ALLELOPATHIC EFFECT OF *Hibiscus sabdariffa* ON THE YIELD OF SOME LOCAL BEST CULTIVARS OF WHITE YAM IN NEMATODE INFESTED SOIL

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Abstract: Field trials were conducted at the Teaching and Research farm of Federal University of Agriculture Makurdi during the 2016 and 2017 planting seasons to study the allelopatic effect of *Hibiscus sabdariffa* on the yield of 3 local best cultivars of white yam in nematode infested soil. Trials were initiated within a difference of 2 weeks on farmland with proven history of root knot nematode infection. The experiment was laid out in a randomized complete block design and replicated four times. The experiment consisted of six treatments of each cultivar with or without *Hibiscus sabdariffa* intercrop. The results obtained showed that the greatest number of tubers, tuber length, tuber weight per plant and tuber yield were obtained from Hembakwase cultivar for both the treated and the untreated. Tuber yield obtained from Hembakwase was significantly ($P<0.05$) higher for both treated and untreated compared to data obtained from Aloshi and Amola cultivars. All the yam cultivars however were susceptible to root-knot nematode with the highest severity observed on untreated Aloshi cultivar (4.33) and the least obtained from treated Hembakwase cultivar (1.0). This study shows that management of *Meloidogyne incognita* infection on yam fields can be achieved with intercrop of *Hibiscus sabdariffa* for improved growth, yield and reduced nematode severity.

Keywords: Allelopathy, cultivars, root-knot, white yam, yield

Introduction

White yam *(Dioscorea rotundata* L. Poir*)* Family Dioscoreaceae is native to West Africa, but it does not occur in the wild, and is probably developed in cultivation from the wild species - *D. praechensilis* Benth. *D. rotundata* Poir is grown on a greater acreage than any other cultivars in West Africa. Other popular cultivated yam species in Nigeria are *D. cayenensis* Lam. (yellow yam) and *D. alata* L. (water yam) **(**Tchabi *et al* 2010**)**. There is a very large number of cultivars of *D. rotundata* that are grown, especially in Nigeria where it originated and is most widely cultivated **(**Osunde, 2006). The various cultivars can be identified by the tuber characteristics after harvest or by their shoot characteristics while they are growing in the field.

Underground tubers vary in size and shape averaging 1.3 - 3.6 kg, sometimes reaching 27.2 kg or more (IITA, 2007). Besides its importance as food source, yam also plays a significant role in the socio-cultural lives of people in some producing regions like the celebrated New Yam Festival in West Africa (Osunde and Orhevba, 2009) and wedding ceremonies (O'Sullivan, 2008). Yam also provides cash income for a wide range of smallholders, including many women as producers, processors and traders (Adekunle *et al*, 2012).

Nutritionally, the content of white yam is mainly carbohydrate, but also contain about 1-2% dietary protein, which is high compared with other tropical root crops (Ekefan *et al*., 1999). However, yam production in West Africa is affected by several threats including effects low soil fertility, pests and diseases. These pests include *Scutellonema bradys*, a yam nematode, and root-knot nematode, *Meloidogyne* spp. (Kofoid & White) which are field and post-harvest pest. Root knot nematodes mainly *Meloidogyne incognita*, *M. javanica* and *M. arenaria* are a major cause of yield decline in the production fields. They alter the plant physiology by producing specific enzymes that induce giant cell formation within the root at the feeding site (Karssen *et al.*, 2006). The objective of this study is to investigate allelopatic and nematotoxic effect of *Hibiscus sabdariffa* on the yield parameters of *D. rotundata* cultivars.

Materials and Methods

Study sites

The trials were conducted at the teaching and Research Farm, Federal University of Agriculture, Makurdi Benue state, Nigeria. The area is significant for extensive cultivation of *D. rotundata* and initial parasitic nematode population densities were perceived to be very high.

Experimental design

Land preparation was done manually by clearing weeds with a cutlass and debris was collected. Stumps were removed with a mattock and pick-axe before mounds were raised at a planting distance of 1 x 1 m. There were 20 mounds for each treatment. Trials were mounted on Randomized Complete Block Design (RCBD) with three replications on a total land area of 360 m^2.

Plant material

Three (3) most popular *D. rotundata* cultivar among farmers in this area; Hembakwase, Aloshi and Amula which are highly patronized by buyers was selected for the trials. The cultivar was purchased from the open markets in the area. Yam sets averaging 350 g were used for planting. Setts were tested for presence of plant parasitic nematodes prior to planting. The experimental plant *Hibiscus sabdariffa* was established with the yam cultivars. Five gram tuber peel samples were taken at planting and processed for plant parasitic nematodes. Peel samples were replicated three times. Setts were placed in the hole made with a hoe in the mound and properly covered with soil. Dry straw was placed on top of the mounds for moisture preservation after planting. After sprouting, yam vines were supported with stakes and the experimental trials were each weeded three times before harvest. The trials had three replications and repeated two times during (2016 and 2017) planting seasons.

Soil sampling for nematodes

Initial soil sampling was collected prior to planting to determine plant parasitic nematodes population densities at the site. Stand establishment was taken 3 months after planting. At harvest, soil samples (200 cm/mound) were randomly collected with a 2.5 cm diameter soil probe to a depth of 20 cm from the mounds. Three soil cores were collected from each mound. Five gram tuber peel samples were processed for nematodes from the tubers at harvest. Three tubers per plot were peeled for extraction. Nematodes were extracted from soil and peel samples using the modified Baermann funnel method. After 24 h of extraction, samples were fixed with TAF (Formalin-37% Formaldehyde 7.6 ml, Tri-ethylamine 2 ml and distilled water 90.4 ml) and second, third and fourth stage nematodes were mounted on aluminum double cover glass slides and specimens were identified (CIH, 1978) by morphology. Plant parasitic nematode population data are expressed as number of nematodes/200 cm^3 soil and number of endo-parasitic nematodes population/5 g of tuber peel.

Data collection

Data collected include yield parameters such as number of ware tubers per plot, weight of ware tubers per plot, total fresh tuber weight, tuber length, tuber diameter. The roots were washed carefully under a gentle stream of tap water, mopped dry and assessed for galls. Eggs were extracted from the roots and estimated. The numbers per 100g of fresh root weight of tuber following extraction using Baerman extraction method was also be assessed.

Data analysis

The means of the two years data (2016 and 2017) was subjected to Analysis of variance (ANOVA). Mean separation was done using Least Significant Difference (LSD) at p = 0.05 using GenStat 8.1 (Lawes Agricultural Trust, VSN International).

Results and Discussion

Table 1 shows allelopatic effect of *Hibiscus sabdariffa* on the yield parameters of some selected cultivars of *Dioscorea rotundata* on nematode infested soils of Makurdi Benue state. The number of tubers is significantly ($P \leq 0.05$) higher in all the treated tubers:Aloshi X *Hibiscus sabdariffa*, (20.67), Amula X *Hibiscus sabdariffa*, (19.67), Hembakwase X *Hibiscus sabdariffa* (27.67)respectively and significantly ($P \leq 0.05$) lower in untreated yam tubers. There is no significant ($P \leq 0.05$) difference in the tuber girth recorded in both the treated and untreated white yam cultivars. No significant ($P \leq 0.05$) difference was also observed in the data obtained for the fresh weight in both the treated and untreated white yam cultivars except in Hembakwase X *Hibiscus sabdariffa* (2.00). Similar trend was observed in the tuber length however there's is no significant difference ($P \leq 0.05$) in data obtained in all the treatments. Aloshi X *Hibiscus sabdariffa* (32.00) and Hembakwase X *Hibiscus sabdariffa* (40.00) gave a significantly ($P \leq 0.05$) higher yield per plot than all other treatments.

The allelopatic effect of *Hibiscus sabdariffa* on the initial, mid and final nematode population of some selected cultivars of *Dioscorea rotundata* on nematode infested soils is shown on Table 2. There's no significant difference in the initial nematode population for all the different cultivars and treatment. The untreated control gave a significantly ($P \leq 0.05$) higher mid nematode population than all other treatments for the different cultivars. There's however no significant difference in the mid nematode populations for the treated plants. Similarly, the untreated control plants gave a significantly ($P \leq 0.05$) higher final nematode population for all the different cultivars while the treated cultivars gave a significantly lower final nematode population.

Table 1: Allelopatic effect of *Hibiscus sabdariffa* on the yield parameters of some selected *Dioscorea rotundata* cultivars in nematode infested soil

Treatment	No of tuber	Tuber girth	Fresh weight (kg)	Tuber length (cm)	Yield per plot (kg)
Aloshi only	11.33	24.33	1.13	22.67	14.60
Aloshi X *Hibiscus sabdariffa*	20.67	24.67	1.50	18.33	32.00
Amula only	12.67	20.00	1.16	22.33	15.67
Amula X *Hibiscus sabdariffa*	19.67	23.33	1.17	25.33	21.67
Hembakwase only	25.00	21.00	1.33	34.00	17.33
Hembakwase X *Hibiscus sabdariffa*	27.67	31.00	2.00	37.33	40.00
L.S.D. (5%)	8.06	4.93	0.54	7.48	10.02

Table 2: Allelopatic effect of *Hibiscus sabdariffa* on the initial, mid and final nematode population of some selected *Dioscorea rotundata* cultivars in nematode infested soil

Treatment	Initial nematode population ('00)	Mid nematode population('00)	Final nematode population('00)
Aloshi only	40.67	65.33	77.33
Aloshi X *Hibiscus sabdariffa*	39.67	22.33	14.00
Amula only	44.33	59.33	73.33
Amula X *Hibiscus sabdariffa*	44.00	26.67	18.00
Hembakwase only	40.67	55.33	68.33
Hembakwase X *Hibiscus sabdariffa*	45.67	16.67	11.33
L.S.D. (5%)	5.35	5.97	7.17

Table 3: Allelopatic potential of *Hibiscus sabdariffa* on the Root knot nematode damage and root gall index on some selected *Dioscorea rotundata* cultivars in nematode infested soil of Makurdi, Benue state

Treatment	No of galls per 10 g of root	Egg mass per 10 g of root	Nematode population per 10 g of root ('00)	Root gall index
Aloshi only	22.33	91.67	40.67	4.33
Aloshi X *Hibiscus sabdariffa*	3.33	7.67	6.00	1.30
Amula only	24.00	103.33	48.33	4.00
Amula X *Hibiscus sabdariffa*	8.67	13.33	10.67	2.00
Hembakwase only	15.00	57.67	34.00	3.00
Hembakwase X *Hibiscus sabdariffa*	3.33	7.67	3.67	1.00
L.S.D. (5%)	4.98	11.91	4.92	0.63

Table 3 shows the allelopatic effect of *Hibiscus sabdariffa* on the number of galls per 10 g of root, Egg mass per 10 g of root, nematode population per 10 g of root and the root gall index of some selected cultivars of *Dioscorea rotundata* on nematode infested soils. There's significant difference in all the result obtained for on the number of galls per 10 g of root, Egg mass per 10 g of root, nematode population per 10 g of root and the root gall index. The untreated control gave a significantly ($P \leq 0.05$) higher number of galls than all other treatments for the different cultivars with tubers treated with tubers treated with *Hibiscus sabdariffa* recording a significantly ($P \leq 0.05$) lowest number of galls per 10 g of root. Similar trend is observed in the data obtained for Egg mass per 10 g of root and nematode population per 10 g of root. Also, the untreated control plants gave a significantly ($P \leq 0.05$) higher root gall index for all the different cultivars while the treated cultivars gave a significantly lower root gall index.

Allelopathy of secondary metabolites is being explored in field crop production for integrated pest and disease management. Production of allelopatic chemicals that function as nematode antagonistic compounds has been demonstrated in many plants such as castor bean, chrysanthemum, velvet bean, sesame, jack bean, crotalaria, sorghum-sudan, indigo, tephrosia, neem, *Tamarindus indica*, flame of the forest (Chitwood, 2002). These chemicals include saponins, tannins, polythienyls, glucosiniolates, cyanogenic glucosides, alkaloids, lipids, terpenoids, triterpenoids and phenolics, among others. When grown as allelopathic cover crops, bioactive compounds are exuded during the growing season or released during green manure decomposition (Chitwood, 2002; Ball-Coelho *et al*., 2003). The result obtained in this experiment is in line with Narwal (2010) where the use of allelochemicals gives higher yields and considerably reduces the density of nematodes. Wood ash increased yield but was ineffective in reducing nematode densities. This suggests that *Hibiscus sabdariffa* has stimulatory (positive) allelopathic ability on shoot and root growth. This enhanced growth may be linked to the production of more auxin at 100% concentration of the extract. Zhung *et al*. (2005) gave similar report on the effect of Lantana (Lantana camera L.) on water hyacinths (*Eichornia crasspes*). Stimulation of growth by plant extracts can be accounted for by the breakdown of functional allelochemicals in the extracts and their subsequent transformation to plant nutrients required for growth. In the opinion of Aladejimokun *et al.* (2014), stimulation of growth by plant extracts can be accounted for by the breakdown of functional allelochemicals in the extracts and their subsequent transformation to plant nutrients required for growth. This unequal susceptibility to different plants could be due to inherent differences in various biochemicals released by the different plants in the intercrop.

Conclusion and Recommendation

The results obtained in this study showed that the highest number of tubers, tuber weight per plant and tuber yield was obtained from yam cultivars treated with allelopatic plants, most especially *Hibiscus sabdariffa* in all the cultivars used for this study. There is sufficient evidence in this study to support that *Hibiscus sabdariffa* had more allelopatic potentials on the growth and yield of white yam cultivars. Also, the stimulatory effect of *Hibiscus sabdariffa* when properly utilized could lead to increase in growth of white yams. Farmers should be encouraged to plant *Hibiscus sabdariffa* around their farms because the allelochemicals produced by the plant could enhance growth in the crops. This strategy is durable, compatible and integrable with the prevailing agricultural practices specific to our people.

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