COMBINATION EFFECT OF COMMERCIAL STARTER FERTILIZERS, PLANT HORMONES AND NEMATICIDES ON SOYBEAN GROWTH AND PEST MANAGEMENT OF *MELOIDOGYNE INCOGNITA*

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Abstract

Increasing use of soybean in food, feed and fuel products has led to an increase in soybean prices and increased production throughout the United States. In the Southeastern United States, sustainable soybean production is challenged by *Meloidogyne incognita*. Fields infested with this nematode suffer significant yield reductions on soybeans which are further exacerbated by soilborne fungi that gain entry to roots penetrated by root-knot nematodes. The objective of this study is to screen starter fertilizers, plant hormone treatments, and nematicide/fungicide packages for efficacy in increasing plant biomass and reducing nematode fecundity. This information will be used to provide a sustainable solution to reduce plant stress caused by the root-knot nematodes and enhance soybean yield in fields infested with this nematode. Greenhouse tests indicated Neptune's Harvest starter fertilizer treatments increased shoot fresh weights at 21 days; Neptune's Harvest and Sure-K treatments retained numeric increases in shoot fresh weights (SFW) at 45 days. Plant hormones delivered in the form of Ascend increased SFW and root fresh weights (RFW) at 21 days; the triple application (ST + FS + IFS treatment) produced the greatest increases and maintained numeric increases in RFW at 45 days. All Hormone treatments significantly increased nematode eggs. All nematicide treatments reduced nematode eggs and eggs per gram of root. ILeVO and Abamectin treatments had the greatest reductions in eggs and eggs per gram of root. Combinations of the aforementioned treatments from each of the three categories will be utilized in field trials to determine the effects on yield and nematode reproduction.

Introduction

Meloidogyne incognita, is one of the main nematode pathogens of soybeans in the Southeast region of the United States; this nematode reduced national soybean crop yield by 7,556,000 bushels in 2010 (Wrather and Koenning, 2010) and has been documented to cause approximately 60% crop loss on soybeans in individual fields (Fourie *et al*, 2010). Infestations of this nematode, also known as the Southern root-knot nematode, are a serious threat to sustainable soybean production.

Fields infested with Southern root-knot nematode may require an integrative pest management approach to ensure sustainable production of soybeans. Soybeans have become an increasingly popular crop because of their widespread use in food products; U.S. soybean exportation reached a record high in 2014-2015 (O'Brien, 2015). The integrative pest management of root-knot nematode focuses on increasing plant biomass to reduce plant stress and reducing nematodes in order to protect yield.

Integrative pest management can be achieved through appropriate selection of starter fertilizer, plant growth promoting hormones, and fungicide and nematicide seed treatments. Starter fertilizers are sources of nitrogen, potassium and phosphorous applied at planting that have been shown to increase soybean yield by 6% (Osborne and Riedelle, 2006) while having no significant impact on *Meloidogyne* populations (Grabau, 2013). Ascend is a popular plant growth promoter product delivering cytokinins, indolebutryic acid, and gibberellic acid used to increase soybean yield by approximately 3% (Nagel et al, 2001). In 2013, 70% of soybean seeds were treated with a fungicide, nematicide or insecticide (Gaspar *et al*. 2014). Seed treated with commercially available fungicides, insecticides and nematicide (FIN) has potential to significantly increase yield and plant stands (Gaspar, 2014).

The long term objective of this study is to provide growers with a sustainable management solution to growing and increasing yields of soybean in fields infested with *Meloidogyne incognita*. This will be accomplished through the screening of commercial products in the categories of starter fertilizers, plant growth promoting hormones, and FIN's in greenhouse trials with further research to be conducted in microplot and field trials.

Materials and Methods

Separate greenhouse trials were conducted to evaluate efficacy of starter fertilizers, plant growth hormone applications in the form of Ascend, and fungicides and nematicide seed treatments (ST). Neptune's Harvest, Sure-K, Pro Germ, and Micro 500 starter fertilizer were evaluated individually and in combinations. Plant growth promoting hormones of indole butryic acid, gibberellic acid and kinetin were delivered in the form of the commercial product Ascend. These were applied in greenhouse trials in the form of seed treatment (ST), foliar spray (FS) and in-furrow spray (IFS) and in varying combinations of these application types. The nematicides Abamectin, Poncho/Votivo, and ILeVO were evaluated individually and compared to their insecticide components. All greenhouse tests were conducted in cone-tainers arranged as RCBD with five replicates and were repeated. Ten thousand *Meloidogyne incognita* eggs per 1,000 cc cone were inoculated at planting. Asgrow variety AG5935 was used in all trials. Plant height, shoot weight and root weights were evaluated at 21 and 45 days after planting (DAP); eggs were extracted from roots by 4 minute agitation in a 0.6% NaOCl solution and collection on a 25 µm sieve 45 DAP. Nematicide trials were conducted in a similar manner with the exceptions of an inoculation rate of 2,000 eggs per 150cc cone and trial length of 45 days only. Data was analyzed with SAS 9.4 using PROC GLIMMIX and mean values were separated by Dunnett's as compared to the untreated control with significance at $P \leq 0.05$.

Results and Discussion

Starter fertilizer

Neptune's Harvest, Sure-K and Neptune's Harvest + Micro 500 starter fertilizer treatments significantly increased SFW at 21 days. These increases resulted in only numeric advantages at 45 days. Pro-Germ increased nematode eggs while Sure-K + Micro 500 reduced nematode eggs (Table 1). Treatments with Micro-500, with the exception of Pro-Germ, recorded the lowest nematode egg counts at 45 days. A possible explanation for this is the role micronutrients have in increasing metabolism of *Bacillus* spp and other microbes which have nematicidal activity (Shapiro, 1989).

Plant hormones

Ascend treatments increased SFW and RFW at 21 days; the three way application treatment (ST+ FS + IFS) produced the largest increases in fresh weights (Table 2). At 45 days the three way application treatment had only numerical advantages in RFW. All Ascend treatments significantly increased nematode eggs. Ascend treatments deliver cytokinins that stimulate cell proliferation, a process involved in giant cell formation induced by *Meloidogyne* nematodes, which may account for increased nematode proliferation (Dropkin *et al*, 1969).

Nematicides

All Nematicide treatments significantly decreased nematode eggs and eggs per gram of root at 45 days (Table 3). Abamectin and CruiserMaxx treatments increased shoot and root weights. The individual Abamectin and ILeVO treatments had the greatest reductions in eggs and eggs per gram of root (Table 3).

Table 1: Starter fertilizer effect on shoot fresh weight (SFW), root fresh weight (RFW) and *Meloidogyne incognita* eggs

	21 Day Trial				45 Day Trial					
Treatment	**SFW**		**RFW**		**SFW**		**RFW**		**Eggs**	
Untreated control	2.1	b	2.3	ab	7.6	a	5.2	a	937.8	ab
Sure-K	2.6	ab	2.1	ab	9.1	a	3.6	a	1,204	ab
Pro-Germ	2.6	ab	2.6	a	6.5	a	5.6	a	1,629	a
Micro-500	2.7	ab	2.2	ab	7.7	a	4.9	a	915	ab
Neptune's Harvest	3.0	a	1.9	ab	7.4	a	5.7	a	1,251	ab
Sure-K & Micro	2.3	ab	1.6	b	8.5	a	5.4	a	330	b
Pro-Germ & Micro	2.9	ab	1.7	b	8.5	a	6.2	a	1,613	a
Neptune & Micro	3.0	a	2.3	ab	9.6	a	5.2	a	613	ab

NSD for means followed by the same letter $P \leq 0.05$.

Table 2: The effect of Ascend on shoot fresh weight (SFW), root fresh weight (RFW) and

Meloidogyne incognita eggs										
	21 Day Trial				**45 Day Trial**					
Treatment	**SFW**		**RFW**		**SFW**		**RFW**		**Eggs**	
Untreated control	1.7	b	1.5	c	8.8	a	5.2	a	3,836	c
Ascend ST	2.2	ab	2.3	ab	7.3	b	3.6	b	8,757	bc
Ascend IFS	2.6	a	2.1	abc	8.0	a	5.6	a	10,147	ab
Ascend FS	2.3	ab	1.9	bc	7.6	b	4.9	b	11,143	ab
Ascend ST/IFS/FS	2.6	a	2.7	a	7.5	b	5.7	a	6,331	bc
Ascend ST+FS	2.3	ab	1.7	bc	7.6	b	5.4	a	8702	abc
Ascend IFS+ST	2.4	a	2.1	abc	7.8	b	6.2	a	12,672	a
Ascend IFS+FS	2.4	ab	2.3	ab	7.6	b	5.2	a	8,582	abc

NSD for means followed by the same letter $P \leq 0.05$.

Table 3: Nematicide seed treatment effects on shoot fresh weight, root fresh weight and *Meloidogyne incognita* eggs and eggs per gram of root

Treatment	**Rate**	**SFW**		**RFW**		**Eggs**		**Eggs/g root**	
Untreated control	N/A	6.03	ab	3.338	abc	816.28	a	292.8	a
CruiserMaxx	0.88mL/lb	6.53	a	3.9	ab	224.03	b	63.4	b
Abamectin	1.8mL/lb	6.79	a	4.322	a	57.95	b	13.8	b
CM+ABA	N/A	4.85	bc	2.27	cd	74.67	b	40.4	b
Poncho/VOTiVO	3.52mL/lb	4.53	c	1.91	d	100.43	b	59.6	b
ILeVO	1.2mL/lb	4.92	bc	2.13	cd	35.4	b	16.8	b
P/V+ILeVO	N/A	5.43	abc	2.77	bcd	113.3	b	42	b

NSD for means followed by the same letter $P \leq 0.05$.

Summary

In greenhouse trials, the starter fertilizer treatments Sure-K + Micro 500 and Neptune's Harvest with Micro 500 showed capacity to increase SFW and reduce nematode proliferation. The three-way combination of plant growth promoting hormones in Ascend (IFS+ST+FS) increased early plant biomass, however all Ascend treatments increased nematode egg production compared with the control. All nematicide treatments reduced nematode populations. Abamectin increased RFW and SFW while CruiserMaxx increased SFW. The Abamectin and ILeVO treatments had the greatest reductions in nematode eggs and eggs per gram of root. Field trials will utilize combinations of these top performing starter fertilizer, Ascend, and nematicide treatments to determine effects on yield and nematode populations.

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