Effectiveness of two bioagents and banana papers on nematodes using vine cuttings as planting materials

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Yams are staples in West Africa with Nigeria, Ghana, Côte d'Ivoire, Benin among the top 5 countries cultivating yam. In these countries, yam is an important staple food providing a valuable source of carbohydrates, proteins and minerals for over 380 million people from an estimated annual production of 67 million MT (Nweke et al., 1991; Orkwor, 1998; Nweke, 2016; FAO, 2018). However, yam production is constrained by several biotic constraints among which nematode remains the main constraint (Kolombia et al., 2017, 2020). Since 2012, intensive research on yam was carried out at the International Institute of Tropical Agriculture (IITA) with major achievement on yam seed system(Aighewi et al., 2015; Maroya et al., 2017). It is now possible to use nematode-free planting material for research or farming purposes. Despite this achievement, it appeared there is a gap in the field management process that need to be filled in order to accomplish the cycle nematode-free planting materials to nematode-free materials at harvest.

In order to investigate possible managements on yam vine cuttings to mitigate nematode infestation in the field, investigations on the selection of resistant materials, the use of effective pesticides and or biological agents are ongoing. The present investigation aims to evaluated the effectiveness of banana paper and biological agents on nematodes using vine cuttings as planting materials.

1 Investigation progress

Timelines for the activities implementation were halted with the COVID-19 with the impossibility to have the materials: banana papers (Banana paper untreated and Ivermectin-treated) and the biological control agents (SUSTAINC and IMPED) shipped to Ibadan. On receiving these material new propagation of planting materials was initiated and the new timelines are as follow:

Treatments update: Arbuscular mycorrhizal fungi (AMF) will be replaced with the bioagent IMPED (*Paecilomyces lilacinus*).

1.1 ***First screen house pot trials 1:*** **Eva1luation of banana leaves and Bioagents (First trial)**

Yam genotype: 1 (Kpamyo TDr 95/19177)

Nematode: Root-knot nematodes

Number of replicates: 10

Treatments:

1. Negative control 1 (no banana paper)
2. Negative control 2 (Non-treated banana paper)
3. Banana paper Ivermectin-treated,
4. SUSTAIN (*Trichoderma asperellum*) + Non-treated banana paper,
5. IMPED (*Paecilomyces lilacinus*) + Non-treated banana paper.

- Start trial: October 2020,
- End trial: March 2021.

First screen house pot trials 1: Evaluation of banana leaves and Bioagents (second trial)

Details: see above

- Start trial: November 2020,
- End trial: April 2021.

1.2 ***Second screen house pot trials 1: Evaluation of banana leaves yam genotypes (First trial)***

Yam genotype: 3 (Kpamyo TDr 95/19177; Asiedu: TDr 89/02665 and Swaswa: TDr 89/01176)

Nematode: Root-knot nematodes

Treatments:

1. Negative control (no banana paper)
2. Positive control (non-treated banana paper)
3. Banana paper Ivermectin treated.

- Start trial: October 2020,
- End trial: March 2021.

Second screen house pot trials 1: Evaluation of banana leaves yam genotypes (second trial)

Details: see above

- Start trial: November 2020,
- End trial: April 2021.

1.3 Field trials: To be finalized with Dr. Maroya

2 Results

2.1 Biocontrol trials: Evaluation of banana leaves and Bioagents

Table 1: Analysis of variance for the effect of biological control treatments and trial on the plant growth parameters (Root length, Root fresh weight and Tubers weight)

Source	DF	F Values[1]: Plant growth parameters		
		Root length (cm)	Root fresh weight (g)	Tubers weight (g)
Treatment (A)	4	0.02**	0.48ns	0**
Trial (B)	1	0.05ns	0.92ns	0.04**
A*B	4	0.33ns	0.23ns	0.49ns

[1]ns, *, ** and *** represent not significant (P>0.05), significant at P ≤ 0.05, 0.01 and 0.001, respectively. N (number of replicates) =10.

Applied treatment significantly affected the roots length and the tubers weight while there was only a significant effect of the repeated trials on the tubers weight Table 1.

Table 2: Analysis of variance for the effect of biological control treatments treatment and trial on the nematode parameters (Number of gall on roots and tubers, number of nematode on roots and total number of nematodes)

Source	DF	F Values[α] [1]: Nematode parameters				
		Total number of`				
		Root galls	Tubers galls	Galls	Root nematode	Nematode
Treatment (A)	4	<.0001***	<.0001***	<.0001***	<.0001***	0**
Trial (B)	1	0.26ns	0.18ns	0.22ns	0**	0.24ns
A*B	4	0.04**	0**	0**	<.0001***	0**

[α]: Data of nematode parameters were Log transformed before statistical analysis
[1]ns, *, ** and *** represent not significant (P>0.05), significant at P ≤ 0.05, 0.01 and 0.001, respectively. N (number of replicates) =10.

The factorial analysis revealed on table 2 that the treatments applied have significantly affected the number of galls on the roots system and on the tubers, the total number of gall, the number of nematodes on the roots and the total number of nematodes.

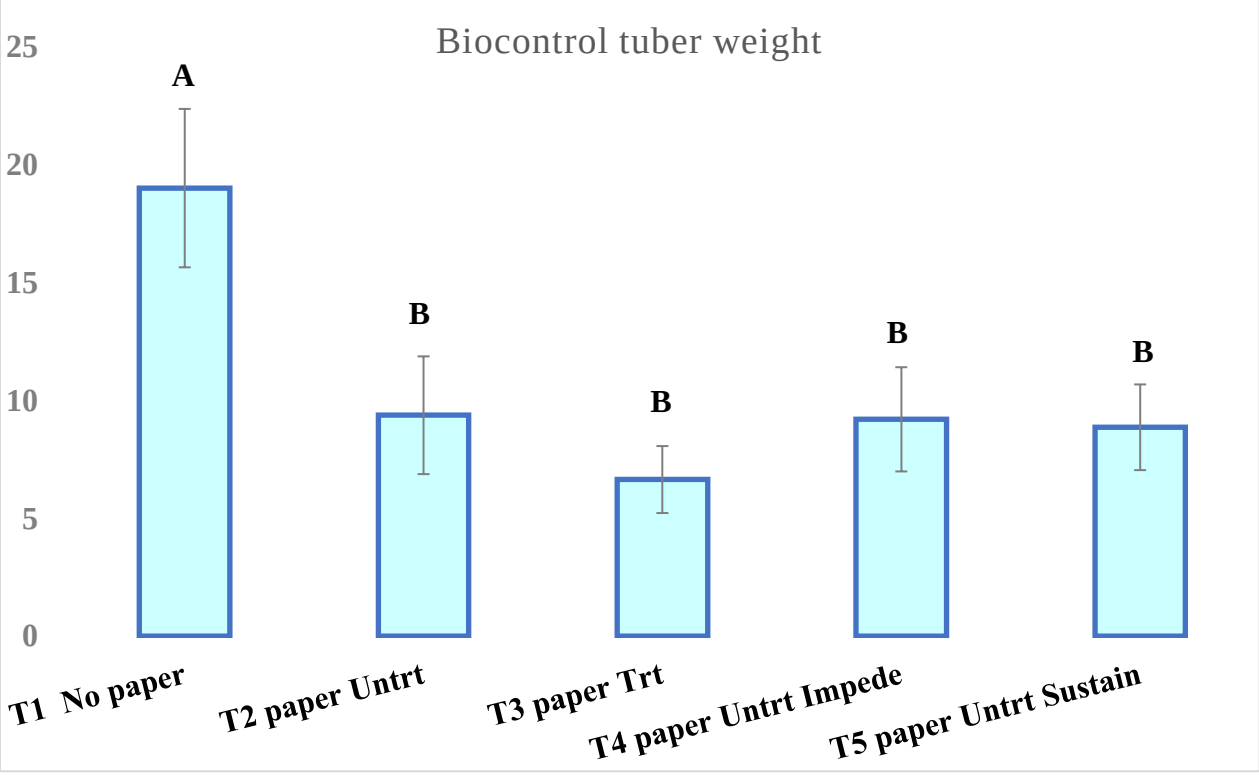

Figure 1: Effect of biological control treatments on yam tuber weight

Bars with the same letter in a graph are not different according to a Student Newman-Keuls test (P ≤0.05); N=10.

Figure 1 shows significantly bigger tubers on treatment without paper compared with treatments with paper (Fig.4). This could be explained by the space constraint given by the paper in the small size pots used.

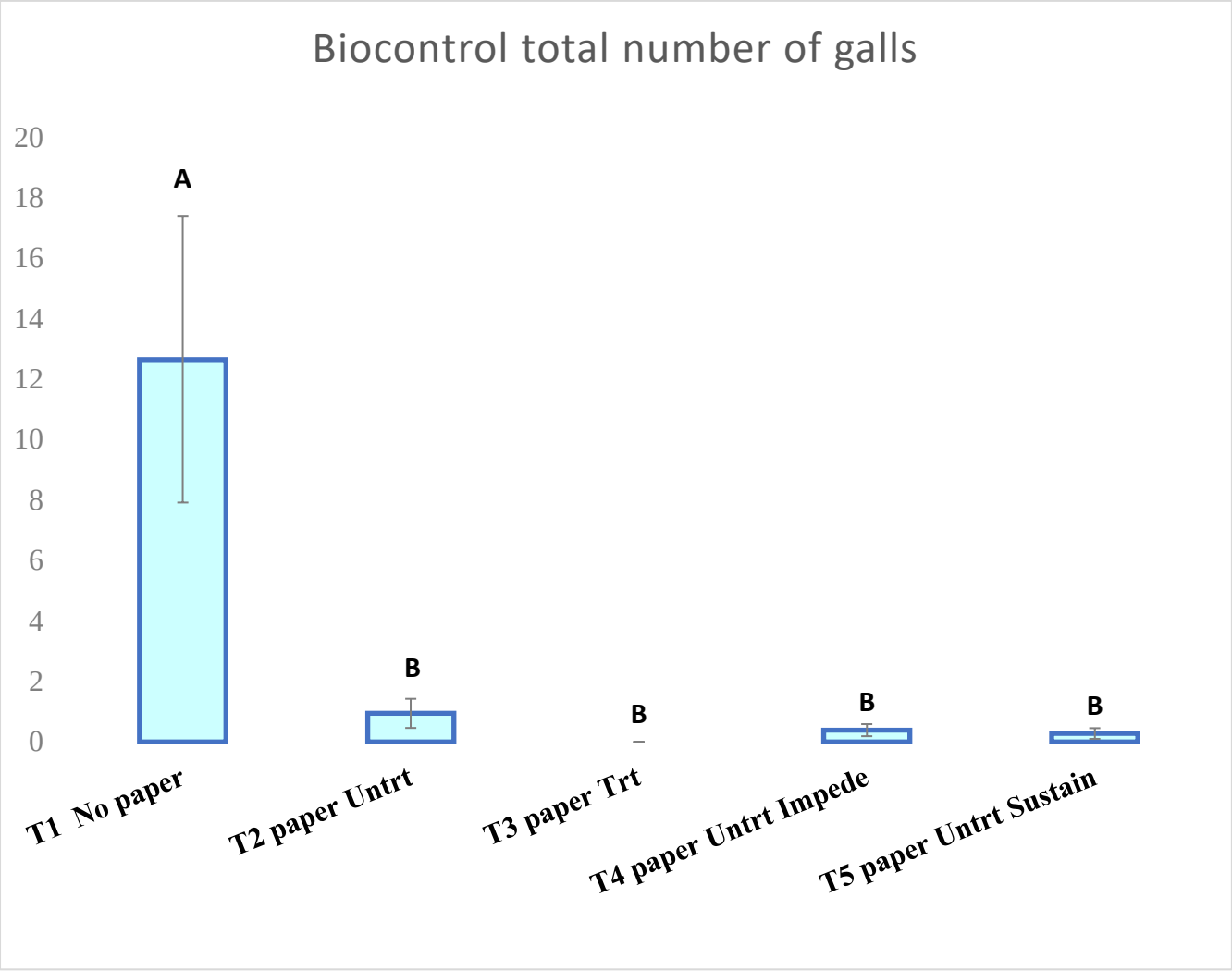

Figure 2: Effect of biological control treatments on total number of galls

Bars with the same letter in a graph are not different according to a Student Newman-Keuls test (P ≤0.05); N=10.

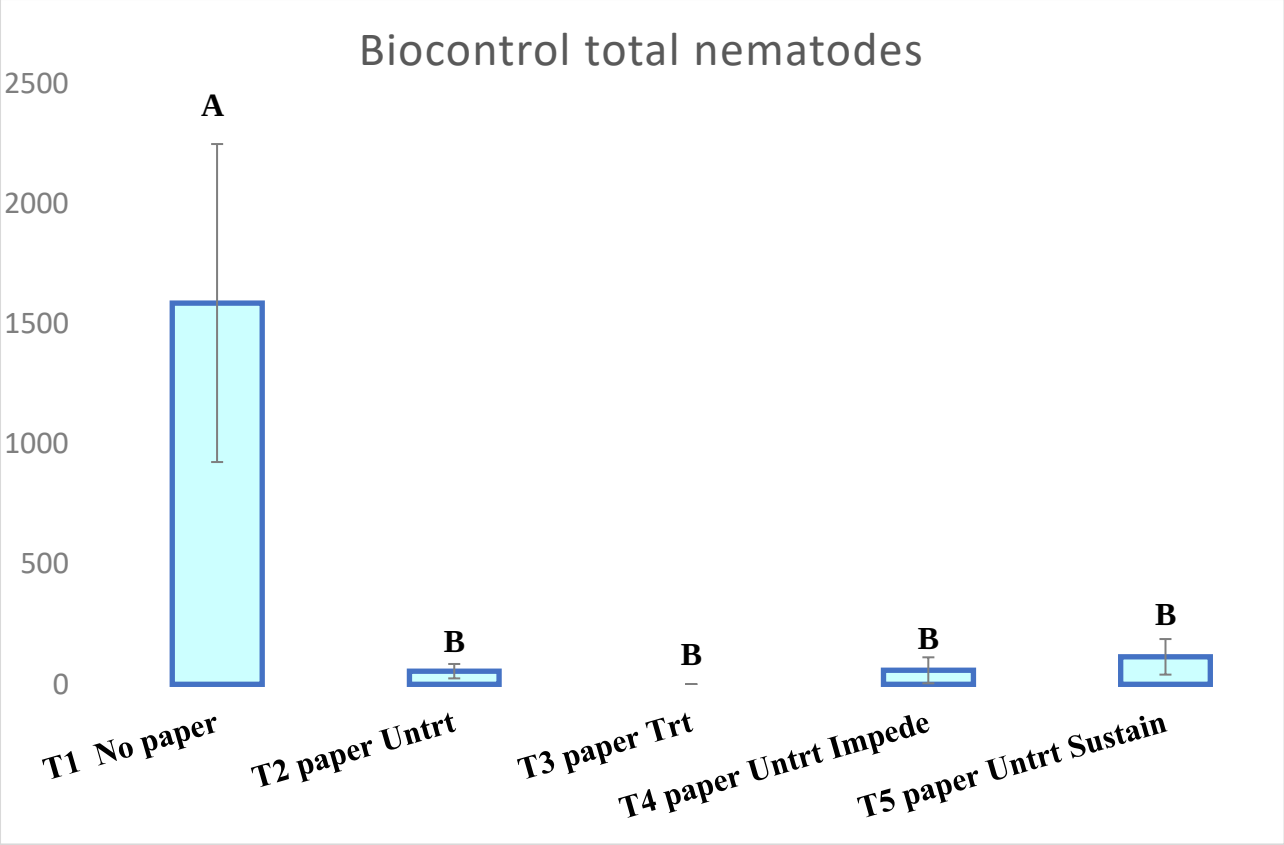

Figure 3: Effect of biological control treatments on total number of nematodes

Bars with the same letter in a graph are not different according to a Student Newman-Keuls test (P ≤0.05); N=10.

Figure 2, 3 and 4 show that the presence of the paper has significantly reduced the number of galls and the number of nematodes compared with treatments without paper.

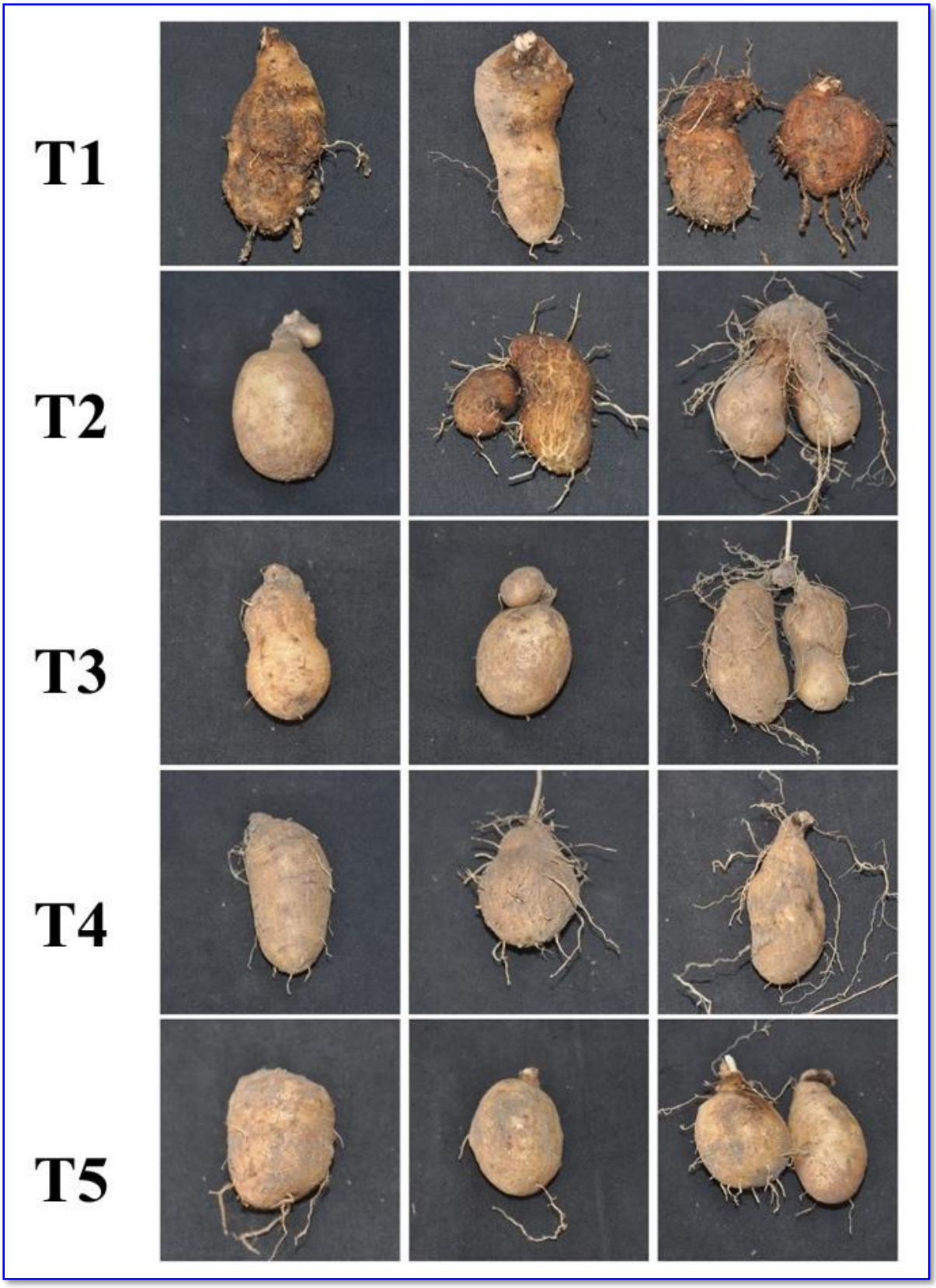

Figure 4: Yam tubers from the effect of biological control treatments on Kpamyo

T1= Kpamyo with no banana paper; **T2**= Kpamyo with banana paper untreated; **T3** = Kpamyo with banana paper Ivermectin-treated; **T4**= Kpamyo with banana paper untreated and SUSTAIN (*Trichoderma asperellum*); **T5**= Kpamyo with banana paper untreated and IMPED (*Paecilomyces lilacinus*).

2.2 Banana paper trials: Evaluation of banana leaves yam genotypes

Table 3: Analysis of variance for the effect of banana leaves on treatments, yam genotypes and trial repetition on the plant growth parameters (Root length, Root fresh weight and Tubers weight)

Source	DF	F Values[1]: Plant growth parameters		
		Root length (cm)	Root fresh weight (g)	Tubers weight (g)
Treatment (A)	2	0.26ns	0.8ns	0.29ns
Trial (B)	1	0.03**	0.98ns	0.02**
Genotype (C)	2	0**	0.47ns	<.0001***
A*B	2	0.52ns	0.39ns	0.57ns
A*C	4	0.58ns	0.08ns	0.36ns
B*C	2	0.47ns	0.34ns	0.28ns
A*B*C	4	0.55ns	0.9ns	0.08ns

[1]ns, *, ** and *** represent not significant (P>0.05), significant at P ≤ 0.05, 0.01 and 0.001, respectively. N (number of replicates) =10.

Treatments applied did not affect significantly the roots length, the roots fresh weight and the tubers weight unlike the yam genotype and the trial repetition that significantly affected the roots length and the tubers weigh (Table 3)

Table 4: Analysis of variance for the effect of banana leaves on treatments, yam genotypes and trial repetition on the nematode parameters (Number of gall on roots and tubers, number of nematode on roots and total number of nematodes and the reproduction factor)

Source	DF	F Values[1]: Nematode parameters					
		Number of galls [α]			Number of nematodes [α]		RF
		Roots	Tubers	Total	Roots	Total	
Treatment (A)	2	0**	0**	<.0001***	<.0001***	<.0001***	0.02**
Trial (B)	1	0.02**	0.09ns	0.01**	0**	0.09ns	0.54ns
Genotype (C)	2	0.16ns	0.65ns	0.33ns	0.01**	0.14ns	0.62ns
A*B	2	0**	0.02**	0**	0.01**	0.11ns	0.86ns
A*C	4	0.02**	0.03**	0.01**	0**	0.02**	0.3ns
B*C	2	0.01**	0.17ns	0.02**	0**	0.01**	0.35ns
A*B*C	4	0.02**	0.49ns	0.02**	0.04**	0**	0.01**

[1]ns, *, ** and *** represent not significant (P>0.05), significant at P ≤ 0.05, 0.01 and 0.001, respectively. N (number of replicates) =10.

[α]: Data of nematode parameters were Log transformed before statistical analysis

The factorial analysis revealed on table 4 that the treatments applied have significantly affected the number of galls on the roots system and on the tubers, the total number of gall, the number of nematodes on the roots, the total number of nematodes and the nematode reproduction factor (RF). The yam genotypes only affected significantly the number of nematodes on the roots.

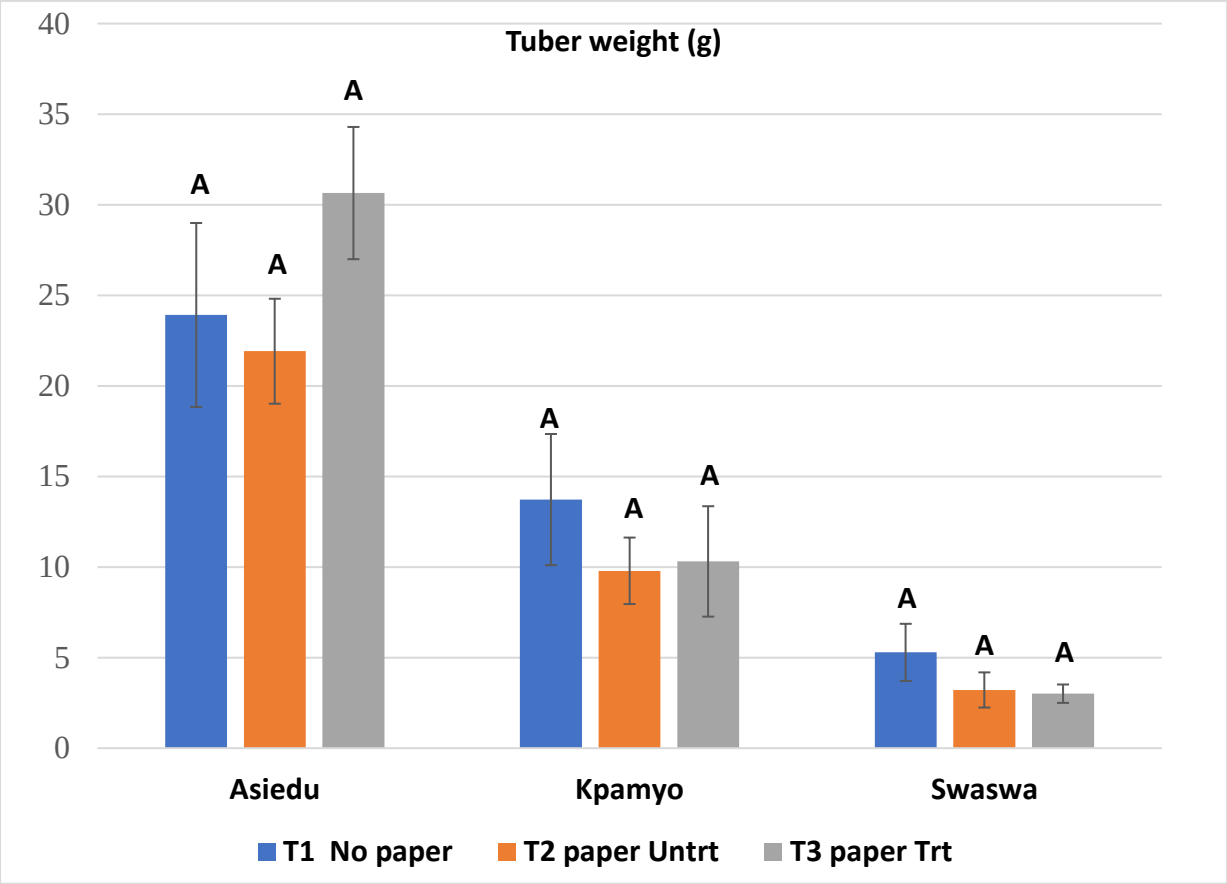

Figure 5: Effect of the banana paper treated and untreated on the tuber weight of three yam genotypes

Bars with the same letter in a graph are not different according to a Student Newman-Keuls test (P ≤0.05); N=10.

As shown in the factorial analysis, banana paper application, treated and untreated, did not have any significant effect on the tuber weigh in the three genotypes evaluated compared with the control (Fig. 5 & 8).

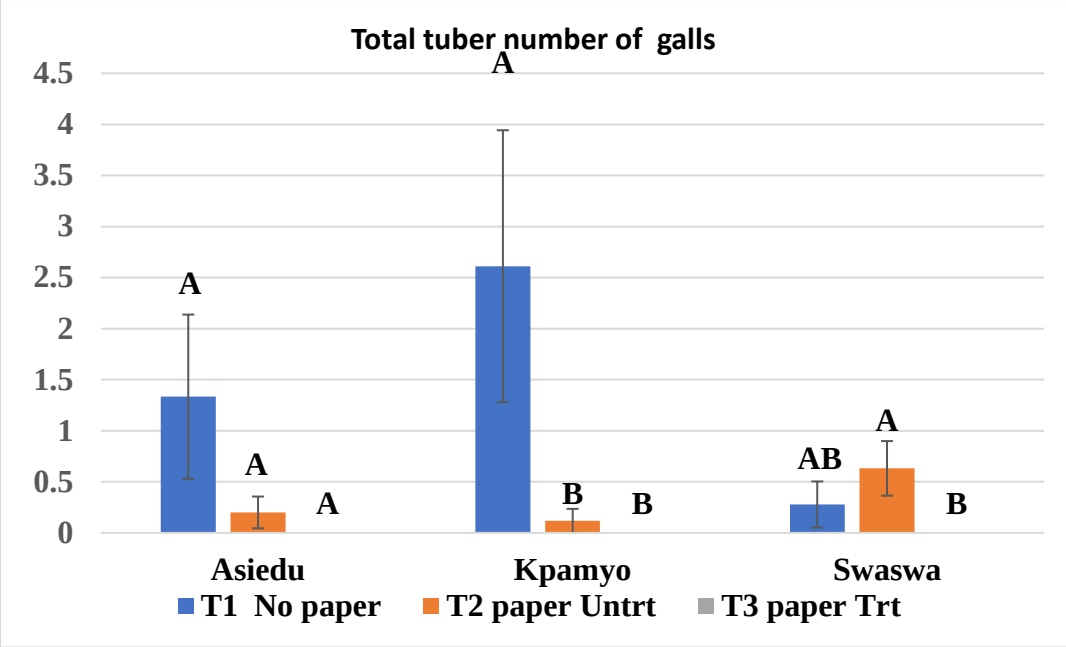

Figure 6: Effect of the banana paper treated and untreated on the number of galls on tubers of three yam genotypes

Bars with the same letter in a graph are not different according to a Student Newman-Keuls test (P ≤0.05); N=10.

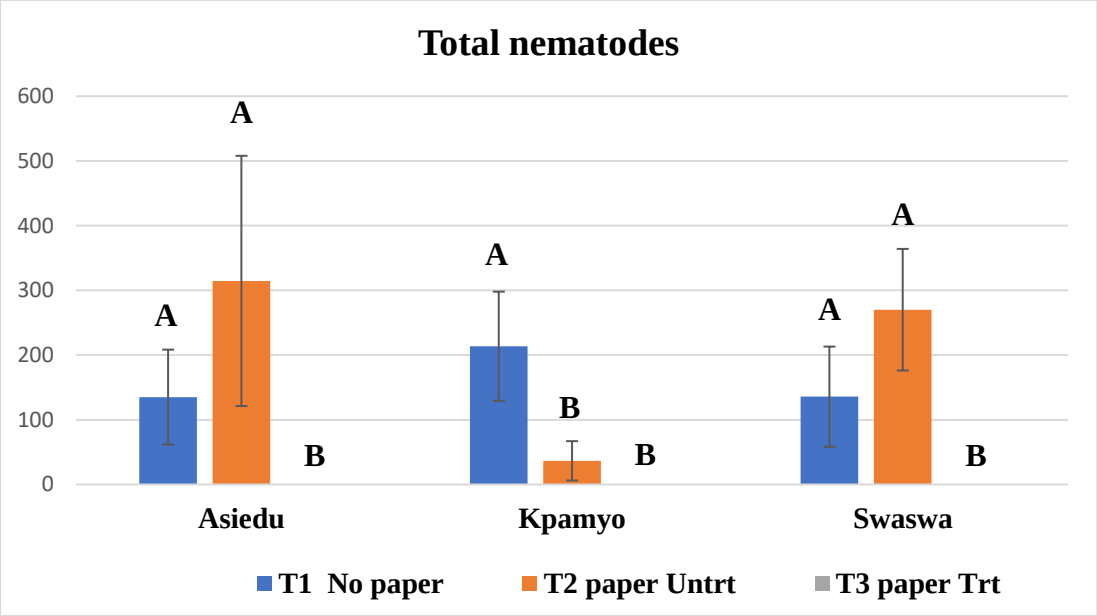

Figure 7: Effect of the banana paper treated and untreated on the total number of nematodes on three yam genotypes

Bars with the same letter in a graph are not different according to a Student Newman-Keuls test (P ≤0.05); N=10.

Except on the number of galls on yam tubers on the genotypes Asiedu, the application of treated banana paper significantly reduced the number of galls and the total number of nematodes (Fig. 6, 7 and 8).

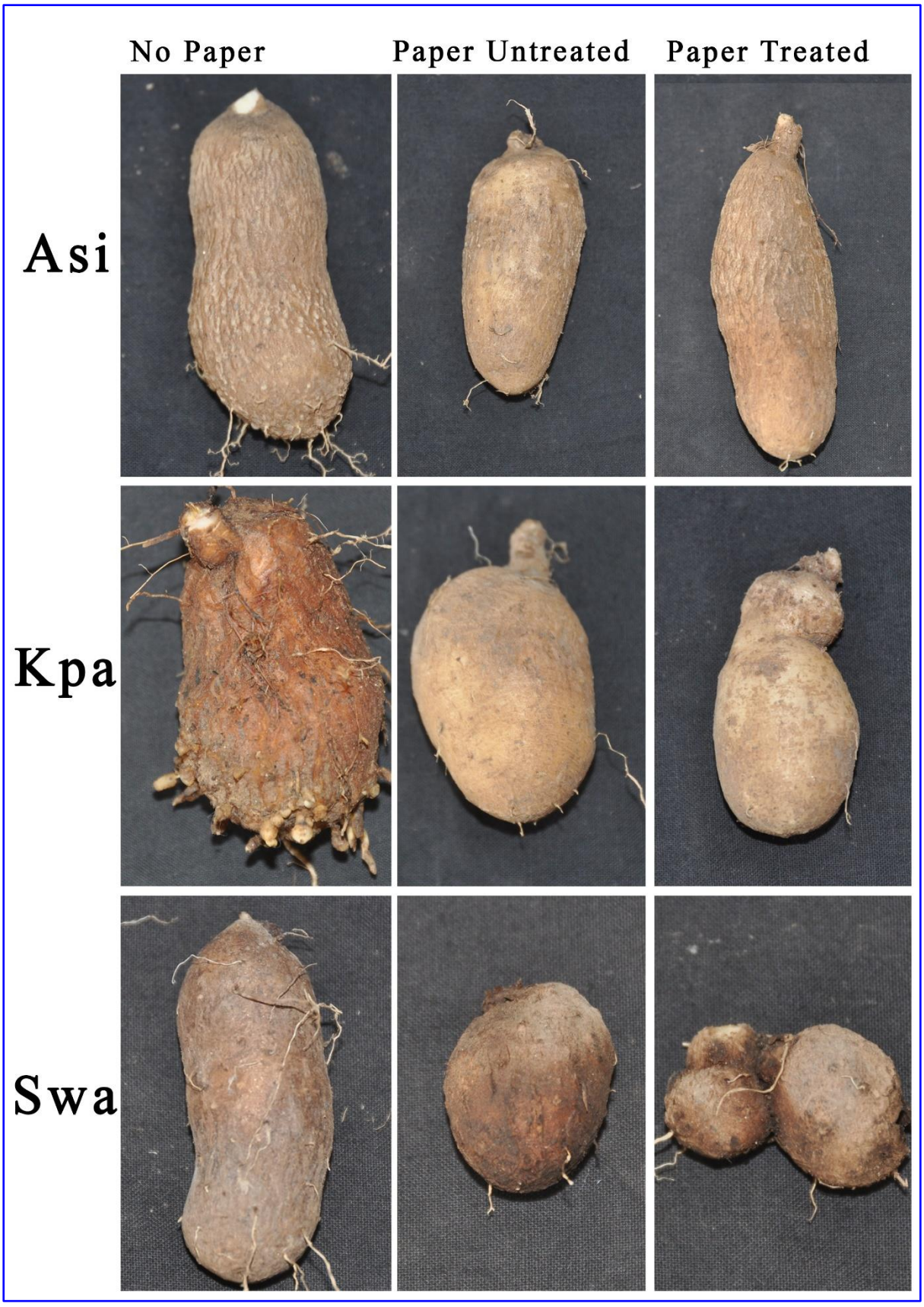
No Paper
Paper Untreated
Paper Treated
Asi
Kpa
Swa

Figure 8: Yam tubers from the effect of treated and untreated banana paper on three yam genotypes (Asi= Asiedu, Kpa= Kpamyo and Swa= Swaswa)

3 Conclusion

i. From the three yam genotypes tested, Asiedu produced bigger yam tubers compared with the two other genotypes while the small size yam tubers were recorded with Swaswa,
ii. The limited tuber size could be related to the pots size used for the trial,
iii. The application of banana paper had significant effect on the nematodes control (number of galls and the total number of nematodes) with more effect when the banana paper where treated,
iv. The effect of the biological control did not express fully probably due to the presence of the banana paper,
v. The trial was established during the period (October) when plants in general and yam in particular perform less due to unfavourable environmental conditions (High temperature, low humidity, …) and this might have impacted the performance of the plants, hence, the treatments.

4 Recommendations

i. The trials need to be conducted during the favourable condition period (April-May) to contrast the results,
ii. Application of the biological control singly, in the absence of the banana paper need to be tested to evaluate the potential of the bioagents,
iii. Promising results obtained need to be validated in a field condition prior recommendation for large scale usage.

5 Reference

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6 Appendix

Appendix 1: Planting material and bioagents used for the trials

Appendix 2: Pots and saucers used for the trial