

Agronomy of Irrigated Tea in
Low Elevation Growing Areas
of
Sri Lanka

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Declaration

NAME:.....PROGRAM:.....

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Abstract

The low elevation tea growing region of Sri Lanka produces 60% of the national production and the most limiting factor affecting productivity in this region is the short but intense inter-monsoonal dry period. Irrigation, along with other methods like cultivar selection, is likely to be the best way to mitigate the impact of drought and generally improve productivity. However the dearth of knowledge of the response, and financial feasibility, of low elevation tea to irrigation retards its adoption. Therefore the Tea Research Institute of Sri Lanka (TRISL) funded a series of trials from 2006 to 2009 with the aim to understand the agronomic and physiological characteristics of low-grown tea in response to irrigation, and the financial practicality of introducing irrigation in the region. This aim was achieved through the following objectives to evaluate: (1) the changes in physiology and yield as affected by the drought and recovery by irrigation; (2) the environmental parameters that govern the water use of tea in low elevation growing areas; (Li, Yang et al.) the physiological and yield responses to different micro-irrigation methods; (4) the effect of soil moisture limitation on young tea plant growth and physiology; and (5) the practical financial feasibility of irrigating tea in the region.

Field trials were conducted at the TRISL's low-country research station at Ratnapura, Sri Lanka using mainly drip, and to a lesser extent sprinkler, irrigation to evaluate the response using different tea cultivars. Irrigation was only applied during the inter-monsoonal dry period of the January to March. Glasshouse experiments with different water stress levels were conducted specially for evaluating the short term drought effect on the post-nursery growth stages, which is critical for long term productivity.

The key results to the research objectives were as follows:

1] Key physiological process underpinning yield (P_n , E_t , g_s , Ψ) were depressed even under drip irrigation. Nevertheless, the drip-irrigated crop had an annual yield increase of 21% ($p < 0.001$) over the rain-fed control. Higher yields were observed even during non-irrigated periods as tea plants irrigated from establishment had better root and canopy structure. Strong cultivar differences were observed. The benchmark high-yielding, but drought-susceptible, cultivar TRI 2023 yielded 16% more under drip irrigation than the benchmark drought-tolerant cultivar TRI 3025. Evaluation of more recently developed cultivars revealed that irrigation will be a more effective drought mitigation strategy than selection of drought-tolerant cultivars. Among a group of 5 leading new cultivars only TRI 4049 showed physiological characters preferred for irrigation.

2] The environmental parameters measured were rainfall, ambient temperature, solar radiation, vapour pressure deficit and potential evapotranspiration. Temperature is the dominant parameter driving transpiration in the wet season ($r^2=0.62$, $P=<0.0001$) and suppressing all the other physiological processes in the dry season. Average daily transpiration was $2.3(\pm 0.3)$ and $1.3(\pm 0.2)$ mm in wet and dry seasons respectively for rain-fed plants. Irrigated plants showed $>100\%$ increase in transpiration than rain-fed plants in dry season.

3] During a very wet year (2008) sprinkler irrigation resulted in 15% higher assimilation rates and produced 6% higher yield increase than drip irrigation on TRI 2023. This was due to the maintenance of $2-4^{\circ}\text{C}$ lower leaf temperature in midday hours than under drip irrigation. Between 6 to 8% higher water use efficiency was achieved under sprinkler than drip irrigation.

4] Glasshouse and field experiments emphasised the importance of irrigation for the establishment of young (<1 year) tea plants. Decreasing the irrigation frequency from daily irrigation to a 4 day interval reduced stem growth by 20% and root growth by 46%. Deficit irrigation of 50% for 20 days, reduced the stem and root growth by 34% and 45% respectively. In the field, short dry spells (<3 weeks), reduced LAI and root growth. Establishing plants on mounds, as opposed to conventional flat ground preparation, enhanced the effect of irrigation to facilitate the growth of more root (12 and 8% increase in fine and coarse root) and leaf (60% increase in leaf area).

5] The on-farm feasibility of irrigating tea in low elevation areas was evaluated using Net Present Value (NPV) analysis. The analysis was based on 10 years (1999-2009) of yield data of TRI 2023 and TRI 3025 under drip irrigation. Long term yield data was not available for sprinkler irrigation. Sensitivity analysis was applied using variables of wage rate, green leaf price and discount rate (2007 as base year). Under these assumptions it is highly feasible to establish TRI 2023 under drip irrigation but not TRI 3025 (NPVs Rs 391779 and Rs -57898 respectively). The threshold levels for feasibility of TRI 2023 are a discount rate of 15%, or a green leaf price below Rs48. Irrigating TRI 3025 is economically viable only if green leaf price reaches Rs 65. Cultivar selection is a key factor in the financial success of tea irrigation. The higher water demand of a sprinkler system may limit its practical application.

The study confirms that irrigation can be used as viable option to improve productivity and to mitigate short term drought effects in low elevation tea growing areas. It is crucial to irrigate from establishment of young plants as early growth determines later yield potential. Cultivars suitable for irrigation are those that are inherently faster growing and less drought tolerant.

Further studies are encouraged comparing sprinkler and drip irrigation, soil moisture based irrigation scheduling and different water application rates under drip irrigation.

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List of Acronyms

| | |
|------------------|--|
| Ψ | Leaf water potential (MPa) |
| Φ | Quantum efficiency ($\mu\text{mol (PAR)}^{-1}$) |
| ADB | Asian Development Bank |
| D_r | root zone water depletion (mm) |
| E | Transpiration (mm/day) |
| E_l | Instantaneous leaf transpiration ($\text{mmol H}_2\text{O m}^{-2}\text{s}^{-1}$) |
| ET_0 | Potential evapotranspiration (mm/day) |
| g_s | Stomatal conductance ($\text{mol H}_2\text{O m}^{-2}\text{s}^{-1}$) |
| I | Incident light intensity ($\mu\text{molm}^{-2}\text{s}^{-1}$) |
| IRR | Internal Rate of Return (%) |
| IRR_i | Irrigation water applied (mm) |
| IWUE | Irrigation water use efficiency (kg/ha/mm) |
| K_c | Crop coefficient |
| K_s | Water stress coefficient |
| LCLWT | Low country live wood termite (<i>Glyptotermes dilatatus</i>) |
| MARR | Minimum Attractive Rate of Return (%) |
| N | Sunshine hours |
| NPV | Net Present Value |
| PAR | Photosynthetically active radiation (Wm^{-2}) |
| P_n | Photosynthesis ($\mu\text{mol CO}_2 \text{m}^{-2}\text{s}^{-1}$) |
| R_d | Dark respiration |
| RF | Rainfall (mm) |
| R_n | Solar radiation (MJm^{-2}) |
| SHB | Shot hole borer (<i>Xyleborus fornicatus</i>) |
| SLTB | Sri Lanka Tea Board |
| T_{avg} | Average air temperature ($^{\circ}\text{C}$) |
| T_{max} | Maximum air temperature ($^{\circ}\text{C}$) |
| T_{min} | Minimum air temperature ($^{\circ}\text{C}$) |
| TAW | Total available water in root zone (mm) |
| TE | Transpiration efficiency (g/mm) |
| TRISL | Tea Research Institute of Sri Lanka |
| TSHDA | Tea Small Holder Development Authority |
| W_i | Instantaneous water use efficiency |
| VPD | Vapor pressure deficit (kPa) |

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