4.2.3. Quality

4.2.3.1. Fineness of crop

The fineness of the crop (Table 4.38) was significantly

Table 4.38 Per cent fineness of plucked crop methods of plucking in different m pruned years

Methods of plucking	April	May	June	Month July
Unpruned year				
Standard	77.9	66.0	69.9	65.3
Black	75.5	60.0	68.5	60.9
Shear	38.7	42.4	39.2	45.1
Machine	36.6	35.5	38.1	37.2
Mean	57.2	51.0	53.9	52.1
SEm+/-	0.0	0.0	0.0	0.0
L.S.D.	0.0	0.0	0.0	0.0
C.V. %	7.45	7.94	7.45	5.73
Pruned year				
Standard	-	79.4	74.2	75.0
Black	-	76.6	68.5	60.9
Shear	-	47.5	48.0	44.5
Machine	-	38.2	42.0	39.9
Mean	—	60.4	58.2	55.1
SEm+/-	—	1.7	1.7	1.1
L.S.D.	-	5.8	5.7	4.0
C.V. %		6.00	5.69	4.15

affected due to different methods of plucking in different months during both unpruned (1990) and pruned (1991) years (Appendix XII).

Table 4.38 reveals that during both the years, the hand pluckings (standard and black plucking) resulted in significantly higher fineness of crop than mechanical methods (shear and machine plucking). Although standard plucking produced the tea with higher fineness than black plucking in all the months during both the years, however, it was significant only in July during pruned year. The comparison of shear and machine plucking showed that fineness of crop was higher in the former in all the months during both the years, but was non-significant excepting in July in unpruned, and May and June in pruned year.

4.2.3.2. Polyphenol content

The different methods of plucking had significant effect on the per cent polyphenol content in plucked crop in all the months of observation excepting September in unpruned year (1990) and August in pruned year (1991) (Appendix XII). The results are presented in Table 4.39.

In general, polyphenol content was higher in hand plucked (standard or black) crop than mechanically plucked. However, the polyphenol content in mechanically plucked crop was comparable with that of standard plucked in April, May and June in unpruned year, and with black plucked in October in pruned year. A comparison between standard and black plucking shows that the crop obtained with both the systems of hand plucking represented

similar contents of polyphenol during all the months leaving August in unpruned year and May in pruned year, whereas black plucking resulted in significantly higher polyphenol content. In October month of pruned year, the content was higher in case of standard plucking than black plucking. Regarding mechanical plucking, crop harvested in pruned year either by machine or shear, had similar polyphenol contents. In unpruned year, the polyphenol content was more in machine plucked crop in June and August.

4.2.3.3. Made tea parameters

4.2.3.3.1. Caffeine content

The caffeine content was significantly altered by different methods of plucking in all months of plucking season in pruned year. In unpruned year, the significant effect was observed only in May, July and October (Appendix XIII). The results have been summarised in Table 4.40.

During unpruned year, the caffeine content was significantly higher due to hand pluckings than mechanical pluckings in May and July. The trend was also same in October but in this month the difference between black and machine plucking was not significant. Standard plucking brought significantly higher caffeine content than black plucking in October.

During pruned year, the caffeine content in crop obtained from standard or black plucking in May, August and September was similar. In June and October, standard plucking resulted in higher caffeine content than black plucking while the trend was

Table 4.40 Per cent caffeine content in m
by different methods of plucki
during unpruned and pruned yea

Methods of plucking	Month			
	May	June	July	Augu
Unpruned year				
Standard	2.884	2.681	2.805	2
Black	2.871	2.788	2.763	2
Shear	2.569	2.618	2.318	2
Machine	2.668	2.513	2.410	2
Mean	2.748	2.650	2.574	2
SEm+/-	0.055	0.076	0.050	0
L. S. D.	0.192	N.S.	0.173	
C.V. %	4.03	5.74	3.88	5
Pruned year (
Standard	2.257	2.997	3.161	3
Black	2.389	2.628	3.542	3
Shear	2.272	2.721	2.661	2
Machine	2.087	2.599	2.183	2
Mean	2.251	2.736	2.887	2
SEmi/-	0.048	0.039	0.042	0
L.S.D.	0.165	0.136	0.144	0
C.V. %	3.74	2.88	2.89	2

reverse in July. Regarding mechanical plucking, crop harvested with shear resulted in higher caffeine content than machine harvested crop in all the months excepting June and October. In June, the caffeine content due to both the methods were non-significant, while in October, machine plucking resulted in significantly higher caffeine content than shear plucking. Overall comparison reveals that the caffeine content in crop due to shear plucking was statistically similar with that due to standard or black pluckings in May. In June, the caffeine content in the produce from black plucking was similar to that due to shear or machine plucking. Shear plucking in September resulted in significantly highest caffeine content.

4.2.3.3.2. Theaflavin content

The TF content was significantly affected by different methods of plucking during both the years of study (Appendix XIII). The data have been presented in Table 4.41.

The TF content in made tea was significantly higher due to hand plucking than mechanical harvesting in all the months of observation, excepting June in unpruned year (1990) and May in pruned year (1991).

During unpruned year, the tea made from standard or black plucked crop had similar TF contents in May, June and July where as the tea from black plucked crop exhibited significantly higher TF content in August, September and October than standard plucked crop. Similarly, tea from machine and shear pluckings had statistically similar TF contents in May, June, July and

September. In August and October, the contents were higher due to shear plucking than machine plucking.

In pruned year, tea made from black plucked crop contained significantly higher TF content than that from standard plucked crop in all the months excepting June and July. In June, the trend was reverse, while in July, both the methods remained at par. Shear plucking resulted in significantly higher TF content in made tea than machine plucking in all months excepting June and August when differences were not significant.

4.2.3.3.3. Thearubigin content

The effect of different methods of plucking on TR content of made tea in unpruned and pruned years has been shown in Table 4.42 and the corresponding analyses of variance in Appendix XIII.

In general, TR content was more in tea made from hand plucked (standard or black) crop than mechanically (shear or machine) plucked crop during both the years.

During unpruned year, the effect of different methods of plucking on TR content in June and July months was non-significant. The TR content in May month was significantly higher due to black plucking than standard plucking. From August to October, the differences in TR content of made tea from these two systems of hand plucking (standard and black) were not significant. The tea manufactured from the crop harvested either by shear or machine contained similar TR content in all the months excepting August.

Table 4.42 Per cent thearubigin (TR) contained by different methods of months during unpruned and pruned

Methods of plucking	Month			
	May	June	July	August
Unpruned year				
Standard	10.378	9.793	9.608	9
Black	11.121	9.313	9.121	10
Shear	8.973	8.874	8.861	8
Machine	8.318	10.121	9.381	7
Mean	9.698	9.525	9.243	9
SEm+/-	0.194	0.392	0.242	0
L.S.D.	0.671	N.S.	N.S.	0
C.V. %	4.000	8.230	5.230	6
Pruned year				
Standard	6.100	7.413	7.004	
Black	6.786	6.393	6.389	
Shear	5.323	6.998	6.559	
Machine	5.113	5.643	5.680	6
Mean	5.831	6.612	6.408	6
SEm+/-	0.099	0.141	0.168	0
L.S.D.	0.344	0.490	0.580	0
C.V. %	3.41	4.28	5.23	

In pruned year, differences in TR content of Bade tea from the crop plucked by standard and black plucking methods were significant from May to July. In May, black plucking resulted in significantly higher TR content than standard plucking but the trend was reverse in June and July. Shear harvesting resulted in significantly higher TR content in June, July and September and; the reverse trend was in October where as in May and August the differences between shear and machine pluckings were not significant.

4.2.3.3.4.Total colour

The effect of different methods of plucking on total colour of made tea was significant in all months of observation during both the years of study (Appendix XIII). The results have been summarised in Table 4.43.

A perusal of the data in Table 4.43 reveals that in unpruned year, the tea made from crop plucked by standard method was significantly rich in colour as compared to the tea obtained by other methods of plucking which did not differ significantly among them in May. In June, July, September and October, the total colour of tea made from standard and black plucked crops were statistically similar and significantly higher than shear or machine plucked crops. In August, black plucking resulted in better total colour of tea than standard plucking. In June and September, crop plucked by shear and machine had statistically similar total colour of made tea. However, in July and August, the total colour of made tea was significantly richer in case of

Table 4.43 Total colour of made tea as infl methods of plucking in diffe unpruned and pruned years

Methods of plucking	Month			
	May	June	July	Augus
Unpruned year (1)				
Standard	2.978	2.810	2.315	2.15
Black	2.679	2.875	2.473	2.50
Shear	2.478	2.215	1.718	2.00
Machine	2.510	2.378	1.915	1.57
Mean	2.661	2.570	2.105	2.05
SEm+/-	0.057	0.086	0.051	0.06
L.S.D.	0.198	0.299	0.175	0.21
C.V. %	4.31	6.73	4.81	5.9
Pruned year (19)				
Standard	1.331	2.013	1.656	1.64
Black	1.513	1.606	1.438	1.60
Shear	1.213	1.388	1.494	1.45
Machine	0.944	1.275	1.294	1.47
Mean	1.250	1.570	1.470	1.54
SEm+/-	0.023	0.032	0.036	0.04
L.S.D.	0.079	0.109	0.125	0.13
C.V. %	3.63	4.02	4.92	5.2

shear plucking where as reverse was the trend in October.

During pruned year, black plucking produced the tea with best total colour in made tea than other methods, in May, September and October where as in June and July, standard plucking resulted in best total colour of made tea. A comparison of tea made from the crop obtained by shear and machine plucking reveals that in May, June, July, and September, the total colour of tea were significantly higher in case of shear plucking but in October, machine plucking had significantly better total colour. In August, the difference between standard and black plucking or between shear and machine plucking was not significant with regard to total colour of made tea.

4.2.3.3.5. Brightness

The effect of methods of plucking on per cent brightness of made tea during both the years of observation has been given in Table 4.44 and corresponding analyses of variance in Appendix XIII.

During unpruned year, the brightness of tea made from standard or black plucked crop was similar but significantly better than that of shear or machine plucked crops in May, June and July. The effect of plucking methods on brightness of made tea was not significant in August. In September and October, tea made from black plucked crop exhibited better brightness than the tea obtained from standard plucked crop. The standard plucking was at par with shear and machine pluckings in September in this regard. Crop obtained by shear and machine pluckings in May, June, and September resulted in statistically similar brightness

Table 4.44 Brightness (%) of made tea as
 erent methods of plucking; in di
 and pruned years

Methods of plucking	Month			
	May	June	July	Augu
‡Unpruned year				
Standard	19.071	17.015	12.978	8.5
Black	18.371	17.151	12.778	7.2
Shear	15.215	13.817	5.439	4.6
Machine	14.384	13.121	8.312	8.3
Mean	16.760	15.276	9.877	7.1
SEm+/-	0.613	0.552	0.340	1.1
L.S.D.	2.120	1.909	1.177	N.S
C.V. %	7.31	7.22	6.88	7
Pruned year (
Standard	8.881	6.542	6.422	5.4
Black	9.120	6.693	6.895	6.4
Shear	8.739	6.921	4.244	5.8
Machine	7.435	5.887	4.288	4.2
Mean	8.544	6.511	5.462	5.4
SEm+/-	0.436	0.398	0.256	0.1
L.S.D.	N.S.	N.S.	0.885	0.5
C.V. %	10.21	12.21	9.37	5.4

of made tea but in July, the brightness was statistically better in case of machine plucking than shear while the trend reversed in October.

In pruned year, the effect of methods of plucking was non-significant in May and June. In July and October, brightness of made tea due to standard or black plucking as well as due to shear and machine harvesting was statistically similar but it was significantly better in tea of hand plucked crop than mechanically plucked. In September, significantly highest brightness was recorded in tea made from crop harvested by standard method followed by black, shear, and machine in descending order and the differences among all the methods were significant. In May, the brightness of tea obtained from shear and machine plucking was similar, but in September, shear harvested crop had significantly more brightness than machine whereas in October, machine plucked crop had significantly better than shear plucked crop.

4.2.3.4. Taster's evaluation

Taster's views on brightness, colour, flavour (based on ratings on 5-point scale), total quality (based on ratings on 15-point scale as sum total of ratings on above three parameters) and valuation of orthodox black tea manufactured from the crop harvested manually (standard or black) and mechanically (shear or machine) have been presented in Tables 4.45 to 4.49. The pertinent analyses of variance have been given in Appendix XIV.

Table 4.45 Taster's report on brightness
 enced by different methods of
 months in unpruned and pruned

Methods of plucking	Month			
	May	June	July	Au
Unpruned year				
Standard	4.00	3.00	2.50	1
Black	3.00	3.00	2.00	1
Shear	2.00	1.50	2.00	1
Machine	2.00	1.63	1.75	1
Mean	2.75	2.28	2.06	1
SEiuV-	0.20	0.12	0.16	0
L.S.D.	0.71	0.41	N.S.	N
C.V. %	14.85	10.49	15.65	28
Pruned year (
Standard	2.00	1.00	2.00	1
Black	2.00	1.00	2.50	1
Shear	1.50	1.00	1.75	1
Machine	1.25	1.00	1.50	1
Mean	1.75	1.00	1.94	1
SEm+/-	0.25	0.00	0.16	0
L.S.D.	N.S.	N.S.	0.56	N
C.V. %	28.57	0.00	16.66	32

* fetings • InPoor; 2=Pair; 3=<Joodi 4=Very

4.2.3.4.1. Brightness

The data on brightness (Table 4.46) reveal that during unpruned year, the brightness of tea in May was highest due to standard plucking followed by black, shear and machine pluckings. In June, tea made from hand plucked crop was significantly brighter than that of mechanically plucked tea. In July, August, September and October months, all methods resulted in statistically similar brightness of made tea.

In pruned year, excepting July, the variation in brightness of made tea due to different methods of plucking was not significant. In July, tea made from the crop of black plucking while not differing statistically with the tea of standard plucked crop, recorded significantly higher rating for brightness than that of shear and machine plucked crops. The ratings assigned to the tea of crop plucked by standard, shear and machine methods were also similar.

4.2.3.4.2. Colour

According to taster's opinion (Table 4.46), the colour of made tea was not influenced by any of the methods of plucking in any of the months in unpruned year, while in pruned year, the colour of made tea manufactured from the harvest of hand plucking (standard or black) was better than that of mechanical harvesting (shear or machine), during all the months of the crop season.

4.2.3.4.3. Flavour

Taster's report on flavour of made tea (Table 4.47) shows that during unpruned year, made tea from crop obtained by

Table 4.46 Taster's report on colour of ma
by different methods of plucking
in unpruned and pruned years

Methods of plucking	Month			
	May	June	July	August
Unpruned year (1)				
Standard	2.00	2.00	2.00	2.0
Black	2.00	2.00	2.00	2.0
Shear	1.75	1.50	1.50	2.0
Machine	1.75	1.50	1.50	2.0
Mean	1.88	1.75	1.75	2.0
SEm+/-	0.20	0.20	0.20	0.0
L.S.D.	N.S.	N.S.	N.S.	N.S
C.V. %	21.77	23.33	23.33	0.0
Pruned year (19)				
Standard	2.00	2.00	2.00	2.0
Black	2.00	2.00	2.00	2.0
Shear	1.00	1.00	1.00	1.0
Machine	1.00	1.00	1.00	1.0
Mean	1.50	1.50	1.50	1.5
SEm+/-	0.00	0.00	0.00	0.0
L.S.D.	0.00	0.00	0.00	0.0
C.V. %	0.00	0.00	0.00	0.0

* Ratings : 1=Poor; 2=Fair; 3=Good; 4:-**Very** g

Table 4.47 Taster's report on flavour* of m
 enced by different methods of pl
 months in unpruned and pruned ye

Methods of plucking	Month			
	May	June	July	August
Unpruned year (1)				
Standard	3.00	2.00	2.00	2.0
Black	2.00	2.00	1.00	1.2
Shear	1.25	1.00	1.00	1.0
Machine	1.25	1.00	1.25	1.2
Mean	1.88	1.50	1.31	1.3
SEm+/-	0.14	0.00	0.13	0.1
L.S.D.	0.50	0.00	0.43	0.5
C.V. %	15.40	0.00	19.05	20.9
Pruned year (19)				
Standard	1.00	1.50	1.50	1.5
Black	1.00	1.25	1.50	1.2
Shear	1.00	1.00	1.00	1.0
Machine	1.00	1.00	1.00	1.5
Mean	1.00	1.19	1.25	1.3
SEm+/-	0.00	0.24	0.14	0.2
L.S.D.	N.S.	N.S.	N.S.	N.S
C.V. %	0.00	40.31	23.09	42.5

* Ratings : 1=Poor; 2=Fair; 3=Good; 4=Very g

standard plucking had significantly higher flavour than other methods in May, July and October. In June, flavour of made tea due to standard or black plucking was similar but significantly higher than shear or machine plucking. In September, the effect of methods of plucking was not significant in this respect. In October, flavour in tea made from the crop of standard plucking and machine harvesting was at par and significantly higher than black and shear plucking which too were non-significant between them. Table 4.47 shows that in all months, plucking by shear and machine did not affect the flavour of tea significantly.

Taster's report on flavour of tea manufactured from the harvest of different methods of plucking from May to October during pruned year, did not show significant variation (Appendix XIV).

4.2.3.4.4.Total quality

The score given by Tasters for total quality on 15-point scale was significantly influenced due to the different methods of plucking during both the years of study (Appendix XIV). The results have been presented in Table 4.48.

In unpruned year, the crop from standard plucking scored significantly higher in respect of total quality in all the months followed by black plucking, the difference between these two methods remained non-significant in June, August and September. In October, the quality of made tea due to mechanical plucking was as high as that due to standard plucking, where as, black plucking got least score for total quality. The quality of

Table 4.48 Taster's report on total quality influenced by different methods in different months in unpruned and pruned

Methods of plucking	Month			
	May	June	July	August
Unpruned year				
Standard	9.00	7.00	6.50	5
Black	7.00	7.00	5.00	4
Shear	5.00	4.00	4.50	4
Machine	5.00	4.13	4.50	4
Mean	6.50	5.53	5.13	4
SEm+/-	0.31	0.16	0.31	0
L.S.D.	1.06	0.54	1.06	0
Pruned year (1				
Standard	5.00	4.50	5.50	5
Black	5.00	4.25	6.00	4
Shear	3.50	3.00	3.75	3
Machine	3.50	3.00	3.50	3
Mean	4.25	3.69	4.69	4
SEm+/-	0.25	0.24	0.26	0
L.S.D.	0.87	0.83	0.90	1
C.V. %	11.76	12.98	11.10	18

* Score in 15 point-scale
(Sum total of scores assigned to brightness)

made tea due to both the mechanical methods (shear and machine) was statistically similar in all the months of unpruned year. These methods were also at par with black plucking in this regard in July and August.

In pruned year, the two methods of hand plucking remained at par in respect of total quality in all the months but resulted in significantly higher score for total quality than both methods of mechanical plucking which, too, were at par. In August, the difference in score due to black and machine plucking was not significant.

2.3.4.5.Valuation

The valuation of tea samples manufactured from the harvest of different methods of plucking in unpruned (1990) and pruned (1991) years have been shown in Table 4.49 and corresponding analyses of variance in Appendix XIV.

The presented in Table 4.49 reveal that during unpruned year, tea of standard plucked crop got highest valuation in May, July, August and October. The value of tea from black plucked crop was statistically similar with that of standard plucked tea in June and September. In October, tea manufactured from machine plucked crop resulted in getting the value as high as that of standard plucking. There was no significant difference in valuation between shear and machine plucked tea in any of the months of observation. The two mechanical methods resulted in valuation of made tea similar to that of black plucking from July to October but in May only shear plucking was at par with black

plucking.

The differences in valuation due to different methods of plucking during pruned year in all months of the season were not significant (Appendix XIV).

4.2.4.Economics

4.2.4.1.Plucking efficiency

Data pertaining to plucking efficiency have been presented in Table 4.50 and corresponding analyses of variance given in Appendix XV.

The data reveal that the efficiency of plucking (expressed in terms of quantity of leaf harvested per hour) was significantly highest due to machine plucking followed by shear plucking which, too, was significantly better than two methods of hand plucking during both the years of study. The efficiency of standard and black plucking was statistically similar during both the years.

Table 4.50 Plucking efficiency (leaf plucked kg/hr) as influenced by different methods of plucking in different in unpruned and pruned years

Methods of Plucking	Unpruned year (1990)	Pruned year (1991)
Standard	1.257	1.378
Black	1.058	1.468
Shear	2.661	3.084
Machine	10.487	8.339
Mean	3.866	3.567
SEm+/-	0.133	0.121
L.S.D.	0.461	0.420
C.V. %	6.891	6.805

Compared with mean of both the hand plucking methods (standard and black), shear plucking was 2.30 times more efficient while machine harvesting was 9.06 times more efficient in unpruned year. In pruned year, the efficiency of shear and machine plucking was 2.17 and 5.86 times of that of the hand plucking. Averaged over two years of study, the efficiency of shear and machine plucking worked out to be 2.23 and 7.46 times of that of the hand plucking, respectively.

4.2.4.2. Cost of plucking

Table 4.51 embodies the number of plucking rounds, average number of mandays required for plucking per round, total mandays employed for plucking per hectare and cost of plucking as influenced by different methods of plucking. The corresponding analyses of variance have been presented in Appendix XV.

4.2.4.2.1. Number of plucking rounds

The plucking frequencies were 21 and 34 in case of machine and standard plucking, respectively in unpruned year. The respective frequencies during pruned year were 17 and 36.

4.2.4.2.2. Number of mandays per round

The number of mandays required for plucking by different methods varied to great extent. During both the years of study, significantly lowest mandays were required by machine plucking while black plucking needed significantly highest mandays followed by standard and shear pluckings and both differed significantly in this respect. On an average, in unpruned year

ble 4.51 Cost of tea plucking as influenc
unpruned and pruned years

ethods of ucking	No.of plucking intervals		Av.raandays/interva per hectare	
	1990	1991	1990	1991
andard	34	36	26.95	17.42
ack	28	27	40.20	21.40
ear	23	20	22.17	15.22
chine	21	17	5.40	6.54
an	26.5	25.0	23.68	15.15
m+/-	-	-	0.72	0.49
S. D.	-	-	2.50	1.69
V. %	-	-	6.10	6.44

@Rs.22/- per manday

1.56 times more mandays per plucking were required than in pruned year.

4.2.4.2.3.Total mandays per hectare

The total requirement of mandays throughout the plucking season was significantly lowest with machine plucking in both the years followed by shear plucking which too required significantly lower number of mandays than hand plucking. In pruned year, the standard and black pluckings required statistically similar number of mandays; while in pruned year, the black plucking involved significantly more mandays than that of standard plucking.

4.2.4.2.4.Cost of plucking

During unpruned year, black plucking required significantly highest cost followed by standard plucking. The lowest cost was required when plucking was done with machine and was followed by shear. The differences in the cost of plucking due to all these methods were significant among them. In pruned year also, the cost of plucking in case of mechanical methods was significantly lower than that of hand pluckings. However, in this year, difference between standard and black pluckings as well as between shear and machine plucking was non significant in respect of cost of plucking.

4.2.4.3.Gross return

The data pertaining to the effect of methods of plucking on average price of harvested crop, gross income and gross income obtained per rupee invested on plucking during unpruned (1990)

Table 4.52 Effect of methods of plucking on pr
hectare and gross income per rupee

Methods of plucking	Av.price of plucked leaf* (Rs/kg)		Gross (Rs 1990
	1990	1991	
Standard	8.25	9.46	75433
Black	7.71	8.54	72974
Shear	4.14	4.80	46312
Machine	3.49	4.08	34724
Mean	5.90	6.72	57361
SEm+/-	0.05	0.07	2351
L.S.D.	0.18	0.23	8137
C.V. %	1.78	1.99	8.20

* Price as paid by The Palampur Cooperative Tea

and pruned (1991) years have been presented in Table 4.52. The corresponding analyses of variance have been given in Appendix XV.

4.2.4.3.1. Average price of leaf

Average price of crop harvested with different methods varied significantly. During both the years, it was significantly lower in case of nechanical plucking as compared to hand plucking. The crop of standard plucking received better price than black plucking in both the years. Similarly, crop harvested with shear got higher price than that of nachine during both the years. In general, average price of crops harvested nanually was double than that of nechanically plucked crop.

4.2.4.3.2. Gross income per hectare

Gross income obtained with hand plucking was significantly higher than nechanical plucking during both the years of study. In unpruned year, the gross income due to standard and black pluckings was statistically sinilar but in pruned year, the income was significantly higher in case of standard plucking. During both the years, shear plucking brought significantly higher gross return than nachine plucking. As such, gross income obtained by hand plucking was 1.86 tines of that of the nechanical plucking.

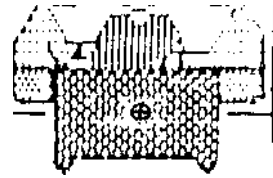
4.2.4.3.3. Return per rupee invested on plucking

Gross income obtained by spending one rupee on plucking varied significantly due to different methods of plucking (Table 4.52).

During unpruned year, machine plucking brought significantly higher income followed by shear, standard and black plucking. The difference between machine and shear, or between shear and standard pluckings was non-significant in this respect. Black plucking resulted in lowest return per rupee invested on plucking in this year.

During pruned year, the highest return per rupee invested was obtained with shear plucking followed by standard, black and machine pluckings. The income obtained per rupee invested in case of shear and standard plucking or standard and black plucking or black and machine plucking were non-significant with each other.

Chapter 5



DISCUSSION

D I S C U S S I O N

The results obtained from the present investigations entitled "Studies on interval and method of plucking on productivity and quality of China hybrid tea (*Camellia sinensis* (L) O.Kuntze)", conducted during 1990 and 1991 in unpruned and pruned tea, respectively have been described in detail in preceding chapter. In this chapter, important findings have been highlighted and an attempt has been made to assign scientific reasoning on the basis of available evidences to establish cause and effect relationship.

5.1.General

5.1.1.Layout of experiments

Tea being a heterozygous crop exhibits considerable variations with respect to growth, yield and quality when plants are seed borne. Thus, the plots of equal number of bushes occupying equal ground area may express variations in growth, flushing pattern, yield and quality. In order to conduct field investigations with such planting material, Tea Experimental Station, Tocklai has recommended formulation of blocks based on the pre-treatment yield of plots for pooling all similar yielding plots in a block (Ann. Sci. Report, TRA, 1971). The procedure reduces the coefficient of variation to minimum possible and, hence, increases the precision of experiment. In the present study Experiment I, was laid out in Randomised Complete Block Design (R.B.D.), on the basis of the same principle. The plots of

low, medium and high pre-treatment yields were grouped in three blocks for replicating the treatments. For the layout of Experiment II, where pre-treatment yield had not been recorded, Latin Square Design (L.S.D.) was considered better because this design makes blocks of the plots in two directions - commonly called "row blocks" and "column blocks". Thus, it ensures the occurrence of each treatment only once in each row and each column block. The procedure makes it possible to estimate variation among row blocks as well as among column blocks and remove them from experimental error. The design is generally recommended when soil fertility gradient is bidirectional (Gomez and Gomez, 1983) and is also used when the fertility gradient is unknown. In Experiment II of the present study also, the yield pattern of different plots was not known. Besides, methods (treatment) under comparison in the experiment were only four, hence Latin Square Design was considered better than other designs commonly followed in agronomic experiments.

5.1.2. Performance of unpruned vs. pruned bushes

The observations recorded on growth of shoot and bush, green leaf and made tea yields, and quality of plucked crop, expressed higher variations during pruned year in comparison to unpruned year.

The bushes, pruned in December 1991, resumed growth with bud break on the pruned sticks in beginning of March, 1992. The shoots were allowed to grow freely and were tipped in first week of May, 1992 at 60 cm above ground level for retaining a layer of

20 cm thick maintenance foliage for sustaining higher yield as suggested by Rahman and Barua (1980). Thus, the observations on growth, yield, and quality were not recorded in April, 1992 during pruned year. The observation for quality of made tea could not be recorded in April during unpruned year also as the manufacturing facilities for orthodox black tea were not available. Irrespective of the treatment imposed, the performance of unpruned and pruned bushes varied to great extent in some respects. The variations observed are being highlighted in the following paras."

The growth of shoot involves the extension of shoot and concurrent leaf growth associated with accumulation of dry matter due to continuous photosynthesis. In the present study, the growth of shoot has been expressed in terms of total number of unfolded leaves on the shoot, fresh and dry weights of shoot and rate at which fresh and dry weight increments (accumulations) occurred in it. The proportion of active to dormant shoots (dormancy index), an important index to indicate growth behaviour of shoot (Wight and Barua, 1955), was also determined. The number of shoots per unit area of tea bush, their growth rate, dormancy index at a time, the frequency and duration of flushing, the size and weight of individual shoot (Herd and Squire, 1976) and surface area of tea bush (Barua, 1969) are the important attributes on which the yield of tea bush depends. Increase in bush surface area and annual creep give an indication of health and potential of tea bush to yield in the subsequent years. Shoot density and weight also indicate the variation in the weekly

yield. According to Tanton (1981), of the total variation in weekly yield, 89% is attributed to the shoot number while 11% to shoot size.

The size of growing shoot, expressed in terms of number of unfolded leaf and its fresh and dry weights was more in pruned year. The fresh and dry weights as well as their rate of increment per shoot were more than double in pruned year as compared to unpruned year. On the other hand, in pruned year the dormancy index was quite low, only 0.064 against 0.32 in unpruned year. Mwakha (1988) also observed the double weight of the similar standard shoot in pruned year over unpruned. The rate of shoot regeneration was also faster in pruned year. The growth of tea shoot is probably influenced by the stimulated effect of pruning as pruning rejuvenates the bush structure. Besides, the higher shoot weight in pruned year may be attributable to lesser number of growing shoots per unit area than in unpruned year (Table 4.9).

The number of plucking points per unit area and per primary recorded at the end of the season were more in unpruned year obviously because of the crow's feet formed in the previous years with continuous plucking. With every round of plucking, there is some creep in the plucking table (Jain and Tamang, 1988). In the present study, the creep was more in unpruned year because of higher number of plucking rounds (29.9) during the year than in pruned year (24.4) (Table 4.26).

In pruned year, green leaf and made tea yields were reduced

due to pruning operation, to the tune of 30.9 and 35.6%, respectively, compared to the unpruned year. Some variation in yield could also be due to seasonal fluctuations in the weather parameters but pruning is known to reduce the yield (Fernando *et al.*, 1969; Grice *et al.*, 1981; Sharma, 1987; and Barbora and Saikia, 1989). Though nade tea is recovered from the green leaf, the present study reveals that there were slight differences in the figures of green leaf and nade tea yield when expressed in percentage. It was due to the difference in dry matter contents in the shoots in both the years. The average dry matter content was more during unpruned year than pruned (Table 4.5). More dry matter content leads to higher nade tea recovery. The lower green leaf and made tea yield during pruned year was due to the loss of most of the early flush (Barbora and Saikia, 1989) which was used to establish a layer of maintenance foliage.

Seasonal distribution of crop is very important in tea as it determines the profitability. The crop of early flush (crop obtained upto mid June) is considered to be more valuable than the crop of rest of the season. In the present study the distribution of crop (green leaf) was found to be highly varying in unpruned and pruned years. It was 39.6, 50.2 and 10.2% in unpruned and 7.6, 70.6 and 21.8% in pruned year during early, main and backend flushes, respectively. So, it is apparent that in comparison to unpruned year, the yield of early flush crop during pruned year was reduced to the extent of 34.4%. In spite of such heavy yield reduction, pruning is essential because in continuous unpruned bushes, the top hamper becomes very

congested; shoot size becomes very small; many shoots fail to regenerate and grow; the growing shoots go *ban j hi* before attaining pluckable size; the branch-system becomes unproductive; and bush starts producing more flowers and seeds than vegetative growth and, thus, results in lower crop yield in the long run. Therefore, in order to remove top congestion and dead, diseased and unproductive branch system and to encourage the vegetative growth, the pruning operation has to be applied periodically (Sarkar, 1988; Barua, 1989).

The tea is cultivated to make commercial beverage. It is, therefore, important that the final product should have, at least, acceptable quality. Different parameters are being used to express the quality of tea. The cooperative tea factories in Himachal Pradesh judge the quality of plucked crop based on its fineness *i.e.* the percentage of fine shoot weight comprising of 1+Bud, 2+Bud, and 1+*banjhi* in the plucked shoots. More fineness is considered to be better quality. Biochemists measure the quality in terms of polyphenol content in tea shoots and concentration of caffeine, TF and TR as well as total colour and brightness in made tea. While, the tea brokers and tasters give much weightage to the physical appearance of tea and consider the "feel" of tea infusion on their tongue. During the present study efforts have been made to express the quality of tea with respect to all the above parameters.

The fineness of crop depends on three factors - (1) the size of harvested shoots, as shoots of size greater than 2+Bud reduce the fineness, (2) the proportion of dormant shoots in the whole

crop as the shoots older than *1+banjhi* are regarded as non - fine shoots, and (3) the loose and broken leaf which, even if succulent , are also graded as non fine component of the crop. Despite higher domancy index (Table 4.2), the fineness was sore during unpruned year than pruned year mainly due to shorter shoot size coupled with lower number of unfolded leaves (Table 4.1).

The caffeine, TR and total colour were also better in unpruned year than pruned year due to better raw material especially during early flush (Table 4.16, 4.18 and 4.19). The taster also rated the tea of unpruned year better than that of pruned year, based on its brightness and flavour and thus assigning higher valuation to the tea of unpruned year.

The yield of green leaf during unpruned year was higher but the mean weight of individual shoot (Table 4.3) was less (about 50%) than that of pruned year. It means that the density of shoots plucked in each round was higher in unpruned year than that in pruned year and it could be the reason for higher mandays requirement per round as well as throughout the season during unpruned year (Table 4.26). The higher mandays requirement increased the cost of plucking in the year.

The results presented in Table 4.25 and described in Section 4.1.4.1 reveal that the plucking efficiency, expressed as quantity of fresh crop (tea shoots) plucked per hour, was more in pruned year than unpruned year. The plucking efficiency depends on the number of shoots plucked in a given time and weight of individual shoot. During pruned year, the higher

weight of individual shoot (about twice that of unpruned) (Table 4.3), and lower density of shoots (recorded at the closure of season, Table 4.9) than that of unpruned year, resulted in higher efficiency. In pruned year, due to higher efficiency and lower yield (Table 4.12), the number of mandays and cost involved in plucking, in a single round and over the season, were less than that in unpruned year (Table 4.26).

Despite the higher dormancy index (Table 4.2) the average price of plucked crop was more in unpruned year than that of pruned year (Table 4.27). The price of crop is based on its fineness (Appendix III) and the latter is dependent on number of unfolded leaves on a shoot. The number of leaves more than two on a shoot reduces the fineness and thus price. In the present study, the average number of unfolded leaves in plucked shoots was less (2.53) in unpruned year than in pruned year (2.93) and hence, the average price was more in case of former.

Gross income is the product of average price of leaf and yield of the crop. Because of higher average price and more yield (Table 4.12), the gross income in unpruned year was more than that of pruned year. The cost of plucking showed pronounced effect of income per rupee invested. During pruned year, the cost of plucking was lower than unpruned year, hence, the income per rupee invested was more in pruned year. The relatively lower mandays requirement and plucking costs helped in increasing the return per rupee investment on plucking.

5.2.Effect *OL* Plucking intervals

5.2.1.Growth studies

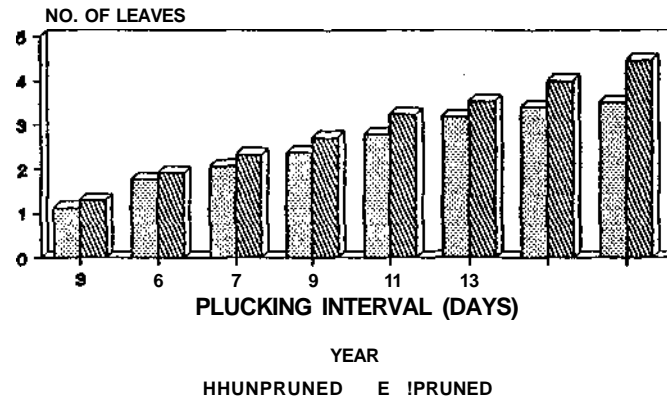
Shoot growth, measured in terms of number of unfolded leaves, fresh and dry weights and rate of fresh and dry weight increment per day in a shoot, was significantly affected by plucking intervals (Fig. 5.1, and Tables 4.1, 4.3, 4.4, 4.6 & 4.7). Besides, the dormancy index and dry matter content of shoots (Table 4.2 & 4.5) were also significantly influenced by the treatments of plucking interval.

The number of unfolded leaves, fresh weight (Fig. 5.J; Table 4.1 & 4.3) and dry weight (Table 4.4) per shoot increased consistently and significantly with increasing plucking interval during unpruned and pruned years. The number of unfolded leaves increased to 3-4 during unpruned and 4-5 during pruned year from young unfolded leaf with increasing plucking interval to 17 days. Fresh and dry weights were increased from 8 to 10 times with increase in plucking interval from 3 to 17 days in both years. Increase in number of leaves and weights per shoot can be attributed to more days available for growth with widening of plucking interval.

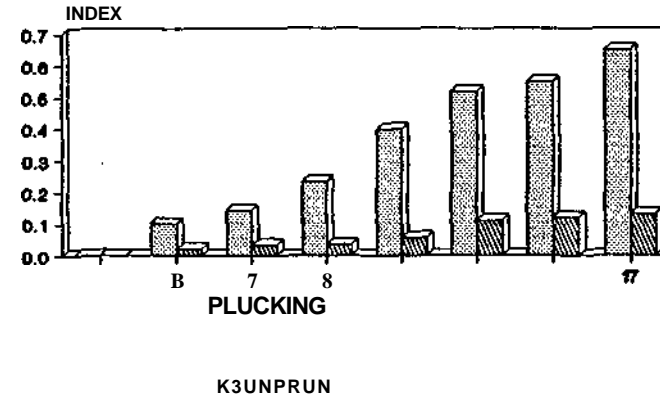
The results on rate of shoot growth increment (Fig.5.1; Table 4.6 and 4.7) indicate that the rate of both fresh and dry weights increment increased consistently and significantly with increase in plucking interval. The photosynthetic capacity of mature leaf is much more than younger one (Sivapalan, 1977). The capacity for photosynthesis develops gradually in young expanding

AS INFLUENCED BY DIFFERENT PLUCKING

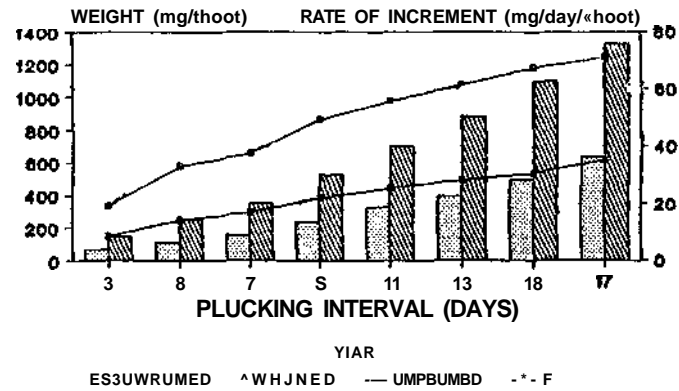
NO. OF UNFOLDED LEAVES



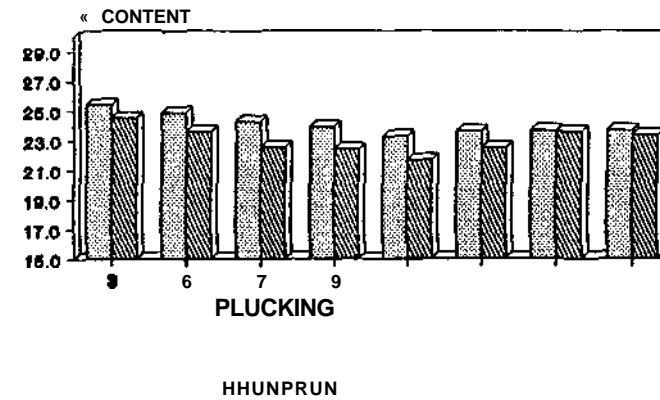
DORMA



FRESH WEIGHT PER SHOOT



DRY MATTER C



G-5.1. EFFECT OF PLUCKING INTERVALS ON GROWTH OF

leaf and it attains full photosynthetic efficiency only after expanding to more than half of its maximum size (Barua, 1953 and 1960). Even third leaf on a growing shoot is photosynthetically less efficient than a mature leaf of same size (Tea Encyclopedia, 1969), this amply explains the reason of increase in shoot weight increment with increase in plucking interval.

Though the number of unfolded leaves per shoot increased, the proportion of dormant shoot (i.e. dormancy index, Table 4.2) also increased significantly with increase in plucking interval particularly during unpruned year. The higher proportion of dormant shoots reduced the fineness of crop. Besides higher proportion of dormant shoots also lowers the value of final product (Barua, 1961). It is clear from Table 4.1 & 4.2 and Fig. 5.1 that if plucking is delayed beyond 7 to 9 days in unpruned year and 5 to 7 days in pruned year, the most of growing shoots exceeded two-leaf stage and a proportion of shoots went *banjhi*. In similar type of studies, Odhiambo (1989) observed that with widening of plucking interval from 6 to 22 days, the proportion of small shoots (particularly 1+Bud) reduced while that of 3+Bud and 4+Bud increased. Nathaniel *et al.* (1986) recorded significant increase in the proportion of dormant shoots with extension of plucking interval.

The recovery of made tea depends on the dry matter content of the crop. In the present study the dry matter content of shoots was significantly affected due to interval of plucking (Table 4.5). The content was highest in the shortest plucking interval i.e. 3 days during both years (Fig.5.1). It decreased

with increase in plucking interval upto 11 days probably due to increase in the proportion of stem which contains higher water content (CSIR Complex Palanpur, unpublished data) but further increase in plucking interval resulted in higher dry matter content due to the development of fibrous tissues. The effect of interval was more pronounced during pruned year, though, the average content was lower than unpruned year. The range of variation in dry matter content was between 23.3 to 25.4% during unpruned year and 21.7 to 24.5% during pruned year due to variation in plucking interval. Thus the variation in dry matter content in the tea shoots affected the made tea recovery.

The density of plucking points expressed per 100 sq. m area and per primary of tea bush was significantly increased with increase in plucking interval during both unpruned and pruned years (Table 4.9). The density increased fastly when shorter plucking intervals of 3 and 5 days were followed. The plucking points reflect the total number of shoots of all generations plucked throughout the cropping season. Due to frequent plucking, the population of subsequent shoot generation also increased which increased total plucking point density. But this variation in plucking point due to variation in plucking interval did not influence the regeneration rate of shoot (Table 4.8).

Plucking acts as a stimulus for the production of subsequent shoots. When a shoot is plucked, it releases the immediately below placed axillary buds on stem leaves from the apical dominance and allows it to grow. The process is repeated in each

plucking.

Barua (1969) has described the bush spread as an important attribute governing yield of tea plant. The present study indicates that the plucking intervals influences the spread of tea bush (Table 4.10). It has been calculated from the data that there was significantly higher increase in bush spread with widening plucking interval from 3 to 7 days. The increase in the spread would be helpful in maintaining the health of tea bush due to increase in the volume of maintenance foliage. The higher coefficient of variation (22.02% in unpruned and 24.88% in pruned year) of the observation was due to the fact that increase in bush spread was not consistent in each plucking interval.

5.2.2.Yield

In tea the yield is cumulative mass of shoots harvested throughout the season from a unit piece of land.

As mentioned earlier, the increase in plucking interval from 3 to 17 days resulted in consistent and significant increase in shoot (Section 5.2.1). It was observed that by extending the plucking interval from 3 to 17 days, the total number of plucking frequencies reduced to one-sixth, but the shoots plucked were about 9 times heavier; thus the product of shoot weight and the total plucking frequencies showed a trend of increase with increase in plucking interval. In the present study, the green leaf and made tea yields also showed the increasing trend with increase in plucking interval from 3 to 17 days during both years (Fig. 5.2; Table 4.12 and 4.13). These findings are supported by

GREEN LEAF YIELD AS INFLUENCED BY DIFFERENT PLUC

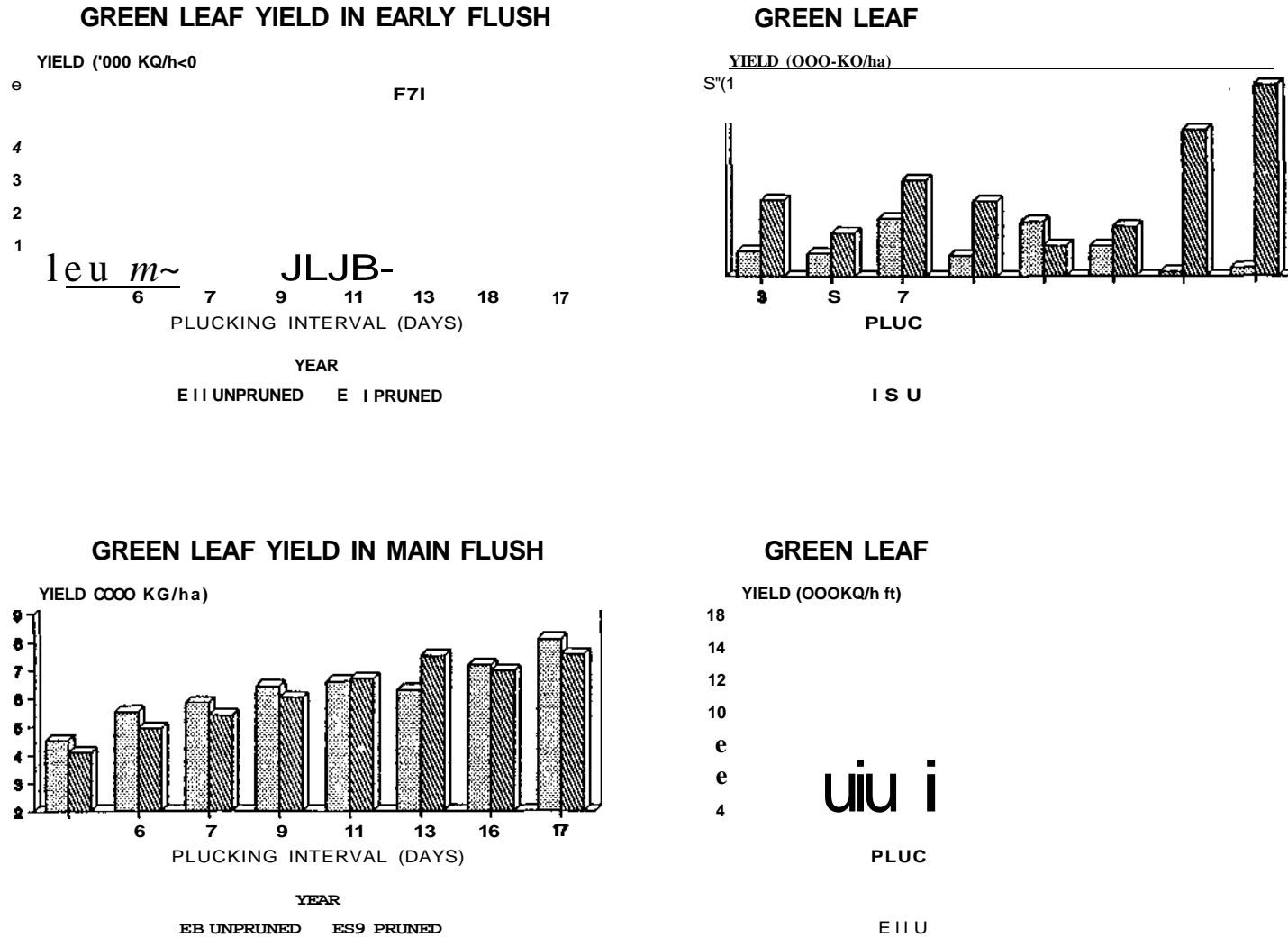


FIG.5.2. EFFECT OF PLUCKING INTERVALS ON GREE

the earlier work of north-east India (Ann. Sci. Report, TRA, 1970-71; and Barbora and Saikia, 1989) and south India (Verghese, 1977; and Ranganathan *et al.*, 1983). Besides, Grice (1984) in Central Africa had also observed similar trend. The higher yield with longer intervals has been ascribed to be due to greater shoot weight owing to extra time for growing (Templer, 1977).

Contradicting these findings, the work done outside India indicates that shorter plucking intervals are more productive (Tubbs, 1938 and 1949; Pethiyagoda, 1967; Palmer-Jones, 1977; Dumur and Naidu, 1985; Nathaniel *et al.* 1986; and Mwakha, 1987). Higher yield in shorter intervals has been reported to be due to the formation of more number of plucking points since plucking acts as a stimulus for further shoot production by temporarily destroying the apical dominance (Portsmouth and Rajiah, 1957). In the present study also the total number of plucking points (recorded at the closure of season) were more due the shorter intervals (Table 4.9) but the proportionate increase in the shoot weight at longer intervals due to extra time for growing was more, resulting in higher yield. Recently, Cloves (1989) reported that increase in plucking interval increased yield upto certain interval but beyond that the yield reduced. The present study reveals that though the green leaf yield increased with increase in plucking interval, the plucking from 5 to 13 days and 11 to 17 days during unpruned year, and from 5 to 11 days and 13 to 17 days during pruned year had statistically similar yield.

The tea of commerce is manufactured from the green leaf. The recovery percentage of made tea from the green leaf depends on

the dry matter content in the leaf (shoots). In spite of decrease in dry matter content with increase in plucking interval from 3 to 11 days, the made tea yield showed a trend of continuous increase upto 17 days interval (Table 4.13), indicating that the decrease in dry matter content was much lower than the increase in green leaf yield with each successive increase in plucking interval from 3 to 17 days. Therefore, the overall trend of made tea yield in all flushes and over the season was similar to that of green leaf yield. It can be computed from the data (Table 4.12 & 4.13) that by extending plucking interval from 3 days to 17 days, the yield (both green leaf and made tea) could be increase upto 50% during unpruned year and 80% during pruned year.

Besides total yield, the seasonal distribution of yield is also important in tea crop. "Early flush" is generally considered quality flush and fetches higher price in the market than other flushes of the season. On the other hand, "main flush" in the major yield flush during the season where 50 to 70 per cent of the crop is harvested. The yield in early and main flushes also showed increasing trend with increase in plucking interval (Fig. 5.2; Table 4.12 & 4.13). Thus, the higher yield can be obtained by following longer intervals in these flushes. The trend of yield in "baekend flush" was not very distinct particularly during unpruned year (Fig. 5.2). The longer plucking intervals of 15 and 17 days in this flush resulted in lower yield than 7 and 11 days probably due to exhaustion of the bushes. But this flush is not considered to be very important as it is of very small duration and contributes only 10-20 per cent of the

total production. Besides yield, the quality aspect has also to be taken into consideration because Verghese (1977) found that crop plucked at longer intervals included a larger proportion of shoots which could not be manufactured into acceptable tea.

5.2.3. Quality

The quality parameters studied were fineness of the plucked crop, polyphenol content in tea shoots, caffeine and other made tea parameters viz. theaflavin (TF), thearubigin (TR), total colour and brightness. Among these the fineness of the crop is directly related with the price of plucked leaf and also the appearance (texture) of made tea where as the polyphenol content is responsible for the development of TF and TR, the made tea parameters, and caffeine for briskness of made tea.

5.2.3.1. Fineness of crop

The fineness of the crop refers to the proportion of the shoots (by weight) consisting of 1+Bud, 2+bud and 1+banjhi to the total harvested crop. Averaged across the months, the fineness of plucked crop decreased continuously and significantly with increase in plucking interval from 3 to 17 days during both the years of study (Fig. 5.2; Table 4.14). The average range of variation in the fineness of crop due to different plucking intervals was between 77.0 to 48.9% during unpruned year and fairly wider between 86.9 to 34.7% during pruned year in 3 and 17 days plucking intervals, respectively. The decrease in fineness with increase in plucking interval might be due to two reasons. Firstly, with increase in plucking interval, the size of plucked

shoot (in terms of number of unfolded leaves, Table 4.1) increased above 2+Bud and the part of shoot below 2+Bud is considered coarse as have also been reported by Sarkar (1988). Secondly, with increase in plucking interval the proportion of *banjhi* shoots increased (Table 4.2) significantly. In a *banjhi* shoot the leaves below first leaf are regarded coarse and hence lower the fineness more sharply. At Tocklai, Barbora and Saikia (1988), in their 7 years study, also observed decrease in fineness of crop with increase in plucking interval in all months from March to November. In the present study, the wider range of decrease in fineness during pruned year might be the result of faster growth as evident from rate of increment in dry matter accumulation (Table 4.7) and number of unfolded leaves per shoot recorded at different intervals (Table 4.1).

5.2.3.2. Polyphenol content

Polyphenol content is the major chemical constituent in tea shoots from where the made tea quality parameters viz. TF, TR, total colour and brightness etc develop. Thus, it can be regarded as a potential quality parameter. The present study reveals that the content of polyphenol differed significantly due to different treatments under study.

Like fineness of the crop, there was significant decrease in polyphenol contents in the tea shoots with increase in plucking interval from 3 to 17 days during both unpruned and pruned years (Fig. 5.3; Table 4.15). Within a shoot, bud contains highest content of polyphenol and it decreases in first, second and subsequent leaves while stem, contains least content (Bhatia,

QUALITY OF TEA AS INFLUENCED BY DIFFERENT PLUCK

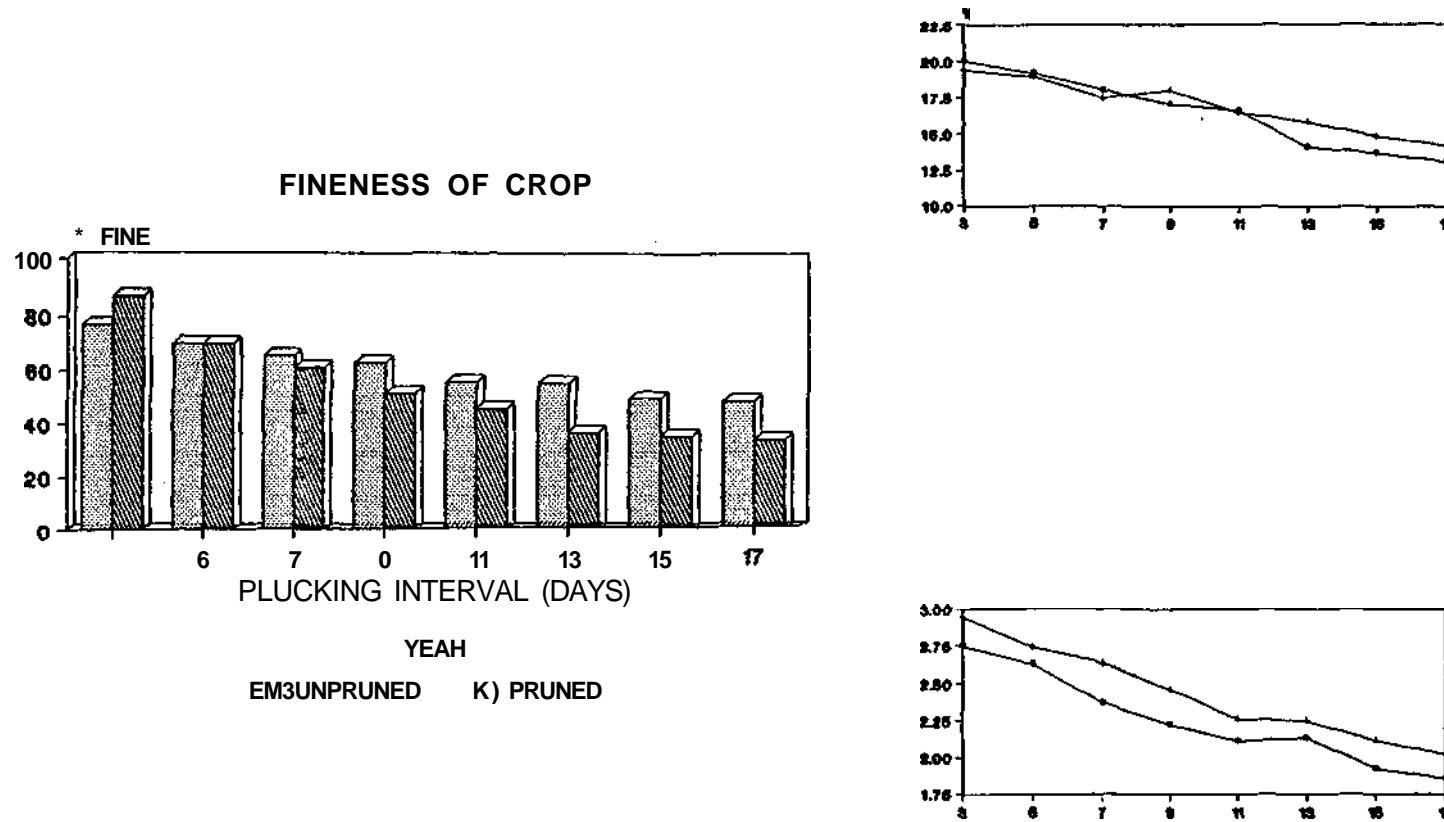


FIG.5.3. EFFECT OF PLUCKING INTERVALS ON Q

1961; Ann. Sci. Report, Tocklai Exptl. Station, 1977-78, and Ullah and Jain 1980). Shoots plucked at longer intervals not only unfolded higher leaves (Fig. 5.1; Table 4.1) but also contained longer stems thus resulted in decrease in polyphenol content.

5.2.3.3. Caffeine content

Caffeine content in tea is responsible for briskness of tea beverage. High levels of caffeine enhance the creaming property of black tea which is considered to be important yardstick to evaluate tea quality (Dev Choudhary, 1980). The present study revealed that the caffeine content is significantly influenced by plucking intervals during both unpruned and pruned years (Table 4.15). Fig. 5.3 depicts the trend of caffeine content as a result of variation in plucking interval.

The main effects of plucking intervals showed that like polyphenol content, caffeine was also highest in the tea crop obtained from 3 days plucking interval and it decreased significantly with increase in plucking interval upto 17 days (Table 4.15). The findings from Tea Exptl. Station Tocklai revealed that like polyphenol content, the caffeine content within a shoot is highest in the bud followed by first, second and third leaf while stem of the shoot contained lowest concentration. In the present study, increase in plucking interval resulted in increased number of unfolded leaves on a shoot (Table 4.1), thus longer stems, resulting in decrease of caffeine content. Owuor and Chavanji (1986) also observed higher caffeine content in the young tender shoots.

5.2.3.4. Made tea parameters

Major changes which take place in tea leaf during manufacturing process are formation of coloured substances - TF and TR from colourless polyphenol (Section 2.9.1). Both of these start forming with the initiation of fermentation during rolling of tea leaf. The TF concentration goes increasing with progress of fermentation till a stage is reached when there is no further fermentation of TF. On prolonging the fermentation period, TF content ultimately shows a significant decline while TR goes on increasing (Roberts, 1958 and 1962; Deb and Ullah, 1968). High levels of TF and adequate levels of TR could be related to high value of tea (Roberts, 1958). The proportion of TF and TR ultimately determine the colour and brightness of made tea.

In the present study the average values of all the made tea parameters viz. TF, TR, total colour and brightness across the months during both years were highest in the tea made from the pluckings of 3 days interval, and there was significant decrease in the parameters with increase in plucking interval upto 17 days (Fig. 5.4; Tables 4.17 to 4.20). This was mainly due to consistent and significant decrease in polyphenol content from where these parameters ultimately develop during manufacturing process.

5.2.3.5. Taster's evaluation

Although different biochemical measures have been developed and used for indicating tea quality, correct valuation of tea in national and international trade is still based on organoleptic

1ADE TEA CHARACTE INFLUENCED BY DIFFERENT PLUC

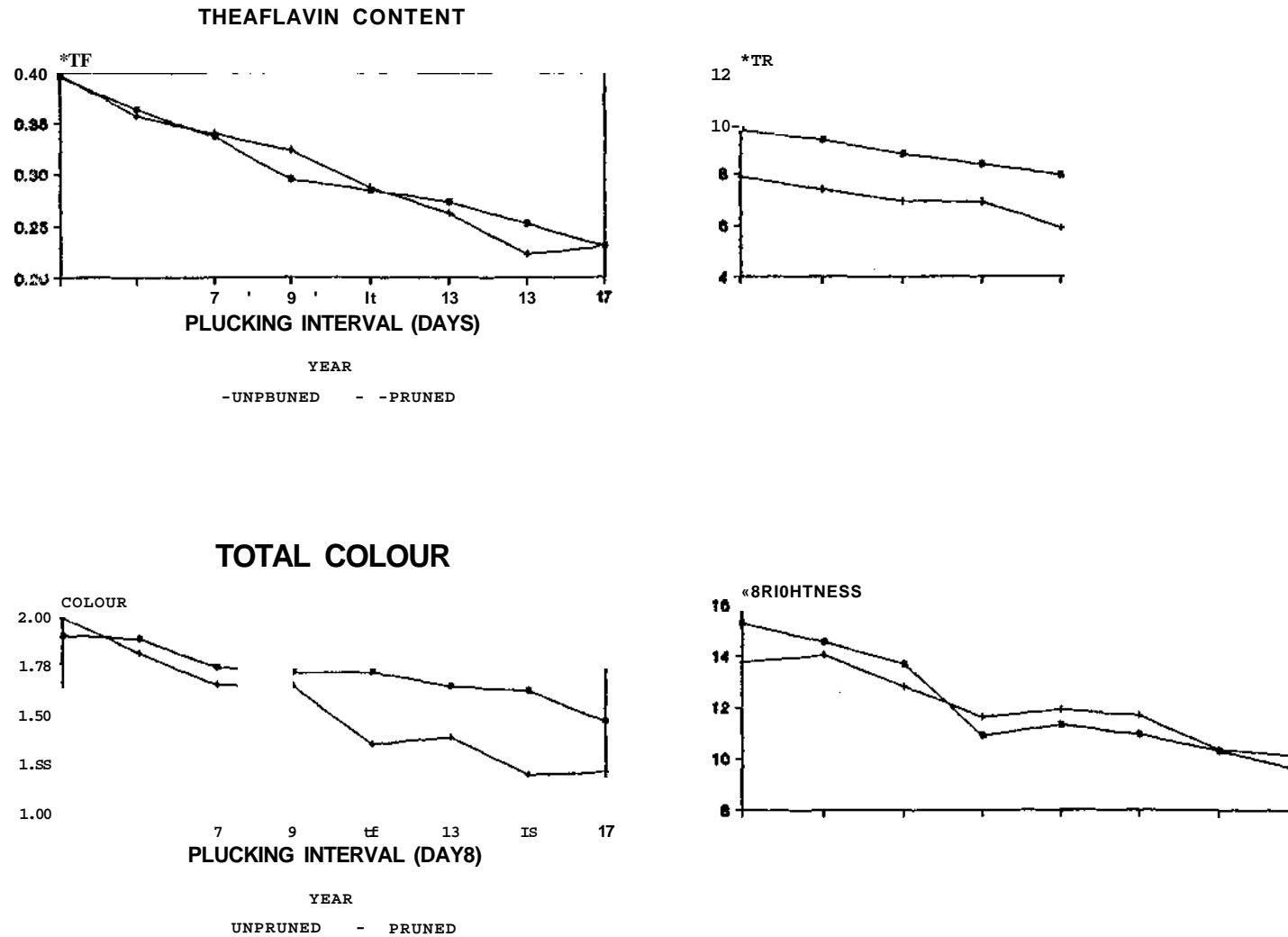


FIG.5A. EFFECT OF PLUCKING INTERVAL

evaluation by experienced tea tasters. In the present studies, the tea made from the harvests of different plucking treatments during both years of study exhibited significant differences (Table 4.21 to 4.24; Fig. 5.5). The tea of all intervals in all months during both year got similar ratings. In biochemical analysis also, very slight differences were recorded in respect of total colour.

In tester's evaluation, brightness, colour, flavour and total quality showed a trend of decrease with increase in plucking interval during both years (Fig. 5.5), supporting the results obtained in biochemical analysis (Fig. 5.4). The decrease in quality in taster's evaluation with increase in plucking intervals has also been reported by Mitni-Nkhoma (1989) and many others.

5.2.4.Economics

Acceptance of any technology depends on its profitability. In tea cultivation, only single operation, the plucking, accounts for 60 to 85% of total cost and (Awasthi and Sarkar, 1983; Mitini-Nkhoma, 1989; Rawlley Beig, 1990) thus, plays an important role in affecting the overall economics of tea cultivation.

The plucking efficiency in terms of quantity of leaf plucked in unit time was lower at shorter intervals and increased with the extension of plucking interval, during both the years of study (Fig. 5.7 ; Table 4.25). The plucking efficiency mainly depends on tenderness or succulency of shoot and weight of individual shoot plucked. In shorter intervals the shoots were

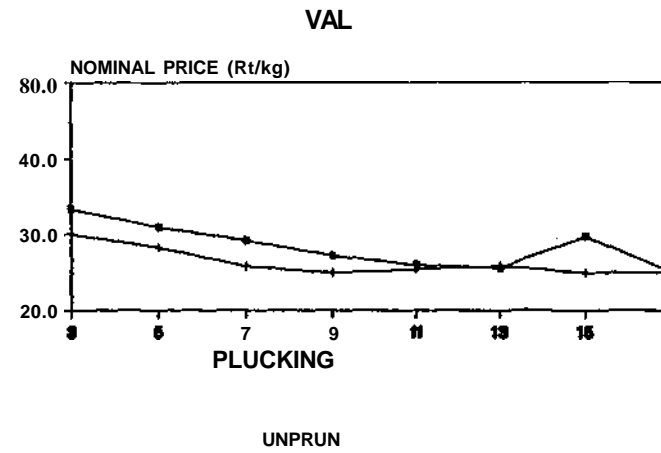
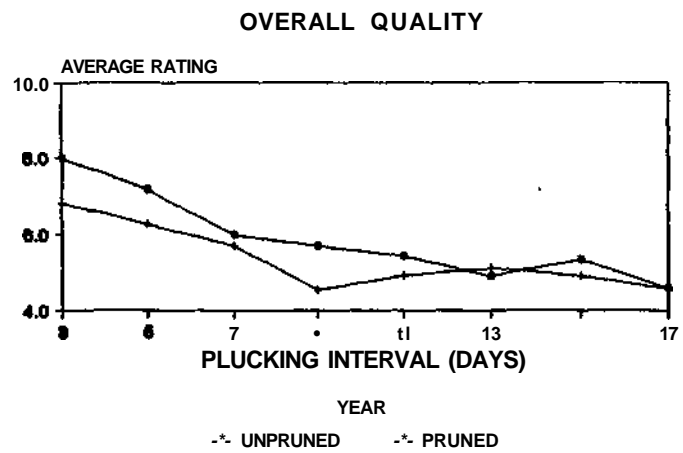
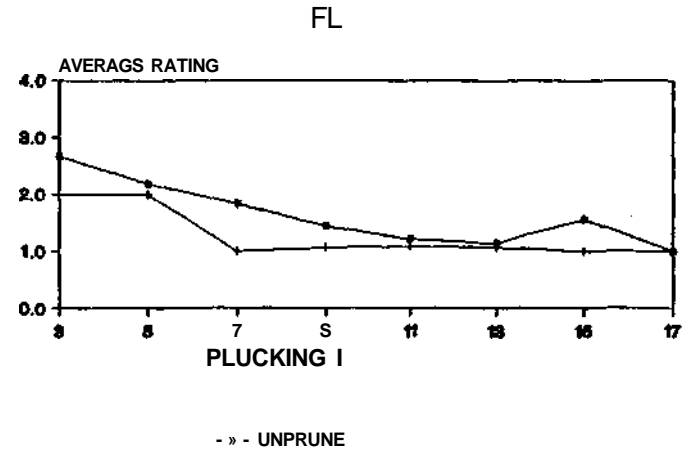
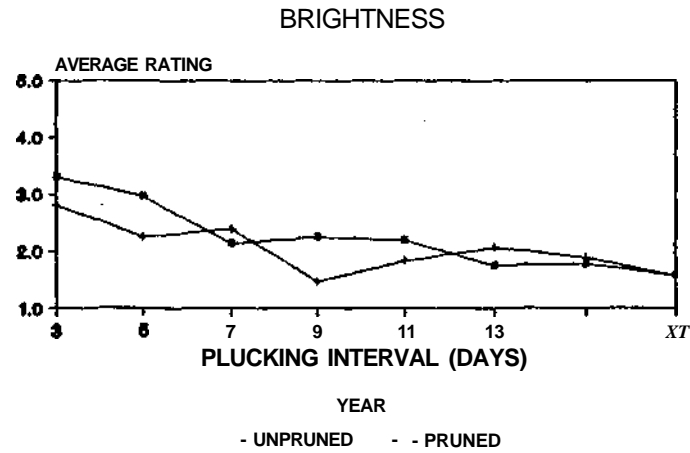


FIG.5.S. EFFECT OF PLUCKING INTERVALS ON TASTERS OF MADE TEA

tender and lighter in weight leading to lower efficiency. With increase in age of shoot from 3 to 17 days, its tenderness reduced and weight increased and consequently the plucking efficiency was enhanced. Overall, the number of shoots plucked at each interval have also influenced the efficiency.

Increase of plucking interval from 3 to 17 days was accompanied by marked decrease in plucking frequencies from 73 to 13 in unpruned and 60 to 11 in pruned years, respectively (Fig. 5.G ; Table 4.26). Increase in plucking frequencies, at shorter intervals, called for more mandays requirement. The requirement was further escalated due to decrease in plucking efficiency at shorter intervals due to the reasons mentioned above. Owing to higher mandays requirement, the cost of plucking also showed consistent and significant increase with decrease in plucking interval. Contrary to this, the average mandays requirement per interval was lower at shorter intervals. This can be attributed to the higher succulency (tenderness) of the shoots at these intervals. In unpruned year, the total mandays required for plucking increased with increase in interval from 15 to 17 days which was contrary to the general trend and might have been due to increased coarseness of the shoots as a result of more fiber content particularly in the months of dormancy.

Average price of harvested crop decreased with increase in plucking interval during both the years (Fig. 5.7 ; Table 4.27). The price of harvested tea is by and large dependent on the fineness of the crop. The fineness decreased with increase in plucking interval from 3 to 17 days during both the years. During

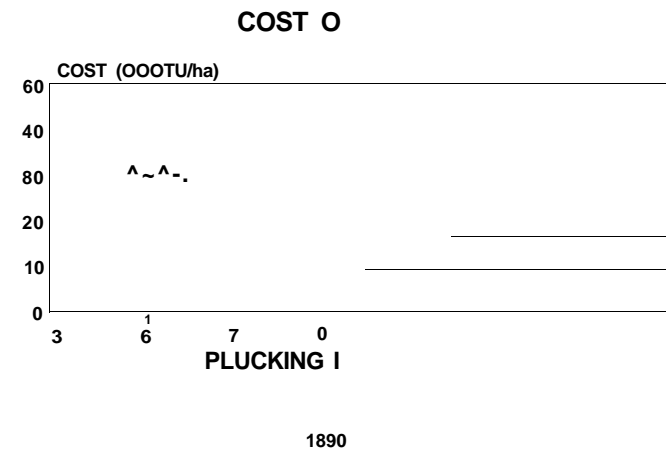
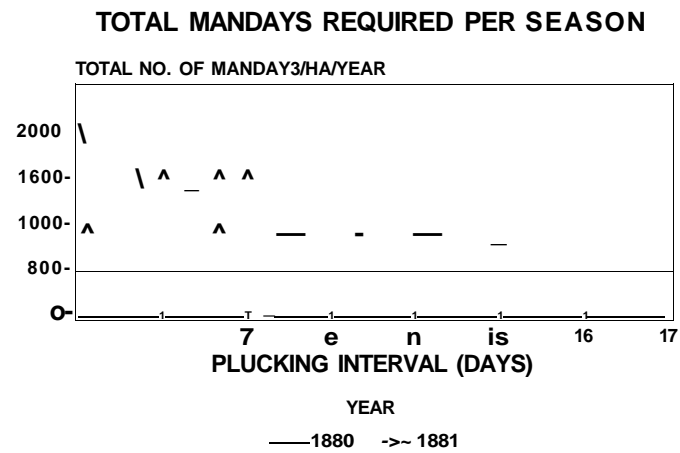
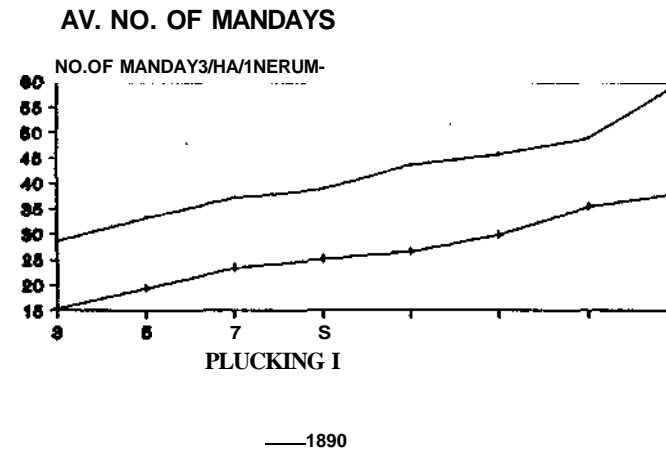
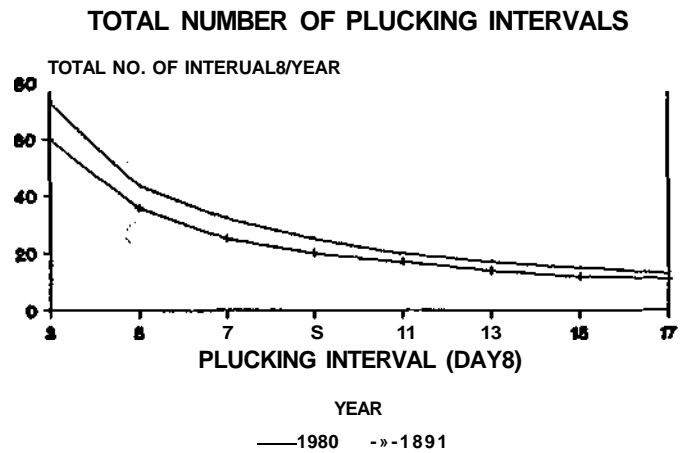


FIG.5.6. EFFECT OF PLUCKING INTERVALS ON COST

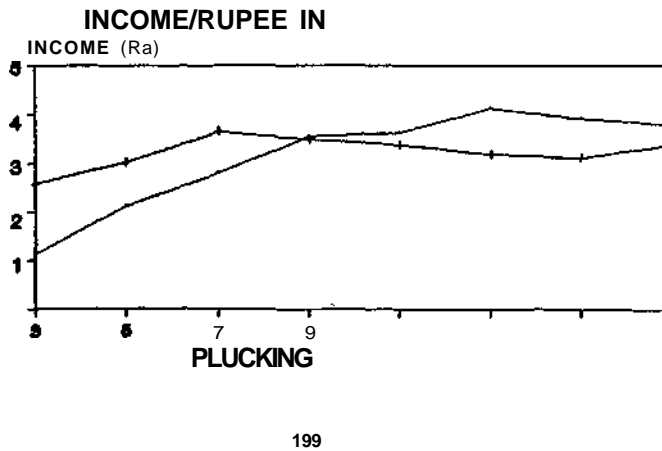
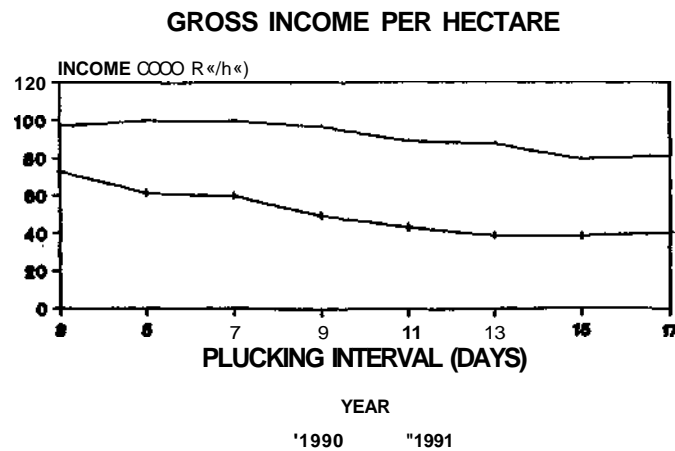
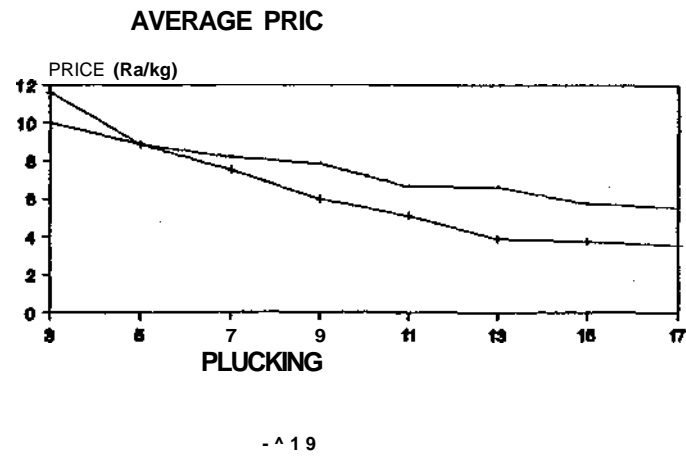
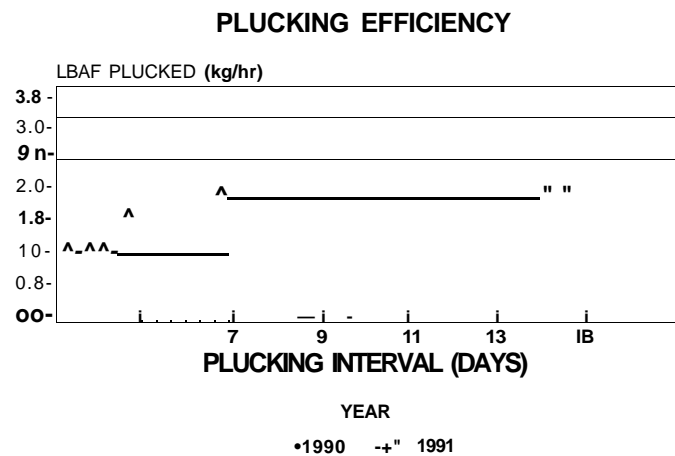


FIG.5.7. EFFECT OF PLUCKING INTERVALS ON ECONOMY OF PLUCKING

unpruned year, in spite of similar shoot size below 2+Bud (Table 4.1), average price of crop plucked at 3 days interval was lower than that of the pruned year, this might be because in unpruned year, the shoot size was smaller (as evidenced by its fresh and dry weights, Table 4.3 and 4.4) and might have had smaller internodes (data not recorded) than that of pruned year; when shoot was plucked, the second leaf got separated from the shoots and this loose leaf was considered 'coarse' as per the procedure of determination of fineness, and hence lowered the fineness and, thus, price. Besides, the range of variation in average price was more in pruned year (Rs 3.56 to Rs 11.61) than that in unpruned year (Rs 5.54 to Rs 10.02). The variation in price range appeared to be associated with the shoot size which varied considerably in pruned year (unfolded leaves ranged between 1.29 to 4.46) as compared to unpruned year.

5.3. Effect of *plucking* of plucking

5.3.1. Growth studies

Variations in the growth and development of tea shoots in different months during the season is well documented and investigations have established significant correlation between weather parameters and rate of shoot growth (Carr, 1972; and Odhiambo, 1986). Besides, other factors being constant, seasonal variations influence the biometric characteristics of the flush shoot (Eden, 1976). The rate of leaf unfolding and growth of shoot have been reported to be influenced by environmental factors (Nakayama and Harada, 1962; Mitsui and Harada, 1962; Green

1,070; flqueira, 1074; *mul Una*, 1004).

In the present investigation the number of unfolded leaves, fresh weight (Fig.5.8; Table 4.1 & 4.3) and dry weight (Table 4.4) per shoot significantly varied in different months of plucking during both unpruned and pruned years. The highest number of unfolded leaves were in April followed by July, August and September during unpruned year while lowest number was recorded in October followed by May and June. Excepting April, the trend of leaf unfolding during pruned year was also similar; (in April the crop was not ready for harvesting). The lower number of unfolded leaves in May and June, during unpruned year indicates the completion of first flush of the crop. The proportion of dormant shoots to active (Fig. 5.8; Table 4.2) in June also confirms the same. During pruned year despite low dormancy index, the number of unfolded leaves was low in May and June than July, August and September. This might be due to the fact that in pruned bushes the regenerated shoots were comparatively bigger in size (having weight more than twice the shoot of unpruned year of same standard, owing to less shoot density, Fig. 5.8; Table 4.3) with longer internodes. Hence, the extension rate of shoots reduced during pruned year due to bigger shoot size. During both the years, the growth conditions were congenial for the rate of leaf unfolding in July, August and September, being rainy months (Figs. 3.1 & 3.2). Decline in number of unfolded leaves after September indicates the completion of main flush. The dormancy index increased after August during both the years of study, showing inverse

GROWTH OF TEA SH AS INFLUENCED BY DIFFERENT MONTH

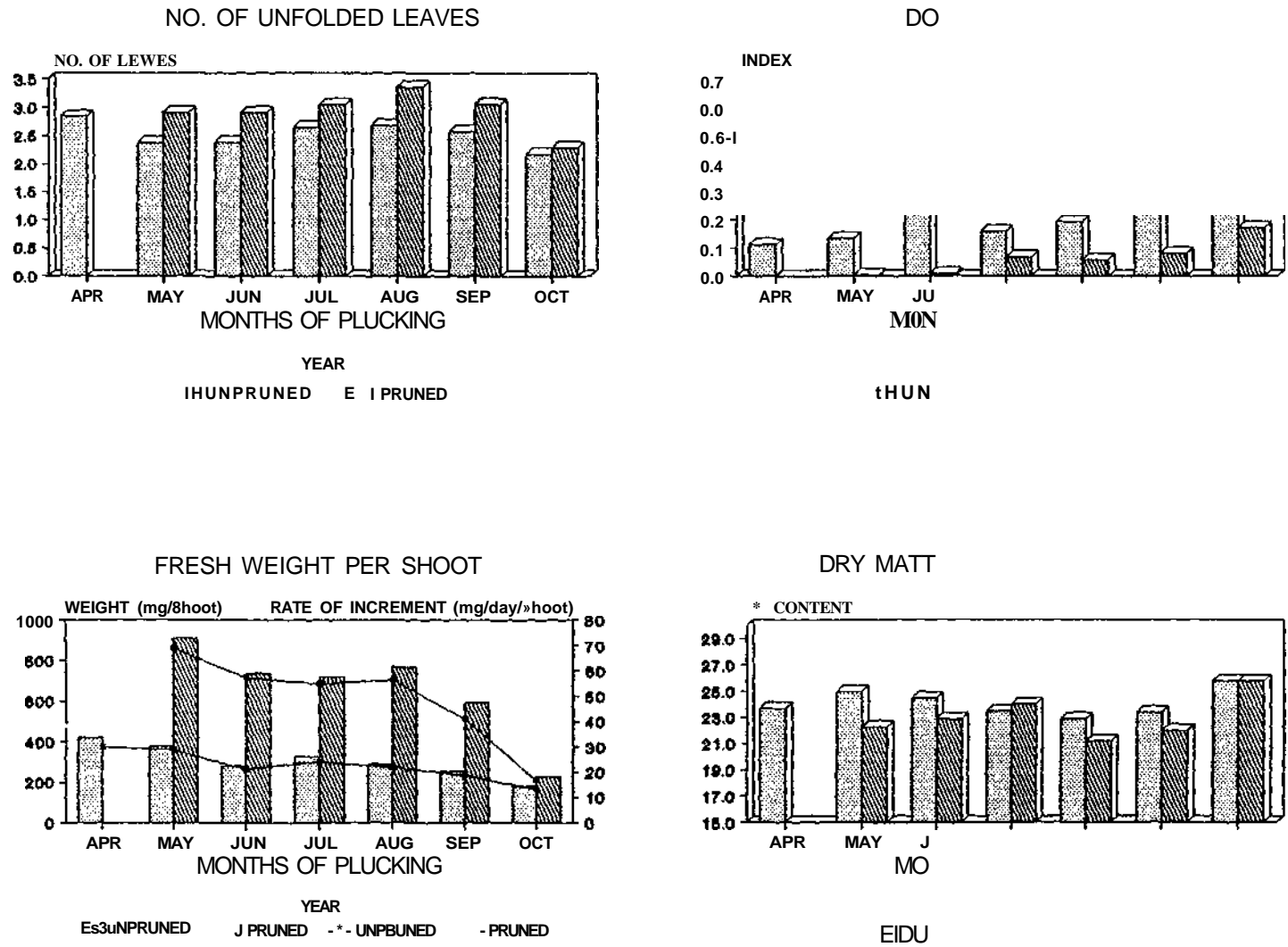


FIG.5.8. EFFECT OF MONTHS OF PLUCKING ON TEA GROWTH

relationship with the number of unfolded leaves. Das (1984), at Tocklai, has tried to establish relationship between rate of leaf unfolding and the climatic condition. He concluded that decrease in temperature and daylength markedly delayed the rate of leaf unfolding. Similar interpretations can also be made from the present studies.

Observations and experiences in Himachal Pradesh reveals that the first or early flush completes during second fortnight of May to June end; the second or main flush during second fortnight of September; and the last or backend flush during first week of November. Higher proportion of dormant shoots and reduced size of active bud mark the completion of different flushes in a season. Similar observations regarding completion of different flushes were recorded during unpruned year also. But in pruned year, the distinction between first and second flush was not very clear because pruning operation had stimulated the fast growth of the shoots and as a result the shoots remained active during June. A slight rise in dormancy index (though very low in comparison to unpruned year) noticed in July revealed that the pattern of flushes is slightly modified by pruning operation.

The fresh and dry weight of shoot were highest in April and May during unpruned and pruned year, respectively (Table 4.3 & 4.4) and with the advancement in season the weights decreased continuously till October. This trend can be explained on the basis that with continuous plucking, the density of plucking points increased and more and more shoots got opportunity to grow from the dormant axillary buds, the shoot number and weight are

generally inversely related with each other and one increases at the cost of other (Rahmnn, 1977 & 1900). According to Tubbn (1936), the decrease in shoot weight occurs due to internal competition among increased number of shoots. Similarly, Portsmouth (1957) considers that the decrease in shoot weight is due . to increased complexity of branching at plucking surface resulting in the interference with movement of water and nutrients to the growing apices. Wight (1955) attributed this to the loss of apical meristems due to ageing. The study further revealed that there was sudden depression in the shoot weight in June during unpruned year. This is attributable to the higher dorsiancy index in this month (Table 4.2). The weight of shoot and the rate at which the fresh and dry weight increment occurred (Table 4.6 and 4.7) were higher in April, July and August during unpruned year and in May, July , August and June during pruned year. While in October, September and June during unpruned year and in October and September during pruned year the shoot had lowest fresh and dry weights as well as rate of fresh and dry shoot weight increments. The findings show that shoot weight and rate of shoot weight increment have negative relationship with dormancy index.

According to Manivel and Hussain (1982) the direction of jaovement of photosynthates during active flush period is towards the growing shoots while during dormancy, a part of photosynthates get diverted towards roots; while during winter months when there is no apparent growth, all photosynthates are stored in the roots in the form of starch. This explains why

shoot weights were lower during October, September and June during both the years. During pruned year, the fresh weight of shoot was higher in August than July but dry weight was similar indicating that due to ample supply of moisture as a result of rainfall, the water content in shoots was also higher resulting in higher fresh weight. Similarly, some fluctuations occurred in the rate of shoot weight increment could also be due to variation in weather parameters.

Plucking operation stimulates the regeneration of apical shoots immediately below the plucking point by temporarily destroying the apical dominance (Portsmouth and Ra.jiah, 1957). The present study revealed that the month of plucking and pruning operation also affected the rate of shoot regeneration (Table 4.8). The shoots plucked in April, in unpruned year, took 24 days to regenerate, while in May and June the rate of regeneration was quite slow taking 42 and 41 days, respectively; further the shoots did not regenerate to 2+Bud level during October indicating the relation of rate of regeneration with dormancy index. The months of higher dormancy have longer rate of shoot regeneration. Though the dormancy index in May was low, the shoot plucked in May regenerated to 2+Bud size in June when dormancy had initiated. Besides, the high temperature and low rainfall during summer months could be the other factor delaying regeneration during June in unpruned year. But during pruned year, the rate of regeneration of shoot was slightly but significantly slower in May, June and July than August and September. This might have been due to bigger size of regenerated

shoot in May to July months as compared to that in August and September. Bigger size of shoot having relatively longer internodes is expected to take more time for unfolding leaf probably owing to its slower rate of shoot extension.

5.3.2. Quality

5.3.2.1. Fineness of crop

The fineness of the crop was highest in the beginning (April in unpruned year and May in pruned year) of the season and decreased continuously upto September but improved slightly in October (Fig. 5.9; Table 4.14). In the beginning of the season, the density of shoots per unit area was comparatively less and as a result their fresh weight was more (Fig¹. 5.8; Table 4.3). Because of the bigger size of the shoots (or longer internodes) the incidence (inclusion) of the loose leaf (which is considered to be non-fine material) was less in the early season. Increase in dormancy index in subsequent months is the other reason for lower fineness as the part of shoot excluding the first leaf with dormant apical bud above it is graded as coarse material. Besides, in the beginning of the season the plucking table was uniform but during peak flush period (especially during early flush, when the rate of leaf unfolding was very fast and main attention was given to pluck all the shoots growing at plucking table) the table became somewhat uneven due to heavy rush of the crop. Therefore, the occurrence of a small proportion of loose and mature leaves in the plucked crop could not be avoided in the subsequent harvestings. Slight improvement in the fineness during

QUALITY OF T AS INFLUENCED BY DIFFERENT MO

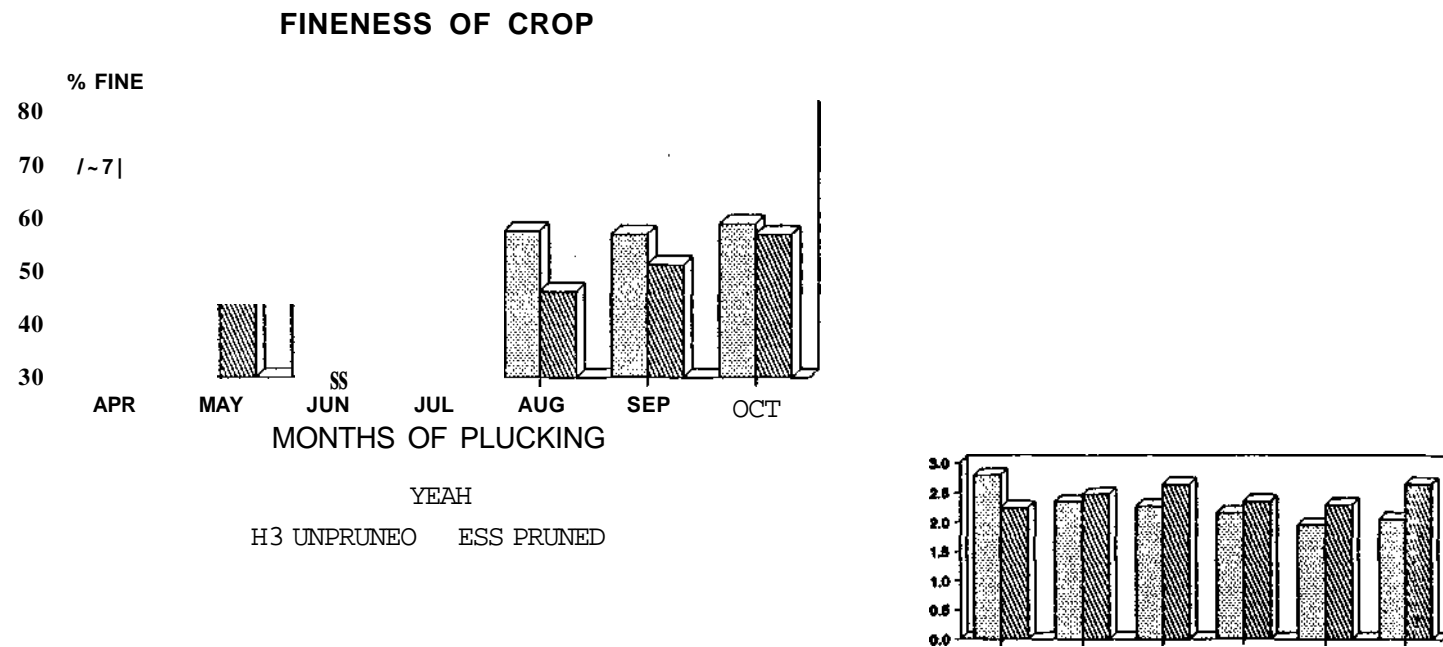


FIG.5.9. EFFECT OF MONTHS OF PLUCKING

October month was due to restricted growth rate of shoot due to low temperature and thus comparatively less number of unfolded leaves.

5.3.2.2. Polyphenol content

Shoots plucked in different months during both unpruned and pruned years exhibited significant difference in polyphenol contents. The differences were more pronounced during pruned year (Fig. 5.9; Table 4.15).

During unpruned year the polyphenol content was higher in early flush particularly in May. The crop of main and backend flushes (*i.e.* from June to October) contained less polyphenol than that of early flush. Significantly low content of polyphenol in the crop of April was probably due to dilution effect as a result of higher shoot growth.

During pruned year, the content was lowest in May pluckings but improved significantly in the subsequent months until October, while remained at par in the rainy months (July and August). The polyphenol content showed a trend of negative relationship with the dry matter content of shoot (Table 4.4) as also reported by Sharma (1988) under agro-climatic conditions of Himachal Pradesh.

5.3.2.3. Caffeine content

The caffeine content varied significantly in different months of plucking during both unpruned and pruned years (Table 4.16)

During unpruned year the content decreased from May to October (Fig. 5.9) indicating that tea in the beginning of season is better in quality (regarding taste and briskness due to higher caffeine content) than the remaining season. Such results have also been reported by Cloughley (1982).

During pruned year, the caffeine content was low in early flush which improved in early part of main flush (July) and in backend flush (October). The pattern of caffeine content in different months was just like to that of polyphenol content and can be explained in terms of rate of shoot growth.

5.3.2.4. Made tea parameters

All made tea parameters showed significant change with month of plucking (Table 4.17 to 4.20) during both years of study. During unpruned year, TF was highest in the pluckings of May and October, and during pruned year, tea of July, June and October (in the order) was having more percentage of TF while lowest content during both years was in the tea of August (Fig. 5-S ; Table 4.17). The most of variations in TF content were in accordance with polyphenol content. The pattern of variation of brightness of made tea was exactly similar to that of TF content during both the years (Fig. 5.9; Table 4.20). A significant positive correlation between TF and brightness under Palampur conditions has already been reported by Sharma (1988).

The trend of TR was also similar to that of TF with few exceptions (Fig. 5.10 j Table 4.18). Slight variations in total colour were also recorded during both years. While other

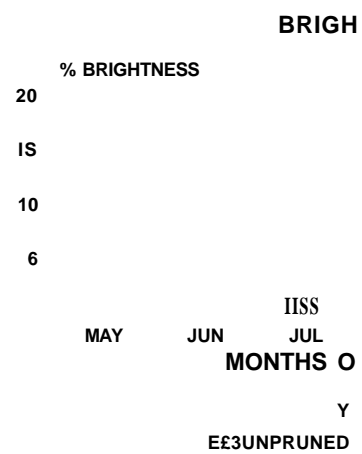
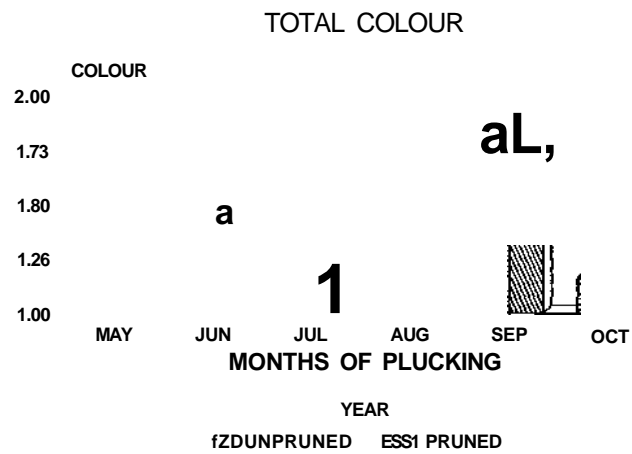
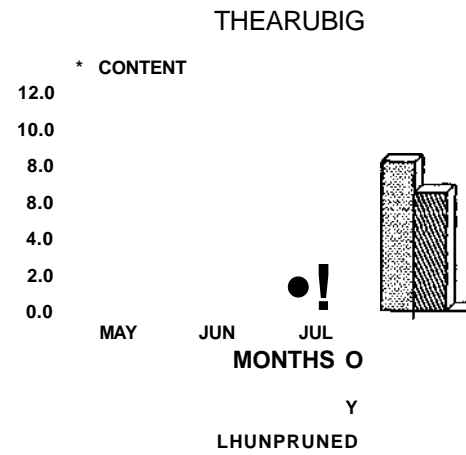
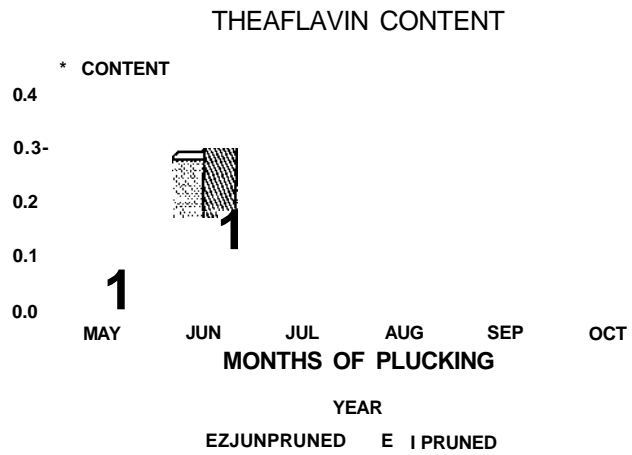


FIG.5.10. EFFECT OF MONTHS OF PLUCKING ON MA CHARACTERISTICS

parameters improved, the total colour reduced in tea of October plucking during unpruned year. As such, total colour did not show much variation especially during unpruned year. Similar results have also been reported by Sud and Bhattacharjee (1990) under Palampur conditions. In fact, variations in made tea parameters depend not only on quality of raw material but also on the condition of manufacturing and weather parameters (Tocklai Exptl. Station 1911-1991, 1992).

5.3.2.5. Taster's evaluation

During unpruned year, the rating for all reported parameters (except colour) was higher in the tea of October pluckings (backend flush) followed by May and June (early flush) (Fig. 5.11). During unpruned year also the ratings were higher for the tea of October month followed by May, June and July. The trend of ratings of quality parameters was similar to that observation biochemical parameters.

5.4. Interaction effect

5.4.1. Growth

Though the trend of growth of shoot at different plucking intervals in different months was similar to the main effects of the intervals, the shoots plucked at longer intervals in April during unpruned year and May during pruned year showed proportionately higher growth as evidenced by the fresh and dry weights of shoots as well as by the rate of their increments (Table 4.1, 4.3, 4.4, 4.6 & 4.7). This may be attributed to the favourable weather conditions as well as due to lower dormancy

TASTERS' EVALUATION OF AS INFLUENCED BY DIFFERENT MON

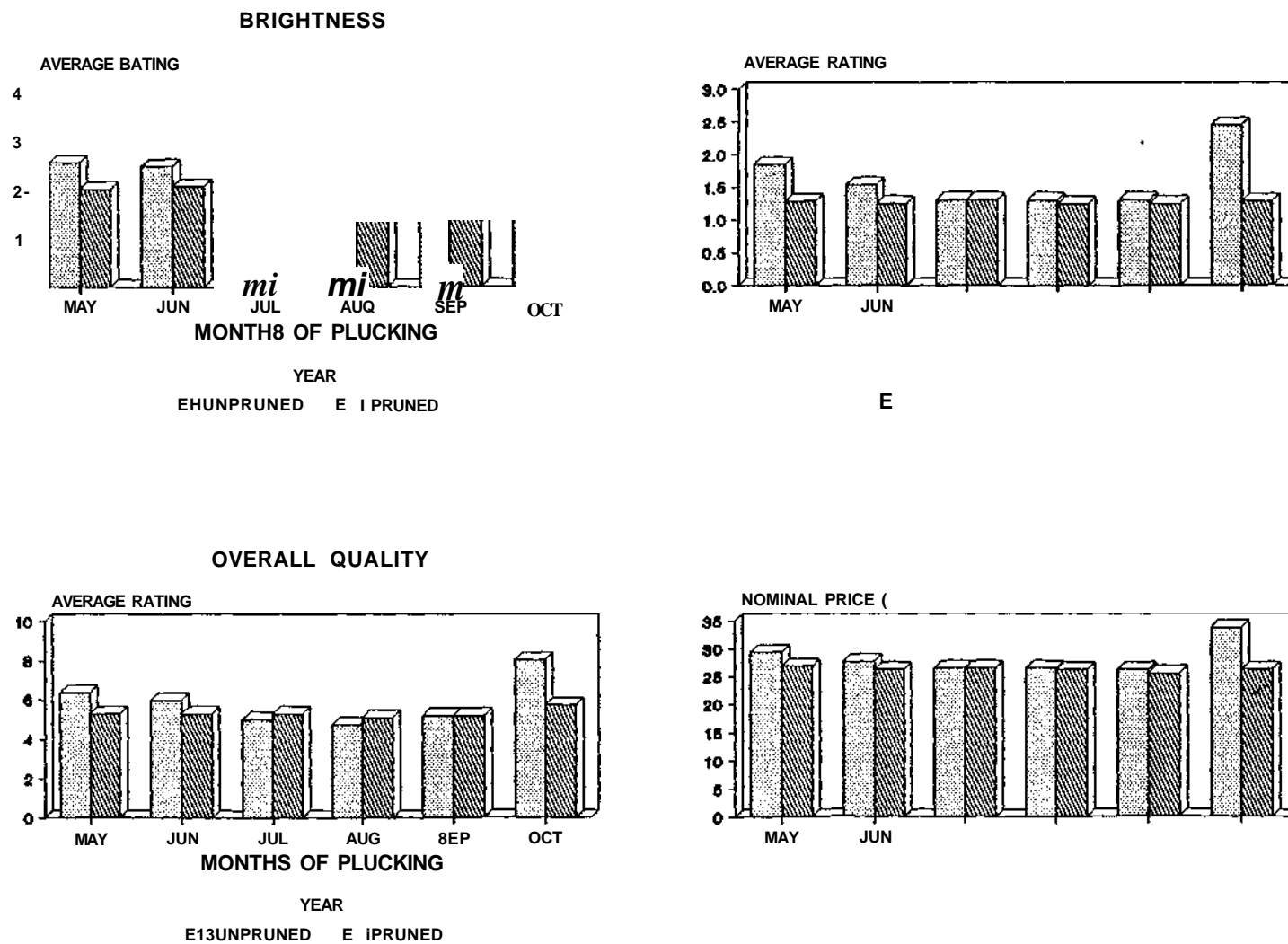


FIG. 5. II. EFFECT OF MONTHS OF PLUCKING ON
EVALUATION OF MADE TEA

index (Fig. 5.8; Table 4.2) in these months. On the other hand, the growth shoot plucked at longer intervals in October during both year had lower fresh and dry weights as well as their rate of increments, and may be attributed to higher dormancy index and low temperature (Appendix I) during this month.

5.4.2. Quality

5.4.2.1. Fineness of crop

The trend of decrease in fineness with increase in plucking interval in all the months during both the years was similar but the range and proportion of decrease with each successive increase in plucking interval varied during both years (Table 4.14). During unpruned year, the highest fineness was 86.2% at 3 days plucking interval in April and lowest was 33.7 at 17 days in October. During pruned year, the range was quite wider from 93.6% at 3 days plucking interval in June to 21.3% at 17 days in August. The variation in fineness in different months during both the years was related to the growth (in terms of number of unfolded leaves). When growth was faster the proportion of coarser shoot (3+Bud and above) was increased as also observed by Mwakha (1991). During the months of slow growth rate, the fineness reduced at longer interval due to higher proportion of dormant shoots in the produce. It has been observed that there was more decrease in fineness with increase in plucking intervals in all the months during pruned year. The fineness recorded at plucking interval of 17 days in all months during unpruned year was at par, if not better, to that of 11 days interval in pruned year. The fineness was even below 30% during

pruned year at 17 days interval in June and September, 15 and 17 days interval in August. The results of the study indicated that for obtaining a crop of around 50% fineness, the plucking interval should be shorter than 9 days during pruned year and it can be extended upto 13 to 15 days during unpruned year.

The variation in fineness of crop at shorter intervals (*i.e.* 3 and 5 days intervals), in different months during both years, was solely due to inclusion of loose leaves as the shoot plucked seldom exceeded 2+Bud (particularly in unpruned year). The shoots plucked at these intervals were snail with shorter internode resulting into lower most leaf usually separated into loose leaf.

5.4.2.2. Polyphenol content

The experimental results revealed that during unpruned year the polyphenol content was significantly highest in the shoots of early flush crop (April to June) at the shorter interval of 3 and 5 days (21-23%) which might have been due to higher proportion of snail tender shoots in the plucked crop. The nade tea of early flush is well known for its quality and, thus, may be related to higher content of polyphenol in the shoots but it is apparent from the data that such high proportion of polyphenol deteriorates if plucking standard is nade coarse by extending plucking interval to 15 and 17 days, especially in April and June. The tea of plucking interval shorter than 13 or 15 days in months from June to October contained significantly lower polyphenol (below 13%) in the season than remaining intervals and was again due to inclusion of higher proportion of

coarse leaves and stems.

During pruned year, significantly highest content of polyphenol (about 20%) was recorded in September and October at plucking intervals of 3 and 5 days. The content was comparatively low even at shorter intervals in early season (May & June) probably due to bigger shoots (having double fresh and dry weights than that in unpruned year, Table 4.3 & 4.4), resulting in dilution of polyphenol concentration. The weight of shoots plucked at 15 and 17 days intervals in May was quite higher than remaining months, and thus, resulted in the lowest polyphenol content (about 11%) during the season.

5.4.2.3. Caffeine content

During unpruned year the tea of early flush (May) plucked at 3 and 5 days intervals had highest caffeine (>3%). Both increase in plucking interval and advancing of season from May to October showed decrease in the caffeine content. The caffeine was below 2% in tea of 13 to 17 days plucking intervals in June, July and August and 13 to 17 days plucking intervals in remaining months.

During pruned year, tea of highest caffeine content (>3%) was produced from the pluckings of 3 and 5 days in July and 3 days in September. The tea containing less than 2% caffeine was obtained from the harvest of 17 days interval in May and June, 13 and 17 days interval in August and 15 and 17 days intervals in September.

The caffeine content was also higher (>2.8%) in the tea of 3 and 5 days intervals in June during both years and of 3 days in

September during pruned year.

5.4.2.4. Made tea parameters

Though the general trend in each month showed decrease in quality (in terms of TF, TR, total colour and brightness) with increase in plucking interval, (Table 4.17 to 4.20) but there have been some variations in the general trend in some months in both years of study and have been described in corresponding sections in Chapter 4. Such variations can be expected because besides polyphenol content of shoot, the quality of tea is dependent on many other factors starting from plucking to drying of final product and even upto storage. For example, during plucking if the shoots are handled tight, they get squeezed and cells get bruised (Trinich, 1962). This cause the polyphenol oxidase and polyphenol to mix resulting in early fermentation which lowers the quality of made tea. Similarly, if plucked green leaf is not properly aerated, gets heated up resulting in breakdown of cell structure and ultimately early fermentation (Trinich, 1962). In same way various other factors including the steps of manufacturing have been reviewed by Owuor and Othieno (1988) which influence the quality of made tea.

It is obvious from the present findings that tea of shorter intervals of 3 and 5 days in all months during both years particularly in May and October during unpruned year and July during pruned year had very high quality especially in respect of TF content.

5.4.2.5. Taster's evaluation

Kirthisinghe (1968 & 1971) studied the effect of length of plucking rounds on Manufacturing quality of harvest and found no difference in the valuation of final product. Similarly, Barbora and Saikia (1989) did not observe any difference in tea quality in tasters' evaluation. They expressed the view that quality and valuation of made tea depends more on manufacture than on the standard of the shoot harvested. However, the effect of the standard of plucking on quality of black tea is well documented (Owuor *et al.*, 1987; Mohanta *et al.*, 1988).

In the present studies, the tea of shorter plucking intervals of 3 and 5 days got higher ratings for brightness, flavour, total quality and valuation in all the months particularly in October and Nay during unpruned year. The tea of 7 days plucking interval also got equal ratings for these parameters during unpruned year, again confirming that the tea made from shorter interval during early and backend flushes are better in quality than remaining main season.

The slight variations in the general trend of quality parameters and almost similar valuation of tea made from the plucking intervals of 7 to 17 days reveal that beside raw material, the manufacturing of tea also play role in tea quality. Besides, while other infusion characteristics of made tea, the physical appearance of the tea is equally important (Abdul Gaffar, 1982) for the valuation of final product.

5.5.Effect of. Methods of. plucking

5.5.1.Growth studies

Ndamugoba (1977) found that leaf plucked by mechanical method was coarser than the leaf plucked by hand. He found that machine plucking have to be done on longer round for better crop. In the present study also the bushes under shear and machine, as well as black plucking took more time to become ready for subsequent pluckings than standard plucking, as a result the longer plucking intervals were followed in the former methods. The average length of plucking interval varied from 8 to 12 days (mean 8.9 days) during unpruned year and from 7 to 11 days (mean 8.8 days) during pruned year with shear plucking, and 8 to 15 days (mean 10.9 days) during unpruned and 8 to 12 days (mean 10.1 days) during pruned year with machine plucking. In hand plucking, the average length of plucking interval in different months varied from 5 to 9 days (mean 6.6 days) during unpruned year and from 4 to 7 days (mean 5.2 days) during pruned year with standard plucking, and 6 to 11 days (mean 7.9 days) during unpruned year and 5 to 10 days (mean 6.5 days during pruned year with black plucking. In standard plucking, all small 1+Bud shoots were left behind on the bushes during plucking (Plate 5.1), which become ready for subsequent plucking after unfolding one leaf and, thus, the bushes under this plucking system were plucked more frequently. Similarly, the longer plucking intervals in black, shear and machine plucking were due to the reason that by these plucking methods, all small 1+Bud shoots which were to be plucked as crop after their growth in the subsequent plucking, were

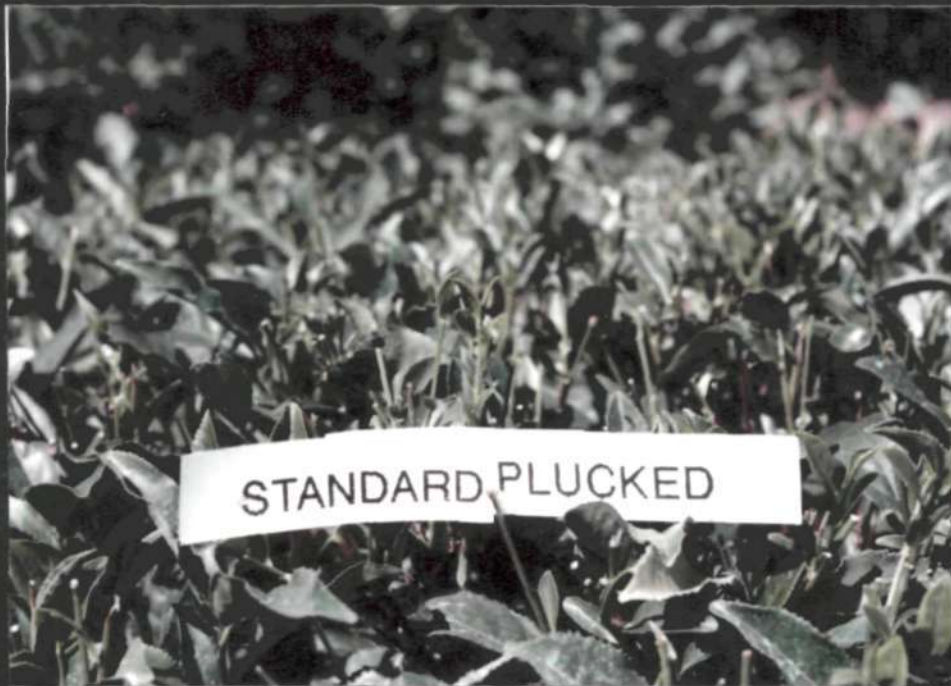


Plate 5.1. Standard plucked tea bush



Plate 5.2. Black plucked tea bush

removed during plucking (Plate 5.2, 5.3, & 5.4). Besides, in mechanical plucking, even the growing buds at plucking table were damaged. The damage was more severe with machine plucking resulted in further increase in the plucking intervals. Due to longer interval, the growth of tagged shoots in terms of the number of leaves unfolded, fresh and dry weights were more in mechanical and black plucking than standard plucking (Fig. 5.12). The higher dormancy index in the former methods than latter was also because of longer plucking intervals during both pruned and unpruned years. In spite of variation in plucking interval, the dry matter content did not show much variation.

5.5.2. Yield

Shear plucking resulted in significantly highest green leaf and made tea yield than remaining methods and was followed by machine, black and standard plucking during unpruned year; the trend was same during pruned year but effects of different methods were non-significant (Fig. 5.13; Table 4.36 & 4.37). The figures on green leaf yield show that compared to standard plucking, yield in shear plucking was 22% more in unpruned year while in pruned year it was only 8% more. Besides, machine plucking also recorded 9 and 7% higher yield during unpruned and pruned year over standard plucking which, however, it was statistically non-significant. The higher yield in case of shear and machine plucking might be due to two reasons: (i) these methods removed a part of maintenance foliage existing at the surface of plucking table (Plate 5.3 & 5.4) and included in the crop, and (ii) these methods removed all types of shoots (new and

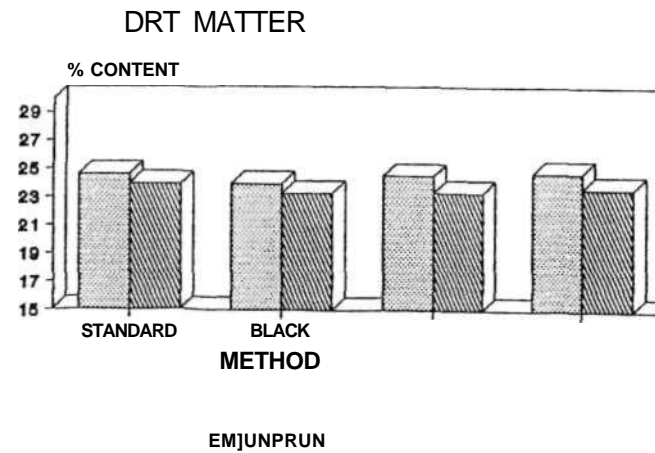
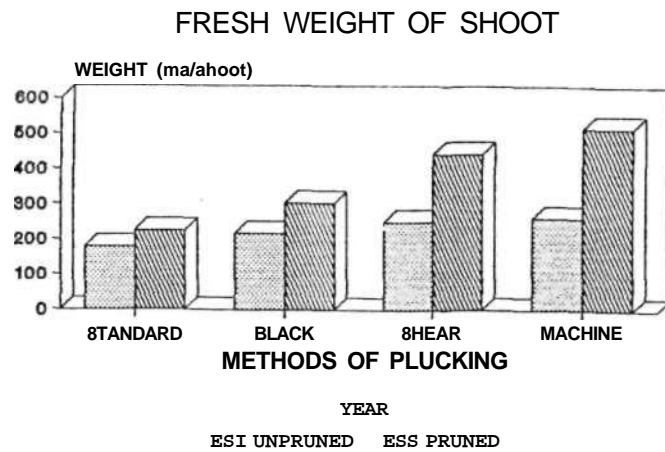
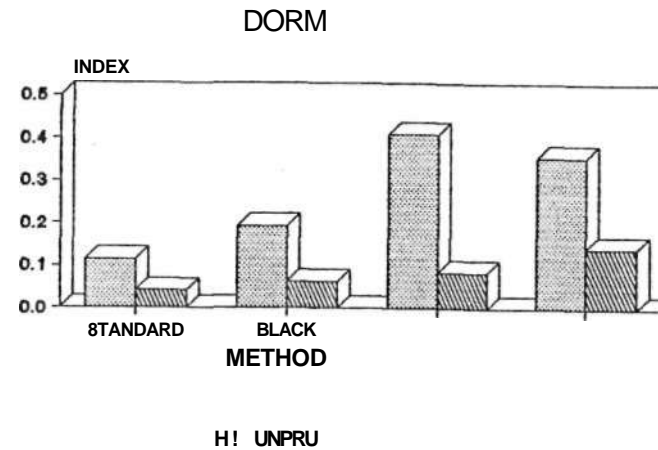
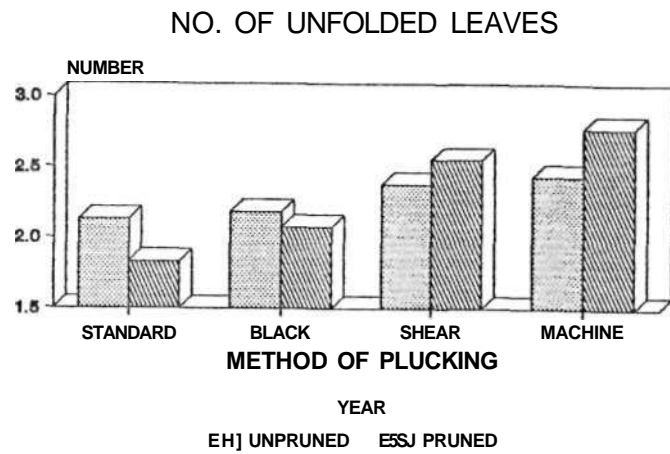


FIG.5.12.EFFECT OF METHODS OF PLUCKING ON GRO
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Plate 5.3. Shear plucked tea bush



Plate 5.4. Machine plucked tea bush

old) from the plucking table, thus, encouraged many axillary buds to grow. An increase in yield with shear plucking ranging between 5 to 12% over hand plucking has already reported from Taiwan (Shin *et al.*, 1974). Similarly, higher yield (to the tune of 12 to 13%) with machine plucking has also been reported from Taiwan (Shin *et al.*, 1974), Central Africa (Rooster, 1975) and Georgia (Theshelashvili and Khukhunaishvili, 1975).

Despite the similar principle of leaf harvesting, machine plucking resulted in significantly lower yield than shear plucking during unpruned year, probably due to the reason that it harmed the growing shoots and active buds as well as removed maintenance foliage to greater extent, adversely affecting the production of young shoots as compared to other methods of plucking. Recent finding of Tocklai indicates that machine plucking, if carried out at a fixed height of plucking, did not increase the yield (Tocklai Exptl. Station 1911-1991, 1992). In the present study also the plucking was done at a constant height, and hence, did not show significant increase in yield.

During both years, the green leaf yield was not affected significantly by black plucking when compared with standard plucking and, thus, can be recommended as and when required.

The flush-wise distribution of green leaf yield show that in early flush, shear plucking resulted in 35% higher yield over standard plucking; while during pruned year it brought 41 more yield than standard plucking. Machine plucking also increased the green leaf yield to the tune of 37% over standard

AS INFLUENCED BY DIFFERENT METHODS

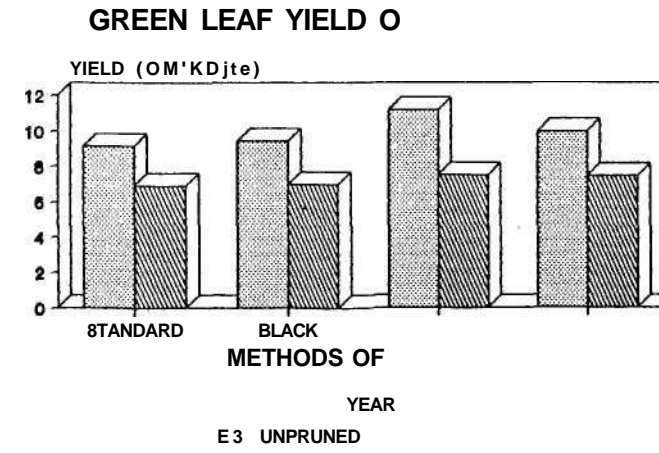
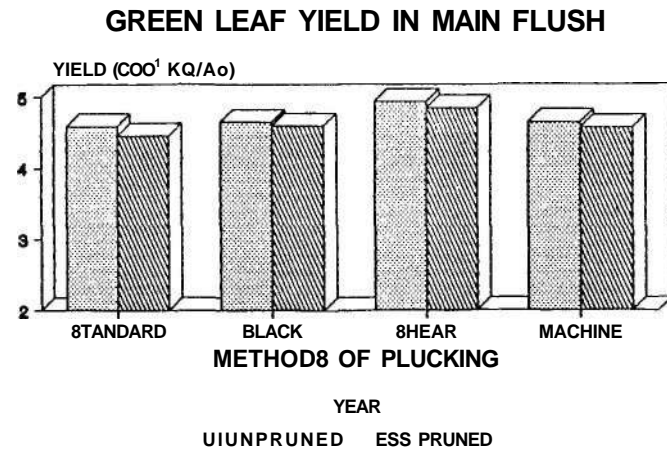
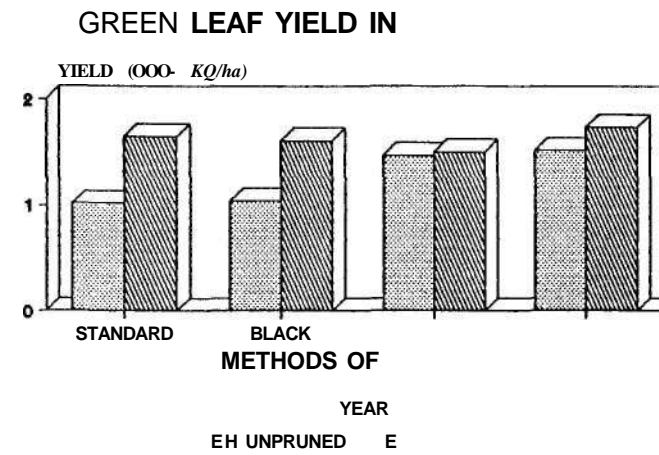
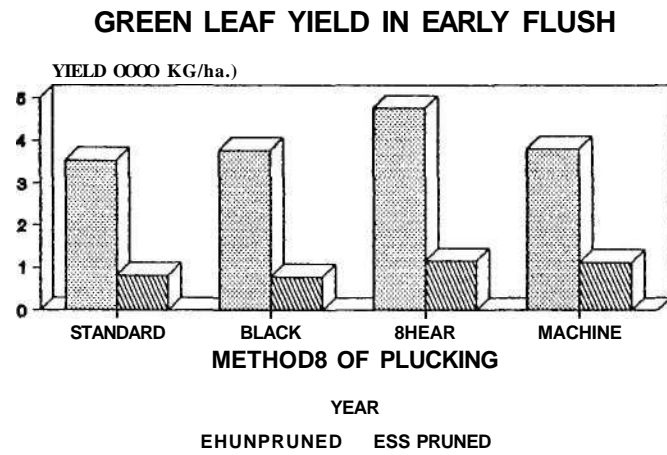


FIG.5.13.EFFECT OF METHODS OF PLUCKING ON GREEN LE

plucking during pruned year in this flush. In biokond flush also shear and machine plucking resulted in higher leaf production during unpruned year (to the tune of 44 and 49%, respectively) over standard plucking but the contribution of this flush towards the total yield was only 12.7%. During pruned year, the yield of shear plucking showed a decline of 9% in backend flush over standard plucking which, however, was not significant and may be because of the exhaustion of the bushes.

The trend of made tea yield was similar to that of green leaf yields in all the flushes and over the season.

5.5.3. Quality

5.5.3.1. Fineness of crop

Crop obtained with hand plucking (standard and black) had significantly better fineness than mechanical (shear and machine) in all the months during both the years of study (Fig. 5.14; Table 4.38). The lower fineness in case of mechanical plucking can be attributed to three reasons, (i) the mechanical plucking resulted in extension of plucking interval where some of the shoots exceeded 2+Bud size, (ii) the mechanical operation removed soft fractions of fine shoot and (iii) the operation also included cut pieces of maintenance foliage and other undesirable materials like cut stems. Besides, some of the buds of shoots were also damaged or removed rendering them as coarse material. The lower fineness in mechanical plucked crop has also been reported earlier by Ndamugoba (1977), Watson *et al.* (1982) and Mwakha (1990).

The study further revealed that despite the variation in plucking interval, the crop plucked by standard and black systems of hand plucking had statistically similar fineness (Fig. 5.14; Table 4.38). It was probably due to greater similarity of the methods of plucking. But in case of two mechanical methods, the fineness was slightly better in shear plucking than machine plucking in all months during both years. The difference in fineness between these mechanical methods was even significant in July during unpruned year and May and June in pruned year (Table 4.38). This may be ascribed to the fact that with the shear, being manually (hand) operated, there had been option for selective plucking. Whereas, in machine plucking there was no such option. Mwakha (1990) also opined that for improvement of fineness of machine plucked crop, judicious use of plucking table by raising plucking height by 1 cm in each consecutive harvesting round, is essential.

5.5.3.2. Polyphenol content

Leaving few exceptions, the polyphenol content was significantly reduced due to mechanical plucking in all months during both years (Fig. 5.14; Table 4.39). As mentioned earlier, mechanically plucked crop contained cut and broken pieces (Goodchild, 1958), overgrown shoots due to longer pluckings (Ndamugoba, 1977), coarse and maintenance foliage (Watson *et al.*, 1982) also, which contain very low polyphenol (Bhatia, 1961 and Ullah and Jain, 1980). Presence of these contents lowered the concentration of polyphenol. In some months the content of polyphenol in mechanical plucking was comparable to that of

QUALITY OF TEA AS INFLUENCED BY DIFFERENT METHOD

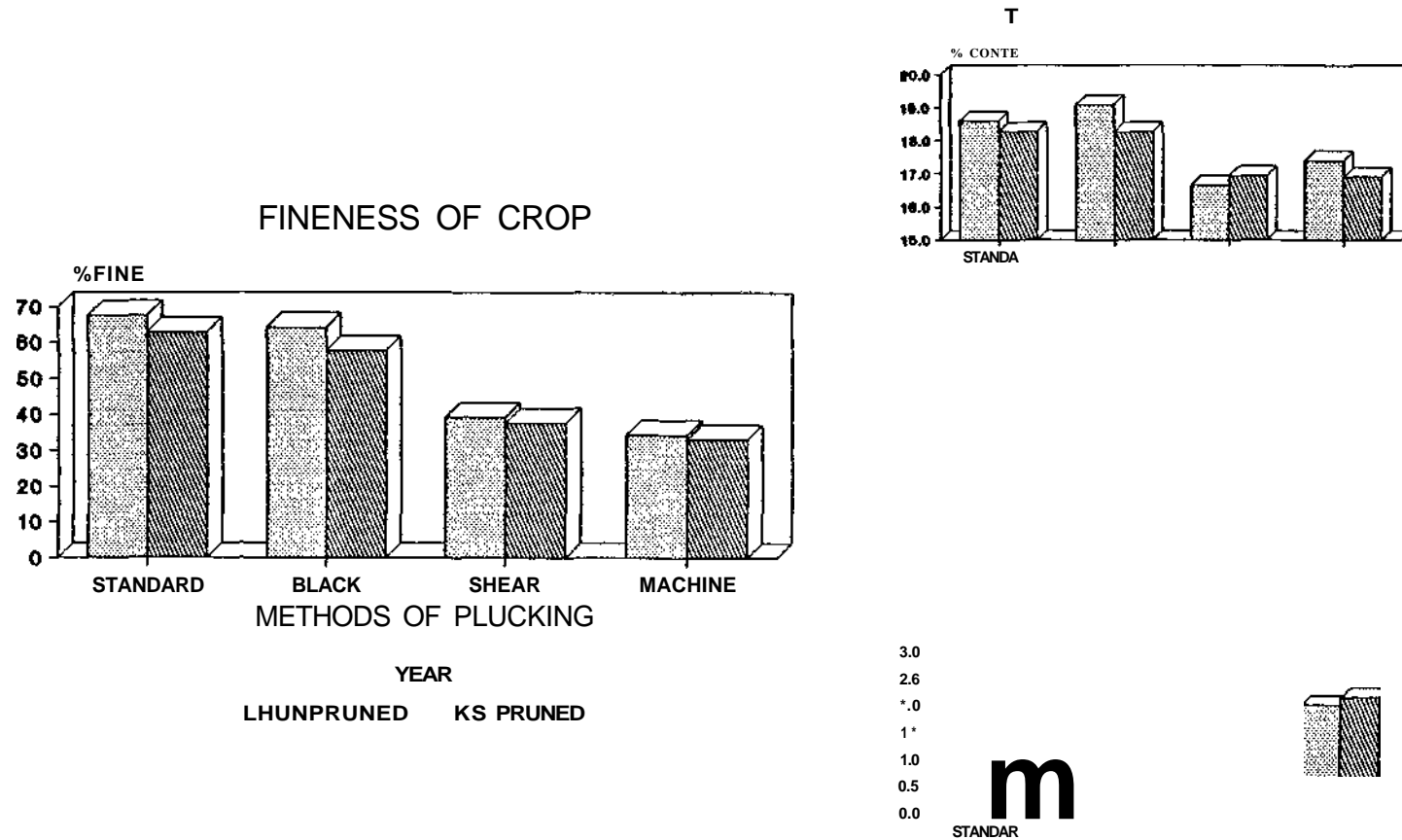


FIG.5.14.EFFECT OF METHODS OF PLUCKING QN QU

standard and/or black plucking in unpruned and pruned years indicating the chances of improvement of quality. Any technique avoiding or minimising the inclusion of coarse leaves, maintenance foliage and stubs etc. e.g. raising height of plucking table (Mwakha, 1990; Tocklai Exptl. Station 1911-1991, 1992) can improve the polyphenol content in the plucked crop and hence overall biochemical quality.

5.5.3.3.Caffeine content

Owuor *et al.* (1991) observed that mechanical plucking reduced the quality of made tea in terms of volatile flavour compounds (TF and caffeine). The findings of the present study also confirm that the caffeine content, on an average, was lower in the tea of mechanically plucked crop (shear and machine) (Fig. 5.14; Table 4.40). This is probably due to the inclusion of overgrown shoots and maintenance foliage which contain low caffeine percentage. During unpruned year, the content was not affected by different methods of plucking in July, August and September, while during pruned year, the shear plucked crop had highest caffeine in September. The crop plucked with mechanical methods in these months probably contained low proportion of maintenance foliage. Recently, Owuor *et al.* (1991) observed that content of volatile flavour compound (TF and Caffeine) in the mechanically plucked crop was improved by raising the plucking level 2 cm from the previous height of plucking table, reducing the inclusion of maintenance foliage in the crop.

5.5.3.4. **Hade tea parameters**

All made tea parameters were significantly lower in tea of mechanically plucked leaf as compared to hand plucked (Fig. 5.15; Tables 4.41 to 4.44). This can be explained on the basis of polyphenol contents which was significantly lower in mechanically plucked crop (Table 4.39) due to the reasons forwarded in Section 5.2.3.2. Average value across the different months indicates that the TF content, which is an important biochemical parameter, was lower in the tea of shear and machine plucked crop to the extent of 19.4 and 21.1% during unpruned and 33.0 and 37.9% during pruned year, respectively over that of standard plucked crop. Reduction in other parameters also occurred which were comparatively less. Owuor *et al.* (1991) had also found reduction in TF content of made tea which, however, was improved when height of plucking was raised by 2 cm from previous plucking height.

5.5.3.5. **Taster's evaluation**

Machine plucking reduces the quality of made tea (De Silva, 1938). In the present studies also, colour, brightness, flavour and total quality as well as valuation (Fig. 5.16; Tables 4.44 to 4.49) were found to significantly lowered in both mechanically plucked (shear and machine) tea in all month during unpruned year. During pruned year, the tea of both mechanical pluckings did not differed much from that of both hand pluckings (standard and black) with respect to colour, brightness, flavour and valuation, but still the overall quality was better in hand plucked crops. As mentioned earlier the inclusion of cut pieces of maintenance foliage and improper rolling of soft cut pieces of

MADE TEA CHARACTER AS INFLUENCED BY DIFFERENT METHO

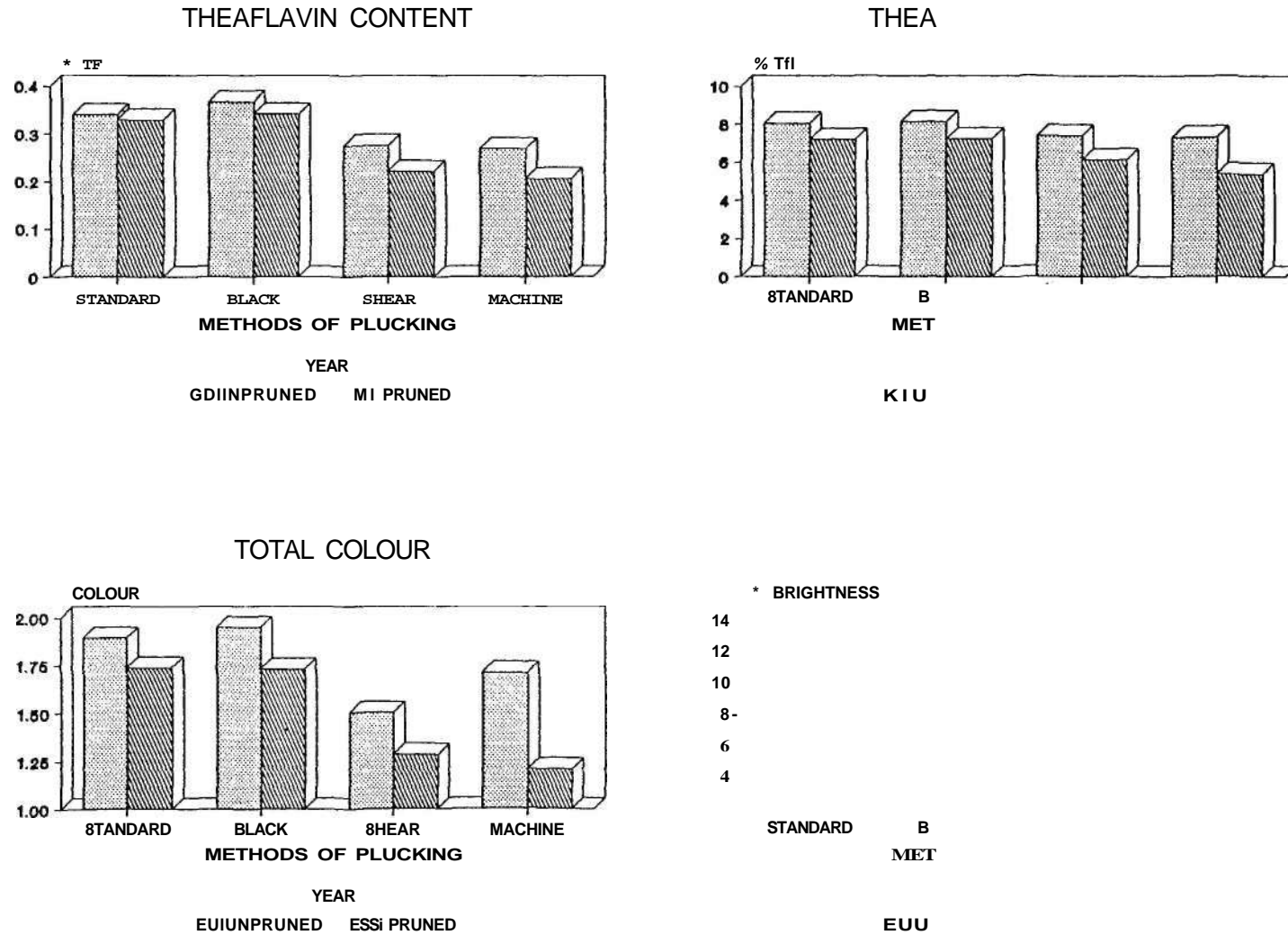


FIG.5.15.EFFECT OF METHODS OF PLUCKING ON CHARACTERISTICS

leaves etc might be responsible for such reductions in the quality both physical and chemical. Mwakha (1990) recorded improvement in the quality of mechanically plucked crop (as per taster's evaluation) when plucking was done with 2 cm rise of plucking table of bush on each consecutive harvesting rounds, thus indicating the chances of improvement of the quality of mechanical harvested crop.

5.5.4.Economics

Main objective of mechanical plucking in tea is to reduce the labour requirement as its availability has become a serious problem in tea plantation particularly in Himachal Pradesh. To meet this requirement, the efficiency of mechanical plucking should be very high besides the produce being comparable quality-wise. The findings of this study revealed that use of mechanical methods served the purpose to great extent (Fig.5.18). The efficiency of machine plucking during unpruned and pruned year was 8.34 and 6.05 times more than that of standard plucking. The reason for the comparatively lower value during pruned year was that the efficiency of standard plucking also increased in this case due to higher shoot weight while it decreased in case of machine plucking due to lower number of plucking points and low bush area particularly in the beginning of the season. Work done elsewhere shows that the efficiency of machine plucking ranges between 6 times (in Sri Lanka, Watson *et al.*, 1982) to 50 times (in central Africa, Mwakha, 1988 and 1990). The wider differences in the efficiency were ascribed to different types of machines used and different standards of plucking.

TASTERS' EVALUATION OF M AS INFLUENCED BY DIFFERENT METHODS

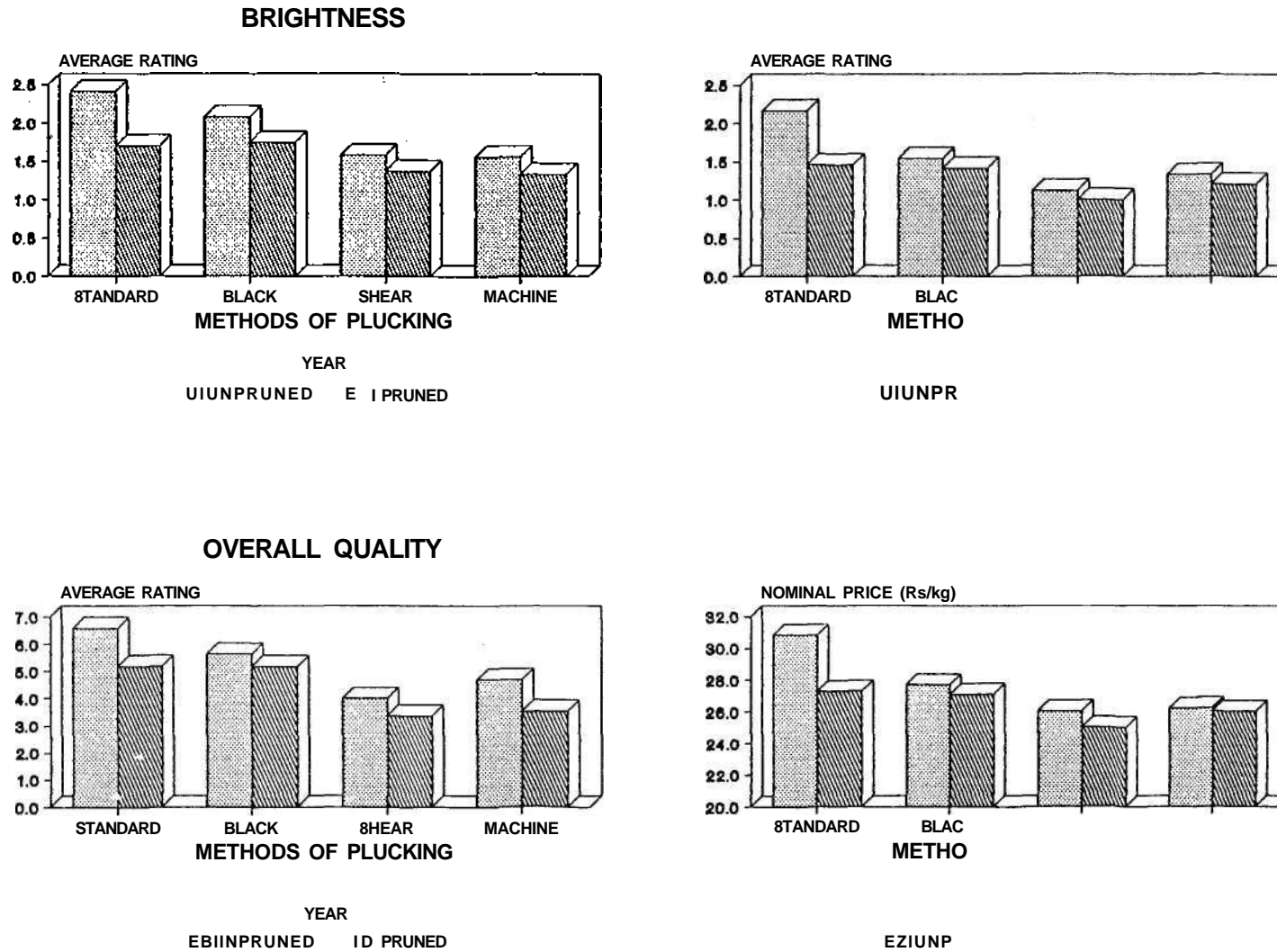


FIG.5.16.EFFECT OF METHODS OF PLUCKING ON

The efficiency of shear was also significantly better than that of both hand plucking systems during both the years. The efficiency of shear plucking was 2.11 and 2.23 times more during unpruned and pruned years, respectively, than that of standard plucking, indicating that use of shear for plucking also reduced the labour requirement. Higher efficiency of shear over hand plucking has also been reported recently by Barborá *et al.* (1992).

The study revealed that the mandays requirement for one plucking with machine was quite low during both unpruned and pruned years (Fig. 5.17), being only 20.0 and 37.5%, respectively, of that of standard plucking. The corresponding figures in case of shear plucking were 82.3 and 87.4%, respectively. The plucking frequencies also varied from method to method, during both the years, due to variation in shoot growth and thus readiness of bush for subsequent plucking. The plucking frequencies were lowest with machine plucking followed by shear and black plucking during both the years. The variation in plucking frequencies resulted in variation in the total mandays requirement throughout the season. The overall mandays requirement with machine plucking during unpruned and pruned years was only 13.0 and 17.7% of standard plucking which is considerably low. The corresponding figures in case of shear pluckings were 58.1 and 48.6%, respectively.

A comparison between standard and black plucking revealed that the black plucking needed 49.2 and 22.8% more mandays per

COST OF PLUCKING AS INFLUENCED BY DIFFERENT METHOD

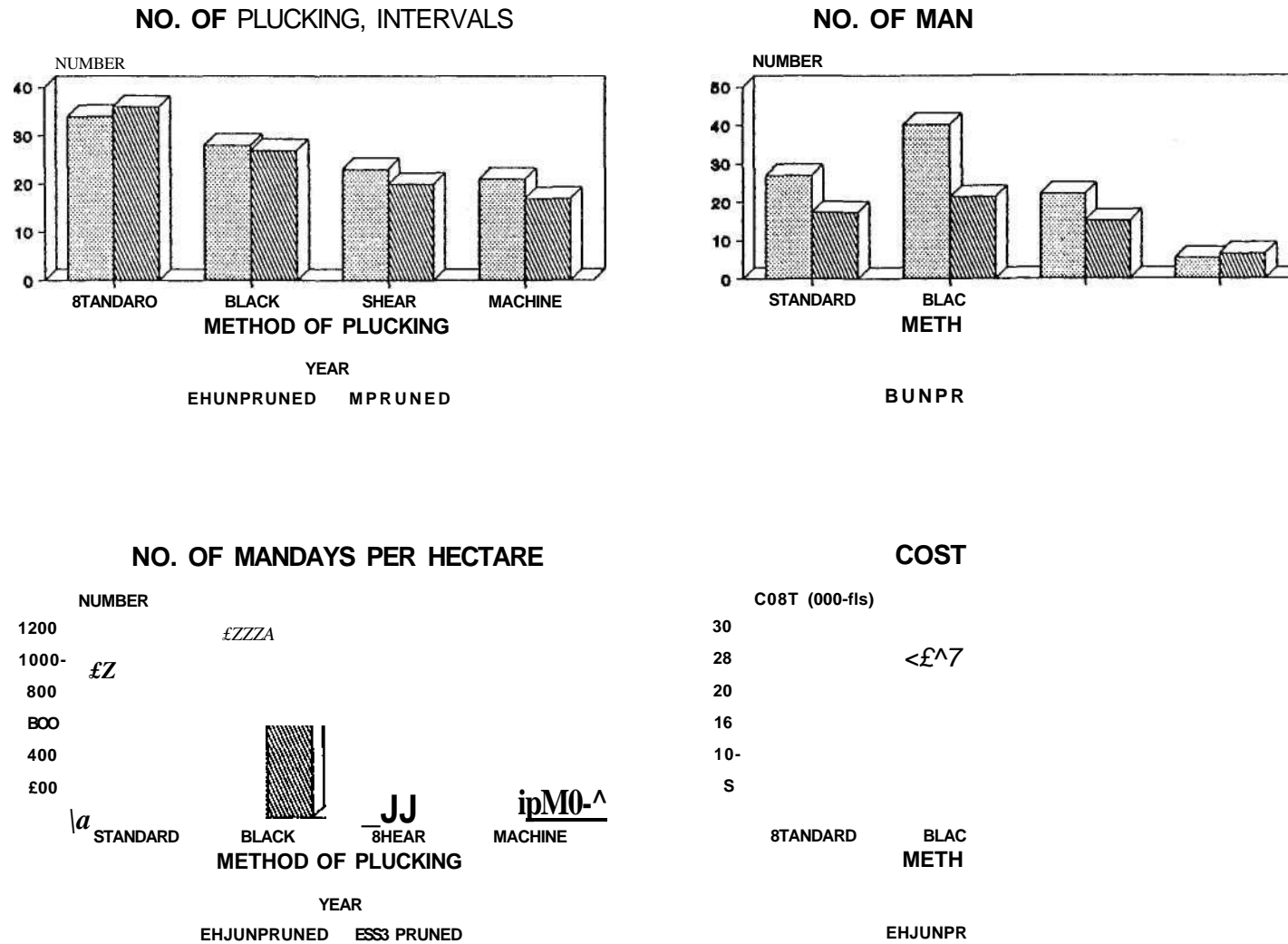


FIG.5.17.EFFECT OF METHODS OF PLUCKING ON CO

interval in unpruned and pruned year, respectively, than standard plucking. This was due to the reason that black plucking entails removal of all small immature 1+Bud shoots whose plucking consumed more time particularly in unpruned year due to their higher density. But black plucked bushes took longer time to become ready for subsequent plucking owing to removal of small 1+Bud shoot thus reducing the plucking frequency. As a result, the overall mandays requirement for the season decreased to the level of that of standard plucking in pruned year and 22.4% higher than that of standard plucking during unpruned year.

Variation in mandays requirement in different methods varied the cost of plucking during both the years (Fig 5.17). The cost of plucking with the use of machine, during unpruned and pruned years, was 39.26 and 54.42% of standard plucking, respectively. The corresponding figures in case of shear plucking were 58.32 and 48.92%. These reductions in plucking cost indicated that mechanical plucking is considerably cheaper than hand plucking (standard).

As discussed earlier with mechanical plucking, the efficiency was very high and total mandays requirement was very low; the quality of leaf plucked (in terms of fineness) was also very low (Fig. 5.14; Table 4.38). All these in ultimate analysis resulted in lower price of plucked crop (Fig. 5.18; Table 4.52). Average price of leaf plucked with shear was only 50% of standard plucked crop during both the years, while it was still below in case of machine plucking (42% in unpruned and 43% in pruned year). Some loss in average price was also observed in

ECONOMICS OF PLUCK AS INFLUENCED BY DIFFERENT METHODS

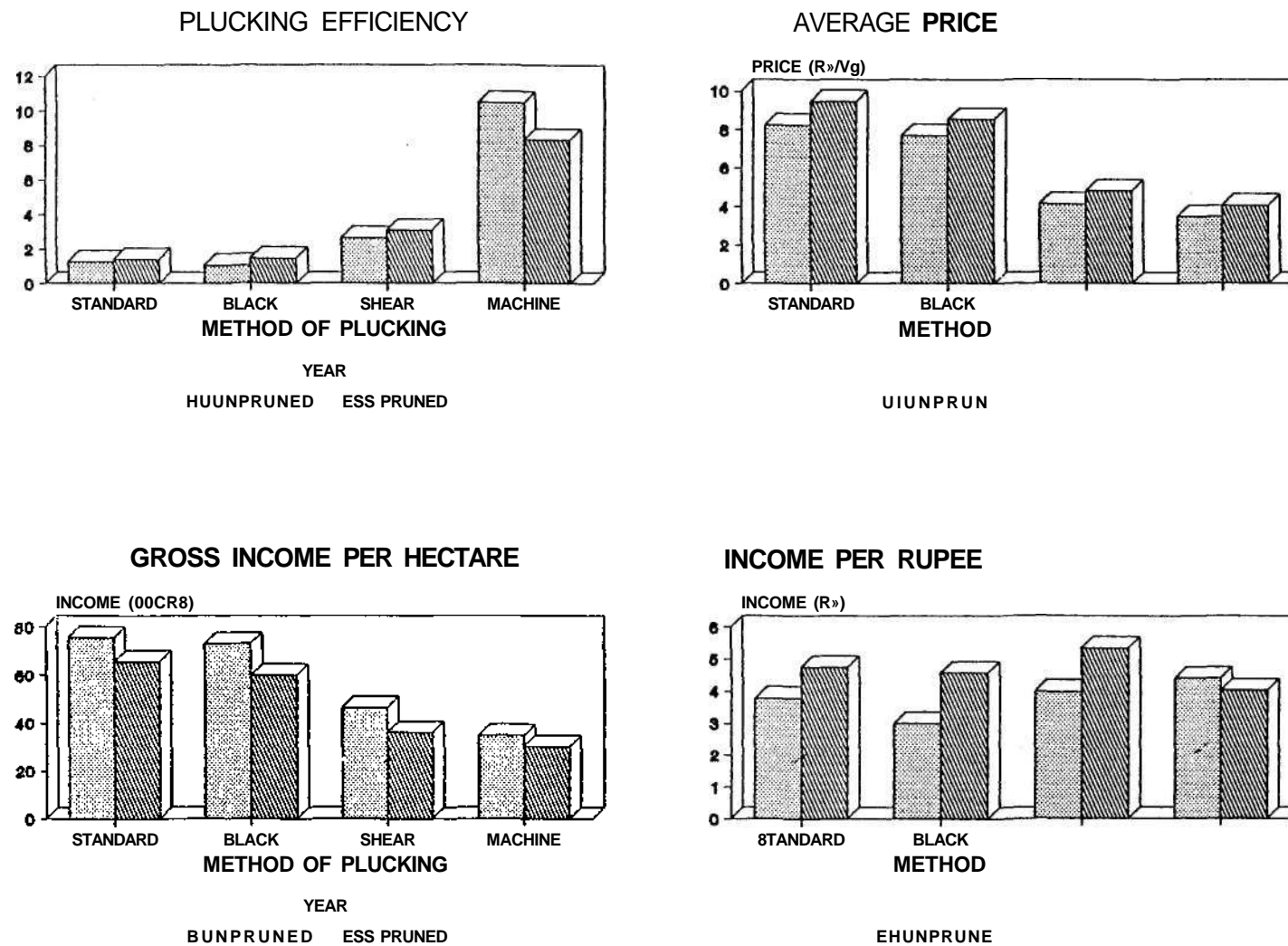


FIG.5.18.EFFECT OF METHODS OF PLUCKING ON ECO

the crop of black plucking (7% in unpruned year and 10% in pruned year) over that of standard plucking.

The low average price of crop in case of mechanical methods affected the gross income per hectare (Fig. 5.18). In comparison to standard plucking, the gross income with shear plucking during unpruned and pruned years was 61 and 55% while it was only 46% during both the years in case of machine plucking. In spite of low gross return in case of mechanical pluckings due to low cost of plucking, the return per rupee invested on plucking was high. The return per rupee during unpruned year was highest (Rs 4.40) in case of machine followed by shear (Rs 3.98), and standard (Rs 3.77) and black (Rs 2.97) while during pruned year, it was highest in case of shear (Rs 5.34) followed by standard (Rs 4.74), black (Rs 4.56) and machine (Rs 4.03). The lower income/rupee in case of machine plucking during pruned year was due to increase in cost of plucking owing to slight decrease in plucking efficiency.

Chapter 6



SUMMARY

Chapter 6

S U M M A R Y A N D C O N C L U S I O N S

A field research study entitled "Studies on interval and method of plucking on productivity and quality of China hybrid tea (*Canellia sinensis* (L) O. Kuntze)" was conducted during 1990 and 1991 at Banuri Tea Experimental Farm of Council of Scientific and Industrial Research Complex Palaapur located at an elevation of 1290.8 m above mean sea level at 32°6' N latitude and 76°3' E longitude, falling in mid-hills wet temperate zone. The objectives of the study were to standardize the interval and method of plucking for maximizing yield and quality of tea *vis-a-vis* to assess their economic feasibility. To **meet these** objectives, two field experiments; one consisting of eight plucking intervals (Experiment I) and other consisting of four methods of plucking (Experiment II); were conducted. The Experiment I with eight plucking intervals ranging from 3 to 17 days was laid out in Randomised Complete Block Design (R.B.D.) with three replications. The Experiment II included four methods of plucking (Standard plucking, Black plucking, Shear plucking and Machine plucking) and was laid out in Latin Square Design (L.S.D.). These methods were imposed with flexible plucking intervals depending on the growth of shoot with an idea to harvest maximum 2-t-Bd sized shoots in each method. The experiments were conducted on 130 years old existing bushes which were rejuvenated in 1984. The year 1990 was unpruned year and 1991 as pruned year. The soil of the experimental area was acidic in reaction with medium availability of N and P, and high K. The

weather conditions were normal during the period of experimentation. There was no serious attack of insect-pests and diseases during the course of investigation.

Observations were recorded on the growth of shoots (number of unfolded leaves per shoot, fresh and dry weights, rate of increment of fresh and dry weights, dormancy index, dry matter content and rate of regeneration of shoots following plucking in each month of crop season; density of plucking points per 100 cm² and per primary at the end of season), bush creep and spread (recorded at the end of crop season), yield (green leaf and made tea yields recorded flushwise), quality (fineness of crop, content of polyphenols in fresh tea shoots, made tea parameters *viz.* caffeine₃, TF, TR, total colour and brightness, and taster's evaluation, all of these were recorded monthwise) and economics (mandays required for plucking, gross return and return per rupee invested on plucking). The detailed description of various treatments of these characters have been described and discussed in the preceding chapters. In this chapter, salient findings of both the experiments have been summarised:

6.1. General

- (i) Growth parameters *viz.* number of unfolded leaves per shoots, fresh and dry weight of shoots and rate of shoot weight increment were more during pruned year (1991) than unpruned year (1990) while the density of plucking points per 100 cm² and per primary, dormancy index and dry matter content of plucked shoot were lower in pruned year as compared to unpruned year.

- (ii) Time taken by dormant axillary bud to grow to pluckable size shoot (2+Bud) following plucking was more by one week in pruned year than in unpruned year.
- (iii) The spread of bushes at the end of season over that of beginning of the season was more in pruned year while annual creep was less as compared to unpruned year.
- (iv) The tea yields expressed in terms of fresh leaf and made tea were considerably lower in pruned year being only 69.1 per cent and 66.4 per cent, respectively, of the yield obtained in pruned year.
- (v) The fineness of the crop (i.e. physical composition of tea shoots) was relatively better in unpruned year than pruned year.
- (vi) The average polyphenol content in tea shoots over the season was almost similar in both the years but the content in shoots in different months during unpruned year was entirely different to that of pruned year [section 6.2(vii)].
- (vii) The made tea quality parameters averaged over the season did not show much variation during pruned and unpruned years. However, the caffeine content was marginally higher in pruned year and reverse was true for TR content.
- (viii) In taster's opinion, tea of unpruned year was better than that of pruned year in respect of brightness, flavour and

thus total quality and was valued higher.

- (ix) The pruning operation exercised in pruned year resulted in reduction in plucking frequencies and the cost of plucking. The latter was reduced to one-half to that of unpruned year.
- (x) The plucking efficiency in pruned year was 33 per cent higher whereas the average price of crop was 15.6 per cent lower than that of unpruned year.
- (xi) In pruned year the average gross return per hectare was 55.4 per cent to that of unpruned year whereas the returns per rupee invested on plucking was relatively more in pruned year.

8.2. Effect of plucking intervals

- (i) The number of unfolded leaves per shoot increased significantly with increase in plucking interval from 3 to 17 days during both unpruned and pruned years in all the months of observation.
- (ii) The dormancy index was lower in shorter intervals but it increased consistently with increase in plucking interval from 3 to 17 days during both the years. During unpruned year, the increase in dormancy index was highly significant with increase in plucking interval from 3 to 17 days in June, September and October while in remaining months, the increase was non significant or was significant only in comparison to shortest interval of 3 days. During pruned

year, there was no dormancy in shoots plucked at an interval of 3 to 15 days while it was very low 17 days in May and June. In other months, significantly higher dormancy index was recorded when tea was plucked at an interval of 13 days or longer particularly in August and October months.

(iii) There was consistent and significant increase in fresh and dry weights of shoot as well as the rate of increment in fresh and dry weights due to increase in plucking interval from 3 to 17 days during both the years. The trend was similar in all the months of observation during both the years.

(iv) The dry matter content in tea shoots varied from 21.1 to 26.8% during unpruned year and from 19.6 to 27.4% during pruned year. The shoots plucked at different intervals in the months of October, May and June in unpruned year and October and July in pruned year showed higher dry matter content while in August they had lower content. Increasing plucking interval from 3 to 11 days resulted in decreased shoot dry matter whereas further increase in plucking interval increased the content during both the years. Shoots plucked in June, August and September in pruned year showed increased content upto 9 days interval only, while in May and June in unpruned year increase was upto 13 days interval.

(v) Rate of regeneration of shoots after plucking varied from 22.5 to 43.1 days in unpruned year and 27.7 to 31.5 days in

pruned year, at different plucking intervals in different months upto September. The effect of plucking interval and its interaction with months of plucking on rate of regeneration was non-significant.

- (vi) Density of plucking points (stubs of plucked shoots recorded at the end of season) per unit area and per primary of tea bush decreased significantly with increase in plucking interval from 3 to 17 days.
- (vii) The spread of bush increased significantly with increase in plucking interval during both the years of investigation. There was non significant effect of plucking interval on the annual creep (bush height) during unpruned and pruned years, though the trend indicated increase in the creep with the interval of plucking.
- (viii) In general, there was increase in green leaf and made tea yields of total season with increase in plucking interval from 3 to 17 days during both unpruned and pruned years, but significant increase was observed only at longer intervals of 13 to 17 days compared with shorter intervals of 3 and 5 days.
- (ix) The yield increase with increase in plucking interval was similar in early, main and backend flushes during both years except that in unpruned year the effect of plucking interval on green leaf and made tea yield was not significant in early flush and plucking interval of 7 and 11 days resulted

in significantly higher green leaf and made tea yields than longer intervals in backend flush.

(x) The average value of quality parameters across the months of observation during both the years of study show that the quality expressed in terms of fineness of crop, polyphenol content in tea shoots, and made tea parameters (content of caffeine, TF and TR as well as total colour and brightness) was highest at the shortest interval of plucking (3 days). The successive increase in plucking interval upto 17 days resulted in consistent deterioration in quality. The trend was common in all the months of observations in both years but the magnitude varied in different months.

(xi) The decrease in TR content and total colour of made tea in different months as a result of increase in plucking interval was not as distinct as in case of other quality parameters during both the years.

(xii) In taster's evaluation, the average rating of tea across the months of plucking for brightness, flavour and total quality as well as valuation were higher at shorter plucking intervals. These parameters showed declining trend with increase in plucking interval during both the years of study. The decrease was more prominent in unpruned year. The rating for these parameters in individual month during both the years exhibited some variations in the trend. The flavour of tea during pruned year did not get different rating in different months. Besides, the tea of all plucking inter-

val during both the years received same rating for colour in taster's evaluation.

(xiii) There was consistent and significant increase in plucking efficiency with increase in plucking interval from 3 to 17 days. On contrary, the average price of plucked leaf decreased with increase in plucking interval.

(xiv) Mandays requirement for single round of plucking increased with increase in plucking intervals from 3 to 17 days but total mandays required throughout the season for plucking and the total cost of plucking decreased with increase in plucking interval from 3 to 13 days in unpruned year, and from 3 to 11 days in pruned year. However, further increase in plucking interval upto 17 days during both the years did not affect the total mandays requirement and cost of plucking to significant level.

(xv) During unpruned year, plucking intervals of 3 to 9 days resulted in statistically similar gross income per hectare which was significantly higher than that of 15 and 17 days intervals. In pruned year, the gross income was highest at the shortest interval of 3 days and it decreased significantly with increase in plucking interval except at 17 days interval which was statistically similar to that of 7 and 9 days intervals.

(xvi) The return per rupee invested on plucking was highest in case of 13 days interval in unpruned year and 7 days interval in pruned year. However, plucking interval of 9 to

17 days in unpruned year and from 7 to 17 days in pruned year did not differ significantly among them in this respect but had significantly higher income per rupee invested than shorter intervals.

6.3.Effect of months of plucking

- (i) In unpruned year, the overall growth of shoot was more in April followed by May, July and August. Similarly, in pruned year, the growth was more in May followed by July and August. The number of unfolded leaves, fresh and dry weights per shoot were higher in these months while dormancy index was lower. On the other side, number of unfolded leaves, fresh and dry weights per shoot were lower while dormancy index was higher in October during both the years. The month was followed by September and June in unpruned year and September and July in pruned year in these respects.
- (ii) The rate of fresh and dry weight increment in shoot was highest in April in unpruned year and May in pruned year. The rate decreased consistently in subsequent months during both years.
- (iii) The average regeneration rate varied from 24 to 42 days in unpruned year and 26 to 30 days in pruned year. In unpruned year, rate of regeneration was faster in April followed by July, August and September, while in pruned year the faster rate was observed in September followed by August, May, June and July. During both years the month of

higher dormancy index had slower rate of regeneration of shoot. Shoots did not regenerate to 2+Bud stage in October during both the years of study.

(iv) Green leaf harvested in early flush (i.e. before mid June), main flush *i.e.* between mid June to mid September) and backend flush (i.e. after mid September) during pruned year was 13.2%, 97.4% and 147.5% of the yield harvested in the corresponding flushes in unpruned year. Thus, compare to total yield of unpruned year the green leaf yield in early and main flushes was 34.4 and 1.3% less while the yield of backend flush was 4.9% more. Similar was the trend in case of made tea yield.

(v) In unpruned year early, main and backend flushes yielded 39.7, 50.1 and 10.2% of the total green leaf produce while corresponding values in pruned year were 7.6, 70.6 and 21.8%, respectively. Similar were the figures in case of made tea yields.

(vi) The fineness of the crop was highest in April during unpruned year and in May during pruned year. It continued decreasing continuously in the subsequent months till September and increased slightly in October during both the years.

(vii) During unpruned year the polyphenol content in tea shoot was highest in April and May (early flush) and decreased in the crop of subsequent months. Contrary to this, the

polyphenol content in tea shoot was lowest in May (i.e. early flush). It continued to rise with increase in month from May to October (i.e. early to backend flush) in pruned year. The crop plucked in July and August had similar polyphenol contents during both the years.

(viii) The 'black orthodox tea' manufactured from the crop of May (early flush) contained higher caffeine content but tea of subsequent months had low contents till October during unpruned year. Slight but non significant improvement in the content was observed in October crop in the year. In pruned year, caffeine content was higher in the tea made from the crop of July and October.

(ix) The tea of May and October months during unpruned year had higher TF and brightness than the tea of remaining months. In pruned year, these were more in the tea of July followed by October and June. During both years, tea of August month had lowest value in respect of these parameters.

(x) During unpruned year, tea obtained from May and June pluckings (representing early flush) contained higher TR which decreased during subsequent pluckings. In pruned year, however, the trend was reversed, the highest content being in the October plucked tea (i.e. backend flush).

(xi) The colour of made tea during unpruned year was similar in all months, excepting October and August when it was lower. During pruned year, colour was more in tea of July

and September months followed by August, June and October. The tea of May plucked crop had poorest colour during pruned year.

- (xii) In taster's evaluation, the tea of May, June and October during unpruned year got higher scores for brightness, flavour and total quality and higher valuation. The tea of July, August and September plucked crop received lower scores for these parameters. During pruned year also the tea of October plucking got higher score for brightness and total quality followed by June, July, May and September. Tea of August plucking had least score for these quality parameters. There was no difference in flavour of the tea when plucked in different months during pruned year. In this year the valuation of tea from May plucking was highest followed by June, July, August and October, while tea of September month got lowest value.

6.4. Effect of methods of plucking

- (i) The growth of tea shoots expressed in terms of number of unfolded leaves, fresh weight and dry weight per shoot was significantly higher in mechanically (shear and machine) plucked bushes during both the years of study in all months except April in unpruned year. In some months black plucking remaining at par with shear and machine plucking, also resulted in better growth parameters than that of standard plucking.

- (ii) In most of the months, shoots plucked with different methods did not show much variation in respect of dry matter content particularly in unpruned year. Black plucking resulted in significantly lower content than other methods in April and August during unpruned year and similar was the trend during pruned year. Besides, in pruned year, dry matter content in standard and black plucked shoot was similar and higher than that of both shear and machine in May and shear in July; but in September, the content was higher in shear plucked shoots than other methods.
- (iii) Though non-significant, in most of the months during unpruned year and in all months during pruned year the dormancy index was higher in shear and machine plucked shoots.
- (iv) Density of plucking points per unit area and per primary was significantly more in shear and machine plucked bushes during unpruned year while in pruned year, the effect was not significant.
- (v) Bush spread was not influenced significantly due any of the methods of plucking.
- (vi) Annual creep was significantly higher in hand plucked (standard and black) bushes than mechanically plucked (shear and machine) ones in unpruned year whereas in pruned year shear plucking was at par with hand plucking.

- (vii) In general, total green leaf and made tea yields were higher with mechanical (shear and machine) plucking during both the years, but significantly higher yield was recorded only with shear plucking over other three methods which were at par and that too in unpruned year only. The yield of early flush during unpruned year had the same trend in respect of effect of methods of plucking.
- (viii) Green leaf and made tea yields were not affected significantly due to different methods of plucking in main flush during both the years.
- (ix) In backend flush of unpruned year and early flush of pruned year, shear and machine pluckings resulted in similar yield which was significantly higher than that of standard and black pluckings.
- (x) Green leaf and made tea yields were similar in both the systems of hand plucking *i.e.* standard and black plucking.
- (xi) All tea quality parameters determined in the present study namely fineness of crop, polyphenol content in tea shoots, and made tea parameters *viz.* content of caffeine, TF and TR as well as total colour and brightness were more in tea made from the crop of standard and black pluckings in most of the months during both the years as compared to shear and machine plucked tea. In some months during both the years the differences in quality of tea plucked by shear and machine with regard to polyphenol, caffeine, TF and TR contents as well as total colour and brightness were not

significant compared to standard or black plucked crops.

(xii) The fineness was better in shear plucked crop than that of machine plucked during both years.

(xiii) In most of the months of plucking during both the years, TF content was higher in black plucked crop than that of standard plucked.

(xiv) In taster's evaluation, the tea of standard and black plucked crop got better ratings for brightness, colour, flavour and total quality as well as value than that of shear and machine in all the months during both the years. The difference between different methods regarding colour in unpruned year and flavour in pruned year of made tea during all months was not significant. Similarly, the differences among methods of plucking regarding brightness of made tea was significant only in May and June during unpruned year and in July during pruned year. The flavour, total quality and valuation of tea manufactured from the harvest of shear and machine were statistically similar to that of standard plucking in October during unpruned year.

(xv) In unpruned and pruned years, the efficiency of machine and shear plucking was 9.06 and 5.86, and 2.30 and 2.17 times more than hand plucking, respectively.

(xvi) During both the years, machine plucking resulted in lowest mandays required for plucking *vis-a-vis* total cost of plucking followed by shear plucking. Black plucking

required highest mandays for plucking and resulted in highest cost of plucking followed by standard plucking during both the years.

(xvii) The average price and gross return per hectare were highest in case of standard system of hand plucking followed by black system, shear plucking and machine plucking in descending order, during both the years of study.

(xviii) Machine plucking resulted in highest return per rupee invested on plucking followed by shear plucking during unpruned year. In pruned year, shear plucking brought higher return followed by standard plucking.

CONCLUSIONS

The experiments conducted on unpruned and pruned tea bushes during 1990 and 1991, respectively under agro-climatic conditions of Palampur led to the following conclusions:

(i) The number of unfolded leaves per shoot increased with increase in plucking interval from 3 to 17 days. The dormancy index which is one of the negative factors for yield and quality in tea also increased with increase in plucking interval. All the growth parameters of tea bush like fresh and dry weights and their rate of accumulation; bush surface area, and annual creep increased with increase in plucking interval during both unpruned and pruned years. Dry matter

content decreased with increase in plucking interval upto 11 days and increase afterwards.

(ii) Productivity is increased by longer plucking interval but the crop plucked at longer intervals contains more coarse leaf particularly during the period of active growth *i.e.* in April-May, July and August. In addition, the dormant shoots increase during the period of slow growth *i.e.* in June, September and October, thus, lowering the quality of produce. The findings clearly establish that for obtaining a crop of around 50% (the acceptable limit) fineness, the plucking interval should not be longer than 9 days during pruned year and 13 to 15 days during unpruned year.

(iii) The quality of tea declined with each increase in plucking interval. For obtaining a good quality raw material for manufacturing high valued tea, the plucking interval should be as short as possible and should not be longer than 7 days during unpruned year and 5 days during pruned year.

(iv) By following longer intervals, the plucking efficiency improved and the cost of plucking decreased considerably. For obtaining highest gross return per unit area based on the price of Palampur Cooperative Tea Factory, the plucking interval should not be longer than 9 days during unpruned year and it should be even shorter than this during pruned year. However, to obtain highest return per rupee invested on plucking (a requirement of small tea planters), an

interval of 13 days during unpruned year and 7 days during pruned year can be followed.

- (v) Mechanical plucking (shear and machine) damaged most of actively growing immature 1+Bud shoots and buds, thus delayed the plucking interval. The undamaged shoots and buds overgrow by the time of successive plucking, though this method of plucking proved as good as standard plucking in respect of other growth parameters of tea.
- (vi) Shear and machine plucking improve the yield over hand plucking but fineness of the crop was lowered down resulting into lesser price and relatively poor quality of made tea. This indicates that there is still scope for improvement in mechanical plucking to avoid inclusion of coarse materials so that quality deterioration could be avoided.
- (vii) The machine plucking increased the efficiency of plucking 6-8 folds and shear plucking by 2 fold over that of hand plucking, thus reducing the plucking cost tremendously. However, the price realisation was not upto the extent of hand plucking owing to reduced fineness. Thereby, the gross income per hectare was lower in case of mechanical plucking than hand plucking. Black plucking proved as good as standard plucking in terms of yield, quality and overall economics. The mechanical plucking, therefore, offer promise in the situations of labour scarcity *vis-a-vis* the tea price based on its quality.

FUTURE LINES OF WORK

On the basis of present investigation certain aspects of tea management need further investigation as given under:

1. The weight of 3+Bud shoot was observed to be twice to that of 2+Bud shoot (two and a bud, a standard shoot). Therefore different standards of plucking i.e. plucking only 2+Bud shoots, 3+Bud shoots and so on may be investigated in relation to yield and quality of tea following standard plucking interval.

2. In mechanical plucking of tea, one of the main reasons for reduction in quality was observed the inclusion of cut leaves (both soft and hard, which do not get rolled properly during the process of manufacturing). Besides, the mechanical plucking also damaged many potential buds and immature 1+Bud shoot³. This indicates that the efforts may be made to reduce the proportion of cut and loose leaves and prevent the harvesting of unopened buds, small 1+Bud shoots, and mature leaves. In achieving this, the following points may be considered:

- (i) Raising the height of the plucking table by 1 to 2 cm at every successive/consecutive plucking interval.
- (ii) Selection of tea bush having horizontal leaves
- (iii) Modification of existing plucking machine or fabrication of new machines for selective plucking which can exclude the harvesting of undesirable shoot components.

3- An effort to adopt integrated plucking programme i.e. the combination of mechanical and hand plucking to strike a balance between quality and cost of plucking, may be another area of future research.

4. In future researches pertaining to Standards and Methods of plucking, observations on following growth parameters may also be included for better understanding of the cause and effect relationship:

- (i) Regeneration of the lateral shoots
- (ii) Number of shoot generations produced
- (iii) Potential buds on plucking points
- (iv) Die back of plucking points
- (v) Bush health including diameter of pruning sticks and weight of pruning litter.

5. Mechanical plucking reduces the cost of plucking drastically, but at the cost of quality. Investigations regarding standardisation of manufacturing process to obtain quality tea even from coarse leaves, may improve the economics of tea cultivation considerably.

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Appendix 1

(&) Mean weekly meteorological data during the year 1990

Date	Week	Mean Temp. (x°C)		Mean R.H. (%)	Total Sun shine (hours)	Total Rainfall (mm)	Total Evaporation (mm)
		Max.	Min.				
MAR:01-07	1	16.0	4.5	53.3	68.5	0.0	15.1
08-14	2	19.2	8.6	49.3	51.4	1.3	20.9
15-21	3	19.0	10.5	65.7	23.0	55.8	21.0
22-28	4	16.2	6.8	51.7	34.4	26.5	19.0
APR:29-04	5	18.3	7.4	45.6	62.4	16.4	23.6
05-11	6	22.3	11.7	45.6	43.3	25.9	33.6
12-18	7	24.7	14.3	46.1	37.5	11.3	32.9
19-25	8	29.1	16.5	26.7	81.0	0.0	56.3
MAY:26-02	9	27.8	16.7	28.0	48.3	0.5	44.7
03-09	10	26.6	16.1	53.7	46.9	14.5	35.6
10-16	11	29.1	18.3	60.9	48.3	30.4	33.8
17-23	12	29.0	18.5	38.1	63.5	62.0	47.9
24-30	13	32.0	20.1	31.7	69.6	65.5	51.1
JUN:31-06	14	31.1	20.2	36.3	70.7	0.0	49.6
07-13	15	30.2	20.0	37.6	51.7	3.7	40.3
14-20	16	31.7	20.6	44.9	62.3	48.1	41.5
21-27	17	28.9	21.5	72.4	26.1	69.0	23.5
JUL:28-04	18	26.0	20.4	81.6	21.2	286.1	25.3
05-11	19	25.3	19.6	80.9	17.3	346.7	18.9
12-18	20	26.2	20.0	78.7	28.8	164.5	17.2
19-25	21	25.9	19.6	76.3	39.3	79.6	19.5
26-01	22	25.9	20.2	82.9	16.9	193.6	20.4
AUG:02-08	23	25.9	19.2	80.0	18.5	363.8	11.3
09-15	24	25.1	19.1	83.4	26.5	189.5	18.3
16-22	25	26.8	19.9	79.3	30.5	61.5	19.4
23-29	26	25.9	19.5	82.9	35.2	137.5	16.5
SEP:30-05	27	25.5	19.2	79.3	32.0	128.0	17.2
06-12	28	24.5	18.5	82.1	28.6	69.3	16.4
13-19	29	25.5	18.5	79.7	37.0	91.0	15.2
19-26	30	24.6	17.2	78.3	38.1	33.9	15.1
26-03	31	24.8	15.6	65.9	61.0	0.0	18.7
OCT:04-10	32	26.0	15.6	54.0	70.9	0.0	24.8
11-17	33	23.9	13.3	51.4	66.6	25.9	28.7
18-24	34	23.0	11.8	45.7	67.2	0.0	23.8
25-31	35	22.0	11.3	53.4	65.8	1.6	19.9
NOV:01-07	36	22.8	11.8	44.6	66.3	0.0	28.9
08-14	37	23.1	11.6	39.9	67.8	0.0	22.5
15-21	38	22.4	10.6	34.4	58.8	1.0	20.8
22-28	39	19.2	8.2	40.0	55.0	2.4	17.6

Appendix KconL.)

(b) Mean weekly meteorological data during the year 19U1

Date	Week	Mean Temp. (x°C)		Mean R.H. (%)	Total Sun shine (hours)	Total Rainfall (mm)	Total Evaporation (mm)
		Max.	Min.				
MAR:01-07	1	16.4	6.4	44.9	40.5	30.3	17.8
08-14	2	19.6	10.3	48.1	43.6	41.5	21.0
15-21	3	22.6	12.2	45.6	36.5	5.8	33.2
22-28	4	21.0	9.3	47.7	59.6	12.7	30.8
APR:29-04	5	26.2	14.0	42.1	68.4	16.2	40.2
05-11	6	21.4	11.3	55.0	42.0	27.0	27.2
12-18	7	20.5	10.5	47.6	48.9	42.6	23.8
19-25	8	23.2	13.5	35.1	69.7	13.0	40.7
MAY:26-02	9	28.6	16.3	34.1	71.7	7.4	47.2
03-09	10	29.2	18.1	34.4	50.9	0.0	42.1
10-16	11	30.1	16.7	29.4	72.2	0.0	53.2
17-23	12	29.0	18.1	41.0	54.1	9.5	59.3
24-30	13	31.1	19.2	32.8	50.8	10.8	49.5
JUN:31-06	14	31.0	20.4	49.3	56.1	0.0	50.7
07-13	15	29.1	19.5	57.1	57.8	50.2	41.8
14-20	16	28.2	18.9	64.4	29.8	18.1	34.2
21-27	17	30.6	20.7	43.7	81.9	0.0	51.8
JUL:28-04	18	32.2	22.5	46.9	60.4	9.9	43.4
05-11	19	30.0	21.9	56.4	53.0	56.1	31.0
12-18	20	27.4	19.7	70.0	32.0	243.2	19.4
19-25	21	26.4	20.4	78.4	38.6	143.0	20.3
26-01	22	27.3	20.7	82.3	26.1	157.9	16.4
AUG:02-08	23	26.1	19.9	83.1	36.7	195.0	20.5
09-15	24	26.5	18.5	75.4	36.9	144.7	14.6
16-22	25	25.5	19.6	82.7	13.2	135.1	16.2
23-29	26	26.0	19.4	78.9	24.2	307.2	13.5
SEP:30-05	27	25.7	19.2	80.7	27.7	77.2	19.2
06-12	28	24.5	18.8	78.9	28.9	100.6	18.7
13-19	29	24.5	17.9	76.6	29.7	94.6	17.9
19-26	30	26.3	16.4	60.4	47.0	0.0	19.9
26-03	31	25.6	14.2	55.7	66.9	0.0	24.5
OCT:04-10	32	26.7	15.0	52.0	71.6	0.0	29.4
11-17	33	25.3	13.4	49.7	63.1	0.0	27.2
18-24	34	24.4	12.5	49.0	68.9	0.0	24.5
25-31	35	23.5	12.0	47.4	67.7	0.0	25.2
NOV:01-07	36	21.7	10.9	45.6	61.4	0.0	18.3
08-14	37	19.5	8.8	48.9	53.0	3.8	17.3
15-21	38	18.9	7.5	49.9	62.3	0.0	16.4
22-28	39	19.0	8.4	44.3	42.1	0.0	15.0

Aupjenciix: II

Co3t of plucking in Experiment I (Plucking interval trial)

Plucking intervals	Mandays required for plucking			Cost of plucking (9 Rs. 22/day)		
	R1	B2	R3	R1	R2	R3
Unpruned year (1990)						
3 days	2044	2114	2086	44972.2	46504.4	45892.6
5 days	1464	1546	1373	32214.9	34005.8	30205.6
7 days	1225	1242	1098	26941.9	27321.6	24148.3
9 days	827	1074	1012	18183.1	23625.0	22268.1
11 days	831	867	917	18280.5	19064.6	20185.0
13 days	734	765	833	16150.1	16823.1	18315.2
15 days	630	866	706	13871.0	19054.0	15541.6
17 days	776	746	800	17070.6	16423.0	17600.6
Pruned year (1991)						
3 days	878	936	949	19319.3	20587.8	20868.6
5 days	700	652	735	15393.4	14343.6	16173.9
7 days	588	636	526	12937.9	13981.3	11562.0
9 days	419	533	553	9216.1	11730.7	12171.9
11 days	406	433	510	8923.3	9516.4	11228.7
13 days	390	419	443	8584.3	9220.9	9756.6
15 days	391	445	438	8610.8	9791.3	9643.7
17 days	432	394	435	9498.4	8657.1	9564.1

Cost of plucking in Experiment II (Method of plucking trial)

Methods	Replications (Rows)				Replications (Rows)				
	II	III	IV	II	III	IV	II	III	IV
	Unpruned year (1990)				Pruned year (1991)				
	Number of mandays required for plucking								
Standard	818.1	1025.2	894.1	928.3	631.5	657.9	641.5	577.0	
Black	1242.1	1065.9	1166.3	1028.6	647.9	644.9	530.3	573.8	
Shear	602.4	501.0	579.6	445.6	292.5	311.7	326.0	287.7	
Machine	115.7	124.1	122.4	113.2	100.9	119.8	116.3	107.9	
	Labour cost for plucking (@ Rs 22 per manday)								
Standard	17998	22554	19669	20422	13893	14473	14112	12694	
Black	27325	23450	25659	22629	14253	14189	11666	12623	
Shear	13253	11021	12752	9803	6436	6857	7172	6329	
Machine	2546	2731	2693	2491	2219	2635	2559	2375	
	ne) and fuel (in case of machine/								
Standard	0	0	0	0	0	0	0	0	
Black	0	0	0	0	0	0	0	0	
Shear	50	50	50	50	50	50	50	50	
Machine	5204	5472	5417	5123	4727	5333	5222	4954	
	Total cost of plucking (Rs/ha)								
Standard	17998	22554	19669	20422	13893	14473	14112	12694	
Black	27325	23450	25659	22629	14253	14189	11666	12623	
Shear	13303	11071	12802	9853	6486	6907	7222	6379	
Machine	7750	8203	8109	7614	6946	7968	7781	7329	

*N.B.:

Price of shear = Rs 500
Price of machine = Rs 15000

Depreciation cost = 10% of actual price
Consumption of fuel (@250 ml/hr) = Rs 32 per manday

Appendix III

Price of green leaf^{1*}

Fineness (%)	Price (Rs/kg)	Fineness (%)	Price (Rs/kg)
30	3.00	66	8.26
31	3.12	67	8.42
32	3.24	68	8.58
33	3.36	69	8.74
34	3.48	70	8.90
35	3.60	71	9.06
36	3.72	72	9.22
37	3.84	73	9.38
38	3.96	74	9.54
39	4.08	75	9.70
40	4.20	76	9.86
41	4.35	77	10.02
42	4.50	78	10.18
43	4.65	79	10.34
44	4.80	80	10.50
45	4.95	81	10.66
46	5.10	82	10.82
47	5.25	83	10.98
48	5.40	84	11.14
49	5.55	85	11.30
50	5.70	86	11.46
51	5.86	87	11.62
52	6.02	88	11.78
53	6.18	89	11.94
54	6.34	90	12.10
55	6.50	91	12.26
56	6.66	92	12.42
57	6.82	93	12.58
58	6.98	94	12.74
59	7.14	95	12.90
60	7.30	96	13.06
61	7.46	97	13.22
62	7.62	98	13.38
63	7.78	99	13.54
64	7.94	100	13.70
65	8.10		

* As paid by The Palampur Co-operative Tea Factory

Appendix IV
Analysis of Variance for g

Source	d.f.	Mean sum			
		No. of unfolded leaves	Dormancy index (1x10 ⁻⁴)	Fresh weight of shoot	D w o s
Unpruned					
Replication	2	0.09	273.9	2134	
P.Intervals	7	14.88*	11984.0*	830509*	
Months	6	1.19*	12632.7*	144884*	
I x M	42	0.07*	1190.1*	11610*	
Error	110	0.04	303.8	2396	
Pruned					
Replication	2	0.01	8.4	39425	
P.Interval	7	20.62*	351.3*	3164336*	1
Month	5	3.02*	398.4*	1407244*	
I x M	35	0.22*	38.3*	100732*	
Error	94	0.04	10.2	9935	

Appendix IV

Anaiyaia of variance for growth atudioa (conl,.)

Mean sum of squares (M.S.) for
Rate of shoot regeneration

Source	d.f.	M.S.	d.f.	M.S.
	Unpruned year (1990)		Pruned year (1991)	
Replication	2	0.158	2	1.467
P.Interval	7	9.968	7	1.393
Months	5	1024.799*	4	6179.050*
l x M	35	5.336	28	2.104
Error	94	4.227	78	1.765

Appendix IV (cont.)

Source	d.f.	Mean sum of squares			
		Plucking points/ 100, sq ² cm bush area	Plucking points/ primary of tea bush	Per cent Increase in bush surface area	Annual creep
Unpruned year (1990)					
Replication	2	8.34	25.5	0.625	0.565
P.Interval	7	1980.01*	899.4*	1.213*	2.034*
Error	14	41.98	117.8	0.425	0.547
Pruned year (1991)					
Replication	2	3..3	38.2	0.67	0.67
P.Interval	7	967.1*	283..2*	0.72	0.72
Error	14	44..0	33.3	0.67	0.50

Appendix V

Analyses of variance for green leaf and made tea yields

Source	d.f.	Mean sum of squares							
		Green leaf yield				Made tea yield			
		Early flush	Main flush	Backend flush	Total season	Early flush	Main flush	Backend flush	Total season
Unpruned year (1990)									
Replication	2	2675562	1634094	16861	8994502	171381	114313	1279	599776
P. Interval	7	1218334	3105702*	284710*	7577304*	49301	132331*	16479*	293816*
Error	14	822514	187937	16691	1499901	49352	11351	1056	93400
Pruned year (1991)									
Replication	2	23330	1438517	177872	2921834	2198	169549	22004	355184
P. Interval	7	118693*	4827709*	943884*	8982288*	6413*	234091*	56270*	478248*
Error	14	34287	640374	68261	923978	1934	38429	4255	57186

Appendix VI

Analyses of variance for quality of tea

Source	d.f.	Mean sum of squares					
		Unpruned year (1990)			Pruned year (1991)		
		Fineness of crop	Polyphenol content in tea shoot	d.f.	Fineness of crop	Polyphenol content in tea shoot	d.f.
Replication	2	5..20	0..68	2	35.70	0.03	
P. Interval	7	1872..70*	145..50*	7	6256.00*	55.11*	
Month	6	599..80*	58..60*	5	562.80*	42.80*	
I x M	42	38..20*	3..06*	35	66.70*	3.52*	
Error	110	12..30	1..64	94	12.50	0.79	

Appendix VII

Analyses of variance for made tea parameters

Source	d.f.	Mean sum of squares				
		Caffeine content	TF content	TR content	Total colour	Brightness
Unpruned year (1990)						
Replication	2	0.09	0.00084*	1.342	0.071	6.87
P.Interval	7	3.43*	0.05634*	67.834*	3.990*	239.83*
Month	5	1.24*	0.00983*	28.338*	1.831*	165.74*
1 x M	35	0.15*	0.00445*	2.731*	0.181*	12.09*
Error	94	0.03	0.00037	0.893	0.050	2.42
Pruned year (1991)						
Replication	2	0.06	0.00101*	1..312	0.059	4.94
P.Interval	7	3.81*	0.04623*	59..345*	2.958*	108.32*
Month	5	1.11*	0.01785*	19..372*	0.943*	95.84*
I x M	35	0.31*	0.00314*	2..431*	0.123*	13.35*
Error	94	0.02	0.00032	0..651	0.038	1.49

Appendix VIII

Analyses of variance for Tasters' evaluation of made tea parameters

Source	d.f.	Mean sum of squares				
		Brightnes	Colour	Flavour	T.Quality	Valuation
Unpruned year (1990)						
Replication	2	0.47*	0.00	0.74*	2.34*	14.63*
P.Interval	7	5.75*	0.00	5.86*	22.32*	154.84*
Month	5	14.77*	0.00	5.02*	36.35*	198.82*
I x M	35	1.65*	0.00	1.46*	5.13*	63.60*
Error	94	0.12	0.00	0.06	0.19	1.55
Pruned year (1991)						
Replication	2	0.51*	0.00	0.05*	0.86*	0.13
P.Interval	7	2.85*	0.00	3.63*	10.41*	62.00*
Month	5	1.23*	0.00	0.02	1.30*	4.14*
I x H	35	0.77*	0.00	0.03	0.87*	6.28*
Error	94	0.09	0.00	0.02	0.09	0.93

Appendix IX

a) Analysis of variance for economics of **plucking** : **Cost of plucking**

Source	d.f.	Mean sum of squares		
		Av.Mandays /interval /hectare	Total Mandays per hectare during season	Cost of plucking
Unpruned year (1990)				
Replication	2	29.2	14897.8	7210532
P.Interval	7	285.3*	648712.9*	2197839313*
Error	14	12.8	5170.0	35031970
Pruned year (1991)				
Replication	2	13.3	4754.4	2301129
P.Interval	7	177.8*	95267.5*	322766237*
Error	14	4.4	1678.2	11371666

b) Analysis of variance for economics of plucking : Returns from plucking

Source	d.f.	Mean sum of squares			
		Plucking efficiency	Av.price of leaf	Gross income per hectare	Income/rupee
Unpruned year (1990)					
Replication	2	0.1205	0.010	402924934	0.631
P.Interval	7	9.2618*	7.381*	197544801*	3.282*
Error	14	0.4112	0.043	50344891	0.118
Pruned year (1991)					
Replication	2	0.0324	0.120	106042868	0.172
P.Interval	7	17.1271*	24.870*	491538975*	0.326*
Error	14	0.3955	0.053	31210410	0.097

Appendix X

Analysis of variance for growth studies

(a) Number of unfolded leaves per shoot

Source	d.f.	Mean sum of squares						
		April	May	June	July	August	September	October
Onpruned year (1990)								
Row	3	0.001	0.011	0.013	0.006	0.001	0.005	0.014
Column	3	0.008	0.015	0.001	0.002	0.002	0.011	0.033
Method	3	0.023	0.312*	0.079*	0.043*	0.125*	0.453*	0.476*
Error	6	0.012	0.035	0.011	0.009	0.003	0.013	0.014
Pruned year (1991)								
Row	3	-	0.005	0.003	0.007	0.007	0.011	0.049
Column	3	-	0.007	0.023	0.002	0.007	0.019	0.005
Method	3	-	0.983*	0.701*	1.012*	1.264*	0.895*	0.982*
Error	6	-	0.004	0.006	0.007	0.002	0.045	0.006

(b) Dormancy index

Source	d.f.	Mean sum of squares (1 x 10 ⁴)						
		April	May	June	July	August	September	October
Unpruned year (1990)								
Row	3	0.602	10.522	48.580	56.848	79.750	1236.280	2907.060
Column	3	12.527	94.222	460.570	41.238	74.390	354.030	5779.440
Method	3	12.368	598.841*	215.160	22.055	213.520*	4900.240*	10056.420
Error	6	19.535	48.581	92.280	46.318	22.670	523.070	4232.540
Pruned year (1991)								
Row	3	-	0.000	4.226	13.010	6.602	33.153	254.010
Column	3	-	0.000	3.132	5.778	4.059	59.982	161.477
Method	3	-	0.000	16.593	5.282	22.603	125.905	1115.079
Error	6	-	0.000	6.554	6.676	6.984	36.412	269.192

Appendix X (cont.)

(c) Fresh weight of shoot

Source	d.f.	Mean sum of squares						
		April	May	June	July	August	September	October
Unpruned year (1990)								
Row	3	773	2766	322	10	10	121	288
Column	3	758	1993	465	164	108	213	3706
Method	3	371	52489*	3630	1835*	3334*	9769*	14693*
Error	6	2037	6671	4036	503	740	328	2987
Pruned year (1991)								
Row	3	-	11	8	244	186	550	1096
Column	3	-	766	982	1767	505	1278	140
Method	3	-	65674	58753	86808	44756	48344	38520
Error	6	~	928	310	1131	359	852	473

(d) Dry weight of shoot

Source	d.f.	Mean sum of squares						
		April	May	June	July	August	September	October
Onpruned year (1990)								
Row	3	45.9	159.0	24.0	9.4	0.4	8.1	24.6
Column	3	58.6	79.8	25.0	18.7	6.0	22.5	160.5
Method	3	44.3	3066.9*	198.5	211.3*	174.3*	208.2*	940.3*
Error	6	128.7	295.1	191.2	20.3	33.4	13.6	173.4
Pruned year (1991)								
Row	3		34.7	55.9	178.6	11.5	23.9	23.5
Column	3		33.6	43.8	23.2	23.3	60.3	5.8
Method	3		4434.2*	3427.1*	4436.0*	2327.5*	2301.2*	2654.3*
Error	6		38.4	88.4	64.3	16.8	43.5	23.3

Appendix X (cont.)

(e) Dry matter content of shoots

Source	d. f.	Mean sum of squares						
		April	May	June	July	August	September	October
Onpruned year (1990)								
Row	3	0.92	0.46	0.17	0.14	0.03	0.08	0.08
Column	3	0.25	1.69	2.14	1.03	0.59	0.49	0.22
Method	3	2.18*	0.31	0.67	0.49	3.27*	0.93	0.65
Error	6	0.29	0.29	0.64	0.11	0.22	0.23	0.33
Pruned year (1991)								
Row	3	-	0.24	0.52	0.61	0.47	0.09	0.06
Column	3	-	0.07	0.39	0.53	0.14	0.02	0.33
Method	3	-	2.17*	0.55	3.60*	0.18	1.25*	2.96*
Error	6	-	0.18	0.42	0.47	0.16	0.13	0.42

(f) Per cent increase in bush surface area, annual creep and number of plucking points

Source	d. f.	Mean sum of squares							
		increase in bush surface area (%)		Annual creep		Number of plucking points			
		1990	1991	1990	1991	per 100 area 1990	per 100 area 1991	per primary 1990	per primary 1991
Row	3	0.067	0.352	0.09	0.16	117.4	31.2	80.75	19.74
Column	3	0.045	0.145	0.02	0.09	31.1	133.2	151.81	10.86
Method	2	1.234	5.049	3.29*	3.99*	881.7*	16.2	431.11	23.23
Error	6	0.486	1.566	0.05	0.05	81.8	89.9	104.00	8.01

1990 : Unpruned year, & 1991 : Pruned year

Appendix XI

Analyses of variance for green leaf and made tea yields

(a) Green leaf yield

		Mean sum of squares			
Source	d.f.	Early flush	Main flush	Backend flush	Total season
Unpruned year (1990)					
Row	3	6317	160131	23935	231158
Column	3	59866	267600	10522	269350
Method	3	1214000*	96523	288288*	3210650*
Error	6	126711	89372	8820	365862
Pruned year (1990)					
Row	3	42141	174781	48534	697560
Column	3	16568	147658	126084	441987
Method	3	151524*	107824	37709*	351229
Error	6	23003	44815	7788	141896

(a) Made tea yield

		Mean sum of squares			
Source	d.f.	Early flush	Main flush	Backend flush	Total season
Unpruned year (1990)					
Row	3	702	8039	1440	13299
Column	3	8077	9344	423	13671
Method	3	80268*	6995	19262*	214678*
Error	6	7753	4810	613	23258
Pruned year (1990)					
Row	3	2660	12002	2948	45018
Column	3	997	8303	8274	25785
Method	3	6606*	3537	3072*	18722
Error	6	1899	2967	407	7181

Appendix XII

Analysis of variance for quality of tea

(a) **Fineness of crop**

Source	d.f.	Mean sum of squares						
		April	May	June	July	August	September	October
Unpruned year (1990)								
Row	3	22.8	21.0	17.9	13.0	8.9	7.7	30.0
Column	3	12.9	2.9	22.9	16.8	12.0	11.9	65.9
Method	3	1043.9*	895.3*	645.8*	834.0*	1235.0*	1045.8*	345.6*
Error	6	18.1	16.4	16.1	8.9	10.0	17.9	30.9
Pruned year (1991)								
Row	3		54.8	36.6	3.4	4.5	9.2	54.9
Column	3		2.1	29.9	6.6	6.6	6.0	59.1
Method	3	-	1099.1*	969.7*	1029.5*	982.1*	1344.1*	455.4*
Error	6		11.1	11.0	5.2	7.6	13.5	27.3

(b) **Polyphenol content in tea shoots**

Source	d.f.	Mean sum of squares						
		April	May	June	July	August	September	October
Unpruned year (1990)								
Row	3	0.089	0.121	0.081	0.007	0.012	0.101	0.471
Column	3	0.020	0.109	0.112	0.121	0.100	0.054	0.171
Method	3	6.121*	5.991*	4.449*	9.421*	3.491*	1.512	3.181*
Error	6	0.816	0.964	0.473	0.486	0.184	0.598	0.598
Pruned year (1991)								
Row	3	-	0.022	0.121	0.021	0.041	0.121	0.314
Column	3	-	0.020	0.012	0.091	0.121	0.074	0.079
Method	3	-	2.889*	2.988*	1.949*	2.493	2.022*	3.369*
Error	6	-	0.264	0.264	0.287	0.626	0.290	0.463

Appendix XIII

Analyses of variance for made tea parameters

(a) Caffeine content

Source	d.f.	Mean sum of squares					
		May	June	July	August	September	October
Onpruned year (1990)							
Row \	3	0.0161	0.0290	0.0146	0.0083	0.0141	0.0121
Column	3	0.0192	0.0112	0.0073	0.0121	0.0138	0.0073
Method	3	0.1862*	0.0823	0.5649	0.0522	0.0241	0.0472*
Error	6	0.0123	0.0232	0.0101	0.0131	0.0072	0.0061
Pruned year (1991)							
Row	3	0.0121	0.0091	0.0321	0.0129	0.0114	0.0021
Column	3	0.0083	0.0042	0.0140	0.0051	0.0121	0.0121
Method	3	0.1128*	0.0504*	0.0699*	0.0284*	0.1021*	0.0930*
Error	6	0.0091	0.0062	0.0071	0.0034	0.0069	0.0086

(b) Theaflavln content

Source	d.f.	Mean sum of squares					
		May	June	July	August	September	October
Unpruned year (1990)							
Row	3	0.00048	0.00069	0.00061	0.00021	0.00012	0.00020
Column	3	0.00081	0.00021	0.00045	0.00014	0.00031	0.00019
Method	3	0.00651*	0.00768*	0.00691*	0.00171*	0.00093*	0.00151*
Error	6	0.00031	0.00038	0.00015	0.00007	0.00008	0.00005
Pruned year (1991)							
Row	3	0.00112	0.00019	0.00041	0.00007	0.00051	0.00018
Column	3	0.00063	0.00022	0.00039	0.00021	0.00050	0.00041
Method	3	0.05624*	0.00101*	0.00151*	0.00111*	0.00115*	0.00132*
Error	6	0.00094	0.00011	0.00014	0.00010	0.00022	0.00019

Appendix XIIKcont.)

(c) Thrugigin content

Source	d.f.	Mean sum of squares					
		May	June	July	August	September	October
Unpruned year (1990)							
Row	3	0.14321	0.84124	0.13421	1.03413	0.29294	0.69325
Column	3	0.07541	1.02541	0.34343	0.98793	0.13213	0.24342
Method	3	1.73241*	2.08341	0.69912	2.99894*	1.19325*	1.53322*
Error	6	0.15049	0.61453	0.23369	0.32055	0.11869	0.23372
Pruned year (1991)							
Row	3	0.08431	0.05231	0.39211	0.01541	0.11121	0.12751
Column	3	0.01212	0.04243	0.12444	0.13422	0.05632	0.29311
Method	3	0.25734*	0.91214*	0.89632*	2.25120*	4.01821*	1.80290*
Error	6	0.03956	0.08013	0.11232	0.18817	0.28702	0.27483

(d) Total colour of tea

Source	d.f.	Mean sum of squares					
		May	June	July	August	September	October
Unpruned year (1990)							
Row	3	0.0081	0.0007	0.0111	0.0101	0.0076	0.0073
Column	3	0.0261	0.0179	0.0081	0.0109	0.0078	0.0041
Method	3	0.1412*	0.2984*	0.2841*	0.1089*	0.0411*	0.0244*
Error	6	0.0132	0.0299	0.0103	0.0151	0.0036	0.0022
Pruned year (1991)							
Row	3	0.0111	0.0052	0.0202	0.0291	0.0005	0.0071
Column	3	0.0181	0.0039	0.0080	0.0211	0.0061	0.0047
Method	3	0.0510*	0.0899*	0.0351*	0.0699*	0.0761*	0.0498*
Error	6	0.0021	0.0040	0.0052	0.0065	0.0099	0.0048

Appendix XIII(cont.)

(e) Brightness of tea

Source	d.f.	Mean sum of squares					
		May	June	July	August	September	October
Unpruned year (1990)							
Row	3	1.1213	0.9421	1.1214	0.0842	0.0845	2.1316
Column	3	2.1470	0.0511	0.0911	1.0111	1.0311	2.0480
Method	3	10.4230*	11.1110*	39.4240*	1.0101	29.4360*	39.3140*
Error	6	1.5010	1.2171	0.4618	0.3180	1.6990	0.2784
Pruned year (1991)							
Row	3	0.9343	0.9859	0.7324	0.0344	0.2542	0.0431
Column	3	1.2312	0.8843	0.6213	0.1235	0.1652	0.0354
Method	3	2.3743	2.1046	1.6024*	0.8883*	1.8334*	0.5473*
Error	6	0.7610	0.6320	0.2618	0.0888	0.2555	0.0578

Appendix:- XIV

Analysis of variance for tasters' evaluation of made tea

(a) Brightness

Source	d.f.	Mean sum of squares					
		May	June	July	August	September	October
Unpruned year (1990)							
Row	3	0.17	0.02	0.19	0.08	0.04	0.08
Column	3	0.17	0.10	0.02	0.00	0.13	0.08
Method	3	3.67*	2.77*	0.40	0.33	0.33	0.25
Error	6	0.17	0.06	0.10	0.13	0.17	0.08
Pruned year (1991)							
Row	3	0.17	0.00	0.19	0.00	0.00	0.06
Column	3	0.50	0.00	0.19	0.33	0.33	0.06
Method	3	0.32	0.00	0.73*	0.33	0.33	0.06
Error	6	0.25	0.00	0.10	0.17	0.17	0.06

Appendix XIV(cont.)

(b) Colour

Source	d.f.	Mean sum of squares					
		May	June	July	August	September	October
Unpruned year (1990)							
Row	3	0.08	0.00	0.00	0.00	0.00	0.00
Column	3	0.08	0.33	0.33	0.00	0.00	0.00
Method	3	0.08	0.33	0.33	0.00	0.00	0.00
Error	6	0.17	0.17	0.17	0.00	0.00	0.00
Pruned year (1991)							
Row	3	0.00	0.00	0.00	0.00	0.00	0.00
Column	3	0.00	0.00	0.00	0.00	0.00	0.00
Method	3	1.33*	1.33*	1.33*	1.33*	1.33*	1.33
Error	6	0.00	0.00	0.00	0.00	0.00	0.00

(c) Flavour

Source	d.f.	Mean sum of squares					
		May	June	July	August	September	October
Unpruned year (1990)							
Row	3	0.13	0.00	0.06	0.25	0.02	0.04
Column	3	0.04	0.00	0.06	0.08	0.19	0.04
Method	3	2.75*	1.33*	0.90*	0.75*	0.56	0.75*
Error	6	0.08	0.00	0.06	0.08	0.19	0.13
Pruned year (1991)							
Row	3	0.00	0.06	0.04	0.06	0.23	0.06
Column	3	0.00	0.06	0.13	0.23	0.06	0.06
Method	3	0.00	0.23	0.33	0.23	0.23	1.06*
Error	6	0.00	0.23	0.08	0.31	0.15	0.06

Appendix XIV(cont.)

(d) Total quality

Source	d.f.	Mean sum of squares					
		May	June	July	August	September	October
Unpruned year (1990)							
Row	3	0.96	0.02	0.38	0.17	0.10	0.21
Column	3	0.13	0.18	0.38	0.08	0.02	0.21
Method	3	14.67*	11.52*	3.58*	1.75*	1.73*	1.50*
Error	6	0.38	0.10	0.38	0.29	0.31	0.29
Pruned year (1991)							
Row	3	0.17	0.06	0.19	0.06	0.23	0.08
Column	3	0.50	0.06	0.35	0.73	0.56	0.25
Method	3	7.83*	2.56*	4.23*	3.73*	3.73*	5.42 *
Error	6	0.25	0.23	0.27	0.56	0.40	0.08

(e) Valuation

Source	d.f.	Mean sum of squares					
		May	June	July	August	September	October
Unpruned year (1990)							
Row	3	2.60	0.00	1.56	2.08	0.52	4.69
Column	3	0.52	0.00	1.56	6.25	4.69	2.60
Method	3	59.90*	33.33*	22.40*	18.75*	14.06*	14.06*
Error	6	3.65	0.00	1.56	2.08	4.69	3.65
Pruned year (1991)							
Row	3	0.00	1.56	1.04	1.56	1.56	1.56
Column	3	0.00	1.56	3.13	5.73	5.73	1.56
Method	3	0.00	5.73	8.33	5.73	5.73	26.56*
Error	6	0.00	5.73	2.08	7.81	3.65	1.56

Appendix XV

Analysis of variance for economics of methods of plucking

(a) Cost of plucking

Source	d.f.	Av.Mandays /interval /hectare	Mean sum of squares		Cost of plucking
			Total Mandays per hectare during season		
Dnpruned year (1990)					
Row	3	6.15	3672.94		1913845
Column	3	17.17	13910.60		6612698
Method	3	826.78*	788140.00*		236490996*
Error	6	2.08	2218.40		1098797
Pruned year (1991)					
Row	3	1.94	1615.18		875824
Column	3	2.33	2140.67		848644
Method	3	157.72*	244362.70*		54574366*
Error	6	0.95	571.71		411569

(b) Returns from plucking

Source	d.f.	Plucking efficiency	Mean sum of squares		
			Av.price of leaf	Gross income per hectare	Income/rupee
Dnpruned year (1990)					
KOW	3	0.224	0.072	40666724	0.479
Column	3	0.089	0.055	20597304	0.294
Method	3	79.976*	23.629*	1606529284*	1.440*
Error	6	0.071	0.011	22116229	0.096
Pruned year (1991)					
Row	3	0.060	0.096	9445234	0.066
Column	3	0.060	0.079	35679947	0.136
Method	3	42.937*	28.625*	1202200219*	1.153*
Error	6	0.059	0.018	9172993	0.156

(XX)