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INFLUENCE OF CULTURAL PRACTICES ON THE DEVELOPMENT OF GRAY LEAF SPOT (GLS) ON MAIZE AT BAKO, WESTERN ETHIOPIA

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A B S T R A C T

The experiment was conducted at Bako Agricultural Research Center from 2008 to 2009 cropping seasons in order to evaluate the effect of sowing dates and ploughing frequency on the development of Grey Leaf Spot (GLS) on maize. The susceptible variety Phb 3253, with three sowing dates (early, optimum and late at 10 days interval) and three ploughing treatments: Minimum tillage (once), farmer's practice (three times ploughing) and four times ploughing were used. All plots were uniformly treated with GLS infected crop residue before first ploughing. Trial was laid out in factorial arrangement in Randomized Complete Block Design (RCBD) with three replications. Among the planting dates, the highest disease severity of 7.60, 7.44 & 7.00, (1-9 scale) and Area Under Disease Progress Curve (AUDPC) 305.83, 280.1 and 280.33 were recorded in early sown minimum (conservation) tillage practices, while the lowest was with AUDPC 161.50, 196.50 and 222.67 in four times ploughed plots in 2007, 2008 and 2009 years respectively. The highest thousand seed weight and grain yield was observed in four times ploughed and in early sown plots, while the lowest thousand seed weights and grain yield were recorded in the conservation tillage practice. Four times ploughed and early sown fields had a mean yield advantage of 474.73kg (6.66%) and a total yield advantage 2020.77kg (36.23.6%) over three times ploughed and minimum tillage practices for the three seasons 2008-2009. In general, higher disease severity, low thousand seed weight and grain yield were recorded for the conservation tillage compared to other practices. The overall results showed that four times ploughing result in superior maize grain yield performance compared to others as it has resulted in reducing the disease development.

Keywords: Grey Leaf Spot (GLS), ploughing frequency, maize residue, sowing date, cultural or farmers practice.

INTRODUCTION

Gray leaf spot is one of the major diseases of maize in Ethiopia in general and in western Oromia region in particular. GLS is a foliar disease caused by the fungus *Cercospora zeae maydis* Tehon and EY. Daniels. The disease was first observed in 1997 in the border of west Wellega and Ilubabor zones, of western Oromia. Recent survey carried out in the country showed that GLS has increased in prevalence and severity in the major maize producing regions of western, southern and northwestern parts of Ethiopia (Dagne *et al*., 1999; 2001). This increment in distribution and severity is associated with the use of susceptible maize varieties, monocropping (Latteral and Rossi 1983) and conservation tillage particularly in southwestern part where crop residue from previously infected maize carry over the inoculums to the next cropping season (Ward and Nowell, 1998; Dange *et al*., 1999). The disease has posed a serious threat to economic production of maize (Ward *et al*., 1994). The yield loss caused by the disease was estimated to reach 50% for moderately resistant and 65% for susceptible hybrid maize in South Africa (Ward *et al*., 1999). Due to GLS problem, the production of maize gradually shifted to low humidity areas in South Africa (Ward *et al.,* 1997). In Ethiopia, it is estimated to be below this percentage (Kernessa et al., 1997). The disease is favored by humid and warm conditions for its development.

Maize is the only known host of *Cercospora zeae maydis* and the pathogen over winters only in infected maize residue (Backman and Payne, 1982; Latterell and Rose, 1983). The higher the residue level on the soil, the higher will be the disease level (Nazareno *et al*., 1993). In most cases, the initial infection of the conidia comes from residue and attacks the lower leaves. The leaves produce lesions and conidia are produced from these lesions to infect the upper leaves as secondary conidia (Stromberg, 1986). The *C. zeae- maydis* conidia produced from this infested maize is disseminated primarily by wind although by rain splash. Payne *et al*., (1987) reported that number of airborne spores was significantly greater in no-tillage plots than conventional tillage. GLS disease mainly attacks the leaves and also cause stem deterioration that leads to sever lodging. According Allison and Watson (1996) the upper eight or nine leaves, which contribute 75 to 90% the photosynthetic for grain fill. This showed that the disease have high impact on yield. The cultural practices such as planting of maize after maize (monocropping) without crop rotation, practicing conservation tillage, which leaves infected residue from previous crop on the soil surface increase initial inoculums of the disease. Moreover, increasing crop residue on the soil proportionally increases the amount of primary inoculums. In U.S.A. (Iowa) increasing minimum tillage practice by 22.9% has resulted in increase of 85% GLS prevalence in the year 1983 to 95% in 1997 (Ward *et al*., 1999).

Although no information was available on planting date and ploughing frequency, meanwhile planting date with maturity group of the variety have influence on disease severity.

Planting date for late maturing varieties mostly planted earlier and needs longer growing season. The late types have higher yield potential. At the same time due to longer stay in the field they are at high risk from GLS and are subjected to blight during the grain filling period (Stromberg and Donahue, 1986). In area where GLS is epidemic, shorter- season hybrids may reaches physiological maturity before the blight is severe and cause serious yield loss (Stromberg and Donahue, 1986). Early season disease is usually slower to develop severe in the later season. Most favorable condition for disease is mid to late season (Ward and Nowell, 1998).

The importance of minimum tillage is to add additional organic matter to the soil and improve water-holding capacity of the soil. On the other hand, this type of practice increases crop damage by fungal pathogen that overwinters in crop residue. At this particular time, NGOs are advising farmers to use minimum tillage without considering the side effects of this practice in this area where diseases like GLS that over winters on crop residue are threatening maize production in the region. The objective of this study was to investigate the impacts of different cultural practices and determine the one that reduces the severity of GLS on maize.

MATERIALS AND METHODS

The study was conducted at Bako Agricultural Research Center (BARC). The treatments were frequency of ploughing using local maresha pulled by oxen: minimum tillage (ploughing once at planting), farmer's practice (three times ploughing) and four times ploughing. There were three planting dates: early (mid-May); optimum (late May) and late planting (early June). A susceptible maize hybrid variety Phb 3253 was used for all treatments. The experiment was conducted in randomized complete block design in factorial arrangement with three replications. The plot size was 6m x 9m =54m^2. Each plot contains 8 rows with 0.75m between rows, 0.3m between plants and 3m between plots and blocks. Maize residue (leaves and stalk) of 12 kg plot^{-1} was applied to each plot on the surface of the soil before ploughing. To protect the spread of inoculums from one plot to another taller sorghum variety. Bobe, was planted between plots and blocks. The middle four rows of each plot were evaluated for GLS and grain yield. In all the ploughing frequencies, the fertilizer rate applied was 92 kg N and 69 kg ha^{-1} P. All the phosphorous and half of nitrogen were applied at planting, while the remaining nitrogen was top-dressed when the crop was at knee height stage. For the early planting the first plough for the four times was carried out at mid-March, the 2nd at the late March, the 3rd at mid-April and the fourth ploughing was done at mid-May. For the three times, ploughing the first was carried out plough at late March, the second at mid-April and the third at early to mid-May at planting. For conservation, tillage one plough at time of planting at early to mid-May. On average dates of ploughing for optimum and late planting was moved by 15 and 30 days respectively. Pre-planting herbicide at the rate of 4 lt ha^{-1} a week before planting and pre-emergence herbicide lasso atrazine at the rate of 5 lt ha^{-1} two to three days after planting before emergence were applied. The application of lasso atrazine was carried out after the soil get moistened.

Planting date for early and late were ten days before and after the recommended (optimum) date respectively. Weeding and insect pest control was carried out as usual recommendations. The trial was hand planted at two and one seed per hill alternatively resulting in 44,444 plants ha^{-1}. To evaluate disease incidence and severity ten plants were tagged in four rows and were assessed at regular interval of ten days. Disease severity was scored visually by using 1-9 scoring scale developed by Saari and Prescott (1975). These data were used to calculate the area under disease progress curve (AUDPC). Grain yield was determined after adjusting the moisture level to 12.5%. ANOVA for AUDPC, final disease severity, infection rate, 1000 seed weight, and grain yield was analyzed by using MSTATC computer program (Nlssen *et al*., 1991).

RESULTS

The analysis of variance indicated that sowing date, ploughing frequency, year, sowing date by year and ploughing frequency by year have shown significant effect ($p < 0.05$) on disease incidence, severity, area under disease progress curve, (AUDPC) and grain yield. However, sowing date by ploughing frequency, year by sowing date by ploughing frequency were non-significant (Table 1).

Table1: Mean squares for AUDPC, disease incidence, disease severity of GLS and 1000 grain yield of maize at Bako (2007 to 2009).

Treatments	AUDPC	Disease Incidence	Disease Severity	Grain Yield
SWD	24801**	103ns	1.19**	3672652**
Year x SWD	5826**	618**	1.57**	8373142**
PLF	6764**	899**	2.58**	23025885**
Year x PLF	645ns	204**	0.97**	2135011**
SWD x PLF	387ns	38ns	0.54ns	397687ns
Year x SWD x PLF	409ns	53ns	0.30ns	689830ns
Mean	236	62	6.54	5850
CV%	12.75	10.68	7.26	15.71

Remark: SWD- Sowing date; PLF- Ploughing frequency, ns - non significant at $p < 0.05$
**-highly significant at $p < 0.01$

The effect of planting date: Early planting date, mid-May significantly ($p < 0.05$) increased the disease incidence, severity, AUDPC and grain yield, while delayed planting in early June reduced disease development and grain yield as mentioned in the Table 3. Early planting with conservation tillage resulted in higher disease severity 7.60, 7.44 & 7.00 in 1-9 scoring scale, in 2007, 2008 and 2009 respectively, AUDPC (305.83; 280.1 and 280.33 in 2007, 2008 and 2009 respectively in early minimum tillage practices, while the lowest was in plots ploughed four times 161.50, 196.50 and 222.67 during 2007, 2008 and 2009. In spite of high disease, severity early sown plots had significantly ($p < 0.05$) higher thousand seed weight and grain yield. Meanwhile, the two planting dates (optimum and late) have resulted in lower disease severity and grain yield as mentioned in Table 3.

The three years analysis of variance indicate that higher disease incidence, severity, and AUDPC was detected in the year 2001 and 2002, while it was lowest in 2007 (Table 2).

The three years analysis of variance indicate that higher disease incidence, severity, and AUDPC was detected in the year 2001 and 2002, while it was lowest in 2007. However, the year 2007 resulted in significantly ($p < 0.05$) higher grain yield than 2008 and 2009 as mentioned in Table 2.

The effect of ploughing frequency: Apparent difference in disease severity was detected between different ploughing frequencies. The lowest grain yield and the highest disease incidence, severity, and AUDPC were shown in the reduced tillage practices, while the highest yield and lower disease severity was shown in increased tillage plots as mentioned in Table 4.

Table2: Effect of year on AUDPC, disease incidence, disease severity of GLS and grain yield of maize at Bako (2007-2009).

Year	AUDPC	Incidence	Severity	Yield
2007	218.26b	52.04c	6.30b	6758.51a
2008	251.39a	72.59a	6.51a	5121.00c
2009	239.74a	60.46b	6.81a	5670.66b
Mean	236.46	61.7	6.54	5813.00
CV%	12.75	10.68	7.26	15.75
LSD (5%)	16.49	3.61	0.26	502.9

Value in each column followed by the same letters are not significantly different at 5% level test.

Table3: Effect of sowing date on AUDPC, disease incidence, disease severity of GLS and grain yield of maize at Bako (2007 to 2009).

Sowing date	AUDPC	Incidence	Severity	Yield
Early	267.02a	63.95	6.76a	6766.65a
Optimum	235.96b	60.69	6.34b	6246.23b
Late	206.41c	60.45	6.52ab	4537.28c
Mean	236.46	61.70	6.54	5813.00
CV %	12.75	10.68	7.26	15.71
LSD (5%)	16.49	Ns	0.26	502.9

ns - non significant at $p < 0.05$, Value in each column followed by the same letters are not significantly different at 5% level test.

Table 4. Effect of Ploughing frequency on AUDPC, disease incidence, disease severity of GLS and grain yield of maize at Bako (2007 to 2009).

Ploughing frequency	AUDPC	Incidence	Severity	Yield
MT	253.21a	67.77a	6.84a	4817.67b
3X	234.41b	61.04b	6.56b	6135.07a
4X	221.76b	56.29c	6.22c	6597.43a
Mean	236.46	61.70	6.54	5813.00
CV %	12.75	10.68	7.26	15.71
LSD (5%)	16.49	3.61	0.26	502.9

Value in each column followed by the same letters is not significantly different at 5% level test.

Table 5. Effect of sowing date by ploughing frequency on AUDPC of GLS on maize at Bako (2007 to 2009).

Sowing date	Ploughing frequency			Mean
	MT	3X	4X	
Early	288.76	262.12	250.18	267.02
Optimum	245.28	241.09	221.52	235.96
Late	225.60	200.08	193.56	206.41
Mean	253.21	234.43	221.75	-
CV	12.75	-	-	-
LSD (5%)	16.49	-	-	-
A X B	Ns	-	-	-

ns - non significant at $p < 0.05$; MT- Minimum tillage; 3X- Three times ploughing; 4X- Four times ploughing.

Table 6: Effects of sowing date by ploughing frequency on incidence of GLS on maize at Bako (2007 to 2009).

Sowing date	Ploughing frequency			Mean
	MT	3X	4X	
Early	71.17	62.33	58.34	63.95
Optimum	67.56	61.22	53.29	60.69
Late	64.58	59.56	57.22	60.45
Mean	67.77	61.04	56.28	-
CV %	10.68	-	-	-
LSD (5%)	3.61	-	-	-
AX B	Ns	-	-	-

ns - non significant at $p < 0.05$; Minimum tillage; 3X- Three times ploughing; 4X- Four times ploughing.

Table 7: Effects of sowing date by ploughing frequency on severity of GLS on maize at Bako (2007 to 2009).

Sowing date	Ploughing frequency			Mean
	MT	3X	4X	
Early	7.35	6.51	6.42	6.76
Optimum	6.48	6.50	6.04	6.34
Late	6.68	6.68	6.19	6.52
Mean	6.84	6.56	6.22	
CV %	7.26	-	-	-
LSD (5%)	0.26	-	-	-
AX B	Ns	-	-	-

ns - non significant at $p < 0.05$; MT- Minimum tillage; 3X- Three times ploughing; 4X- Four times ploughing.

Table 8: Effect of sowing date by ploughing frequency on grain yield of maize GLS at Bako (2007 to 2009).

Sowing date	Ploughing frequency			Mean
	MT	3X	4X	
Early	5577.71	7165.92	7556.33	6766.67
Optimum	5346.62	6611.80	6780.28	6246.23
Late	3528.68	4627.48	5455.68	4537.28
Mean	4817.67	6135.07	6599.43	-
CV %	15.71	-	-	-
LSD (5%)	502.9	-	-	-
AX B	Ns	-	-	-

ns - non significant at $p < 0.05$; MT- Minimum tillage; 3X- Three times ploughing; 4X- Four times ploughing.

DISCUSSION

Maize gray leaf spot disease severity in early-planted minimum (conservation) tillage practices is higher than the other tillage treatments (three times and four times ploughed plots). In the minimum tillage practices large amount of infested maize residue will be left on the surface of the soil from the previous season crop. The fungus pathogen *Cercospora zeae-maydis* that causes GLS of maize over winters only in infected maize debris (Payne *et al*., 1987; Beckman and Payne, 1982; Stromberg and Donahue, 1986, Nazareno *et al*., 1990; 1992; Latterell and Rossi, 1983). Thus GLS infected maize residue therefore, serves as primary sources of inoculums to infect the newly grown maize as previously reported by Ward and Nowell, (1998). Several researchers (Nazareno,1990; Ward, 1997; Payne and Waldron, 1983) have shown that any tillage practice leaving infested maize residue on the top of soil surface favor the development of the disease. The use of reduced tillage in major maize production area increased the probability that neighboring maize field, to be infested with *C. zeae- maydis* inoculums. In developed countries like South Africa and USA, reduced tillage practice is used just to reduce production cost. According Nazerno *et al*. (1992) sporulation was detected from maize leaves and sheath residue placed on the top of soil. This disease is highly dependent on weather condition. High humidity and warm condition favor the development of the disease. The year 2007 was the most favorable year for the development of GLS (Fig. 1, 2 and 3) higher disease incidence and severity was recoded specially on early-planted minimum tillage and other tillage practices. It is clear from the figure 1, 2 and 3 the years 2008 and 2009 were less favorable for disease development.

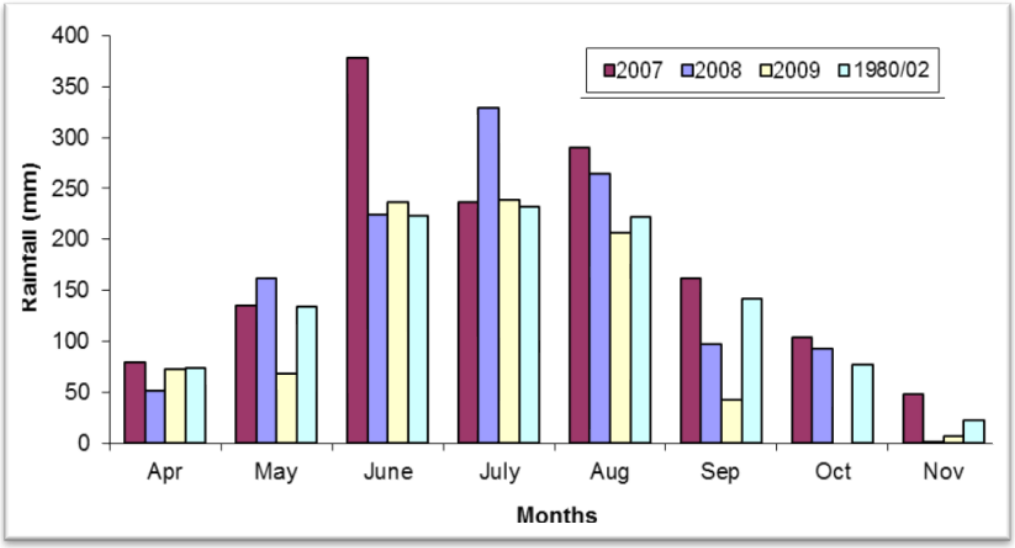

Fig. 1. Rainfall in mm of maize growing period of Bako 2007-2009.

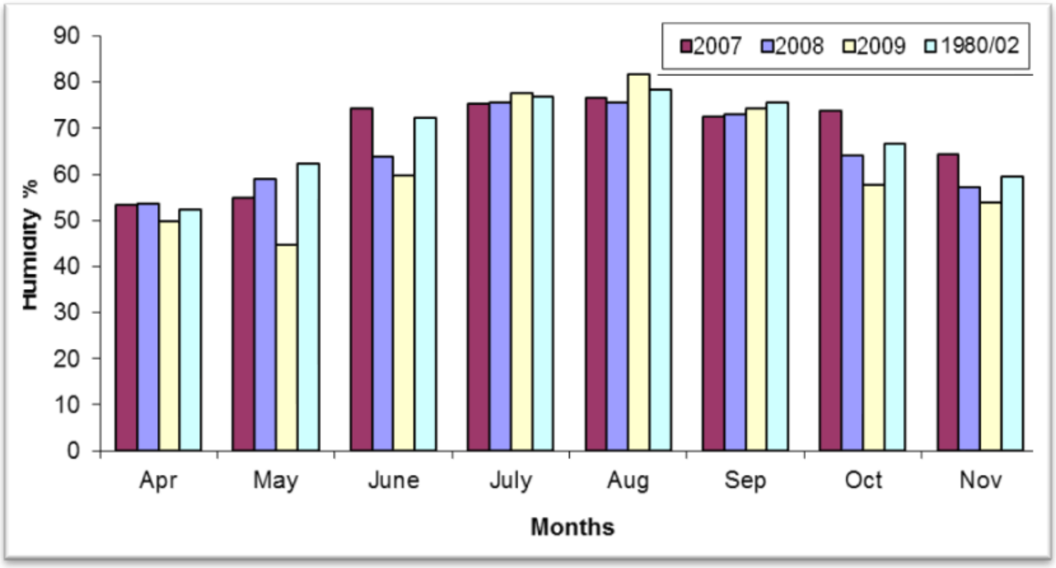

Fig. 2. Relative humidity in percent (%) of maize growing period of Bako 2007-2009.

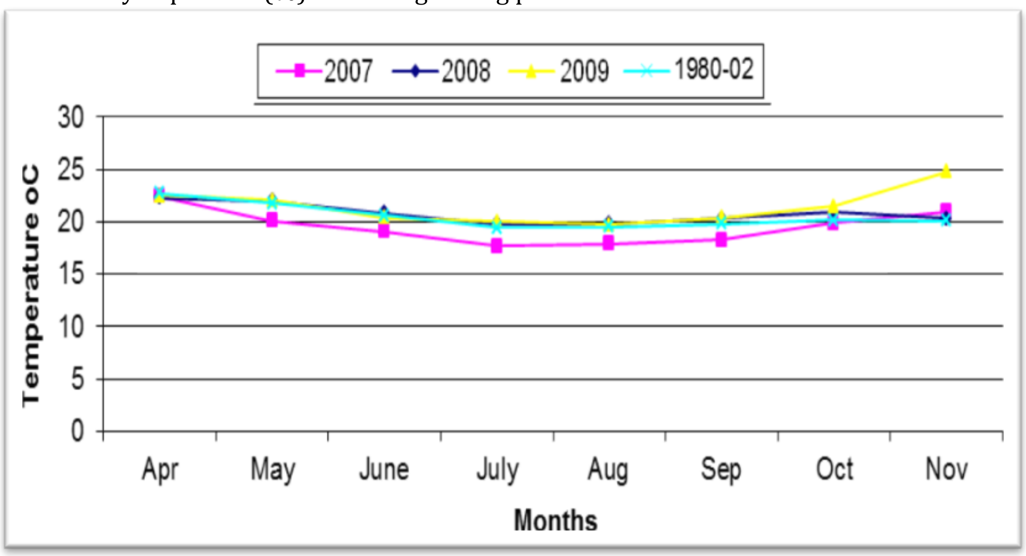

Fig. 3. Optimum temperature in ^{o}C of maize growing period of Bako 2007-2009.

In the year 2009, the rain was uneven in distribution and stopped at grain filling stage of the crop (Fig. 1). Due to its higher disease severity, the four times ploughed plots had better yield than other treatments. Due to failure, of timely rainfall the last ploughing was delayed until mid-May. In this type practice, GLS infested maize residue will be buried in the soil and the pathogen dies after few months. A tillage practices that reduce initial inoculums from previous crop residue have been suggested as one of the possible disease management practices where external inoculums are minimal (Payne and Waldron, 1983; Payne et al., 1987). However, exercising minimum tillage adjacent to conventional tillage field will increase external inoculums of GLS. The impact of infested residue levels on epidemic development is not serious under dry weather condition. Therefore, conservation tillage is encouraged only in moisture stressed and in low risk or less favorable area for maize GLS disease development (Ward and Nowell, 1998).

The planting date data showed that early planted crop was infected earlier but the disease development was slower than in optimum and late planted maize. On tillage practices little or no information was available in the country to control GLS disease of maize and this study provides additional useful information on disease management aspects that can be included in integrated disease management practice as a component. Further study on time, tillage practices with different types of farm implement rotations, yield losses, chemical control, and variety with different maturity groups, plant density, soil fertility irrigation and management strategies should be tested under different agro-ecology to give more information about disease management.

CONCLUSIONS

From this experiment the following conclusion and recommendation can be made:

1. Increased ploughing frequency (four times ploughing) resulted reduced disease severity and higher grain yield compared to the other two treatments (conservation and three times ploughed plots). However, economic analysis is very important.
2. Among the planting date, early planting gave higher grain yield than the late sowing date.
3. In moisture stress and dry land region where GLS is at lower risk, conservation tillage with early planting may give better result. Only in area where moisture stress is major problem, using conservation tillage is more appropriate.
4. Further, more conventional tillage practice can be exercise even in hot and dry area in minimizing primary inoculums better than conservation tillage.

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