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Distribution and Status of Maize Common Smut (*Ustilago maydis*) at West Wollega, Ethiopia

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Abstract: Maize common smut assessment survey was conducted in the five districts of west and kellem Wollega zones namely Dale Sadi, Gimbi, Haru, Homa and Lalo Kile in 2015 during crop season. Among all cereals, maize is second to tef in area coverage in Ethiopia, but first in productivity and total production. Maize smut was seen as an outbreak at Kellam Wollega although it was not well known so before. The survey was conducted in 36 peasant associations (PA) and 67 fields in the five districts of the two zones. Stratified sampling technique was applied in the survey. Peasant association were randomly selected from all Districts and was based on randomly selected maize farm fields. The locations in each Peasant association were at least 4 km (by car speedometer) apart depend on the topography and the relative importance of maize production. The common smut surveyed was moved diagonally "X" shape from one angle to other angle points using 3m x 3m (9 m^2) quadrates. Prevalence of maize common smut was 100% in all the districts and the exotic disease species have recently been introduced to the two Zones. This common maize smut was how to introduce not well known. The lowest and highest disease incidence recorded in Haru and Dale Sadi 14.65% and 22.99%, respectively. Dale sadi was recorded the highest average severity of 23.55%, followed by Lalo Kile District with an average severity of 21.7% and the Haru District with lowest disease severity record of 16.21%. The linear regression showed that highly significant different (p<0.01) and for each 100 m decrease in altitude disease incidence and severity of maize smut at (dough stage) increase by 0.212% and 0.232% respectively. The objectives of this study were to determine the prevalence, incidence and severity of maize common smut species in two Zones.

Keywords: *Ustilago maydis*, Maize Common Smut, Distribution, Status

1. Introduction

Maize is the cereal which has had more importance in the economy sector worldwide during all the 20th century and the beginning of the 21st. It is one of the main staple crops that is grown worldwide. Following rice (*Oryza sativa* L.) and wheat (Triticum aestivum L.), it is the third most important cereal crop in Sub-Saharan Africa [1, 2]. Traditionally maize is used for human consumption (white maize) [1] and for animal feed (yellow maize) [2].

In diverse agro climatic conditions, it is one of the most important strategic crops selected for food security mainly due to its high productivity and wider adaptability. Among all cereals, maize is second to teff (*Eragrostis tef*) in area coverage in Ethiopia, but first in productivity and total production [3]. Maize is currently produced by more farmers than any other crop. According to the agricultural sample survey 2017/18 provided by central statistical agency of Ethiopia, at the national level, there are about 10,573,934.00 maize cropping smallholder farmers.

In mid altitude regions of south, west and North West, maize is normally growing in the main rainy season starting from March to November and depending on maturity groups and onset of rains for each location [4]. Corn is Ethiopia's largest cereal crop in terms of total production, area planted, and number of farm holdings. Maize accounts for 16.79% of the total area covered by cereal and around 27.43% of the total cereal production [5]. In addition to the highest total production per annum and the highest per hectare yield. Maize is also the single most important crop in terms of number of farmers engaged in cultivation [6].

Unknown disease may appear and cause loss. Therefore,

regular surveillance for unknown disease and knowledge on the scope and intensity of damage cause by any known disease is crucial. Decade was given to disease survey, loss assessment, screening of maize genotypes against economically important diseases, chemical, cultural and botanical management and study on ear, kernel and stalk rot diseases [7].

Smut *(Ustilago maydis)* a fungus disease of maize, causes smut masses to form that may be seen on any parts of maize plant roots, stalks, leaves, ears and tassels. The smut masses at the first are covered with white membranes that latter rupture and expose the black sooty spores. These spores carry the fungus over winter and produce secondary spores that may infect the succeeding crops. Infection may take place at any time during the growth of plant [8].

Periodical surveillance to identify the status (severity and prevalence) of economically important crop disease is crucial to decide the damage level and declarer management options. Maize smut was seen as an outbreak at Kellam Wollega although it was not well known so before. Frequent report of maize smut damage was observed from different districts of the administrative zones regardless of cultivars and cropping system used. Economic impact, its status, distribution factors

with the current outbreak was not studied and documented. Thus, this survey was initiated with the objectives of assessing the distribution, incidence and severity of common maize smut at Western Wollega.

2. Materials and Methods

2.1. Description of the Study Area

The Field survey was conducted in Western Oromia in west and kellemWollega Zones during 2015 main cropping season. The common smut assessment survey was conducted in the five districts of west and kellemWollega zones namely Dale Sadi, Gimbi, Haru, Homa and Lalo Kile. In most of the areas, the survey was conducted after dough to maturity growth stages of maize ear. The survey was conducted from 30th September to 8th October 2015. The annual mean minimum and maximum temperature of the area is 12°C and 27.4°C, respectively, while the annual rainfall is 1415.2 mm. The geographical locations of the surveyed areas were located in a range of longitude and latitude of 08°50.124'-09°12.322'N and 035°10.316'-035°54.280'E, respectively.
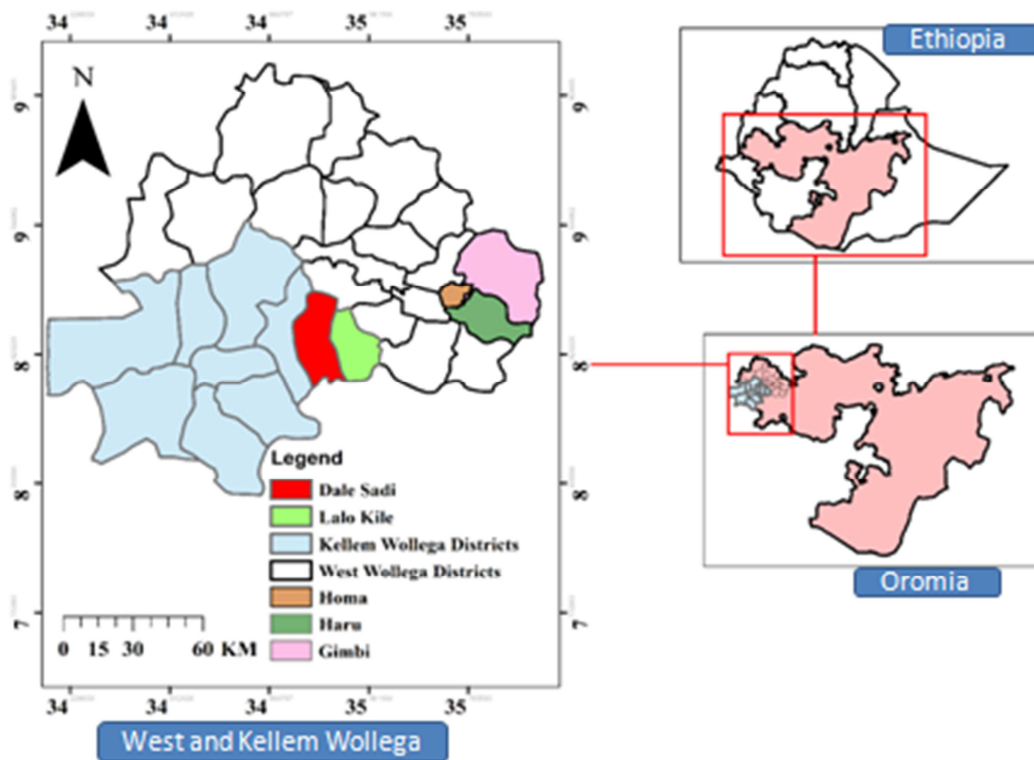

Figure 1. Map of Ethiopia and West and Kellem Wollega showing the surveyed Districts.

2.2. Maize Common Smut Field Assessments

Common smut survey was conducted in five districts of West and Kellem Wollega zones during main seasons of 2015 in all five districts of two Zones in western Oromia regional state. The five districts had almost near to mid highland (1467-2011 meters above sea level) agro-ecologies. In this area most farms are covered by maize and followed coffee

plantation. The survey was conducted in 36 peasant associations (PA) and 67 fields in the five districts of the two zones. Stratified sampling technique was applied in the survey. Peasant association were randomly selected from all Districts and was based on randomly selected maize farm fields. As a result, PAs were distributed as follow: Gimbi 10 samples, Haru 15 samples, Homa1 3 samples, Lalo Kile 17

samples and Dale Sadi 12 samples. The locations in each PAs were at least 4 km apart and the distance locations depended on the topography and the relative importance of maize production within each location. The common smut surveyed was moved diagonally "X" shape from one angle to other angle points using 3m x 3m (9 m^2) quadrates and some questioner rise to farmers. In each field, plants within the quadrates were counted and recorded as diseased/infected and healthy/non-infected and the different parameters were measured as follows. Disease incidence (DI) was the proportion of common smut infected plants to the total number of plants in the quadrate and it is calculated as:

$$DI\ (\%) = \frac{number\ of\ diseased\ plants}{total\ no.of\ plants\ in\ quadrate}\ X\ 100$$

Disease Severity: was expressed as the percentage or proportion of plant area affected by maize common smut disease. More often, disease assessment scales were used to express the relative proportions of affected tissue at a particular point in time. Diseased plants were classified into five classes according to the size of gall in order to have the disease severity expressed as percentage severity index (PSI) as adopted by Johnson IJ, according to this scale, the actual ear area covered by common smut was estimated [9]. Disease severity was assessed by counting all plants from a single quadrate and added all in five quadrates in single field sample. Finally the average of five quadrate numerical rating was converted to percentage severity index (PSI) using the equation suggested by [10] formula.

$$PSI(\%) = \frac{\sum Individual\ numerical\ ratings}{(Total\ number\ of\ plants\ assessed\ x\ Maximum\ score\ in\ the\ scale)}\ x\ 100$$

Other independent variables like Altitude of the field in meters were estimated by using GPS. Growth stage of the crop at time of assessment was obtained by visual observation using Zadoks scale. Types of cultivars, Date of planting, Agronomic practices such as number of cultivation, frequency of weeding, fertilizer use were obtained by asking the farmers. All the parameters measured were analyzed by using descriptive statistical analysis over peasant associations, districts and altitude ranges.

Table 1. *Disease rating and description of disease symptom used for assessment of maize common smut diseases.*

Scale	description
0	Very small gall (< 2.5 cm in diameter)
1	Small galls (2.5 to 5 cm in diameter)
2.5	Medium galls (5 to 10 cm in diameter)
5	big galls (> 10 cm in diameter)

Source; [9]

3. Results and Discussion

3.1. Importance of Maize Common Smut

A total of 68 fields were surveyed in five districts of West and Kellem Wollega Zones. Disease incidence of maize common smut in the fields was computed for peasant associations, districts and the entire study areas. The indicated analysis shows that maize common smut incidence among peasant associations and districts appeared similar (Table 3). The overall mean incidence at district level was 18.5% within the surveyed areas.

3.2. Disease Distribution

Prevalence of maize common smut was 100% in all the districts (Table 3). This exotic disease species have recently been introduced to the two Zones. The maize common smut is now recognized as a serious problem of maize production in the area, particularly in two Zones (from field interview). This maize common smut was how to introduce not well known because any literature no written the domestication of such disease in the country in all the surveyed areas the rainfall distribution was normal distribution and not significant different from previous seven to eight years. The disease outbreak 2013 production year in Dale Sadi, Dale Wabara and Lalo Kile only for the first time and the disease was expanded to other districts in 2014 production year. In surveyed year 2015 almost every districts in the Zones affected (Districts and two Zones office of Agriculture and Ruler development report). Most of farmers not know any information about maize common smut disease and its controlling methods (From interviews).

Table 2. *Metrology data last ten years (annual temrature and rain fall).*

year	annual mean minmum temprature	annual mean muximum temprature	annual mean rain fall
2006	13.2	25.5	1322.7
2007	13.2	25.8	1201.5
2008	13.1	25.3	976.7
2009	13.5	25.6	1279.3
2010	13.3	27.2	1421.1
2011	12.8	24.8	1044.6
2012	13.2	25.7	1453.9
2013	13.2	25.1	1795.3
2014	13.1	24.6	1415.2
2015	12.9	25.3	1474.4

Source =Dambi Dolo local metrology station.

Table 3. *Disease prevalence, incidence and severity of maize common smut in five districts of West and KellemWollega zones.*
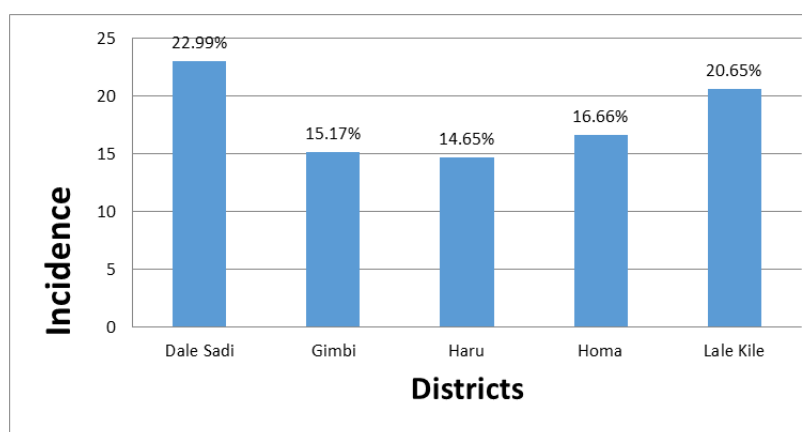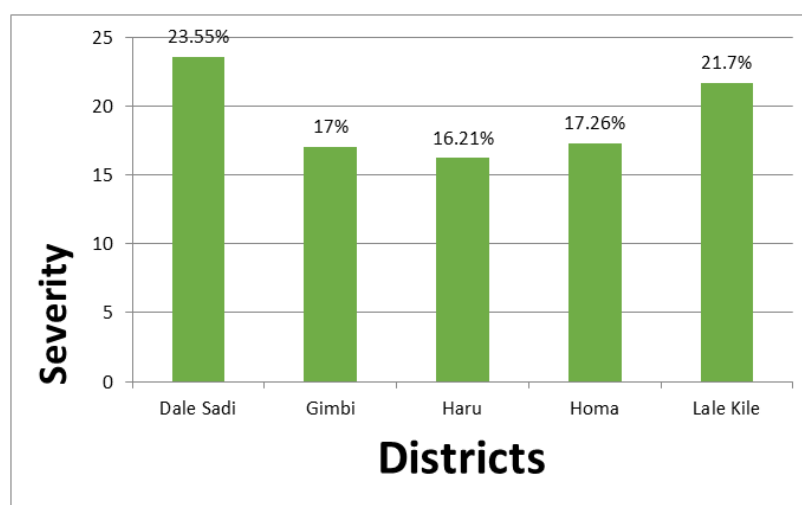
Districts	Prev. (%)	Inc. (%)	Sev. (%)	Disease Incidence class						Diseases severity class					
				L	%	M	%	H	%	L	%	M	%	H	%
Dale Sadi	100	23	23.6	4	33.3	7	58.3	1	8.3	4	33.3	7	58.33	1	8.3
Gimbi	100	15.2	17	8	80	2	20	0	0	8	80	2	20	0	0
Haru	100	14.7	16.2	11	73.3	4	26.7	0	0	11	73.3	4	26.67	0	0
Homa	100	16.7	17.3	9	69.2	4	30.8	0	0	8	61.5	5	38.46	0	0
LaleKile	100	20.7	21.7	6	40	9	60	0	0	5	33.3	10	66.67	0	0

Prev = Prevalence, Inci = incidence, Sev = Severity, L=low disease class designated 0_20% Incidence and Severity), M =medium disease class designated from 20<x<40% (Incidence and Severity), H=high disease class is greater than 41% (Incidence and Severity).

3.3. Disease Incidence

The incidence of maize common smut in the fields was estimated for peasant associations (PA), districts and for the entire study area (Tables 4 & 5). A total of 67 fields were surveyed in five districts of west and kellemWollega zones. The lowest and highest disease incidence recorded in Haru and Dale Sadi 14.65% and 22.99%, respectively (figure 2). More than 58.21% of surveyed areas were categorized under low maize common smut incidence which was below 20%. At PA level, the highest incidence of 41.2% was recorded in Chole in Dale Sadi district while the lowest incidence of 3.2% was also recorded in Kombolcha Yonge PA in Haru district About 66.67% of the fields in Dale Sadi district, 60% of the fields in

LaloKile district, 30% of the fields in Homa district, 26.67% of the fields in Haru District and followed by 20% in Gimbi had incidence greater than 20% (Table 3). This study showed that common maize smut in all the districts was grouped under low to medium incidence category which ranging from 0%-40% (Tables 4 & 5). The common maize smut incidence of the zones showed that disease was relatively higher in Dale Sadi and Lalo Kile districts, because these districts relatively low land which to cause wormer the Districts than the rest three Districts and the disease have seen for the first time 2013 in these districts. Corn smut was adapted to worm weather. Temperature for spore germination is 26.7-36.1 C0 which is considerable higher than for many other smuts [11].

Figure 2. Maize common smut incidence in five districts.

Figure 3. Maize common smut Severity in five districts.

3.4. Disease Severity

Severity of Maize common smut was recorded and found to vary from low to high at districts and PA levels (Tables 4 & 5). Dale sadi was recorded the highest average severity of 23.55%, followed by Lalo Kile District with an average severity of 21.7%, Homa District 17.26%, Gimbi District with 17.0% and the Haru District with lowest disease severity record of 16.21% (figure 3). Severity was below 20% for majority PA's in Haru, Gimbi and Homa districts. Similarly, severity of the disease majority PA's was between 20% - 40% at Dale Sadi and Lalo Kile districts (Tables 4 & 5). The overall maize common smut severity mean was 19.0% for the five districts in West and Kellem Wollega zones indicating maize common smut was important in the all surveyed areas. Disease is the most responsible cause for the damage of the maize towards the reduction of yields and quality of productions at all five surveyed area of maize grown.

Table 4. *Maize common smut incidence and severity in the peasant associations of two districts of KellemWollega zone.*

Districts	PA	No. of field assessed	Incidence (%)	Severity (%)
Dale Sadi	Arere Gabi	2	23.4	20.75
	Arere Laku	1	31.3	32.4
	Arere Ogiyo	2	27.15	30.4
	Chole	4	29.78	29.43
	Gandaso	1	20.5	21.2
	Gonsidaraba	1	13.5	14.3
	Hawitu Gandaso	1	15.3	16.4
			22.99	23.55
			±1.56	±1.8
LaloKile	Amarokocho	2	16.4	16.9
	Bila Bube	3	28.1	28.77
	Dagno Dumuga	1	18.8	20.7
	Farda Jami	2	19.4	20.34
	Jenu	1	11.8	13.4
	Lalo Ganda 1	1	20.3	21.7
	Lalo Ganda 2	1	20.3	22.1
	Mangoso Jiru	1	24.5	25.4
	Madfo	2	26.5	27.4
	Sago	1	28.8	26.4
	Odongoru	1	13.4	18.5
	Wayu Badas	1	19.5	18.6
			20.65	21.7
			±0.30	±0.13

Table 5. *Maize common smut incidence and severity in the peasant associations of three districts of West Wollega zone.*

Districts	PA	No. of field assessed	Incidence (%)	Severity (%)
Gimbi	BikiltuTokuma	5	10.9	12.1
	Lalisa Iyasus	4	11.01	12.2
	LalisaYamsi	1	23.6	26.7
			15.17	17.0
			±3.98	±3.31
Haru	Chonge	1	28.9	30.3
	Gadi	1	26.5	28.6
	Golja Kata	1	9.2	10.1
	Guracho Ujumo	2	8.4	9.7
	Guracha Mulata	1	20.2	20.4
	Jitu 01	1	6.2	9.7
	Kake Adara	2	15.95	17.95
	KobolchaYonge	4	8.08	9.1
	Wara Baro	2	8.4	10
			14.65	16.21
			±2.57	±2.18
Homa	Bonjo Ganji	1	21.4	22.2
	Gonja Alata	1	12.2	15.5
	Homa Birbir	4	21.8	18.45
	Sewa Gorgis	1	20.3	20.5
	Siba Iyasis	4	11.5	12.2
	Siba Matiyos	2	12.75	14.7
			16.66	17.26
			±0.22	±1.06

Figure 4. *Sample of common maize smut disease.*

3.5. Cultivars Grown and Maize Common Smut

The growers in the surveyed areas use six different kinds of maize cultivars namely, Agar, BH-543, BH-661, Limu, Local, and Shone. The most widely grown cultivar Shone occupied 36 (53.73%) fields in the surveyed five districts of the zones. Local 19 (28.36), BH-543 4 (5.97%), Limu 4 (5.97%), Agar 2 (2.99) and BH-661 2 (2.99%) of the surveyed fields (Table 6). Shone was more popular in the two zones but *Tircicum* leaf blight and gray leaf spot also important issue in the area. However, maize common smut frequency and degree of incidence and severity differ from cultivar to cultivars and field to fields. The study showed that all cultivars were affected. Even thought, different levels of common maize smut incidence and severity was observed on different cultivars grown indicating that some cultivars were less affected by the disease than others; Agrios stated that any maize cultivar, resistant to corn smut disease, had been unknown but some maize cultivars could be tolerant to U. maydis [12]. this may need further study to full reason out. But it may be due to the genetic makeup of cultivars which confer difference in resistance under different environmental condition to the maize common smut (Table 6).

Table 6. *Maize common smut incidence, severity by cultivars grown in the five districts of West and KelemWollega zones.*

Dostricts	Cultivar	No. of fields	Incidence (%)	Severity (%)
Dale Sadi	BH-661	1	20.5	21.2
	Local	4	28.43	29.2
	Shone	7	22.92	23.74
Gimbi	Agar	1	4.2	5
	Limu	1	9.1	8.3
	Shone	8	13.6	15.48
Haru	BH-661	1	10.59	9.45
	Local	9	14.47	16.37
	Shone	5	9.33	10.74
Homa	Agar	1	26.4	25.7
	BH-543	4	11	11.93
	Limu	3	20.8	22.87
	Local	2	18.3	18.8
	Shone	3	15.63	20.37
Lalo Kile	Local	4	17.05	18.23
	Shone	13	23.08	22.25

3.6. Common Maize Smut and Altitude

Linear regression of maize smut disease incidence and severity with altitude was established using regression analysis to look the effect of altitude on smut developments. The result linear regression showed that highly significant different ($p<0.01$) and for each 100 m decrease in altitude disease incidence and severity of maize smut at (dough stage) increase by 0.212% and 0.232% respectively. The value of coefficient determination (r^2) explain that 21.1% and 17.3% for disease incidence and severity affect maize respectively (figure 5). This is smut problem the surveyed districts of the West and kellem zones. Therefore, the disease needs critical management to save our farmers and environments.
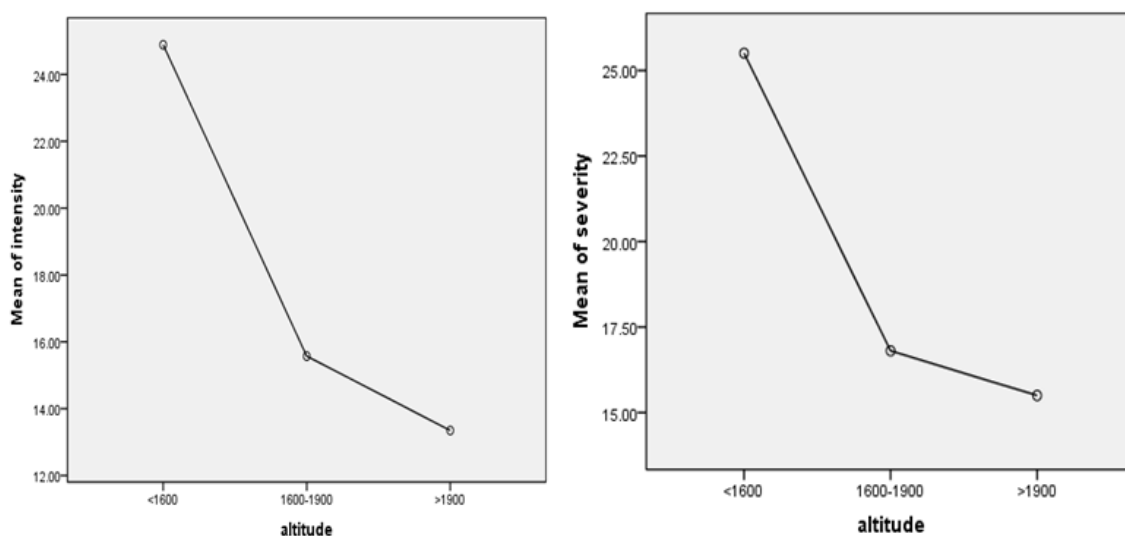
Figure 5. Maize common smut incidence, severity by their altitude in surveyed area.

4. Conclusions

Results from common maize smut survey in five Districts of West and Kelem Wollega zones reveals that common maize smut of maize was widely distributed in all surveyed area. The maize common smut is now recognized as a serious problem of maize production in the farms field, particularly in two Zones. The highest incidence and severity of smut 41.2% and 23.55% were recorded in Dale Sadi district, respectively. Dale Sadi and Lalo Kile districts were more devastated. The overall maize common smut severity mean was 19.0% for the five districts. The surveyed areas use six different kinds of maize cultivars namely, Agar, BH-543, BH-661, Limu, Local, and Shone. All cultivars were affected with maize smut disease. Most probably in the near future the severity common maize smut may increase because of new disease for new environment. It was for the first time that the disease was identified and recognized by researchers in the surveyed area. Therefore, since disease important it is better doing its management to predict its character and control method. Furthermore, every research institute and stakeholder should pay attention to U. Maydis, before affected livelihood of numerous small-scale farmers.

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