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Population Dynamics of *Pratylenchus brachyurus* in Maize Treated with Inorganic Fertilizer

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Authors' contributions

This work was carried out in collaboration among all authors. Author AAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ADA and TSE managed the analyses of the study. Author TSE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Field studies were conducted in the early and late season of 2010 in the tropical rainforest zone of Nigeria to investigate the effects of NPK fertilizer as an inorganic soil amendment at 75 kg/ha and 150 kg/ha in four replications on population densities of *Pratylenchus brachyurus* and on crop yield of maize. Seeds of maize variety, DMR LSR-Y were collected from Institute of Agricultural Research and Training, Ibadan. The experimental field was naturally infested with *Pratylenchus* spp. due to subsequent continuous cultivation of susceptible crop on the field. Seeds were planted and NPK was applied around the roots of maize plants 3 weeks after seedling emergence. Soil samples were taken on treatment plots at planting and harvest to determine the percentage change in nematode population. At the end of experiment, NPK application resulted in the increase in the nematode population. However, the grain yield of maize was not reduced by the increased nematode densities. The results of this study suggests that the usage of NPK caused a surge in the nematode reproduction on the field due to the availability of more feeding sites on the actively growing root system of the crop.

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1. INTRODUCTION

Maize is a major cereal and one of the most important food crops in Nigeria. Over the years, maize has become an important crop, taking over acreages from traditional crops such as millet and sorghum. In 2017, it was reported that Nigeria produced 10.5 Million metric tons of maize in 2016/2017 making the country the highest producer [1]. Several nematode species reportedly found in maize fields include; root-lesion nematodes (*Pratylenchus* spp.), root-knot nematodes (*Meloidogyne* spp.), needle nematodes (*Longidorus* spp.), sting nematodes (*Belonolaimus* spp.), stubby-root nematodes (*Paratrichodorus* spp.), lance nematodes (*Hoplolaimus* spp.), spiral nematodes (*Helicotylenchus* spp.), cyst nematodes (*Heterodera* spp.) and dagger nematode (*Xiphinema* spp.) [2]. Globally, root-lesion nematodes are the most common pests associated with maize causing much damage [3,4,5]. In Nigeria, root-lesion nematodes have also been reported to the most common nematode pest of maize [6]. Infections due to *P. brachyurus*, *P. zeae* and *P. penetrans* have resulted into stunted growth and poor yield [7]. *P. brachyurus* was observed to be responsible for 28.5% yield reduction in Nigeria [8]. This genus causes deterioration of the cell wall of the host and thereby weakens its defense mechanisms through its feeding habits [9]. *Pratylenchus* spp. is migratory and endoparasitic. It injects toxins inside the tissues, causing damages in host plant roots. Symptoms associated with this nematode infection can be similar to those caused by other pathogens, nutritional deficiencies and water stress [10].

Soil fertility maintenance is important to sustain food security with the application of the required soil amendments [11]. Use of chemical fertilizers have been reported to have caused changes in soil biological activities [12]. For instance, Habash and Al-Banna [13] observed that inorganic fertilizer had suppressive effects on populations of root-knot nematodes. According to Ferraz et al*.* [14], applying fertilizer had the tendency to compensate for the damage caused by nematode by enhancing plant growth. In view of this, an experiment was carried out to assess the effect of NPK on the population of *Pratylenchus brachyurus*. and on grain yields of maize.

2. MATERIALS AND METHODS

2.1 Experimental Site

Field trials were conducted in the early and late season of 2010, May and September respectively at Obafemi Awolowo University, Ile-Ife, located in the rain forest on latitude 7°28'N and longitude 4°33'E at 244 m above the sea level. A field previously cultivated with susceptible maize for five years and confirmed to be infested with root-lesion nematode was cleared, ploughed and harrowed. The identity of *Pratylenchus brachyurus* was confirmed from each sample when examined at 100 – 400x under a light microscope to identify the species using perineal patterns as described by Eisenback et al. [15]. Low to moderate population densities of root knot nematode, *Meloidogyne* spp., Dagger nematode, *Xiphinema* spp., and Spiral nematode, *Helicotylenchus* spp., were also present on the experimental site as determined in soil samples subjected to conventional nematode analysis.

2.2 Layout of the Experimental Site

The experimental plot was ploughed and harrowed in the rainy season (May 2010). Plot size was 3 m x 2 m and arranged in a randomized complete block design with four replicates. Seeds of maize were planted at a spacing of 75 x 50 cm. Seeds of maize variety, DMR LSR-Y were collected from Institute of Agricultural Research and Training, Ibadan. Three seeds were planted per hole and later thinned to one plant per stand one week after emergence.

2.3 Nematode Identification and Soil Analyses

At planting and harvest, soil samples were collected from each treatment plot to determine the initial and final population densities of the nematode respectively. A bulk sample consisting of 20 cores (diameter, 1.9 cm; depth, 0-20 cm) was collected from each plot, from which 200 ml was taken after mixing and used as a subsample to represent each plot. The sub-samples were processed for nematode extraction using the tray method of Whitehead and Hemming [16]. Nematode population was estimated in Doncaster counting dish [17] under a stereomicroscope (250x magnification). Nematodes were killed by heating at 45ºC for 1 h, fixed in 4% (w/v) formaldehyde. Individual nematodes from each sample were then examined at 100 – 400x under a light microscope to identify the genus and species levels.

2.4 Application of NPK Fertilizer as an Inorganic Amendment

NPK fertilizer was applied through side-dressing three weeks after seedling emergence at rates of 150 kg/ha, 75 kg/ha and 0 kg/ha. Weeds were controlled by hand weeding. At 15 weeks after germination, harvesting was done. Although, maturity was reached at 12 weeks, there was a need for reduction in moisture content of the grain yield. Soil sampling was done to determine the final nematode population at harvest. The field trial was repeated in September, 2010 on the same experimental site, with the same experimental design and procedures.

2.5 Statistical Analysis

All data collected were subjected to analysis of variance using the PROC GLM procedure in Statistical Analysis System (SAS) software Version 9.1 (SAS Institute, 2001). Significant treatment means were separated using Fisher's Least Significant Difference (LSD) test at $P < 0.05$. Mean values of *Pratylenchus* species population densities and grain yields of maize for the two rates of soil amendment and the control treatment were compared separately for each planting season. Mean squares for the combined analysis of variance of grain yields of maize and the nematode population densities in the crop in response to inorganic fertilizer application were presented.

3. RESULTS AND DISCUSSION

There were significant differences in the percentage increase in the population of *P. brachyurus* on maize treated with NPK in both seasons (Table 1). This shows that NPK fertilizer resulted in the increase of the nematode population, suggesting that the treatment enhanced the abundance of the nematode by increasing their chances to survive and reproduce. This agrees with the findings of Okae-Anti et al. [18] who reported that NPK fertilizer significantly increased various species of nematode populations associated with plantain and also had a corresponding adverse effect on its growth and yield. This also agrees with the findings by Castaner [19] who observed that the densities of *Meloidogyne* and *Pratylenchus* increased in the fields in the presence of nitrogen. This also confirms the findings by Ross's [20] that fertilizer application promotes roots growth and thus makes available more feeding sites for nematodes. Increasing total number of nematodes due to application of chemical fertilizer was also reported by other studies [21,22]. Similarly, Zhang et al. [23] reported that inorganic fertilizer application effectively improved soil physicochemical properties and were also beneficial for nematode survival within small aggregate size fractions. Higher dry grain yields were recorded in plots treated with 150 Kg/ha and 75 kg/ha NPK fertilizer compared to the untreated control in the two seasons despite the increase in nematode population (Table 2). This suggests that the presence of NPK improved the tolerance of the maize variety against *P. brachyurus*. Hu et al. [24] similarly reported that the application of organic manure combined with chemical fertilizer could increase nematode abundances and raise the grain yields of rice and wheat. This disagrees with the findings of Okae-Anti et al. [18] where the resulting increase in nematode population caused a decrease in the yield of plantain. On the contrary, Kolawole et al. [25] reported that NPK fertilizer significantly reduced root-knot nematode populations in the roots, soil, and on the tuber of yam, however, the nematodes increase did not reduce yam tuber weight, but

Table 1. Percentage changes in soil population densities of *Pratylenchus* spp. infecting maize in response to NPK in the early and late season of 2010 (number/200 ml soil)

Treatment	Early season (% change in population)	Late season (% change in population)
NPK at 150 Kg/ha	+68.78a	+49.04a
NPK at 75 Kg/ha	+54.90a	+44.01a
Control (0 Kg/ha)	+22.07b	+33.85b
LSD (P<0.05)	28.87	8.74

*Each value is a mean of four replicate. Means in the column followed by the same letters are not significantly different. **Probability level of 5%*

Table 2. Effects of NPK on the yield of maize (t/ha) infected with *Pratylenchus brachyurus*

Treatment	Early season (t/ha in dry weight)	Late season (t/ha in dry weight)
NPK at 150 Kg/ha	12.9a	3.48a
NPK at 75 Kg/ha	4.10b	2.86a
Control (0 Kg/ha)	2.58c	1.86b
LSD (P<0.05)	0.73	0.78

*Each value is a mean of four replicate. Means in the column followed by the same letters are not significantly different. **Probability level of 5%*

Table 3. Mean squares from combined analysis of variance of grain yield and population densities of *Pratylenchus* spp. infecting Maize in response to NPK at the Teaching and Research Farm in the early and late season, 2010

Source	DF	Grain yield (t/ha)	*Pratylenchus brachyurus*
Replicate	3	0.0002	1.17736
Season	1	30.9628**	214.0245**
Rate	2	28.9573**	2005.8449**
Rate x Season	2	16.8201**	496.4457**
Error	6	0.0007	0.1841
CV (%)		0.99	0.95

***Probability level of 5%*

reduced its quality. Table 3 recorded that season of planting was highly significant on grain yield and population of *Pratylenchus brachyurus*. This suggests that water level in the soil didn't only affect the grain yield but also the nematode population. This is consistent with those of Gilmar et al. [26] who reported that plant parasitic nematodes densities including those of *Pratylenchus* spp. were more populous in wet soils but decline during the dry season.

4. CONCLUSION

This study suggests that the application of NPK fertilizer to *Pratylenchus brachyurus*-infected maize plants enhanced the growth of root system and likewise the abundance of the nematode by increasing their capacity to survive and reproduce. However, the yield of maize was not affected as the fertilizer was likely to have improved the tolerance of the plant.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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