Afropolitan Journals

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ISSN: 2730-7603X www.afropolitanjournals.com

Evaluation of the Effect of Arbuscular Mycorrhizal Fungi on the Root and Shoot Growth of Some Cowpea Varieties (Vigna Unguiculata (L.) Walp) Under *Alectra Vogelii* Inoculation

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Abstract

The aim of this research was to evaluate the effect of *Glomus clarum* on the root and shoot fresh weight of four cowpea varieties on *Alectra vogelii* inoculated soil. Four cowpea varieties used were: SAMPEA 7, IFE 82-12, IT97K-499-35 and TVX 3236. The sterilized sandy-loam soil used for this experiment consisted of a mixture of topsoil and sand in ratio 1:1 (v/v). *Glomus clarum* was applied in five rates: the control without *Alectra*, control with *Alectra*, 10, 20 and 30 g/pot. A constant quantity of *Alectra* was maintained. The treatments were arranged in complete randomized design. Four cowpea seeds were planted per pot but later thinned to two seedlings per pot at two weeks after planting (WAP). These cowpea plants were sampled for root and shoot fresh weight at 5, 7 and 9 WAP. The ANOVA of the three years' data showed that *Glomus clarum* treatments at different rates significantly increased root and shoot fresh weights compared with the two control treatments. *Glomus clarum* treatment at 30 g/pot resulted in the highest root and shoot fresh weight of the cowpea varieties Cowpea variety SAMPEA 7 mostly resulted in the higher values compared with other cowpea varieties for root and shoot fresh weight at 9 and 7 WAP respectively. From this study, *Glomus clarum* treatments significantly increased root and shoot fresh weight of the four cowpea varieties. Therefore, in relation to root and shoot fresh weight of the four cowpea varieties, *Glomus clarum* is recommended as a biological control agent on an *Alectra vogelii* infested soil.

Keywords: *Glomus Clarum*, *Alectra Vogelii*, Cowpea, Root, Shoot.

Introduction

Cowpea (*Vigna unguiculata* (L) Walp.) is an important grain legume and a major staple food crop in sub-Saharan Africa, especially in the North of the Savannah belt of Nigeria (Omoigui *et al*., 2020). It plays an important role in human nutrition, food security, and source of income for both farmers and food vendors in the region (Omoigui *et al*., 2020). It is a dicotyledonous crop, a diploid plant having 22 chromosomes with an estimated nuclear genome size covering 620 million base pairs (Timko *et al.*, 2008; Agbogidi, 2010). It belongs to the order Fabaceae, sub-family Faboideae (Syn. Papillionoideae), tribe Phaseolea, sub-tribe Phaseolinae, genus *Vigna* (Agbogidi, 2010). Cowpea is grown across the world on an estimated 14.5 million hectares of land, planted each year and the total annual production is 6.2 million metric tons (Boukar *et al*., 2016). The crop has the ability to survive under harsh environmental conditions where other major crops fail to grow. Its foliage is regarded as an important source of high-quality livestock feed. It also has the ability to restore soil fertility through nitrogen fixation, making it a good crop to use in crop rotation with major cereal crops (Daryanto *et al.*, 2015). Vesicular Arbuscular Mycorrhizal (VAM) also known as arbuscular mycorrhizae (AM) belongs to the endomycorrhizal fungi group. Arbuscular mycorrhiza fungi are ubiquitous in soil, in a symbiotic relationship with most terrestrial plants including major crops such as legumes and horticultural plants (Dalpe and Monreal, 2004; Wang and Shi, 2008). The fungus benefits from the host plant by receiving carbohydrates from it while the host plant obtains a wider surface area that supports uptake of nutrients from the soil as a result of the symbiotic association (Diagne *et al.*, 2020; Anderson *et al.*, 2018). *Glomus* is a genus of arbuscular mycorrhizal fungi with all species forming symbiotic relationships (mycorrhizas) with plant roots. *Glomus* is the largest genus of AM fungi, with 85 species described but currently defined as non-monophyletic (Kirk *et al.*, 2008). *Glomus clarum* form symbioses with plant roots, where they obtain carbon (photosynthate) from the host plant while the host plant obtains nutrients and other benefits. The mycorrhizae consist of arbuscules, vesicles, as well as intra and extra radical hyphae (Kirk *et al.*, 2008). *Alectra vogelii* which affects cowpea adversely belongs to the Orobanchaceae family (Broomrape family) or sub-family Orobanchoideae of Scrophulariaceae. It is also a serious weed of late planted groundnut and soybean in the same ecological zone (Nikcrent and Musselman, 2004).

Christine *et al.* (2012) investigated the effects of AMF and mycorrhizal root exudates on the initial steps of *Meloidogyne incognita* infection, namely movement towards and penetration of tomato roots. It was discovered that; nematode penetration was reduced in mycorrhizal tomato roots and mycorrhizal root exudates probably contributed at least partially by affecting nematode motility. Avis *et al.* (2008) studied the effect of vesicular-arbuscular mycorrhizal (VAM) (*Glomus mossae)* on the growth and productivity of legumes. They observed that VAM have significant effect when compared with non-mycorrhizal plants. Mycorrhizal plants performed better than non-mycorrhizal plants. The substantial improvement in the growth of mycorrhizal plants could be a result of a combination of AMF-induced mechanisms of plant tolerance under drought conditions, notably enhanced water and nutrient uptake in host plants and increased photosynthetic activity since plant size closely links with measured physiological parameters. The increased plant biomass and nutrient uptake in AM plants could be more pronounced during seedling growth stages (Katalin and Nguyen, 2019).

Statement of Problem

Cowpea production is constrained by many biotic and abiotic factors, including low soil fertility and a wide range of factors such as insects, diseases, parasitic weeds, and unavailability of improved seeds **(**Bolarinwa *et al.*, 2021**).** One notable parasitic weed that affect cowpea production is *Alectra vogelii* which can often lead to total yield loss

(Mwaipopo, 2014). The current pest control measures being used by some farmers to control parasitic weeds (such as cultural, mechanical, physical, chemical e.t.c) have disadvantages. For instance, the chemical control method could lead to land pollution and death of aquatic organisms. Therefore, due to the limitations of each control method there is a need to search for an effective control measure that can be suitable for the host plant, safe for the environment, control the parasite and can be easily adopted by poor resource farmers.

Objective of Study

This research was carried out to determine the tripartite interactions between cowpea varieties, Arbuscular Mycorrhizal Fungi and *Alectra vogelii* with emphasis on the role of the fungi on root and shoot fresh weight of cowpea varieties. This is of importance because some farmers grow cowpea plant particularly to use it as a fodder crop.

Materials and Methods

This pot experiment was conducted on a fenced farmland at Agwa New Extension, Trikania, Kaduna, beginning from May in 2016, 2017 and 2019 wet seasons. Four cowpea varieties which comprised of two susceptible varieties (SAMPEA 7 and TVX 3236) and two moderately resistant varieties to *Alectra* (IFE 82-12 and IT97K-499-35) were obtained from the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria. Also, the *Alectra* seeds and AM inoculum were gotten from IAR farms, Zaria and University of Ibadan, Ibadan respectively. The method of Heckman and Angle (1987) was used to prepare *Glomus clarum* inoculum. Soil composed of a mixture of topsoil and sharp sand in ratio 1:1 was sieved, sterilized and placed in polythene bags (used as pots) and used for planting. Four seeds each of the different cowpea varieties were planted in each polythene bag. These pots were arranged at an intra-row spacing of 0.30 m. The cowpea plants were inoculated with propagules of *Glomus clarum* depending on the treatments (control without *Alectra*, control with *Alectra*, 10, 20 and 30 g per pot) with a constant quantity of *Alectra*. The AM fungal inoculum was mixed with the top 3 cm of the pot soil for the relevant treatments. Each treatment was assigned eight pots in three replicates. The treatments were arranged in Complete Randomized Design (CRD).

The plants were thinned to two plants per pot at two weeks after planting. The cowpea seedlings were sprayed with Benlate (Benomyl) and Dithane M45 (Carbendazim) at the product rate of 0.6 kg/ha and 2.5 kg/ha respectively (to control fungal diseases) and Rogor (dimethoate) at 0.75 L/ha at 4 WAP, to prevent viral diseases. Sherpa with (cypermethrin + perfekthion) was applied fortnightly at the rate of 1.0 L/ha, beginning from 7 WAP until harvest, to control insect pests during flowering and pod development. Weeds with the exception of *Alectra* were controlled by hand pulling as at when necessary from 2 WAP. At each sampling, cowpea plants were carefully uprooted from three pots. The sampled plants were brought to the laboratory in labeled polythene bags, washed carefully with tap water and the surface water was allowed to drain. The selected cowpea plants were separated into roots and shoots using a knife and each part was weighed when still fresh. Root and shoot fresh weights were taken fortnightly beginning from 5 to 9 WAP.

Analysis of Data

To compare the varietal reaction of cowpea varieties to parasitism by *Alectra vogelii* in the presence of Arbuscular mycorrhizal fungi the data obtained on the above growth parameters were subjected to analysis of variance (ANOVA) as described by Lawes Agricultural Trust (1980). Significant differences between treatments means were compared using the Duncan Multiple range test (DMRT).

Results

Most *Glomus clarum* treatments resulted in root fresh weights in the cowpea varieties at 5 WAP in 2016 and at 9 WAP in 2017 comparable with the control treatments (Table 1). The control without *Alectra* treatment generally resulted in the highest root fresh weight in SAMPEA 7 and TVX 3236 at 5 and 9 WAP in 2017 (Table 2). At 5 WAP, 10 g/pot *Glomus clarum* treatment resulted in the highest root fresh weight in SAMPEA 7, IFE 82-12 and IT97K-499-35 in 2019 (Table 3). Most treatments resulted in comparable root fresh weights in the cowpea varieties at 7 and 9 WAP in 2019 (Table 3). Most rates of *Glomus clarum* treatments resulted in shoot fresh weights in SAMPEA 7 and TVX 3236 at 7 and 9 WAP in 2016 comparable with the control treatments (Table 4). The control without *Alectra* treatment mostly resulted in a higher shoot fresh weight in 1FE 82 – 12, IT97K-499-35 and TVX 3236 at 5-9 WAP in 2017 compared with that of the other treatments (Table 5). Most *Glomus clarum* treatments resulted in higher shoot fresh weight compared with the two control treatments in most cowpea varieties at 5 - 9 WAP. However, *Glomus clarum* at 30 g/pot treatment mostly resulted in the highest shoot fresh weight in most varieties at 5 - 9 WAP in 2019 (Table 6). The ANOVA of the three years data based on *Glomus clarum* treatment showed that, 30 g/pot *Glomus clarum* treatment resulted in the highest root fresh weight which was significantly higher than that due to all the other treatments. This was followed by that due to the control without *Alectra* treatment. The lowest root fresh weight due to 20 g/pot *Glomus clarum* was significantly lower than that due to all the other treatments (Figure 1). Also, *Glomus clarum* treatments recorded the lowest root fresh weight in IT97K – 499 – 35 which was only significantly lower than the highest observed in SAMPEA 7. The root fresh weight recorded at various cowpea plant ages varied significantly from each other with the highest root fresh weight recorded at 9 WAP significantly higher than at 5 and 7 WAP. The lowest root fresh weight at 5 WAP was significantly lower than that at 7 and 9 WAP (Table 7).

The ANOVA of the three years data based on *Glomus clarum* treatments showed that, 30 g/pot *Glomus clarum* treatment resulted in significantly higher shoot fresh weight than that due to all the other treatments. This was followed by that due to the control without *Alectra* treatment. The lowest shoot fresh weight due to the control plus *Alectra* treatment was significantly lower than that due to all the other treatments (Figure 2). The shoot fresh weight varied significantly among cowpea varieties with the highest shoot fresh weight recorded in SAMPEA 7 significantly higher than that observed in all the other varieties. This was followed by that observed in IFE 82-12 and TVX 3236. The lowest shoot fresh weight in IT97K – 499 – 35 was significantly lower than that observed in all the other varieties (Table 7). The shoot fresh weight recorded at various cowpea plant ages varied significantly from each other with the highest shoot fresh weight at 7 WAP significantly higher than that at 5 and 9 WAP. The lowest shoot fresh weight at 5 WAP was significantly lower than that at 7 and 9 WAP (Table 7).

Table 1: Effect of G*lomus clarum* on Root Fresh weight of cowpea Varieties in 2016

Cowpea variety	VAM CONC (g)	PLANT'S AGE (WAP) Root fresh weight		
		5	*7*	*9*
SAMPEA 7	0 – parasite	2.73a	6.83b	7.60b
	0+ parasite	2.30a	6.03c	7.73b
	10	2.30a	8.47a	10.03a
	20	2.67a	6.00c	4.60c
	30	1.93a	8.90a	8.20b
	Mean	2.39	7.25	7.63
	SE ±	0.32	0.21	0.27
IFE 82 -12	0-Parasite	1.13b	6.37a	3.20b
	0+ parasite	1.67ab	6.37a	5.90a
	10	1.93ab	4.80c	3.47b
	20	2.27a	5.87ab	3.77b
	30	2.20a	5.13bc	5.27a
	Mean	1.84	5.71	4.32
	SE ±	0.24	0.29	0.28
IT97K – 499 – 35	0- parasite	2.13a	3.63d	5.77a
	0+ parasite	1.70a	5.80b	4.23b
	10	1.93a	4.27c	4.53ab
	20	1.80a	4.43c	1.97c
	30	2.73a	8.07a	2.80c
	Mean	2.06	5.24	3.86
	SE ±	0.31	0.19	0.43
TVX – 3236	0-parasite	1.83a	6.57a	4.57ab
	0+ parasite	1.60a	5.97a	4.77ab
	10	1.70a	5.77a	4.47b
	20	2.20a	4.53b	5.70a
	30	2.07a	5.53ab	5.63ab
	Mean	1.88	5.67	5.03
	SE ±	0.20	0.31	0.34

NB: Means followed by the same letter(s) in each column, under each parameter are not significantly different (P≤ 0.05), using DMRT. NS = Not Significant, *= Significant, WAP- Weeks after Planting

Table 2: Effect of *Glomus clarum* on Root Fresh Weight of Cowpea Varieties in 2017

Cowpea variety	VAM CONC (g)	PLANT'S AGE (WAP) Root Fresh Weight (g)		
		5	7	9
SAMPEA 7	0 – parasite	5.07a	5.63a	7.13a
	0+ parasite	4.33b	3.83b	4.70b
	10	5.20a	4.43b	4.37b
	20	4.13b	6.60a	3.87b
	30 Mean SE ±	3.33c 4.41 0.18	4.30a 4.96 0.33	6.57a 6.57 0.35
IFE 82 -12	0-Parasite	4.03b	4.57ab	4.77ab
	0+ parasite	2.93c	4.37bc	4.97ab
	10	4.13b	3.13d	5.47a
	20	5.93a	5.27a	4.20b
	30 Mean SE ±	3.70b 4.14 0.20	3.63cd 4.19 0.24	4.43b 4.77 0.29
IT97K – 499 – 35	0- parasite	4.37bc	3.57c	5.17b
	0+ parasite	5.63a	4.27bc	5.00b
	10	4.07c	4.50ab	5.37b
	20	4.17c	2.63d	4.40b
	30 Mean SE ±	4.73b 4.59 0.16	5.17a 4.03 0.23	6.80a 5.35 0.32
TVX – 3236	0-parasite	4.30a	4.03b	5.60a
	0+ parasite	3.87a	2.70c	1.97c
	10	3.57abc	2.70c	4.13b
	20	2.77c	4.60ab	5.30a
	30 Mean SE ±	3.07bc 3.52 0.25	5.57a 3.92 0.34	4.00b 4.20 0.15

NB: Means followed by the same letter(s) in each column, under each variety, in each year are not significantly different (P ≤ 0.05), using DMRT.
WAP- Weeks after Planting

Table 3: Effect of *Glomus clarum* on Root Fresh Weight of Cowpea Varieties in 2019

Cowpea variety	VAM Conc.(g)	Plant's age (WAP) Root Fresh Weight (g)		
		5	7	9
SAMPEA 7	0-	2.07a	2.33a	3.70ab
	0+	1.57a	2.03ab	4.07a
	10	2.37a	1.47b	2.43bc
	20	1.10a	2.07ab	2.13c
	30	1.60a	1.77ab	4.13a
	Mean	1.74	1.93	3.29
	SE ±	0.45	0.19	0.42
IFE 82-12	0-	0.63b	1.60a	2.50a
	0+	1.00b	2.03a	2.40a
	10	2.97a	1.60a	2.10a
	20	2.63a	1.80a	2.43a
	30	2.17a	2.90a	2.30a
	Mean	1.88	1.99	2.35
	SE ±	0.32	0.43	0.49
IT97K-499-35	0-	1.10b	1.53b	2.43a
	0+	1.03b	1.03b	2.47a
	10	2.03a	1.10b	2.23a
	20	1.50ab	1.70b	1.07a
	30	1.67ab	2.63a	1.53a
	Mean	1.47	1.60	1.95
	SE ±	0.24	0.21	0.47
TVX 3236	0-	0.70c	2.10a	1.90a
	0+	3.47a	2.03a	1.77a
	10	1.77b	1.63a	2.53a
	20	1.80b	2.23a	1.97a
	30	3.03a	1.53a	2.20a
	Mean	2.15	1.91	2.07
	SE ±	0.30	0.31	0.38

NB: Means followed by the same letter(s) in each column, under each variety, are not significantly different ($P \leq 0.05$), using DMRT. WAP- Weeks after Planting

Table 4: Effect of *Glomus clarum* on Shoot Fresh Weight of Cowpea Varieties in 2016

Cowpea variety	VAM CONC (g)	PLANT'S AGE (WAP) Shoot Fresh Weight (g)		
		5	7	9
SAMPEA 7	0 – parasite	12.97a	21.83b	27.73a
	0+ parasite	8.30c	22.33b	30.20a
	10	8.57c	28.80a	30.23a
	20	10.00b	22.23b	16.07b
	30	8.83bc	30.77a	38.20a
	Mean	9.73	25.19	28.49
	SE ±	0.39	0.61	3.41
IFE 82 -12	0-Parasite	6.50c	18.60c	11.00c
	0+ parasite	7.27bc	21.97b	22.97a
	10	8.17b	27.27a	11.97c
	20	9.80a	21.03b	11.87c
	30	9.27a	21.80b	19.30b
	Mean	8.20	22.13	15.42
	SE ±	0.34	0.54	0.76
IT97K – 499 – 35	0- parasite	8.90b	11.00c	11.70b
	0+ parasite	6.43c	14.90b	22.80a
	10	7.10c	17.67b	11.87b
	20	9.67b	16.57b	7.40c
	30	13.17a	21.73a	7.40c
	Mean	9.05	16.37	12.23
	SE ±	0.30	0.82	0.92
TVX – 3236	0-parasite	8.03b	24.70a	19.70b
	0+ parasite	5.83c	20.60b	20.53b
	10	8.73ab	25.20a	16.83b
	20	9.83a	20.33b	24.93a
	30	9.67a	18.83b	20.43b
	Mean	8.42	21.93	20.49
	SE ±	0.40	0.71	1.09

NB: Means followed by the same letter(s) in each column, under each variety, in each year are not significantly different ($P \leq 0.05$), using DMRT.
WAP- Weeks after Planting

Table 5: Effect of *Glomus clarum* on Shoot Fresh Weight of Cowpea Varieties in 2017

Cowpea variety	VAM CONC (g)	PLANT'S AGE (WAP) Shoot Fresh Weight (g)		
		5	7	9
SAMPEA 7	0 – parasite	12.87a	16.20b	13.73b
	0+ parasite	7.23cd	9.97d	9.27d
	10	9.00b	11.03c	6.37e
	20	7.73c	17.20a	10.73c
	30	6.37d	10.60cd	17.57a
	Mean	8.64	13.00	11.53
	SE ±	0.29	0.20	0.25
IFE 82 -12	0-Parasite	12.40a	14.87a	15.03a
	0+ parasite	5.67d	15.00a	10.27c
	10	9.20c	9.23c	12.27b
	20	10.00bc	14.53a	9.30d
	30	10.73b	13.27b	10.27c
	Mean	9.60	13.38	11.43
	SE ±	0.44	0.21	0.09
IT97K – 499 – 35	0- parasite	10.40a	12.97a	14.57a
	0+ parasite	8.97b	10.17b	10.40c
	10	7.47c	12.73a	10.93c
	20	7.00c	7.70c	12.47b
	30	9.10b	12.83a	9.07d
	Mean	8.59	11.28	11.49
	SE ±	0.38	0.35	0.25
TVX – 3236	0-parasite	13.70a	17.00a	13.17a
	0+ parasite	5.53d	9.87d	3.83d
	10	10.20b	11.90c	9.60b
	20	5.03d	10.20d	9.10b
	30	8.07c	15.50b	6.13c
	Mean	8.51	12.89	8.37
	SE ±	0.39	0.24	0.23

NB: Means followed by the same letter(s) in each column, under each variety, in each year are not significantly different ($P \leq 0.05$), using DMRT.
WAP- Weeks after Planting

Table 6: Effect of *Glomus clarum* on Shoot Fresh Weight of Cowpea Varieties in 2019

Cowpea variety	VAM Conc.(g)	Plant's age (WAP) Shoot Fresh Weight (g)		
		5	7	9
SAMPEA 7	0-	2.93c	6.43b	10.30b
	0+	3.23bc	6.63ab	7.87d
	10	4.53ab	5.33c	8.70c
	20	5.23a	7.13ab	12.07a
	30	4.70a	7.57a	10.87b
	Mean	4.13	6.62	9.96
	SE ±	0.43	0.31	0.23
IFE 82-12	0-	2.87c	5.63d	7.93c
	0+	3.07c	6.20cd	7.97c
	10	6.60a	6.53c	13.73b
	20	5.77b	11.80b	12.63b
	30	5.40b	13.10a	17.13a
	Mean	4.74	8.65	11.88
	SE ±	0.25	0.22	0.46
IT97K-499-35	0-	2.97c	7.17c	4.80c
	0+	2.10d	4.40d	8.27b
	10	4.47b	4.80d	10.37ab
	20	2.73c	8.87b	8.23b
	30	6.20a	12.37a	12.47a
	Mean	3.69	7.52	8.83
	SE ±	0.19	0.37	0.78
TVX 3236	0-	2.10c	7.10c	4.03c
	0+	3.93b	5.87d	5.90c
	10	4.93b	7.03c	10.23b
	20	4.17b	13.00a	12.23b
	30	8.53a	11.30b	19.70a
	Mean	4.73	8.86	10.42
	SE ±	0.46	0.28	1.10

NB: Means followed by the same letter(s) in each column, under each variety, are not significantly different (P≤ 0.05), using DMRT.
WAP- Weeks after Planting

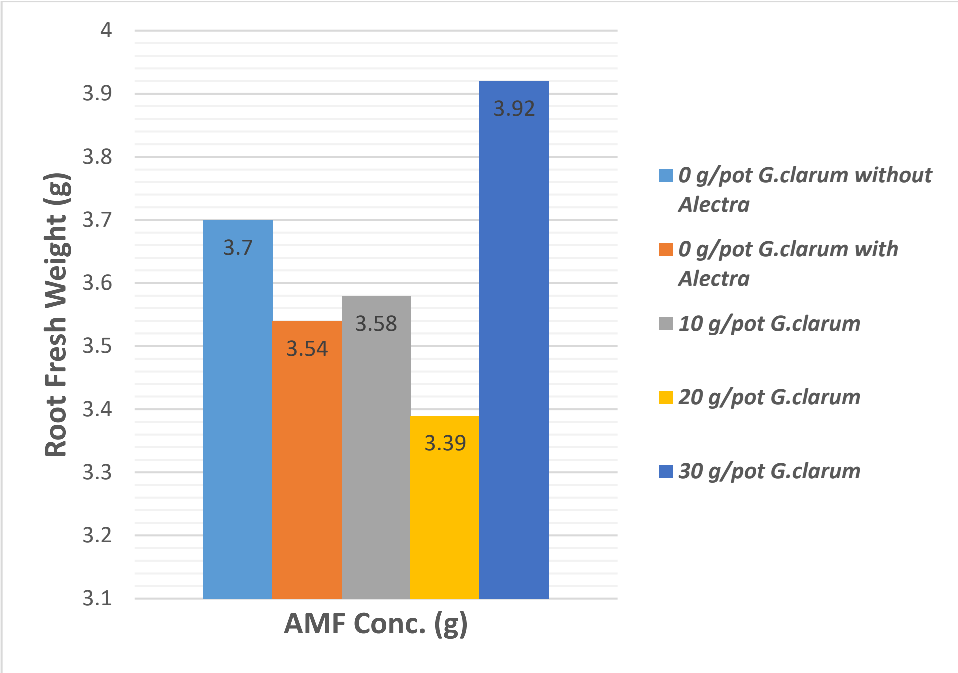

Figure 1: Effect of *Glomus clarum* on root fresh weight of cowpea varieties in 2016, 2017 and 2019 (combined data)

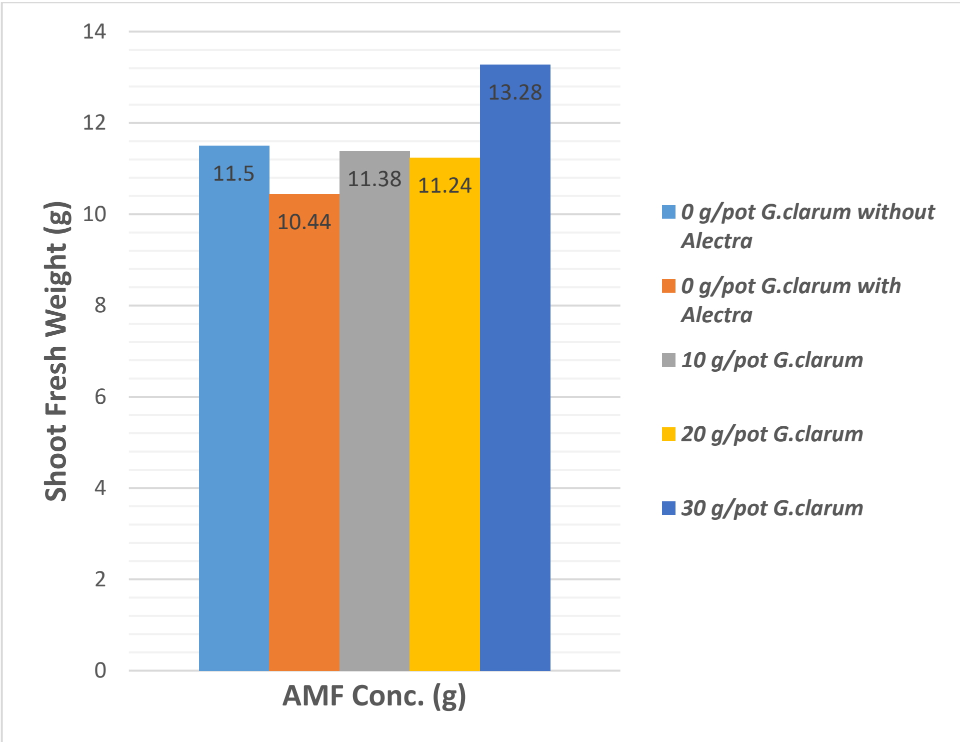

Figure 2: Effect of *Glomus clarum* on shoot fresh weight of cowpea varieties in 2016, 2017 and 2019 (combined data)

Table 7: Effect of *Glomus clarum* on Root and Shoot fresh weight of cowpea varieties in 2016-2019 (combined)

Treatment	Root fresh weight (g)	Shoot fresh weight (g)
Variety		
SAMPEA 7	4.33a	13.03a
IFE 82-12	3.47b	11.71b
IT97K-499-35	3.35b	9.89c
TVX 3236	3.37b	11.62b
Mean	3.63	11.57
SE±	0.05	0.11
Age		
Week 5	2.67c	7.34c
Week 7	4.03b	13.99a
Week 9	4.18a	13.38b
Mean	3.63	11.57
SE±	0.04	0.09
Year		
2016	4.41a	16.47a
2017	4.45a	10.73b
2019	2.03b	7.50c
Mean	3.63	11.57
SE±	0.003	0.007
Interactions		
Var*Treat	*	*
Var*Age	*	*
Var*Year	*	*
Treat*Age	*	*
Treat*Year	*	*
Age*Year	*	*
Var*Treat*Age*Year	*	*

NB: Means followed by the same letter(s) on each column, under each parameter are not significantly different (P≤ 0.05), using DMRT. NS = Not Significant, *= Significant

Discussion

The higher values of root and shoot fresh and dry weights mostly observed in *Glomus clarum* treatments compared with the control plus *Alectra* treatment suggests that AMF concentration supports a high degree increase in the fresh and dry weights. The highest values of root and shoot fresh and dry weights at 30 g/pot *Glomus clarum* treatment might be due to host root systems been extended by widespread extraradical mycelium (due to AMF inoculation) enabling colonized roots to reach more water and nutrient pools unavailable to uncolonized roots (Katalin and Nguyen, 2019). Also, the lower values of root and shoot fresh and dry weights recorded in the control plus *Alectra* treatment might have been due to the parasitic effect of *Alectra* in the treatments. This suggests that the influence of mycorrhization might have reduced or minimized the effect of the parasite. This is in agreement with the reports of Lendzemo *et al*. (2009), that mycorrhization reduced the impact of *Striga* on crop plants when soils infested with *Striga* were inoculated with AMF and used for crop cultivation.

The highest root and shoot fresh and dry weights observed in SAMPEA 7 compared with other cowpea varieties might have been due to the fact that the cowpea variety had ensured adequate biomass accumulation with a higher level of photosynthesis. This is similar to the findings of Salahedin *et al*. (2013) that mycorrhizal treatments significantly increased the shoot and root lengths of chickpea in a calcareous soil. Also, it may be due to the preference of association between these cowpea varieties and the AM fungi species. AMF mycorrhization aids water and mineral elements uptake, especially P, which might facilitate photosynthesis resulting in improved growth or development (Isobe *et al*., 2014). Rolden-Fajardo (1994) posited that each plant has a specific reaction to certain associated mycorrhizal fungal strain. The influence of mycorrhization might have reduced or minimized the effect of the parasite. The findings of Klironomos (2003) and Scheublin *et al*. (2004) showed that AMF and the composition of AMF communities regulate plant interactions and influence the structure of plants. Root fresh weight having their highest values at 9 WAP and shoot fresh weight at 7 WAP might be due to an indication of the peak period of rapid vegetative growth or crop level of maturity involving the synthesizing of growth stimulating hormones and an increased rate of photosynthesis. The rapidly growing shoot produced more assimilates that supported its further growth, synthesizing higher levels of growth stimulating hormones to affect the rapid vegetative growth (Alonge, 2000). This is in agreement with Das *et al*. (2008) that dry matter production in plants gradually increases with crop age and attains maximum at maturity. Also, this may be due to AMF mycorrhization which brings about an increase in nutrient uptake through exploitation of a larger soil volume by the AMF fungal hyphae (as the roots elongate) which in turn enhances plant growth and nitrogen fixation (Diagne *et al*., 2020; Anderson *et al*., 2018).

Conclusion and Recommendations

The result of this work shows that *Glomus clarum* at different treatment concentrations resulted in significant increase in root and shoot fresh weight compared with the control with *Alectra* treatment in the four cowpea varieties considered. Therefore, the following are being recommended:

1. Cowpea varieties SAMPEA 7 could be cultivated on soils infected with *Alectra*, if *Glomus clarum* treatments are applied in order to obtain higher values for root and shoot fresh weight.

2. The use of each *Glomus* species at 30 g/pot treatment in soils, with *Alectra*, is recommended to obtain higher values for root and shoot fresh weight.
3. Further research work is needed to determine the interactions between the root and shoot fresh weights of cowpea varieties, other strains of AMF, on *Alectra* inoculated soil, under sterilized and unsterilized conditions.

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