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The effects of inter-cropping maize with beans on maize diseases infestation

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Abstract

A study was carried out to assess the effects of inter-cropping maize with beans on maize diseases infestation.Eight diseases were recorded to affect maize with maize streak virus, northern leaf blight (*Exserohilum turcicum*), gray leaf spot (*Cercospora zeae-maydis*), and *Sternocarpella macrospora* leaf blight (*Sternocarpella macrospora*), being most prevalent. Disease incidence ranged between 0% for sorghum downy mildew (*Peronosclerospora sorghi*) to 80% for gray leaf spot. Gray leaf spot was the most common and was in some instances the most severe disease and attacked all varieties irrespective of the cropping system. Despite the high severity scores however, gray leaf spot disease did not affect maize yield. Other diseases also developed irrespective of whether the maize was sole or inter-cropped thus, resulting in no significant difference in disease reaction between mono or inter-cropped maize. In this particular study, intercropping maize with beans was not found to reduce maize streak virus disease incidence and severity as reported in earlier studies. These variable findings underscore the need for further work on disease incidence and development under mixed cropping systems.

Key words: Cropping system, gray leaf spot, yield, *Zea mays*

Introduction

Maize (*Zea mays*) is a major cereal crop in Uganda both as food and cash crop. The importance of the crop has been steadily increasing since 1994 when it ranked second to coffee in fetching foreign exchange for the country (Anon., 1995). Since then it has been among the first five major exports. Most of the maize grown comes from the farms of the poor resource farmers whose yields average about 1.2 t ha^{-1} (FAO, 1998). There are several reasons for this scenario, among them is the growing of low yielding varieties and the others include pests and diseases, declining soil fertility, drought and low plant populations partly due to intercropping systems (Kikafunda-Twine *et al.*, 2000).

Crop mixtures create micro-environments which may be beneficial to one or all the crops involved. However, in some instances the microclimate may create ideal conditions for disease or pest development. There are occasions when they act as alternate hosts for instance maize and sorghum in the case of sorghum downy mildew (Bigirwa *et al.*, 2000). Maize is commonly grown under two cropping systems; as a mono-crop and as an inter-crop mostly with beans. There is however, very limited information on the disease pressure within this cropping system. The trial was therefore set-up with two objectives: (i) to establish whether inter-cropping maize with beans has an effect on reducing maize disease development and progression. (ii) to compare the performance of a commercial open pollinated variety (Longe 1) with local variety under two cropping systems.

Materials and methods

The trials were established on farmers' fields in two sub-counties, Bulamagi and Baitambogwe in Iganga district for a period of four seasons starting from second season 1997 to first season 1999. In each sub-county, two farmers were used and their choice was based on the availability of land, interest and willingness to work with the researchers and ability to manage the trials. During the second season 1997, each of the four farmers was used as a replication, first season 1998, two replications were established at each farm while second season 1998 and first season 1999, three replications were established on each farm. The number of replications increased in the later seasons of testing as a result of farmers' willingness to offer land and confidence in the researchers since all the produce was left with the farmer. More land availed to researchers meant more produce at the end of the season.

Establishment of experimental plots

Two maize varieties, Longe 1 a commercial open pollinated variety and farmers own local variety were used. Each variety was grown as mono-crop and an inter-crop with a bean variety, K132. Each plot measured 10m x 8m. Maize varieties were planted at a spacing of 75cm x 60cm, two plants per hill. Two fertilisers. Phosphorous (as P_2O_5 at 45kg ha^{-1}) and nitrogen (as urea at 60 kg ha^{-1}) were applied. Plots were kept weed- free by regular hand hoeing. Bean (variety K132) was planted at a spacing of 75 cm x 15 cm, one row of beans between two rows of maize, in the commercial variety.

Data collection

Recording of maize diseases commenced 50 days after planting and this was done at an interval of 14 days for five recordings. Two approaches were used in recording diseases. First, incidences of major diseases affecting maize were determined. This was done on 10 plants randomly selected in a row in each plot. The number of diseased plants and the diseases affecting them were recorded. This was repeated three times in different positions of each plots.

In the second approach, 10 plants were randomly selected and tagged per plot and progression of four major diseases, was monitored by scoring severity using a scale of 1-5 (where 1= no or very minor infection, 5= very heavy infection). Disease progression was monitored five times in the growing season. During the last two seasons of testing, a Smith scale was used for scoring severity of gray leaf spot disease (Freppon *et al.*, 1996). Three methods were used to establish the effects of diseases on the 2 maize varieties in the various combinations. These were; assessing severity using a 1-5 scale, area under disease progress curve (AUDPC), for northern leaf blight it was the 1-5 severity scale and AUDPC, while with maize streak virus it was by all assessment methods.

Data analysis

Incidence data were acsine transformed to harmonise variances (Steel *et al.*, 1997). Data were subjected to analysis of variance (ANOVA) using MSTATC statistical software of Freed *et al.* (1988). Area under disease progress curve (AUDPC) (Campbell and Madden, 1990) was calculated for both incidence and severity using the midpoint rule standardized by dividing the AUDPC by the number of days from the first to the last assessment. Since the number of replications and plot sizes were different each season, the data set were not balanced to conduct a season location analysis (Steel *et al.*, 1997). Thus, data for individual seasons and locations are presented.

Results and discussion

A total of eight diseases were recorded during the study period with maize streak virus, northern leaf blight (*Exserohilum turcicum*), gray leaf spot (*Cercospora zeae-maydis*), Common rust (*Puccinia sorghi*), tropical rust (*Puccinia polysora*), brown spot (*Physoderma maydis*), sternocapella leaf streak (*Sternocapella macrospora*) and downy mildew (*Peronsclerospora sorghi*). Of the eight diseases recored, only three were most prevalent; maize streak virus, northern leaf blight and gray leaf spot. Disease incidence ranged between 0% particularly for downy mildew to 80% for gray leaf spot. Gray leaf spot was the most common disease in all fields and had the highest severity, this was followed by northern leaf blight. Although gray leaf spot was most prevalent and severe, it came in late compared to northern leaf blight, maize streak virus and downy mildew which appeared early. The diseases can be grouped into three categories, the early invaders (maize streak virus, northern leaf blight and downy mildew); mid period invaders (brown spot, common rust); late invaders (gray leaf spot, sternocarpella leaf streak and tropical rust). Disease development and progression were generally low during all the 4 seasons of testing due to dry spells experienced.

Disease incidence varied from disease to disease, being conspicuously high on gray leaf spot, followed by sternocarpella leaf streak and northern leaf blight. The highest incidence was recorded on gray leaf spot ranging from 2.7% to 87%. Although severity and incidence were high for gray leaf spot, the disease did not affect yield. This was clearly shown by severely affected plants having big cobs. A possible explanation for this is perhaps due to the fact that the disease tends to set in late when enough photosynthates required for cob formation and development have been accumulated.

Disease pressure on the four farms was similar except during the second season of 1997, where significant differences ($P=0.02$) in incidence were observed on gray leaf spot and tropical rust (Table 1). During the 1999A (first rains of 1999) season however, the level of maize streak virus was noted to vary among farms, being highest at the farms of Kulata and Mukalazi, with scores of 3.3 and 3.2, respectively as opposed to 2.3 at the farms of Byekwaso and Kisseke. The interaction between farmer and crop combination was highly significant ($P \leq 0.001$). In all instances it was high in the local variety irrespective of whether as sole or inter-crop (Table 2).

Significant ($P= 0.003$) variety differences in disease incidence and severity were recorded for maize streak virus (Tables 3-5). Farmers' local varieties were susceptible to maize streak virus compared to Longe 1 the commercial variety. This is not surprising for Longe 1 because it was bred for streak resistance (Anon., 1996). It is also for this reason that farmers are constantly advised to plant Longe 1 for its resistance to maize streak virus in addition to early maturity of four months and high yields. Response to other diseases was not significantly different irrespective of whether the variety was improved or local. This was also found true with the cropping pattern.

There were no significant differences in disease reaction between sole and inter-cropped maize (i.e., inter-cropping did not reduce the level of maize diseases). This is contrary to the findings of Page *et al.* (1999) that inter-cropping maize with beans or finger millet reduces maize streak incidence and severity. The reason given for this is that the inter-crops interfere with the mate seeking behaviour of the male vectors. There are also several instances of the successful use of inter-cropping to alter vector behaviour and thus, reducing the incidence of virus disease. For instance, Ahohuendo and Sarkar (1995) observed that intercropping cassava with cowpeas or groundnut reduced the incidence of African cassava mosaic disease and the population of its whitefly vector. The observed reductions were considered to be due to an effect on the host finding and feeding behaviour of the whitefly. Bottenberg and Irwin (1992) also reported that the incidence of aphid-borne soybean mosaic potyvirus was reduced in soybean intercropped with sorghum.

During the time of disease assessment, there are occasions when one can see clear differences in varietal response to diseases. However, some assessment methods used could not reveal such differences. For instance, differences in *Sternocarpella macrospora* and *Puccinia polysora* were only detected using area under disease progress curve (AUDPC). This tends to imply that for diseases which

Table 3. Disease severities under sole and intercropping cropping systems during the first season of 1998 (1998A).

Farmer	[a]MSV		GLS		NLB		SLS		PP	
	[b]Sev	AUDPC	Sev	AUDPC	Sev	AUDPC	Sev	AUDPC	Sev	AUDPC
Longe	1.44±0.08b	1.34±0.06	2.74±0.13	2.09±0.10	1.88±0.16	1.58±0.08	1.27±0.56	1.26±0.04	1.25±0.03	1.20±0.03
Longe+beans	1.42±0.09	1.35±0.05	2.50±0.03	2.11±0.08	1.99±0.18	1.83±0.21	1.46±0.16	1.31±0.06	1.43±0.05	1.35±0.04
Local	2.61±0.22a	2.04±0.11	2.84±0.14	2.20±0.10	1.90±0.18	1.51±0.08	1.31±0.05	1.24±0.04	1.40±0.10	1.35±0.04
Local+beans	2.32±0.15a	1.95±0.11	2.64±0.09	2.04±0.09	1.60±0.11	1.40±0.04	1.31±0.10	1.29±0.08	1.40±0.07	1.84±0.04

[a]MSV = Maize streak virus, GLS = Gray leaf spot, NLB = Northern leaf blight, PP = *polysora* rust, SLS = *Sternocarpella* leaf streak, PS = *Puccinia sorghi*

[b]Sev = Severity assessment on 1 – 5 scale except for GLS where the Smith scale was used; AUDPC = Area under disease progress curve

Values within a column followed by the same letter are not significantly different $LSD_{(0.05)}$.

Table 4. Maize disease severity under sole and inter-crop with beans cropping systems during the second season of 1998 (1998B).

Tretment	[a]MSV		GLS		NLB		PP		SLS	
	[b]Sev	AUDPC	Sev	AUDPC	Sev	AUDPC	Sev	AUDPC	Sev	AUDPC
Longe	1.6±0.1	35.7±2.0	20.5±1.1	89.4±4.7	1.8±0.1	63.5±2.1	1.3±0.1	50.6±2.0	1.4±0.1	5.1±2.0
Longe+beans	1.5±0.1	36.6±0.8	20.8±2.0	92/1±4.1	1.9±0.0	62.4±4.5	1.3±0.0	49.5±1.0	1.4±0.0	49.5±1.1
Local	3.6±0.2	69.1±4.3	21/9±2.3	99.9±3.8	1.5±0.1	59.9±2.0	1.4±0.1	53.7±2.1	1.4±0.1	53.1±2.1
Local+beans	3.4±0.1	64.5±5.4	22.0±1.7	93.5±2.3	1.7±0.1	60.0±1.5	1.3±2.2	49.4±2.2	1.4±0.1	51.1±1.7

[a]MSV = Maize streak, GLS = Gray leaf spot, NLB = Northern leaf blight

PP = *Puccinia polysora* rust, SLS = *Sternocarpella macrospora* leaf streak

[b]Sev = Severity assessed on 1 – 5 scale except for GLS the Smith scale was used; AUDPC = Area under disease progress curve.

Table 5. Yields (kg ha^{-1}) performance of improved and local maize varieties as a mono-crop and intercrop with beans.

Farmer	Treatment	Maize yield kg ha^{-1}				Bean yield kg ha^{-1}	
		1997B	1998A	1998B	1999A	1998B	1999A
	Longe	3347.7±785.5	9312.1±212.8(53)[a]	5354±243.0(59)	8744.7±949.7(62.5)		
Byekwaso	Longe + beans	2968.5±950.3	9166.6±1395.6(55)	4985.7±467.1(55)	8566.7±1038.7(60.6)	524.7±65	347.9±105.7
	Local	1801.7±152.4	7667.9±677.4(42)	4309.7±513.0(48)	6355.6±1512.0(49.0)		
	Local + beans	1775.0±80.0	6481.1±715.0(49)	4512.3±462.9(54)	4889.8±781.3(59)	389.8±79	422.4±107.4
	Longe	2916.2±281.2	6981.1±715.0(65)	4984.0±343.6(54)	8505.8±267.9(62.7)		
Kiseka	Longe + beans	2376.1±281.2	5733.9±261.1(55)	4657.0±550.1(43)	7056.8±1402.5(60.3)	998.5±143	350.7±107.7
	Local	1848.7±125.6	4232.1±530.2(44)	3969.7±779.0(34)	8075.5±342.5(59.3)		
	Local + beans	1927.0±126.0	5060.7±1235.4(44)	3325.7±117.4(40)	6894.3±1317.6(57.3)	1004.5±54	359.1±61.2
	Longe	-	3529.1±1172(52)	5714.7±561.9(43)	7197.5±724.7(50.3)		
Mukalazi	Longe + beans	-	2629.1±1172.7(52)	4651.3±285.7(43)	6364.7±433.5(53.0)	-[b]	605.1±120.4
	Local	-	2615.6±126.9(43)	3149.0±287.3(34)	5630.9±409.1(51.3)		
	Local + beans	-	2219.9±32.8(50)	3550.0±392.5(36)	5455.9±1253.1(52.0)	-	649.7±121.5
	Longe	-	7774.3±2084.1(58)	3220.0±453.0(53.3)	7040.2±364.4(51.3)	752.6±92	915.5±266.7
Kulata	Longe + beans	-	6206.8±1491.9(60)	3116.7±645.2(46.7)	7798.9±1453.7(52.0)		
	Local	-	7059.4±634.8(61)	2298.7±618.1(41.0)	5796.8±1388.4(55.8)		
	Local + beans	-	7548.6±139.9(58)	1872.0±0326.2(35.7)	5733.3±3554.9(52.0)	602.7±100	512.2±151.5

[a]Figures in parentheses are number of maize plants harvested

[b]It was not possible to get bean yields because of drought.

progressively increase with time, their assessment should not be done only once but rather over time and AUDPC calculated to detect differences.

Significant (P=0.01) variety differences were also recorded in yield for nearly all seasons of testing with exception of second season 1997 (Table 4). Longe 1 almost consistently out-yielded the local variety. Higher yields were also realised during the first season of 1998 and least in the second season of 1997 this is partly due to the drought experienced at the time. In many places farmers got no yields as was the case with the last two farmers (Table 4). This was more so with farmers who planted other varieties other than Longe 1 which is known to be tolerant to drought partly because it matures early (Imanywoha and Kyetere, 1997). This can further be reflected by the yields obtained in the second season of 1997 which were almost twice as much as the local variety. Significant (P=0.03) differences among cropping systems were revealed for yield. In all instances the sole crop out yielded the inter-crop. This can be attributed to less competition between the two crops and optimum plant population.

There was no significant difference in disease reaction between mono or inter-cropped maize. Therefore, inter-cropping did not reduce the level of maize diseases. Certain plant combinations however, help reduce disease incidence and severity for some pests. Khan *et al.* (1997) observed that inter-cropping maize with *Desmodium uncinatum* reduces the level of *Striga* infestation while an intercrop of maize and *Pennisetum purpureum* reduces the level of cereal stem borers on maize. Inter-cropping maize with beans reduces the severity of bean rust and bean common mosaic virus while the severity of angular leaf spot and ascochyta are increased in beans (Sengooba, 1994). In this particular study however, inter-cropping maize with beans did not have any effect on maize diseases. Diseases developed irrespective of whether the maize was sole or inter-cropped.

The common practice of farmers intercropping maize with beans cannot be encouraged as a means of reducing diseases of maize. However, for reasons like crop security in case one crop fails, land equivalent ratio, as a means of crop diversification and soil erosion control on hilly slopes, the method can be seen to be of advantage.

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