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Occurrence of Root Rot Disease of Common Bean (*Phaseolus vulgaris* L.) In Association with Bean Stem Maggot (*Ophyiomia* sp.) In EMBU District, Kenya

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Abstract: Two surveys were carried out in October 2001 (season 1) and April 2002 (season 2) in five divisions of Embu district during the short and long rains, respectively. Ten farms were randomly selected per division and fifteen bean plants were sampled from every farm and used to determine the occurrence and incidence of bean root rot and bean stem maggot. Each bean root was examined for the presence of bean stem maggot and root rot pathogen. The incidences of bean root rot diseases and bean stem maggot were significantly ($p = 0.05$) higher during the short rain than during the long rains. Wetter agro-ecological zones such as LH2 and UM1 had more incidence of root rot than UM2, UM3 and UM4. During both seasons *Fusarium solani*, *Rhizoctonia solani* and *Macrophomina phaseolina* were the major root rot pathogens isolated. The species of bean stem maggot found in Embu district were *Ophyiomia spencerella* and *O. phaseoli*, with the latter being the dominant species. Agro-ecological zones had no significant effect on the incidence of bean stem maggot. Root rot disease was frequently associated with bean stem maggot. Pearson correlation (r) between bean root rot disease and bean stem maggot was 0.495. The result is important in the management of bean root rot and bean stem maggot.

Key words: *Fusarium* sp., *Macrophomina phaseolina*, *Ophiomyia* sp., *Phaseolus vulgaris*, *Rhizoctonia solani*, root rot disease

INTRODUCTION

The common bean (*Phaseolus vulgaris* L.) is currently the most important edible pulse in the world (Debouck, 1990) and it is the second most important crop after maize as a staple crop in eastern and central Africa (ASARECA, 1995; MOALDM, 1996). The size of land under bean production in Africa is about 4 million hectares (CIAT, 1995; Wortmann *et al*., 1998) with an annual production of approximately 2 million tons (Allen and Edje, 1990; Chrispeels and Savada, 2003). Eastern and central Africa produce the bulk of beans with approximately 61% coming from Burundi, Kenya, Rwanda and Uganda (Londono *et al*., 1980). It is produced in areas between 800 and 2300 m above sea level with average rainfall of 500 to 2000 mm and temperature of 16 to 24°C (Allen and Edje, 1990; Wortmann *et al*., 1994). MOALDM (1994) classified the main bean producing areas to be Eastern, Central, Rift Valley and Western Provinces of Kenya. Approximately 600,000 to 700,000 hectares are under bean production with annual average of 3.7 million bags (MOALDM, 1996). In Kenya, small scale farmers are the main bean producers mainly as intercrop with other crops such as maize (*Zea mays* L.), sorghum [*Sorghum bicolor* (L.) Moench], cowpeas [*Vigna unguiculata* (L.) Walp.], cotton (*Gossypium* sp.), cassava (*M. esculenta* Crantz) and potatoes (*Solanum tuberosum* L.) (Acland, 1971; Mwaniki *et al*., 2000).

A number of bean varieties are grown in Kenya; these include the Rosecoco (GLP-2), Canadian Wonder (GLP-24), Red harricot (GLP-585), Mwitemania (GLP-92), Mwezi Moja (GLP-1004) and Zebra (GLP-806). All these varieties were released by Grain legume project of the National Horticulture Research Station, Thika, for different agro-ecological zones (Origa, 1992). Realization of optimal bean yield in Embu district is hampered by a number of constraints. Previous studies carried out by Mwaniki (2000) identified angular leaf spot caused by *Phaeoisariopsis griseola* and root rot diseases and bean stem maggot as major constraints beside lack of market for

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the produce. However, the study did not quantify the levels of occurrence, incidence and the association of root rot diseases and bean stem maggot. The objectives of this study were to document the occurrence and incidence of bean root rot disease and bean stem maggot and the association between these two pests in Embu district.

MATERIALS AND METHODS

Two field surveys were conducted in October 2001 (season 1) and April 2002 (season 2) during the short and long rains, respectively, in Embu district to determine the incidence and prevalence of bean root rot disease in association with bean stem maggot. The Agro Ecological Zones (AEZs) covered were Lower Highlands (LH2) and upper midlands (UM1, UM2, UM3 and UM4). The divisions surveyed were Manyatta (LH2, UM1, UM2), Runyenjes (UM2, UM3), Kyeni (UM2, UM3, UM4), Central (UM2, UM3) and Nembure (UM1, UM2, UM3, UM4). Fifty farmer's fields in the five divisions, 10 farmers per division, having bean plants at different stages of growth and development were randomly selected at intervals of 2 to 3 km apart. From each farm five 1 m^2 quadrants were drawn randomly. In each quadrant the number of bean plants showing symptoms such as poor plant growth, stunting, leaf chlorosis, premature defoliation and death were taken as percentage of total plants in the quadrant. The means were taken as the percentage incidence of the farm.

From each of the five quadrants, three infected bean plants were carefully uprooted using a shovel. The uprooted bean plants were kept in paper bags and transported in a keep-cool-box to the laboratory for analysis. In the laboratory, the five plant samples per quadrant from each farm were observed for the presence of bean root rot pathogens and bean stem maggot and the same were used to make isolations of the fungi causing root rot. To make observation and identification of bean stem maggot, the plant samples were carefully dissected using a scalpel blade from hypocotyls to the root to expose the pupae and the larvae. The percent number of plants having the pupae or the larvae of bean stem maggot was taken as the percentage incidence of the farm. Using a hand lens, the number and the species of *Ophiomyia* sp. was determined and recorded. To isolate the pathogens causing bean root rot, one centimetre portions were sliced from each plant and washed in running tap water and 1% sodium hypochlorite (NaOCl) was used to surface sterilize the tissues for 3 to 5 min. They were rinsed 5 times in sterile distilled water, then plated aseptically onto PDA medium and incubated at 23 to 25°C for 3 days, after which hyphal tip transfer was done onto fresh PDA medium and incubated at 23 to 25°C for 7 days. The pathogens were then identified using cultural and morphological characteristics and confirmed by pathogenicity tests.

The data obtained from the field on the level of bean root rot disease and bean stem maggot incidence were transformed using arc sine transformation (Gomez and Gomez, 1984) before analysis. The data were analyzed by analysis of variance (ANOVA) procedure using GENSTAT (6.1 version) computer software. Mean separation was by Least Significant Difference (LSD) at $p = 0.05$. The Pearson correlation (r) between seasons was also determined.

RESULTS

Symptoms of bean root rot disease bean stem maggot complex: Farmers in Embu district practiced either bean monoculture or mixed cropping systems. Short rains season was the major bean-growing season in Embu. Symptoms typical of root rot infection that formed the basis of data collection were general stunting of the beans coupled with the yellowing of the vegetative parts of the crop. Infection by a particular pathogen was manifested by signs characteristic of that pathogen. For example, *Fusarium* root rot disease was detected by observing narrow, longitudinal, red to brown streaks on the hypocotyl and taproot of young seedling and longitudinal cracks in mature bean plants. The symptoms of *Rhizoctonia* root rot were damping off in young seedlings; elongate, sunken reddish-brown lesion or canker was observed on the hypocotyl and taproots; and under moist condition, mycelial appeared as brownish tufts. *Macrophomina* root rot was detected by damping off in young seedlings characterized by deep black lesions and ashy colour on stems and petioles due to presence of numerous pycnidia beneath the translucent epidermal layers. The presence of bean stem maggot was noted through the observation of pupa embedded in the base of the stem or pupal remains after the adult had moved away. The presence of the larvae in the stem was identified by split of base of the stem. Both brown and black species of bean stem maggot were recorded.

Occurrence and incidence of bean root rot disease complex: Bean root rot disease complex occurred in all the farms surveyed in Embu district during the short and long rains. The incidence of the complex was significantly different ($p = 0.05$) among the farms with a mean of 46.6% and a range of 5.0-99.0% during the sort rains and a mean of 17.8% and a range of 5.0-95.0% during the long rains. There was no significant difference in incidence among the divisions, but significant difference was observed

among the seasons and AEZs. During the short rains, the mean incidence for the divisions were 52.4, 44.4, 46.7, 42.6 and 47.0% for Manyatta, Nembure, Runyenjes, Kyeni and Central, respectively. During the long rains, the mean incidence for the divisions were 19.6, 21.1, 14.9, 23.2 and 10.4% for Manyatta, Nembure, Runyenjes, Kyeni and Central, respectively. During the short rains, AEZs with the highest disease incidence were UM1 (73%) and LH2 (67%) and AEZs with lower incidence were UM2 (52%), UM3 (50%) and UM4 (36%). During the long rains, AEZs with the highest disease incidence were LH2 (70%) and UM1 (68%) and AEZs with lower incidence were UM2 (25%), UM3 (21%) and UM4 (23%).

Frequency of causal agents of bean root rot diseases: The long rain season was characterized by a significantly (p = 0.05) low incidences of root rot diseases as compared with the short rain season (Table 1 and 2). No root rot pathogen was isolated from 22.9% of the bean roots samples during the long rains as compared to 13.5% during the short rains. There were significant differences in the frequency of the occurrence of the bean root rot pathogens among the seasons, the divisions and the farms. *Fusarium* sp. was frequently isolated from the bean roots during both seasons as compared to *Macrophomina phaseolina* and *Rhizoctonia solani*.

Table 1: Frequency (%) of causal agents of bean root rot disease in Embu District during the short rains (season 1)

	Frequency (%)							
Division	FM	F	M	R	FR	RM	FMR	X
Manyatta	11.9	4.2	0.7	2.2	8.0	2.2	0.8	2.2
Nembure	10.6	14.3	2.2	3.3	3.7	0.8	0.7	8.3
Renyenjes	7.8	37.2	10.2	4.7	3.7	0.7	3.6	18.0
Kyeni	15.8	45.4	6.6	10.1	7.8	0.8	0.7	23.6
Central	17.0	34.5	5.1	6.8	10.7	2.2	0.8	15.3
Mean	12.6	27.1	5.0	5.4	6.8	1.3	1.3	13.5
LSD (p = 0.05)	11.38	11.81	6.92	6.78	7.80	2.68	2.54	7.39

F = *Fusarium* sp., M = *Macrophomina phaseolina*, R = *R. solani*, FM = *Fusarium* sp. and *Macrophomina phaseolina*, FR = *Fusarium* sp. and *Rhizoctonia solani*, RM = *Rhizoctonia solani* and *Macrophomina phaseolina*, FMR = *Fusarium* sp., *Macrophomina phaseolina* and *Rhizoctonia solani* and X = Saprophyte or no pathogen isolated

Table 2: Frequency (%) of causal agents of bean root rot disease in Embu District during the long rains (season 2)

	Frequency (%)							
Division	FM	F	M	R	FR	RM	FMR	X
Manyatta	13.8	44.7	11.2	8.0	7.7	0.8	2.2	27.3
Nembure	14.9	37.0	19.7	2.2	3.7	0.8	0.8	27.5
Renyenjes	17.3	43.1	7.7	8.8	18.5	0.8	2.2	15.5
Kyeni	24.6	44.2	9.5	5.7	8.6	2.2	0.8	16.8
Central	12.7	43.4	16.5	6.6	3.7	0.8	0.8	27.3
Mean	16.7	42.5	12.9	6.3	8.4	1.1	1.4	22.9
LSD (p = 0.05)	7.78	5.64	9.00	6.77	7.63	1.87	2.29	8.04

F = *Fusarium* sp., M = *Macrophomina phaseolina*, R = *Rhizoctonia solani*, FM = *Fusarium* sp. and *Macrophomina phaseolina*, FR = *Fusarium* sp. and *Rhizoctonia solani*, RM = *Rhizoctonia solani* and *Macrophomina phaseolina*, FMR = *Fusarium* sp., *Macrophomina phaseolina* and *Rhizoctonia solani* and X = Saprophyte or no pathogen isolated

Table 3: Mean incidence (%) of root rot disease and bean stem maggot in different divisions of Embu District

	Mean incidence (%)			
Division	Bean stem maggot	Root rot disease	Root rot diseases + Bean stem maggot	Saprophyte
Manyatta	5.3	42.9	44.8	6.0
Kyeni	4.4	71.5	6.8	19.6
Runyenjes	2.0	65.3	16.8	15.0
Nembure	4.4	46.0	36.8	8.0
Central	3.7	64.2	18.0	13.9
Mean	4.0	58.0	24.6	12.5
LSD (p = 0.05)	3.39	13.98	13.98	4.97

Incidence of bean stem maggot: Bean stem maggot occurred in all the farms surveyed but the incidence differed significantly (p = 0.05) among the divisions and among the farms in both seasons and not among AEZs. However, the incidence was remarkably higher during the short rains (40.9%) compared to the long rains (17.5%). During the short rains, the mean incidence for the divisions were 69.3, 59.8, 30.8, 16.0 and 28.5% for Manyatta, Nembure, Runyenjes, Kyeni and Central, respectively. During the long rains, the mean incidence for the divisions were 19.6, 20.3, 14.9, 24.5 and 8.4% for Manyatta, Nembure, Runyenjes, Kyeni and Central, respectively. BSM incidence during short rains for AEZs were 23, 69, 42, 43 and 53% for LH2, UM1, UM2, UM3 and UM4, respectively. BSM incidence during long rains for AEZs were 24, 12, 12, 15 and 3% for LN2, UM1, UM2, UM3 and UM4, respectively.

Two species of *Ophiomyia* were found in Embu district, namely *Ophiomyia spencerella* Greathead (black species) and *Ophiomyia phaseoli* Tryon (brown species). The mean incidence of *O. spencerella* was 20.1% while that of *O. phaseoli* was 4.5% during the short rains. The incidence of *O. spencerella* during the short rains was 37.5, 31.7, 12.2, 6.3 and 12.7% in Manyatta, Nembure, Runyenjes, Kyeni and Central division, respectively. On the other hand, the incidence of *O. phaseoli* during the same season was 5.8, 9.0, 4.4, 0.8 and 1.5% in Manyatta, Nembure, Runyenjes, Kyeni and Central division, respectively.

Association between bean root rot and bean stem maggot: Common bean plants sampled in Embu district showed the presence of bean stem maggot alone or in combination association with root rot disease. Generally, the occurrence of bean stem maggot alone (4.0%), root rot disease alone (58.0%) and in combination (24.6%) differed significantly (p = 0.05) among the farms sampled. The Pearson correlation (r) between bean stem maggot and root rot diseases was 0.493.

Bean root rot disease when occurring alone differed significantly (p = 0.05) among different divisions in both seasons and the highest mean incidence was recorded in

Kyeni (71.5%) and the lowest was recorded in Manyatta (42.9%) (Table 3). Similarly, root rot disease in combination with bean stem maggot was significantly different among the five divisions in both seasons and highest mean incidence was recorded in Manyatta (44.8%), while the lowest was recorded in Kyeni (6.8%). In general, the problem of root rot disease and bean stem maggot was more pronounced in Manyatta division as only 6.0% of the bean sampled had neither root rot disease nor bean stem maggot. On the other hand, Kyeni division recorded the highest percentage of saprophytic fungi (19.6%).

Bean root rot disease when occurring alone during the long rains was significantly ($p = 0.05$) higher (68.0%) compared to short rains (47.9%). However, root rot in combination with bean stem maggot was significantly higher during the short rains (38.7%) than during the long rains (10.6%). Bean samples with bean stem maggot alone were significantly higher during short rains (5.3%) than during the long rains (1.7%). Bean roots, which did not have root rot diseases or bean stem maggot, were significantly higher during the long rains (17.1%) than during the short rains (7.9%).

DISCUSSION

All the farms were found to have bean root rot diseases and bean stem maggot. It was also observed that there was poor bean germination. This could be attributed to the root rot diseases such as *Rhizoctonia* root rot which leads to pre-emergence damping off as opposed to *Fusarium* root rot which causes post emergence root rot (Burke and Kraft, 1974; Hall, 1983). Although crop rotation is known to reduce the incidence of root rot diseases, this is not practiced in Embu due to the small sizes of the farms. Thus, with each subsequent crop there is a build up of the pathogen in the soil through the debris. Embu district experience high rainfall which results in high soil moisture, a condition that favours root rot pathogens especially the *Rhizoctonia solani* and *Fusarium solani* (Songa, 1995). This further leads to transmission of the pathogen from one season to another. Damping off before and after emergence of the seedlings due to infection by *Fusarium* sp. and *Macrophomina phaseolina* may be due to farmers planting uncertified seeds infected by these pathogens (Kendrick, 1933; Andrus, 1938).

The incidence of bean root rot disease was higher during the short rain than during the long rains. The frequency of the causal agents also differed, with *Fusarium* spp. being more frequent followed by *Macrophomina phaseolina* and *Rhizoctonia solani*. This was in line with previous studies which show that higher rainfall leads to stimulation of root growth and root infection (Hall and Phillips, 1992). This subsequently translates into accumulation of higher levels of potential inoculum in the infected tissues. The impact of this is felt during the short rains when higher levels of inoculum are released in the soil (Hall and Phillips, 1992) which leads to higher root rot incidence. Variation in root rot incidence also depended on AEZs LH2 and UM1 having higher root rot incidence compared to UM2, UM3 and UM4 in both seasons. The former AEZs have more moisture than the latter, which encourages establishment of root rot diseases.

Yellowing of the leaves, stunted seedlings, wilt and eventual death manifested the presence of the beanfly. All the bean fields were infested with bean stem maggot during the short rains unlike during the long rains where most of the fields had low or no bean stem maggot infestation. Two species of bean stem maggot were found in Embu with *O. spencerella* being dominant over *O. phaseoli* as has also been reported in earlier studies (Nderitu, 1988). In Embu the most frequently occurring bean stem maggot was found to be *Ophiomyia spencerella*, which agree with other findings in E. Africa (Greathead, 1969; Spencer, 1985) and Central Kenya as noted by Nderitu (1988) and Tengecho *et al*., (1988). Swaine (1969) and Wallace (1939) noted that beanflies incidence was more pronounced during the hotter drier seasons than during the cooler seasons a fact also noted in the present study. This was also observed in Kiboko and Katumani by Songa and Ampofo (1999). High temperatures have been found to shorten both the larval and the purpal stages of bean stem maggot (Goot, 1930; Ho, 1967).

The lower bean stem maggot incidence during the long rains may be attributed to the vigour with which the crops grew due to adequate rain as reported by Ho (1967) crops recovered by producing the adventitious roots. Infestation rate of bean stem maggot increases with delay in the date of sowing (Davies, 1998). Early planted crops are able to escape bean stem maggot attack to a greater degree than the late planted crops (Ross, 1998). During the long rains there is a build up of bean stem maggot and the impact is felt during the short rains. In addition, volunteer crops do act as reservoirs of insects (Wallace, 1939; Rose *et al*., 1978). In Embu land scarcity is a problem and thus majority of the farmers cannot practice rotation with non-hosts which are known to reduce beanfly infestation (Irving, 1986). Low soil fertility aggravated by not applying inorganic fertilizers by the farmers leads to weakly growing bean plants which are vulnerable to beanfly attack (Autrique, 1991). AEZs had no effect on BSM incidence in both seasons.

The association between bean stem maggot and root rot disease was documented during the surveys. A clear variation was found to occur between the incidences recorded during the short and the long rains with higher incidences in the former season. Studies undertaken in Eastern, Central and Southern Africa region established that bean root rot diseases and bean stem maggot occur in a complex and there is a positive correlation especially where the soil fertility is low (CIAT, 1992; Ampofo, 1993). It can be hypotheses that damage by bean stem maggot creates avenue for the entry of the root rot pathogens. However, there is need to investigate which of the two pests precedes the other in the attack of the bean crop.

Farmers should be encouraged to control both bean stem maggot and bean root rot diseases. There is need for research to quantify the extent of yield losses on common bean caused by root rot diseases and bean stem maggot and in combination.

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