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Screening of Red Small Common Bean Genotypes for Resistance to Angular Leaf Spot and Cercospora Leaf Spot Disease of Common Bean at Bako Area

Abay Guta

Oromia Agricultural Research Institute, Bako Agricultural Research Center, Bako, Shoa, Ethiopia

Email address:
abbayg12@gmail.com

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Abstract: Common bean (Phaseolus vulgaris L.) is an important crop worldwide, comprising of both dry beans and snap (green) beans. The crop has significant economic importance both in income and food sources with high nutritional value in developing countries of Africa, Asia and Latin America. Despite the economic and food security importance of these crops, actual smallholder farm yields are by far below the potential production. The effect of diseases may be restricted to certain production systems, locations and cropping seasons. This activity was initiated to screen resistance or moderately resistance Common bean genotypes against to Angular leaf spot and cercospora leaf spot disease of common bean. 121 common genotypes were used in the experimental with arranged in simple lattice design two rows for one genotype. Disease severity was assessed from 8 per-tagged plants as the percentage with regular intervals using a 1-9 scale. The highest final angular leaf spot and cercospora leaf spot disease severity index was recorded G27 (61.7%) and G92 (38.3%) followed by G172 (60%), and G163 (37.7%) respectively. Among genotypes 121 genotypes, none was found immune or resistant, 49 genotypes found to be moderately resistant (10.1-20% severity), 61 genotypes found to be moderately susceptible (21.-50% severity) and 20 genotypes found to be susceptible (50.1-70% severity), for angular leaf spot and 3 genotypes was found immune or resistant (1-10% severity), 32 genotypes found to be moderately resistant (10.1-20% severity), 85 genotypes found to be moderately susceptible (21.-50% severity) and None of genotypes found to be susceptible (50.1-70% severity) to cercospora leaf spot, disease severity index respectively. In the study it was investigated that significant variation observed in angular leaf spot and cercospora leaf spot disease resistance, growth, grain yield and yield components among the 121 genotypes evaluated at Bako.

Keywords: Screening, Common Bean, Resistance, Disease

1. Introduction

Common bean (Phaseolus vulgaris L.) is an important crop worldwide, comprising of both dry beans and snap (green) beans. It is widely grown in the temperate and sub-tropical Africa and on other continents [1]. According to the study of Broughton *et al*. [2], the common bean is the most important legume consumed by man and 30% of the crop is produced by small-scale farmers in Latin America and Africa. The crop has significant economic importance both in income and food sources with high nutritional value in developing countries of Africa, Asia and Latin America [3]. The crop is rich in protein and micronutrients, such as calcium, folate iron, zinc, magnesium, phosphorus, potassium and vitamin B [4-6]. The crop offers the second most important source of dietary fiber for humans and the third most important source of calories among all agricultural products in Eastern and Southern Africa [7]. Although beans vary considerably in seed size, shape and color, their nutritional components are remarkably similar [8]. The edible leaves, pods and seeds are low in fat content but packed with protein, carbohydrates, vitamins and minerals [9].

Common bean is widely grown in Ethiopia and is an increasingly important commodity in the cropping systems of smallholder farmers for food security and income generation. The major production areas are in the Rift Valley areas and Southern parts of Ethiopia (SNNPR). Farmers grow a wide range of bean types, in terms of color and size, but the most

common types are the pure red and white beans. Most of the beans produced, traded and consumed in the domestic Ethiopian bean markets, are the medium and small red beans whereas white beans are virtually all exported. These market types of beans are a valued source of foreign exchange with an annual value in the range of USD 25-30 million [10]. Moreover, for more than 40 years it has been an export crop [11]. It is cultivated in a wide range of agro ecologies and farming systems including well-watered and drought-stressed areas [12].

Despite the economic and food security importance of these crops, actual smallholder farm yields are by far below the potential production. For instance, the national average yield of common bean is 1.15 t/ha (2011 cropping season) while the potential yield at research stations and researcher managed farmers' field is 3.4 t/ha [13]. There are various production constraints that contribute to the low yields of common bean.

Diseases are known to be the major factors, which directly or indirectly, affect the production of this crop in Ethiopia. Common bean is attacked by a wide range of diseases that affect leaf, stem, root, and seed. The major diseases that are threatening common bean production in Ethiopia include anthracnose [Colletotrichum lindemuthianum (Sacc. & Magnus) Lams. Scrib], rust (Uromyces appendiculatus), common bacterial blight (Xanthomonas phaseoli), halo blight (Pseudomonas syringae pv. phaseolicola), angular leaf spot (Phaeoisariopsis griseola), Ascochyta blight (Ascochyta phaseolorum) and bean common mosaic virus. Fungal and bacterial diseases are among the main production constraints in the major bean growing areas of the country [14]. The effect of diseases may be restricted to certain production systems, locations and cropping seasons [15]. Among the listed disease of beans in Ethiopia, common bacterial blight, rust, anthracnose and angular leaf spot are economically important [14].

Amongst the important and common fungal diseases affecting beans in the tropical and sub-tropical regions is angular leaf spot (ALS) caused by Pseudocercospora griseola (Sacc.) Crous & U. Braun [16, 17]. It is the second important limiting factor after nitrogen deficiency in Africa causing yield losses of 40 - 80% [18, 19]. Some conditions favor disease spread through accelerating pathogen proliferation, premature defoliation, reducing photosynthetic capacity, and retarding the grain filling process which eventually reduces yield [20].

Also Another most important common bean disease, is anthracnose caused by Colletotrichum *lindemuthianum* is the most devastating seed-borne disease of common bean [21] Infested debris and soils are among the potential sources of primary inoculum. Sharma et al. [22] reported maximum disease incidence and severity occurrence on highly susceptible cultivars on both seed-borne infection and background contamination. Also, the disease drastically affects the growth parameters and yield components in susceptible cultivars causing significant reduction in yield of both the crops raised from internally infected seeds and under background or surface contamination. Seed-borne infection causes more yield losses than background contamination. Further, the pod infection has direct effect on seed quality [22]. The pathogen causes an estimated yield loss of 63% in Ethiopia [23] and 42.4% at Haramaya [24].

In western parts of Ethiopia angular leaf spot and anthracnose are serious problem which most destructive disease. Anthracnose is the most common disease of white seeded common bean due to high rainfall intensity and warm temperature and it makes common bean out of production [25]. Previously, [26] reported that the intensity of anthracnose on white type common bean was higher at Bako. Therefore, we must find the solution to reduce it from being epidemic. The ideal and most economical mean of managing the common bean angular leaf spot and anthracnose disease would be the use of resistant genotypes. Thus, this activity was initiated with the following objective of to screen resistance, moderately resistance and susceptible Common bean genotypes against to Anthracnose and Angular leaf spot disease of common bean.

2. Materials and Methods

2.1. Description of the Study Area

The activity was conducted in Bako Agricultural Research Center (BARC). It is located at 9°05'33.366 N latitude and 37°02'41.202 E longitude and at an altitude of 1654 m.a.s.l. the annual mean minimum and maximum temperature of the is 14.5°C and 29.3°C, respectively, while the annual rainfall is 1605mm.

2.2. Experimental Materials and Design Used

121 common genotypes were used in the experimental study. A total of 121 treatments were arranged in simple lattice design two rows for one genotype with two replications and plot size was consisted of 3m×0.8m, between block 1m and 1.5m, an inter-row and intra-row spacing of 40 cm and 10 cm, respectively.

2.3. Disease Assessment

Disease Incidence: Disease Incidence the mean percentage of infected leaves of showing typical symptom of the disease per total leaves of plant units will be assessed at ten days interval from the beginning of disease symptom. Both diseased and healthy plants were counted from the row plants and the percentage of disease incidence (PDI) were calculated according to the formula used by Wheeler [27] and ICARDA [28].

$$PDI(\%) = \frac{Numberof diseased\ plants}{Total\ number\ of plants\ inspected} \times 100$$

Disease severity: Disease severity was assessed from 8 per-tagged plants as the percentage of the total leaf surface covered with angular leaf spot and cercospora leaf spot lesions on each expanded leaflet separately at regular intervals using a 1-9 scale (Table 1) [29]. The severity grades were converted into percentage severity index (PSI) according

to the formula by Wheeler [27] and ICARDA [28].

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

Table 1. *Percent of infection and scale for common bean anthracnose and leaf spot.*

Scale	Description
0	No visible infection rate
1	A few dot-like accountings for less than 5% of total leaf area
3	Discrete spots less than 2 mm in diameter (6–25% of leaf area)
5	Numerous scattered spots with a few linkages, diameter 3–5 mm (26–50% of leaf area) with a little defoliation
7	Confluent spot lesions (51–75% of leaf area), mild sporulation, half the leaves dead or defoliated
9	Complete destruction of the larger leaves (covering more than 76% of leaf area), abundant sporulation, heavy defoliation and plants darkened and dead

Source: Ding et al. [30]

2.4. Area Under Disease Progress Curve (AUDPC)

The progress of angular leaf spot and cercospora leaf spot was plotted over time using mean percentage severity index (PSI) for each common bean genotypes at each plot, and the PSI values were calculated AUDPC values (%-day) for each genotype according to the mid-point rule formula of Berger [31]; Campbell and Madden [32].

$$\mathbf{AUDPC} = \sum_{i=1}^{n-1} \mathbf{0.5}(\boldsymbol{X_{i+1}} + \boldsymbol{X_i})(\boldsymbol{t_{i+1}} - \boldsymbol{t_i})$$

Where *Xi* is the disease severity of angular leaf spot and cercospora leaf spot at I th assessment date, *Ti*is the time of the I th assessment in days from the first assessment date and *n* is the total number of disease assessments. Because severity was in percentage and time in days, AUDPC was express in proportion days.

2.5. Growth Parameters

a) Days to 50% emergence: Days from planting to the emergence of 50% plants per row was recorded.
b) Days to 50% flowering: Days to flowering was recorded for each row when 50% of the plants in a plot flowered.
c) Days to 90% maturity: days to 90% maturity of the crop when 90% of the pod reached physiological maturity.
d) Plant height (cm): The height of plants from the ground to the tips plants were measured eight randomly selected plants per plot at maturity.

2.6. Yield and Yield Components

a. Number of pod per plant: Number of pod per plant was counted on 8 randomly taken plants from 8 tagged plants means was recorded as number of pods/plants.
b. Seed yield per row (g): The grain yield per row was recorded.

Adjusted yield per plot = (Fw (100-Amc) *)/RDW

Where: Fw = Field weight; Amc = Actual moisture content; RDW = Recommended dry weight

c. Total grain yield (t ha^{-1}): The grain yield in gram per row was then calculated per hectare basis.

2.7. Data Analysis

The analysis of variance (ANOVA) was performed for the disease parameters (incidence, severity, AUDPC) and yields parameters using GenSast software (GenSast 18th ed.). DMR values was used to separate treatment means (P<0.05) among the treatments analysis of variance using GenStat, 18th edition software, following analysis using the standard procedure Gomez and Gomez, [33].

3. Result and Discussion

3.1. Disease Assessments

Analyses of variance disease parameters, growth, grain yield and yield components data were significant variation all genotypes except for days of to 50% emergence. Therefore, results were separately presented for disease, growth, yield and yield components. Common bean Angular leaf spot (ALS), Cercospora leaf spot (CLS) and Anthracnose disease incidence was observed in 2021 cropping season as major disease in Bako Agricultural research center.

There was high variation disease incidence and severity observed between genotypes, it might be due to the difference in resistance levels of the genotypes. Disease incidence and severity data for ALS, CLS and anthracnose were recorded from 8 randomly selected and tagged plants in the two rows of each plot. The disease data was recorded nine days' interval beginning from the first onset of disease symptoms based on a 1-9 disease scale.

3.1.1. Angular Leaf Spot

Common bean Angular leaf spot (ALS) was first observed on susceptible genotypes 45 days after sowing (DAS) in experimental fields at the early September in 2021 and it was recorded on the leaves of common bean genotypes tested after ten days later. On the experimental plots, angular leaf spot was spread on almost all genotypes three to seven day later from first observation. The angular leaf spot disease incidence was started recording after ten days later. There was a significant difference (P<0.05) between genotypes angular leaf spot incidence recorded (Table 2). The mean

final angular leaf spot disease incidence ranged from 21.33% to 92.33% in in 2021 cropping season. The highest (92.33%) angular leaf spot incidence was observed on genotype G59 and L25, flowed by L108 (91.0%), L6 (90.33%), G81 (90.0%) and etc. during the 2021 cropping season. The disease was more rapidly spread on the susceptible genotypes which showed higher level of final disease incidence (92.33%).

3.1.2. Disease Severity

The analysis of variance indicates that there were significant ($p<0.01$) differences among the genotypes, at Bako the mean final angular leaf spot disease severity ranged from 15%% to 61.7% in 2021. The highest final angular leaf spot disease severity index was recorded G27 (61.7%) followed by G172 (60%), G17 (58.7%), G165 (57.7%) and etc.

Screening of genotypes done during in 2021 cropping season at Bako revealed that among seventy-seven genotypes, none was found immune or resistant, forty-nine genotypes found to be moderately resistant (10.1-20% severity), G10, L75, G120, G49, G107, G115, G65, L54, G156, G163, G127, G147, L28, L88, G21, G62, G8, G86, L3, G121, G145, G152, G26, L13, G168, G35, G63, G158, G38, G74, G96, G43, G46, G5, G80, G82, G89, G128 and G177 with 15.7%, 15.7%, 16.3%, 16.3%, 16.7%, 17.3%, 17.3%, 17.3%, 17.7%, 17.7%, 18%, 18%, 18%, 18%, 18.3%, 18.3%, 18%, 18.3%, 18.3%, 18.7%, 18.7%, 18.7%, 18.7%, 19%, 19%, 19%, 19%, 19.3%, 19.3%, 19.3%, 19.3%, 19.7%, 19.7%, 19.7%, 20%, 20%, 19.7%, 20% and 20% respectively. Sixty-one genotypes found to be moderately susceptible (21.-50% severity), G40, G79, G66, G60, G22 etc. with 20.3%, 22.3%, 23.7%, 24.3%, etc. respectively. Twenty genotypes found to be susceptible (50.1-70% severity), G81, G69, G85, L6, etc. and 50.3%, 50.7%, 51%, 51% etc. and disease severity index respectively (Table 2).

3.1.3. Area under Disease Progress Curve (AUDPC)

The analysis of variance indicates that there were significant ($p<0.001$) different among genotypes and cropping season for AUDPC value. Area under disease progress curve of angular leaf spot ranged from 313.5%%-days to 1000.5%-days in 2021. The highest (1000.5%-days) AUDPC value computed from genotypes G65 followed by G69 (898.5%-days), G27 (934.5%-days) and etc. (Table 2). AUDPC values varied among the common bean genotypes depending on the resistance levels of the genotypes and it is known that AUDPC is directly related to the yield loss (Singh and Rao, 1998).

3.2. Cercospora Leaf Spot

3.2.1. Disease Incidence

Cercospora leaf spot of common bean was first observed on susceptible genotypes 47 days after sowing (DAS) in experimental fields at the early September in 2021 cropping season and on the experimental plots, cercospora leaf spot was exhibited almost on all genotypes three to seven day later from first observation. Disease data recording was started after eight later from first observation. The analysis of variance indicates that there was a significant difference ($P<0.05$) between cercospora leaf spot disease incidence ranged from 16.3% to 55% in 2021 cropping season. The highest (55.0%) cercospor leaf spot incidence was observed on genotype G65, flowed by G14 (53.3%), L54 (53.0%), L24 (52.2%) and etc. during 2021 cropping season.

3.2.2. Disease Severity

The analysis of variance indicates that there were significant ($p<0.01$) differences among the genotypes, at Bako the mean final cercospora leaf spot disease severity ranged from 8% to 38.3% in 2021. The highest final cercospora leaf spot disease severity index was recorded G92 (38.3%) followed by G163 (37.7%), G152 (37.0%), G21 (36.3%) and etc.

Screening of genotypes done during in 2021 cropping season at Bako revealed that among 121 genotypes, three genotypes was found immune or resistant (1-10% severity), G10, L25 and L24 with 8.0%, 8.3% and 9.7% respectively. Thirty-two genotypes found to be moderately resistant (10.1-20% severity), G22, L112, G162, G145.1, G74, G26, G107, L103, G156, G2, G65, G145, G110, G157, L108, G109, G81, L141, G101, G16, L102, G99, G128, G7, G137, G11, G169, G165, G87, G59, G170 and G27 with 11.3%, 11.3%, 11.3%, 11.7%, 12%, 12%, 12.3%, 13%, 13%, 14.3%, 15%, 15.3%, 15.7%, 16.7%, 16.7%, 17%, 17%, 17%, 17.3%, 17.7%, 17.7%, 18%, 18%, 18%, 18.3%, 19%, 19%, 19.7%, 19.7%, 20%, 20% and 20% respectively. Eight-five genotypes found to be moderately susceptible (21.-50% severity). G92, G163, G152, G49, G21 etc. with 38%, 37.7%, 37%, 36.3%, 36.3% etc. and disease severity index respectively. None of genotypes found to be susceptible (50.1-70% severity), and disease severity index respectively (Table 2).

3.2.3. Area under Disease Progress Curve (AUDPC)

The analysis of variance indicates that there were significant ($p<0.001$) different among genotypes and cropping season for AUDPC value. Area under disease progress curve of cercospora leaf spot ranged from 129%-days to 577.5%-days in 2021. The highest (577.5%-days) AUDPC value computed from genotypes G164 followed by G73 (553%-days), L94 (546%-days) and etc. (Table 2). AUDPC values varied among the common bean genotypes depending on the resistance levels of the genotypes and it is known that AUDPC is directly related to the yield loss [34].

Table 2. *Mean disease incidence, severity and AUDPC of common bean Angular leaf spot and cercospora leaf spot on common bean genotypes at Bako during 2021 main cropping season.*

Genotypes	Angular leaf spot			Cercospora leaf spot		
	PDI (%)	PSI (%)	AUDPC	PDI (%)	PSI (%)	AUDPC
G10	35.7	15.7	397.5	28.3	16.7	223.5
G101	64.0	46.0	649.5	27.3	19.0	259.5

Genotypes	Angular leaf spot			Cercospora leaf spot		
	PDI (%)	PSI (%)	AUDPC	PDI (%)	PSI (%)	AUDPC
G107	40.0	16.7	421.5	26.7	13.0	265.5
G109	57.7	37.0	544.5	34.3	17.7	222.0
G11	71.3	28.0	516.0	20.3	15.3	241.5
G110	65.7	41.7	628.5	32.3	11.7	129.0
G115	54.7	17.3	433.5	39.0	26.7	337.5
G116	73.0	45.7	705.0	31.3	12.3	141.0
G119	73.3	44.7	601.5	33.0	18.0	238.5
G120	33.0	16.3	369.0	42.0	19.7	255.0
G121	57.7	18.7	409.5	29.0	17.3	181.5
G122	85.7	53.3	651.0	34.3	11.3	148.5
G127	39.0	18.0	471.0	42.3	25.0	330.0
G128	32.3	20.0	427.5	26.7	12.0	142.5
G137	67.7	42.0	622.5	40.3	19.0	249.0
G139	77.7	37.3	577.5	28.7	16.7	181.5
G145	29.7	18.7	361.5	22.3	8.0	180.0
G145.1	80.0	52.7	861.0	23.3	11.3	148.5
G147	25.0	18.0	403.5	42.7	23.3	352.5
G15	66.0	38.0	640.5	42.3	22.7	360.0
G152	19.7	18.7	402.0	36.7	25.7	382.5
G153	87.3	57.7	825.0	43.3	23.7	423.0
G154	87.0	55.7	841.5	40.3	28.7	294.0
G156	37.0	17.7	387.0	29.0	13.0	138.0
G157	84.7	57.7	796.5	16.3	9.7	174.0
G158	47.7	19.3	516.0	39.7	23.3	229.5
G16	54.0	40.0	643.5	21.7	20.0	286.5
G160	55.7	29.7	526.5	50.0	33.3	381.0
G162	65.7	49.0	735.0	32.7	27.0	319.5
G163	31.7	17.7	334.5	31.3	20.3	234.0
G164	62.7	41.7	693.0	53.3	37.7	577.5
G165	88.7	57.7	813.0	27.0	20.0	259.5
G166	69.0	52.0	834.0	41.3	23.7	300.0
G167	45.7	29.7	531.0	51.7	33.0	349.5
G168	30.3	19.0	393.0	33.7	23.7	261.0
G169	48.7	28.0	517.5	28.0	18.0	214.5
G17	87.3	58.7	871.5	28.7	15.7	210.0
G170	67.0	40.3	646.5	31.3	12.0	157.5
G172	84.0	60.0	825.0	25.7	11.3	210.0
G173	47.0	32.0	622.5	32.0	22.0	301.5
G174	71.0	40.7	708.0	50.7	28.0	373.5
G177	44.3	20.0	559.5	37.0	25.0	267.0
G178	67.0	42.0	687.0	39.3	24.7	298.5
G180	82.0	39.7	687.0	43.3	24.0	307.5
G19	87.3	57.3	1000.5	45.7	24.3	336.0
G2	74.3	50.0	793.5	43.3	23.7	348.0
G21	29.7	18.3	369.0	37.0	17.7	228.0
G22	40.7	25.0	472.5	27.3	17.0	219.0
G26	30.3	18.7	369.0	32.3	22.3	243.0
G27	91.7	61.7	934.5	43.7	27.3	324.0
G29	68.3	49.0	753.0	36.3	24.3	297.0
G35	25.7	19.0	444.0	38.0	25.0	279.0
G36	78.0	46.0	753.0	44.7	22.3	289.5
G38	21.3	19.3	517.5	33.3	19.7	300.0
G4	74.0	34.3	615.0	51.0	30.3	405.0
G40	35.7	20.3	472.5	40.3	24.7	297.0
G43	31.7	19.7	390.0	47.3	28.7	307.5
G46	33.3	19.7	409.5	47.0	34.3	519.0
G47	35.3	16.3	336.0	40.0	26.7	376.5
G49	42.3	25.7	486.0	55.0	37.0	414.0
G5	42.0	19.7	397.5	34.0	17.7	283.5
G50	82.7	44.0	804.0	31.0	20.3	282.0
G55	77.0	41.0	699.0	45.0	36.3	330.0
G59	92.3	46.0	759.0	30.3	17.0	280.5
G60	49.3	24.3	492.0	32.0	23.0	285.0
G62	44.7	18.3	361.5	34.3	22.0	283.5
G63	40.0	19.0	330.0	42.3	24.0	342.0
G65	37.3	17.3	313.5	41.0	27.0	357.0

Genotypes	Angular leaf spot			Cercospora leaf spot		
	PDI (%)	PSI (%)	AUDPC	PDI (%)	PSI (%)	AUDPC
G66	61.3	23.7	502.5	27.3	22.7	325.5
G66.1	64.0	48.0	768.0	43.0	26.7	358.5
G67	70.3	41.0	718.5	30.7	21.3	256.5
G69	87.3	50.7	898.5	33.7	18.3	265.5
G7	71.0	40.7	633.0	32.0	21.3	268.5
G70	70.7	41.7	559.5	35.0	25.0	306.0
G73	72.0	38.7	643.5	50.0	34.0	552.0
G74	53.7	19.3	415.5	27.3	15.0	171.0
G76	60.3	36.0	636.0	42.0	23.3	391.5
G79	51.7	22.3	477.0	34.7	25.7	366.0
G8	48.7	18.3	351.0	29.0	8.3	174.0
G80	34.0	19.7	349.5	34.0	29.0	393.0
G81	90.0	50.3	831.0	37.0	28.0	391.5
G82	39.7	19.7	394.5	43.0	27.7	354.0
G85	87.7	51.0	853.5	41.3	27.3	321.0
G86	44.3	18.3	337.5	47.0	26.3	330.0
G87	85.7	51.7	801.0	35.0	27.3	388.5
G89	49.0	19.7	472.5	45.3	22.3	303.0
G9	89.3	49.7	777.0	34.7	26.3	363.0
G92	88.3	50.0	751.5	45.7	22.3	321.0
G93	87.0	52.3	765.0	52.7	29.3	435.0
G96	51.3	19.3	393.0	31.7	17.0	180.0
G97	69.7	38.7	636.0	36.0	21.7	324.0
G98	67.0	41.7	681.0	40.3	22.7	259.5
G99	74.7	41.0	741.0	36.7	28.3	381.0
L102	59.0	30.7	534.0	34.0	21.0	316.5
L103	60.7	32.0	570.0	20.7	14.3	159.0
L108	91.0	56.0	799.5	28.0	20.7	256.5
L112	63.3	41.0	694.5	28.3	20.0	205.5
L117	67.0	33.7	603.0	30.0	22.3	243.0
L13	34.0	18.7	345.0	49.0	24.7	325.5
L141	61.3	38.7	597.0	42.7	30.7	403.5
L18	67.3	44.3	681.0	43.3	28.7	376.5
L24	66.7	32.7	621.0	52.7	38.3	405.0
L25	92.3	53.0	757.5	41.3	24.0	433.5
L28	49.3	18.0	342.0	35.0	23.0	291.0
L3	49.3	18.3	372.0	41.3	24.3	321.0
L39	60.3	32.3	550.5	28.7	23.3	259.5
L44	69.3	47.0	697.5	28.7	22.7	351.0
L45	60.7	41.3	711.0	35.0	26.7	354.0
L53	66.7	44.7	654.0	47.3	31.7	381.0
L54	52.3	17.3	361.5	53.0	32.0	441.0
L6	90.3	51.0	784.5	35.3	24.7	321.0
L61	56.3	29.7	517.5	41.3	28.3	352.5
L64	58.7	32.7	561.0	50.7	29.7	375.0
L72	71.0	47.7	709.5	37.3	23.7	300.0
L75	48.0	15.7	340.5	39.0	26.0	327.0
L83.1	61.0	31.0	469.5	41.7	27.7	328.5
L84	75.0	48.0	666.0	47.0	23.7	325.5
L88	46.3	18.0	352.5	33.0	21.3	319.5
L91	67.3	33.3	636.0	42.0	20.3	300.0
L94	66.0	54.3	834.0	47.3	36.3	546.0
Mean	60.3	34.5	587.6	37.2	23.0	303.0
LSD (P<0.05%)	10.48**	7.715**	115.24**	9.30**	6.745**	83.5**
CV	10.8	13.9	12.2	15.6	18.2	17.1

PDI= percentage disease incidence, PSI= percentage severity index, AUDPC= area under disease progress curve, LSD= least significant difference, CV= coefficient of variations, *= significant difference at p< 0.05), **= highly significant difference at p< 0.01)

3.3. Growth Parameters

The analysis of variance exhibited that there was significant ($P \leq 0.05$) differences on day to 50% flowering among all genotypes. The longest (days 51.3) period of flowering was recorded on G49, G97 and L28 genotypes, respectively while the shortest (days 41) period of flowering was taken by the genotype G167. Analysis of variance showed that there were significant differences ($P \leq 0.05$) day to 50% pod setting days' common bean genotypes. Analysis of variance showed that there were significant differences ($P \leq 0.05$) day to 90% maturity common bean genotypes. The longest (days 100)

period of maturity was recorded on G164 while the shortest (days 86.67) period of maturity was recorded on G139 genotype (Table 3). Thus the variability in attaining the maturity for the genotypes might be attributed to their inherent genetic variability, environmental conditions and the effect of the disease.

3.4. Yield and Yield Components

Data on yield parameters showed highly significant differences (P<0.01) among genotypes in the number of pods per plant, seeds per pod, 100 seed weight and yield kg per hectare (Table 3). The analysis of variance (ANOVA) numbers pod per plant revealed that there were significant differences (p<0.05) between the genotypes. The highest of number of pod per plant 25.2 was recorded on the genotypes of G26 while the least number pod per plant 6.73 was recorded by genotypes L108 (Table 3). The analysis of variance revealed that there was significant difference (p<0.05%) number of seeds per pod among the common bean genotypes. There was significant different (p<0.05%) on hundred seeds weight between genotypes (Table 3). The high hundred seeds weight was recorded 26.6 gram by genotypes G162.

There was highly significant difference (p<0.001) on grain yield in Kg/ha among the genotypes. The highest 3093 Kg/ha yield was observed on genotype G35, flowed by G152 (2952 Kg/ha), G62 (2820 Kg/ha), G63 (2662 Kg/ha) and etc. there were highly significant different (p<0.01) grain yield Kg/ha between moderately resistance and susceptible genotypes.

Table 3. *Growth parameters, Yield and yield components of common bean genotypes at Bako during 2021 main cropping season.*

Genotypes	FD	PSD	MD	PH	PPP	SPP	HSW	G. Yld/kg
G10	43.0	53.33	92.33	61.8	14.43	3.947	23.93	2628
G101	43.33	54.0	92.67	66.33	9.63	3.493	21.7	1654
G107	47.33	56.33	95.33	58.53	13.1	4.193	20.27	2267
G109	49.33	59.33	95.0	65.93	9.33	5.027	24.2	1599
G11	42.0	54.33	89.0	59.4	10.27	4.457	22.43	1672
G110	43.67	54.67	94.0	53.53	8.37	4.507	22.6	1571
G115	46.0	55.67	88.33	58.13	15.07	3.293	20.5	1860
G116	44.0	54.67	95.33	40.0	7.4	4.187	23.63	1196
G119	49.33	56.33	87.0	55.53	10.2	4.077	23.6	1031
G120	46.67	57.33	98.67	48.07	12.17	4.167	22.93	2099
G121	45.0	55.67	95.33	70.1	16.17	4.26	21.43	1785
G122	45.67	57.33	99.33	42.07	12.4	4.28	22.97	1288
G127	44.67	54.33	91.33	48.0	11.6	3.653	25.1	2127
G128	48.33	57.0	91.0	53.13	12.93	3.377	22.93	2229
G137	45.67	55.33	93.67	52.34	14.33	3.9	22.87	1566
G139	48.0	56.67	86.67	51.47	12.53	3.667	24.7	1295
G145	50.67	59.33	90.67	45.93	14.4	4.333	21.13	2326
G145.1	48.0	59.33	93.33	38.27	11.53	4.08	21.07	1181
G147	49.0	57.33	96.0	55.64	15.4	2.667	25.67	2213
G15	46.0	57.0	94.67	61.93	10.23	3.133	23.03	1756
G152	49.67	60.0	93.67	69.2	21.67	3.313	19.23	2952
G153	45.33	54.67	96.67	63.67	11.93	3.043	19.73	1335
G154	46.67	57.0	98.67	44.6	10.0	3.8	23.6	1430
G156	49.0	60.0	99.33	51.13	13.33	4.833	21.97	2203
G157	46.33	57.67	92.33	47.47	9.0	3.347	21.5	1312
G158	44.33	54.33	89.33	58.13	14.47	3.457	20.47	2118
G16	43.33	53.33	94.33	53.33	15.8	3.17	23.0	1793
G160	49.33	61.33	94.67	53.6	14.27	2.757	19.67	2082
G162	42.67	52.67	84.67	50.67	9.73	3.583	26.6	1705
G163	46.67	56.0	94.67	55.4	11.8	3.337	24.03	2627
G164	47.33	56.67	100	65.07	14.0	3.987	21.6	2080
G165	46.33	56.67	95.0	35.67	11.07	2.917	21.27	1482
G166	41.0	53.0	88.0	53.87	14.0	3.487	22.77	1677
G167	41.33	52.33	93.33	55.87	16.4	3.83	27.6	1982
G168	47.67	56.0	92.33	54.6	14.93	3.003	22.7	2389
G169	46.0	56.0	95.0	56.8	10.07	3.45	20.0	1902
G17	51.67	55.0	95.0	60.93	10.6	3.813	20.73	1447
G170	48.33	58.0	91.33	65.87	13.53	3.343	19.83	1565
G172	45.0	57.67	97.33	52.4	7.53	4.217	21.9	1315
G173	46.33	56.0	97.0	75.6	16.13	2.54	21.17	2083
G174	46.67	58.0	96.67	52.87	12.57	4.15	20.07	1703
G177	47.33	59.67	93.0	58.4	12.07	3.32	21.4	1931
G178	45.33	55.0	91.67	48.93	13.67	4.547	24.17	1737
G180	48.33	58.0	97.33	67.8	11.67	3.513	20.43	1621
G19	46.67	56.33	94.33	40.87	10.33	3.27	21.63	1387
G2	44.0	55.67	91.67	51.0	10.33	3.847	22.5	1656
G21	43.33	54.0	94.0	56.4	14.87	4.287	24.6	1872

Genotypes	FD	PSD	MD	PH	PPP	SPP	HSW	G. Yld/kg
Gabisa	46.67	58.33	93.0	43.73	12.53	3.34	23.33	2387
G26	45.33	55.33	95.33	53.4	25.2	3.09	22.73	2284
G27	44.0	56.0	95.67	52.53	12.6	3.037	21.87	1510
G29	45.0	53.67	93.67	48.67	9.47	4.277	20.43	1676
G35	46.33	56.67	94.0	55.33	20.33	3.397	24.8	3093
G36	43.0	54.0	93.67	57.6	13.5	3.737	22.93	1776
G38	50.0	62.33	91.0	75.6	17.0	3.477	17.5	1918
G4	44.33	55.67	96.0	64.27	15.07	3.59	21.1	1767
G40	44.67	56.0	94.33	45.67	11.33	3.217	22.1	2073
G43	46.67	56.0	92.0	50.8	17.33	2.76	26.27	2115
G46	42.67	55.33	99.0	53.67	12.73	3.457	23.4	2116
G47	43.67	55.67	91.33	51.73	15.13	4.607	22.57	1982
G49	51.33	62.33	95.33	50.07	11.87	3.93	21.67	1990
G5	47.0	56.0	88.67	56.87	11.0	3.943	20.47	1901
G50	45.33	55.0	94.0	39.6	16.47	2.863	20.33	1748
G55	42.0	49.33	90.33	43.34	12.6	3.347	22.83	1704
G59	45.67	55.67	91.0	38.13	8.27	4.43	22.53	1523
G60	45.67	56.0	96.67	49.73	9.6	4.163	22.07	1814
G62	47.0	56.67	90.0	62.07	14.67	3.49	23.73	2820
G63	45.33	55.0	94.0	55.87	14.4	3.847	23.97	2662
G65	46.0	58.33	97.67	55.4	15.93	4.1	21.47	2243
G66	45.0	56.0	94.33	51.93	17.2	2.553	24.0	1914
G66.1	44.67	57.67	90.33	73.47	10.63	3.927	22.17	1671
G67	49.67	58.67	96.0	44.74	12.07	3.393	23.03	1810
G69	45.33	56	95.33	61.13	9.8	4.36	21.87	1307
G7	43.0	58.33	94.33	64.94	10.0	4.43	20.43	1799
G70	44.33	55.67	95.33	39.4	16.27	2.7	23.23	1818
G73	48.0	57.33	91.0	54.8	14.6	4.497	19.43	1804
G74	46.67	56.0	96.0	71.33	12.67	3.513	21.6	1933
G76	45.67	51.67	90.33	51.47	12.27	3.06	22.13	1679
G79	44.67	57.67	98.33	60.67	10.6	4.677	22.27	1953
G8	51.0	60.33	93.67	67.47	21.47	2.69	17.67	2619
G80	44.0	53.67	96.67	63.0	15.53	4.833	25.0	2293
G81	44.0	55.0	92.0	46.33	20.0	2.367	21.9	1406
G82	45.0	58.0	95.33	47.75	17.4	3.747	22.43	2171
G85	44.33	56.67	89.33	46.73	11.33	3.423	18.17	1379
G86	42.33	57.0	91.67	68.2	17.2	3.99	23.1	2409
G87	45.0	55.33	92.0	62.6	12.8	4.0	21.3	1538
G89	48.67	58.33	97.67	67.07	20.6	2.447	16.93	2236
G9	50.0	61.67	99.67	54.27	13.93	4.183	19.8	1567
G92	42.67	56.67	95.0	62.93	11.67	3.877	23.5	1683
G93	44.0	59.0	92.33	58.0	10.07	4.493	23.1	1352
G96	46.0	58.67	95.33	49.13	16.67	3.03	22.37	2218
G97	51.33	61.33	95.33	59.81	10.53	3.473	22.1	2039
G98	44.67	55.67	92.67	65.63	20.87	3.193	22.37	2029
G99	43.67	55.33	93.0	63.47	9.17	3.027	20.03	1586
L102	48.0	58.0	95.67	63.53	11.53	3.423	23.37	2007
L103	43.67	53.0	93.67	51.07	9.2	3.307	23.83	1942
L108	43.67	53.67	95.33	49.67	6.73	4.11	21.43	1149
L112	49.0	58.33	92.33	42.4	15.6	2.613	19.8	1678
L117	49.33	59.0	99.33	65.33	9.2	3.457	21.4	1657
L13	43.67	54.67	92.0	46.47	18.0	3.717	24.27	2504
L141	48.67	57.33	94.33	47.67	11.33	3.58	21.63	1748
L18	43.67	55.33	95.67	58.33	10.0	4.577	22.63	1778
L24	45.67	55.33	90.67	60.73	17.8	3.16	21.47	1639
L25	42.0	53.67	91.67	57.6	13.87	3.44	20.9	1251
L28	51.33	60.33	93.33	61.73	13.6	3.017	21.27	2304
L3	45.0	53.67	90.67	58.07	13.8	4.063	25.07	2290
L39	47.67	58.33	89.33	45.67	11.27	3.463	23.4	1951
L44	42.67	55.33	94.33	70.33	13.93	4.367	21.93	1621
L45	44.67	56.0	88.67	64.73	14.4	2.887	21.9	2110
L53	41.67	52.0	89.67	49.53	6.8	3.973	20.77	1320
L54	48.33	59.0	96.33	42.8	12.6	4.083	23.83	2542
L6	45.0	57.33	88.67	41.4	9.8	4.033	22.77	1429
L61	48.0	59.33	93.33	60.0	10.4	4.13	22.5	1828
L64	43.0	53.33	91.67	44.6	12.87	3.513	24.37	2156
L72	44.67	55.0	93.0	56.2	10.33	3.697	24.07	1847

Genotypes	FD	PSD	MD	PH	PPP	SPP	HSW	G. Yld/kg
L75	48.0	58.67	93.0	58.6	16.47	3.75	20.17	2387
L83.1	41.33	54.0	93.33	62.33	13.2	3.63	25.2	1883
L84	43.67	55.33	89.0	60.13	9.6	3.73	23.1	1597
L88	45.0	54.67	94.67	55.27	11.8	3.93	22.23	2483
L91	48.0	58.0	86.67	64.73	23.07	2.3	20.07	2048
L94	42.0	54.67	91.67	50.47	12.4	3.767	23.67	1676
Mean	45.86	56.39	93.47	55.3	13.16	3.66	22.22	1874
CV	6.3	4.3	8.3	19.2	20.9	19.3	8.8	18.2
LSD (p<0.05%)	4.6*	3.86*	5.73*	17.12**	6.75*	1.13*	3.13*	548.3**

DF= days of flowering, DPS= days of Pods setting, PH= plants height, DM= days of maturity, PPP= pods per plant, Kg/ha= kilo gram per hectare, LSD= least significant difference, CV= coefficient of variations, *= significant difference at p< 0.05), **= highly significant difference at p< 0.01)

4. Conclusion and Recommendation

In the study it was investigated that significant variation observed in angular leaf spot and cercospora leaf spot disease resistance, growth, grain yield and yield components among the 121 genotypes evaluated at Bako. The study revealed that angular leaf spot and cercospora leaf spot were most important and dominant disease occurred on the screened common bean genotypes. Some common bean genotypes were found as potential source for resistance and better yield performances, could serve to develop superior high-yielding and disease resistant genotypes. Around forty-six genotypes could be recommended for high grain yield as well as sources of resistance to angular leaf spot and cercospora leaf spot disease.

Conflicts of Interest

The author has not declared any conflict of interests.

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