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Efficacy of *Trichoderma harzianum*, Poultry manure and Yeast on the Growth and Yield of Soybean Grown on Nematode Infested Soil

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Abstract
Field experiments were carried out during 2010 and 2011 planting seasons in order to assess the effect of *Trichoderma harzianum*, cured poultry manure and palm wine yeast, singly and in combination, on the growth and yield of soybean, variety TGx 536-02D, grown on nematodes infested soil. The treatments were control, *T. harzianum* T22 isolate, cured poultry manure, palm wine yeast, *T. hazianum*T22 isolate + cured poultry manure, *T. hazianum*T22 isolate + palm wine yeast, cured poultry manure + palm wine yeast and *T. hazianum*T22 isolate + cured poultry manure + palm wine yeast. Control experiment did not receive cured poultry manure, palm wine yeast or *T. hazianum*T22 isolate. In each trial, there were 8 treatments replicated 5 times fitted into randomized complete block design. The results indicated that application of *T.hazianum*T22 isolate, cured poultry manure, palm wine yeast, *T. hazianum* + cured poultry manure, *T. hazianum* + palm wine yeast, cured poultry manure + palm wine yeast and *T. hazianum*T22 isolate + cured poultry manure + palm wine yeast significantly ($p<0.05$) increased the growth and yield of soybean, and also significantly ($p<0.05$) reduced the soil population dynamics of nematode pests of soybean. Prominent nematode genera were *Meloidogyne, Xiphinema* and *Helicotylenchus*. Control plants that were not treated with palm wine yeast, *T. harzianum* T22 isolate and cured poultry manure had significantly ($p<0.05$) reduced the growth and yield of soybean,and had increased soil nematode population. Data collected on both trials were analyzed using analysis of variance and significant differences among treatments were separated using Duncan's multiple range test at probability level of 5%.
Keywords: *Trichoderma harzianum*; poultry manure; yeast; soybean; control; nematode.

1. Introduction

Soybean (*Glycine max* (L.) Merrill) thrives very well in the tropical, subtropical and temperate climates. Soybean is an important high quality and expensive protein and oil sources. It has an average protein content of 40% and oil content of 20%. It also has a superior amino acid profile.

Soybean protein has a great potential as a major source of dietary protein. The oil produced from soybean is with a highly digestible and contains no cholesterol. A by-product from the oil production (soybean cake) is used as high-protein animal feed in many countries. Soybean also improves soil fertility by adding nitrogen to the soil from the atmosphere.

Compost utilization as manure is becoming wide spread during recent years as consequences of the rise in price of conventional fertilizers. Beneficial effects of *Trichoderma harzianum* and organic fertilizer application on the growth and yield of some field crops have been established (Radwan & Hussein, 1996; Mekki *et al*., 1999). Nowadays, more emphasis has already been placed on research and development activities that led to the concept of multi-strain *T. hazianum*, that have definite beneficial well-known role in supporting plant growth in the developing sustainable soil fertility and in bio-controlling soil borne diseases. Palm wine yeast as a natural bio-stimulant has appeared to reduce astonished influences on growth and yield of some crops (El-kholy & Gomaa, 2000)

Plant parasitic nematodes are major agricultural pests worldwide responsible for global agricultural losses (Karssen & Moens, 2006).Nematodes live in the soil and they are widely distributed or spread and persist as soil plant pest for indefinite period (Caveness, 1976; Whiting *et al*., 2007).All crops grown in Nigeria are prone to nematode attack, causing farmers' significant crop loss annually (Oyedunmade *et al*., 2009). Farmers are not always aware of losses being caused as a result of nematodes because they are hidden from sight and at times misconstrue to be loss from other pathogenic organism, nutrient loss or certain environmental factors. Plant parasitic nematodes are microscopic organisms that feed on plant roots. Nematodes cause damage to roots, resulting in root systems which are less able to take up nutrients and water. They live in the soil and plant tissues (Wang & McSorley, 2005; Westerdah & Kodira 2007).

The objective of this research work was to assess the effects of *Trichoderma harzianum*, cured poultry manure and palm wine yeast, singly and in combination, on the growth and yield of soybean grown in nematode infested

soil.

2. Materials and Methods

In 2010 and 2011 planting seasons, naturally infested field of the Teaching and Research Farm of the Ladoke Akintola University of Technology, Ogbomoso, Nigeria was sown with nematode susceptible soybean variety TGx 536-02D. The attempt was to assess the effect of *T. harzianum*, cured poultry manure and palm wine yeast, singly and in combination, on the growth and yieldof soybean sown on nematode infested soil. The soil used for this experiment had been previously confirmed as being naturally nematode infested (Oyedunmade *et al*., 2009) and TGx 536-02D soybean variety that was used as test crop had been confirmed to be nematode susceptible (Oyedunmade & Olabiyi, 2004).The soybean seeds were obtained from International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. There were 8 treatments, each replicated 5 timesand fitted into randomized complete block design. The treatments and application rates were *T. harzianum* ($1x10^7$ spores); cured poultry manure (10g); palm wine yeast ($1x10^7$ spores); *T. harzianum* ($1x10^7$ spores) + cured poultry manure (10g); *T. harzianum* ($1x10^7$ spores) + palm wine yeast ($1x10^7$ spores); palm wine yeast ($1x10^7$ spores) + cured poultry manure (10g); *T. harzianum* ($1x10^7$ spores) + palm wine yeast ($1x10^7$spores) + cured poultry manure (10g) and control.Composite soil samples were collected from the experimentalplots; the soil was air-dried, crushed and sieved to remove stones, and thereafter analyzed in the laboratory.

Two seeds were planted per stand which was later thinned down to one healthy seedling per stand 2weeks after planting. Also at two weeks after planting and during both trials, the experimental plots were inoculated with pure cultured nematodes obtained from International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Weeding and other agronomic practices were manually done as at when due. Palm wine yeast was obtained through palm wine yeast cultured on nutrient agar while *T. harzianum* T 22 isolates was supplied from Istituto per la Protezione delle Piante, CNR, Via Università 130, Portici (NA), Italy. The poultry manure used was well cured for a period of 5 months before use. Treatments were applied at 3 weeks after planting.

The growth and yield parameter measured include plant height, number of leaf per plant, root length, number of branches/per plant, number of flower/plant, pods weight/ plant, number of pods / plant, number of seeds/pod, seeds weight/plant and seed weight.Final soil nematode populations and identification were obtained (Whitehead & Hemming, 1965; Eisenback *et al*., 1981; Byrd *et al*., 1983).Data collected on both trials (2010 and 2011) were analyzed using analysis of variance and significant differences among treatments were separated using Duncan's multiplerange test (DMRT) at 5% probability level.

3. Results

The result presented on Table 1 shows the physical and chemical composition of the soil used for the experiment in both trials. The soil texture was sandy loam with pH 6.8. The soil has low nutrient status.The soil has 9.5% organic carbon, 16.4% organic matter, 1.7% nitrogen, $0.66mgKg^{-1}$and $0.38molKg^{-1}$ calcium. The soil also has very low micro-nutrients. Iron, magnesium and zinc were as low as 0.3, 1.05 and 1.8 $mgKg^{-1}$.

Table 2 elicits the effects of *T. harzianum*, cured poultry manure and palm wine yeast, singly and in combination, on the growth of soybean sown on nematode infested soil. The application of palm wine yeast, *T. harzianum* + cured poultry manure and palm wine yeast + cured poultry manure significantly ($p<0.05$) increased the plant height more than other treatments; this was closely followed by soybean that received *T. harzianum*, cured poultry manure, *T. harzianum* + palm wine yeast, *T. harzianum* + palm wine yeast + cured poultry manure treatments. However, *T. harzianum* + cured poultry manure significantly ($p<0.05$) enhanced the number of leaves per plant, this was closely followed by palm wine yeast + cured poultry manure treatment. Control plant had the least growth rate. It was evident that the effects of different treatments on the growth of soybean, sown on nematode infested soil, followed the same trend at both trials.

Table 1: Soil Analysis of the experimental site

Properties	0-15cm
Mechanical analysis	
Coarse sand %	45.0
Fine sand %	31.0
Silt %	6.3
Clay %	2.7
Soil texture	Sandy loam
Chemical analysis	
P^H	6.8
Organic carbon (%)	9.5
Organic matter (%)	16.4
Nitrogen (%)	1.75
Calcium (mol Kg^{-1})	0.38
Potassium ($MgKg^{-1}$)	0.66
Sodium ($molKg^{-1}$)	0.57
Micronutrients	
Iron (Mg Kg^{-1})	0.30
Magnesium (Mg Kg^{-1})	1.05
Zinc (Mg Kg^{-1})	1.18
Copper (Mg Kg^{-1})	0.25
Lead (Mg Kg^{-1})	0.1
Cadmium (Mg Kg^{-1})	0.12
Chromium (Mg Kg^{-1})	0.05
Nickel (Mg Kg^{-1})	0.05

Table 2: Effects of *Trichoderma harzianum*, cured poultry manure and palm wine yeast on the growth of soybean sown on nematode infested soil.

Treatments	Application rate	2010 planting season				2011 planting season			
		Mean plant height (cm)	Mean number of leaf/plant	Mean number of branches/plant	Root length(cm)	Mean plant height (cm)	Mean number of leaf/plant	Mean number of branches/plant	Root length(cm)
Control	Nil	19.1c	61.5d	4.0b	7.9c	20.3c	60.1d	4.2b	7.4c
Trichoderma harzianum	1x10^7 spores	28.3b	98.5c	10.5a	19.0a	32.7b	103.7c	11.6a	20.9a
Cured poultry manure	10 g	26.9b	97.7c	11.3a	14.3b	31.1b	104.1c	12.0a	16.1b
Palm wine yeast	1x10^7 spores	31.1a	97.0c	10.0a	14.3b	37.6a	103.9c	11.8a	15.6b
T. harzianum + Cured poultry manure	1x10^7 spores + 10 g	31.4a	138.0a	12.0a	18.9a	38.2a	147.0a	12.9a	19.8a
T. harzianum + Palm wine yeast	1x10^7 spores each	27.7b	97.0c	11.0a	16.6b	30.1b	102.9c	12.0a	16.9b
Palm wine yeast + Cured poultry manure	1x10^7 spores + 10g	29.4ab	113.7b	12.3a	15.9b	29.9ab	122.7b	12.8a	16.3b
T. harzianum + Palm wine yeast + Cured poultry manure	1x10^7 spores each + 10 g	27.9b	94.0c	10.3a	16.4b	31.7b	103.4c	11.7a	16.8b

Figure followed by the same letter(s) in the column are not significantly different at 0.05 using Duncan's Multiple Range Test.

Table 3: Effects of *Trichoderma harzianum*, cured poultry manure and palm wine yeast on the yield of soybean sown on nematode infested soil.

Treatments	Application rate	2010 planting season						2011 planting season					
		Mean no of flower /plant	Mean pod weight/ plant (g)	Mean no of pod/ plant	Mean no of seed/ pod	Mean seed weight /plant (g)	Average weight of 100 seeds (g)	Mean no of flower /plant	Mean pod weight/ plant(g)	Mean no of pod/ plant	Mean no of seed/ pod	Mean seed weight /plant (g)	Average weight of 100 seeds (g)
Control	Nil	7.5c	11.9b	33.0c	3.7b	5.3c	5.0b	6.8c	10.1b	31.0c	3.7b	5.0c	4.5b
Trichoderma harzianum	1x10^7 spores	13.0b	28.2a	63.5b	5.6a	11.4ab	8.6a	18.2b	34.6a	74.1b	6.0a	13.1ab	9.1a
Cured poultry manure	10 g	14.3b	29.7a	63.7b	5.8a	12.7ab	8.4a	19.0b	35.8a	73.9b	5.9a	12.9ab	9.6a
Palm wine yeast	1x10^7 spores	14.7b	30.5a	65.7b	5.9a	10.4b	8.3a	19.2b	37.3a	75.0b	6.0a	11.0b	9.0a
T. harzianum + Cured poultry manure	1x10^7 spores + 10 g	14.7b	31.5a	66.0b	5.2a	13.0a	9.3a	20.1b	36.1a	74.5b	5.9a	13.8a	9.8a
T. harzianum + Palm wine yeast	1x10^7 spores each	16.7a	31.5a	64.3b	5.8a	14.7a	9.7a	22.8a	34.9a	75.7b	5.7a	14.5a	9.9a
Palm wine yeast + Cured poultry manure	1x10^7 spores + 10g	16.5a	31.3a	65.0b	5.1a	14.0a	9.3a	21.5a	37.6a	74.6b	5.9a	14.2a	9.6a
T. harzianum + Palm wine yeast + Cured poultry manure	1x10^7 spores each + 10 g	17.0a	32.2a	87.6a	5.6a	15.7a	9.7a	22.2a	37.4a	92.5a	6.0a	15.3a	9.8a

Figure followed by the same letter(s) in the column are not significantly different at 0.05 using Duncan's Multiple Range Test.

Table 4: Effects of *Trichoderma harzianum*, cured poultry manure and palm wine yeast on the final nematode population of soybean sown on nematode infested soil

Treatments	Application rate	2010 planting season			2011 planting season		
		Meloidogyne species	*Xiphinema* specie	*Helicotylenchus* specie	*Meloidogyne* species	*Xiphinema* specie	*Helicotylenchus* specie
Control	Nil	3771	87	43	4511	93	46
Trichoderma harzianum	1x10^7 spores	450	42	15	410	32	8
Cured poultry manure	10 g	410	51	12	380	44	10
Palm wine yeast	1x10^7 spores	512	61	28	482	50	18
T. harzianum + Cured poultry manure	1x10^7 spores + 10 g	241	36	11	192	28	9
T. harzianum + Palm wine yeast	1x10^7 spores each	455	54	18	387	42	10
Palm wine yeast + Cured poultry manure	1x10^7 spores + 10g	442	48	16	400	44	9
T. harzianum + Palm wine yeast + Cured poultry manure	1x10^7 spores each + 10 g	201	26	7	179	20	4

The result on Table 3 shows that *T. harzianum* at the rate of 1x10^7 spores per plant; cured poultry manure at the rate of 10 g per plant; palm wine yeast at the rate of 1x10^{7}spores per plant; *T. harzianum* at the rate of 1x10^7 spores + cured poultry manure at rate of 10g per plant; *T. harzianum* at the rate of 1x10^7 spores + palm wine yeast at the rate of1x10^{7}spores; palm wine yeast at the rate of 1x10^7 spores + cured poultry manure at the rate of 10g per plant; *T. harzianum* at the rate of 1x10^7 spores + palm wine yeast at the rate of 1x10^7 spores + cured poultry manure at the rate of 10g per plant significantly increased number of flower, pod number, number of seed and the weight of soybean seeds at both experimental trials. The control plants had significantly lower number of flower per plant, pod number per plant, number of seed per pod, and the weight of soybean seeds than the soybean that received treatments.

Table 4 shows the population dynamic of the soil inhabiting nematodes dynamics grown with soybean. It was evident that the species of nematodes present in the experimental plots were *Meloidogyne, Xiphinema* and *Helicotylenchus*. The *T. harzianum*, cured poultry manure and palm wine yeast, singly and in combination, reduced the population of the soil inhabiting parasitic nematodes present in the experimental plots at both trials. The experimental plots that did not receive any treatment (control plots) have higher number of soil inhabiting plant parasitic nematodes.

4. Discussion

The findings corroborate the earlier works of some scientists (Gomaa, 1995; El-kholy & Gomaa, 2000), who reported that *Trichoderma harzianum* could replace 50% of the chemical fertilizer recommended for millet plants without decreasing the green and dry fodder, this could be attributed to the plant growth promoting

substances produced by the *T. harzianum*, in addition to the reasonable quantity of atmospheric nitrogen fixed by the *T. harzianum*.Application ofcured farm yard manure had resulted into increased number of branches/plant and significant increased (21%) in final grain yield of wheat (Badaruddin *et al*., 1999). Application of *Trichoderma harzianum* associated with organic manure on groundnut had resulted in an increase in yield and its components (Ahmed *et al*., 1997).

Trichoderma spp. are widely known in plant agriculture, both for disease control and yield increases, even under axenic conditions (Lo *et al*., 2000; Yedidia *et al*., 2001; Harman, 2006). *Trichoderma* species have evolved multiple mechanisms that result in improvements in plant resistance to disease and plant growth and productivity (Vinale *et al*., 2008). Possible explanations of this phenomenon include: control of minor population of pathogens leading to stronger root growth and nutrient uptake, secretion of plant growth regulatory factors such as phytohormones and release of soil nutrients and minerals by increased saprophytic activity of *Trichoderma* in the soil (Ousley *et al*., 1994; Yedidia *et al*., 2001; Celar & Valic, 2005; Muthukumar *et al*., 2005; Harman, 2006). Moreover, recent studies have indicated that these fungi also induce localized or systemic resistance systems in plants (Yedidia *et al*., 1999; Hanson, 2000; Howell, 2003).

5. Conclusion

From the results obtained in this study, it could be concluded that *Trichoderma harzianum*, cured poultry manure and palm wine yeast, applied either singly or in combination enhanced the growth and yield of soybean sown in nematode infested field. The application of *Trichoderma harzianum*, cured poultry manure and palm wine yeast, being eco-friendly, would be good measures that could enhance the growth and yield of soybean in a nematode infested field.

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