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**RESEARCH ARTICLE**

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# Effect of Field Dodder (*Cuscuta campestris* Yunck.) on Tea Clones' Growth Parameters and Yield in Nandi County, Kenya

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**Abstract**

*Plants of the genus Cuscuta, commonly known as dodder belong to the family of Cuscutaceae and consists of about 200 species found almost everywhere in the world. A study was conducted to assess the effect of Cuscuta on tea leaf count, leaf area, trunk diameter and harvest biomass (yield). The study was laid out in a complete random design with three replicates. The twigs of Cuscuta campestris (3 twigs of 11-inch length) were collected from infected tea plants at Nandi hills tea Estates and were used to infect potted tea plants at the Tea Research Institute. The Cuscuta campestris significantly affected trunk diameter of clone TRFK 306 by increasing its diameter, reducing leaf area of clones TRFK 31/8 and TRFK 301/4 compared with the control. Mean leaf area for the infected clone TRFK306/1 (40.33±6.50) was significantly different (t=-3.01, p=0.04) from the control mean (46.00±14.00). Mean number of infected leaves of TRFK 303/577 clone was highest (73.00±5.29) followed by EPK TN14-3 (61.66±4.72). For the effect of Cuscuta campestris on tea harvest biomass, differences in mean control and mean infected harvest biomass was assessed. All the six clones showed a significant difference between the biomass means of infected and control. These results indicate that there may be varietal preference in the attack by the parasite.*

**Keywords**: Tea Clone, Leaf Area, Biomass, Trunk Diameter, Parasitic Plant

## INTRODUCTION

There are about 400 species of known parasitic plants, some become weeds posing a threat to major crops. Among the agricultural parasitic plants is dodder. Dodder (*Cuscuta* spp) is a parasitic plant belonging to the family of Cuscutacecae which comprises about 200 species of obligate holoparasitic plants (Garcia et al., 2014). Due to the reduced amount of chlorophyll, *Cuscuta* parasitic plants may be able to carry out insignificant amount of photosynthesis or are unable to carry out photosynthesis altogether (Rubin and Artikhovskaya, 2013). Most *Cuscuta* species have been introduced to various regions of the world together with seeds of commercial crops, especially legumes such as alfalfa (*Medicago sativa*) and trifoliate species [e.g. clover (*Trifolium repens*)] and therefore are widely distributed throughout the temperate and tropical zones (Kaiser, 2015). According to Bore et al. (2014), the parasitic weed has been in existence in Kenya from the year 2007 and found to attack mostly Mauritius thorn, K-apple, bougainvillea, mango tree, Nandi flame, loquat, *Acacia* and tea plants.

In Nandi County, a large tea growing area in Kenya, tea bushes have been under attack since 2013 and this is threatening the existing tea estates, natural ecosystems and human livelihood (Kerich, 2014). The destructive effects of *Cuscuta* on its host are well illustrated in the work of Shen et al. (2005; 2011) and Lanini (2014). A range of physiological effects are described which resulted in complete prevention of flowering and almost complete death of the host plant after 70 days. In other host plants, *Cuscuta* has led to premature fruit drop, yellowed or dead leaves, as whole plant early senescence. *Cuscuta* is able to withdraw water, carbohydrate and other soluble materials (polyphenols and flavanoids) from the susceptible host by twining around the host and penetrating the stem via the haustoria to the vascular bundles (Westwood et al., 2012).

When attached to a host, *Cuscuta* operates as a "super-sink" overcoming the host's sinks system resulting in heavy loss in terms of yield. It has also been reported that *Cuscuta* invasion may cause 50% - 98% yield loss in many cultivated crops including but not limited to clover, onion, legumes, pepper, water melon and sugar beet (Zharasov, 2009). Eradication of invasive plants requires certain standards (IUCN, 2009). These standards include proper planning, commitment of both local communities and the planners, putting all risks into perspective and removal of the invasive plants before they reproduce. *Cuscuta* invasion in Nandi tea estates may be due to disturbances such as fires, floods, grazing, long periods of rain, human modifications of the habitat that create avenues for invasion or fluctuations in soil nutrients. Despite the ecological and economic significance of *Cuscuta*, its effect on tea clones' growth parameters and yield is poorly understood.

## MATERIALS AND METHODS

### Study Area

This study was undertaken in Nandi tea estates found in Nandi County, Kenya (Figure 1). The County lies between latitude 0034N and longitude 34045E to the West. It covers an area of 2,884.4 Km.

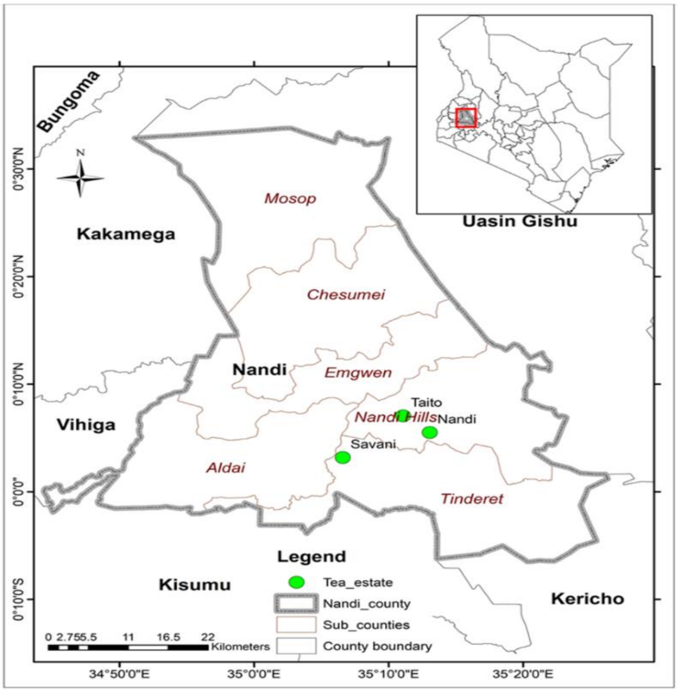


Figure 1: Location of the study area.

### Description of Genetic Material

For the purpose of this study, six tea clones with superior properties were selected from the existing tea bushes. The six tea clones were high yielding and widely cultivated in East Africa (Table 1).

### Research Design

This study utilized experimental design. Completely randomized design was used in the arrangement of the treatments of the six experimental tea clones and their replicates used in determining the effect of *Cuscuta* on tea clones yield.

Table 1: Characteristics of the six tea clones under investigation

| Clone | Variety type | Special attributes | Status |
|---|---|---|---|
| TRFK 301/4 | Cambod type, local selection | High yield, high quality black tea and drought tolerant | Widely grown in Kenya, recently introduced to Tanzania and Rwanda |
| TRFK 31/8 | Assam type, local selection | High yielding acceptable black tea quality | Widely distributed in East Africa |
| TRFK 430/90 | Assam type, local hybrid | High black tea quality, high yielding | Recently released in Kenya for commercial use |
| TRFK 303/577 | Assam/China hybrid. op 6/8 | High black tea quality, high yield | Widely distributed in East Africa |
| TRFT 306/1 | Assam type of purple tea | Moderate yield, medicinal properties | Released for specialty tea in 2011 |
| TN14-3 | Assam type, local selection | Moderate yield, high black tea quality | Widely distributed in East Africa |

### Selection and Infection of Experimental Tea Clones

On the 20$^{th}$ December 2018, the six tea clones with their 3 replicas were randomly selected from mature healthy shoots of single stem of uniform height of 4 cm and planted in a greenhouse at the Tea Research Institute in Kericho. Twigs of *Cuscuta campestris* were collected from infected tea clones at Nyayo tea Estates in Nandi County on 2$^{nd}$ February 2019, on 3$^{rd}$ February 2019 each of the six tea clones with their respective 3 replicas were each infected with 1 twig of *Cuscuta* of 27.94 cm length. The clones were planted in experimental pots covered with polythene papers with 75% of each pot filled with a mixture of top soil and 25% with sub-soil in the ratio of 3: 1. DAP fertilizer (10 g) was used in planting. Row to row and plant to plant distance was maintained at 100 cm. Watering was done twice a day with 200 ml of water. Irrigation was done twice a day daily (0900 hrs and 1600 hrs) for treatment resembling the wet season regime and once in two days (at 0800 hrs) for treatments that represented the dry season regime. Top dressing with CAN fertilizer (10 g) was done at the sixth month. Weed control was done till the end of experimental period. A control for each experimental set up was also replicated 3 times. Greenhouse was maintained at temperatures of between 23$^0$C and 28$^0$C.

### Data Collection and Instruments

Data were collected on trunk diameter (cm$^3$), leaf area of each plant (cm$^2$), number of leaves per a plant, dry weight in grams of harvest-biomass (two leaves and a bud), below and above ground crop biomass (g). The same procedure was repeated for the control experiments. Leaf area was measured using Licor portable leaf area meter. For dry weight, each treated tea clone had their moisture removed using blotting papers, and the plant dried in an oven at 80$^0$C for 48 hours and dry weight recorded.

### Statistical Data Analyses

Data on trunk diameter, leaf area, leaf count, harvest-biomass, below and above ground crop biomass from each infected clone and control were tested for normality using the Smirnov-Kolmogorov test and all were found to conform to normality. The differences in trunk diameter, leaf area, leaf count, harvest-biomass, below and above ground crop biomass between infected clone and control were therefore determined using paired t-test.

## RESULTS

### Effect of *Cuscuta campestris* on Tea Growth Parameters

There were six clones tested for mean difference between infected and control for trunk diameter. Among the six clones, only TRFK 306/1 had a significance difference (t=3.60, p=0.02) between infected (1.04±0.15) and control (0.7±0.04) while the others were not (Table 2). For the leaf area (cm$^2$), two clones had a significant difference between means of infected and control. Mean leaf area for the infected TRFK 306/1 clone (40.33±6.50) was significantly different (t=-3.01, p=0.04) from its mean control (46.00±14.00). For the TRFK 301/4 clone, mean leaf area (29.33±2.08) was significantly different (t=-2.94, p=0.04) from the mean leaf for control (34.33±2.08) (Table 3). There was no significance difference in mean number of infected leaves and control for all the six clones. Mean number of infected leaves of TRFK 303/577 clone was highest (73.00±5.29) followed by TRFK TN14-3 (61.66±4.72) with insignificant differences from mean control (Table 4).

Table 2: Mean difference in trunk diameter

| Clone | Infected | Control | t | p |
|---|---|---|---|---|
| TRFK430/90 | 0.91±0.09 | 0.92±0.03 | -0.23 | 0.84 |
| TRFK31/8 | 1.18±0.19 | 1.00±0.08 | 1.46 | 0.23 |
| TRFK306/1 | 1.04±0.15 | 0.7±0.04 | 3.60 | 0.02* |
| TRFK303/577 | 1.07±0.03 | 0.97±0.18 | 0.89 | 0.43 |
| TRFK301/4 | 1.07±0.16 | 1.10±0.28 | -0.14 | 0.90 |
| EPKTN14-3 | 1.03±0.17 | 1.09±0.08 | -0.53 | 0.62 |

*Significant mean difference is indicated with **

Table 3: Mean difference in leaf area (cm$^2$)

| Clone | Infected | Control | t | p |
|---|---|---|---|---|
| TRFK430/90 | 30.33±1.52 | 37.00±4.35 | -2.50 | 0.07 |
| TRFK31/8 | 40.33±6.50 | 47.33±7.57 | -1.21 | 0.29 |
| TRFK306/1 | 21.33±2.30 | 46.00±14.00 | -3.01 | 0.04* |
| TRFK303/577 | 33.00±3.00 | 38.00±2.00 | -2.40 | 0.07 |
| TRFK301/4 | 29.33±2.08 | 34.33±2.08 | -2.94 | 0.04* |
| EPKTN14-3 | 37.66±5.85 | 38.66±6.42 | -0.20 | 0.85 |

*Significant mean differences are indicated with **

Table 4: Mean difference in number of leaves

| Clone | Infected | Control | t | p |
|---|---|---|---|---|
| TRFK430/90 | 24.33±8.73 | 31.66±12.09 | -0.85 | 0.44 |
| TRFK31/8 | 30.66±10.40 | 37.33±15.69 | -0.61 | 0.57 |
| TRFK306/1 | 39.33±17.21 | 47.33±2.08 | -0.80 | 0.47 |
| TRFK303/57 | 73.00±5.29 | 75.00±5 | -0.48 | 0.66 |
| TRFK301/4 | 33.33±14.57 | 43.33±11.93 | -0.92 | 0.41 |
| EPKTN14-3 | 61.66±4.72 | 7±8.96 | -2.17 | 0.10 |

**Effects of *Cuscuta campestris* on Harvest-Biomass (g)**

For the effect of *Cuscuta campestris* on tea harvest-biomass (g), differences in mean control and mean infected of harvest-biomass between was assessed. All the six clones showed a significant difference. For the TRFK 430/90 clone, mean biomass of the infected (2.53±0.55 g) was significantly different (t=-3.48, p=0.3) from mean biomass control (4.15±0.58 g). Clone TRFK 31/8 showed significance difference between the biomass means of infected (3.91±0.50 g) and control (8.76±0.57 g). For the TRFK 306/1 clone, there was a significant difference (t=-4.18, p=0.01) between means of infected biomass (2.67±0.61 g) and control (4.17±0.06 g) (Table 5).

Table 5: Mean difference in harvest-biomass (g) (two leaves and a bud)

| Clone | Infected | Control | t | p |
|---|---|---|---|---|
| TRFK430/90 | 2.53±0.55 | 4.15±0.58 | -3.48 | 0.03* |
| TRFK31/8 | 3.91±0.50 | 8.76±0.57 | -10.99 | 0.00* |
| TRFK306/1 | 2.67±0.61 | 4.17±0.06 | -4.18 | 0.01* |
| TRFK303/577 | 4.01±0.10 | 6.62±0.28 | -15.13 | 0.00* |
| TRFK301/4 | 4.81±0.27 | 10.87±0.57 | -16.47 | 0.00* |
| EPKTN14-3 | 3.06±0.91 | 6.45±0.61 | -5.311 | 0.01* |

*Significant mean differences are indicated with **

**Below Ground Crop Biomass (g)**

Differences in mean control and mean infected root biomass (g) was assessed for all the six clones. All the six clones showed a significant difference. For the TRFK430/90 clone, mean biomass of the infected root (85.63±0.55 g) was significantly different (t=12.92, p=0.00) from mean biomass for control (79.66±0.57 g) (Table 6).

Table 6: Mean difference in below ground crop biomass (g)

| Clone | Infected | Control | t | p |
|---|---|---|---|---|
| TRFK430/90 | 85.63±0.55 | 79.66±0.57 | 12.92 | 0.00* |
| TRFK31/8 | 47.63±0.55 | 31.43 | 37.27 | 0.00* |
| TRFK306/1 | 37.20±1.05 | 31.8±0.10 | 8.79 | 0.00* |
| TRFK303/577 | 122.63±0.55 | 125.0±1.00 | -3.59 | 0.02* |
| TRFK301/4 | 78.2±0.10 | 50.66±0.66 | 70.82 | 0.00* |
| EPKTN14-3 | 47.63±0.55 | 31.43±0.51 | 37.27 | 0.00* |

*Significant mean differences are indicated with **

**Above Ground Crop Biomass (g)**

There was no significance difference in means of infected and controls of TRFK430/90 clone. Mean number of control biomass of TRFK306/1 clone was highest (125.00±1.00) with significant differences from mean control (Table 7).

Table 7: Mean difference in biomass of above ground crop biomass (g)

| Clone | Infected | Control | t | p |
|---|---|---|---|---|
| TRFK430/90 | 81.6±7.73 | 68.76±6.62 | 2.18 | 0.09 |
| TRFK31/8 | 78.20±0.10 | 50.66±0.66 | 70.8f3 | 0.00* |
| TRFK306/1 | 122.63±0.55 | 125.00±1.00 | -3.59 | 0.02* |
| TRFK303/577 | 85.63±0.55 | 79.66±0.57 | 12.95 | 0.00* |
| TRFK301/4 | 47.63±0.55 | 31.43±0.51 | 37.27 | 0.00* |
| EPKTN14-3 | 94.30±2.98 | 80.13±2.62 | 6.719 | 0.00* |

*Significant mean differences are indicated with **

## DISCUSSION

### Effects of *Cuscuta campestris* on Tea Clones

There were six clones tested for mean difference between infected and control for the trunk diameter. Among the clones, only TRFK 306/1 showed a significance difference between infected and control. This concurred with the findings of Saric-Skranomovic (2018), on the diameter of central cylinder of alfalfa infested with *Cuscuta* that showed little but significant reduction in its size.

The leaf area of the infected clone: TRFK 306/1 and TRFK 301/4 was significantly lower than that of the control while all the other clones were not affected. This might either be due to the inhibition in leaf expansion resulting from nutrient deprivation or to the reduction in the number of leaves or both, which is consistent with the findings of Watling & Press (2001) on *Sorghum bicolor* infected by *Striga asiatica* and *S. hermonthica* which had no effect on the leaf area. The findings are also in consistent with those of Shen et al. (2005) where *Cuscuta campestris* had an effect on the leaf area of its host Mikania (*Mikania micrantha*). This indicates that *Cuscuta campestris* is selectively aggressive on tea clones upon infection. According to Shen et al. (2005); *Mikania micrantha* allocates more resources to leaves, however the allocated resources do not result into an increase in the leaf area probably because of reduced remobilization of reserves from the infected leaves.

*Cuscuta campestris* did not significantly reduce the number of leaves after parasitizing. This indicates that the clones might have had a way of defending themselves against infestation which is consistent with a study by Shen et al. (2005) that showed that number of leaves/plants had a slight non-significant small negative correlation with the infestation level of dodder in Fahl ecotype of the Egyptian clover. Shen *et al*. (2011) revealed that *Cuscuta* parasitism suppressed host photosynthesis, captured host resources and consequently slowed host growth.

### Effect of *Cuscuta campestris* on Harvest-Biomass (g)

All the six clones showed a significant difference in harvest-biomass between infected and control. Moreover, the present results indicate that dry mass of *Cuscuta* plus host was less than that of uninfected clones. This is owed to the powerful metabolic sink effect of *Cuscuta* on its host where the damage to infected hosts can be severe, to the extent of total crop loss. In comparison to other plants such as lucerne, harvest-biomass can be reduced significantly with infestation by *Cuscuta*. This was consistent with Shen et al. (2005) who showed that the relationship between *Striga hermonthica* and *Cuscuta. campestris* led to depression of biomass accumulation in infected plants. The results were also consistent with those of Westwood et al. (2009) that *Cuscuta* was able to withdraw water, carbohydrates and other soluble materials from the susceptible host. *Cuscuta* operating as a “super-sink” overcomes the host’s sinks system resulting in heavy loss in terms of yield.

In line with Koskela et al. (2001), field dodders parasitize many different plants, induce negative impacts on the growth and yield of infested hosts and have significant effect on the structure and functioning of plant communities that are infested. Kaiser (2015), compared the susceptibility of different crops in India and measured yield losses of 82% in green gram, 27% in black gram, 67% in sesamum, 48% in soya bean, 86% in Niger seed, 25% in pigeon pea and 18% in groundnut. In a comparative study, Farah and Al-Abdulsalam (2004) ranked six legumes as highly susceptible suffering greater than 50% loss - hyacinth bean, lentil, chickpea, faba bean, lucerne and fodder pea; four as susceptible (10-50% loss) - fenugreek, Egyptian clover, lupin and garden pea, while kidney bean and vetch were unaffected.

**Effect of *Cuscuta campestris* on Below and Above Ground Crop Biomass**

The above and below ground crop biomass were higher in the infected clones than in the control. Contact stimulates the development of haustoria that forms connections between the vascular bundles and the host (Kaiser, 2015) increasing stem and root biomass. The host also develops wound tissue on the area of infection as a defense mechanism preventing the establishment of cytoplasmic connection between the host and the parasite (Yen et al., 2008) contributing to increase in biomass of roots and stem.

## CONCLUSION

The study revealed that among the six clones tested, only TRFK 306/1 showed a significance difference in trunk diameter between infected and control probably because *Cuscuta campestris* causes little reduction in trunk diameter size as has been observed in alfalfa infected by *Cuscuta*. Leaf area of the infected clone TRFK 306/1 and TRFK301/4 was significantly lower than that of control while all the other clones were not affected which could be attributed to the inhibition in leaf expansion or to the reduction in the number of leaves or both. The number of tea leaves was not reduced by *Cuscuta* attack proving a presence of defensive mechanism against intense infestation by parasitic *Cuscuta*. The study also observed that dry mass of *Cuscuta* plus host was less than that of uninfected clones probably owing to the powerful metabolic sink effect of *Cuscuta* on its host where the damage to infected hosts can be severe. The study recommends more work to be done to assess other contributing factors leading to variable attack of tea by *Cuscuta*. As well as the best ways of controlling *Cuscuta* attacks on tea.

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