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Effect of *Trichoderma* Isolates on Root Growth of Different Tea (*Camellia Sinensis)* Clones; Nursery Based Study

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Abstract: ***Most farmers depend on tea as a cash crop and raising it is challenging due to pathogens and other factors which lower the vigour hence production of weak vegetative propagated plants. Some Trichoderma species promote growth in a wide range of plant species by establishing robust and long-lasting colonization of the root surfaces penetrating into the epidermis and promote roots development; crop productivity and resistance to abiotic stresses. The objectives of this study were to investigate the effect of Trichoderma spp. isolates on development of roots and root biomass of ten selected clones. The Trichoderma spp. was isolated from forest soil (F) and tea root rhizospheres (TR) using modified Martin's Rose Bengal Agar. Standard isolate, (Trichodermaharzinum) -T4 was from stock cultures. They were cultured, purified and characterized using cultural morphological, and microscopic characteristic. Pure cultures were multiplied using Potato Dextrose Agar and 1ml (2.0 x 10^6 cfu/ml) suspension used for inoculation. Experiments were set up with controls using DAP fertilizers in a randomized complete block design with three replicates. Observations were made after 120 days. Data was analysed using Statistical Analysis Software (2018) and Two-way analysis of variance (ANOVA). Results showed the isolates significantly (P≤0.05) enhanced development of root and root biomass in the treated tea clones. It was concluded that Trichoderma spp. promote growth in different tea clones and hence, is recommended for use when raising cuttings in the nursery.***

Keywords: *Trichoderma* spp -Forest isolate; T4-Standard isolate TR-Tea root Rhizosphere isolate; Clones

1. Introduction and Background to the Study

The development of biological control agents of plant pathogens has attracted significant amount of interest in the recent years due to global concerns to conserve the environment and the negative impacts of chemical pollutants on human health worldwide. The research conducted in this field has led to the discovery of many potential fungal biocontrol agents some of which have reached the stage of commercialization [5].The ability of some *Trichoderma spp*. to parasitize and kill destructive plant pathogens have attracted attention of agricultural scientists, farmers and policy makers worldwide and hence; a large body of information on biological control of plant pathogens have accumulated in the recent past [2].

The most recent reports on some of the beneficial microorganisms from different parts of the world have demonstrated their role in the promotion of plant growth and induction of defenses response on host plants in addition to antagonistic action on plant pathogens [4]. Inoculation of tea cuttings with different species of Arbuscular Mycorrhizal Fungi isolated from different tea rhizospheres in Assam (India) significantly improved the survival of the cuttings [1]. *Glomus fasciculatum species* was found to be the most efficient and had the highest shoot length, root length, dry weight and nutrient uptake in tea cuttings. Field experiments conducted in Assam revealed increased leaf harvest in the Arbuscular Mycorrhizal Fungi inoculated plants in comparison to the control [1]. In Morocco, the Carob tree (*Ceratonia siliqua)* is an agro-forest-pastoral species having an enormous socio-economic and ecological interest. Research on the effect of double inoculation with endomycorrhizae species and *Trichoderma harzianum species* on the growth of Carob plants showed a significant effect on the growth of these plants [11].

In Kenya investigations carried out on *Trichoderma spp.* have shown their potentials in enhancing the overall growth in tea plants [10]. Research carried out at Tea Research Institute showed antagonistic properties of some *Trichoderma* species against *Armillaria spp.* fungi in tea establishment [8], [9] & [3]. However, no research has been done on the effects of *Trichoderma* spp. on any specific tea clone. This research was aimed at carrying out an investigation on the nursery-based screening of ten selected commercial tea clones inoculated with *Trichoderma spp.* isolates for enhanced growth of roots; the number of roots and biomass to bridge the identified gaps.

2. Materials and Methods

Experimental design

The research was carried out at Tea Research Institute nursery section for a duration of 120 days. The experiments were set up in a Completely Randomized Block Design (CRBD)in which tea clones were planted in polythene sleeve and randomly placed in the experimental blocks in the nursery. The experiments involved 7 treatments namely; Tea Rhizosphere (TR) +DAP; Forest (F) + DAP; Standard (T 4) +DAP; Tea Rhizosphere (TR only); Standard (T4 only) and control (DAP only) in three replicates.

Source of *Trichoderma spp.* isolates

The standard *Trichoderma harzianum* (T4) isolates; was obtained from the stock cultures in the TRI laboratory

through sub culturing in Potato Dextrose Agar (PDA) while isolates; F and TR were obtained from virgin forest soil and old tea root rhizospheres respectively, through isolating using Martin's Rose Bengal Agar (1950). Identification and characterization were done in the laboratory using microscopic, cultural and morphological characteristics. The isolates were multiplied on PDA and appropriate concentrations were obtained for inoculating all the experimental tea clones in the nursery.

Source of Tea Clones

Tea clones used for the experiments were TRFK 6/8; TRFK 7/9; TRFK 31/8; TRFK 56/1; TRFK 301/4; TRFK 303/577; TRFK 7/3; TRFK 306/1; TRFK 597/1; TRFK 704/2, their cuttings obtained from the Tea Research Institute-Timbilil Estate mother bushes. Each cutting had two buds and a leaf obtained from mother bush 2.5 cm to 4 cm in length. The Criteria used to select ten clones for the study involved sampling of 10 clones out of 59 commercial clones developed by Tea Research Institute. The 10 samples represented the popular commercial clones which were the standard check for adaptability, high quality and high yielding. Selection of the ten Clones was based on; Yield potential kg/mt/ha/yr.; Quality index of black tea; Rooting of cuttings; Current utilization status [6].

Trichoderma species isolates; T4; TR; and F spore harvesting

The method adopted for harvesting of *Trichoderma species* spores from mature cultures was by scrubbing off using a sterile glass slide. The harvested spores were counted using haemocytometer and the concentration adjusted to 2.0 X 10^6 colony forming units per ml with sterile distilled water.

Nursery Bed Establishment

Polythene sleeves (10 cm diameter by 26 cm long) were used to pot nursey soil comprising of a mixture of both topsoil and subsoil mixed with DAP fertilizers with the application rate recommended and adopted by the Tea Research Institute (600g of DAP per 1, 000, 000 cm^3 volume of soil). The sleeves were filled with the nursery soil, cuttings were planted and watered and covered with polythene sheet. There were 10 different clones per plot each with Replicate 1 (R1); Replicate 2 (R2) and Replicate 3 (R3) respectively. Each replicate was further replicated three time to give a total of ninety (90) plantlets per plot. There were seven (7) plots each with ninety plantlets to give a total of 630 plantlets in the experimental plotsin the nursery. Tinder net was used to provide 60% shading in order to reduce the impact of direct sun.

Inoculation with Trichoderma spp. isolates

The *Trichoderma* treatments**,** *T.harzianum*- T4; TR; and F were applied onto each sleeve using a pipette to enhance colonisation by the inoculum. Two millilitres of spore suspension containing 2.0 X 10^6 cfu was introduced into each respective sleeve. A control experiment was set up using (DAP only) for each clone.

Data Collection;

Growth measurements on root lengths by destructive sampling and getting the length using a ruler &, number of roots and Biomass were taken randomly after 120 days for each tea clones. Biomasses (dry weights) were recorded after drying the plant materials and weighing until the weight became consistently constant. Details of the data collected were recorded on a designed table for analysis and drawing of general conclusion.

Data Analysis

The collected data was subjected to Statistical Analysis Software (SAS version 9.0) for analysis and drawing of general conclusions based on the results obtained

3. Results and Discussions

The interaction of Treatment and Clones in Table 1 showed varied results when; 10 different clones of tea were subjected to 7 different treatments, to test on their length of roots after 60 days. From the findings the root length development did vary significantly (P≤0.05) in all the treatments. *Trichoderma* isolates F only, TR only and *T. harzianum* -T4 only enhanced the mean root length development (2.3a) compared to their controls (DAP only). From the findings of (Barthakur, 2005) inoculation of tea cuttings with different species of arbuscular mycorrhizal fungi (AMF) isolated from different tea rhizospheres in Assam (India) significantly improved the survival of the cuttings [1]. *Glomus fasciculatum* species was found to be the most efficient and registered the highest shoot length, root length, dry weight and nutrient uptake in tea cuttings. Growth and survival of the cuttings from the above finding showed a common trend.

Growth and survival of clone TRFK 6/8, TRFK 7/9, TRFK 56/89, TRFK 306/1, TRFK 597/1, and TRFK 704/2 were enhance at their initial stage of establishment (Table 1). Research conducted by (Zouheir, 2016), showed that double inoculation with endomycorrhizae species and *T.harzianum*on the growth of Carob plants had a significant effect on the growth of these plants [11]. These finding (Table 1) also showed a common trend with those of other researchers.

The root length development varied significantly (P≤0.05) in all the treatments compared to their controls after 120 days (Table 2).Generally, the mean *Trichoderma* isolates treatments without DAP; F only; TR only; T4 only and *T.harzianum* -T4+DAP had significantly higher root length than those with DAP and control (Table 2). The effects of interactions between the clones and *Trichoderma* spp showed that clones TRFK 56/89, TRFK 7/9, TRFK 704/2; TRFK 306/1 and TRFK 597/1 had significantly (P≤0.05) high root length (Table 2).Wanjiru (2009) pointed out in his studies that *Trichoderma* spp. inoculant improve root development in tea cuttings by 50% [10].Therefore from the results and finding from other researchers showed a similar trend.

The number of roots did vary significantly (P≤0.05) in all the treatments when 10 different clones were subjected to 7 different treatments, to test on their number of roots after 60 days (Table 3).The *Trichoderma* isolates; TR only; *T.harzianum* -T4 only; and F only showed the highest number of roots. The treatments; isolate F+DAP; isolate TR+DAP; *T.harzianum* -T4 +DAP; and Control also did not

exhibit significant variation in their means and showed low number of roots. The same trend was also observed after 120 days (Table 4).

The interaction of Clones with *Trichoderma* spp showed varied results with clone TRFK 56/89, TRFK 306/1 and TRFK 704/2 producing the highest number of roots after 60 days (Table 4). The same trend was observed after 120 days when clone TRFK 704/2 produced the highest number of roots, followed by clones TRFK 56/89 and TRFK 306/1 respectively. Clones TRFK 7/9; TRFK 301/4; TRFK 597/1; TRFK 6/8 and 31/8 showed moderate numbers of roots. Clone TRFK 7/3 had the lowest root numbers (Table4).

The findings when10 different clones were subjected to the different treatments to test on biomass also showed a similar trend after 60 days with treatments TR only, F+DAP and TR+DAP having the highest mean dry weight (Table 5).A similar trend was observed after 120 days where treatments; TR+DAP; and TR+DAP had the highest dry weight followed by isolate F+DAP; F only; TR only; and *T.harzianum* -T4 +DAP respectively (Table 6). Treatments; *T.harzianum* -T4 only showed moderate mean dry weight. The control (DAP only) showed the lowest dry weight.

The interaction of Clones with *Trichoderma* spp showed varied results with clone TRFK 306/1 and TRFK 301/4 producing the highest mean dry weight followed by clones TRFK 31/8; TRFK 597/1; and TRFK 6/8 respectively. Clones TRFK 56/89; TRFK 704/2 and TRFK 7/9 showed moderate mean dry weight. Clone TRFK 7/3 recorded lowest mean dry weight (Table 3).Investigations done by Wanjiru (2009) showed that *Trichoderma* spp inoculant improved shoot and root development and root dry weight by 83.78% and 50% respectively [10]. He further argued that *Trichoderma* spp isolates + DAP fertilizers interactions with tea improved shoot and root dry weights.

Table 1: The effects of *Trichoderma* on the growth of root lengths after 60 days

	Clonesroot length measurement (cm)										
Treatments (*Trichoderma* spp.)	TRFK 6/8	TRFK 7/9	TRFK 31/8	TRFK 56/89	TRFK 301/4	TRFK 303/577	TRFK 7/3	TRFK 306/1	TRFK 597/1	TRFK 704/2	Mean treatments
Isolate F +DAP	3.9 (1.7)	3.6 (1.73)	6.5 (2.1)	1.1 (1.13)	4.1 (1.81)	0.0 (0.69)	0.9 (1.1)	0.5 (0.9)	1.7 (1.3)	1.8 (1.33)	1.4 b
Isolate TR +DAP	1.8 (1.3)	3.4 (1.68)	1.2 (1.1)	2.1 (1.41)	0.0 (0.69)	0.0 (0.69)	0.0 (0.7)	0.3 (0.8)	1.5 (1.24)	6.2 (2.1)	1.2 b
T. harzianum (T4) +DAP	0 (0.69)	0.9 (1.06)	0.0 (0.6)	2.8 (1.56)	4.0 (1.79)	0.0 (0.69)	1.5 (1.3)	2.7 (1.5)	1.6 (1.29)	6.8 (2.17)	1.3 b
Control (DAP)	2.5 (1.5)	0.6 (0.96)	1.4 (1.2)	3.0 (1.6)	3.0 (1.6)	1.1 (1.13)	0.2 (0.8)	1.0 (1.1)	2.3 (1.46)	1.3 (1.2)	1.2b
Isolate FOnly	4 (1.8)	9.0 (2.4)	7.4 (2.2)	10.6 (2.5)	10.6 (2.5)	8.6 (2.36)	2.9 (1.6)	8.5 (2.3)	8.8 (2.38)	11.9 (2.6)	2.3a
Isolate TROnly	10.6 (2.5)	10.1 (2.4)	6.2 (2.1)	12.7 (2.6)	6.2 (2.1)	8.5 (2.35)	1.5 (1.3)	8.6 (2.3)	11.2 (2.5)	9.7 (2.46)	2.3a
T. harzianum (T4) Only	8.1 (2.3)	11.3 (2.5)	6.2 (2.1)	8.4 (2.34)	10.3 (2.5)	10.3 (2.51)	1.9 (1.4)	8.0 (2.3)	8.8 (2.38)	8.7 (2.37)	2.3a
Mean clone	1.7ab	1.8ab	1.7b	1.9ab	1.9ab	1.6b	1.1c	1.6b	1.8ab	2.0a	
C.V. (%)	35.02										
LSD (P≤0.05) Treatments	0.30										
Clones	0.37										

Table 2: Effects of treatments on growth of root lengths after 120 days

	Tea clones and root length measurement (cm)										
Treatments (*Trichoderma* spp.)	TRFK 6/8	TRFK 7/9	TRFK 31/8	TRFK 56/89	TRFK 301/4	TRFK 303/577	TRFK 7/3	TRFK 306/1	TRFK 597/1	TRFK 704/2	Mean Treats
Isolate F + DAP	2 (1.47)	17 (2.9)	8 (2.2)	7 (2.24)	2 (1.47)	1 (1.12)	1 (1.12)	3 (1.53)	8 (2.2)	15 (2.83)	1.93c
Isolate TR +DAP	5 (1.9)	13 (2.7)	2 (1.47)	16 (2.87)	5 (1.9)	14 (2.7)	0 (0.7)	7 (2.21)	3 (1.53)	12 (2.6)	2.08c
T. harzianum (T4) +DAP	14 (2.8)	7 (2.1)	6 (2.1)	11 (2.56)	19 (3.04)	6 (2.05)	6 (2.0)	17 (2.9)	3 (1.53)	13 (2.69)	2.51b
Control (DAP)	15 (2.8)	14 (2.7)	14 (2.7)	16 (2.87)	20 (3.09)	16 (2.87)	14 (2.7)	16 2.87)	16 2.87)	12 (2.6)	2.83ab
Isolate F Only	16 (2.9)	17 (2.9)	17 (2.9)	17 (2.92)	16 (2.87)	13 (2.74)	11 (2.6)	16 (2.87)	16 2.87)	17 (2.9)	2.88a
Isolate TR Only	12 (2.6)	16 2.87)	14 (2.7)	17 (2.9)	18 (2.98)	17 (2.9)	3 (1.53)	16 (2.87)	16 2.87)	15 (2.83)	2.72ab
T. harzianum (T4) Only	11 (2.5)	12 (2.6)	2 (1.47)	14 (2.7)	1 (1.12)	2 (1.47)	4 (1.7)	2 (1.47)	2 (1.47)	6 (2.14)	1.90c
Mean clone	2.46bc	2.71ab	2.22c	2.74a	2.35bc	2.26c	1.81d	2.45abc	2.40abc	2.68ab	
C.V. (%)	26.28										
LSD (P≤0.05) Treatments	0.32										
Clones	0.39										

Table 3: The effects of *Trichoderma*spp.on growth of the number of roots after 60 days

Clones	Tea clones and number of roots										
Treatments (*Trichoderma* spp.)	TRFK 6/8	TRFK 7/9	TRFK 31/8	TRFK 56/89	TRFK 301/4	TRFK 303/577	TRFK 7/3	TRFK 306/1	TRFK 597/1	TRFK 704/1	mean treatments
Isolate F + DAP	2.8 (1.56)	5.2 (1.98)	4.9 (1.93)	2.5 (1.5)	3.4 (1.68)	2.6 (1.53)	0.0 (0.69)	1.1 (1.13)	0.0 (0.69)	2.3 (1.46)	1.4b

Isolate TR +DAP	3.4 (1.68)	4.4 (1.85)	0.7 (1)	3.2 (1.64)	0.0 (0.69)	0.0 (0.69)	0.0 (0.6)	0.7 (1)	1.7 (1.31)	5.6 (2.03)	1.3b
T. harzianum (T4) +DAP	0.0 (0.69)	1.0 (1.11)	0.0 (0.69)	3.0 (1.61)	4.1 (1.81)	0.0 (0.69)	1.7 (1.3)	5.1 (1.96)	0.3 (0.83)	7.4 (2.24)	1.3b
Control (DAP)	3.0 (1.61)	1.2 (1.15)	0.5 (0.92)	2.4 (1.48)	2.8 (1.57)	1.9 (1.36)	0.0 (0.69	1.3 (1.19)	4.5 (1.87)	2.5 (1.51)	1.3b
Isolate F Only	6.8 (2.17)	6.5 (2.14)	3.9 (1.78)	17.1 (2.95)	10.9 (2.56)	14.1 2.78)	3.5 (1.7)	13.0 (2.71)	14.4 (2.8)	20.2 (3.1)	2.5a
Isolate TR Only	16.7 (2.93)	13.0 (2.71)	8.8 (2.38)	17.5 (2.97)	7.1 (2.21)	10.1 2.49)	2.8 (1.56	31.1 (3.5)	19.3 (3.06)	21.1 (3.14)	2.7 a
T. harzianum (T4) Only	6.5 (2.14)	10.9 (2.56)	8.9 (2.39)	8.0 (2.3)	16.7 (2.93)	16.7 2.93)	0.9 (1.06)	29.8 (3.46)	8.9 (2.39)	20.2 (3.1)	2.6a
Mean clone	1.8bc	1.9bc	1.6c	2.2ab	1.9bc	1.8bc	1.1d	2.2ab	1.9bc	2.4a	
C.V. (%)	36.94										
LSD (P≤0.05) Treatments	0.35										
Clones	0.42										

Table 4: Effects of treatments on growth of the number of roots after 120 days

	Tea Clones and number of roots										
Treatments (*Trichoderma* spp.)	TRFK 6/8	TRFK 7/9	TRFK 31/8	TRFK 56/89	TRK 301/4	TRFK 303/577	TRFK 7/3	TRFK 306/1	TRFK 597/1	TRFK 704/2	Mean treats
Isolate F + DAP	3 (1.6)	18 (2.9)	15 (2.82)	4 (1.8)	4 (1.7)	2 (1.33)	1 (0.9)	1 (0.9)	16 (2.91)	30 (3.47)	2.06d
Isolate TR +DAP	3 (1.6)	16 (2.88)	3 (1.6)	23 (3.2)	10 (2.5)	18 (2.9)	0 (0.6)	21 3.13)	3 (1.6)	31 (3.5)	2.37cd
T. harzianum (T4) +DAP	10 (2.5)	5 (1.9)	8 (2.31)	16 (2.88)	27 (3.3)	13 2.71)	4 (1.7)	18 (2.9)	28 (3.41)	28 (3.41)	2.73b
Control (DAP)	17 (2.9)	18 (2.9)	28 (3.41)	19 (3.03)	20 (3.0)	18 (2.9)	25 (3.2)	25 (3.3)	24 (3.24)	30 (3.45)	3.17a
Isolate F Only	15 (2.8)	23 (3.2)	14 (2.76)	25 (3.3)	25 (3.3)	19 3.03)	12 (2.6)	24 3.26)	27 (3.38)	26 (3.33)	3.10ab
Isolate TR Only	15 (2.8)	16 (2.9)	16 (2.88)	23 (3.21)	28 (3.4)	13 2.68)	6 (2.1)	27 (3.3)	25 (3.29)	26 (3.34)	3.01ab
T. harzianum (T4) Only	21 (3.1)	27 (3.3)	2 (1.29)	16 2.88)	1 (1.1)	7 (2.21)	6 (2.1)	10 2.45)	3 (1.6)	12 (2.63)	2.27d
Mean clone	2.49bc	2.91ab	2.44c	2.90ab	2.65bc	2.56bc	1.95d	2.78bc	2.75bc	3.30a	
C.V. (%)	27.16										
LSD (P≤0.05) Treatments	0.37										
Clones	0.44										

Table 5: The effects of *Tricherma* spp. on growth of dry weight after 60 days

	Tea clones and root biomass (g)										
Treatments (*Trichoderma* spp.)	TRFK 6/8	TRFK 7/9	TRFK 31/8	TRFK 56/89	TRFK 301/4	TRFK 303/577	TRFK 7/3	TRFK 306/1	TRFK 597/1	TRFK 704/2	Mean treatment
Isolate F + DAP	0.8	0.59	0.94	0.77	0.81	0.81	0.51	0.85	1.03	0.89	0.80abc
Isolate TR +DAP	0.91	0.72	0.86	0.67	1.48	0.75	0.33	1.07	0.84	0.65	0.83ab
T. harzianum (T4) +DAP	1.16	0.46	0.8	0.61	0.86	0.72	0.29	1.37	0.71	0.63	0.76bc
Control (DAP)	0.7	0.71	1.07	0.64	1.36	0.98	0.43	1.14	0.77	0.76	0.86ab
Isolate F Only	0.81	0.7	0.88	0.63	1.52	0.94	0.46	0.97	0.96	0.87	0.88a
Isolate TR Only	0.61	0.7	0.79	0.57	1.01	0.72	0.42	1.25	0.93	0.71	0.77abc
T. harzianum (T4) Only	0.62	0.56	0.75	0.88	0.95	0.86	0.26	0.87	0.58	0.63	0.70c
Mean clone	0.80bcd	0.64e	0.87b	0.69de	1.14a	0.83bc	0.38f	1.07a	0.83bc	0.74cde	
C.V. (%)	27.32										
LSD (P≤0.05) Treatments	0.112										
Clones	0.133										

Table 6: Effects of treatments on root biomass after 120 days

	Tea clones and root biomass (g)										
Treatments (*Trichoderma* spp.)	TRFK 6/8	TRFK 7/9	TRFK 31/8	TRFK 56/89	TRFK 301/4	TRFK 303/577	TRFK 7/3	TRFK 306/1	TRFK 597/1	TRFK 704/2	Mean Treats
Isolate F + DAP	1.17	1.49	0.79	1.81	2.37	1.18	1.16	1.71	1.51	1.14	1.4ab
Isolate TR +DAP	0.97	0.69	1.7	1.78	1.4	1.09	0.74	1.79	1.48	1.3	1.3bcd
T. harzianum (T4) +DAP	0.96	1.44	1.68	1.63	1.82	1.31	0.8	1.2	1.43	1.29	1.4ab
Control (DAP)	0.84	1.46	1.65	1.67	1.43	0.69	0.61	1.63	1.63	3.49	1.5a

Isolate F Only	0.86	0.75	2.54	1.72	1.84	2.16	0.56	1.22	1.49	1.86	1.5a
Isolate TR Only	0.91	0.9	1.81	0.94	1.95	1.28	0.49	1.34	1.85	1.25	1.3cd
T. harzianum (T4) Only	0.8	0.7	0.789	1.24	1.65	0.97	0.54	1.64	1.22	1.43	1.1d
Mean clone	0.9d	1.1c	1.6b	1.5b	1.8a	1.2c	0.7e	1.5b	1.5b	1.7ab	
C.V. (%)	21.7										
LSD (P≤0.05) Treatments	0.15										
Clones	0.18										

4. Conclusions and Recommendations

Treatments; F ONLY; TR ONLY; T4+DAP and T4 ONLY showed the highest development of roots. Treatments; TR ONLY; T4 ONLY; F ONLY; T4+DAP showed the highest number of roots. Treatments; F ONLY; T4 ONLY; TR+DAP; F+DAP showed the highest dry weight. Clones; TRFK 56/89; TRFK 7/9; TRFK 704/2 produced the highest root length, Clones; TRFK 704/2; TRFK 7/9; TRFK 56/89 produced the highest number of roots, Clone TRFK 301/4; TRFK 704/2;597/1; 306/1;56/89 producing the highest mean dry weight. *Trichoderma* spp. F, TR, T4 enhanced growth of tea clones when applied singly or in combination with DAP fertilizers. Further research should be carried out on clone TRFK 7/3 whose overall growth was least enhanced by all the treatment compared to the other clones. Further research to be carried out on the effects of the other Trichoderma spp. isolates on growth of tea cuttings and other tea clones not covered by the research.

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References

[1] Barthakur, B.K. (2005). Effect of VAM association in tea plantation in North-east India. *Crop Research*, **29 (**3):441-445.
[2] Bissett, J, G. W. (2015). Accepted *Trichoderma* names in the year 2015. *IMA Fungus*, **6** (2): 263-295.
[3] Cheruiyot, H. Rono, G. Cheramgoi, E. And Lngat J. (2016). The effect and interaction of *Trichoderma* isolates on *Armillaria* fungus of tea. *A Sustainable Tea Industry for Social, Economical and Technological Development*, **2**: 1-7.
[4] Contreras-Cornejo, H.A., Macías-Rodríguez, L., del-Val, E. and Larsen, J. (2016).Ecological functions of *Trichoderma* spp. and their secondary metabolites in the rhizosphere: interactions with plants. *FEMS Microbiology Ecology*, **92** (4): 1093.
[5] Kabaluk, J.T., Svircev, A.M., Goettel, M.S. and Woo, S.G. (2010). Report on India in the Use and Regulation of Microbial Pesticides in Representative Jurisdictions Worldwide.IOBC Global.Vol (**10)** : pg 7-99:.Available online through www.IOBC-Global.org
[6] Kamunya, M.S. Wachira, F.N. (2012). *TRFK Clonal Catalogue.*Tea Research Foundation of Kenya. Central Research Unit.1st Edition.Kericho, Kenya.
[7] Mujtaba, Ahmed. (2011). Studies on production of oil based formulation of *Trichoderma* and their efficacy on foliar diseases. Dharwad, India: College of Agriculture.
[8] Onsando and Waudo. (1994). Interaction between Trichoderma isolates and Armillaria root rot fungus of Tea in Kenya. *International journal of Pest Management*, 40:69-74.
[9] Otieno, W 2002. Armillaria root rot of tea in Kenya Characterization of the pathogen and approaches to disease management. University of Wageningen PhD Thesis page 51
[10] Wanjiru, M., Ethel, O., Okoth, S. and Mefwa, J. (2009). Effect of *Trichoderma harzianum* and arbuscular mycorrhizal fungi on growth of tomato seedlings, napier grass and tea cuttings. *Tropical and Sub-tropical Agroe-cosystems*, Vol (**11)**: 423-429.
[11] Zouheir, T., Chliyeh, M. Mourria, B. Asri, A. (2016). Effect of double inoculation with endomycorrhizae and *Trichoderma harzianum* on the growth of Carob plants. *International Journal of Advances In Pharmacy , Biology and Chemistry*, Vol **5 (**1): 44-58.