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Review Article

Harvesting the Critical Determinant in Achieving the Target Productivity in Tea (Camellia Spp.)

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Abstract

When inputs and management practices are tuned to a target yield, then harvesting strategies play a crucial part in getting the full benefits out of all the efforts put in to coerce the plants to respond to all resources made available to them. Harvesting techniques and problems encountered thereat vary from plant to plant; but one thing common is that they, all, involve human labor irrespective of the proportion of manual and mechanical components in them. A study made in harvesting management in tea crop is discussed in this paper.

Keywords

Ultimate Yield Equation; Taking End Product Out of the Field.

Introduction

In tea the harvesting is known as plucking and this is a labor intensive operation. The breakup of cultivation expenses and labor employment in a tea estate with a mean annual productivity around 2500 Kg per ha is shown in Table1 below:

Table 1: Break up of labor employment

Heading	$mdha^{-1}yr^{-1}$	$mdha^{-1}yr^{-1}$as%	COP as%
Fixed charges	105	1.0	44
Variable Charges			
Manuring	19	2.5	8
Plucking	510	63.0	27
Manufacture	65	8.0	16
Others	4	0.5	5
Sub-total	598	87.0	56
Total	705	87.0	100

About 63% 0f labor is used in plucking and it constitutes about 27% of cost of production. Traditionally plucking is done manually with their efficiency rated on what one plucks in a day (commonly known as PA Plucking average) according to standards for quality and yield. Lot of work has gone in to improve the efficiency of plucking without affecting the quality parameters and generation of shoots for future crop. It includes fixing standard of leaves to be plucked, style of plucking, intensity of plucking according to the climatic variations, intensive plucking for getting the crop and rigid adherence to plucking rounds. On practical side time and motion studies were done In Assam to increase the plucking time which is about five hours only out eight hours duty. Time is lost on walking to weighing spots for every weighing, long walks after completing a field to go to the next field, and commuting plucking gang to far off fields by walking and so on. All these factors bear complex interacting relations requiring day to day attention of the man on the spot and it is no wonder that the plucking receives 80% of the management's attention, With this back ground the basis of ultimate determinate in achieving the target is perceived and analyzed.

Productivity and Efficiency of Harvesting

When the yield potential has been built on the bushes with inputs and, other cultural and plant protection measures supported by good climatic conditions the productivity exploited is determined as follows

$$Y = PHA/R \times PR \times PA \times OT \text{----------(1)}$$
$$Pha^{-1}yr^{-1} = PHA/R \times PR \text{--------------(2)}$$
$$Y = Pha^{-1}y^{-1} \times PA \times OT \text{---------------(3)}$$

Y is the yield kg ha^{-1}: PHA/R is the pluckers used per ha per round: PA is the plucking average in kg green leaf per man-day: OT is the factory out turn which on average is 23%: $Pha^{-1}yr^{-1}$is the pluckers used per ha per year.

PHA/R depends on crop on the bushes and hence on the yield potential built in the bushes; the interactions among PHA/R, PR, PA and yield are shown below. (Table 2)

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Table 2: Interaction of plucking parameters

	Y tha^{-1}	P $ha^{-1}yr^{-1}$	PHA/R	PR	PA
H	2.0 to 2,5	560	16	35/40	19/20
H	2.5 to3.0	648	18	35/40	19/20
H	3.0to 3.5	738	21	35/40	19/20
H	3.5 to 4.0	945	27	35/40	19/20
H	4.0 to 4,5	1170	34	35/40	19/20
S	2.5 to 3.0	304	16	18/20	36/50
M	2.5 to 3.0	184	10	18/20	40/200

H – Hand plucking. S= hand shearing: M1 – different types of one man and two men operated machines requiring one or more additional worker for handling collected crop

Though there is a saving in number of workers with hand shearing or mechanized harvesting, the cost of plucking per kg green leaf remains almost the same as they involve hidden expenditure on work-shop for maintenance of machines, cost of fuel and handling of transmission rope in case of electrically operated machines. However with increasing migration of labor to urban areas mechanization of at least certain percentage of area in tea estates has become a necessity for their viable running. The impact of cost of plucking and manufacturing of extra crop on COP is given by the equation taking 27% and 21% as their contribution respectively towards COP. Breakeven point in cost of plucking is as follows

$$Z=100[1—(100+XC^1+YC^2)/(100+X)]$$

X -% Increase in PC Y- % increase in Crop ;C_1 and C_2 are relative contribution of plucking and manufacturing costs towards COP: Z- % increase or decrease in COP (Cost of Production /kg tea)

There is no change in COP if there is one % increase in crop for a three percent increase in plucking cost

Plucking interval: Once a leaf is plucked, the bud(s) in the axil of leaf below it is activated and starts growing. The distinct stages of growth and their time line are shown in Table 3.

The time taken for the bud to grow into a pluckable shoot from the time of its activation to three leaves and a bud stage varies from 40 to 110 days depending on growing conditions defined in terms of water availability and temperature. The annual mean shoot growth period (as it is called) for various tea regions

Table 3: Distinct stages in shoot growth

	Stage	Time taken As % of duration from 1 to 9th stage
1	No visible change	48
2	Swelling of bud	9
3	Sprouting	9
4	Scale leaves	9
5	Fish leaf and a bud	9
6	Mother leaf and a bud	4
7	One leaf and a bud	4
8	Two leaf and a bud	4
9	Three leaf and a bud	4
	total	100

Mean Shoot growth time: Central Travancore: 65 ± 10 days: Wynaad 70 ± 10 days: High Range: 74 ± 10 day; Nilgiris: 90 ± 10 days Anamallais: 60 ± 10 days

in South India is shown in Table 3.

After the fish leaf is formed, then further growth to a pluckable stage takes 12to 16% time of SGP – during growing seasons with 45 days SGP (shoot growth period) it is 5 to 7 days ; during normal growing conditions with 70 days SGP it is 8 to 11 days and, during lean months with a mean 100 days SGP it is 12 to 16 days. Based on these growth rhythms 7 to 9 days and 10to15 days plucking intervals for rush and lean periods respectively have come into vogue and practiced traditionally for hand plucking. Of late the concept 0f "Phyllochron" (P) which is the time interval (day) between a terminal bud unfurling its second and third true leaves(Burgess and Carr 1998) is used to quantify the plucking interval in terms of mean air temperature.

$$1/p=0.0162–(Tmean –9)$$

Where "9" is apparent base temperatures for leaf appearance rate which also varies with the cultivar but a mean value taken for general application. The South Indian norms of plucking interval are equivalent to 2P in terms of "Phyllochron".

In any case the plucking interval depends on growing conditions. Under regular plucking, the number of stages or horizontal generations of growth seen is equal to SPG (shoot growth period) divided by PI (plucking interval) only 50% of generations will be visible above the surface (See Table 4). At shorter plucking intervals the number of generations on the surface is more and a plucker has to spend time in selecting shoots of standards fixed by the management. As such the plucking average goes down. With increasing length of plucking intervals, the selectivity quotient for the plucker decreases with increase in plucking average. The percentage of growing points plucked at a time is a function of the rhythm of appearance of generations by the interaction of shoot growth period and plucking intervals maintained (Table 4). Any disturbance to the rhythm results in crop loss for few rounds until the new rhythm gets stabilized. That is why in the early shearing trials where shearing and hand plucking alternated, the crop loss occurred when shearing was introduced and also on reverting back to hand plucking. Another reason is the removal of banjee leaves on and below the surface after shearing on reasons that the buds in their axil take a long time to get activated if banjee leaf is not removed. Banjjee leaves on the surface or below the surface are photosyntheticaly as efficient as normal leaves and their presence is required to support the new growing points for the next crop. The long plucking interval in shearing and mechanical harvesting bestows enough time for banjees to get activated and grow and close up the gaps and adding new growing points on the bush surface.

In any type of plucking systems banjees on and below the surface and, breaking back of multiple shoots should be avoided as they have a negative effect on shoots coming up from below and fill the plucking surface for future crop. Shearing and mechanized harvesting at 18 to 25 days interval will create only 3 to 4 generations out of which 1to2 generations will be above the surface. Flat shearing on the muttom (plucking surface LEVEL) with hand shears or machines will remove the shoots on the surface that are ready for manufacture. Once the rhythm is established it should not be disturbed until the bushes are pruned. Quality of leaves is not affected as the shoot age remains the same at all pluckings as programmed once the rhythm gets established after few rounds. In Central Travancore there was no reduction in auction prices for mid elevation orthodox teas after introduction of shearing (R&D division RBT Ltd. Cochin).

Table 4: Growth rhythm as influenced by Plucking interval

Plucking	Plucking Interval	Horizontal Generations	Generations plucked	Selectivity	Plucking points
system	PI	GH	GH/no	coefficient	% harvested
A	6 to 10 (8)	7to 11(9)	1 to2	1 in 5	9 to 14(11)
B	10 t0 15 (13)	4 to 8 (6)	1 to2	1 in 3	10 to 25 (17)
C	20to 30(25)	2to 4(3)	1to3	1in 2	25 to 50 (33)

A - Hand plucking - 6 t0 8 days during rush and 10 days during lean months
B - Hand plucking-10 to 12 da ys during rush and 12 to 15 days during lean months
C - Shearing and mechanized plucking-19 t0 23 days during rush and 25 to 30 days during lean months
Shoot growth period 40 to 110 days (75) :
Figures in brackets denotes average for the range imposed by varying growing conditions occurring within the year

Intensity of Plucking

It refers to the number of horizontal generations removed or plucked at a time depending on growing conditions so that those retained on the surface do not become coarse at the time of next plucking. Intensive plucking means the percent removal of shoots which are ready to go to the factory. The tendency of laborers is to walk fast plucking only big ones to gain plucking average and finish their task of the day. This is known as fly plucking in which around 70 % shoots are plucked.

The crop losses due to under plucking or fly plucking are shown in Table 5

These tendencies result in direct crop loss of 30% and delay the creation of future generation from these points. Loss of vertical generations from continued fly plucking is about one out of four to six generations possible - equivalent to a cumulative annual crop loss of 30 to 50%. This is one of the reasons for stagnating productivity levels in many of the tea areas though well managed in other aspects. In level shearing and machine shearing this loss is eliminated to a major extent.

Table 5: Plucking discipline (Intensity) and crop loss

Intensity of plucking %	commercial tea $kgha^{-1}$	Green leaf $Kgha^{-1}$	Pluckers per ha/annum	PA	Plucking Discipline	Crop Loss %
70	1800	8442	650	13.0	Fly plucking	45
75	2200	10318	650	15.9	Fly plucking	32
80	2500	11725	650	18.0	Fly plucking	23
85	2700	12663	650	19.5	Normal plucking	17
90	2800	13132	650	20.2	Normal plucking	14
95	2950	13836	650	21.3	Normal Plucking	9
100	3250	15243	650	23.5	Intensive plucking	0
100	3250	15243	716	21.3	Pluckers for Normal plucking	0

Seasonal crop Distribution; There is a seasonal variation in crop imposed by climatic factors defined in terms of agro-climatic potential. The crop distribution inflicted by agro-climatic potential for some tea growing areas is presented in Table 6. The relationship is highly significant and in most of the cases the actual monthly crop distribution closely follows the one inflicted by the climatic factors with marginal variations due to some over plucking in lien months and under plucking in rush seasons and areas pruned that are out of plucking and at different stages of recovery. There is a time lag of about five weeks in the pruned year and four weeks in other years between photosynthetic yield and expression in terms of growth. To-day's crop is a reflection of photosynthetic Yield obtained four to five weeks ago and the prevailing growing condition. Dry weather with water deficit and low temperature, and monsoon months with continuous down pour, reduced sun shine hours and choked soil produce low crop. Other periods with favorable soil and climatic factors produce huge crop which, at sometimes, becomes unmanageable.

Rush crop is created by overlapping or crowding of generations created at plucking in lean months which pick up growth rates as they enter into favorable growing conditions and approach pluck able stage much faster than what could have been but for the change in weather conditions. Instead of one generation to come to harvestable stage at each plucking, one or more generations created in previous plucks reach harvesting stage. Rush crop is not due to creation of more growing points but it is due to one or more generations created in the past reaching the harvestable stage due to picking of growth rates as they enter the favorable season.

Table 6: Crop distribution based on climatic factors

Region Latitude/longitudes Mean altitude +MSL	Assam 26'44N94'13"E 100m		Anamallais 10'19"N76'57"E 1200		Ratnapura 6'41"N80'40"E 30		Malawi 13'15"S34'18"E 1000	
Month	Ø	CD%	Ø	CD%	Ø	CD%	Ø	CD%
January	0.14	0.8	0.61	6.1	1.78	6.6	1.6	11.8
February	0.20	1.2	0.57	5.7	2.10	7.7	1.52	11.2
March	0.35	2.1	0.75	7.5	2.00	7.4	1.38	10.2
April	1.29	7.7	1.12	11.2	2.73	10	1.28	9.4
May	1.76	10.5	1.27	12.7	3.01	11.1	0.83	6.1
June	2.33	13.7	1.05	10.5	2.47	9.1	0.49	3.6
July	2.76	16.4	0.48	4.8	2.33	8.6	0.40	2.9
August	2.96	17.6	0.53	5.3	2.17	8.0	0.63	4.6
September	2.34	13.9	0.90	9.0	2.06	7.6	0.93	6.9
October	1.70	10.1	1.12	11.2	2.31	8.5	1.43	10.5
November	0.71	4.2	0.94	9.4	2.40	8.8	1.62	11.9
December	0.23	3.4	0.63	6.3	1.82	6.7	1.52	11.2
Mean	*1.40*	*8.25*	*0.83*	*8.25*	*2.28*	*8.25*	*1.13*	*8.25*

Ø =Agro-climatic Potential : CD% = crop distribution based on climate
Agro-climatic potential (Ranganathan IJPS 2014)

The reverse happens when the weather conditions turn adverse and the generations wean out and on an average one generation less than the possible 5 to 6 generations is plucked from a growing pointThe productivity, therefore, is a function of various factors related to harvesting management to achieve the targeted productivity. In manual harvesting labor requirements vary with the season and depends on factors which affect the plucking average mainly relating to plucking interval and crop on the bush. The impact of some factors affecting PA and plucker requirement are presented in Table 7. The complexity of plucker deployment depends on growing conditions and if the rush season crop is not harvested fully the annual productivity target cannot be achieved. The cropping sequence in a tea estate and plucker requirement is elaborated in Tables 8 & 9.

The cropping periods change with regions and also

Table 7: Factors affecting plucking average and plucker requirement

A	Plucking average interaction- Year from pruning						
	Year from prune	Pruned year	2nd year	3rd year	4th year	5th year	Mean
	Plucking average	23	24	21	18	16	20
B	Plucking average interactions (mean of six fields and mean for the pruning cycle)						
	Mean yield Kg/ha	2796	3000	2120	3161	2100	1700
	Pluckers / ha	293	462	608	721	625	540
	Plucking Rounds	37	35	28	38	35	35
	Plucking Average	19	25	17	21	21	20

Table 8: Plucking management–*manual (for 3000 kg made tea per ha with 40 rounds harvesting)*

Cropping Pattern	Duration days	% annual crop	% crop/day	Made tea	Green Leaf	Plucking average kg	LPH for the period Per ha for the period	LPH for the period Per ha per day	Area harvested Per day %	Labor per ha to be harvested in a day
Lean	120	21	0.18	630	2772	12	231.0	1.93	13	14.8
rush	155	68	0.44	2040	8976	19	472.4	3.05	13	23.4
Peak rush	14	10	0.71	300	1320	23	57.4	4.10	13	31.5
Highest crop	1	1	1.00	30	132	25	5.3	5.28	13	40.6
T0tal	300	100	0.33	3000	13200	17.5	766.1	2.55	13	19.6
Sundays & holidays	65									

Area to be harvested in a day ;) expressed as % over the acreage

Table 9: Management of plucking with shears and machines

A ; Shears; 3000 kg ha-1-mean 20 rounds shearing								
Cropping Pattern	**Duration Days**	**Green Leaf Kg/ha**	**For the period shears**	**PA**	**%Area harvested per day**	**Av per day shears**	**Shears /day /ha for the area to be harvested in day**	**Remarks**
Lean	120	2772	120	23	6.7	1	14.3	450 to 700 bushes or about 700
Rush	180	10426	180	58	6.7	1	14.3	m^2 bush surface per day per
Total	300	13200	300	44	6.7	1	14.3	shear-------------------------
B; machine harvesting 3000 kg ha^{-1}-mean 20 rounds harvesting								
Cropping Pattern	Duration Days	Green Leaf Kg/ha	%Area harvested per day	Machines per day	Machines per ha	Machines PA GL kg	Machines/day /ha for the area to be harvested in day	Task; 2000 to 3000 m^2 bush surface area per day per machine Labor requirement per machine varies from two to three at field level
Lean	120	2772	6.7	0.2	24	116	3	depending on design, energy
Rush	180	10426	6.7	0.2	36	290	3	resources for operation
Total	300	13200	6.7	0.2	60	220	3	besides maintenance ones for them.

Area to be harvested in a day -(area * no. of rounds of harvesting / no of working days per annum) is expressed as % over the acreage; Sundays and other holidays -65 : PA – Plucking Average per labor employed

with climatic vagaries from year to year within the region and one should always be hard on heels to manage the harvesting as the crop comes. For manual plucking the requirement of plucker is roughly 0.8 per ha per day for every 1000kg productivity levels I.e. for 300 ha estate yielding 3000 kg ha^{-1} the average plucker requirement per day is 720 if the cropping is uniform throughout the year. But as the crop comes in flashes and the requirement varies with the crop on the bush. A typical example of crop distribution in a tea garden and labor employment for manual and machine harvesting are shown in Tables 8 & 9.

The sequence of rush and lean seasons vary from region to region. In south India and Sri Lanka, there are two rush and two lean cropping periods alternating - dry winter with low growth, heavy cropping spring, low cropping heavy monsoon months, second high cropping period as the monsoon tails off till winter sets in. Subtropical and temperate regions beyond 15 -18^{0}S & N experiences winter dormancy due to day length falling below 11hr. and 15 min., the length of duration varying at about 30 days for every 3 to 5^0 beyond this range. Assam experiences 1 to 2 months of dormancy followed by the first crop (Spring crop) followed by a mad rush during monsoon months which tails off into moderate cropping before entering into low cropping winter season. Japan experiences 5 to 7 months of dormancy followed by cropping period. Malawi blessed with deep soils goes through six months of drought period with low cropping and six months of high cropping periods. In equatorial belt with rains throughout the year as In Kenya (Africa) and Ratnapura (in Sri Lanka), the cropping is almost even throughout the year except for a short period during short drought periods.

Summing up

The productivity in tea is built by cultural and nutritional practices, the ultimate exploitation of which depends on the continual creation of plucking points and sustaining them- and taking the crop to factory by appropriate harvesting practices. The carbohydrates produced during lean cropping periods are stored in the roots and converted to crop when again entering into favorable growing conditions .The crop is never lost in tea culture if it is collected as it comes. Therefore utmost attention to each and every detail in maintaining the rhythm of growth,(be it manual, shear or machine harvesting) needs to be bequeathed ensuring at the same time the harvesting of around 95 to 98 % of tea shoots that are ready to go the factory at the time of each plucking.

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