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Evaluation of Agronomic Performance and Resistance to Cercospora (*Cercospora sojina*) Leaf Spot of Selected Soya bean Genotypes in Western Tigray, Ethiopia

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AA and GA designed the study, performed the statistical analysis and wrote the protocol and first draft of the manuscript. Authors YB, WN, FB, AA and DG managed the analysis of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aim of the current study was to evaluate soya bean genotypes for yield and yield traits and cercospora (Cercosporasojina) leaf spot disease under field condition. Field experiment was conducted at Humera district during 2018 cropping season using 16soya bean genotypes. Treatments were evaluated with RCBD and replicated three times. Number of days from planting

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to days of flowering and days of maturity, number of pod per plant, pod shattering, seed yield and cercospora leaf spot disease were showed a significant (P<0.01) variation among genotypes. All varieties were moderately resistance to pod shattering except PN13-1 (3.1) was moderately susceptible and Parc-3, Parc-5 and PN13-10were resistance. Highest yields were recorded from genotypes PN13-2 at 20.32q/ha and PN13-9 at 19.77q/ha. On the other hand, the lowest yields were recorded from genotypes PN13-3 at 7.49q/ha and PN13-1 at 9.95q/ha. Genotypes PN13-2 and PN13-7 have been identified as displaying resistance to Cercospora leaf spot. Highest disease severity recorded in genotypes Awassa 04 and PN13-1. Further research is needed in future to cover a wide range of environments and genotypes to screen high yielder and cercospora leaf spot disease resistance.

Keywords: Soya bean Genotypes; seed yield; pod shattering and cercospora leaf spot.

1. INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is one of the most important oil grain legume crops in the world [1]. Soya beans stand out as a nutritional powerhouse due to their high protein and oil content, as well as the presence of functional components like flavones that offer various health benefits [2]. In Ethiopia, soybean is used for a variety of purposes including preparation of different kinds of soybean foods, animal feed and soy milk [3]. Soya beanis classified into different maturity groups based on the length of the growing period from planting to maturity. These maturity groups help choose the right genotypes that will mature within the suitable growing season in their region. The classification typically includes early, medium, and late maturing varieties. This phonological attribute is determined by two abiotic factors: photoperiod and temperature [4], and these factors can dictate the most suitable maturity groups of soybean varieties for a particular geographical location [2].

The production and productivity of soya bean is affected by abiotic and biotic factors. The biotic constraints include diseases, insect pests, and weeds are limiting the crop yield.The major economically important diseases are rust, wilts, leaf spot, rots, powdery mildew, bacterial and viral diseases [5]. *Cercospora* leaf spot is a common fungal disease that affects a variety of crops, including soybeans. It is caused by the fungus *Cercospora sojina* and can lead to significant yield losses if not properly managed. The disease typically manifests as small, dark spots on the leaves, which can coalesce and cause defoliation in severe cases [6]. *Cercospora* leaf spot cause a significant yield loss of soybean (10–60%) [7]. Management strategies for *Cercospora* leaf spot in soya bean include cultural practices such as crop rotation, planting resistant varieties, and maintaining proper plant spacing to improve air circulation.

Screening of early mature groups of soya bean genotypes and resistance to cercospora **(***Cercosporasojina)* leaf spot disease in Western Tigray, Ethiopia, is a crucial agricultural practice aimed at identifying and selecting soya bean genotypes that exhibit early maturity traits and *cercospora* leaf spot disease resistance. This process involves evaluating different genotypes of soya beans to determine their performance in terms of early maturity, yield potential, disease resistance, and other agronomic characteristics.

2. MATERIALS AND METHODS

2.1 Description of Experimental Site

The field experiment was conducted during 2018 in main crop growing season at Humera station. The experimental site is described as having hot to warm temperatures and high evaporation conditions. This specific environment is classified as a hot to warm semiarid lowland agro ecology. In such areas, the climate tends to be characterized by high temperatures and limited precipitation, leading to increased evaporation [8]. The site is located at 14o 00’ 85" North latitude and 36o 34’ 52" East longitude. The elevation of this station is about 600 meters above sea level. The mean annual temperature of the area is 29 0c and the rainy months extend from late June to the middle of September. The remaining 8-9 months are dry and hot.

2.2 Experimental Treatment and Field Management

A total of 16 different soya bean genotypes were used in a field experiment (Table 1). The genotypes were obtained from Federal research institute. The experiment was laid out in randomized complete block design (RCBD) with

three replications. Each treatment were randomly assigned into a plot area of 15m2 (5m row length and 3m width), which consisted of 5 rows of soya bean. The spacing between block and plot will be 2m and 1m, respectively. The spacing between plants and rows were 5 cm and 60 cm, respectively. Seeds are sown on June 2017 on three time's ploughed plots of land. Each experimental plot are received the same rate of NPS (100 kg/ha). The other management practices were applied equally and properly as per the recommendations.

2.3 Data Collection

Yield components including plant height, branches per plant, pod per plant, hundred seed weight, seed yield and shattering were determined. Plant height and branches per plant were measured from ten randomly selected plants in each plot. However, number of pods per plant was counted from ten randomly selected plants. The weight of hundred counted seeds was recorded in gram for individual plots. Similarly, seed yield (kg/ha**)** was measured from threshed and cleaned plots separately using a sensitive balance and converted into kilogram per hectare.

2.4 Pod Shattering

Pod shattering was measured on visual observation in the field. The number of shattered pods were counted and expressed as percentage. Varieties were classified into five categories based on their reaction to pod shattering as described in Table 2.

2.5 Disease Data

Disease incidence (%): it was calculated by (total infected plant*100)/total observed plant. PSI (%) for easy analysis: it was calculated by (sum of rating scales*100)/ (No. of plants scored * maximum score of scale)

❖ Percent Severity Index (PSI)

The mean per cent disease index was transformed into disease reaction as 0%=No infection/immune;

0-10%= resistance (R); 10.1-20%=moderately resistant (MR); 20.1- 30%=moderately susceptible (MS); 30.1-50%= susceptible (S) and >50%=highly susceptible (HS). The genotypes were categorized into resistance groups (0-9) accordingly to rating score description; 0: (0) Leaves apparently free from spots; 1: (0.01-1.0) Very small area of leaf covered with lesions; 3: (1.1-10) Considerable leaf area covered with spots, no spots on stem; 5: (10.1-25) One- fourth of leaf area covered with spots, no defoliation of plants; little damage; 7: (25.1-50) Some leaves dropped, death of a few plants, damage to plant is conspicuous; 9: (> 50) More than half of the leaf area covered with spots, lesions very common on all plants, defoliation common, death of plants is common[10].

Table 1. Description of soya bean genotypes in this experiment

S.No.	Genotypes	S.No.	Genotypes
1	PN13-2	9	Awassa 04
2	PN13-3	10	Nyala
3	PN13-4	11	parc-3
4	PN13-5	12	parc-5
5	PN13-6	13	PN13-1
6	PN13-7	14	PN13-10
7	PN13-8	15	PN13-11
8	PN13-9	16	PN13-12

Table 2. Percent and reaction for recording pod shattering.

Scale	Percentage	Reaction
1	0	No shattered
2	1-10	Resistance
3	>10-25	Moderately resistance
4	>25-50	Moderately susceptible
5	>50	Susceptible

Source; [9]

2.6 Data Analysis

Analysis of variance was done for yield and yield components (stand count at emergence, days to 50% flowering and maturity 95%, plant height, branches per plant, number of pods per plant, and thousand seed weight) from the field experiment, to know the main effects and their interactions using Genstat version 18 software. Least Significant Difference (LSD) values were used to separate differences among treatment means at 5% probability level.

3. RESULTS AND DISCUSSION

3.1. Agronomic Traits

3.1.1 Day of flowering

There was a significant *(P< 0.001)* variation observed in the number of days from planting to flowering among tested soya bean genotypes underscores the importance of genetic diversity in crop improvement programs. In the given data, the lowest days of flowering was measured from genotypes Parc-3 (34), Parc-5 (34), and PN13-12 (37). On the other hand, the highest days of flowering was observed in genotypes PN13-7 (50.77), PN13-1 (50.67), and PN13-5 (49.67) (Table 3). This result suggests that there is a significant variation in the flowering dates among different genotypes. The differences in flowering times can be influenced by various genetic factors, environmental conditions, and interactions between genes and the environment.

3.1.2 Date of maturity

It was found that there was a significant variation in the number of days from planting to maturity among the tested genotypes. The statistical analysis revealed a p-value of less than 0.01, indicating a high level of significance in the differences observed. The overall average of maturity ranged from 64 to 92.67 days. The lower end of the range at 64 days implies instances where maturity is achieved relatively quickly, while the upper end at 92.67 days indicates cases where a longer period is required for maturity to be reached. Maximum day of maturity was recorded from genotypes PN13-7 (92.67), PN13-3 (92), PN13-5 (90.67) and PN13-6 (90.67). However, minimum date of maturity was recorded from Parc-5 (64), Parc-3 (69) PN13-12 (74.33) and PN13-4 (77). Intermediate days of maturity were recorded from genotypes PN13-10 (80.67), PN13-2 (82.33) and PN13-9 (82.67) (Table 3). The result was in similar [11] who stated that the range of days to maturity from 107.33 to 79.33 shows variability among the different soya bean varieties in terms of how long they take to mature. This result was in agreement with the report of Hunde and Tefera [12] who reported that days to maturity were significantly affected by soybean varieties.

3.1.3 Branches per plant and Plant height

In the study of soya bean genotypes, it was found that there wasn't significant variation among most of the genotypes except for the comparison between Parc-5 and PN13-8 genotypes. This suggests that the branches per plant in soya bean genotypes did not differ significantly at $P < 0.01$except for these two specific genotypes. In the study comparing different genotypes of soybean for plant height, it was found that there was a highly significant ($P < 0.01$) difference in plant height among the tested genotypes. The significant difference in plant height indicates that certain genotypes may have genes that promote taller growth, while others may have genes that restrict vertical growth. Highest plant height was measured from genotypes Awassa 04 (64), Parc-3 (63.33), PN13-6 (61.33) and PN13-7 (61). However, lowest plant height was measured from genotypes PN13-3 (33.33) and PN13-1 (37.33) (Table 3). These findings were in line with [13] who reported that plant height significantly difference among soybean genotypes. Similarly, [14] also evaluated soybean varieties resulted a significantly difference at plant height in soybean varieties.

3.1.4 Pod per plant

Pod per plant was showed that significant ($P<0.01$) difference among the soya bean genotypes. Maximum number of pod counted from genotypes PN13-2 (72.67) followed by PN13-9 (62.67) and PN13-6 (54.33). While, minimum number of pod was counted from PN13-3(24) and PN13-1 (28.67). The data provided indicates that the genotypes PN13-2 and PN13-9 had significantly higher yields in terms of the number of pods produced compared to other genotypes in the study. Conversely, genotypes PN13-3 and PN13-1 had lower yields with fewer pods produced overall (Table 3). It could be due to; water deficit poses a significant threat to soybean production by reducing pod formation, seed quantity, and seed quality. The current findings align with a study by Basal and

Szabó [15] which highlighted the impact of water deficiency on yield and yield traits. Water is a critical factor in plant growth and development, influencing various aspects of crop productivity.

3.1.5 Hundred seed weight

There was a significant *(P < 0.01)* variation in hundred seed weight between the genotypes. The heaviest seed weights were measured from three different soya bean genotypes; PN13-12, PN13-11, and Parc-5. The specific weights for these seeds were 12.4 grams, 11 grams, and 10.13 grams, respectively. On the other hand, the smallest seed weights were recorded from two other soya bean genotypes; PN13-2 and Nyala. The specific weights for these seeds were 6.1 grams and 6.7 grams, respectively.

3.1.6 Seed yield

In the study conducted on soya bean genotypes, there was a significant difference at P <0.01 in seed yield among the tested genotypes. Overall result of seed yield ranged from 7.49q/ha to 20.32q/ha. The highest yields were recorded from genotypes PN13-2 at 20.32q/ha and PN13-9 at 19.77q/ha. On the other hand, the lowest yields were recorded from genotypes PN13-3 at 7.49q/ha and PN13-1 at 9.95q/ha. Early maturing soybean varieties allow farmers to harvest their crops sooner, reducing the risk of yield losses due to adverse weather conditions or pest infestations. The result was support by Tariku et al. [11] early-maturing varieties (Coker and Gonzela) are suitable for short rainfall areas.

3.1.7 Pod shattering

Pre-harvest soybean pod shatter refers to the phenomenon where soybean pods split open prematurely before harvest, leading to yield losses. This issue is particularly concerning as it can significantly affect the overall yield potential of a soybean crop, especially if it occurs while the plants are still in their green stages. Pod shattering based on the shattering level shows there was significant (*P<0.05*) variation among the soya bean genotypes. All genotypes were moderately resistance to pod shattering except PN13-1 (3.1) was moderately susceptible and Parc-3, Parc-5 and PN13-10were resistance (Table 4). The result was supported by [16, 17] who reported that five soya bean lines was resistance (7-10%) to pod shattering. In addition also [18] stated that genotypes SB-8, Gazelle, SB-74, SB-4 and Nyala were the most resistant to pod shattering and high grain yield, while Genotypes SB-90 and SB-25 were highly susceptible [19].

Table 3. Mean values of yield and yield component of soya bean genotypes

Genotypes	DF (50%)	DM (95%)	NBP	PH (cm)	PPP
Awassa 04	44.67bcd	82.67bcd	1.67ab	64a	39.67b-e
Nyala	48.33abc	88.33abc	1.33ab	59.67ab	39b-e
parc-3	34f	69.67ef	1.33ab	63.33a	38b-e
parc-5	34f	64f	1b	44.67cd	33.67cde
PN13-1	50.67ab	91ab	2ab	37.33de	28.67de
PN13-10	43cde	80.67cd	1.67ab	54.67ab	41.33b-e
PN13-11	40def	83bcd	2ab	42cd	35b-e
PN13-12	37ef	74.33de	1.33ab	56.67ab	43.33b-e
PN13-2	45.67a	82.33bcd	2ab	59.67ab	72.67a
PN13-3	47.67abc	92a	1.67ab	33.33f	24e
PN13-4	48.67abc	77de	1.67ab	51bc	45bcd
PN13-5	49.67abc	90.67ab	2ab	55.33ab	41.33b-e
PN13-6	49.33abc	90.67ab	1.67ab	61.33ab	54.33b
PN13-7	50.77ab	92.67a	1.67ab	61ab	46.67bcd
PN13-8	49abc	89abc	2.333a	38.67ef	31de
PN13-9	43.67cd	82.67bcd	1.67ab	57.67ab	62.67bc
Lsd (5%)	5.82	7.65	0.92	9.11	17.44
CV (%)	7.7	5.5	32.8	10.7	24.5

Note; DF: Date of flowering; DM: Date of maturity; PPP: pod per plant; PH: Plant height;

Table 4. Mean values of hundred seed weight, yield and Pod shattering character of soya bean genotypes

Genotypes	Hundred seed weight	Seed yield (qt/ha)	Scale (pod shattering)	Reaction (pod shattering)
Awassa 04	8.77cde	13.37abc	2.67a	MR
Nyala	6.7f	12.2abc	2.33ab	MR
parc-3	9.47cd	12.49abc	1.33ab	R
parc-5	10.13bc	10.6abc	1b	R
PN13-1	7.73e	9.95bc	3.1ab	MS
PN13-10	9.8bcd	13.92abc	2ab	R
PN13-11	11b	16.68abc	1.33ab	MR
PN13-12	12.4a	13.85abc	1.67ab	MR
PN13-2	6.1f	20.32a	1.67ab	MR
PN13-3	7.67e	7.49c	1.67ab	MR
PN13-4	8.4de	13.11abc	2.33ab	MR
PN13-5	8.4de	14.09abc	1.67ab	MR
PN13-6	8.67cde	15.9abc	1.67ab	MR
PN13-7	7.43ef	11.54abc	2ab	MR
PN13-8	7.4ef	12.92abc	1.67ab	MR
PN13-9	8.37de	19.77ab	1b	R
Lsd (5%)	1.36	8.49	1.158	
CV (%)	9.4	37.3	39.7	

Table 5. Incidence and severity of *Cercospora* (*Cercospora sojina)* leaf spot on soya bean genotypes

Genotypes	Incidence	Severity (scale)	Severity (%)	Reaction
Awassa 04	100	2.7a	29.5	MS
Nyala	100	2.47ab	24.7	MS
parc-3	100	2.4 7ab	24.2	MR
parc-5	100	1.7ab	13.2	MR
PN13-1	100	2.67ab	25.4	MS
PN13-10	100	2.47ab	24.2	MR
PN13-11	100	2.47ab	24.2	MR
PN13-12	100	2.03ab	18.9	MR
PN13-2	100	1.03b	8.9	R
PN13-3	100	2.03ab	18.6	MR
PN13-4	100	2.03ab	18.6	MR
PN13-5	100	2.47ab	24.2	MR
PN13-6	100	2.03ab	17.9	MR
PN13-7	100	1.4ab	9.2	R
PN13-8	100	2.47ab	24.5	MR
PN13-9	100	2.03ab	17.5	MR
Lsd (5%)	ns	2.46		
CV (%)	*	29.3		

Note; R: Resistance; MR: Moderately resistant, MS: Moderately susceptible, ns: Non-significant, PSI: Percentage severity index

4. CONCLUSON

Soybean crop plays a crucial role in Ethiopia's agriculture sector and contributes significantly to food security and nutrition. Host resistance is the most effective and economical management practice for frogeye leaf spot. Overall result of seed yield ranged from 7.49q/ha to 20.32q/ha. The highest recorded yields were from genotypes PN13-2 at 20.32q/ha and PN13-9 at 19.77q/ha. On the other hand, the lowest yields were recorded from genotypes PN13-3 at 7.49q/ha and PN13-1 at 9.95q/ha. Genotypes PN13-2 and PN13-7 have been identified as displaying resistance to *Cercospora* leaf spot. Highest disease severity recorded in genotypes

Awassa 04 and PN13-1. Both genotypes exhibited a disease severity rating of 2.7 and 2.67, respectively. Further research is needed in future to cover a wide range of environments and genotypes to screen high yielder and disease resistance.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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