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Impact of rubber tree providing shade conditions on the growth dynamics and chemical processes of tea

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Abstract

Tea (*Camellia sinensis* (L.) O. Kuntze) is among the most widely consumed beverages worldwide, next to water, because of its nutritional, medicinal, and stimulating properties. In Assam, shade is a crucial component of tea cultivation due to the region's specific agro-climatic conditions. Although tea is generally grown as a monocrop, it can often be combined with other economically valuable crops to enhance productivity. One such crop is Rubber (*Hevea brasiliensis* Muell Arg.), which has been considered as a potential alternative shade tree. The experiment was carried out in the Experimental Garden for Plantation Crops, Department of Tea Husbandry and Technology, Assam Agricultural University, Jorhat to evaluate the influence of rubber-based shade on the growth and chemical characteristics of tea. Two cropping situations were studied: tea grown as monocrop (conventional shade) and tea – rubber-based cropping system (rubber as shade). The effect of rubber leaf canopy on the tea bushes were compared with that of traditional shade tree. The results showed that the growth parameters of tea recorded the highest value under *Albizia chinensis* shade and the lowest value was recorded under rubber tree shade. The study generated a considerable amount of important information on the effect of *Albizia chinensis* shade and rubber shade on growth of tea leaves and chemical parameters. Overall results clearly showed that conventional (T₁) shade favours more growth in terms of yield, leaf area and weight of leaves as compared to rubber tree shade (T₂, T₃ and T₄). Better performance was noticed under conventional shade over rubber tree providing shade conditions.

Keywords: Tea, rubber, shade tree, growth, chemical parameters

Introduction

Tea is one of the most popular herbal drink which is being consumed throughout the world. It is being consumed by over two thirds of the world's population and is known to occupy an important place among plantation crops of the world. Since tea is a shade-adapted plant, maintaining controlled shade has the added benefit of lowering leaf temperatures, reducing photo-inhibition impacts, and enhancing the health of tea plants in subtropical conditions of Assam. Owing to the geographical location of Assam, shade is an essential component for this region. In the plains of N.E. India including Assam, the air temperature remains above 30°C for a greater part of the harvesting period. But air temperatures above 30°C and below 13°C are harmful for growth of tea plant. Hence shade trees are inter-planted in tea gardens to keep the temperature within the optimum limit. Moreover wind velocity is useful in reducing high leaf temperature. However, the velocity of wind in Assam is low due to the shelter effect of the hills on either side of the valley. So shade is needed in a tea plantation to keep the leaf temperature down.

At an ambient temperature of 30-32 °C, the temperature of a horizontal and erect leaf in direct sunlight may reach 40-45 °C. However, in leaves that receive shade, they can survive at a temperature that is just 1-2 °C higher than the surrounding air (Hadfield, 1968). Shade trees create microclimate within a tea plantation that might aid in the growth and productivity of tea plants.

Though tea cultivation is considered as a mono cropping system, it is the only plantation crop integrated with other crops of economic importance such as pepper, coffee, arecanut, etc. to maximize productivity in tea plantations.

Rubber is an economically important crop which may be used in place of commercial shade trees. Rubber tree in addition to providing shade would also act as a cash crop and thus might act as a source of additional income. The effect of rubber leaf canopy on the tea bushes were compared with that of traditional shade tree. The concept of shade as a thin and unbroken cover of foliage over tea bushes is prevalent only in North-East India. Such a cover of foliage was achieved to a fair extent under well grown and properly spaced stands of *Albizzia chinensis* trees. The tea bush is kept in such a way that the upper surface of the canopy receives full sunlight. However, because they receive filtered light, the lower canopy's leaves serve as shade leaves.

Methods and Materials

The experiment was conducted at the Experimental Garden for Plantation Crops, Department of Tea Husbandry and Technology, Assam Agricultural University, Jorhat, Assam. Both tea and rubber were originally planted in 2013. The tea planting material used was TV 23, while rubber consisted of RRIM 600 (*Hevea brasiliensis* Muell Arg.). The study was carried out under two cropping systems: one with tea grown as a monocrop under conventional shade, and the other with a tea-rubber based system where rubber served as the shade component. The experiment spanned from March 2022 to November 2022 and was laid out in a Randomized Block Design. A total of four treatments were evaluated with four replications. Each treatment plot covered an area of 66 m² and included 105 tea plants. In the control plot, six shade trees were maintained, whereas in the other treatment plots, four rubber plants were present. Tea bushes were planted at a spacing of 105 cm × 60 cm. In the control treatment (T₁), *Albizzia chinensis* trees were established as permanent shade at a spacing of 5.5 m × 5.5 m. In contrast, rubber trees were planted at three different spacings—8.5 m × 5.5 m, 9.5 m × 5.5 m, and 12 m × 5.5 m—representing treatments T₂, T₃, and T₄, respectively. The experimental period was divided into four flushes as follows:

- First flush: March, 2022- April, 2022
- Second flush: May, 2022- June, 2022
- Rain flush: July, 2022- September, 2022
- Autumn flush: October, 2022- November, 2022

Measurement of Leaf Area

The maintenance leaf from tea plant were plucked and leaf area of individual leaves were calculated at an interval of one month using a well calibrated leaf area meter (Model No.: BIOVIS PSM; Model: Portable L 3000). It was expressed in cm² (Pandey and Singh, 2011) ^[13].

Nitrogen content in leaf

Nitrogen content of tea leaves was calculated based on Humphries' (1956) ^[9] method using the Microkjeldahl method.

Phosphorus content in leaves

The phosphorus content in leaves was calculated by using vanado-molybdate phosphoric yellow colour method described by Jackson (1973) ^[10].

Potassium content in leaves

Potassium content was assessed using a flame photometer as described by Jackson, 1973 ^[10] after dilution of appropriate volume of the aliquot.

Fresh weight of pluckable shoots

The fresh weight of 100 numbers of pluckable shoots at random was calculated and expressed in g.

Dry weight of pluckable shoots

The freshly harvested shoots (100 number of pluckable shoots) were oven dried at 60 °C until totally dry, and the dry weight was calculated using an electrical balance in g.

Green leaf yield

Green leaf yield was recorded treatment wise for 4 replications on 7 days plucking round. The yield was recorded using spring balance and expressed as kg green leaf/plot.

Relative Leaf Water Content

By using Weatherley's (1950) ^[19] approach, the relative leaf water content was assessed. Relative leaf water content (rlwc) was calculated by using the following formula and expressed in percentage (%) (Barrs and Weatherly, 1962) ^[2]:

$$rlwc = \frac{\text{fresh weight} - \text{dry weight}}{\text{turgid weight} - \text{dry weight}} \times 100$$

Stem girth of rubber plant at tapping height

Circumference (Girth) of the rubber tree trunk at a height of 120 cm from the ground (tapping height) was measured using a measuring tape. (Silva *et al.*, 2014) ^[17].

Canopy spread

The canopy spread of rubber tree was measured in meter (m) using a measuring tape and bamboo poles in two directions i.e. East-West and North-South direction. The mean of areas from both the directions was taken into consideration.

The area of the canopy spread was calculated using the formula:

$$\text{Canopy spread} = \pi r^2$$

Results and Discussion

Growth Parameters in Tea

Leaf Area

Data recorded on leaf area of tea plants are presented in Table 1.

Table 1: Mean Leaf area (cm²) of tea leaves in the four flushes

	1 st Flush	2 nd Flush	Rain Flush	Autumn Flush
T ₁	41.08	42.35	46.07	47
T ₂	35.46	37.2	38.33	38.64
T ₃	34.99	36.11	41.93	42.34
T ₄	40.18	41.2	44.93	45.86
F-Test	S	S	S	S
CD (p≤0.05)	2.97	3.95	4.25	1.56
SE(m)	0.92	1.23	1.32	0.48
SE(d)	1.31	1.74	1.88	0.68

From the Table 1 it can be seen that in the first flush, leaf area was found to be highest in T₁ (41.08 cm²) and lowest was found in T₃ (34.99 cm²). T₁ and T₄ was found to be statistically at par, while both varied significantly over T₂ and T₃. T₂ and T₃ were found to be statistically at par. In the second flush, leaf area was found to be highest in T₁ (42.35 cm²) and lowest was found in T₃ (36.11 cm²). T₁ and T₄ was found to be statistically at par, while both varied significantly over T₂ and T₃. T₂ and T₃ were found to be statistically at par. In rain flush it was found that the leaf area

was highest in T₁ (46.07 cm²) and lowest in T₂ (38.33 cm²). T₁, T₃ and T₄ were found to be statistically at par. T₁ and T₄ varied significantly over T₂, while T₃ did not vary significantly over T₂. In the autumn flush, the highest leaf area was found in T₁ (47 cm²) and lowest in T₂ (38.64 cm²). T₁ and T₄ was found to be statistically at par, while both varied significantly over T₂ and T₃. T₃ was found to be significant over T₂.

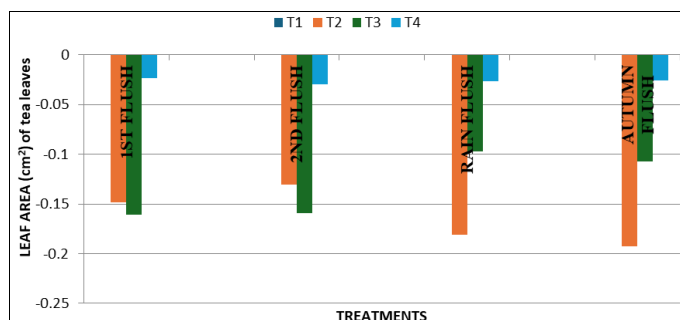


Fig 1: Percentage Decrease In Leaf Area Of Tea Leaves Under Different Spacing Of The Rubber Tree Shade Over Control (*Albizia chinensis*)

Leaf area is an important parameter in assessing plant productivity since it impacts light interception. Leaf area was found to be highest under *Albizia chinensis* shade (T₁) compared to other rubber tree shade under different spacings (T₂, T₃ and T₄). Many researchers have documented an increase in leaf area when light intensity is reduced (Barua, 1956; Barua, 1964; Gogoi, 1976) [3, 4, 8]. The increasing leaf area contributed to the improved photosynthetic capacity. The canopy photosynthesis was greatly impacted by the leaf area. There exists a positive correlation between leaf size and yield (Mamedov, 1961) [12]. The leaf area was found to increase in T₁ due to reduced light intensity as compared to direct light, due to the presence of conventional shade trees. But the leaf area was found to decrease in rubber tree shade under different spacing, even though the light intensity was found to be reduced. This may be due to the over-shading effect of rubber trees which may reduce the leaf area, instead of increasing it.

Fresh weight of tea leaves

The fresh weight of tea leaves under rubber tree shade and under *Albizia chinensis* shade are presented in Table 2.

Table 2: Mean fresh weight (g) under rubber tree shade and under *Albizia chinensis* shade

	1st Flush	2nd Flush	Rain Flush	Autumn Flush
T ₁	131.38	135.43	146.58	142.63
T ₂	98.46	98.93	106.56	102.18
T ₃	85.93	98.15	102.63	108.01
T ₄	129.48	132.53	140.44	139.24
F-Test	S	S	S	S
CD (p≤0.05)	7.70	7.23	6.10	10.15
SE (d)	3.40	3.20	2.70	4.49
SE (m)	2.41	2.26	1.91	3.17

From the Table 2 it can be seen that in the first flush, the fresh weight was found to be highest in T₁ (131.38 g) and the lowest fresh weight was found in T₃ (85.93 g). T₁ and T₄ was found to be statistically at par, while both varied significantly over T₂ and T₃. T₂ was found to be significant over T₃. In the second flush,

the fresh weight was found to be highest in T₁ (135.43 g) and the lowest fresh weight was found in T₃ (98.15 g). T₁ and T₄ was found to be statistically at par, while both varied significantly over T₂ and T₃. T₂ and T₃ were found to be statistically at par. In the rain flush, the fresh weight was found to be highest in T₁ (146.58 g) and the lowest fresh weight was found in T₃ (102.63 g). T₁ was found to be significant over T₂, T₃ and T₄. T₄ was significant over T₂ and T₃, while T₂ and T₃ were found to be statistically at par. In the autumn flush, the fresh weight was found to be highest in T₁ (142.63 g) and the lowest fresh weight was found in T₂ (102.18 g). T₁ and T₄ was found to be statistically at par, while both varied significantly over T₂ and T₃. T₂ and T₃ were found to be statistically at par.

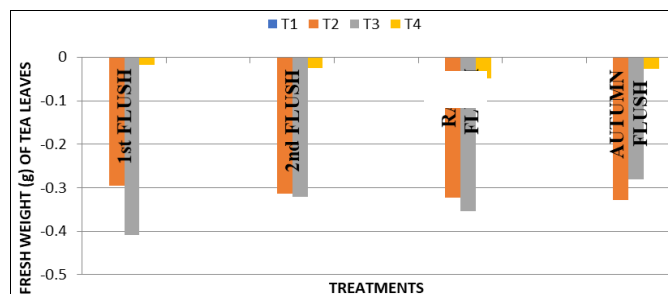


Fig 2: Percentage Decrease In Fresh Weight Of Tea Leaves Under Different Spacing Of The Rubber Tree Shade Over Control (*Albizia chinensis*)

Dry weight of tea leaves

The dry weight of tea leaves under rubber tree shade and under *Albizia chinensis* shade are presented in Table 3.

Table 3: Mean Dry weight (g) under rubber tree shade and under *Albizia chinensis* shade

	1st Flush	2nd Flush	Rain Flush	Autumn Flush
T ₁	26.27	27.08	29.31	28.52
T ₂	19.69	19.78	21.31	20.43
T ₃	17.18	19.63	20.52	21.6
T ₄	25.89	26.5	28.08	27.84
F-Test	S	S	S	S
CD (p≤0.05)	1.54	1.44	1.22	2.03
SE(m)	0.48	0.45	0.38	0.63
SE(d)	0.68	0.64	0.54	0.89

From the Table 3 it can be seen that in the first flush, the dry weight was found to be highest in T₁ (26.27 g) and the lowest dry weight was found in T₃ (17.18 g). T₁ and T₄ was found to be statistically at par, while both varied significantly over T₂ and T₃. T₂ was found to be significant over T₃. In the second flush, the dry weight was found to be highest in T₁ (27.08 g) and the lowest dry weight was found in T₃ (19.63 g). T₁ and T₄ was found to be statistically at par, while both varied significantly over T₂ and T₃. T₂ and T₃ were found to be statistically at par. In the rain flush, the dry weight was found to be highest in T₁ (29.31 g) and the lowest dry weight was found in T₃ (20.52 g). T₁ was found to be significant over T₂, T₃ and T₄. T₄ was significant over T₂ and T₃, while T₂ and T₃ were found to be statistically at par. In the autumn flush, the dry weight was found to be highest in T₁ (28.52g) and the lowest dry weight was found in T₂ (20.43 g). T₁ and T₄ was found to be statistically at par, while both varied significantly over T₂ and T₃. T₂ and T₃ were found to be statistically at par.

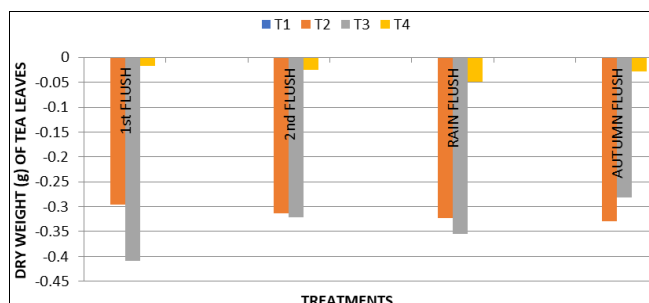


Fig 3: Percentage Decrease In Dry Weight Of Tea Leaves Under Different Spacing Of The Rubber Tree Shade Over Control (*Albizia chinensis*)

A crucial factor that affects bush output is shoot weight. The dry matter composition of the shoot determines the recovery of the made tea. The plants under *Albizia chinensis* shade had the

highest fresh weight and dry weight of tea leaves as compared to rubber tree shade under different spacings. This might be because the apical bud is an active and strong sink that improves net photosynthesis, and the resulting activities might have an impact on the partitioning of photosynthates among different plant parts. Similar observations were also recorded by Rajaske *et al.* (2000) and Taparia (2004) [18]. According to Wijeratne (1994) [20], a tea shoot with a terminal bud that is active, weighs 10-18 per cent higher than a shoot with a dormant bud that has the same number of leaves. Moreover, shade increases the size of the shoots and also the total weight of the shoots as compared to shoots grown under no shade.

Yield

The green leaf yield of tea recorded for different treatments is presented in Table 4.

Table 4: The green leaf yield of tea recorded for different treatments

	March	April	May	June	July	August	September	October	November
T ₁	3.38	4.63	6.25	16.50	16.00	26.87	27.37	24.75	13.75
T ₂	1.13	1.50	2.00	4.62	4.37	7.37	7.50	6.75	3.87
T ₃	1.38	1.75	2.50	5.75	5.75	9.25	9.50	8.75	4.87
T ₄	1.50	1.88	2.63	7.25	7.00	12.00	12.12	11.12	6.37
F-Test	S	S	S	S	S	S	S	S	S
CD (p≤0.05)	0.84	1.1	1.14	1.41	1.36	1.26	1.16	1.01	1.48
SE (d)	0.37	0.48	0.5	0.62	0.6	0.55	0.51	0.44	0.65
SE (m)	0.26	0.34	0.35	0.44	0.42	0.39	0.36	0.31	0.46

Table 4 shows that for T₁, the yield was found to be highest in September (27.37 kg green leaf/plot) and lowest in the month of March (3.38kg green leaf/plot). For T₂, the yield was found to be highest in the month of September (7.5 kg green leaf/plot) and lowest in the month of March (1.13 kg green leaf/plot). Similarly in T₃, the yield was highest in September (9.5 kg green leaf/plot) and lowest in the month of March (1.38 kg green leaf/plot). In T₄, the yield was highest in the month of September (12.12 kg green leaf/plot) and lowest in March (1.5 kg green leaf/plot). The yield was found to gradually increase from March to June, with a slight decrease in the month of July and again increasing rapidly in August and September with the highest yield in the month of September. From October the yield starts decreasing towards November as the crop approaches winter dormancy. The green leaf yield showed statistical significant difference over the control in all the months.

The yield was found to gradually increase from March to June, with a slight decrease in the month of July and again increasing rapidly in August and September with the highest yield in the month of September. From October the yield starts decreasing towards November as the crop approaches winter dormancy. The increase from March to June may be due to gradual increase in the availability of light intensity during these months as compared to the winter months. The decrease in the month of July may be due to rainy season leading to decrease in the availability of light intensity and more number of cloudy days. From October the yield starts decreasing towards November due to decrease in the availability of light intensity as the crop approaches winter dormancy.

It has been observed from earlier researches that when two or more crops are grown as intercrops, their yields are generally reduced in intercropping system as compared to their yields obtained under sole cropping systems, although combined yield may be higher than either of the sole crops. The same has been observed in the present research conducted. Though it was found

that the yield of tea was less as compared to monocropping system, but this loss would be compensated by the rubber latex from the rubber trees.

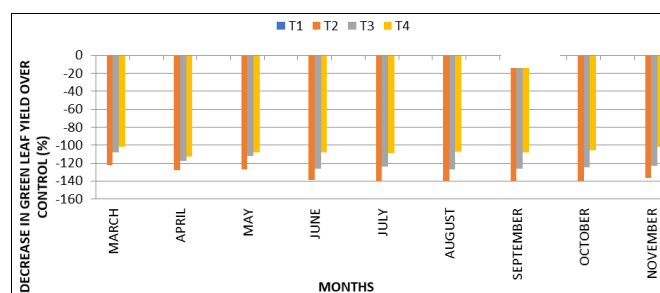


Fig 4: Percentage Decrease of Green Leaf Yield Of Tea Under Different Spacing Of The Rubber Tree Shade Over Control (*Albizia chinensis*)

Chemical Parameters in Tea

Leaf Nitrogen(N) Content

Nitrogen content in the plucked shoots under different treatments on per cent dry weight basis is presented in Table 5.

Table 5: Mean Nitrogen content (%) in plucked tea shoots

	1st Flush	2nd Flush	Rain Flush	Autumn Flush
T ₁	3.325	3.110	2.923	2.858
T ₂	3.038	2.945	2.778	2.738
T ₃	3.010	2.863	2.793	2.730
T ₄	3.205	3.100	2.920	2.855
F-Test	NS	NS	NS	NS

The data presented in the Table 5 reveals that the nitrogen content was found to be non- significant in all the four flushes. In the first flush, the nitrogen content was found to be highest in T₁ (3.325%) and lowest in T₃ (3.01%). In the second flush, the

nitrogen content was found to be highest in T₁ (3.11%) and lowest in T₃ (2.863%). In the rain flush, the nitrogen content was found to be highest in T₁ (2.923%) and lowest in T₂ (2.778%). In the autumn flush, the nitrogen content was found to be highest in T₁ (2.858%) and lowest in T₃ (2.73%).

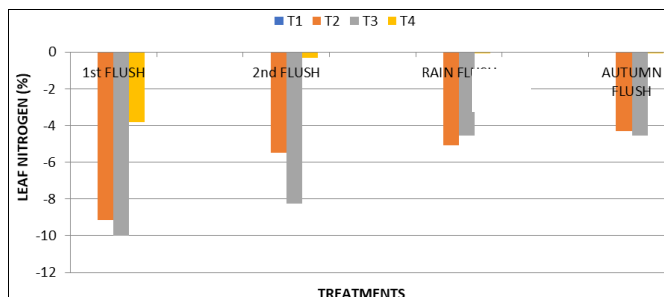


Fig 5: Percentage Decrease In Nitrogen Content In Tea Leaves Under Different Spacing Of Rubber Tree Shade Over Control (*Albizzia chinensis*)

Leaf Phosphorus (P₂O₅) Content:

Phosphorus content in the plucked shoots under different treatments on per cent dry weight basis are presented in Table 6.

Table 6: Mean Phosphorus content (%) in plucked tea shoots

	1st Flush	2nd Flush	Rain Flush	Autumn Flush
T ₁	0.253	0.241	0.225	0.220
T ₂	0.215	0.203	0.200	0.194
T ₃	0.212	0.209	0.207	0.205
T ₄	0.248	0.233	0.221	0.217
F-Test	NS	S	NS	NS
CD (p<0.05)		0.029		
SE(m)		0.009		
SE(d)		0.012		

The data presented in Table 6 reveals that the phosphorus content was found to be significant in the second flush only, while it was non-significant in the first flush, rain flush and in the autumn flush.

In the first flush, the phosphorus content was found to be highest in T₁ (0.253%) and lowest in T₃ (0.212%). In the second flush, the phosphorus content was found to be highest in T₁ (0.241%) and lowest in T₂ (0.203%). T₁ and T₄ were found to be statistically at par. T₁ was found to be significant over T₂ and T₃. T₄ was found to be significant over T₂ but not over T₃. In the rain flush, the phosphorus content was found to be highest in T₁ (0.225%) and lowest in T₂ (0.200%). Similarly, in the autumn flush, the phosphorus content was found to be highest in T₁ (0.220%) and lowest in T₂ (0.194%).

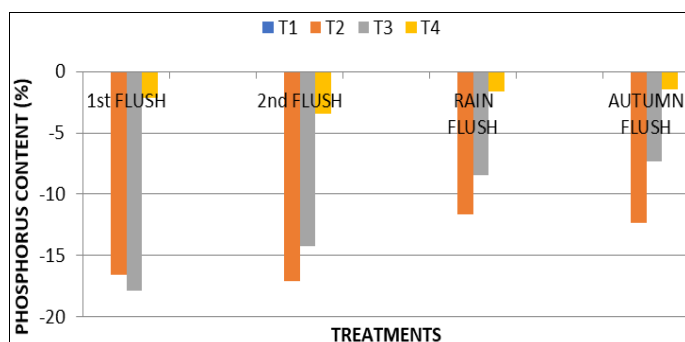


Fig 6: Percentage Decrease Of Phosphorus Content In Tea Leaves Under Different Spacing Of Rubber Tree Shade Over Control (*Albizzia chinensis*)

Leaf Potassium (K₂O) Content

Potassium content in the plucked two leaves and a bud shoots under different treatments on per cent dry weight basis are presented in Table 7.

Table 7: Mean Potassium content (%) in plucked tea shoots

	1st Flush	2nd Flush	Rain Flush	Autumn Flush
T ₁	1.725	1.718	1.703	1.690
T ₂	1.688	1.680	1.679	1.675
T ₃	1.689	1.686	1.685	1.679
T ₄	1.712	1.703	1.699	1.695
F-Test	S	S	S	NS
CD (p<0.05)	0.021	0.017	0.014	
SE(m)	0.007	0.005	0.004	
SE(d)	0.009	0.008	0.006	

In the first flush, the potassium content was found to be highest in T₁ (1.725%) and lowest in T₂ (1.688%). T₁ and T₄ were found to be statistically at par, while both were significant over T₂ and T₃. T₂ and T₃ were found to be statistically at par. In the second flush, the potassium content was found to be highest in T₁ (1.718%) and lowest in T₂ (1.680%). T₁ and T₄ were found to be statistically at par, while both were significant over T₂ and T₃. T₂ and T₃ were found to be statistically at par. In the rain flush, the potassium content was found to be highest in T₁ (1.703%) and lowest in T₂ (1.679%). T₁ and T₄ were found to be statistically at par, while both were significant over T₂ and T₃. T₂ and T₃ were found to be statistically at par. Similarly, in the autumn flush, the potassium content was found to be highest in T₄ (1.695%) and lowest in T₂ (1.675%). There was no significant difference of potassium content in tea leaves under rubber tree shade over *Albizzia chinensis* shade in the autumn flush.

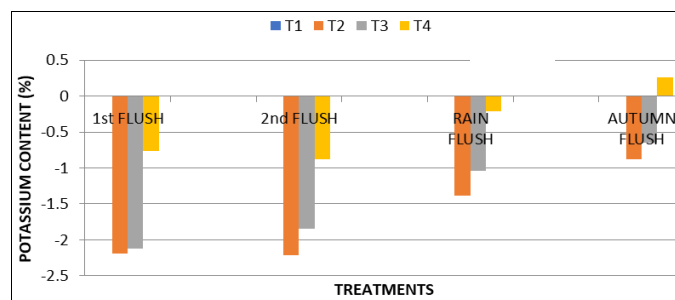


Fig 7: Percentage Decrease Of Potassium Content In Tea Leaves Under Different Spacing Of Rubber Tree Shade Over Control (*Albizzia chinensis*)

Nitrogen is one of the important elements for plant growth and is present in the most vital substances in plant such as chlorophyll, nucleotides, hormones, protoplasm, vitamins etc. The rate of light intensity on the uptake of nitrogen by tea shoot was investigated by Pan Genshan and Gao Ranjum (1986) [14]. Other than tea in cacao (*Theobroma cacao* L.), BurrIDGE *et al.* (1964) [6] found positive effect of shade on nitrogen uptake. Highly significant correlation between monthly crop distribution pattern and nitrogen percentage was reported by Baruah (1994) [5]. Photosynthesis of tea is strongly related to leaf N (Aoki, 1987; Sakai, 1975) [1, 16].

The average N level decreased from early in April to May, and then in July, and followed by a transient increase in August, and then decreased thereafter with the lowest in October (Zhang *et al.*, 2020) [21].

The amount of Nitrogen and Phosphorus content in tea leaves was found to be highest at first harvest; however Potassium

content was found to be highest at 2nd harvest time. (Ercisli *et al.*, 2008) ^[7].

Relative Leaf Water Content (RLWC)

There was a significant difference in terms of relative leaf water content in the different flushes (Table 8). In the first flush, the RLWC was found to be highest in T₁ (83.69%) and lowest was found in T₂ (80.41%). T₁ was found to be significant over T₂, T₃ and T₄; while T₂, T₃ and T₄ were found to be statistically at par. In the second flush, the RLWC was found to be highest in T₁ (84.46%) and lowest was found in T₂ (80.62%). T₁ was found to be significant over T₂, T₃ and T₄; T₄ was found to be significant over T₂. T₃ and T₄ were found to be statistically at par. Similarly, T₂ and T₃ were also found to be statistically at par. In the rain flush, the RLWC was found to be highest in T₁ (89.33%) and lowest was found in T₂ (84.04%). T₁ was found to be significant over T₂, T₃ and T₄. T₄ was found to be significant over T₂ and T₃; while T₃ was found to be significant over T₂. In the autumn flush, the RLWC was found to be highest in T₁ (88.12%) and lowest was found in T₂ (83.57%). T₁ was found to be significant over T₂, T₃ and T₄. T₂, T₃ and T₄ were found to be statistically at par.

Table 8: Mean Relative Leaf Water Content of tea leaves under different treatments in the four flushes

	1st Flush	2nd Flush	Rain Flush	Autumn Flush
T ₁	83.69	84.46	89.33	88.12
T ₂	80.41	80.62	84.04	83.57
T ₃	80.82	81.17	85.65	83.99
T ₄	81.53	82.4	87.62	85
F-Test	S	S	S	S
CD (p≤0.05)	1.56	1.26	1.07	1.73
SE(m)	0.48	0.39	0.33	0.54
SE(d)	0.69	0.55	0.47	0.76

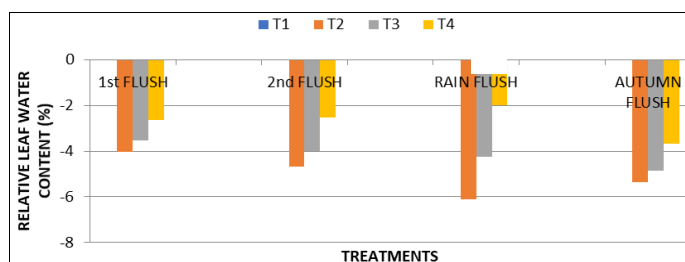


Fig 8: Percentage Decrease In Relative Leaf Water Content Of Tea Leaves Under Different Spacing Of Rubber Tree Shade Over Control (*Albizzia chinensis*)

Relative leaf water content is an important parameter used to estimate the water potential under stress condition (Kumar *et al.*, 2004) ^[11]. The findings of the present investigation indicated a higher amount of relative leaf water content in the conventional shade (*Albizzia chinensis*) indicating a good water status in the plant which is required for efficient food accumulation in the plants. This will subsequently result in higher relative growth rate.

Growth Parameters of Rubber

Stem girth

Girth of rubber recorded significantly ($p \leq 0.05$) higher value (69.75-64.21 cm) compared to that of *Albizzia chinensis* (56.75 cm). However, the girth of rubber under rubber tree microclimate irrespective of spacing was found to be statistically at par. The values of stem girth are presented in the Table 9.

Table 9: Stem girth (cm) of rubber at tapping height in Tea-Rubber intercropping and *Albizzia chinensis* under conventional shade

Treatment	Stem Girth(cm)
T ₁	56.75
T ₂	69.21
T ₃	64.79
T ₄	69.75
F-test	S
CD (p≤0.05)	7.63
SE (d)	3.37
SE (m)	2.38

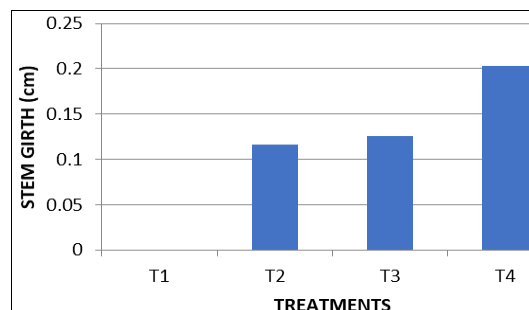


Fig 9: Percentage Increase Of Stem Girth Of Rubber At Tapping Height In Tea-Rubber Intercropping Over *Albizzia Chinensis* Under Conventional Shade

Girth of rubber recorded higher value (69.75-64.21 cm) compared to that of *Albizzia chinensis* (56.75 cm). Girth is considered to be a measure of vigor and is also an economically important character. It is important in determining the age at which a *Hevea* clone can be commercially exploited by tapping and is, therefore, important in shortening the uneconomic immature period of the clone. Girthing rate on tapping is important when considering future yield and wind damage. In addition, good girthing in tapping, according to Tan (1987), sustains yield and reduces wind damage losses through trunk snap.

Canopy spread

The canopy spread of rubber did not vary significantly over the canopy of *Albizzia chinensis*. (Table 10)

Table 10: Canopy spread of Rubber (m²) under Rubber tree shade and *Albizzia chinensis* under conventional shade

Treatment	Canopy Spread (m ²)
T ₁	36.01
T ₂	59.03
T ₃	56.45
T ₄	53.94
F- Test	NS

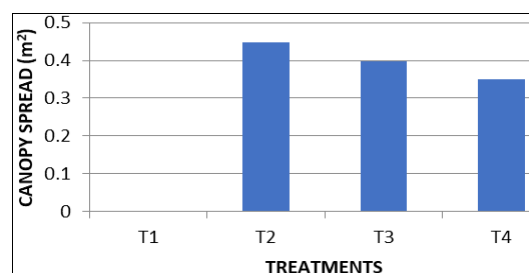


Fig 10: Percentage Increase Of Canopy Spread Of Rubber In Tea-Rubber Intercropping Over *Albizzia Chinensis* Under Conventional Shade

Canopy spread is one of the tree measurements taken at the crown of a tree, which consists of the mass of foliage and branches growing outward from the trunk of the tree. The canopy spread of rubber varied between (59.03 m² – 53.94 m²) and the canopy spread of *Albizzia chinensis* was found to be 36.01 m².

Summary and Conclusion

The study was undertaken to observe the impact of rubber tree shade on some growth and chemical processes of tea. From the above study, it may be concluded that there is a significant variation in the growth parameters in tea bushes under rubber shade over conventional shade. The study generated a considerable amount of important information on the effect of *Albizzia chinensis* shade and rubber tree shade on growth of tea leaves and their chemical parameters. The leaf area of tea was found to be highest under *Albizzia chinensis* shade (T₁) compared to other rubber tree shade under different spacings (T₂, T₃ and T₄). The plants under *Albizzia chinensis* shade had the highest fresh and dry weight of tea leaves as compared to rubber tree shade under different spacings. The yield of tea was found to gradually increase from March to June, with a slight decrease in the month of July and again increasing rapidly in August and September with the highest yield in the month of September. From October the yield starts declining towards November. The leaf nitrogen, phosphorus and potassium content were found to be highest under conventional shade. The findings of the present investigation indicated a higher amount of relative leaf water content in the tea leaves under conventional shade (*Albizzia chinensis*) indicating a good water status in the plant which is required for efficient food accumulation in the plants. Girth of rubber recorded higher value (69.75-64.21 cm) compared to that of *Albizzia chinensis* (56.75 cm). The canopy spread of rubber varied between (59.03 m² – 53.94 m²) and the canopy spread of *Albizzia chinensis* was found to be 36.015 m². Overall results clearly showed that conventional (T₁) shade favours more growth in terms of yield, leaf area and weight of leaves as compared to rubber shade (T₂, T₃ and T₄). As this is an intercropping system, the profit from both the crops would be helpful in increasing economic benefit.

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