RESEARCH ARTICLE

Effects of Epiphytes on Tea Production and their Management

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Abstract

Epiphytes are a group of non-parasitic plants that settle to obtain support from plants. Under the natural forest ecosystem, the presence of epiphytes is an indicator of unpolluted and undisturbed environment. However, massive infestation by epiphytes to commercial tree crops including tea is a concern to productivity. A study was conducted initiated to determine the influence of different management options on epiphytes which included mosses, ferns, maidenhair ferns, and tongue ferns. The study evaluated the influence of different management options on epiphytes and to determine the effect of the management options on tea yields. The experiment was laid on a field infested with epiphytes in split plot design treatment structure in a randomized complete block layout, replicated three times. In the main plots the epiphytes were manually removed from the tea bush branches whereas the control was left in situ while the subplots involved use of agricultural chemicals; Copper nordox, Cuprocaffaro, Milraz, Hydrate of lime, round up Turbo and control (untreated). Post-treatment scoring for 3 years of all types of epiphytes was done using a scale to determine the level of yellowing, scorching, and regrowth. Yield data were also recorded for one prune cycle of four years and data was subjected to analysis of variance. The main treatments (disturbed and undisturbed) management options did not influence the efficacy of the chemical products on epiphytic mosses but disturbance reduced ($p \leq 0.05$) levels of the epiphytic ferns. Copper-based products (Copper nordox and Cuprocaffaro) reduced ($p \leq 0.05$) in mosses levels (reducing the degree of yellowing and regrowth) than other products and the control. However, all chemical products reduced ($p \leq 0.05$) levels of epiphytic ferns. The removal of epiphytes on the tea branches increased ($p \leq 0.05$) the yield of tea, while chemical products were ineffective in improving yields. This study, therefore, concludes that the epiphytes on the tea frame have effects on the functioning of the tea bush and removal of the massive epiphytes is necessary for improved productivity of tea bush.

Keywords: Epiphytes, Ferns and mosses, Management options, Tea.

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Introduction

Tea is a small tree which grows as an evergreen broad-leaved and is culturally maintained as a bush less than 150 cm high by pruning every three or five years.[1,2] The cultural manipulation practice makes it possible to pluck constantly the two leaves, and a bud from which tea is manufactured keeps the tea plant in a vegetative state.1 Pruning the tea breaks their canopy regularly making them an important host for many epiphytes under favorable environmental conditions. Nadkarni[3] described epiphytes to have epitomized a neutral, or commensalistic symbiosis with their hosts, and have historically been considered to only minimally affect the nutrient relations of supporting trees and the ecosystem as a whole. They settle on branches and trunk of other plants for support[1,4] and are fully autotrophic.[5,8] However, under the natural forest ecosystem, biomass and volume of epiphytes present are such that they are of functional importance to the forest itself.[3,5,6] Epiphytes contribute about 10 percent of all the global plant biodiversity and up to 25% in the tropics.[7,8] They typically grow on the surface of trees but remain fully autotrophic since they obtain water, nutrients, and minerals aerially and not from the host trees.[3-5,9] Their roots can derive anchor and assimilate water from surfaces other than the ground. In addition, they have a unique characteristic that includes thick and waxy leaves that allow them to require small amounts of water.[10] In a natural ecosystem, epiphytes provide unique microclimates and habitats for other species; thus their decline could negatively affect many animals and plants that rely upon them in terms of biomass and nutrient and water cycling.[11,12] In an ecosystem, epiphyte is influenced by varied light conditions ranging from the nearly full sun on open branches to deep shade on the bases of stems within an ecosystem[13] and are susceptible to the current climate change due to continuous exposure of environmental changes Ruzana et al.[14] However, Sanger and Kirkpatrick[15] reported that rainforest epiphyte distribution is determined by three main factors, micro-climate within the host tree, landscape changes in macro-climate, and the characteristics of the host tree. Under a tea cropping system, epiphyte management has not received important consideration despite cases of increased occurrences. According to a study by Johansson et al.,[16] most epiphytic lichens positively related to the size and sites of an oak tree. However, Sanger and Kirkpatrick[15] found out that host characteristics (bark roughness and host size) did not affect the moss and vascular epiphytes species composition or richness, but for the host tree possessed a strong influence, moisture, temperature and light in Australia's rainforests.

Tea growers attribute epiphyte occurrence and yield loss by epiphytes to poor bush sanitation and disease Hypoxylon wood rot management through prompt surgical pruning. Poor sanitation involving 'bowel' cleaning, surgical removal of diseased branches by Hypoxylon wood rot disease and inappropriate timing of pruning which leads to poor growth thus encouraging rapid colonization by epiphytes on the tea bush. Mechanical tea harvest regime has also been suspected to enhance the problem since it has been

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reported to heavily reduce the foliage cover of tea and therefore, encourages fast growth of moss and ferns. In addition, debris left and trapped on bowels and the tea branches during harvesting trap additional nutrients especially fertilizers which together with moist environmental conditions, cause favorable growth environments for the epiphytes. This is supported by Nadkarni[17] who demonstrated that epiphytes absorb atmospheric-borne nutrients during the dry season as demonstrated by greater nutrients from branches with epiphytes than from those whose epiphytes had been experimentally stripped. The deliberate removal of epiphytes from tree crops is not common and scanty information exists in shade tree in the coffee plantation of Latin America, cocoa in Central Sulawesi, Indonesia.[15,18] Removal of epiphytes from tea bush branches and the truck is not a common practice within the tea farming system in Kenya. However, in the recent past, reports of epiphyte occurrence on tea has increased. It is also believed that the epiphytic layer may limit the development of new secondary branches of tea bushes, thereby causing decreased canopy shoot growth, leading to crop losses. This study, therefore, was initiated to evaluate epiphyte management options and their influence on the tea yield in Bomet County in Kenya.

MATERIALS AND METHODS

The experiment was carried out at Simotwet Estate, James Finlay (K) Ltd. in Bomet County on a section of epiphytes affected fields and laid in a split-plot design arranged in a randomized complete block layout (RCBD) for 4 years (2013–2016). In the main plots, the epiphytes were manually removed from the tea bush branches whereas the control was left undisturbed. The subplots involved the application of agricultural chemicals; Copper Nordox at 50g/L, Cuprocaffaro at 37.5 g/L, Milraz at 30 g/L, Hydrate of lime at 30 g/L, Round up Turbo at 10 mL/L and control (untreated). The sub-plot comprised of 20 bushes and 3 bushes were randomly selected in each plot and tagged for data scoring. The types of epiphytes were identified (mosses and ferns), and post-treatment effects (yellowing, scorching, and regrowth) on types of epiphytes were scored for 3 years on a scale of 0–5, where; 1 = no effect, 2 = very mild effect, 3 = mild effect, 4 = severe effect, 5 = very severe effect. The crop yield (green leaf) was harvested from each plot under normal estate management standard and weighed and converted into made tea per hectare. Normal agronomic practices were carried out throughout the trial period.[2]

All data were subjected to the analysis of variance (ANOVA) using the SAS software package version 9.1 and least significant difference (LSD) at $p \leq 0.05$ was used to separate means.

RESULTS

Effect of Management Options on Mosses

Copper-based agricultural chemical products (Copper Nordox and Cuprocaffaro) had significantly ($p \leq 0.05$) high scorching effect on moss epiphytes compared to other treatments and control in 2013, but in 2014 there was a significant difference between the products and control (Figure 1). The regrowth of moss in 2014 and 2015, showed that Copper-based products had significantly ($p \leq 0.05$) lower regrowth of moss compared to other products and the control (Figure 2). However, the main treatments (disturbed and undisturbed), did not significantly ($p \leq 0.05$) influence the effect of the products on the degree of moss scorching and regrowth (Figs 1 and 2). Similarly, the interaction between main treatments and sub-treatments did not show significant ($p \leq 0.05$) differences, implying that the effects of agricultural chemical products were not influenced by disturbing (removal) nor leaving the epiphytes in situ (undisturbed).

Effect of Management Options on Ferns

All the agricultural chemical products showed significant ($p \leq 0.05$) degree of yellowing on ferns compared with the control in 2013 and 2014 (Figure 3). The removal of epiphytes (disturbed) ($p \leq 0.05$) influenced the effect of the agricultural chemical products by increasing

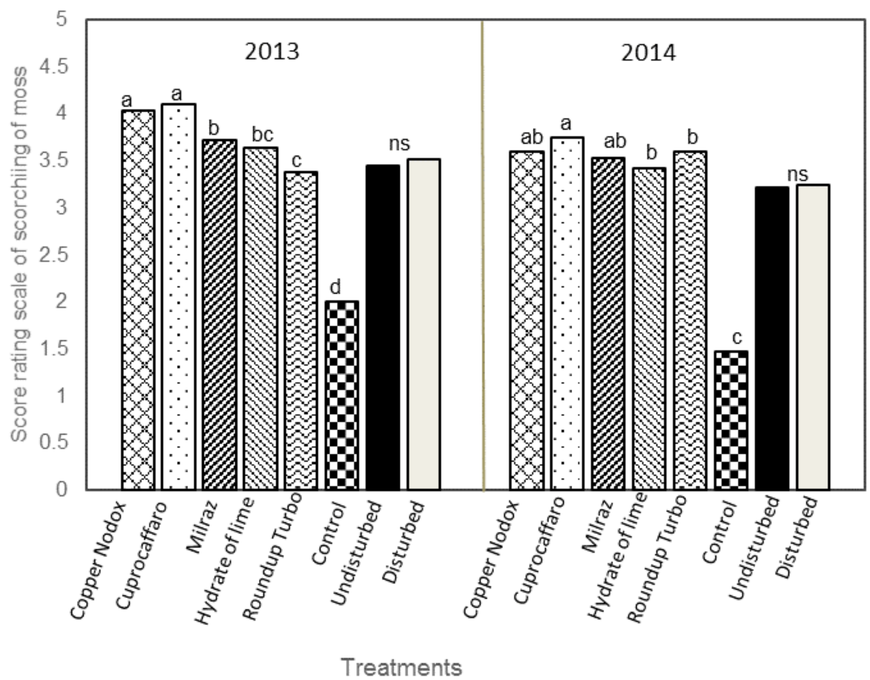

Figure 1: Effect of Epiphyte management options on the degree of scorching on mosses in 2013 and 2014

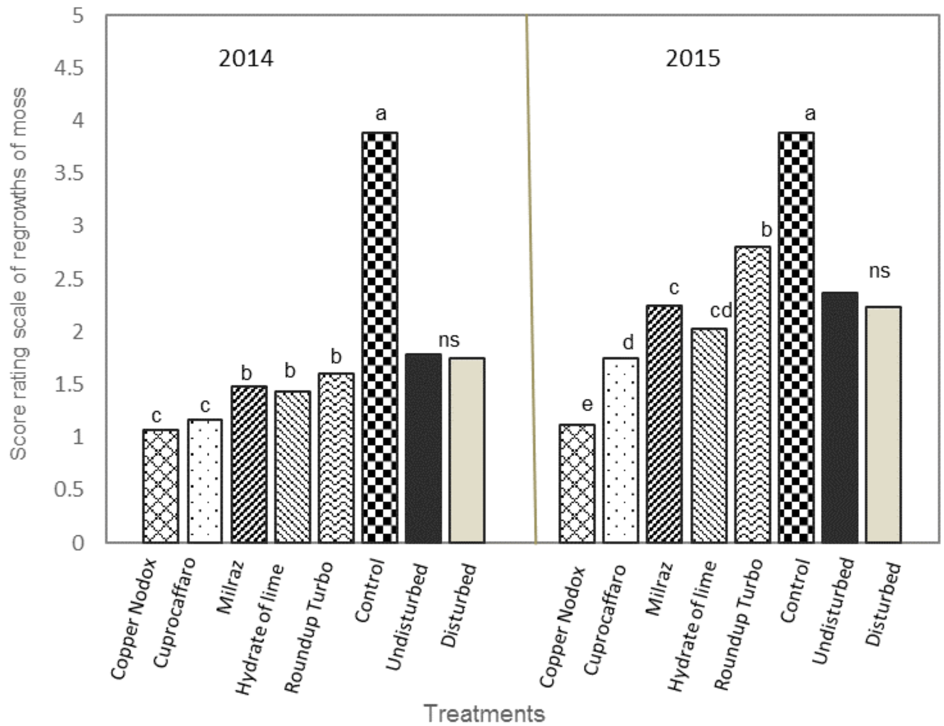

Figure 2: Effect of Epiphyte management options on the degree of regrowth of mosses, 2014 and 2015

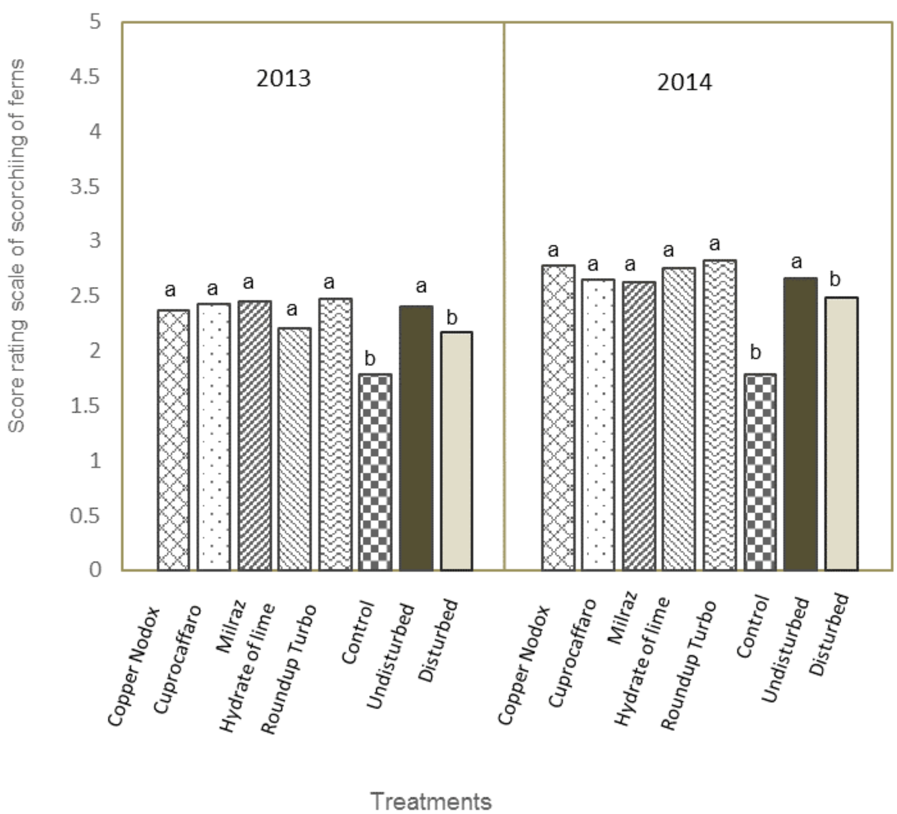

Figure 3: Effect of epiphyte management options on the degree of yellowing of ferns in 2013 and 2014

the degree of yellowing of ferns (Figure 3). The interaction between the main treatments and the agricultural chemical products significantly ($p \leq 0.05$) influenced the degree of yellowing in the first year (2013) only.

The regrowth of ferns was significantly ($p \leq 0.05$) inhibited by all the applied agricultural chemical products than the control throughout the study period (Figure 4). Roundup turbo exhibiting the highest degree of

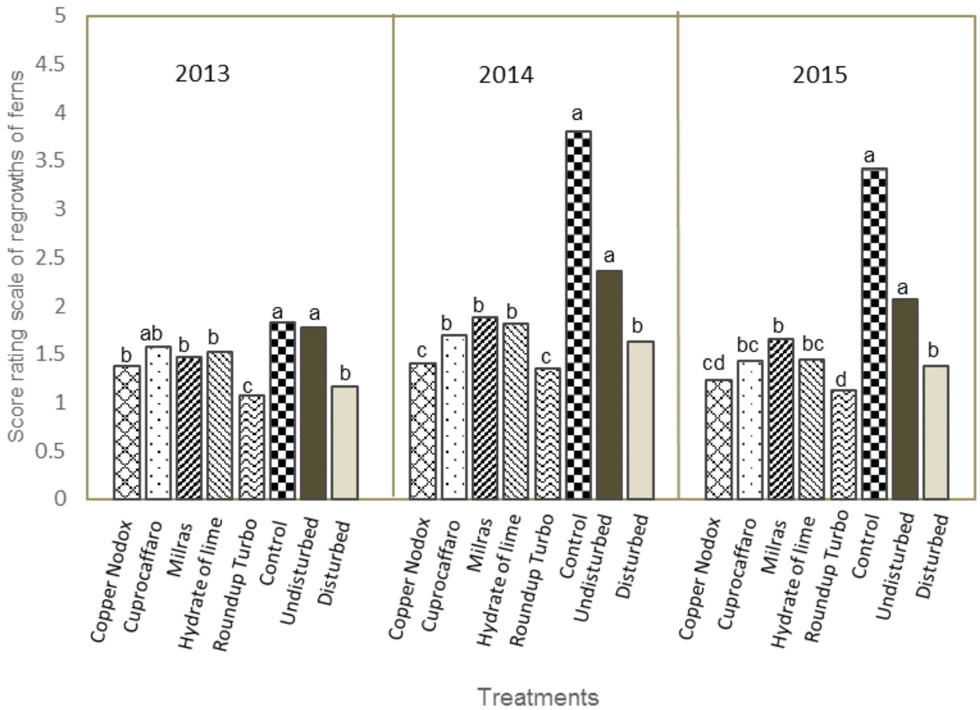

Figure 4: Effect of epiphyte management options on the degree of regrowth of ferns from 2013 to 2015

inhibition on fern-regrowth compared with the other products in 2013. However, both Roundup turbo and Copper nodox showed significantly ($p \leq 0.05$) lowest same degree of inhibition in 2014 and 2015 (Figure 4). The removal of epiphytes (disturbed) significant ($p \leq 0.05$) influenced positively the effect of agricultural chemical products by reducing the degree of regrowth of ferns compared to undisturbed (Figure 4). It was also noted that the interaction between the main treatments and sub-treatments significantly ($p \leq 0.05$) influenced positively the degree of ferns regrowth throughout the period.

Effect of Management Options on Yields

In all the years and cumulative yield (2013–2016), the sub treatments did not show any significant ($p \leq 0.05$) variation of the yield of tea (Table 1). During the first year, the undisturbed treatment recorded significant ($p \leq 0.05$) higher yield than disturbed treatment (Table 1). In the second and third year, the disturbed main treatment had significant ($p \leq 0.05$) higher yield than the undisturbed treatment, but there was no significant variation in the fourth year (2016). Generally, in cumulative yield of tea (2013–2016) disturbed treatment showed significantly ($p \leq 0.05$) higher yield than the undisturbed treatment (Table 1).

DISCUSSION AND CONCLUSION

Generally, the agricultural chemical products (sub-treatments) used in this study appears to have negative effects on the growth of epiphytes on tea bushes. Copper-based agricultural chemical products (Copper nordox and Cuprocaffaro) seemed to have the highest effect on scorching and inhibition (regrowth) compared to any other products and control for epiphytic mosses. On the other hand, all the agricultural chemical products had a significant effect on epiphytic ferns compared to control. There was no significant interaction between main treatment and sub-treatments in mosses management options indicating that their removal does not enhance the effects of the agricultural chemical products used. This is an indication that mosses are relatively more resistant to the agricultural chemical products and that mature epiphytic mosses are relatively more resistant. Unlike mosses, in ferns, there was significant interaction between main treatment and sub-treatments indicating that the removal of ferns (disturbed) exhibited compounded effects of the main and the sub-treatments. This also indicates ferns are relatively more susceptible to agricultural chemical products. This is true in that in the ferns in the disturbed plot were new regrowths and therefore, are relatively susceptible to the agricultural chemical products applied compared with the mature ferns in un-disturbed

Table 1: Effect of different epiphytes management options on yields of tea (Kg mt/ha)

Treatments	Mean yields of tea (Kg mt/ha)				Cumul-ative
	2013	*2014*	*2015*	*2016*	
Copper Nordox	1442	1390	1397	656	4885
Cuprocaffaro	1412	1251	1428	688	4779
Milraz	1339	1552	1392	672	4955
Hydrate of Lime	1416	1440	1465	698	5019
Round up Turbo	1318	1463	1381	667	4829
Control	1372	1442	1386	636	4836
Undisturbed	1419[a]	1329[b]	1353[b]	676a	4778[b]
Disturbed	1347[b]	1517[a]	1463[a]	664a	4989[a]
CV (%)	5.6	13.5	6.1	10.8	4.6
LSD (p ≤0.05)					
Main treats	26	132	60	NS	156
Sub-treats	NS	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS

(*in situ*) plot. Similar results were obtained by Bartok,[6] where frequency and different pesticide usage negatively influenced epiphytic lichen floras of different orchards.

Based on the results, there was a significantly higher yield of tea in the disturbed (removal of epiphytes) than the undisturbed treated plots implying that epiphytes in a way affect the functioning of the tea bush. Thus, possibly the dormant buds on primary branches, exposed by removing epiphytes increase the tea bush canopy eventually translating to the increased tea yields. Contrary to the above, in cocoa farming, the removal of epiphytes had no significant effect on the development of the cauliflorous flowers leading to fruit development hence productivity of Cocoa trees.[18] Though there was no significant variation in yields of tea due to the chemical products tested, it could be highly variable indicating that their influence does not directly positively affect the yield of tea or the chemicals may be having another adverse effect on the tea bush and their effect is long term (> 5 years). This is an area which requires further in-depth studies. In conclusion, the study indicates that removal of epiphytes (moss and ferns) on the tea trunk and branches from the main management approach against epiphytes in tea bushes, and has a significant yield benefit.

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