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Original Article

Defining Viable Population Density in Tea (*Camellia L. Spp.*) New Clearings

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Abstract

Decisions on population density to start with in new clearings or replanting old tea, depends on how soon the leaf area index attains optimum level to make the plants productive so that the break-even point is reached at the earliest to get back the cost of plants, planting and their maintenance till they become productive. Critical review of results from the experiments conducted over the years with varying population ranging from 408163 plants per ha (245 cm^2 per plant) to 6944 plants /ha (1.44m^2per plant) show the optimum population density lie between 10000 to 20000 plants per ha depending on the spreading habit of the cultivar and initial investments on cost of plants, planting and their maintenance.

Keywords

New Clearing; Replanting Old Tea; Viable Population Density at Planting.

Introduction

The main concern in opening new clearings, replanting old tea and increasing population density by infilling at the time of rejuvenation prune and low clean prunes is how soon the breakeven point could be reached on the recovery of investments involved in cost of plants, planting and their maintenance till such time the endeavor makes a profit.

Lot of struggles have gone in to bring the plants to plucking at the earliest and to reach a reasonable productivity level before the first prune with the object of achieving breakeven point within that period. The young Tea is trained to get crop from second year onwards with an aim to reach a productivity level of around 2000 to 3000 kg ha^{-1} or more by $4/5^{th}$ year after planting before the first prune. In this study, the cost of plants, planting, and their maintenance, (including the cost of manuring and the first prune) and theprofit from harvested tea both commuted per ha up to first prune are applied for appraisal offallouts. Nutrients were applied in adequate quantities so that they didn't become a limiting factor in the expression of the productivity by the plants

Experimental results; Data on productivity up to first prune, along with number of plants planted and those survived at the time of first prune are summarized in Table 1.

The Survival Percentage of plants at first pruning decreases with the population density atplanting– around 98 to 99% at population below 14000 /ha and less than 90% atpopulation around 20 000 /ha and decreases fast at population above one lakh /ha, (Figure 1)

The productivity per bush also decreases with increase in population density and it linear with $\sqrt{P}$. The productivity per bush is about 0.70 kg/bush for population below14000/ha and tending to approach around 0.10 kg/bush at population around two lakhs /ha. However the productivity per ha increases with increasing population density and higher than what could normally be obtained with traditional population densities practiced. It has tempted the Agronomists to exploit the population input to achieve early break-even investment on new/ replanting projects. The relation between population and yield per bush is shown in Figure 2.

Mortality and reduction in yield per bush due to competition for survival result in hyperbolic relation between population and Yield with R^2 of 0.99 against 0.86 for linear regression. The relationship between

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Table 1: Productivity of Tea as influenced by population density and mortality of plants

No.	Population/ha, no.			Per bush yield in kg made tea		Yield kg/ha made
	At planting	At 1st Prune	Survival %	From Regression	Actual	tea (up to 1st Prune)
1	6000	5946	99.1	0.78	0.80	4742
2	10000	9850	98.5	0.74	0.75	7426
3	14000	13706	97.9	0.71	0.71	9786
4	20000	19389	97.0	0.67	0.69	13097
5	30000	28636	95.5	0.61	0.60	17726
6	60000	54670	91.1	0.49	0.45	24729
7	100000	85600	85.6	0.37	0.31	26801
8	237000	164004	69.2	0.16	0.18	28815
9	300000	188400	62.8	o.11	0.15	28925

Y_{max} kg^{-ha}

1. From equation given below -Mean of calculated Y max from number of pairs of "P" and "y" is around 30000Kg /ha made tea*A" is "Y" maximum when X approaches μ in hyperbolic equation $Y= A-A\ e^{-CP}A = Log\ Y_1 + \{(Log\ Y_2 - Log\ Y_1)* (P_2/P_2-P_1)2)$
2. From I/p vs log Y (Figure-3) y = -965.08x + 4.4628 $R^2 = 0.9912$ Where X=1/p and Log y_{max} = 4.4628 ; y_{max} = 29027 kg / ha

population and yield is perceived in many angles. The ultimate yield is the product of yield per bush (Y_B) and the surviving population (P).

$Y_B = (a–b\sqrt{P})$ (Figure 2)

Where "a" is a constant representing maximum yield per bush, "b" is a rate constant and "P" population per ha at planting. ('a'= 0.93 and 'b'=0.0019)

- $P_S = P_* 10^{(m-kP)}$ (Figure 1)

Where 'P' is the population planted and,

"m" and 'k" are constants

($K =6.735x10^{-7}$& m= 2.00) (Figure 1)

- $\mathbf{Y}_= Y_B * P_S$ i.e. $(a-b\sqrt{P})\ (P*10^{(m-kP)})$

The ultimate result is the relation between Population and yield is asymptotic, tending to approach a maximum at infinity (Figure 3).

Then the relation between *lnY* and 1/P is linear enabling to get

Y_{max} as 1/ P approaches zero (Figure 4)

'A', the Y_{max} may also be derived from 'lnY-1/P' data (Table 1).

• The overall effect of population at planting on yield is represented by the equation :

$Y = A–Ae^{-CP}$ ————1

'A' – the maximum yield possible under a given set of agroclmatic conditions; 'P' – population /ha planted; 'C' – constant and is equal to $3*10^{-5}$ in the present study

The economic population is then deduced from the ratio of investments to returns ratio (IR) i.e of cost per ha of planting and maintenance to the returns ha upto the first prune.

IR = tP / wY ———————2

't' –cost of plants planting and maintenance up to first prune per plant;

'P'- no.of planted / ha;

'w'- return per kg of made tea and

'Y' yield, kg /ha up to first prune (12 to 54 months from planting).

The economic population 'P_E' is then arrived by applying the IR ratio to equation –1.

$P_E=\{(lnCP – ln(tP/WP)\}/C\}$

The critical/ economic population is defined as the population above which any further increase in population density may not have any effect on impact on breakeven values at a given I/R ratio. The achievable investments-returns ratio (tP/WY) of new clearing or replanting projects up to the first prune decides the optimum density.

The currently observed IR ratios vary between 0.5 to 0.63, which support economic population between 11to 18 thousands plants per ha with the achievable yield of 8000 to 12360 kg per ha to first prune. If the cost of planting could be brought down and profit per kg of tea increases, higher population densities could be exploited to increase total production but within the maximum yield limited by agro climatic conditions.

In-filling vacancies in mature tea fields in plucking is routinely done to maintain population density at reasonable level tune to the changing trends in management policies with time to sustain productivity. Twenty to thirty percent single and multiple vacancies depress the yield by 5 to 8 percent only.Loss of crop due to block vacancies occurs inproportion to their area. As far as in- fillingthe vacancies in tea fields are concerned, it is normally

Table 2: Economic Population and I/R ratios

IR ratio	WY/TP	P_E	Y at P_E
Uneconomic zone			
2.50	0.40	-35154	0
1.25	0.80	-12049	0
1.00	1.00	-4611	0
0.87	1.15	-98	0
0.83	1.20	1466	1249
Achieved IR ratios			
0.71	1.40	6605	5217
0.63	1.60	11056	8194
0.56	1.80	14982	10508
0.50	2.00	18494	12360
Worth trying at high tea prices			
0.45	2.20	21671	13875
0.42	2.40	24571	15138
0.38	2.60	27239	16206
Above theoretical maximum –not achievable			
0.36	2.80	29710	17122
0.33	3.00	32009	17916
0.29	3.50	37148	19503
0.25	4.00	41599	20694

Table 3: Pre-monsoon planting /Post – monsoon Pruning

Period	May/March	April/March	April/March	April/March	April/August
Age since planting	0 to 9 months	9 to 21 months	21 to 33 months	33 to 45 months	45 -54 months
% crop Distribution	1	13	26	40	20
Post monsoon planting / Pre-monsoon pruning					
Period	**August/March**	**April/March**	**April/March**	**April/March**	**April/March**	**April/March**
Age since planting	0 to 6 months	6 to18 months	18 to 30months	30 to 42months	42t0 54months	54 to 58months
%Crop distribution	0	5	10	30	40	15

Table 4: Productivity growth pattern kg/ha at selected Population levels in young Tea in new clearings Pre-monsoon Planting

Population no./ha	Yield per ha kg 1st year April/Mar	2nd year	3rd year	4th year	5th year up to prune April/August	Total
6605	52	678	1356	2087	1043	5217
14982	105	1366	2732	4203	2102	10508
24571	151	1968	3936	6055	3028	15138
Post-monsoon Planting						
population no/ha	**Yield per ha kg 1st year August/march**	**2nd year**	**3rd year**	**4th year**	**5th year**	**6th year up to prune April /MAY**	**Total**
6605	0	261	522	1565	2087	783	5217
14982	0	525	1051	3152	4203	1576	10508
24571	0	757	1514	4541	6055	2271	15318

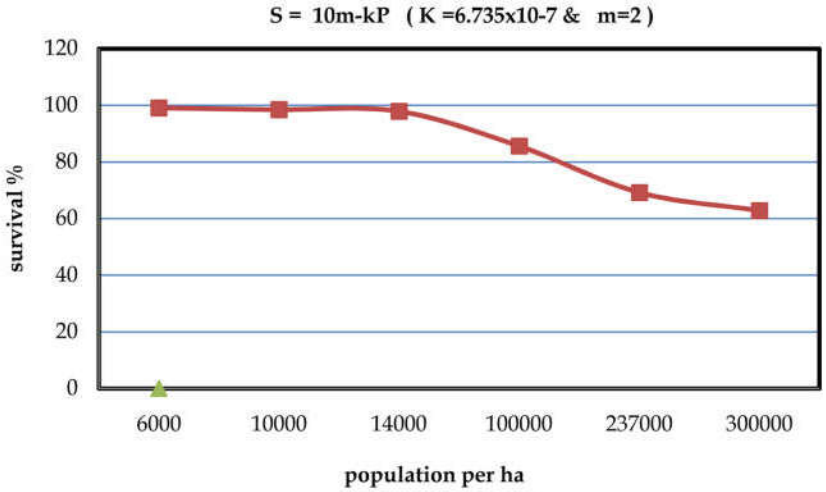
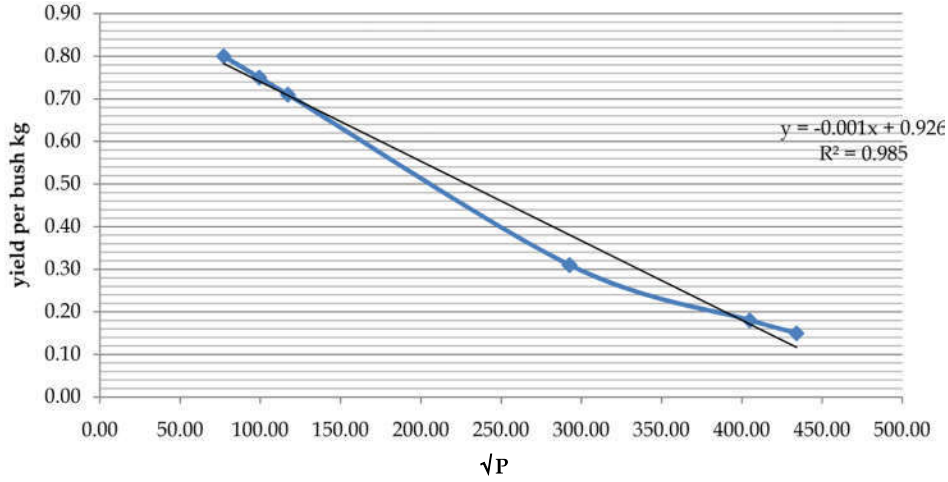


Fig. 1: Population per ha vs survival % S = 10m-kP (K =6.735x10-7 & m=2)



(Ya=a–b√P i.e. Y+0.93-0.0019√P

Fig. 2: Population (√P) vs yied per bush

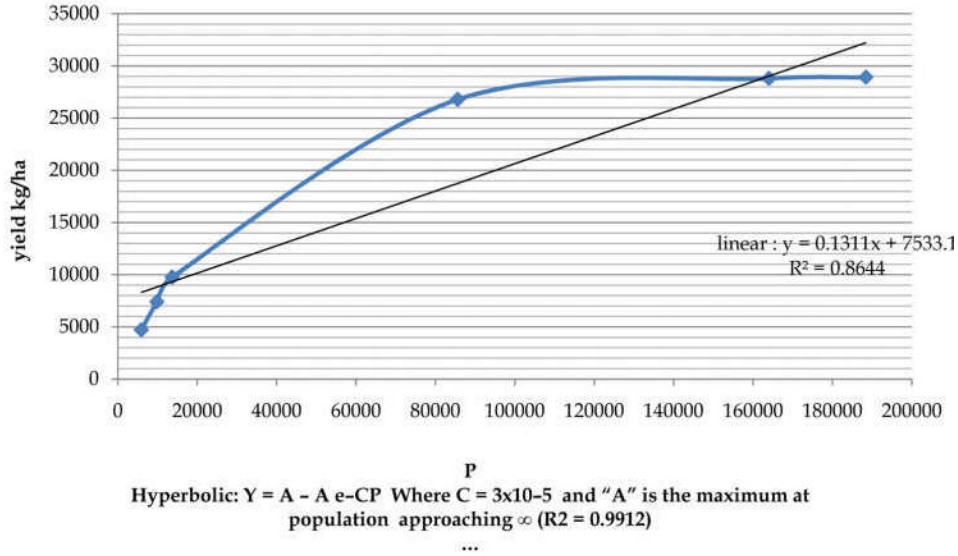


Fig. 3: Population vs yield

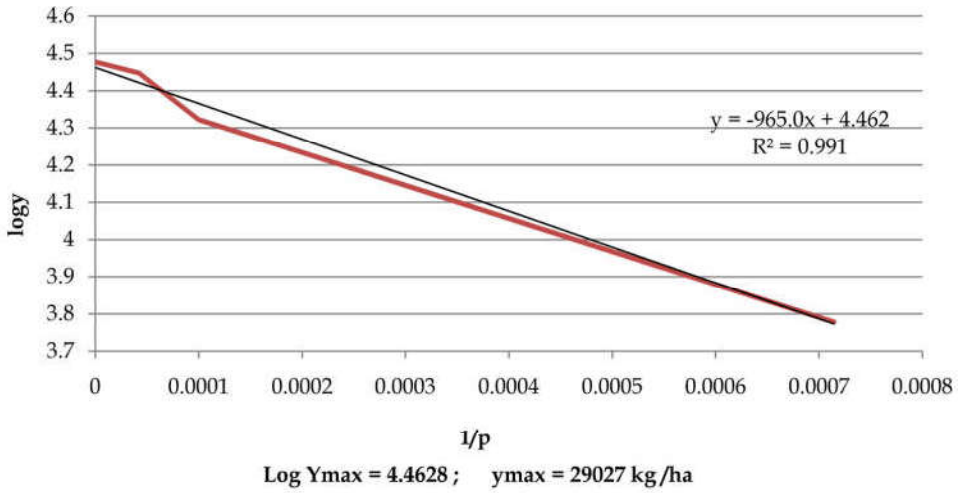


Fig. 4: Yield (LogY) vs Population (1/P) (Finding Y_{max})

taken up at the time of clean low prune or rejuvenation pruning. The general norms are:

1. As single plant vacancies do not cause any significant crop losses as the lateral growth covers the area between the bushes, such of them are ignored.
2. Multiple plant vacancies are in-filled at the rate of (2n+1) plants per vacant stretch where 'n' are the numberof continuous vacant spots between two bushes.
3. Block vacancies are treated like new planting.

The productivity per unit area in the initial years increases with the plants per unit area, though the per bush yield decreases due to reduced plucking surface per bush. Mortality of bushes also increases with increasing planting density trending to stabilize around 20000 plants per ha after the first prune reaching optimum leaf area index and stabilize the productivity around what could be supported by the agro-climatic conditions of the region.

The yield distribution in the initial years of establishment up to first prune depends on building leaf area index under different population levels.To achieve this decentering the leader growth is done as early as possible, when about 20 leaves are formed, below 20 cm with a cut across prune to the branches at 35 cm. The second decentering wherever necessary to keep branching below 20cm at around 8to 12 months Tipping is done at 55 cm and plucking continued always above the height avoiding breaking back, putting hands below the table and allowing lateral spread. In the fourth year, 45 cm cut across is done and tipped at 65 cm. Thereafter the normal pruning and plucking practices are followed. There are two seasons for planting.

1. Pre- monsoon planting: The planting is done May/June before setting of monsoon into the rainy weather. The first decentring is done immediately after the cessation of monsoon and the second decentring if required before setting of dry weather. After 48 months since planting, the first prune is done at post monsoon at its tailing phase,normally after second/third week of August.
2. Post-monsoon planting: The planting is done August as the monsoon tails off. The first decentering is done in Oct/Nov and the second one if required in March/April depending on springshowers. The first prune is done pre-monsoon at about 54 months from planting;

The percent distribution of crop year wise up to first prune for the above two seasons of Planting is given in Table 3.

To Appreciate the Productivity Growth Pattern the year wise of distribution of crop yield in the initial years of establishment at some selected population levels are given in Table 4.

Summing up, though the population density in the initial years of planting has an advantage on early high crop to start with, yetit is decided by overall economics of investments-returns interactions. More over on the long run, population density tends to stabilize around a level that could be supported by the agro-climatic potential of the region. The optimum population seems to lie between 10000 to 20000 plants per ha.

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