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Review Article

Emerging and Reemerging Diseases of Common Bean (*Phaseolus vulgaris L.*) in Major Production Areas: In the Case of Ethiopia

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ABSTRACT

Common bean (*Phaseolus vulgaris L.*) is one of the important cash crops to Ethiopian smallholder farmers and an important agricultural commodity which contribute to export earnings. A total of twenty five common bean diseases were recorded in Ethiopia and this high value crop is constrained by Anthracnose, Rust, Web blight, Angular leaf spot, Leaf blight, Floury leaf spot, *Rhizoctonia solani*, *Fusarium* wilt, *Sclerotium rolffsii*, Common bacterial blight, Halo blight, Common bean mosaic virus and Root rot nematode. Among these diseases the major one is Anthracnose, Rust, common bacterial blight and Halo blight causing 100%, 85%, 62% and 45% yield loss respectively. However the newly emerging and the status of existing diseases were frequently changing based on climate variability. Except rust, anthracnose, halo blight and common bacterial blight is seed borne and easily spread long distance by seed. Use of seed from unknown source and importing common bean seed without inspection has an impact on countries economy. Common bean diseases can be managed by cultural, chemical and host resistance. Reducing initial inoculum source by field sanitation, burning of crop residues, crop rotation and planting healthy seed is among common bean diseases management. Disease free seed and resistant/tolerant planting materials is a source of common bean disease management options and reduce the distribution of seed borne diseases to new areas. Since major common bean diseases are seed borne, the seed import should have to pass through quarantine system of the country. Studies on epidemiological element should have to be conducted to identify the biology of common bean diseases to devise management options. Any planting materials should pass through quarantine system to the county before entering to production system. The research should intensively concentrate on germplasm screening to obtain multiple disease resistant varieties to replace susceptible common bean variety. Country wide survey is important for early detection of newly emerging diseases. In this review attempt has been made to summarize relevant scientific studies on this economically important crop, Common bean diseases such as Anthracnose, Common bacterial blight, Rust, Halo blight and associated factors in Ethiopia as well as its different disease management options, challenges and future prospects.

Keywords: Common bean; Ecology; Epidemiology; Management

INTRODUCTION

Common bean is legume crop which is consumed worldwide for its edible seeds and pods. It is the most important source of proteins for nearly five hundred million people in Africa, Latin America and the Caribbean particularly for low income earning households. Common bean is high source of different nutrition. This crop is one of the most important cash crops to smallholder farmers in many lowlands and mid land areas of Ethiopia. It is used as food in different form, i.e., the green unripe pods are cooked as vegetable and the ripe seeds cooked for "*nifro*" or boiled with mixed with sorghum or maize and the powder is consumed as "woti" using powder form.

In Ethiopia, common bean is grown under diverse climatic conditions from 1200 masl–2400 masl. It is grown primarily by small-scale farmers who have limited resources and usually produce the crop under adverse conditions such as low input use, marginal lands, and intercropping with competitive crops like sorghum, maize and some other perennial tree crops like coffee. The Rift valley area accounts for more than half of the country's common bean production, mainly the white pea bean type that is grown for export. However, productivity of common bean under the optimal management conditions, can reach to 2.5 ton to 3.0 ton per

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hectare. The national average yield of common beans in Ethiopia is 1.6 ton ha^{-1}, which is far below the corresponding yield recorded at research sites (2.5-3 tones ha^{-1}) using improved varieties. The average production in 2019 was 1.85 t/ha which is very far below the potential yield of the crop (Figure 1) [1].

LITERATURE REVIEW

Despite the importance of common bean in Ethiopia, total crop failure due to diseases has been common and sometimes farmers are forced to abandon their production due to excessive disease pressure in the field. The diseases that are threatening common bean production and productivity in Ethiopia is emerging and reemerging due to climatic change happening frequently. Fungal disease such as Anthracnose, Rust, Web blight, Angular leaf spot, Leaf blight, Floury leaf spot, *Rhizoctonia* spp, *Fusarium* wilt and *Sclerotium* spp; Bacterial disease such as Common bacterial blight, Halo blight; Common bean mosaic virus and Root rot nematode are among reported diseases on common bean. Among these in Ethiopia; Anthracnose, Rust, Common bacterial blight, Halo blight and Angular leaf spot are more important and widely distributed in the country, while the remaining are also important in some areas and much more restricted in their distribution. Therefore, this paper presents the emerging and reemerging disease of common bean in major production areas, economic importance and management options in Ethiopia [2].

Economic significances of common bean in Ethiopia

Common bean is grown for the export market and as food legume in parts of country. It is a major crop produced as staple food and for export market in Ethiopia. Now a day one can produce and sale to different markets in the county. Common bean is among legume which contribute to smallholder crop production, nutrition as a cost-effective source of protein and income as a high-value export crop. Ethiopian white canning beans are exported to Europe, Africa, the Middle East, South Asia and Far East (Figure 2) [3].

Due to high content of nitrogen, Common bean is used as improving soil fertility through biological nitrogen fixation, livestock feed, soil erosion control, source of fuel and a range of other benefits. Common bean is mainly cultivated in the East Shewa, South Shewa, Sidamo, Keffa, Gamo Gofa, Wollega, Gojjem and Hararghe areas (Table 1).

Common bean in Ethiopia is produced in almost all the regional states with varying intensity. Production is concentrated in two regions: Oromia and the Southern National Nationality Peoples Region (SNNPR), which account for about 85 percent of the total national production. The remaining 25 percent comes from Afar, Amhara, Tigray, Somali, Gambella and Benishangul-Gumuz. About 80-90 percent of the area allocated to common bean in SNNPR is designated for red varieties while the white varieties occupy10 percent-20 percent of the area [4].

Even though this crop has economic significance and wide area coverage, the national annual yield is low, ranging from 0.615 tons/ha-1.487 tons/ha between the years 2004 and 2010, but the productivity is better increased and the average yield in 2019 was 1.85 tons/ha (Figure 3). According to Atnaf, the current average common bean yield is 12 quintals per hectare, but research demonstrated 34 quintals per hectare, which is triple to national average yield [5].

Economic significances of common bean disease in Ethiopia

The production of this crop is not stable as needed due to biotic and abiotic factor. In 2014 at Central Rift Valley of Ethiopia, total loss occurs due to ellino. In this year drought affects the entire crop produced in this area. Beside ellino biotic factor is the limiting factor in production of common bean in Ethiopia. In Ethiopia several bean diseases are reported with different economic importance. A total of 25 diseases were recorded and characterized as a causal agent of common bean in the country [6].

The status of Anthracnose, Rust, Leaf spots, Mosaic and Bacterial blight listed as a major during 1967 in Ethiopia (Table 2). The remaining are either of intermediate or minor importance. In study conducted by Habtu indicate that, common bacterial blight was most severe, but rust and anthracnose were also observed.

The major diseases identified on haricot bean in this country include Bean rust, Bacterial blights, Anthracnose, viruses, Phoma blight and Root rots. Of these, Bacterial blights, Phoma blights, Anthracnose and viruses are seed-borne. Anthracnose, Rust, Leaf spots, Mosaic and Bacterial blight listed as a major during 1967 in Ethiopia; however during 1997-2002, the intermediate disease causing pathogens become emerge and become major disease causing pathogens (Table 3). This indicate that, the frequent climate change also favor and disfavor the variability and occurrence of plant disease (Figure 4) [7].

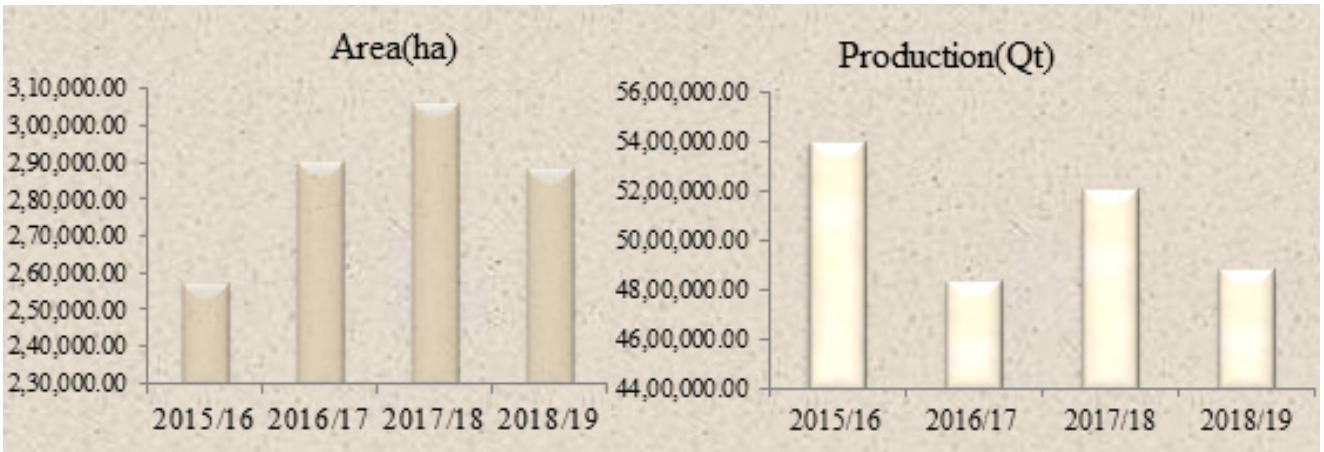

Figure 1: The status of common bean in area coverage and total production trend from 2015 to 2019 in Ethiopia.

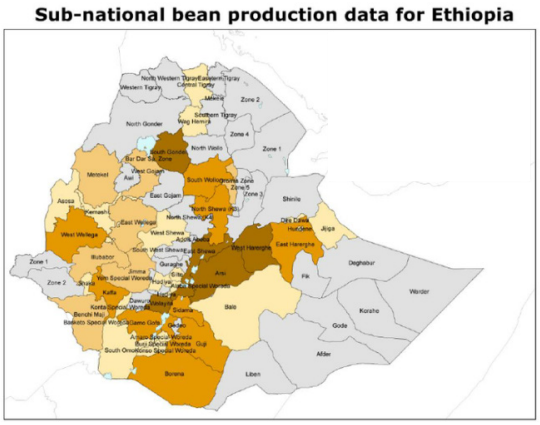

Figure 2: Common bean production and distribution in Ethiopia, 2007. **Note:** (▭) 0or Nodatya, (▭) 0-2500 Ha, (▭) 2500-5000, (▭) 5000-10000. (▭) 10000-25000.

Table 1: Agro-ecological zonation of major common bean production areas.

Zone	Region	Altitude(Masl)	Rain fall(mm)	Season
Central Rift Valley	East Shewa	1500-1700	450-950	Bimodal
	South Shewa	1500-1700	450-950	Bimodal
Eastern	Hararghe highland	1700-2200	950-1500	Unimodal
Southern	Sidamo	1500-1900	950-1500	Bimodal
	Gamo Gofa	1500-1900	950-1500	Bimodal
Western	Keffa	1500-1700	950-1500	Unimodal
	Wollega	1500-1700	950-1500	Unimodal
	Ilubabor	1500-1700	950-1500	Unimodal
	Gojjem	1500-1700	950-1500	Unimodal

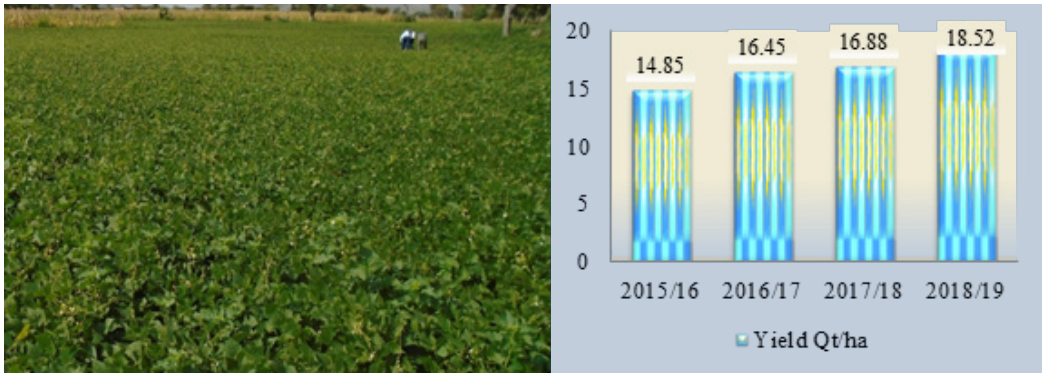

Figure 3: Picture taken from West Arsi Zone (Shalla) and yield per hectare in quintals (2015-2019).
Note: (▭) Yield Qthe

Table 2: Common bean diseases status in Ethiopia.

Common name	Causal agent	Status
Leaf Spot	*Ascochyta phaseolorum Sacc.*	Minor
Angular Leaf Spot	*Isariopsie sriseola Sacc.*	Major
Leaf Spot	*Ceraoapora zurunaris Ell.Sev*	Minor
Anthracnose	*Colletotriohum lindermthiamm*	Major
Stem Anthracnose	*C. trunatamm (Schw.)*	Minor
Leaf Spot	*Phyllosticta phaseolina (Sacc.)*	Minor
Powdery Leaf Spot	*Mycospaerella phaseoli*	Intermediate
Root-Rot	*Saterotiwn rofsii Sacc. It*	Intermediate
Rust	*Uromyces phaseoli*	Major
Common Bacterial Blight	*Xanthompnas campastria pv phaleoli*	Intermediate

Halo Blight	*P. syringae pv. Phaseolicola*	Intermediate
Leave/Leaf Spot	*Ceroosporidium spp.*	Minor
Leaf Spots	*Mycosphaerella pinodea*	Minor
Leaf Spots	*Periconia byssoides Pers. ex. Merta.*	Minor
Leaf Spots	*Phoma exigua Desm.*	Major
Leaf Spots	*P. phoselina Pass.*	Major
Pot Spots	*P. sorghina (Sacc.)*	Unknown
Mosaic	Virus/BCMV	Major
Root Rot	*Sclerotinia sclerotiorum (Lib)*	Minor
Wilt	*Fusarium solani (Mart.)*	Intermediate
Ashy Stem Blight	*Macrophomina phaseoti(maub1.)*	Minor
Leaf Spot	*Ascochyta sojicola Abaram off.*	Minor
Charcoal Rot	*Macrophomina phaseoli*	Minor
Leaf Spot	*Mycosphaerella creuenta (Sacc.)*	Minor
Bacterial Blight	*P. syringae pv glycinea*	Major

Table 3: List of pathogens causing diseases of common bean in Ethiopia, 1997-2002.

Causal agent	Common name	Distribution	Status
Colletotrichum lindemuthianum	Anthracnose	Wide	Major
Uromyces appendiculatus	Rust	Wide	Major
X. campestris Pv. Phaseoli	Common bacterial blight	Wide	Major
Rhizoctonia solani	Web blight	Limited	Major
Phaeoisariopsis griseola	Angular leaf spot	Limited	Major
Phoma exigua var. diversispora	Leaf blight	Limited	Intermediate
P. syringae pv. Phaseolicola	Halo blight	Limited	Intermediate
Mycovellosiella phaseoli	Floury leaf spot	Limited	Intermediate
Bean common mosaic poty virus	Bean common mosaic virus	Limited	Intermediate
R. solani, FOC, Sclerotium rolffsii	Root rots and wilts	Unknown	Minor

Figure 4: Picture showing symptom of common bacterial blight (from Boset, 2016).

The major disease identified on haricot bean during 1967 was Bean rust, Anthracnose, viruses, Bacterial blight and Leaf spot. Rust, Anthracnose and Leaf spot diseases are among major common bean diseases in Ethiopia since 1967. However, Common bacterial blight and Web blight is reemerged common bean disease in 1997-2002. Halo blight and Angular leaf spot is among major common bean a disease which requires management options.

Economic importance of common bacterial blight

Common bacterial blight is first reported in 1893, and the causal agent was named *Bacillus phaseoli* by Smith in 1897. After seventy four years, in Ethiopia the pathogen, *Xanthomonas campestris pv. phaseoli* is among the main constraints to common bean production. During the first report in 1967 the status of the pathogen is in categorized as intermediate. However starting from 1997 Common bacterial blight re-emerge and categorized as major disease causing agent. Since then this pathogen is major constraint in all common bean producing areas of Ethiopia. Efforts are made on the studies on disease variability, biology and management options since 1967 [8].

Disease symptoms first appear on leaves as small, water-soaked spots, light green areas, or both (Figure 5). As these spots enlarge, the tissue in the center dies and turns brown. Common Bacterial Blight (CBB) attacks leaves, stems, pods and seeds.

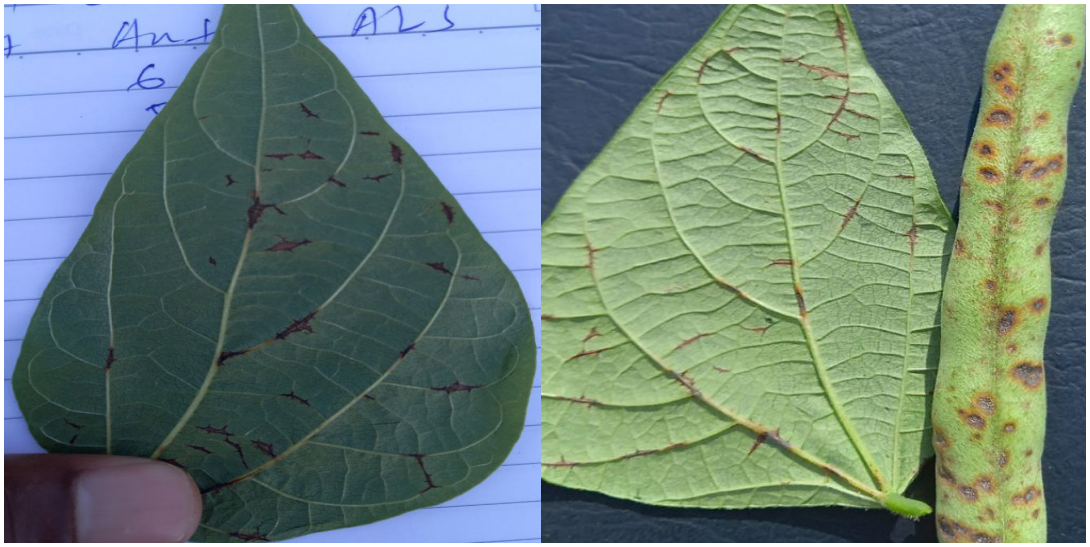

Figure 5: Figure showing severity of anthracnose on common bean, Picture taken by Endriyas G., 2021.

The causal agents of this pathogen are named and after several studies the species name are changed from *X. campestris* to *X. axonopodis*. Research finding indicates that, *Xanthomonas axonopodis pv. phaseoli* (Xap) and *X. axonopodis pv. phaseoli var. fuscans* (Xapf), is the most destructive bacterial disease of bean causing up to 62% yield losses. Yield reduction of up to 35% recorded by common bacterial blight in susceptible varieties of beans. In eastern Hararghe, in the 1999 and 2000 cropping seasons, an actual yield loss of 21% was reported due to Common bacterial blight.

Recent survey conducted by MARC in 2014 showed that, from assessed common bean growing districts Common bacterial blight average severity recorded was 40 percent. This indicates that, Common bacterial blight is important pathogen in Ethiopia [9].

Diversity of common bacterial blight

CBB pathogen belongs to the genus *Xanthomonas,* a Gram-negative group of γ-proteobacteria. During the time when the identification of *Xanthomonas* as a causal agent of CBB in 1897, the taxonomy of infecting strains has been debated, owing to their changing genetic diversity even in a common bean host. Until 1995, fuscous and non-fuscous strains were grouped in a single taxon, *X. campestris pv. phaseoli*. Following taxonomical revision of the genus *Xanthomonas, pathovar phaseoli* was transferred to *X. axonopodis,* with fuscous strains forming a variant within this pathovar. Previously in Ethiopia the causal agent are named as *Xanthomonas campestris pv. phaseoli*. However, now a day there is a change of name and revision on the characteristic features of the pathogen [10].

This Characteristic features by classical disease diagnosis should have to be confirmed in Ethiopia. During the 2003 cropping season a study by Selamawit showed that two variants/strains, including the fuscan type exist in the Central Rift Valley areas of Ethiopia. Similarly, the occurrence of *Xanthomonas axonopodis pv. phaseoli and Xanthomonas axonopodis pv. phaseoli var. fuscan* strains on common bean leaves were investigated from isolates in Eastern Amhara region of Ethiopia [11].

Ecology and epidemiology

Seed-borne nature of CBB in common bean has been established, and even some seeds without the disease symptoms were found to have infection from 10% to 12%. This suggests that visual assessment or direct inspection alone is not good enough to conclude on the magnitude of seed infection occurring in a particular seed lot. It survives in the soil, infected plant debris and seeds [12].

A number of factors influence temporal spread of the disease including cropping systems. Fininsa and Yuen reported that CBB develops more rapidly in sole stand of common bean crops than those intercropped with maize. According to the authors, intercropping delays CBB epidemic onset; reduces disease progress rate and area under the disease progress curve, as well as final disease incidence and severity [13].

During extended period of warm and humid weather, the disease can be highly destructive and causes losses in both yield and seed quality of bean in many production areas of Ethiopia. Minimum temperatures for growth range is between 5°C to 9°C and maximum temperatures range from 30°C to 39°C. The pathogen is a principal constraint in mid-altitude production areas and is favored by warm temperatures and high relative humidity. For disease epidemics, primary inoculum source plays a vital role in determining the level of CBB development and its effect on yield as well as seed quality. The Study conducted in eastern Ethiopia revealed that primary inoculum from infested debris is relatively more damaging than other inoculum sources, causing early epidemic development and yield reduction. CBB is major disease in mid altitude areas of the country which have similar result with recent survey conducted in 2014 by Melkassa Plant Pathology team. This pathogen is frequently seen than other diseases in the Central Rift Valley areas of Ethiopia [14].

Management of common bacterial blight

Cultural practice: Common bacterial blight management options include components that reduce initial inoculum source such as field sanitation, crop rotation whenever feasible, planting healthy seed, early incorporation of bean debris into soil, burning of crop residues and effective seed treatment. The pathogen is seed borne and planting the seed from certified and known seed source is best option. Rain splash is other spread method of CBB and keeping the common bean production field free of weed to reduce field

suffocation and free of Common bacterial blight. Reports on the efficacy of varietal mixture in the control of CBB in common beans are available from eastern and western Hararghe areas, Ethiopia [15]. For instance, varietal mixtures with the resistant variety, Gofta (G-2816), consistently reduce CBB incidence, severity, area under disease progress curve. Therefore, cultivar mixtures can be used as a component of integrated disease management scheme for food type's common bean. Bean-maize intercropping could also be component of CBB integrated disease management. The type of cropping system and crop growth stage influence the CBB severity and yield loss. Research conducted by Habtu In broadcast and mixed intercropping, for example, for each increase in CBB severity, about 5.2 and 9.1 kg ha^{-1} seed yield loss, respectively, occurred at physiological maturity [16].

Host resistance: Host pathogen interaction and breeding for disease resistance is the effective component in plant disease management. Resistance by itself is not sufficient alone, if it is not integrated with other disease management method. The various research systems in the country have managed to develop and release numerous haricot bean varieties that possess good level of CBB resistance. Gofta (G-2816) is one of the varieties which have resistant gene against CBB in Ethiopia. AG-7117 lines were reported from Turkey to be resistant to Xap. Mutlu developed an ABCP-8 genotype using resistance markers SAP6 and SU91 that showed greater resistance to common bacterial blight. Miklas, developed USDK-CBB-15, a dark red kidney, USWK-CBB-17 (a white kidney), and USCRCBB-20 (a cranberry) that had disease scores of 3.6 (the most resistant), 4.8, and 5.3. Marker assisted selection for disease resistant cultivar development is the classical method now the world is using. This experience should be practiced in Ethiopia, since there is diverse gene in wild type which can be used as a source of disease resistance [17].

Chemical control methods: Pesticide use in plant disease management is one of the components of integrated disease management approach. There is bactericide used to control CBB, when applied at the right time. Copper containing pesticide is effective to control this pathogen. Kocide, Copper hydroxide and bactericide is the best fungicide/bactericide which controls the pathogen. Fungicide such as Copper sulphate, Copper hydroxide, and Potassium methyl dithiocarbamate can control leaf infection. It is reported that application of copper-based bactericides could reduce population of the bacteria. Applying these contact bactericides early in the seasons can decrease the severity of bacterial pathogen [18, 19]. Foliar sprays of Kocide-101 chemical at the rate of 3.0 kg ha^{-1} at two times were reducing CBB epidemics on common bean, increased seed yield and yield components of the crop and net return over cultivars at Eastern Amhara Region of Ethiopia. Frequent use of single active ingredient made the pathogen to change the genetic makeup and results gene mutation. Therefore, availing different active ingredient having products will reduce resistance development among pests [20].

Economic importance of Anthracnose on common bean in Ethiopia

Bean anthracnose is caused by *Colletothricum lindemuteianum* and it was first discovered in Germany. The pathogen is distributed worldwide including Ethiopia and affects all vegetative anatomy as well as seeds. The disease anthracnose is a seed-borne disease and can easily establish to uninfected areas. In seed multiplication program on farmers' field, the released variety Roba-1 failed to give seed due to anthracnose in 2002 cropping season [21].

Disease symptoms on bean leaves are evident as dark, linear, and black to brick-red lesions found on the lower surface of the leaf and mainly seen at primary and trifoliate leaf stage along the veins. The most characteristic symptom of the disease is the black-red sunken cankers or spots that develop on infected pods (Figure 5). As these spots become older, the edges develop a black ring with a red outer border and show pink ooze in the center, which contains the spores of the fungus [22-25].

Anthracnose is among the destructive disease of common beans globally and in Kenya. The fungus is highly viable with more than 100 pathogenic variants and races reported in the scientific literature. Losses may be up to 100% under climatic and soil conditions favorable to the disease [26-30]. The fungus *C. lindemuthianum* can attack all aerial plant parts and may cause yield losses as high as 100%. The disease can inflict a huge yield loss in susceptible varieties. The yield loss of about 67% is observed in the susceptible bean variety Mexican-142 with anthracnose severity of 77 %. This pathogen becomes minor disease in some localities and major in humid, high rain fall areas of Ethiopia [31-35].

Ecology and epidemiology

Common bean anthracnose is particularly important in Uganda, Kenya, Tanzania, Rwanda, Burundi, Ethiopia and Congo. The initiation of anthracnose epidemics starts from primary inoculum sources (infected seed, infested debris and soil) and their effect on seed yield and quality. The primary inoculum sources had differential effect on levels of disease development assessed at flowering, podding, and yield and seed quality compared to treated seeds. Seed is the main means for spreading from year to year and from location to location [36-40].

For the epidemics of the pathogen environmental condition such as cool and wet weather favor the occurrence and yield loss. Temperatures of 13°C-26°C with an optimum of 17°C, relative humidity above 92% and free moisture favour the germination of spores and initial infection.

The spores of anthracnose can spread by insects, animals and man, especially when the foliage is moist. Frequent shower of the leaf and cool temperature is among climatic elements which further aggravate disease epidemics. Primary infection can occur anytime during growth at cool, wet weather however, secondary infections can occur from spores forming on infected plants and spreading in wind and splashing rain, or being transported on equipment [41, 42].

Management of common bean anthracnose

Cultural method: Growing common bean in cultivar mixture is one strategy of controlling anthracnose. Cultivar mixtures are among anthracnose management option by integrating at least 50% of a resistant cultivar can control the disease. The level of control achieved depends upon the proportion of the resistant cultivar in the mixture, i.e., the higher the percentage of the resistant cultivar in the mixture, the lower the disease severity. Bean debris previously infected should be removed after harvest to reduce winter survival and gradually to reduce the inoculum level. When plant parts are wet the pathogen easily sporulates and further spread from diseased plants to healthy ones. Seeds from previous infected field with anthracnose should not be used as planting materials. The

production of disease free seeds in the area where environments are not conducive for anthracnose is among integrated management options. Crop rotation for two years with non-associated crop is recommended to reduce inoculum source and the methods also serve to minimize inoculum load. Anthracnose of common bean can also be managed by hot-water seed treatment and resulting that the treated seed did not show germination problem [43-46].

Host resistance: The production and the use of anthracnose resistant variety is one management measure that is effective, safe and cheap in dealing with the disease. Glasshouse and field experiments were carried out to identify bean genotypes that are resistant to the Ethiopian isolates of *C. lindemuthianum* and as a result, genotypes Widusa, *GLP X 1132*, *A482*, *A 193*, *G-7*, *HAL 5* and *G 2333* were identified as sources of Anthracnose resistance. In addition, genotypes *RAZ-18* and *REN-20* possess field resistance to Anthracnose and Angular leaf spot. Some knowledge was gained during the past few years on the degree of variability in the pathogen [47]. This disease complicated by the presence of several forms or races of the fungus, and the fact that plants resistant to one race may be susceptible to another. In the common bean Anthracnose interaction, different genes having resistance been reported so far in different parts of the world. There is the source of Anthracnose resistance gene indicating that cultivars *AB 136* and *G 2333* could be used as sources of resistance in the bean breeding program since they are found to be highly resistant or immune to different races of *C. lindemuthianum* found in Africa, North and Central America [48].

Chemical control methods: Chemotherapy has a role to play in the control of Anthracnose, particularly in large-scale bean production. Data generated from efficacy trials on fungicides evaluation revealed that a combination of dressing common bean seeds with Benomyl and a foliar spray of bean plants with Difenoconazole or foliar application of Difenoconazole alone adequately protects common beans against Anthracnose. Benlate used as a seed dressing at a rate of 2 g/kg seed, Difenoconazole at a rate of 87.5 g a.i., per ha as a foliar spray reduced Anthracnose severity and incidence and increased the yield per plot and 100 g seed weight. Seed treatment by Mancozeb at a rate of 3 g/kg seeds followed by application of Carbendazim foliar spray at a rate of 0.5 kg/ha and Carbendazim seed treatment at a rate of 2 g/kg seeds followed by Carbendazim foliar spray at a rate of 0.5 kg/ha have been suggested to reduce Anthracnose severity and incidence [49].

Economic significance of common bean rust

Bean Rust (BR) caused by *Uromyces phaseoli* has a wide geographical distribution and one of the major common bean diseases occurring in most parts of Ethiopia. Although it can infect many species of *Phaseolus* it has been particularly damaging to haricot bean in this country. It pauses one of the most important production problems in areas such as Hawassa, Jimma, Bako, Hararghe, and Melkassa [50-55].

Common bean rust causes yield loss up to 85%. Bean rust caused by *Uromyces phaseoli* is widely distributed wherever common bean is grown and is one of the most economically important diseases of common bean, causing 25% to 100% yield loss in susceptible cultivars. The loss caused by Bean rust is mainly related to the reduction in the number of pods per plant which is directly resulted due to infection of photosynthetic parts. According to Habtu, the seed yield loss for each unit increase in rust severity ranges from 2.6% to 7.8% for every unit increase in rust severity. common bean disease assessment in Metekel Zone indicate that, less than 50% prevalence, 19.3% incidence and 2.5% common bean rust severity was recorded. This result indicate that in assessed environment the pathogen is not major [56,57].

Ecology and epidemiology

The intensity of *U. appendiculatus* is influenced by cropping system, geographical area, altitude and season. Based on climatic condition, the level of rust in humid and sub-humid agro ecologies is low and intermediate level of rust in sub-humid and moist agro-ecologies were reported. Similarly, the magnitude of the pathogen occurrence is based on location, weed management and plant density. Good indications are found in many common bean growing areas of Ethiopia [58].

Similarly, varietal proportion (susceptible: resistant) in a bean crop and geographic area play a role in determining the spread of the disease over space. Depending upon the location, the speed with which spores of *U. appendiculatus* travel in a bean crop with a mixture of 20% susceptible variety and 80% resistant variety is about 2.5 to 5 times slower than in a bean crop with a pure susceptible variety. In tropical and subtropical climates severe losses occur due to rust epidemics in common bean growing regions of the world [59].

Management of common bean rust

Cultural practice: Common bean rust can be managed by cleaning the field and removing alternate host grown around the field. Crop rotation, proper handling of the field by reducing succulence of the crop by weeding is the major activities in managing the pathogen. In the Hararghe highlands, for instance, rust incidence and severity, respectively, are reduced by about 25% and 16% in intercropping [60]. Growing common bean in cultivar mixture is one strategy of controlling common bean diseases. Growing resistant cultivar having 50% resistant reaction with cultivar mixtures can control the disease. The study on cultivar mixture indicate that, higher the percentage of the resistant cultivar in the mixture, the lower the disease severity. Bean debris previously infected should be removed after harvest to reduce winter survival and gradually to reduce the inoculum level [61].

Host resistance: There is genetic variability among varieties toward rust as stated by Habtu and Zadoks. Many of the genotypes exhibit multiple resistances (resistance to two or more of the major diseases): Common bean rust, Anthracnose, Common bacterial blight and Angular leaf spot. Among bean genotypes evaluate in the open environment where the major disease reported, *HAL-5*, *Atndaba*, *Awash Melka*, *Pan-173*, *A-197*, *TY-3396-1*, *Zebra*, *A-409*, *Bat-73*, *Bat24*, *Bonita nigra*, *Redlands pioneer*, *Xan-175*, *Emp-87*, *Emp-110*, *Hal-5*, *Pvad-1022*, *Pan 173*, *Pva-1145*, *Xan-41*, *Pan-64*, *Ica-15541*, *Icapijas*, *Xan-162*, *Zaa-84057*, *TY-3396-16*, *Bat-1629*, *G-3124*, *G-11044*, *G-19428* and *G-19792* showed multiple disease resistance reaction. Rust resistant bean varieties such as "Yocto Negro" are available in Ethiopia. The majority of the recently released varieties are resistant/moderately resistant to rust and two or more of haricot bean diseases. Most of bean variety in Ethiopia is horizontally resistant in which their resistance can be checked by environmental condition [62].

Chemical control: Recently recommended chemical are effective to this pathogen if appropriately applied at right time. In Integrated

rust management approach, application of fungicide can be a very effective tool for rust management [63]. Triazole (DMI, FRAC 3) fungicides, including Proline, Folicur and generics, are among the most effective rust products available. Fungicides such as Tebuconazole, Chlorothalonil, Propiconazole, Mancozeb and Maneb are effective in controlling rust, which is essential to improve economic return, requires good disease monitoring and a weather forecasting system [64].

Economic significance of halo blight on common bean

Halo blight is caused by *Pseudomonas syringae pv. phaseolicola* and the pathogen is a strict aerobe, and is rod shaped with a gram negative staining reaction. This pathogen is seed-borne and recently it is a major in common bean growing areas of Ethiopia. Among Common bean diseases, halo blight is major pathogen causing economic significance that can plague common bean production worldwide. Previously this pathogen is counted as intermediate in causing economic loss, but now a day it is very important pathogen which needs attention to find management option. Regarding the re-emerged pathogen called Halo blight there is some effort made to identify the distribution and characteristic features of the pathogen in Ethiopia [65]. It is not always possible to separate the losses caused by Common bacterial blight and Halo blight, since they often occur at the same time in the production field. However recent study reported that it causes yield losses of up to 45%. Additionally, the severity of blight varies depending on climatic conditions mainly, temperature, relative humidity and rain fall. Common bean yield losses estimated at 22% and 45% have been obtained by natural and artificial infections, respectively, in Colombia.

The characteristic symptoms of Halo blight are induced on leaves, stems, pods, and seeds. Initially the leaf symptoms appear as water-soaked spots which gradually enlarge and frequently coalesce with adjacent lesion. The tissues appear flaccid and lesions are often encircled by narrow area of lemon-yellow tissue when infected. After infection cell death develops and may become widespread enough to cause defoliation. The infection occurred when the pods were young; the seed may deterioration or crumpled and shriveled. If the bacteria enter by way of the funiculus, only the hilum may be discolored, but this is true only for white colored varieties and it is difficult to detect on dark-seeded varieties.

Ecology and epidemiology

The epidemics of halo blight occur when the temperatures are cooler and rapidly increase during the rainy period. Under high rainfall and humidity, the disease is severe, with maximum development around 28°C temperature. For *Pseudomonas syringae* development and cause yield loss the optimal temperature thrives is 20°C-23°C. Above 28°C, Halo blight disease symptoms will usually not develop even though some water soaked spots may be present. The cool and humid environments favor the pathogen, occurring in tropical and sub-tropical regions in Africa and South America. The pathogen gets in to the plant through wounds or stomata and hydathodes during periods of high relative humidity. Rain splash can allow the disease to spread rapidly, especially when there is a widespread wind to allow the bacteria to transmit even farther. Human or animal can also allow for the spread of the disease by contaminating the infected filed to uninfected areas through moisture. The mammal can spread the disease to a whole new environment and introduce the pathogen to new hosts (Figure 6) [66].

Subsequently halo blight invades the intercellular spaces, causing a gradual dissolution of the middle lamella. The stem is entered in three ways: *via* the stomata of the hypocotyl and epicotyl; through the vascular system of the leaf; or from infected cotyledons. The pathogen remains in the seed coat and when the seed germinates, resulting in infection of the newly emerged seedling. The bacterium can remain viable for several years beneath the seed coat during storage period and easily causes during the plantations if condition is conducive.

Management of common bean halo blight

Cultural practice: To early manage the epidemics of Halo blight, reduction of initial inoculum source such as field sanitation, crop rotation whenever feasible, planting healthy seed, early incorporation of bean debris into soil, burning of infected crop remains and seed treatment among the common recommended cultural practice. In addition, planting disease free seed, avoiding disease by suitable choice of planting date and crop rotation is among options. In spite of the importance of the disease much research attention has not been given to this disease on management options. Its economic importance increases now a day and this pathogen are counted as re-emerging disease in Ethiopia. Therefore, research on biology and epidemiology should be conducted and develop management strategies (Figure 7).

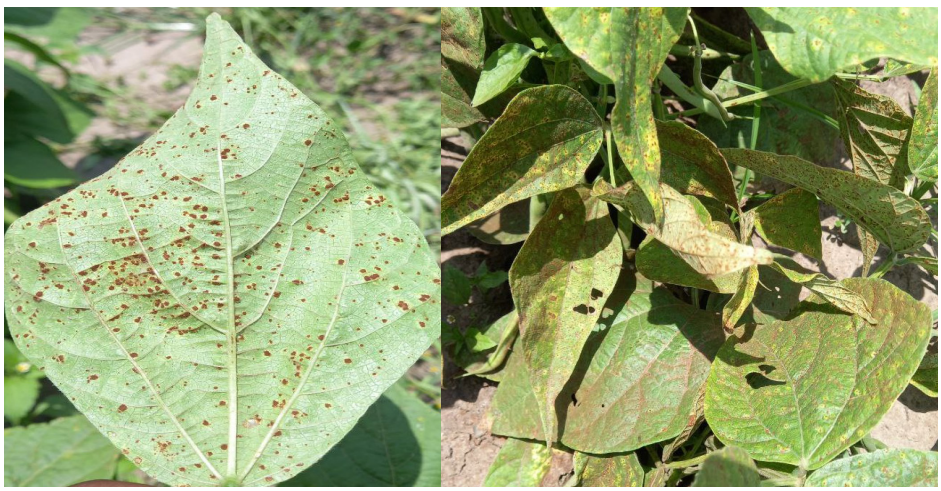

Figure 6: Sign of rust on common bean, Picture taken by Endriyas G., 2021 from Dugda district.

Figure 7: Halo blight symptom on mungbean and haricot bean.

Host resistance: Plant pathogen interaction for disease resistance is the effective method to reduce the effect of crop loss worldwide. Sources of disease resistance to major common bean diseases have been identified and used in cultivar development programs. Various sources of tolerance to Halo blight have been identified, but breeding is complicated by the fact that different genetic systems control the reactions in pods and leaves. Halo blight is cause by nine races, however race 1, 2, 5, 6 (the most common), and 7 are distributed worldwide. Designation of races has been defined by differential cultivar that means the reaction of specific bean cultivars to specific race. Information on race types and their variability are important for resistance breeding [67].

Chemical control: There is bactericide used to control Halo blight, when applied at the right time. Copper based pesticides are effective to control this pathogen. Kocide 2000, Copper hydroxide and bactericide is the best fungicide/bactericide which controls the pathogen. Mancozeb seed treatment at a rate of 3 kg seeds and such seed borne pathogen is managed by seed treatment with antibiotics i.e. streptomycin.

DISCUSSION

Common bean is used as sources of income to smallholder farmers and as exchange earning commodity worldwide. It is rich in starch and source of potassium, selenium, molybdenum, thiamine, vitamin B6 and folic acid. The green unripe pods are cooked or conserved as vegetable and the ripe seeds cooked for "nifro" or boiled with mixed with sorghum or maize and can be consumed as "*woti*" using powder form. The crop serve as soil fertility improvement, livestock feed, soil erosion control, source of fuel and a range of other benefits.

It is summarized that, this high value crop is constrained by Anthracnose, Rust, Web blight, Angular leaf spot, Leaf blight, Floury leaf spot, *Rhizoctonia solani*, *Fusarium* wilt, *Sclerotium rolffsii*, Common bacterial blight, Halo blight, Common bean mosaic virus and Root rot nematode. Among these; Anthracnose, Rust, Common bacterial blight, Halo blight and Angular leaf spot are more important and widely distributed. This review was made on economic importance of disease, disease ecology, disease epidemiology and management options of Common bacterial blight, Halo blight, Anthracnose and Rust. The maximum common bean yield loss identified as 100%, 85%, 62% and 45% was caused by anthracnose, rust, common bacterial blight and halo blight respectively.

CONCLUSION

In conclusion, except Rust, Anthracnose, Halo blight and Common bacterial blight is seed borne and easily spread by seed to long distance. Disease free seed and improved planting materials should be provided for the farmers to boost the production and productivity of common bean. Common bean diseases can be managed by cultural, chemical and host resistance.

It is recommended that, Common bean seed should pass through quarantine system to the county. The research should thoroughly concentrate on germplasm screening to obtain multiple disease resistant varieties to replace susceptible common bean variety. Country wide survey is important for early detection of newly emerging and identifying the status of existing diseases. Integrated disease management strategies should have to be developed by using compatible management options. Studies on epidemiological element should have to be conducted to identify the biology common bean diseases.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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