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Research Article

Faba Bean (*Vicia faba* L.) Variety Evaluation for Disease Resistance, Yield, and Agronomic Traits in South Gondar, Ethiopia

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A field study was conducted to evaluate faba bean varieties for yield and yield components and disease reactions in the Lay Gayint district during the 2020 and 2021 cropping seasons. Six faba bean varieties, including local, were arranged in a randomized complete block design with three replications. The crop and disease data were collected, and the disease severity was assessed five times in 7 and 10 days intervals using the disease rating scale for chocolate spot and faba bean gall disease, respectively. The combined analysis variance showed significant ($P < 0.01$) differences among faba bean varieties in agronomic traits, disease severity, and area under the disease progress curve. The variety Numan had a higher chocolate spot (46.52%) and faba bean gall (40.46%) disease severity. The area under the disease progress curve (AUDPC) of the chocolate spot was higher on local (1292.85%-days). For faba bean gall, a higher AUDPC value (994.08%-days) was calculated from the Numan variety. The lowest severity of chocolate spot (27.37%) and faba bean gall (21.02%) was assessed from the variety Gora, and this variety also had the lowest chocolate spot AUDPC. The variety Gora and Ashebeka provided the highest grain yield (21988 kg·ha^{-1}) and (20624 kg·ha^{-1}), respectively. The results of the correlation analysis also indicated that the highest yield was associated with lower disease occurrence. In conclusion, varieties Gora and Ashebeka are found to be moderately resistant varieties to chocolate spot and faba bean gall disease than other varieties with higher yields, and these varieties are recommended for production in the study area and other similar ecologies.

1. Introduction

Legume crops are essential components of the diverse farming systems of the world. In Ethiopia, legume crops occupied 12.90% (1,674,950.34 hectares) of the grain crop area and 9.36% (3,199,998.865 tons) of the grain crop production [1]. From the same source, it is explained that faba beans, common beans, chickpeas, and field peas covered 3.89% (504,569.99 hectares), 2.4% (311,583.58 hectares), 1.7% (220,719.2 hectares), and 1.69% (219,927.59 hectares) of the grain crop area and 3.13% (1,070,636.538 tons), 1.61% (552,564.074 tons), 1.33% (457,319.37 tons), and 1.10% (376,236.883 tons) of the grain production, respectively.

Faba bean (*Vicia faba* L.) is an annual herbaceous crop that belongs to the family Fabaceae with a diploid chromosome number of $2n = 12$. It covers roughly 2.6 million hectares globally and is also known as broad bean, horse bean, and occasionally field bean [2]. Ethiopia is the world's second-largest producer of faba beans, after China [3, 4]. According to the CSA [5], the faba bean makes up around 29.9% of the yearly production of pulses and is the main source of protein for Ethiopians living in rural areas [6, 7]. As a potential rotational crop that improves soil fertility through nitrogen fixation, it makes a significant contribution to soil fertility [3, 8]. It is an excellent protein complement to cereals and other starchy root and tuber foods in human

nutrition due to its high lysine and tryptophan content [9]. While its dried seeds, green haulm, and dry straw are utilized as animal feed, it also produces items that are a high-quality source of protein for human use [10].

The crop was widely cultivated in prospective mid- and high-altitude regions of the nation, with elevations ranging from 1800 to 3000 meters above sea level, according to [11]. The Arsi and Bale Highlands, the Central highlands of Ethiopia (Southwest, West, and North Shewa), Tigray, North and South Wollo, North and South Gondar, the East and West parts of Gojjam, Wollega, the Guji highlands, Hadiya, Sidama, and Gamo-Gofa are just a few eco-geographical regions where it can be found growing. It was one of the best-performing crops under global warming and climate change, according to [12], because of its exceptional capacity to thrive in the majority of climatic conditions and extensive adaptability to a variety of soil settings.

Despite its wider area and agroecology coverage as well as its diverse importance as food, animal feed, improving soil fertility, and foreign currency earnings, the productivity of faba bean in Ethiopia is far below ($1.912\,t{\cdot}ha^{-1}$) the crop's average potential (more than $5\,t{\cdot}ha^{-1}$). Among the major barriers to faba bean production in Ethiopia, the lack of access to improved and high-yielding varieties (in spite of the release of a large number of improved varieties) and the impact of various forms of disease-causing pathogens took the lion's share. The South Gondar zone is among the major cool-season faba bean growing areas of the Amhara region, with no or limited access to high-yielding and disease-resistant varieties. Consequently, the farmers of the locality are forced to cultivate low-yielding and susceptible varieties. Therefore, in order to reduce the actual and potential yield difference due to limited access to improved varieties, the high-yielding varieties should be tested, introduced, and made accessible to farmers within the shortest possible period of time.

The two main diseases affecting faba bean production in Ethiopia are faba bean gall (*Olpidium viciae* Kusano) and chocolate spot (*Botrytis fabae* Sardina), which both frequently cause a decrease in faba bean production [13]. Chocolate spot is characterized by the emergence of reddish-brown spots on leaves that expand and merge, causing severe premature defoliation. The disease severely affects faba bean production and causes yield reduction of up to 61% on susceptible cultivars in Ethiopia [14]. The yield losses in faba bean reached up to 30% due to faba bean rust, and when rust infection appeared together with chocolate spot, the yield losses increased up to 50% [15]. The faba bean gall disease causing-pathogen is primarily soilborne and survives up to 2 years in the soil with diseased plant debris [16]. The gall disease symptoms establish on faba bean leaves, stem, pod, petiole, and flower [17]. At first, diseased plant leaves showed chlorotic small gall symptoms with sunken on the opposite side, rolling up at the leaf margin and finally, the collapse of stems in severely infected plants [11, 18, 19]. The faba bean gall caused yield losses of up to 100% [4].

Faba bean diseases are managed using various management systems, depending on the type of disease and climate conditions. Moderately resistant variety, late planting, and chlorothalonil or mancozeb fungicide have been recommended in Ethiopia for chocolate spot management [20, 21]. For faba bean gall disease, crop rotation, Bayleton fungicide spray, and seed treatments have been documented for its management [22, 23]. However, management of faba bean diseases using fungicides is criticized for their expensive cost and their effects on the environment and human and animal health. As a result, the use of resistant or tolerant varieties has been recommended as the most economical, safest, and environmentally friendly method of crop disease control. Thus, evaluation, identification, and introduction of improved and disease-resistant faba bean varieties have a paramount impact on the production and productivity of the crop in the study area and other potential agroecologies where such resistant varieties have not previously been cultivated.

Aside from the agronomic performance and disease resistance, plant breeders are also concerned about the relationship that may exist between plant characters, and the association between them is a distinguishing aspect of plant traits. Investigation of the association between plant traits is essential for the indirect selection of plant characters, particularly those that are difficult to quantify and have low heritability. Based on the foregoing justifications, this study was carried out to evaluate the agronomic performance of improved faba bean varieties, their resistance to faba bean gall and chocolate spot disease, and the relationship between yields, yield-related traits, and disease severity in the South Gondar zone of Ethiopia.

2. Materials and Methods

2.1. Description of the Study Areas. The field experiment was carried out in the Lay Gayint district during the 2020 and 2021 main cropping seasons. Lay Gayint is part of the South Gondar zone of Amhara region, Ethiopia, which is located 75 km from Debre Tabor, the administrative center of the South Gondar zone. The elevation of Lay Gayint ranges from 1494 to 3991 meters above sea level [24]. Geographically, it is located at a latitude and longitude of 12° 00′ 00″ N and 38° 19′ 00.00″E, respectively (https://latitude.to/articles-by-country/et/ethiopia/301492/lay-gayint).

The average annual rainfall in the area is 1352.2 mm, with minimum and maximum temperatures of 9.8°C and 14.3°C, respectively. The long-term monthly average rainfall and temperature are presented in Figure 1. Nitisol and vertisol are the major soil types of Lay Gayint. Major crops grown in the study area are faba bean, barley, field pea, potato, wheat, oat, lentil, chickpea, teff, and root crops. The average monthly minimum and maximum temperatures for Lay Gayint are 7.59°C and 18.09°C, respectively (Figure 1). The rainy season is from June to August, with the rest of the year being dry [25].

According to data from the Ethiopian Mapping Agency [26], and a reconnaissance survey conducted in 2018, the most commonly existing land use types, soil order, and climatic zones are cultivated land (43.03%), cambisols (40.82%), and Woina-Dega (79.60%) (Figure 2).

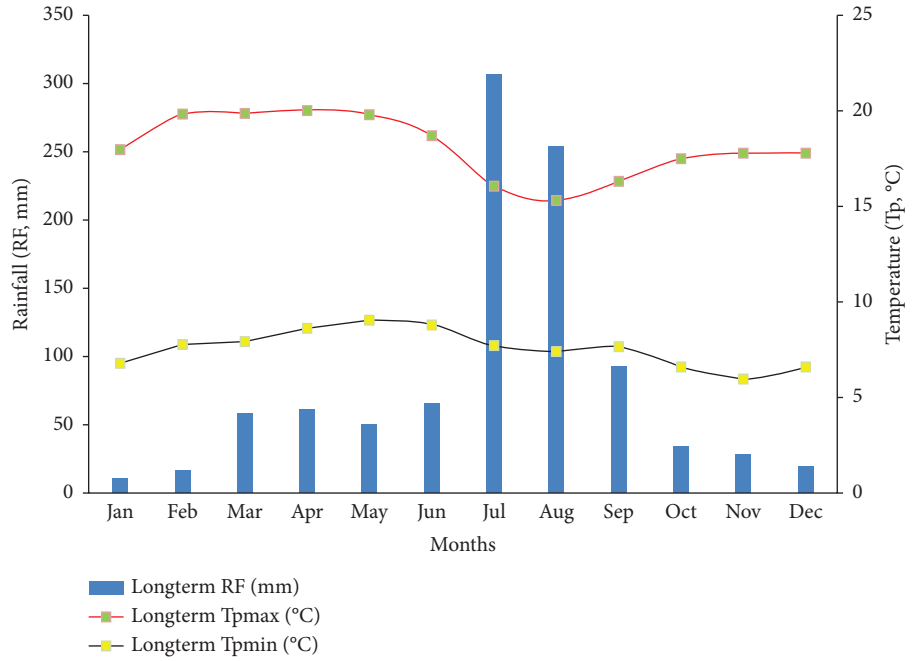

Figure 1: Long-term (1994–2021) monthly rainfall and temperature at Lay Gayint.

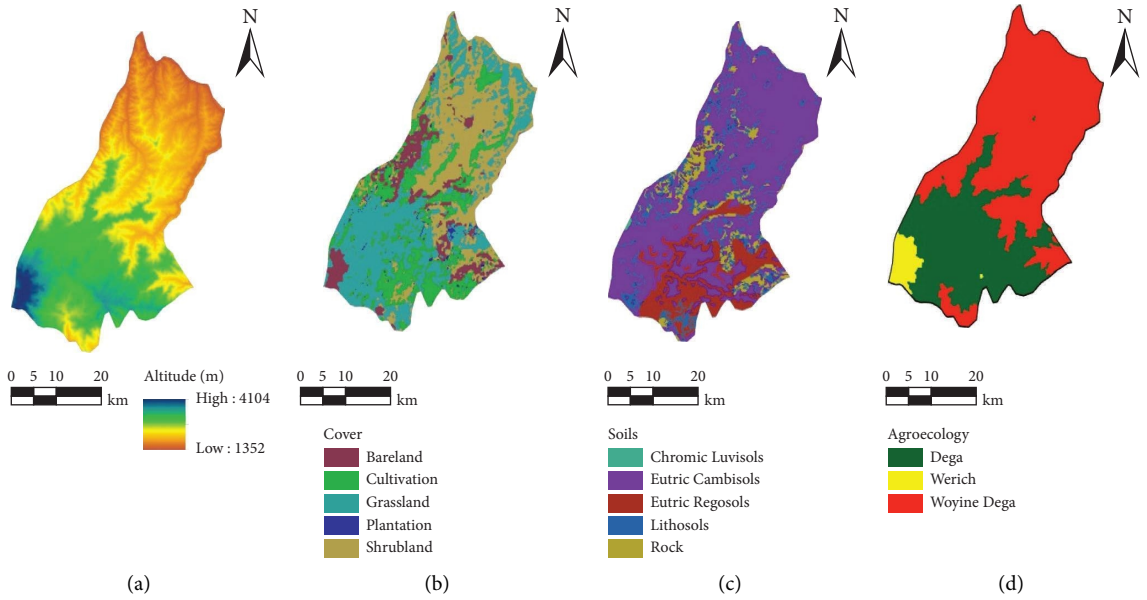

Figure 2: Description of the study area. (a) Altitude. (b) Land-use type. (c) Soil type. (d) Agroecology maps.

2.2. Experimental Materials. Five improved faba bean varieties (Table 1) were collected from Kulumssa and Holeta Agricultural Research Centers and evaluated for their agronomic performance and disease reaction. The local variety was also collected from the farmers and used as a local check.

2.3. Experimental Design and Fieldworks. The study was laid out in a randomized complete block design with three replications in the Farmers Training Center. The experimental plot was 1.4 m by 4 m, with 0.4 m between rows and 0.1 m between plants, respectively. Blocks and plots were separated by 1.5 m and 0.5 m, respectively. Each plot had four rows, the inner two rows were used for data collection, and the two outermost rows served as a border.

In both cropping seasons, all the necessary agronomic management activities were undertaken. Three rounds of plowing were carried out for land preparation, and two seeds per hill were planted with a spacing of 10 cm between plants during the onset of rainfall after the soil received the

Table 1: List of experimental materials studied at Lay Gayint.

SN	Variety name	Year of release	Breeder
1	Ashebeka	2015	KARC
2	Diba	2015	KARC
3	Gora	2013	KARC
4	Numan	2016	KARC
5	Tumsa	2010	HARC
6	Local		

KARC = Kulumssa Agricultural Research Center; HARC = Holeta Agricultural Research Center.

optimum amount of soil moisture. Thinning was conducted 10 days after emergence, and two rounds of hand weeding were undertaken at the 21st and 45th days after planting. The recommended amount of NPS fertilizer (100 kg·ha^{-1}) was applied during sowing.

2.4. Crop Data. On a plot basis, crop information such as days to 50% flowering and days to 75% physiological maturity was recorded. The number of pods per plant, the number of seeds per pod, and plant height were recorded from ten randomly selected plants in two middle rows. The average number of pods per plant obtained from ten randomly selected plants from the two central rows at maturity was used to determine the number of pods per plant. A hundred-seed weight (g) was determined by manually counting 100 seeds from the bulk of threshed seeds from each plot. The yield (g) of each plot was measured from two middle rows and converted on a hectare basis.

2.5. Disease Assessment. The severity of faba bean gall and chocolate spot disease was assessed five times at 10- and 7-day intervals starting the onset of disease symptoms. The disease severity of each disease was assessed by 10 randomly tagged plants in two central rows using a disease scoring scale. The rating scales of each disease are 0–9 for faba bean gall [18, 27] and 1–9 for chocolate spot [27]. The disease severity was converted into the percentage severity index [28] using the formula:

$$\text{PSI} = \frac{\text{sum of numerical ratings}}{\text{number of plants scored x maximum score on a scale}} \times 100. \quad (1)$$

Using the Campbell and Madden formula, the area under the disease progress curve (AUDPC) was calculated from the percent severity index [29]:

$$\text{AUDPC} = \sum_{i=1}^{n-1} \left[0.5\left(X_i + X_{i+1}\right)\left(t_{i+1} - t_i\right)\right], \quad (2)$$

where X_i is the cumulative disease severity at the i^{th} observation, t_i is the time of the i^{th} assessment, and n is the total number of observation.

2.6. Data Analysis. The collected data for individual seasons were subjected to independent analysis of variance using R software [30]. The homogeneity of error variance from the individual analyses of variance was tested through the application of the Brown and Forsythe test, and all the measured crop and disease data were found to have homogeneous error variance. Because the error variance was homogeneous over the two growing seasons, a combined analysis of variance was performed, and the least significant difference was utilized to compare treatment means at a 5% probability level. Pearson's method of correlation analysis was applied to determine the character association between yield, agronomic traits, and disease intensity.

3. Results and Discussion

3.1. Yield and Yield-Related Parameters. The results of the pooled analysis over years are depicted in S1 Table and Table 2. The pooled analysis revealed highly significant ($P < 0.01$) differences among varieties, years (except hundred-seed weight), and the interaction of varieties with years in yield and yield components of faba bean varieties for all assessed traits (S1 Table). In the other study, there was a significant difference among the tested faba bean varieties across seasons [31–34].

In phenological data, the lowest (53 days) days to 50% flowering was recorded for varieties Ashebeka, Numan, and local, while the variety Tumsa took longer (71.83 days) days to produce flowers. In this regard, the early matured (124.5 days) variety was Ashebeka and the late (140 days) matured was the variety Tumsa. The variety Gora had a higher (2.2) number of branches per plant than other varieties tested. In a previous study, Kindie and Nigusie [32] reported the maximum number of branches per plant on the Gora variety among other evaluated faba bean varieties.

The plant height ranged from 90.5 cm to 105.43 cm, with a mean of 96.30 cm. The highest (105.43 cm) plant height was recorded for the Gora variety, while the lowest (90.5 cm) was measured for the Tumsa variety. Asefa and Adare [35] recorded the highest plant height for the Gora variety. The variety Gora had the highest (9.68) number of pods per plant and the number of seeds per pod (7.99). Varieties Tumsa and local had the lowest number of pods per plant with values of 4.75 and 4.83, respectively. The lowest number of seeds per pod was recorded for Numan and Tumsa varieties (Table 2). In other studies, variations in the number of pods per plant and the number of seeds per pod have been reported among evaluated faba bean varieties [18, 32, 36].

In the present study, there was a variation among varieties in yield and yield-related traits. The variation may be attributed due to genetic makeup of the variety, environmental

Table 2: The combined mean performance of yield and yield components of faba bean varieties in the 2020 and 2021 cropping seasons.

Variety	Yield and yield components[a]							
	DF	DM	NBP	PH (cm)	NPP	NSP	HSW (g)	GY (kg·ha^{-1})
Ashebeka	53.33^{d}	124.5^{d}	1.75^{b}	99.5^{b}	7.68^{b}	6.17^{b}	77.33^{cd}	20624^{b}
Diba	68^{b}	129.33^{c}	1.32^{c}	98.83^{b}	6.08^{c}	4.55^{c}	89.16^{ab}	18897^{c}
Gora	54.5^{c}	129.17^{c}	2.2^{a}	105.43^{a}	9.68^{a}	7.99^{a}	98.83^{a}	21988^{a}
Numan	53^{d}	134.5^{b}	1.18^{c}	92.03^{c}	5.37^{d}	2.4^{e}	86.66^{bc}	7012.5^{e}
Tumsa	71.83^{a}	140^{a}	1.35^{c}	90.5^{c}	4.75^{e}	2.48^{e}	70.00^{d}	10786^{d}
Local	53.83^{cd}	129^{c}	1.13^{c}	91.5^{c}	4.83^{de}	3.28^{d}	75.50^{d}	10128^{d}
CV (%)	1.44	2.26	15.91	2.66	7.67	8.09	9.71	7.35
LSD (5%)	1.02	3.56	0.29	3.08	0.59	0.44	9.69	1320.5

[a]DF = days to flowering; DM = days to maturity; NBP = number of branches per plant; NPP = number of pods per plant; NSP = number of seeds per pod; PH = plant height; HSW = hundred-seed weight; GY = grain yield. CV = coefficient of variance; LSD = least significance difference. The varieties represented by "b, c, d, and e" are statistically different from the variety represented by "a" at 5% level of significance for both traits. The variety represented by "a" has a greater value than varieties assigned "b, c, d, and e." The same procedure is true to compare varieties represented by "b" with those represented by c, d, and e.

effects, and the varieties' response to disease reactions. This finding is consistent with the findings of [35], which discovered Gora has the tallest (46.6 cm) plant of the evaluated varieties. Similar to Kindie and Nigusie's [32] findings, Gora recorded the highest (46.6 cm) plant, while Tumsa revealed the longest plant height (117.40 cm). Tadele et al. [33] and Kumar et al. [37] also reported genotypic variations among tested varieties in days to flowering, plant height, number of pods per plant, and hundred-seed weight traits.

Correspondingly, a significant ($P < 0.05$) variation was observed in hundred-seed weight and grain yield between tested faba bean varieties in combined analysis over years (Table 2). The variety Tumsa had the highest 100-seed weight (111.33 g), while the variety Ashebeka had the lowest (70.67 g). A similar finding has been reported by Yitayih and Azmeraw [18] that obtained the highest hundred-seed weight from the Tumsa variety in South Gondar, Ethiopia. The variety Gora had the highest (21988 kg·ha^{-1}) grain yield, followed by Ashebeka (20624 kg·ha^{-1}), while the lowest (7012.5 kg·ha^{-1}) yield was obtained from the Numan variety. The study by Wondwosen et al. [36] reported the highest (4.4 t·ha^{-1}) yield from the Gora variety in North Shewa, Ethiopia. In other studies, Gora was also reported as the highest-yielding variety among other tested varieties [34, 35]. In the present study, the highest number of branches per plant, number of pods per plant, number of seeds per pod, and 100-seed weight measured from the variety Gora were important traits to indicate the genetic potential of Gora in providing high yield.

3.2. Response of Faba Bean Varieties to Diseases

3.2.1. Disease Severity. There were highly significant ($P < 0.01$) differences in disease severity of both diseases among faba bean varieties in combined analysis over the two years (S2 Table and Table 3). The response of varieties to faba bean diseases such as faba bean gall and chocolate spot varied in inducing disease severity.

Among the tested faba bean varieties, the highest (46.52%) chocolate spot disease severity was assessed on Numan and Tumsa, while the lowest severity (27.37%) of this disease was recorded for the Gora variety with a mean value of 39.47% (Table 3). The result indicated that the tested varieties responded differently to chocolate spots (Figures 3 and 4). A previous study by Ashenafi and Mekuria [38] and Yitayih and Azmeraw [39] reported varying levels of chocolate spot disease severity among evaluated faba bean varieties in Ethiopia, which is inconsistent with the current findings. The varying response of improved faba bean varieties to chocolate spots suggests the necessity for evaluation and identification of resistant varieties to be produced in potential agroecologies. On the contrary, Sahile et al. [40] found no significant differences in chocolate spot resistances among the faba bean varieties, which could be due to the varieties' similar disease resistance or an unfavorable environment for the pathogen to express its disease-causing genetic potential.

The severity of faba bean gall disease varied significantly among the studied faba bean varieties (Table 3). Numan had the greatest gall severity value (30.46%), whereas Gora had the lowest (21.02%) severity (Figures 3 and 4). Similarly, Wondwosen et al. [36] and Kassa et al. [34] reported the Gora variety to be moderately resistant to faba bean gall disease, with the lowest severity value, which is consistent with the results of this study. Furthermore, research findings from across locations and over the years [18, 36] revealed that the studied faba bean varieties had significant variations in faba bean gall disease severity. In general, the present study demonstrated that the variety Gora was a relatively resistant variety to chocolate spot and faba bean gall diseases when compared to all of the tested improved faba bean varieties.

3.2.2. Area under Disease Progress Curve. Significant ($P < 0.05$) variations were observed in an area under the disease progress curve (AUDPC) of both assessed diseases among improved faba bean varieties in combined analysis over the years. The values of AUDPC of chocolate spot and faba bean gall varied in the tested varieties (Table 3). Similar to this study, Yitayih and Azmeraw [18] and Wondwosen et al. [36] reported significant differences among improved faba bean for gall disease over the years.

Yitayih and Azmeraw [39] also noted various levels of chocolate spot epidemics among varieties. In the current study, the highest (1292.85%-days) AUDPC value of chocolate spot was calculated for local cultivars, while the lowest (976.19%-days) value of AUDPC was computed for the variety Gora. In another study without the variety Gora, chocolate spot-infected

Table 3: The response of improved faba bean varieties to severity and AUDPC of faba bean diseases in the 2020 and 2021 cropping seasons.

Variety	Chocolate spot[a]		Faba bean gall	
	PSI	AUDPC (%-days)	PSI	AUDPC (%-days)
Gora	27.37^{e}	976.19^{b}	21.02^{d}	847.85^{bc}
Diba	42.17^{b}	1244.38^{a}	23.89^{bc}	838.04^{bc}
Ashebeka	34.28^{d}	1039.36^{b}	22.59^{c}	791.46^{c}
Numan	46.52^{a}	1224.29^{a}	30.46^{a}	994.08^{a}
Tumsa	46.52^{a}	1215.02^{a}	23.93^{bc}	816.01^{bc}
Local	39.94^{c}	1292.85^{a}	24.8^{b}	869.76^{b}
LSD (5%)	0.89	133.03	1.54	74.02
CV (%)	1.88	9.48	5.21	7.15

[a]PSI = percent severity index; AUDPC = area under disease progress. CV = coefficient of variance; LSD = least significance difference at a 5% level. The varieties represented by "b, c, d, and e" are statistically different from the variety represented by "a" at 5% level of significance for both traits. The variety represented by "a" has a greater percent severity index and area under the disease progress curve than the other varieties, and this variety is more susceptible than the others.

Figure 3: Evaluation of the improved faba bean variety at Lay Gayint in the 2020 main cropping season.

Figure 4: Evaluation of the improved faba bean variety at Lay Gayint in the 2021 main cropping season.

faba bean varieties in different levels and the variety Tumsa induced the lowest AUDPC value in South Gondar [39].

In this study, early infection of faba bean varieties by gall disease was greatly differed. In this regard, the variety Numan had the highest (994.08%-days) AUDPC value, whereas Ashebeka had the lowest (791.46%), followed by Tumsa (816.01%). A previous study by Yitayih and Azmeraw [39] reported the lowest amount of AUDPC on the variety Tumsa, which is moderately resistant to gall disease, in South Gondar. Similar to the current study, Wondwosen et al. [36] noted a lower gall disease epidemic in a variety Gora in North Shewa.

The disease progress curve indicated the duration of the disease epidemic over time and the effects of faba bean varieties on the epidemic of faba bean diseases were demonstrated (Figures 3 and 4). In this regard, the diseases appeared 57 days after planting (DAP) and progressed up to 83 DAP for chocolate spot and also appeared at 40 DAP and progressed up to 80 DAP for faba bean gall disease. The chocolate spot progressed quickly on Numan, local, and Diba varieties compared to other varieties. However, the disease progress of chocolate spot was reduced on varieties Gora, Ashebeka, and Tumsa (Figure 5). The disease progress of faba bean gall was increased on the variety Numan compared to other varieties, while gall disease progression was decreased on the variety Gora (Figure 6).

3.3. Association of Yield and Yield Components and Severity of Diseases. Pearson's correlation coefficient analysis of agronomic traits and yield and disease severity is presented in Table 4. Correlation coefficient research revealed the association between essential crop variables, indicating a guiding model for direct and indirect grain yield improvement [41]. Days to 50% flowering had a highly significant and positive relationship with a date of 75% physiological maturity ($r = 0.42$), as well as a substantial and low positive relationship with chocolate spot ($r = 0.39$). This finding suggested that the severity of the chocolate spot increased as the date of maturing approached. The date of physiological maturity at 75% showed a highly significant and negative relationship with hundred-seed weight ($r = 0.45$).

Plant height ($r = 0.64$), number of pods per plant ($r = 0.77$), and grain yield ($r = 0.67$) showed a highly significant and substantially positive relationship with the number of branches per plant. The number of branches per plant ($r = 0.82$) was found to have a highly significant and very strong positive relationship with the number of seeds per pod. This means that as the number of branches increased, so did the yield. This finding aligned with the findings of Zebire and Tadesse [35] and Elshafei et al. [42], who found a significant and positive relationship between plant heights, number of pods per plant, number of seeds per pod, and seed yield per plant. The number of branches per plant was found to have a highly significant and negative association with faba bean gall ($r = 0.49$). This

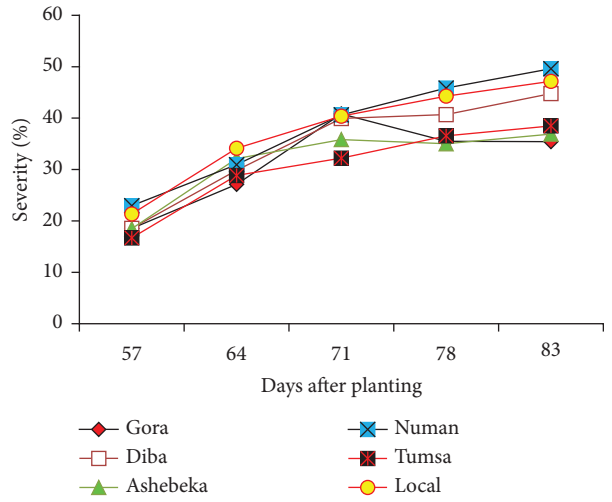

Figure 5: Disease progress curve of the improved faba bean variety for chocolate spot at Lay Gayint in the 2020 and 2021 main cropping seasons.

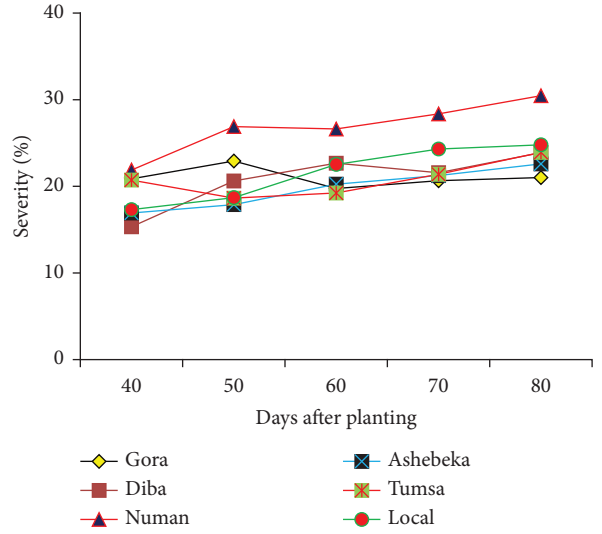

Figure 6: Disease progress curve of the improved faba bean variety for faba bean gall at Lay Gayint in the 2020 and 2021 main cropping seasons.

Table 4: Correlation coefficients (r) between faba bean yield and yield component and severity of diseases during the 2020 and 2021 cropping seasons.

Trait[a]	DF	DM	NBP	PH	NPP	NSP	HSW	GY	ChPSI	FgPSI
DF	1									
DM	0.42**	1								
NBP	−0.09	−0.05	1							
PH	0.07	0.28	0.64**	1						
NPP	−0.17	0.08	0.77**	0.86**	1					
NSP	−0.21	−0.15	0.82**	0.67**	0.86**	1				
HSW	−0.26	−0.45**	0.31	−0.01	0.19	0.31	1			
GY	0.02	−0.19	0.67**	0.57**	0.76**	0.89**	0.23	1		
ChPSI	0.39*	0.48**	−0.18	0.23	−0.03	−0.43**	−0.23	−0.45**	1	
FgPSI	0.11	0.37*	−0.49**	−0.75**	−0.59**	−0.57**	0.05	−0.36*	—	1

[a]DF = days to flowering; DM = days to maturity; NBP = number of branches per plant; NPP = number of pods per plant; NSP = number of seeds per pod; PH = plant height; HSW = hundred-seed weight; GY = grain yield; ChPSI = chocolate spot severity; FgPSI = faba bean gall severity, ** = significant difference at 0.01, * = significant difference at 0.05.

suggested that when disease infected faba bean, the number of branches decreased. Plant height ($r = 0.86$) had a highly significant and very strong positive association with the number of pod plants. Plant height ($r = 0.67$) was found to be a highly significant and strong positive factor in the number of seeds per pod. Plant height was found to have a highly significant and positive association with grain yield ($r = 0.57$). Plant height was highly significant and negatively correlated with faba bean gall disease ($r = -0.76$). The number of pods per plant had a highly significant and strong positive relationship with the number of seeds per pod ($r = 0.86$) and grain yield ($r = 0.76$). The number of pods per plant had a highly significant and negative relationship with chocolate spot ($r = -0.59$) and faba bean all disease($r = -0.78$).

The number of seeds per pod had a highly significant and strong positive association with grain yield ($r = 0.898$). Similarly, Elshafei et al. [42] reported a positive association between the number of pods per plant with seed per pod and grain yield. The number of seeds per pod was highly significant and negatively associated with chocolate spot ($r = -0.43$) and faba bean gall ($r = -0.57$). Grain yield was highly significant and negatively associated with chocolate spot ($r = -0.45$) and faba bean gall ($r = -0.359$). The present results indicated that the severities of the diseases are critical factors in determining yield and yield component loss of faba bean. In line with this result, the negative association between grain yield and faba bean gall disease has been reported [36]. In other research, the severity of chocolate spot and faba bean gall was a key factor in lowering grain production [18].

4. Conclusion and Recommendation

The faba bean is one of Ethiopia's most important legume crops, with enormous nutritional and economic value. This study's combined analysis of variance revealed significant variations in grain yield among the tested varieties. Gora was found to be the highest-producing variety among the studied faba bean varieties and can be recommended for cultivation in the study area. Chocolate spot and faba bean gall diseases are the most economically devastating biotic constraints that affect faba bean production anywhere, particularly in the highlands of Ethiopia. The evaluated faba bean varieties showed significantly different levels of disease severity for chocolate spot and faba bean gall diseases. In this regard, Gora and Ashebeka produced lower disease severity with an increased amount of yield than the other tested varieties. Therefore, Gora and Ashebeka, which produced lower disease severity coupled with higher grain yield, can be considered moderately resistant varieties so that they can be used to manage the epidemic of chocolate spot and gall diseases in faba bean-growing areas. In addition to variety performance and their disease resistance ability, positively correlated plant characteristics like the number of branches per plant, plant height, number of pods per plant, and number of seeds per pod should be considered and given due attention during the selection and yield improvement program of faba bean varieties.

Data Availability

The data that support the findings of this study are available on request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Tiringo Yilak designed the experiments, carried out the experiments, and wrote the paper after analysing and interpreting the data. Kassahun Amare developed the experiment's design, conducted the experiment, and summarized and analysed the data. Dereje Belay developed the experiment's design and summarized and analysed the data. Huluager Abebe developed the experiment's design and summarized and analysed the data.

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Supplementary Materials

S1 Table: mean squares of combined analysis of variance values for yield and yield components of faba bean varieties grown at Lay Gayint in the 2020 and 2021 main cropping seasons. S2 Table: mean square of combined analysis of variance values for disease severity and AUDPC for faba bean varieties grown at Lay Gayint in the 2020 and 2021 main cropping seasons. (*Supplementary Materials*)

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