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GEROLD RAHMANN, VICTOR OLOWE, TIMOTHY OLABIYI, KHALID AZIM, OLUGBENGA ADEOLUWA (Eds.) (2018) Scientific Track Proceedings of the 4TH African Organic Conference. "*Ecological and Organic Agriculture Strategies for Viable Continental and National Development in the Context of the African Union's Agenda 2063*". November 5-8, 2018. Saly Portudal, Senegal

Influence of Tillage Systems on Diversity and Abundance of Insect and Nematode Pests of Maize in Malete, Kwara State, Nigeria

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Keywords:
Quality Protein Maize, Pest, Tillage Practices and Management

Abstract

Pests are major biotic factors causing up to 45% yield reduction in maize production in sub-Saharan Africa. To develop improved methods for maize management, the species and abundance of insects and nematodes associated with ten quality protein maize varieties (QPMVs) were evaluated with two commonly used tillage practices, 'plough only plots (POP)' and 'plough and harrow plots (PAHP)'. The experiment was carried out using QPMVs at the Teaching and Research Farm of the Kwara State University, Malete, Nigeria, and arranged in a randomized complete block design with 11 treatments replicated 3 times, including local check "pambo". A total of 833.1±4.0 and 799.3±3.4 arthropods specimens were collected from POP and PAHP, respectively, comprising 8 orders and 18 families. Ootheca mutabilis was the most abundant species with 5.47% (POP) and 5.68% (PAHP) and the least abundant was Rhopalosiphum maidis 1.82% (POP) and 1.80% (PAHP). As indicated by Shannon-Wiener (3.46±0.023) and Simpson indices (0.97±0.0008) there are even distribution in the tillage practices. Three genera of plant parasitic nematodes (PPNs) were identified, Meloidogyne spp. (POP (78.33±19.65), PAHP (1.33±0.33), Pratylenchus spp. (POP (41.67±9.26), PAHP (5.00±2.31), and Helicotylenchus spp. (POP (58.33±38.35), PAHP (23.33±14.50). The use of PAHP tillage practices is effective in reducing insects and nematodes associated with maize in Nigeria and therefore recommended for the management of both pests in maize production.

Introduction

Maize (*Zea mays*) is a cereal crop that belongs to grass family *Poaceae*. It is a crop of global importance with a significant adaptability in a wide range of climates and more diversely distributed than any other cereal crops (Ibeawuchi *et al*., 2008). It was introduced to West Africa by the Portuguese in the 16th century (Oladejo and Adetunji, 2012). Maize is one of the most important grain crops in Nigeria, not only on the basis of the number of farmers that engaged in its cultivation, but also in its economic value. Maize *is* a major fodder and grain crop being cultivated in the rainforest and the derived savannah zones of Nigeria (Hussan *et al*., 2003) and has been in the diets of Nigerians for hundreds of years. Maize was cultivated initially in Nigeria as a subsistence crop and since has become more important commercially, as many agro-based industries depend on it for raw materials (Iken and Amusa, 2004). Maize is a versatile crop as each part of the plant has economic value. Its grain, foliage, stalk, tassel and cob can all be used to produce a large variety of food and non-food products (IITA, 2001). Its yield, among other grass family, is the most affected by variations in plant density due to its low tillering ability and the presence of a short-lived flowering period (Vega *et al*., 2001). In the study carried out by (Abdulrahaman and Kolawole, 2008), about 28 food items and 6 medical values of maize were discussed.

Maize production is constrained by climatic factors, edaphic or soil factors, differences among cultivar yields, birds, weeds, insect pests and diseases (caused by fungi, bacteria, viruses, and plant- parasitic nematodes). More importantly, insects and nematodes cause serious yield and quality reduction in maize production. In different part of the world, over 60 nematode species have been found associated with maize and most of these have been recorded from roots, or soil around maize roots (Keetch, 1989). It is therefore essential to identify and estimates these pests in order to formulate appropriate management strategies. This project therefore aims at studying the diversity, damage and assessment of insect pest and nematodes of maize in Malete, Moro local Government, Kwara State, Nigeria. The objective of this study was to evaluate ten quality protein maize varieties for pest occurrence, abundance and diversity and to evaluate the influence of tillage practices in the management of these pests.

Materials and Methods

This study was carried out during the 2015 rainy season at the Teaching and Research Farm of Kwara State University (KWASU), Malete (latitude 08^0 71'N; longitude 04^{0}44'E) at 360m above sea level (Olowoake *et al*., 2015). KWASU is located in Malete, Moro Local Government Area of Kwara State, Nigeria. The inhabitants of the community are engaged more in farming, hunting, transport, riding and trading. This experiment was conducted on Ferric Acrisol under rain fed conditions using POP and PAHP tillage practices. The QPMVs were evaluated for diurnal insect and nematode occurrence, abundance and diversity. The experiment was arranged in a randomized complete block design in four replicates on primary and secondary tillage plots. Data were collected on insect and nematode populations and yield parameters on each maize variety. Data collected were analyzed using analysis of variance (ANOVA) with descriptive statistics. Paleontological Statistics 3.14 (PAST, 2016) software was used for measuring standard diversity indices such as Shannon Weiner index (H), Simpson diversity index (1-D).

Results

Abundance and diversity of diurnal insects associated with maize in KWASU teaching and Research (T & R) farm varied significantly between the ploughed only plot (POP) and ploughed and harrowed plot (PAHP). A total of 883.1 ±4.0 individuals in POP and 799.3 ± 3.4 in PAHP comprising adults and immature stages of different insects from 17 families and 8 orders of insects were encountered during the field assessments. The six most abundant species in ploughed only plot were *Ootheca mutabilis* 48.3 ± 4.5(5.47%), *Locusta migratoria migratoroides* 43.1± 4.3 (4.88%), *Podagrica sjostedti* 34.9± 4.6 (3.95%), *Leucania convecta* 34.34 ± 4.8 (3.89%), *Diabrotica barberi* 33.1 ± 4.0 (3.75%), and *Zonocerus variegatus* 32.1± 4.1 (3.63`%) while ploughed and harrowed plot were *Ootheca mutabilis* 45.4 ±4.5(5.68%), *Locusta migratoria migratoroides* 39.7 ±4.5 (4.97%), *Podagrica sjostedti* 33.6 ±4.4 (4.20%), *Leucania convecta* 31.6 ±4.5 (3.95%), *Diabrotica barberi* 30.6 ±3.8 (3.83%) and *Zonocerus variegatus* 30.8 ±4.2 (3.85%). In PAHP, the populations of *Ootheca mutabilis* 45.4 ±4.5 and *Locusta migratoria migratoroides* 39.7 ±4.5 were not significantly ($P>0.05$) different from POP, and no significant ($p>0.05$) difference were recorded in the population of *Podagrica sjostedti* 34.9± 4.6 (6.13%), *Leucania convecta* 34.34 ± 4.8, *Diabrotica barberi* 33.1 ± 4.0 (5.50%), and *Zonocerus variegatus* 32.1± 4.1 (3.99%) from that of POP. The most abundant species encountered during the study period was *Ootheca mutabilis* with a total of 48.3 ± 4.5 in POP and 45.4 ±4.5 in PAHP. This was followed by *L. migratoria migratoroides* with a total of 43.1± 4.3 in POP and 39.7 ±4.5 individuals in PAHP. The species were highly diversified with Simpson diversity index of 0.97±0.00 in POP and this was not significantly (p>0.05) different with species diversity recorded in PAHP. Similarly, the index of evenness was high being 0.95 ± 0.02 and 0.92 ± 0.02 for POP and PAHP respectively. However, the defoliation inflicted by the insect species on maize plant was higher in POP (58.5%) than PAHP (41.5%) as shown in Table 4. On the whole plant stand, the number of leaves infested was higher in PAHP (64%) than in POP (35.6%). From the soil samples collected from both tillage practices, three genera of plant parasitic nematodes (PPNs) namely: *Meloidogyne* spp (POP = 78.33 ± 19.65, PAHP = 1.33 ± 0.33), *Pratylenchus* spp (POP = 41.67 ± 9.26, PAHP = 5.00 ± 2.31), and *Helicotylenchus* spp (POP = 58.33 ± 38.35, PAHP = 23.33 ± 14.50) were identified. At the end of the experiment, maize cobs were harvested, shelled, dried to safe moisture (13.5^{0}C) and weighed. In POP, variety PVASYN11F_2 had the highest yield (2173.3 ± 792.1Kg/ha) while variety TZE QI20 recorded the highest yield (1729.3 ± 546.1) in PAHP. The local variety 'PAMBO' recorded least yield in both tillage practices (POP = 406.3 ± 12.2 and PAHP = 908.0 ± 4.6).

Discussion

Pests are the most important factors limiting the quality and yields of maize production in Nigeria. In this study, *Ootheca mutabilis*, leaf eating beetle was the most devastating and abundant coleopteran pest while *Locusta migratoria migratoroides* was the most abundant Orthoptera pest causing considerable damage by defoliating leaf of maize plant. This finding was previously described in detail by Aderolu *et al*., 2013 who conducted similar studies on Amaranth. Also, Akinlosotu, 1977 found that *Hypolixus truncatulus* was the most abundant coleopteran pest causing considerable damage to amaranth.

The Shannon Weiner and Simpson indices of diversity revealed that there is no species dominance among the identified arthropods as the species were evenly distributed and highly diversified in both tillage practices under consideration implying the ease of using natural enemies and other eco-friendly methods in managing the identified pest species. This is in line with the findings of Aderolu *et al*., 2013.

However, secondary tillage may enhance significantly higher physiological growth and yield performance. This is similar with earlier report of Borin *et al*., 1995, that among conventional tillage, minimum tillage and no-tillage in maize growing, the highest yield had been obtained with the conventional tillage. Maurya, 1988 reported lower maize grain yield achieved with no-till system than with conventional tillage. Furthermore, conventional tillage improved the soil environment, resulted in increased maize yield and reduced insect infestation as poinyed out by Paramu *et al*., 2016. On the contrary, no-till farming may cause soil compaction and increase weed infestation which could harbour insect pests. Secondary tillage could lead to improved soil structure and texture which supported easy percolation of water and air into the soil thereby improving activities of soil organisms which transform organic matter into nutrients that were assimilated by maize plants (FAO, 2005). The organic matters could also bind the *soil* particles into aggregates, maintain tilth, improve root penetration and minimize erosion.

Generally, maize plants infected with plant-parasitic nematodes are prone to root necrosis, galling and lesions (and other symptoms similar to that caused by fungal and bacterial infections) causing reduced quality and yield (John, 1988). From the soil extraction in this study, three genera of plant parasitic nematodes were associated with maize plant including *Meloidogyne* spp, *Pratylenchus* spp and *Helicotylenchus* spp were identified. This findings are different from earlier reports by Fawole, 2009 and Nicole *et al*., 2011, who reported that between 11% -38% annual losses in production are caused by plant parasitic nematodes namely: *lance nematode (Hoplolaimus spp),* root lesion nematode, *(Pratylenchus spp)*, root-knot-nematodes (*Meloidogyne spp), dagger nematode, (Xiphenema spp)*, *needle (Longidorus spp), and spiral (Scutellonema spp)*. However, the nematode observations were in agreement with Keetch, 1989 who stated that the most important groups of plant parasitic nematodes demonstrated to be significant limiting factors in maize production from all over the world include the root knot nematodes, *Meloidogyne* spp., the root lesion nematodes, *Pratylenchus* spp. and the cyst nematodes, *Heterodera* spp. Moreover, the intensity of soil cultivation and plant cover has been reported to impact the diversity and number of soil invertebrates more than fertilizers and herbicides (Wang and Hook, 2011). Therefore, the variation in nematode genera could be due to soil variations in the experimental sites.

The pulverized soil in plough and harrow plot resulted in a reduction in nematode population when compared with plough only plot. This was probably due to exposure of nematodes in the secondary tillage practice to intense heat from sun rays. Hence, the outermost layer of the nematode cuticle is a thin, *thermolabile*, lipoid membrane (Southey, 1978) and could be easily destroyed by exposure to sunlight.

Conclusion

The results of this study showed that ploughing followed by harrowing tillage practice significantly suppresses insect infestation and damage and improve growth rate and yield of maize varieties. There is no significant different in insects' diversity in both PAHP and POP tillage practices. Hence, arthropod diversity in the maize field was homogenized and field margins had a high diversity. However, insect infestation and nematode population were higher in POP than in PAHP thus implying suitability of PAHP for nematode management in Maize production. Also, the quality protein maize variety (TZE QI 20) had better yield with minimal insect infestation and nematode infection under PAPH. Therefore, among other quality protein maize, TZE QI 20 is recommended for breeding programme considering its nutritive attribute, lowest insect infestation, lower nematode infection and high yield potential compared with local check, pambo.

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