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Full Length Research Paper

Study on occurrence and importance of faba bean diseases with special consideration to the newly emerging "faba bean gall" in Tigray, Ethiopia

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Faba bean is one of the most important crops in Ethiopia. The production of the crop is, however, constrained by several disease infections including fungal diseases. A survey was conducted in 2013 to assess the occurrence and importance diseases affecting faba bean in south Tigray. The observed diseases were gall, chocolate spot, ascochyta blight, alternaria leaf spot, black root rot and rust in order of their prevalence. The overall mean incidences of 66, 45.5, 45.9, 28.9, 5.7, 1.1, and 0.4% and with severities of 64.4, 47.5, 15.3, 7.7, 11.8 and 0.2%, respectively. Faba bean gall was the most devastating newly identified disease in Tigray. The severity of the disease ranged from 30% in Emba-Alaje to 100% in Ofla, Enda-Mekoni and Raya-Alamata districts indicating the seriousness of the disease in the area. In addition, improved varieties were relatively tolerant to most identified diseases as compared to the local cultivars except for the new "gall" disease wipes-out fields without any tolerance. Hence, it is very important to use integrated management tactics and risk forecasting that operate on different aspects of the disease etiology.

Key words: Disease, faba bean, gall.

INTRODUCTION

Faba bean is botanically known as *Vicia faba* L.; with the common names including broad bean, horse bean, tic bean and field bean, is one of the earliest domesticated food legumes in the world, probably in the late Neolithic period (Metayer, 2004). Faba bean is used as an important human food in developing countries and as an animal feed in industrialized countries. Feeding value of faba bean is high and this legume has been considered as a meat extender or substitute due to its high protein content (20 to 41%) (Crépona et al., 2010). It has been produced for centuries in Ethiopia and provide the much needed protein supplement to the diet of rural households, which otherwise includes mainly cereals or root crops. From the economic standpoint, faba bean is a source of cash to the farmers and foreign currency to the country. Ethiopian farmers are also cognizant of the role of legumes in general and faba bean in particular in improving soil health by fixing atmospheric nitrogen, and widely use them in rotation with cereals (Sahile et al., 2008). It takes the largest share of the area and production of the pulses grown in Ethiopia including Tigray region. It occupies close to 574, 060 ha of land

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with annual production about 943, 964.2 tones. In Tigray region, it covers an area of 18, 580 ha and production of 32, 175.2 tons annually (CSA, 2013).

Even though Ethiopia is the world's second largest producer of faba bean after China, its share is only 6.96% of world production and 40.5% within Africa (Chopra et al., 1989). The average yield of faba bean under small-holder farmers is not more than 1.6 t ha^{-1} (CSA, 2013). The low productivity of the crop is attributed to susceptibility to biotic and abiotic stresses (Mussa et al., 2008; Sahile et al., 2008). Of the biotic category, diseases are important factors limiting the production of food-legume crops as a whole and faba bean specifically in Ethiopia (Berhanu et al., 2003; Nigussie et al., 2008). More diseases are affecting faba bean, but only a few of them have either major or intermediate economic significance. Among them, fungi are the largest and perhaps the most important groups affecting all parts of the plant at all growth stages. Diseases such as chocolate spot (*Botrytis fabae* Sard.), rust (*Uromyces vicia-fabae*), black root rot (*Fusarium solani*), and foot rot (*F. avenaceum*) are among fungal groups that contributes to the low productivity of the crop (Berhanu et al., 2003; Nigussie et al., 2008).

Furthermore, a newly emerging disease known as "faba bean gall" incited by the pathogen *Olpidium viciae* Kusano causing up to complete crop failure over wide areas within short period of time and aggravates the diminution of yield to maximum nationwide (Dereje et al., 2012). Therefore, disease monitoring and surveillance are of paramount significant for sustainable faba bean production and tackle food insecurity. The assessment of diseases involves the measurement and quantification of plant diseases and is therefore of fundamental importance in the study and analysis of plant disease epidemics. Hence, the paper presents the major faba bean diseases with special focus on the newly emerging "faba bean gall" with respect to the distribution and economic importance.

MATERIALS AND METHODS

Study area description

The survey was conducted in south Tigray, Ethiopia. South Tigray is one of the seven administrative zones in Tigray National Regional State. It is bounded by Afar region in the East, Eastern zone of Tigray in the North, Amhara region in the South and South West. It lies 12°57'37''.19 North latitude and 39°31'41''.91 East longitude. The zone includes five districts namely, Raya-Alamata, Ofla, Enda-Mekoni, Emba-Alaje and Raya-Azebo. The former four districts are the major faba bean growing areas of the zone and the region as a whole.

Survey of faba bean diseases

The study was conducted in 2013 main cropping season (July to September) to determine the spatial and temporal occurrences of faba bean affecting diseases. Faba bean farmers' sown fields in the four districts and research experimental sites were included in the assessment. The survey trips was made following the main roads and accessible routes in each survey district, and stops were made randomly at every 5 to10 km intervals based on vehicles odometers. Five stops or samples were made in each faba bean field by moving in 'W' fashion of the fields using 1 m^2 quadrants and data were collected from individual quadrants. Data included were the number of affected and non affected plants per quadrant, the percent severity of each disease, the variety grown, the response of varieties to each disease and other pertinent data. The collected samples that is, five samples per field were used as one site after averaged. Hence, a total of 50 faba bean fields were surveyed from flowering up to maturity growth stage of the crop.

The assessment of each disease was based on the disease incidence, the number of diseased plants compared to the total number of assessed plants expressed as a percentage, and on the disease severity, as the infected area of tissue to the total area of tissue expressed as a percentage. The severity of the disease was examined visually on the whole plants within the quadrants and recorded as the percentage of plant part (tissue) affected, using respective scoring scale of each disease. Faba bean gall, chocolate spot, ascochyta blight and alternaria leaf spot severities were recorded based on both the percentage of infected leaves/leaf and/or stem (for gall) area damaged and the extent of defoliation when scoring infection level symptoms on the foliage using a 0–9 scale (Bernier et al., 1985; Ding et al., 1993).

The following infection levels on the scale were used: 0, no visible infection on leaves; 1, a few dot-like accounting for less than 5% of total leaf area; 3-4, discrete spots/galls less than 2 mm in diameter, accounting for 6 to 25% of leaf area; 5, numerous scattered spots/galls with a few linkages, diameter 3 to 5 mm, on 26 to 50% of leaf area with a little defoliation; 6, confluent spot lesions/galls accounting for 51 to 75% of leaf/stem area, mild sporulation, half the leaves dead or defoliated; 7, complete destruction of the larger leaves, spot lesions/galls covering more than 76% of leaf area, abundant sporulation,; 8, 80% of the defoliated and plants darkened and dead; 9, disease covering more than 80% of the foliar tissue heavy defoliation and plants darkened and dead. The severity of black root rot was determined according to (Abdou et al., 2001) rating scale of 0 to 5 on the basis of root discoloration or leaf yellowing as follows, 0 = neither root discoloration nor leaf yellowing, 1= 1 to 25% root discoloration or one leaf yellowed, 2= 26 to 50% root discoloration or more than one leaf yellowed, 3= 51- 75% root discoloration plus one leaf wilted, 4= up to 76% root discoloration or more than one leaf wilted, and 5= completely dead plants. Scale (1 to 9) was used for the evaluation of the reaction of faba bean plants to rust under field conditions (Van Schoonhoven and Pastor-Corrales, 1987). For the simplicity purpose, the severities of the identified diseases were expressed in percentage (Zadoks and Schein, 1979). The prevalence of the disease was computed by using the number of fields affected divided by total number of fields assessed and expressed in percentage.

RESULTS

The occurrences and intensities of faba bean diseases during 2013 are presented in Tables 1 and 2. The survey results indicated that six diseases were found to be important throughout the inspected routes. Among them, faba bean leaf and stem gall disease was the most frequently occurring and devastating disease during the survey (Table 1).

It is for the first time that the disease was identified in Tigray region in 2013. The percentage of distribution or

Table 1. Prevalence and intensities of faba bean leaf and stem gall in south Tigray, in 2013.

District	Altitude range (m.a.s.l)	Total fields	Prevalence (%)	Incidence (%)		Severity (%)	
				Range	Mean	Range	Mean
Ofla	2125-2793	20	80	0-100	77.5	0-100	71.9
Enda-Mekoni	2423-2938	14	78.6	0-100	43.9	0-100	63.8
Emba-Alaje	2463-2767	11	36.4	0-25	9.1	0-30	22.5
Raya-Alamata	2200-2517	5	40	0-5	2	0-100	85
Total/mean	2125-2938	50	66	0-100	45.5	0-100	64.4

Table 2. The percentage distribution and intensities of the main faba bean diseases in South Tigray in 2013.

District	Altitude range (m.a.s.l)	Total field	Chocolate spot			Ascochyta blight			Alternaria leaf spot			Root rot			Rust		
			Pre	Inc	Sev	Pre	Inc	Sev	Pre	Inc	Sev	Pre	Inc	Sev	Pre	Inc	Sev
Ofla	2125-2793	20	65	55.8	61.6	40	8.5	8.8	10	0.3	3	5	40	20	0	0	0
Enda-Mekoni	2423-2938	14	57.1	34.6	45.1	64.3	34.6	25.6	7.1	2.1	10	9.1	2	4.5	0	0	0
Emba-Alaje	2463-2767	11	63.6	33.3	13.6	81.8	40	9	72.7	22.7	7.8	7.1	5	10	18.2	1.8	0.9
Raya-Alamata	2200-2517	5	80	66	20	80	70	18	60	5.2	10	40	6	12.5	0	0	0
Total/mean	2125-2938	50	64	45.9	47.5	60	28.9	15.3	28	5.7	7.7	10	1.1	11.8	4	0.4	0.2

Pre: Prevalence; Inc: Incidence and Sev: Severity.

prevalence of the disease was of 66%. Faba bean leaf and stem gall was highly distributed in all surveyed districts namely: Ofla, Enda-Mekoni, Raya-Alamata and Emba-Alaje with prevalence values of 80, 78.6, 40 and 36.4%, respectively. The incidence range of the disease varied from 5% in Raya-Alamata to as high as 100% in Ofla and Enda-Mekoni districts. The mean incidence of gall was 77.5 and 43.9% in Ofla and Enda-Mekoni districts, respectively. The severity of the disease ranged from 30% in Emba-Alaje to 100% in the rest of three districts. The mean severity value of the disease in Raya-Alamata, Ofla, Enda-Mekoni and Emba-Alaje were 85, 71.9, 63.8 and 22.5%, respectively. The intensity of the disease escalated as the increase of elevation.

The prevalence of chocolate spot in all districts was higher than 57%. It was highly distributed in Raya-Alamata (80%), Ofla (65%) and Emba-Alaje (63.5%). The overall incidence of chocolate spot was reached 45.9%. The severity of the disease was higher in Ofla and Enda-Mekoni with mean values of 61.6 and 45.1%, in that order (Table 2). In similar way, ascochyta blight was also among the diseases identified during the year. The prevalence of this disease was greater than 60% in Enda-Mekoni, Raya-Alamata and Emba-Alaje. The intensity (incidence and severity) of ascochyta blight was also higher as that of its prevalence (Table 2). In addition, alternaria leaf spot and black root rot were also among the diseases found throughout the surveyed routes. Alternaria leaf spot was dominantly present in Emba-Alaje (72.7%) and Raya- Alamata (60%). The incidence of disease was 22.7% in Emba-Alaje, while, lower than 6% in the rest of districts. Black root rot was found in all surveyed districts with less than 10% mean incidence except in Ofla district reached 40%. Faba bean rust was rarely found only in few localities of Emba-Alaje District (Table 2).

Most of the varieties grown by the farmers were affected by one and/or more of the identified diseases. Among the cultivated faba bean varieties, improved varieties (Walki, Moti, CS20DK, and Gebelcho) were relatively tolerant to most diseases except faba bean gall as the compared to local cultivars. The percentage

Table 3. Response of faba bean varieties to different diseases (%).

Diseases	Improved released varieties			Local land races		
	Prevalence (%)	Incidence (%)	Severity (%)	Prevalence (%)	Incidence (%)	Severity (%)
Faba bean gall	37.5	20.04	38.5	92.3	59.1	69.2
Chocolate spot	58.3	34.8	23.8	73.1	58.7	54.8
Ascochyta blight	50	24.4	8	69.2	22.3	19.7
Alternaria leaf spot	12.5	11.7	7.7	42.3	1.2	7.8
Root rot	4.2	3.5	11.3	7.8	23	12.3
Rust	8.3	0.8	0.4	0	0	0

distribution of faba bean gall, chocolate spot and ascochyta blight on the local cultivar were 92.3, 73.1 and 69.2%, respectively (Table 3). The two most destructive diseases namely faba bean leaf and stem gall and chocolate spot were highly important and scored more than 50% mean incidence and severity on local cultivars. Likewise, the mean severity of gall and chocolate spot were 38.5 and 23.8% on the improved varieties, in that order, while other diseases were below 12%. All diseases affected both improved and local faba bean genotypes except for rust that was absent in the local (Table 3).

DISCUSSION

Diseases are the most devastating agents from an economic standpoint and the most difficult to protection efforts. This is mainly associated with complexity of pathogens and unavailability of fungicides to small scale farmers or due to the fact that their use in low input systems is not economically justifiable. Furthermore the importance and distribution of diseases varied as a result of climatic change and other bio-physical phenomenon. According to this study, six diseases; faba bean leaf and stem gall, chocolate spot, ascochyta blight, alternaria leaf spot, black root rot and rust in order of percent distribution. Among them, the newly emerging devastating disease “faba bean leaf and stem gall” was the most dominant both in terms of occurrence and intensity. This disease was characterized by the formation of chlorotic gall and then progressively enlarges to become light brown, circular or elliptical rough spots on both sides of the leaves and finally tissues decay (Li-juan et al., 1993). The industry of faba bean has been further complicated by addition of new disease in the region and the country as a whole. Though, the mechanism of introduction of faba bean gall to Tigray region is questionable; the disease was first reported in the country starting from 2010 at few localities (Dereje et al., 2012). Currently, the occurrence of the disease increased to an epidemic level in almost all fields for no crops to recover and any seed harvest (Dereje et al., 2012). Xing (1984) first identified the pathogen of the disease as *Olpidium viciae* by means of microscopic examination, inoculation, symptom and host range determinations. It was reported as new specie in 1912 in Japan. In 1936, S. Kusano confirmed that the small galls in Japan were caused by the same pathogen which had a wide host range, including faba bean and pea (Li-juan et al., 1993). In Tigray region, the production of faba bean in the area is now very much checked and farmers are frustrated by the nature of the disease. The distribution pattern of the disease was at escalating speed like fire-wood within short period of time. Furthermore, the occurrence of the disease at early growth stage of the plant aggravates the diminution of crop yield to maximum and wipes-out fields without any tolerance. The seriousness of the disease was linearly associated with the increases of elevation. According to Li-juan et al. (1993), the disease was more important at higher elevation between 2500 and 3400 meter above sea level. More recently, Dereje et al. (2012), reported that wider distribution of the disease at higher elevation (2500-3000 meter above sea level). The importance of disease has been getting more serious, because of the fact that most of the local available fungicides were ineffective to manage the disease.

Chocolate spot was among the widely distributed and importance diseases. According to Nigussie et al. (2008) and Teshome and Tagegn (2013) reports, chocolate spot was among the priority important diseases in Ethiopia. It is causing yield loss up to 61% in susceptible genotypes and 34% for tolerant genotypes

(Berhanu et al., 2003) and 62% yield loss in Tigray region (MRC, 1994). Ascochyta blight was also widely distributed disease in the area. However, lower disease severity was recorded with a peak value of 25.6% in Enda-Mekoni District. This is in line with the previous report that disease was categorized as minor in Ethiopia (Nigussie et al., 2008). In addition, alternaria leaf spot and black root rot were among the diseases identified during the survey. Nonetheless, the severity of alternaria leaf spot was not more than 10%. This is in line with the previous report that the disease was less important (Nigussie et al., 2008). Black root rot was found in all surveyed districts with less than 10% mean incidence except in Ofla reached 40%. However, according to the previous report black root rot was the second most important disease of faba bean causing up to complete loss in severe infection condition and when favorable conditions prevail (PPRC, 1996). This could be due to the environmental disparity and variety grown in a specific area. Faba bean rust incited by the pathogen *Uromyces vicia-fabae* was rarely occurred during the year. This could be due to the cool environmental conditions as most fields were surveyed at higher elevation (>2100 m). According to Nigussie et al. (2008) report that faba bean rust has no significant effect in the highland areas of Ethiopia, but, up to 2-15 and 14 to 21% yield loss has been recorded in lowland and midland areas, respectively. During the survey some improved varieties such as CS20DK, Walki, Moti, Gebelcho were showed relative tolerant to the identified diseases than the local cultivar. However, faba bean gall with an explosive character wipes-out most faba bean fields without any tolerance. Previous reports indicated that most improved varieties were moderately resistant to moderately susceptible for most faba bean fungal diseases (Nigussie et al., 2008), except for gall (Dereje et al., 2012). Hence, it is very important to use integrated management tactics and risk forecasting that operate on different aspects of the disease etiology, such that they complement each other and can be applied together in farmers' fields collectively to provide farmers with maximum economic return.

Conflict of Interest

The authors have not declared any conflict of interest.

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