Fusarium Wilt Disease Manifestation in Cotton Fields of Tanzania

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ABSTRACT

Investigations were conducted in Tanzania to assess factors affecting rapid spread of Fusarium wilt disease in cotton fields. The main areas of this study were the Mara and Mwanza regions where this Fusarium wilt disease is becoming increasingly important. Fusarium wilt disease is caused by Fusarium oxysporum f.sp. vasinfectum. Interviews were conducted with farmers to assess their understanding of the disease and soil samples were taken from each field surveyed. Field surveys were complemented by glass house and field experiments. Farmers in both regions showed little perception of this disease. Fusarium wilt incidence ranged 0-50%. Mixing of cotton seed issues and continuous planting of cotton seeds in contaminated soils were observed to spread Fusarium wilt disease. Accumulation of infected crop residues was also observed to spread the disease. Nematodes, particularly Meloidogyne and Tylenchus, were found to be associated with the disease. Fusarium wilt is most frequently found in sandy soils.

Introduction

Cotton is second in importance to coffee among Tanzanias expot crops. About 20% of the Tanzanian population is enganged in cotton production. It is estimated that cotton contributes about 3.7% of the Tanzanian gross national product (GNP). This crop is mainly grown to the south of Lake Victoria, called the Western Cotton Growing Area (WCGA). This area produces about 90% of the crop and the remainder comes from the coastal area known as the Eastern Cotton Growing Area (ECGA).

Most of the WCGA is affected by *Fusarium* wilt disease, caused by a fungus known as *Fusarium oxysporum* f.sp. *vasinfectum* (AtK.) Snyder and Hansen. *Fusarium* wilt disease has become an increasing problem due to its destructiveness and long persistence in soils (Stover, 1970). *Fusarium* pathogen of cotton is differentiated into six races of which race one is common in sandy soils in Tanzania (Ebbels, 1975). The development of the *Fusarium* wilt pathogen is favoured by low pH of 5.6-7.2, soil temperatures of 25$_o$C, high relative humidity and soil moisture holding capacity at 40% (El-Abyad and Saleh, 1971). *Fusarium* wilt development is reported to be influenced by the presence of parasitic nematodes particularly the genus *Meloidogyne* spp. (Perry, 1963; Brown, 1968; Hillocks, 1985).

In Tanzania, *Fusarium* wilt disease was first reported at Buchosa ginnery zone in the Sengerema district of the Mwanza region in 1952. Since then, the disease spread throughout the Western Cotton Growing Area (WCGA), particularly, in the northern breeding zone, comprising Mwanza, Kagera, Kigoma and Mara regions (Hillocks, 1984; Kibani, 1987; Kibani *et al.*, 1995). This breeding zone has more favourable climatic conditions than the southern part of the WCGA and cotton from this area, therefore, produces higher quality fiber. In previous years, Tanzania produced a substantial amount of cotton lint, averaging 450,000 bales (181 kgs) annually.

A number of field surveys have been conducted in Tanzania to assess the extent of spread of *Fusarium* wilt disease and the damage it causes. The surveys conducted in the WCGA in 1987 showed a dramatic increase in the number of villages found to be affected by *Fusarium* wilt disease compared to the previous survey in 1979. About 30% of villages growing cotton were found to be affected by *Fusarium* wilt throughout the WCGA (Kibani, 1987).

In view of the importance of *Fusarium* wilt disease, efforts have been made to identify factors responsible for spread of the *Fusarium* wilt disease in cotton fields with the hope of finding better disease control strategies.

Methodology

Field surveys

Farmer group and individual interviews complemented by field surveys were conducted in Mwanza (Misungwi, Kwimba, Sengerema, Geita, Magu, Ukerewe districts) and Mara (Musoma, Bunda, Tarime, Serengeti districts) regions in selected villages. During these surveys, 11 and 30 villages were selected in Mwanza and Mara regions respectively. In each village, after the group interviews, ten randomly selected farmers were interviewed individually by the questionnaire method and their cotton fields assessed for wilt and nematode incidence. Each individual

farmer was shown cotton specimens infected by *Fusarium* wilt disease and his/her perceptions of the disease were assessed.

Soil sampling and nematodes extraction

Soil samples were collected in the cotton fields of ten randomly selected farmers. In each cotton field, soils were collected from five points and bulked to form one sample per cotton field. These soils were later processed in the laboratory for nematode extraction, counts and identification work. A tray method was used in the extraction of nematodes and a Hawksley slide was used to count them.

Studies on Fusarium wilt perpetuation in cotton

Studies were carried out on unplanted cottonseeds for planting and crop residues to determine their role in the spread of *Fusarium* wilt disease in cotton. This was done following observations during surveys in which farmers complained about deteriorating seed quality. Nine surviving infected cotton plants (cv.UK 82) grown on artificially infected land, were harvested and their seed cotton ginned separately. All cottonseeds from individual plants were grown in clean fields and the emerging cotton plants were assessed for wilt incidence over a period of ten weeks.

The role of crop residues in disease carry-over were conducted using infected plants of cv UK 82. cotton plants. Organs of these cotton plants (roots, stems and leaves) were chopped separately and each incorporated into clean sandy soils in 9.5cm pots. A randomized block design was used and treatments were replicated five times. After 240 days of incubation, cotton seeds (cv.UK 82) were planted in each pot and the *Fusarium* wilt incidence and stem discoloration were assessed. The fungal colonies were transformed to logarithimic values (Gomez and Gomez 1984) for statistical analysis.

Similarly, cotton husks obtained from infected seed cotton were collected from the ginneries and subjected to isolation of the *Fusarium oxysporum* fungus in a selective Nash medium by dilution technique adapted from Crossan (1967). The isolates were tested for pathogenicity to cotton plants, according to the method adapted from Hillocks (1986).

Survival of the *Fusarium* pathogen was tested in rumen of cattle. Cotton seed cake was inoculated with cotton *Fusarium* pathogen and incubated for fourteen days. This infected seed cake was fed to starved cattle kept indoors and the faeces collected. Isolation of the *F oxysporum* fungi was attained using Nash selective medium. The pathogenicity tests of the isolates were made to cotton plants on a 1-8 scale using a method adapted from Hillocks (1986).

Results

In both Mara and Mwanza regions, most farmers did not recognize *Fusarium* wilt symptoms and were not aware of correct procedures. Farmers in the Mwanza region showed greater recognition of *Fusarium* wilt symptoms (Table 1).

Results of the *Fusarium* wilt root knot nematode study did not show a clear relationship (Table 2).

Results from field surveys showed that farmers were supplied with substandard cottonseeds for planting and that they were not aware of the disease control measures. The factors responsible for spread of the *Fusarium* wilt disease in cotton fields were the use of contaminated cottonseeds and infected crop residues. Results from seed test experiments showed that not all cottonseeds from the infected cotton plants gave rise to wilted seedlings in the field. Only an average of 18% wilted plants emerged out of the sown cottonseeds from one infected cotton plant, with a range of 7-51%.

The stems of infected crop residues showed significantly larger *F. oxysporum* f.sp. *vasinfectum* populations than roots or leaves that were not significantly different from each other. Cotton plants sown in soils incorporating infected crop residues (roots, stems, leaves) for 240 days decomposition period, were also assessed for wilt incidence (Table 3). All crop residues put inoculum into the soil. However, cotton plants sown in soils incorporated with infected stem and leaf residues, gave significantly more wilt incidence and xylem discoloration.

Similarly, *F. oxysporum* f.sp. *vasinfectum* were isolated from cotton husks and these proved pathogenic to cotton plants (Table 4).

The survival of *Fusarium* wilt pathogen in rumen of cattle was also assessed following those of animal faeces used as farmyard manure (FYM) in cotton fields. The *F. oxysporum* was recovered in faeces from cattle fed on seed cake inoculated with wilt. Isolates of *F. oxysporum* were recoverd from six out of 10 samples tested, at frequencies of between 13 and 240 colonies/g_{-1}. These isolates proved to be pathogenic to cotton plants.

Discussion

Results show that most farmers in the cotton growing areas are not aware of the *Fusarium* wilt symptoms or disease control measures. This implies that there is a gap in the linkage between extension and farmers. Inadequate farmer awareness of the disease may have contributed to continuous perpetuation of *Fusarium* wilt disease pathogen in the WCGA. Results have, also, shown that there is inadequate cottonseed supply for sowing, a condition that might have contributed to the use of substandard cottonseeds infected with wilt. In some circumstances, farmers were forced to buy cotton seeds on the black market, a situation that might lead to the use of mixed seed issues, some of which are susceptible to the disease like cultivar UK 82 and UK 74.

The *Fusarium* wilt incidence in the field ranged between 0 and 50%, a situation that may have been

caused by the frequent use of infected cotton seeds for planting. Hillocks (1981) observed local losses caused by *Fusarium* wilt disease in Tanzania of about 20%. The race of *Fusarium* wilt pathogen common on sandy soils in Tanzania is race one. *Fusarium* wilt disease has also recently been observed in calcareous soils. This might be caused by another race of the *Fusarium* wilt pathogen. Race 4 of the *Fusarium* wilt pathogen is reported on heavy soils in India and Russia (Charudatan, 1969).

Nematodes were identified in soils collected in cotton fields. Large populations of parasitic nematodes were observed in soils collected in highly infected wilt areas. The parasitic nematodes of genus *Tylenchus* and *Meloidogyne* spp. were frequently observed. These parasitic nematodes might also be involved in the perpetuation of the *Fusarium* pathogen in these areas. Similar findings were obtained by the earlier investigators (Powell, 1971; Perry, 1963; Brown, 1968; Hillocks, 1985).

Results from glass house experiments have shown that infected crop residues and seeds can perpetuate *Fusarium* wilt disease. (Crop residues are cotton remains after harvest and defoliated leaves caused by stress or senescence). These results were in agreement with the findings reported by Higgins (1911) who observed perpetuation of inoculum in the soil as mycelium and chlamydospores when infected crop residues were incorporated into the soil. Similarly, Linder and Gilbert (1969) observed increases in micro-organisms when crop residues were incorporated into the soil. Uprooting infected cotton plants may put inoculum into the soil if these rogued plants are left in the field. Cottonseeds have been found to perpetuate *Fusarium* wilt disease in subsequent emerged cotton plants. Results on seed transmission of the *Fusarium* wilt disease was in agreement with the findings reported in East Africa (Perry, 1962; Hillocks, 1983). Cottonseed husks have been shown to be infected by *Fusarium* wilt disease and may put inoculum in the soils if used as organic fertilizers in cotton fields. However, in most cases, cottonseed husks are used as animal feeds that are likely to transmit *Fusarium* wilt pathogen through the rumen of cattle to faeces. The low pH in the rumen of cattle might have favoured survival of *Fusarium* wilt pathogen. In some cotton growing areas, livestock graze on infected cotton residues after harvest that might spread wilt pathogen through use of livestock faeces as manure. However, more studies on *Fusarium* wilt pathogen in farmyard manure need to be done to warrant pertinent conclusion.

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References

Brown, A.G.P. (1968): Effects of fumigation to control nematodes and *Fusarium* wilt of cotton. Empire Cotton Growing Review 35:128-132.

Charudatan, R. (1969): Studies on strains of *Fusarium oxysporum* f.sp. *vasinfectum* AtK 1. On their morphology and pathogenicity in cotton. Proceedings of the Indian Academy of Sciences 70:139-156.

Crossan, D.F. (1967): Selective isolation of soil micro-organisms by means of differential media: In Source Book of Laboratory Exercise in Plant Pathology. W.H. Freeman and Company; San Francisco and London. Pp. 19-21.

Ebbels, D.L. (1975): *Fusarium* wilt of cotton: a review with special reference of Tanzania. Cotton Growing Review 52:295-339.

Elliot, J.A. (1923): Cotton wilt: A seed borne disease. Journal of Agricultural Research 23:387-93.

El-Abyad, M.S. and Y.E. Saleh. (1971): Studies with *Fusarium oxysporum* f.sp. *vasinfectum*, the cause of cotton wilt in Egypt: germination, sporulation and growth. Transaction of the British Mycological Society 57:427-37.

Gomez, K.A. and A.A. Gomez. (1984): Statistical Procedure for Agricultural Research (2nd Ed.) John Wiley and Sons, New York. 680 pp.

Hillocks, R.J. (1983): Infection of cotton seed by *Fusarium oxysporum* f.sp. *vasinfectum* in cotton cultivars resistant or susceptible to *Fusarium* wilt. Tropical Agriculture 60:141-3.

Hillocks, R.J. (1981): Cotton Disease Research in Tanzania. Tropical Pest Management 27(1):1-12.

Hillocks, R.J. (1986): Cross protection between strains of *Fusarium oxysporum* f.sp. *vasinfectum* and its effects on vascular resistance mechanism. Journal Phytopathology 117:216-225.

Hillocks, R.J. (1985): The effect of root knot nematodes on resistance to *Fusarium* wilt in the stems of cotton plants. Annals of Applied Biology 107:213-218.

Hillocks, R.J. (1984): Production of cotton plants resistant to *Fusarium* wilt with special reference to Tanzania. Tropical Pest Management 30:234-46.

Higgins, B.B. (1911): Is neo *Cosmopora vasinfecta* (AtK) Smith, the perfect stage of the *Fusarium* which causes cowpea wilt. 32 nd Ann. Rept; NC. Exp. Sta; 1909:100-116.

Kibani, T.H.M. (1987): *Fusarium* wilt disease of cotton in Tanzania. Tanzania Agricultural Research Organization, Newsletter, 2:9.

Kibani, T.H.M., R.T.V. Fox and F.M. Shao. (1995): Inoculum sources and control of *Fusarium* wilt disease in cotton. PhD Thesis University of Reading, Britain. 206 pp.

Linderman, R.G. and R.G. Gilbert. (1969): Stimulation of *Sclerotium rolfsii* in soil by volatile components of alfalfa hay. Phytopathology 59:1366-1372.

Lema, G. (1995): Cotton production in the Western Cotton Growing Areas of Tanzania, Cotton Marketing Board, TCMB, Tanzania.

Powell, N.T. (1971): Interaction between nematodes and fungi in disease complexes. Annu Rev. Phytopathology 9:253-274.

Perry, D.A. (1963): Interaction of root knot and *Fusarium* wilt of cotton. Empire Cotton Review 40:41-47.

Perry, D.A. (1962): *Fusarium* of wilt of cotton in the Lake province of Tanganyika. Empire Cotton Growing Review 39:14-16.

Stover, R.H. (1970): In Root Disease of Soil Borne Pathogens. T.A. Toussoun, R.V. Bega and P.E. Nelson (Ed.). Univ. of California Press, Berkeley. Pp. 197-200

Snyder, W.C. and H.N. Hansen. (1940): The species concept in *Fusarium* Amer. Jour. Bot. 27:64-67.

Table 1. Farmers description of the cause of damage on plants that were in fact caused by *Fusarium* wilt (% of farmers).

	Mara region				Mwanza
Farmer opinion	Musoma	Bunda	Tarime	Serengeti	region
Nutrient deficiency	5	0	0	0	1
Insect damage	16	7	0	0	3
Drought/hail damage	13	5	0	0	1
Fusarium wilt	0.7	0	0	0	21
Not known	65	87	100	100	74
Respondents	150	110	10	20	108
Villages	15	11	2	2	11

Table 2. *Fusarium* wilt (%) and nematode pop/200 mls soil in cotton soils of Mara region.

	Musoma	Bunda	Tarime	Serengeti	Mean
Cotton fields with wilt %	40.7	27.3	0	0	17
Parasitic nematodes					
Aphelenchus spp.	9.20	6.63	6	1	5.71
Meloidogyne spp.	4.07	9.10	5	0.5	4.67
Tylenchus spp.	3.13	6.10	10	0.5	4.93
Aphelencoides spp.	2.00	1.90	1	0	1.22
Rotylenchulus spp.	0.50	1.70	0	1	0.80
Pratylenchus spp.	1.87	2.00	0	0	1.00
Helicotylenchus spp.	1.20	2.40	0	0.5	1.00
Atylenchus spp.	0.00	0.20		0	0.30
Paratylenchus spp.	0.00	0.20		0	0.05
Tylenchorhynchus spp.	0.07	0.3		0	0.10
Xiphnema spp.	0.07	0.3	0	0	0.10
Total	21.70	30.80	23	3.5	
Samples	150.00	110.00	10	20	

Table 3. Crop residues ploughed into the soil as source and spread of *Fusarium* wilt disease.

Section of crop residues	*Fusarium* colonies g^{-1} tissue	*Fusarium* wilt incidence %	Xylem discoloration 1-6
Roots	2060(3.28)b	4.44(12.16)ab	1.27
Stems	6930(3.84)a	11.98(20.25)a	1.93
Leaves	2250(3.33)b	9.50(17.94)a	1.68
Control	-	0.02(0.81)b	1.01
Mean	3.48	12.79	1.47
SE	0.06	4.14	0.10

Table 4. *F. oxysporum* populations (colonies g^{-1}) from cotton husks and their pathogenicity to cotton plants (cv UK 82 and UK 77).

Sample	Colonies g^{-1}	Pathogenicity UK 82	Pathogenicity UK 77
1	67	3	3.5
2	293	4	2
3	107	4.5	2
4	93	4	2
5	2040	4	2
6	253	5	3.5
7	133	4	2
8	188	3	3.5
9	53	4.5	2
10	2413	3	3.5
Mean	564	3.9	2.6