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Diversity and behaviour of the naturally regenerated vegetation in commercial tea soils under herbicide free integrated weed management

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Abstract

Weed management is essential in agriculture to prevent *Economic Crop Damage* in farm products due to quality and quantity losses. *Herbicides* are profusely being used to meet this objective despite their hazardous nature on human health and the environment caused by residual contamination of food and drinking water. Sri Lanka imported 7,967,852 kg and 5,675,611kg of Herbicide chemicals in the forms of bulk and ready to use formulations in year 2013 and 2014 respectively and Commercial Tea Plantations too are heavily depend on herbicides to maintain “*Clean and Clear Ground Concept*” (CCGC) based mind set established in the sector. However, CCGC is not recommended by Tea Research Institute of Sri Lanka due to severe degradation in the tea soils resulted. Many of the so called weed species has the ability to thrive in degraded poor soils forming a quick ground cover arresting further depletion in soil and upgrade same by addition of Organic Carbon as leaf litter and root secretions feeding soil microbes. This study explored the diversity and perennial behaviour of the *Natural Vegetative Regeneration* (NVR) in Commercial Tea Soil under *herbicide-Free* Conditions to demonstrate the possibility of practicing *Herbicide-Free Integrated Weed Management* (HFIWM) in the Tea Industry at commercial scale in Sri Lankan conditions. The survey commenced in Hapugastenne estate Maskeliya Plantations PLC., following to pruning, on a weed free, exposed Tea field in an extent of one hectare, where natural regeneration of vegetation was allowed and monitored, under a *Treatment of “Herbicide - Free Integrated Weed Management”* (HFIWM), for three years. *Non-IWM* (Control) area of similar extent was demarcated adjoining to said area and sprayed with Diuron, Paraquat and Glyphosate, as recommended by the Tea Research Institute of Sri Lanka. The naturally regenerated Terrestrial Vegetation in treated and control areas, was surveyed periodically and simultaneously, by investigating 3m X 3m sample plots with four replicates each time, concerning species diversity and recorded the variations observed. Non-IWM section displayed a continuous increase in plant diversity up to 76 species, within three years, dominated by Herbicide tolerant weed species. Vegetation established on HFIWM area reached a peak of 64 plant species within the first year itself, forming a complete ground cover whilst effectively suppressing many of the targeted notorious weeds which cause severe economic damage in Commercial Tea Plantations.

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Introduction

Weed management is essential in agriculture near Economic Crop Damage Level, to arrest quality and quantity losses in farm products. Usage of toxic, plant killer chemicals (herbicides) to meet this objective is a common practice in today's context of agriculture and Sri Lanka imported 7,967,852 kg and 5,675,611kg of Herbicide chemicals in year 2013 and 2014 respectively¹. Main reason behind this marked drop in Herbicide imports to the Island was the restrictions imposed by the various institutes devoted in food security, and the controls set by the government on such chemicals, mainly due to the exposure of their harmful residual effects on human health by contamination of food and drinking water. However a major fraction of these Herbicides imports are absorbed by the Commercial Tea Plantations where four to five Herbicide applications per annum is common mostly due to the “*Clean and Clear Ground Concept*” (CCGC) mind set established in the sector. It is debatable whether we really need to maintain CCGC in Commercial Tea Gardens which certainly debilitate the soil conditions, and is not recommended even by the Tea Research Institute of Sri Lanka since this concept result in severe degradation in the tea soil². Many of the so called weed species has the ability to thrive in degraded poor soils forming a quick ground cover arresting further depletion in soil and upgrade same over the time by addition of Organic Carbon in the forms of leaf litter and root secretions feeding soil microbes. Although there are many definitions to describe weeds, they should be suppressed only when economic crop damages are caused by such plant species. Thus, it is important to make wise decisions on selective weed management and, also with a careful understanding whilst considering comparative long term benefit levels on the ecosystem holistically. The purpose of this study is to explore the floral diversity of the Natural Vegetative Regeneration (NVR) in commercial tea soils and the perennial behavior of this vegetation under herbicide - free conditions over the time in the first place, and also to demonstrate the possibility of practicing Herbicide - Free Integrated Weed Management (HFIWM) in the Tea Industry at commercial scale in Sri Lankan conditions.

Methodology:

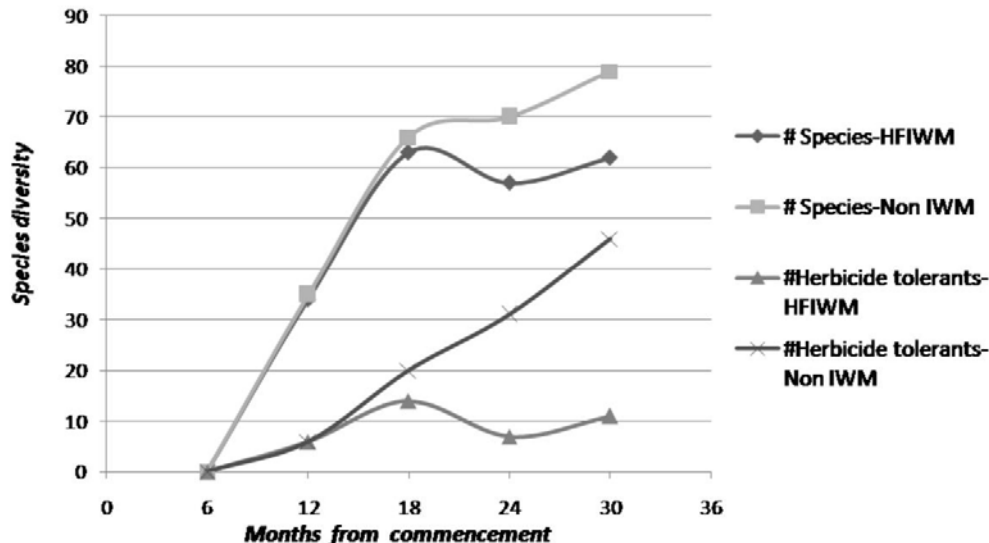
A commercial scale trial on HFIWM was conducted in Hapuhastenne Estate, Maskeliya Plantations PLC, which commenced after pruning with a complete clearing of the undergrowth beneath tea bushes following to mowing and ferning. An extent of one hectare was selected as the area under HFIWM (Treatment), where natural regeneration of vegetation was allowed, ceasing the usage of herbicides completely, over a period of three years, whilst selective removal of harmful weeds grown in the experimental Tea area by manual uprooting. Rest of the vegetation was allowed to establish as a ground cover over the land and slashed regularly near ground level. A similar Tea extent was demarcated adjoining to said area as non-IWM (Control) and natural regeneration of the vegetation over the ground on same, was manipulated by sporadic spraying of herbicides, namely Diuron 80% (1.2kg ha⁻¹), Paraquat 6.5% (3.3 l ha⁻¹) and Glyphosate 36% (2.0 l ha⁻¹) in 480 l of water per ha³, depending on the types of weeds present and their stage of growth, as per the recommendations set by the Tea Research Institute of Sri Lanka. The naturally regenerated Terrestrial Vegetation in the experimental extent including both treated and control areas, was surveyed periodically and simultaneously, within the demarcated experimental extent consisting of both treated and control areas. These data from treated extent and the control area were collected concurrently, just before the spraying of Herbicides over the control area. Plant specimens collected were identified comparing against the specimen collection of National Herbarium⁴, Peradeniya. These results obtained from HFIWM extent were compared against the data collected from adjacent control plots of non-IWM Tea area in the Garden.

3. Results, Discussion, Conclusion and Recommendations:

The naturally regenerated vegetative community consisted in both treated and control areas initially were recorded with 34 and 35 total species respectively and seen dominated by broad leaved plant species within the first three months. Namely, *Ageratum conyzoides* (Asteraceae), *Polygonum nepalense* (Polygonaceae), *Crassocephalus*

crepidioides (Asteraceae), *Hedyotis auricularia*, *H. neesiana* (Getakola), and *Commelina benghalensis* (Amalai), were the leading species observed out of the 34 and 35 total species recorded. Only a few grass species were recorded at this phase of the study. However at 12 months from the commencement, following to four consecutive slashes of the undergrowth vegetation, floral species diversity in HFIWM section had raised up to 64 species. Non-IWM segment in the mean time recorded 66 species, after three periodic chemical weeding rounds which consisted one round each of Diuron, Paraquat and Glyphosate correspondingly, also followed with one manual weeding round as per the usual practice. Meanwhile, the composition of dominant species had displayed a marked change in the HFIWM area. Initial high populations of *A. conyzoides*, *C. crepidioides*, *H. auricularia* and *H. neesiana*, were gradually smothered and their growth was suppressed by both grass and broad leaf creeper species as they established over the ground. *Elusine indica*, *Digitaria* spp., *Brachiaria brizantha*, (Poaceae) and other species such as *Centella asiatica*, *Hydrocotyle sibthorpioides*, (Rosaceae), *Desmodium heterophyllum*, (Fabaceae) and *Drimaria cordata* were found dominating species registered covering the ground in areas of multi species mats, and isolated mono species patches scattered over the place. Interestingly, the growth of *A. conyzoides* and many other plant species including *C. crepidioides*, *C. hirta* and *Hedyotis* spp. were greatly suppressed either by making them dwarf in size or pushing their population densities down to diminutive levels of below 05 individuals per square metre, especially by the species like *H. sibthorpioides*, *C. asiatica* and *C. benghalensis* with shallow root systems. Climber species such as *Mikania scandens* (Asteraceae) and *Ipomoea learii* (Convolvulaceae) too were seen stunted in growth where the ground was covered by above said shallow rooted runner species. However, many of the soft herbaceous species dried up during the persistent rain free periods. But *C. asiatica*, *C. benghalensis* and many of the grass species were capable of withstanding dry spells. Next interesting observation made was the gradual over-running of the areas which previously covered by *Brachiaria brizantha* (Poaceae) and *Cymbopogon confertiflorus*, (Poaceae) by *C. benghalensis* in the HFIWM zone declared. All open land area with soil in the HFIWM block had been thoroughly covered, mostly by *C. benghalensis* at the end of the first year. The HFIWM zone was treated with 10 periodic slashes by 24th months from the beginning of the study registered 57 weed species in the understory.

Figure 1: Diversity and the Behavior of Naturally Regenerated Vegetation on Tea Soils under regular Herbicide application and Herbicide Free Integrated Weed Management.



C. benghalensis was performing the main role as the ground cover at this point forming a thick mat masking over 80% of the land extent. Balance area was covered up by the rest of the plant species and chiefly by *C. asiatica*, *H. sibthorpioides*, *D. heterophyllum*, *Digitaria* spp. and *D. cordata*. Non-IWM section demarcated too was provided with 07 chemical weeding rounds in the mean time, 05 out of which were conducted with Glyphosate. Out of the total 70 weed species recorded. *C. hirta*, *H. neesiana*, *H. auricularia*, *A. conyzoides*, *C. crepidioides*, *M. scandens*, *I. learii*,

and *C. benghalensis*, were still playing the dominating role within the plant community here. Apart from that another important observation made at this juncture was the emergence of *Fern species* in both treated and control areas. This phenomenon resulted in further increase in plant species diversity up to 79 terrestrial flora species in the non-IWM area by the third year, where 18 species were Ferns, which completely Herbicide tolerant. The HFIWM section recorded overall terrestrial floral species count of 62 by the third year from the commencement including 08 fern species. Therefore, the results of this study strongly confirm that HFIWM could be used successfully to suppress and control the targeted weed species, which cause economic damage in Commercial Tea Plantations under Sri Lankan conditions.

1. References

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