academicJournals

Vol. 11(4), pp. 228-233, 28 January, 2016
DOI: 10.5897/AJAR2015.10534
Article Number: 021418256855
ISSN 1991-637X
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African Journal of Agricultural Research

Full Length Research Paper

Effect of tillage method on *Fusarium* blight severity and yield of soybean in Omu-Aran, Southern Guinea Savannah of Nigeria

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Received 15 October, 2015; Accepted 12 November, 2015

***Fusarium* blight of soybean, caused by *Fusarium oxysporum* is one of the most destructive diseases of the legume. The pathogen is difficult to control owing to its persistence in the soil and wide host range. Soil tillage practice is one of the most important components of cultural soil management techniques that have a great influence on intensity of plant diseases. This study investigated the effect of tillage practice on the severity of *Fusarium* blight and yield of soybean. The land used for the trial was artificially inoculated with inoculum suspension of *F. oxysporum* left for one week before tillage. The experiment was laid out in a randomized complete block design (RCBD) with four treatments, each replicated three times. The treatments consist of ploughing only (P), ploughing followed by harrowing (PH), harrowing only (H) and no tillage (control). The parameters assessed include disease severity, number of pods per plant, pod length, pod weight, 100 seed weight and total seed yield. Findings from this study showed that at 4 weeks after planting, the highest disease severity (1.9) was recorded in soybean planted on ploughed land while the least blight severity (0.8) was recorded with no tillage. Soybean sown under no tillage produced significantly (P<0.05) higher number of pods per plant (41.6) while the lowest pod number (23.3) were produced on soybean sown on ploughed land. Soybean sown under no tillage produced a significantly (P<0.05) higher seed yield (328.0 kg/ha) than all other treatments. Tillage practice is an effective way of managing soybean diseases owing to its potential to adjust soil temperature and moisture. The tillage methods used in the current study incorporated *Fusarium* blight pathogen at varying soil depths, with no tillage being the most effective approach of reducing the severity of soybean *Fusarium* blight in infected soil.**

Key words: Blight, *Fusarium oxysporum*, soybean, tillage, disease severity, yield.

INTRODUCTION

Soybean, *Glycine max* L. (Merr) is a leguminous crop widely cultivated in tropical, subtropical, and temperate climates of the world (IITA, 2009). The legume provides cheap and high quality protein comparable to meat,

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poultry and eggs. Soybean is the richest source of complete plant protein, containing all amino acids essential for human nutrition.

More than 216 million tons of soybeans were produced worldwide in 2007 with Africa accounting for only 1.5 million tons of this production estimate (Hartman et al., 2011). Nigeria is the largest producer and consumer of soybean in Sub-Saharan Africa with a low yield of less than 1 ton per hectare (IITA, 2009). Several abiotic and biotic constraints threaten soybean production, resulting in reduced yield and quality. The major biotic factors are weeds, pests and diseases (Hartman et al., 2011). More than 300 diseases have been reported on soybean (Hartman et al., 1999). Losses attributed to soybean diseases alone are estimated at 11% (Hartman et al., 1999).

The increase in the number of soybean diseases and their expansion emanate from intensive production and increased acreage in new regions of the world (Hartman et al., 2011). In areas where soybean is grown every year or even every other year, propagules of various types of pathogens have increased to densities that cause economic yield losses.

Fusarium blight or wilt disease of soybean, caused by the common soil-borne fungus, *Fusarium oxysporum*, is one of the most destructive diseases of soybean (Hashem et al., 2009; Fayzalla et al., 2009). The pathogen can affect soybeans at any stage of development (Ferrant and Carroll, 1981). Disease symptoms are first noticed on the lower (older) leaves. The middle and lower leaves turn yellow or have pale yellow spots. As the disease progresses, the younger leaves become affected. The upper leaves of infected plants wilt and appear scorched. Affected plants also show a wilting of the stem tips. In severe cases, the leaves dry up and drop prematurely, leaving the petiole behind (Nelson et al., 1997). *Fusarium* blight symptoms are more noticeable under reduced moisture and hot conditions. The pathogen is difficult to control owing to its persistence in the soil and wide host range (Abdel-Monaim et al., 2011).

Soil tillage practice is one of the most important components of cultural soil management techniques that have a great influence on intensity of plant diseases. The tillage practice embarked upon during land preparation could have influence on the intensity and frequency of soil-borne pathogens. Depending on soil tillage method, varying amount of plant residues remain in or on the soil surface (Jug et al., 2011) which, through interactions with other agro-ecological components has various effects on diseases (Jordan and Hutcheon, 2003).

F. oxysporum is a soil-borne fungus with infected plant debris serving as a source of inoculum for the pathogen (Arias, 2012). Although, extensive research studies have been carried out on soybean production and improvement in Nigeria, there is a paucity of information on cultural soil management techniques that influence disease intensity, severity and yield losses in soybean arising from blight (Hartman et al., 1999). The present study therefore investigated the effect of tillage practice on the severity of *Fusarium* blight and yield of soybean.

MATERIALS AND METHODS

Study site

The experiment was carried out in the Teaching and Research Farm of Landmark University, Omu-Aran, Kwara State. Omu-Aran is located in the north central part of Nigeria in the south-eastern direction of Ilorin. The site lies between latitude 8.9°N and longitude 50°61 E of the equator. The annual rainfall pattern of the area is 600 to 1,500 mm between the months of April and October, with peaks in June. The humidity ranges from 50% in the dry season to about 85% during the wet season.

Isolation of *F. oxysporum*

Roots and basal stems of naturally infected soybean plants showing wilt disease symptoms were collected from an infected field and taken to the Crop Science Laboratory of Landmark University, Omu-Aran where pathogen was isolated using procedures described by Ferrant and Carroll (1981). The samples were thoroughly washed in tap water, cut into small pieces of 0.5 cm and surface sterilized for 2 min in 2% sodium hypochlorite solution, then rewashed several times in sterilized distilled water and dried between a number of folds of sterilized filter papers. The surface sterilized samples were plated on Potato Dextrose Agar (PDA) medium supplemented with penicillin (20 µl ml^{-1}) and incubated at 25±1°C for 6 days. The developed fungal colonies were purified by single spore techniques to obtain pure culture of *F. oxysporum*.

Preparation of fungal inoculum

Disks taken from one week old culture of *F. oxysporum* prepared were inoculated on 75 ml Potato Dextrose (PD) broth medium in 250 ml flask and incubated at 25 ± 1°C. The obtained fungal suspension was collected on No. 1 Whatman filter paper and rinsed with sterile distilled water, then placed in a warring blender with a small amount of sterile water and blended for 2 min at high speed. Sterile distilled water was then added to each inoculum suspension to give a final volume of 200 ml.

Experimental design and treatment application

The land used for the trial was artificially inoculated with 100 ml of inoculum suspension of *F. oxysporum* every 50 cm apart and left for one week before tillage. The experiment was laid out in a randomized complete block design (RCBD) with four treatments, each replicated three times. The treatments consist of ploughing only (P), ploughing followed by harrowing (PH), harrowing only (H) and no tillage or control (C). Each plot measured 3.0 x 3.5 m and plots were separated from one another by 1.0 m alleys.

Soybean planting and maintenance

Three seeds of cultivar TGx 1448-2E soybean was sown per hill at

Table 1. Effect of tillage method on severity of *Fusarium* blight of soybean.

Tillage method	Disease severity				
	4 WAP	6 WAP	8 WAP	10 WAP	12 WAP
P	1.9^{a}	2.1^{a}	2.7^{a}	3.3^{a}	4.3^{a}
PH	1.4^{b}	1.6^{a}	2.2^{a}	2.6^{b}	3.6^{b}
H	1.3^{b}	1.4^{a}	2.0^{a}	2.4^{b}	3.5^{b}
NT	0.8^{c}	0.9^{b}	1.2^{b}	1.8^{c}	2.4^{c}

P=Ploughing only, PH= Ploughing + harrowing, H= Harrowing only, NT= No tillage, WAP= Weeks after planting. Values are means of three replicates. *Means in columns followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (P≤0.05).

a depth of 2 to 3 cm and at a spacing of 70 cm between the rows and 40 cm within the row in each treatment. The seedlings were thinned to one plant per stand one week after emergence. An artificial water supply and weeding were carried out regularly throughout the duration of the study.

Data collection and analysis

Six plants were randomly selected from each plot and tagged for assessment of disease severity. Commencing from four weeks after planting, scoring for disease severity was carried out at two weeks interval over a period of 10 weeks. Soybean blight severity was determined according to Abdou et al. (2001) using rating scale of 0 to 5,

0 = no yellow leaf
1 = 1-25% yellow colouration on one leaf
2 = 26-50% yellow colouration on more than one leaf
3 = 51-75% yellow colouration plus one wilted leaf
4 = 76-100% yellow colouration with more than one wilted leaf, and
5 = completely dead plants.

Data were collected from each plot on the following yield components; number of pods per plant, pod length, pod weight, 100 seed weight. At harvest, seeds obtained from the two inner rows in each plot were weighed separately to obtain total seed yield. The data collected was subjected to analysis of variance (ANOVA) and the means were separated using Duncan's Multiple Range Test (DMRT) at 5% probability level.

RESULTS

Disease severity

Tillage method had a significant effect on severity of *Fusarium* blight of soybean (Table 1). At four weeks after planting, the highest disease severity (1.9) was recorded in soybean planted on ploughed land while the least blight severity (0.8) was recorded on the treatment with no tillage. There was no significant difference (P≤0.05) in *Fusarium* blight severity in soybean plants in the ploughed + harrowed and harrowed lands. At six and eight weeks after sowing, no significant differences in disease severity were noticed in soybean plants grown in ploughed, ploughed + harrowed and harrowed lands.

At ten and twelve weeks after sowing, the highest disease severities were recorded on plants in the ploughed land and this was significantly higher than all other treatments. No significant difference in *Fusarium* blight severity was observed in soybean plants in the ploughed + harrowed and harrowed lands.

Table 2. Effect of *Fusarium* blight of soybean on number of pods per plant.

Tillage method	Number of pods per plant
P	23.3^{c}
PH	34.6^{b}
H	35.7^{b}
NT	41.6^{a}

P=Ploughing only, PH= Ploughing + harrowing, H= Harrowing only, NT= No tillage, WAP= Weeks after planting. Values are means of three replicates. *Means in columns followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (P≤0.05).

Number of pods produced per plant

Soybean sown under no tillage produced a significantly (P≤0.05) higher number of pods per plant (41.6) while the lowest pod number (23.3) were produced on soybean sown on ploughed land (Table 2).

Pod length

Effect of *Fusarium* blight of soybean on pod length is presented in Table 3. The result shows that soybean sown under no tillage had a significantly higher pod length (16.0 cm) than all other treatments. The pod length was not significantly (P≤0.05) influenced by *Fusarium* blight on soybean plants sown on ploughed, ploughed + harrowed and harrowed lands.

Pod weight

Results of the effect of *Fusarium* blight of soybean on

Table 3. Effect of *Fusarium* blight on soybean pod length (cm).

Tillage method	Pod length (cm)
P	12.8[b]
PH	13.4[b]
H	13.6[b]
NT	16.0[a]

P=Ploughing only, PH= Ploughing + harrowing, H= Harrowing only, NT= No tillage, WAP= Weeks after planting. Values are means of three replicates.*Means in columns followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (P≤0.05).

Table 4. Effect of *Fusarium* blight on pod weight (kg).

Tillage method	Pod weight (kg)
P	1.7[a]
PH	1.8[a]
H	1.7[a]
NT	2.1[a]

P=Ploughing only, PH= Ploughing + harrowing, H= Harrowing only, NT= No tillage, WAP= Weeks after planting. Values are means of three replicates.*Means in columns followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (P≤0.05).

Table 5. Effect of *Fusarium* blight on 100 seed weight (g).

Tillage method	100 seed weight(g)
P	10.1[a]
PH	10.3[a]
H	10.3[a]
NT	10.5[a]

P=Ploughing only, PH= Ploughing + harrowing, H= Harrowing only, NT= No tillage, WAP= Weeks after planting. Values are means of three replicates.*Means in columns followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (P≤0.05).

Table 6. Effect of *Fusarium* blight on soybean seed yield per hectare (kg/ha).

Tillage method	Seed yield(kg/ha)
P	216.7[c]
PH	244.2[b]
H	254.8[b]
NT	328.0[a]

P=Ploughing only, PH= Ploughing + harrowing, H= Harrowing only, NT= No tillage, WAP= Weeks after planting. Values are means of three replicates.*Means in columns followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (P≤0.05).

pod weight is presented in Table 4. *Fusarium* blight did not significantly influence the weight of pods in all the treatments, although numerically higher pod weight (2.1 kg) was recorded with no tillage.

100 seed weight

Results on the effect of *Fusarium* blight of soybean on 100 seed weight is presented in Table 5. The result shows that *Fusarium* blight did not significantly influence 100 seed weight in all the treatments.

Total seed yield

Effect of *Fusarium* blight of soybean on seed yield per hectare is presented in Table 6. Soybean sown under no tillage produced a significantly (P≤0.05) higher seed yield (328.0 kg/ha) than all other treatments. The least yield of 216.7 kg/ha was recorded in soybean plants on ploughed land. There was no significant difference in the yields of soybean in ploughed+harrowed land and harrowed land only, although numerically higher seed yield per hectare (254.8 kg) was obtained in the latter.

DISCUSSION

The present study investigated the effect of tillage method on severity of *F. oxysporum* and the concomitant effect on yield components and yield of soybean. Findings from this trial revealed that the tillage method embarked upon during land preparation influenced disease severity, number of pods produced per plant, pod length and total yield.

Fusarium species are widespread soil-borne organisms capable of surviving for long periods of time as chlamydospores and as mycelium in plant residues and in the soil (Arias, 2012). Infected plant debris serve as a source of inoculum for the pathogen. Cool temperatures and wet soils, particularly early in the growing season, often favour infection by *Fusarium* species (Marasas et al., 1984; Nelson et al., 1997; Yang, 1997). As soil moisture becomes more limiting, soybeans may become stressed, thereby increasing susceptibility to infection by *Fusarium* (Zhang et al., 2010). The reduced moisture condition of the soil during the growing period in this study could have triggered the susceptibility of the crop to *Fusarium* blight.

Tillage practices have varying efficacies on disease management. Soil tillage practices involving various depths, intensity, and different methods of loosening the soil and treating plant residues can significantly influence plant diseases (Vanova et al., 2011). The residues may be an infection source for several important diseases caused by fungi of the *Fusarium* genus (Váňová et al., 2009a). The pathogens have a chance to stay in the soil, reproduce and spread. Depending on tillage method, different amount of plant residues remain on the soil surface (Jug et al., 2011) which, through interactions with other agro-ecological components, has various effects on pests, diseases and weeds (Jordan and Hutcheon, 2003).

Since many plant pathogens can survive on plant debris, ploughing has traditionally been used to incorporate crop residues (Poštić et al., 2012). *Fusarium* blight pathogen was incorporated at varying soil depths during the tillage operation. Soybean plants on ploughed land had the highest disease severity (Table 1). The lowest disease severity observed with no tillage in this study agrees with the findings of Perez-Brandan et al., (2012) that reported good soil quality, increased level of microbial activity, nutrient cycling, microbial diversity and enhanced natural disease suppression under zero tillage. Krupinski et al., (2002) also reported that no till reduces many crop diseases because of their direct and beneficial effects on soil biology. A healthy soil with diverse and balanced populations of soil micro-organisms will provide substantial competition against root pathogens as these often use the same organic carbon substrate. Furthermore, Yang (2008) reported that soybean cyst nematode and some soil-borne diseases, such as *Rhizoctonia* root rot, would not be reduced by tillage practices. Indeed, tillage practices increase the movement of soybean cyst nematode and further spread the risk of soil-borne pathogens.

Several soybean diseases prevalent in some areas can be effectively controlled with tillage practices while some cannot (Yang, 2008). Tillage methods have proved very effective in reducing the risk of many foliar and stem diseases of soybean, such as *Cercospora* leaf spot, brown spot, frog-eye leaf spot, downy mildew, bacterial blight, brown stem rot, and *Phomopsis*. Pathogens of these diseases survive in crop residues in the absence of soybean crop. When infested crop residues are buried in soil, their decomposition rate increases and the fungi die.

As such, this tillage approach reduces the amount of pathogens that survive to the next crop season.

Soil moisture is usually higher and temperatures are cooler in conservation tillage systems than in conventional tillage systems. These factors, especially cooler temperatures, could have caused a reduction in disease development with no tillage as observed in this trial. This is corroborated by the findings of Porter and Wright (1991) who reported that warmer temperatures favour the development of *Cercospora arachidicola*, causal organism of early leaf spot of peanut. The researchers observed that pod yields were greater in conventional tilled plots even though leaf spot was less in conservational tilled plots.

Conclusion

Tillage practice is an effective way of managing several crop diseases owing to its potential to adjust soil temperature and moisture. The tillage methods used in the current study incorporated *Fusarium* blight pathogen at varying soil depths, with no tillage being the most effective approach of reducing the severity of soybean *Fusarium* blight in infected soil. Increased number of pods and yield were also obtained with no tillage.

Conflict of Interests

The authors have not declared any conflict of interests.

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