International Journal of Bio-resource and Stress Management https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM September 2024, 15(9): 01-15

Article AR5540

Research Article

Stress Management

DOI: HTTPS://DOI.ORG/10.23910/1.2024.5540

Effect of Plant Types on Lodging Resistance and Yield of Field Pea (*Pisum sativum* L.) and Lodging Impact on Yield and Ascochyta Blight Severity

Kedir Yimam, Gizachew Yilma, Temesgen Abo, Deresa Tesfaye and Gebyaw Achenef

Ethiopian Institute of Agricultural Research, Kulumsa Agricultural Research Center, Highland Pulse Improvement Division, Asella, Ethiopia

Open Access

Corresponding kediryimam81@gmail.com

0009-0001-0498-5316

ABSTRACT

The present investigation was conducted during June–November, 2020 at Bekoji and Kofele, Ethiopia with the objective to analyse the effect of plant type on yield and lodging resistance potential and to assess the impact of lodging on ascochyta blight disease severity and seed yield of field pea. A total of 49 Field pea genotypes, representing two different plant types were evaluated for 13 characters using 7*7 simple lattice design. Plant types had significant effect on most of the studied traits. Considerable variation was observed for response against lodging and ascochyta blight with respect to plant types as well as genotypes even if high level of resistance was not identified. Normal leafed type had significantly higher lodging and ascochyta blight severity score than semi-leafless type. Even though the same plant type did not give the highest seed yield consistently in the two study locations, semi-leafless type did give significantly higher mean seed yield with 17% yield advantage over normal leafed type at Kofele. The regression analysis showed that lodging had negative significant influence on seed yield of field pea. Significantly largest yield reduction was observed by lodging in normal leafed type than in semi-leafless. The ascochyta blight severity was more increased by lodging in normal leafed type than the semi-leafless one. In other words genotypes with more susceptible to lodging were also susceptible to ascochyta blight with high yield reduction in normal leafed type. Thus, yield losses caused by ascochyta blight may be reduced by breeding for improved resistance to lodging.

KEYWORDS: Ascochyta blight, lodging, plant type, prostrate, semi-leafless

***Citation* (VANCOUVER):** Yimam et al., Effect of Plant Types on Lodging Resistance and Yield of Field Pea (*Pisum sativum* L.) and Lodging Impact on Yield and Ascochyta Blight Severity. *International Journal of Bio-resource and Stress Management,* 2024; 15(9), 01-15. HTTPS://DOI.ORG/10.23910/1.2024.5540.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 18th June 2024 RECEIVED in revised form on 30th August 2024 ACCEPTED in final form on 17th September 2024 PUBLISHED on 21st September 2024

1. INTRODUCTION

Field pea (*Pisum sativum* L.) is one of a major cool-season pulse crop, which is widely cultivated in different regions of the world for different purposes (Rana et al. 2013; Anonymous, 2021). In 2020, more than 14.6 and 19.8 million tons of field pea were produced in the world on around 7.19 and 2.33 million hectares of land as grains and green pods, respectively (Anonymous, 2021). Ethiopia ranked 10th in the world in field pea production with which around 268 thousand tons of seed yields were produced in 2020 (Anonymous, 2021).

Field pea is the fourth most important staple food legume next to faba bean, common bean and chickpea among the pulse crops in Ethiopia (Anonymous, 2020). It covers about 219,927.59 ha of arable lands with a total production of 3,762,368.83 quintals with average yield of 1.71 t ha^{-1}; which accounts for 13% of the total area covered by pulses and 11.76% of the total pulses production in the country in the main growing season (Anonymous, 2020).

Classification of field pea into plant types is based on leaf characteristics. Field peas can be conventional-leaved/ prostrate/, leafless or semi-leafless). Normal leafy (prostrate) type which has normal leaves and vine lengths of three to six feet. The semi leafless type that has modified leaflets reduced to tendrils, resulting in shorter vine lengths of two to four feet.

In Ethiopia, field pea plays a significant role in the livelihood of the agricultural communities. However, the national average yield is low due to low yielding local varieties coupled with traditional practices, biotic and abiotic factors.

Disease such as Ascochyta blight and powdery mildew, natural lodging and frost are largely the major production constraints in field pea in high and mid land areas of Ethiopia (Getachew et al., 2022; Teshome and Tegegn, 2017). Yield loss on field pea due to Ascochyta blight disease was reported up to 53% in Ethiopia, especially in the major production areas of the central highlands (Gorfu and Hiskias, 2001). Getachew et al. (2022) had been reported yield losses ranging from 61.3% to 70.5% in untreated plot of field pea variety under field conditions of Chencha in Southern Ethiopia. Chemicals control is effective in controlling biotic stresses but too expensive for most small holders, so the most effective control strategy is the use of resistant and / tolerant cultivars.

Lodging can cause up to 74% yield loss in some dry pea cultivars as cited by Singh and Srivastava (2015). Besides, most growers prefer a variety that will stand upright at harvest because that allows a faster harvest, minimal equipment modification and higher seed quality (Endres and Kandel, 2021). Thus, strong efforts are needed to enhance field pea productivity and to satisfy the demand of stakeholders by selecting genotypes with high standability (lodging resistant) and stable yield.

In addition to the above facts, a number of researchers have generated information on the performance of Ethiopian field pea genotypes for a number of important traits (Benti, 2019; Yimam et al., 2020).

However, there is limited information available on yield, lodging and disease resistance potential of exotic semi-leafless type genotypes in comparison with conventional normal leaf type genotypes in Ethiopian field pea growing areas. Therefore, the present investigation was undertaken to analyse the effect of plant type on yield, yield components, lodging and disease resistance potential and to assess the impact of lodging on Ascochyta blight disease severity and seed yield of field pea.

2. MATERIALS AND METHODS

2.1. *Experimental site*

The experiment was conducted at two locations of South Eastern Ethiopia namely Bekoji and Kofele substation of Kulumsa Agricultural Research Center during the main cropping season (June–November, 2020) under rain fed condition. Bekoji is located at an altitude of 2780 m.a.s.l with a geographic co-ordinate of 070 32'37"N latitude and 390 15'21" E longitudes. The area receives mean annual rainfall of 1020 mm. The mean annual maximum and minimum temperature of the site is about 18.6°C and 7.9°C, respectively. The geographical location of Kofele is 070 04'28"N latitude and 380 47'11" E longitudes with an altitude of 2660 meter above sea level (m.a.s.l). The agro-ecology of the area is characterized by an average annual rain-fall of 1211 mm, with annual mean maximum and minimum temperatures of 18°C and 7.1°C respectively.

2.2. *Experimental materials and design*

For the present experiment 49 field pea genotypes were chosen belonging to two different plant type groups (28 prostrate/normal/ leaf type and 21 semi-leafless type genotypes). The experiment was carried out using 7-x-7 simple lattice design; each replication containing seven incomplete blocks and each incomplete block containing seven genotypes. Each plot had two rows of 4 m length, with spacing of 20 cm between rows and 5 cm between plants. Each genotype was planted in a plot size of 1.6 m^2.

2.3. *Data collection*

Data were collected on single plant and plot bases. On a plant basis, data were collected from ten randomly selected plants from each genotype in each replication, namely, plant height (PH) (cm), number of pods plant^{-1} (NPPP) (number), number of seeds pod^{-1} (NSPP) (number) and total number of seeds plant^{-1} (NSPPL) (number).

While the data on plot basis were collected include days to 50% flowering (DF), days to 90% maturity (DM), lodging score (LS), stand count at harvest (SCH), Ascochyta blight (AB), powdery mildew (PM), Frost score, thousand seed weight (TSW) (gram) and seed yield (SYPH) (kg ha^{-1}). Assessment of lodging score was made at physiological maturity using a 1–9 scale (Wang et al., 2006); where, 1=main stems strictly upright, 2=main stems incline slightly, 3=main stems at 60° angle, 4=main stems at 45°angle, 5=main stems at 30° angle, 6=1/2 of the main stems flat, 7=2/3 of the main stems flat, 8=4/5 of the main stems flat and 9=all main stems flat

Ascochyta blight and powdery mildew disease scores of individual genotypes were recorded (1–9 scale). Ascochyta blight disease score was recorded 70 days after Planting. Based on the disease score, test genotypes were categorized for their reaction to AB infection according to (Paul et al., 2013) scale where, 1, asymptomatic (A); 1.1–3.0, resistant (R); 3.1-5.0, moderately resistant (MR); 5.1–7.0, susceptible (S); and 7.1–9.0, highly susceptible (HS).

2.4. Data analysis

The analysis of variance was carried out using the procedure of simple lattice design and considering plant type as a factor for all traits to assess the significance of the difference between plant types and among the genotypes by using lm function of stats package in R software version 4.1.2 (Anonymous, 2019). Comparisons of mean were made with Duncan's Multiple Range Test. Simple linear correlations were made among traits for each plant type. Simple linear regression were also carried out for some selective pair of traits (plant height with lodging score, lodging score with ascochyta blight, thousand seed weight and seed yield, and ascochyta blight with seed yield) at Kofele.

3. RESULTS AND DISCUSSION

3.1. Analysis of variance

The analysis of variance (ANOVA) showed that there were a significant to highly significant difference between plant types for most of the studied characters at each individual and combined location (Table 1, 2 and 3). In agreement to this result, significant differences were reported between plant types for yield and yield components in field pea (Munakamwe et al., 2012). The tested genotypes revealed a significant to highly significant differences almost for all studied traits at each location and combined over location except ascochyta blight, lodging and frost score at Bekoji and seeds pod^{-1}, pods and seeds plant^{-1} at Kofele (Table 1, 2 and 3). The significant differences between plant types and among genotypes for the characters in the present study suggested the presence of considerable genetic variability that provides an opportunity to improve the desired characters through selection and or hybridization.

Table 1: Mean square from the analysis of variance for 13 traits of 49 field pea genotypes tested at Bekoji

	Mean squares						
Traits	REP (df: 1)	Block (REP) (df: 12)	Plant type (df: 1)	Genotype (df: 47)	Residuals (df: 36)	CV (%)	R^2
DF	0.37	7.62	0.97	8.97***	1.49	1.58	91.00
DM	8.58	7.87	1.56	8.94**	3.15	1.33	82.00
PH	3008.66	749.86	4307.39***	429.99**	143.27	12.70	88.00
SCH	119.02	153.63	451.64***	86.29***	19.95	5.10	90.00
LS	2.95	5.31	120.73***	1.28	1.32	24.55	84.00
PPP	30.87	4.89	1.82	2.90*	1.06	12.49	86.00
SPP	0.09	0.72	5.77***	0.41	0.25	10.25	79.00
SPPL	597.59	222.52	185.49*	96.55**	30.66	13.88	88.00
TSW	360.65	1123.23	4736.43***	1075.22***	60.53	3.63	97.00
SYPH	9365792.00	2930564.69	506515.40**	140604.93**	388677.5	16.75	89.00
AB	0.16	0.32	1.91*	0.39	0.31	17.72	68.00
PM	0.04	0.14	0.04	0.14*	0.07	23.33	77.00
Frost	1.02	0.27	0.00	0.08	0.07	23.24	77.00

DF: Days to 50% flowering; DM: Days to 90% maturity; PH: Plant height; SCH: Stand count at harvest; LS: Lodging score; NPPP: Number of pods plant^{-1}; NSPP: Number of seeds pod^{-1}; NSPPL: Number of seeds plant^{-1}; TSW: Thousand seed weight; SYPH: Seed yield ha^{-1}; AB: Ascochyta blight; PM: Powdery mildew

Table 2: Mean square from the analysis of variance for 13 traits of 49 field pea genotypes tested at Kofele

	Mean squares						
Traits	REP (df: 1)	Block (REP) (df: 12)	Plant type (df: 1)	Genotype (df: 47)	Residuals (df: 36)	CV (%)	R^2
DF	0.16	4.33	0.31	7.89***	0.93	1.23	93.00
DM	18	14.85	1.65	6.41***	1.53	0.81	90.00
PH	689.80	299.34	4777.27***	204.97***	58.50	6.00	90.00
SCH	1536.16	168.15	813.52***	95.53**	41.63	8.00	85.00
LS	5.40	8.32	171.43***	1.39**	0.64	15.92	94.00
PPP	1.02	1.51	0.62	1.56	1.02	11.98	72.00
SPP	0.5	0.54	4.30**	0.68	0.48	13.50	71.00
SPPL	156.90	53.54	512.28*	99.68	81.28	20.72	67.00
TSW	13.22	413.37	910.05**	741.78***	90.89	5.85	93.00
SYPH	5132808	3502853.7	1723818.3*	4866266.5**	415796.3	16.60	95.00
AB	0.65	1.97	0.35**	0.98**	0.42	11.97	82.00
PM	1.02	1.13	0.48	0.86*	0.41	14.86	79.00
Frost	9.81	1.77	1.91*	0.67*	0.37	14.28	83.00

DF: Days to 50% flowering; DM: Days to 90% maturity; PH: Plant height; SCH: Stand count at harvest; LS: Lodging score; NPPP: Number of pods plant^{-1}; NSPP: Number of seeds pod^{-1}; NSPPL: Number of seeds plant^{-1}; TSW: Thousand seed weight; SYPH: Seed yield ha^{-1}; AB: Ascochyta blight; PM: Powdery mildew

Table 3: Mean square from the analysis of variance for 13 traits of 49 field pea genotypes tested combined over location

	Mean squares								
Traits	LOC (df=1)	REP (df: 1)	Block (REP) (df: 12)	Plant type (df: 1)	Genotype (df: 47)	Genotype× Loc (df=48)	Residuals (df: 36)	CV (%)	R^2
DF	43.18***	0.27	5.98	0.09	15.45***	1.40	1.21	1.42	91.8
DM	16512.25***	13.29	11.36	3.21	12.35***	2.93	2.34	1.07	99
PH	53724.62***	1849.23	524.60	9078.58***	487.33***	144.67	100.87	9.1	93.7
SCH	2809***	827.59	160.89	1238.73***	125.34***	55.86*	30.79	6.62	89
LS	5.22*	4.17	6.81	289.95***	1.66*	1.04	0.98	20.4	89
PPP	1.84	15.94	3.20	2.29	2.73**	1.70*	1.04	12.23	81
SPP	4.59**	0.30	0.63	0.05	0.50	0.79**	0.37	12.1	75.6
SPPL	639.37**	377.25	138.03	40.63	124.72**	83.71	55.98	17.9	78
TSW	130011.76***	186.94	768.30	4899.39***	1538.32***	288.44***	75.71	4.61	97.8
SYPH	1294393.8	7249300	3216709.2	439590.9	4680717***	1690719***	402236.9	16.68	93.2
AB	246.94***	0.41	1.14	1.95*	0.76**	0.60*	0.37	14.13	92.8
PM	490.31***	0.53	0.63	0.12	0.57**	0.42*	0.24	18	97
Frost	474.62***	5.41	1.02	1.00*	0.40**	0.37*	0.22	17.38	97

DF: Days to 50% flowering; DM: Days to 90% maturity; PH: Plant height; SCH: Stand count at harvest; LS: Lodging score; NPPP: Number of pods plant^{-1}; NSPP: Number of seeds pod^{-1}; NSPPL: Number of seeds plant^{-1}; TSW: Thousand seed weight; SYPH: Seed yield ha^{-1}; AB: Ascochyta blight; PM: Powdery mildew

Test locations exerted highly significant to significant influence on all of the studied characters except pods plant^{-1} and seed yield (Table 3). This indicates the phenotypic expression of those characters were different at both locations. The analysis of variance revealed highly significant to significant influence on most of studied characters except days to 50% flowering, days to 90% maturity, plant height, lodging score and number of seeds plant^{-1} due to interaction effect of genotypes and locations (Table 3). A similar result was reported for genotype by location interaction effect in one or more of the studied traits (Tamene, 2017). The presence of significant genotype by location (L) interaction in this study, implying the differential performance (response) of genotypes for those traits at each location.

3.2. Mean performance of genotypes

Mean performance and range of parameters of 49 field pea genotypes have been presented in Table 4. The result of the range of parameters in Table 4 and 5 suggested that there were considerable differences observed for most of the traits under investigation. The genotypes required 73.50 to 82.75 days for flowering and 139.25 to 147.25 days to physiological maturity. Plant height was ranged from 83 to 141.50 cm, with the mean across two locations of 110.83 cm plant^{-1}.

Table 4: Mean performance and range of parameters of 49 field pea genotypes evaluated across two locations

Entry	Code	plant type	DF	DM	PH	SCH	LS	PPP	SPP	SPPL	TSW	SYPH	AB	PM	Frost
GPHA-05	G-1	pros-trate	80.25	147.25	139.5	87.5	7	9.25	5.25	48.5	161.75	3145.5	4.75	3.25	2.5
GPHA-013	G-2	pros-trate	82.75	143.25	106.5	91.75	6.25	8.75	4.75	41.75	176.5	2808.8	4.5	3.25	3
GPHA-03	G-3	pros-trate	76.5	144.25	106.5	74.5	4.75	8.75	4.75	41	152.5	2173	3	3	2.75
GPHA-019	G-4	pros-trate	78	143	120.25	83.5	6	6.75	4.75	33	213	3742	4.5	3.25	3.25
GPHA-02	G-5	pros-trate	74.5	142	112.25	82.5	6.5	8.5	4.25	36.25	167.75	4104.8	5	2.5	2.75
GPHA-010	G-6	pros-trate	77.25	141.5	119.5	82.5	6.25	9	5.25	46.25	192.75	3787.5	4.5	2.75	3
GPHA-07	G-7	pros-trate	76.75	140.25	108.25	92.5	6.25	8.5	4.75	40.75	201.75	2780.3	4.5	2	2.75
GPHA-08	G-8	pros-trate	81.5	144.75	123.75	87	7	9.5	4.75	44.75	197	3212.5	4	2.5	2.5
GPHA-06	G-9	pros-trate	74.25	142.25	114	89.5	5.5	7.25	4.5	33	206.25	4477.5	4.25	2.5	3
GPHA-012	G-10	pros-trate	78.25	141.25	123.5	84.5	6.75	7	5	35	187.5	3121	4.75	2.75	3.25
GPHA-04	G-11	pros-trate	77.25	142	134	91	6.5	8.25	4	33	190.75	3495.8	5	3	2.5
GPHA-016	G-12	pros-trate	75	139.75	109	85	6.25	7.75	4.5	35.25	174.5	2437.3	4.25	2.5	2.75
GPHA-09	G-13	pros-trate	80.25	143.5	106.5	88.5	5	8.25	4.75	39.25	207	3771.3	4.75	3.25	3.25
GPHA-01	G-14	pros-trate	77.75	142.25	120.75	92.25	7	8	4.75	38.5	254	2851	4.25	2	2.25
GPHA-018	G-15	pros-trate	79.25	144	119	90.25	7	7.75	5.25	40.75	189.5	3125	4.25	2.5	2.75
GPHA-017	G-16	pros-trate	79.5	139.5	127	92.25	7.25	8	5.25	42.25	261.75	2705.5	5	2	2.75

Table 4: Continue...

Entry	Code	plant type	DF	DM	PH	SCH	LS	PPP	SPP	SPPL	TSW	SYPH	AB	PM	Frost
GPHA-014	G-17	prostrate	76	140	115.25	90	6.5	8	5	40	181.5	2766.3	4.75	2	2.5
GPHA-011	G-18	prostrate	73.5	139.5	97.75	87.5	5.75	7.25	4.25	30.25	194.25	2120.5	4.75	3	2.5
GPHA-015	G-19	prostrate	75	141.5	112.75	90.5	6	9.5	5	47.5	186.5	4912.5	5.25	3.25	3.5
P-313-010	G-20	erect	78.5	143	93	78.75	2.25	9.25	5	46.75	197.75	3927.3	4	2.75	2.5
P-313-045	G-21	erect	76.75	143.5	107.5	87.5	3.25	8.25	4.75	38.75	179.5	3248	4	3.5	2
P-313-086	G-22	erect	79	145.5	111.75	78.25	3.75	8.25	5.25	43.25	161.75	3757.5	3.75	3.25	3.25
P-313-082	G-23	erect	77.75	140.75	83	79	2.5	8.25	4.75	39.25	183.5	4514.8	3.25	2.25	3
P-313-042	G-24	erect	76.75	141.25	94	78.5	2.75	8.5	5	41.5	182.5	3401.5	4.5	2.5	2.25
P-313-071	G-25	erect	81.25	142.25	89.25	78	2.75	8.25	5	41	187	2828.5	4	2.5	2.75
PDF-PTBEK	G-26	erect	76.75	142.75	121.25	87.25	3.75	8	5.5	44	220	7166.5	3.25	2.75	2
G227 63-2C	G-27	prostrate	77.75	144.5	109	90.5	6.25	8.25	5.25	42.25	155.75	3441.8	4	3	3.25
P-313-053	G-28	erect	78.5	144.5	107.75	77.75	2.5	9.5	5.75	55.25	200.75	5764.8	4.75	2.25	2.5
P-313-070	G-29	erect	79.75	142.5	106.25	80.5	4.25	8.75	5.25	45.75	163.5	3596	4.25	2.75	2.5
P-313-027	G-30	erect	80	140.25	84.25	72.75	3.25	7.25	4.75	34.25	175.5	2745	4.5	3	2
P-313-065	G-31	erect	81	142.75	91.75	58	2.75	8	5.25	41.5	162	3031.5	4	2.5	2.5
P-313-026	G-32	erect	79	142.75	105.75	85	3	9	4.75	42.75	184.5	4475.3	4.5	2.5	2.75
P-313-090	G-33	erect	78	141.75	102.75	72.5	3	8.75	4.75	41	181.75	3762.5	5	2.5	2.5
P-313-046	G-34	erect	74.75	143.75	120.5	86.5	3.75	9	5.5	50	196	4367	4	2.25	2.75
MIL-KEY	G-35	prostrate	77.75	143	125.25	85.25	6	10.5	4.75	49.75	183.25	4992	4	2.75	2.75
P-313-098	G-36	erect	77.75	143.25	96.25	77.25	3	7.75	5	39	176	2525.8	3.75	2.75	3
HAS-ABE	G-37	prostrate	78.25	141.75	97	74.5	5.5	9	5.25	47.75	185.75	3058	4	2.75	2.5
HO-LETA	G-38	prostrate	80.25	146.25	120.75	80.5	5.75	7	5.5	39	166	4080.5	4.25	2.25	3

Table 4: Continue...

Entry	Code	plant type	DF	DM	PH	SCH	LS	PPP	SPP	SPPL	TSW	SYPH	AB	PM	Frost
WAL-MERA	G-39	pros-trate	76	140.25	110.5	82.25	5.75	7.5	5.25	40.25	196.75	4531.5	4.5	3	3
P-313-059	G-40	erect	73.5	140	84.75	79.5	2.5	7.5	4.75	35	199.25	2866	4	2.5	2.25
P-313-061	G-41	erect	77.75	145	120.75	83	4.5	8.75	5.25	45.5	165.25	3791.5	3.75	3	2.5
P-313-068	G-42	erect	76.5	143.25	116.5	86.75	3.75	8.75	5.25	46.75	170.25	3505.5	3.25	2.75	2.75
P-313-089	G-43	erect	79	139.25	86.25	85.25	2.75	8.25	5	41.25	185.5	2577.8	4.5	2.25	2.75
P-313-067	G-44	erect	77.5	142	96	79.25	2	6.75	4.75	32	185.5	5005.3	3.75	2.75	2.75
P-313-003	G-45	erect	75.75	143.25	114.5	85	4.25	8	5.25	41.75	184.75	3574.8	4.75	3.25	2.5
ADI	G-46	pros-trate	76.25	143.25	141.5	86	5.75	8.5	5.25	44.75	197	6009	4.25	2.5	2.5
BUR-KITU	G-47	pros-trate	77	142.25	122.25	84.5	5.5	9	5.25	46.5	198.5	5104.8	4.75	2.75	2.5
BI-LALO	G-48	pros-trate	77.5	146.75	117.5	92.25	5.5	8.5	5.5	46.75	234	6925	4.5	3.25	2
BURSA	G-49	pros-trate	78.25	145.25	137.25	89.5	5.75	9.25	5.75	53.25	190	6227.3	4.25	2.5	2.5
Minimum			73.50	139.25	83.00	58.00	2.00	6.75	4.00	30.25	152.50	2120.50	3.00	2.00	2.00
Maximum			82.75	147.25	141.50	92.50	7.25	10.50	5.75	55.25	261.75	7166.50	5.25	3.50	3.50
mean			77.71	142.62	110.83	83.77	4.85	8.33	5.00	41.70	188.69	3802.88	4.29	2.70	2.68
CV			1.42	1.07	9.1	6.62	20.4	12.23	12.1	17.9	4.61	16.68	14.13	18	17.38
LSD (p=0.05)			1.55	2.16	14.16	7.82	1.39	1.44	0.85	10.55	12.27	893.99	0.85	0.69	0.66

DF: Days to 50% flowering; DM: Days to 90% maturity; PH: Plant height; SCH: Stand count at harvest; LS: Lodging score; NPPP: Number of pods plant^{-1}; NSPP: Number of seeds pod^{-1}; NSPPL: Number of seeds plant^{-1}; TSW: Thousand seed weight; SYPH: Seed yield ha^{-1}; AB: Ascochyta blight; PM: Powdery mildew

Table 5: Effect of location on yield, yield components, disease and lodging resistance of 49 field pea genotypes

Traits	Bekoji		Kofele		Traits	Bekoji		Kofele	
	Mean	Range	Mean	Range		Mean	Range	Mean	Range
DF	77.24^{b}	73-83	78.18^{a}	73-82.5	SPP	4.85^{b}	4–6	5.15^{a}	4–6
DM	133.44^{b}	129-139	151.8^{a}	147.5-155.5	SPPL	39.9^{b}	22-55.5	43.51^{a}	32-61
PH	94.28^{b}	51-142	127.39^{a}	101-156.5	TSW	214.45^{a}	172-311.5	162.94^{b}	129.5-215
SCH	87.55^{a}	52.5-97	79.98^{b}	57-92	SYPH	3721.59^{a}	1623-6088.5	3884.12^{a}	1768-9058
LS	4.68^{b}	2.5-7.5	5.01^{a}	1--8	AB	3.16b	2.5-4	5.41^{a}	3.5-7
PPP	8.23^{a}	5.5-11	8.43^{a}	7--11	PM	1.12b	1-- 2	4.29^{a}	3-5.5
					Frost	1.12b	1-1.5	4.23^{a}	3--6

Yield component traits including number of pods plant^{-1}, number of seeds pod^{-1}, number of seeds plant^{-1} and 1000 seed weight, were significantly varied ranging from 6.75 to 10.50 pods plant^{-1}, 4 to 5.75 seeds pod^{-1}, 30.25 to 55.25 seeds plant^{-1} and 152.50 to 261.75 g 1000 seeds^{-1}; the overall mean being 8.33, 5, 41.70 and 188.69 g for number of pods plant^{-1}, number of seeds pod^{-1}, number of seeds plant^{-1} and 1000 seed weight, respectively (Table 4).

The mean grain yield of field pea genotypes ranged from 1623 kg ha^{-1} to 6088.5 kg ha^{-1} and 1768 kg ha^{-1} to 9058 kg ha^{-1} with an overall mean of 3721.59 kg ha^{-1} and 3884.12 kg ha^{-1}, respectively at Bekoji and Kofele (Table 5). Genotype G-49 (Prostrate type) yielded the best of 6088.5 kg ha^{-1} at Bekoji, whereas G-48 (prostrate type) yielded the best of 9058 kg ha^{-1} at Kofele. The mean grain yield of field pea genotypes across locations varied from 2120.50 kg ha^{-1} for genotype G-18 (prostrate type) to 7166.50 kg ha^{-1} for G-26 (Semi leafless type), with an overall location mean of 3802.88 kg ha^{-1} (Table 4)

Based on location mean performance of considered traits, all traits showed differences significantly between the two locations except pods plant^{-1} and seed yield (Table 5). For example the traits like lodging score (4.68 and 5.01), ascochyta blight (3.16 and 5.41), powdery mildew (1.12 and 4.29) and frost severity score (1.12 and 4.23) revealed a high variation under Bekoji and Kofele with their respective orders (Table 5). From this result Kofele was more conducive environment for those biotic and abiotic yield limiting factors that might be due to high rain fall and wind conditions. Similar finding was reported by Yimam (2020). Therefore multi locations trial helps to inspect the genetic potential of a field pea genotype to the targeted problem.

3.3. Effect of plant types on yield and yield components

The data on mean value of yield and yield components of 49 field pea genotypes with respect to plant type are presented on Table 6. Plant types did not show any significant differences in phonological traits i.e. mean days to 50% flowering and days to 90% maturity and also pods plant^{-1} consistently at each location as well as combined over location.

3.3.1. Plant height

Plant height differed significantly between plant types consistently grown at each location and across over location. Prostrate/normal leafed type had significantly longer plant height (101.21 cm, 134.29 cm and 117.75 cm) than semi-leaf less type (85.02 cm, 118.19 cm and 101.61 cm) consistently at Bekoji, Kofele and over location, respectively (Table 6). In line to this finding, longer plant height was observed in normal leafed than semi-leafless type (Singh et al., 2012; Singh and Srivastava, 2015).

3.3.2. Number of seeds pod^{-1}

Plant types differed significantly with respect to number of seeds pod^{-1}. However, in comparing the two plant type the magnitude of variation was not consistent at each location. Semi-leaf less type had significantly higher number of seeds

Table 6: Effect of plant type on yield, yield components, disease and lodging resistance of 49 field pea genotypes at Bekoji, Kofele and combined over location

Traits	Bekoji				Kofele			
	Prostrate/normal leafed		Erect/semi-leafless		Prostrate/normal leafed		Erect/semi-leafless	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
DF	77.04^a	74.00–83.00	77.52^a	73.00–81.00	78.14^a	73.00–82.50	78.24^a	74.00–81.50
DM	133.52^a	129.00–139.50	133.33^a	130.00–136.50	151.84^a	147.50–155.50	151.74^a	148.50–155.50
PH	101.21^a	72.50–142.00	85.02^b	51.00–111.00	134.29^a	112.50–156.50	118.19^b	101.00–137.50
SCH	90.07^a	77.00–97.00	84.19^b	52.50–93.00	83.38^a	71.50–92.00	75.45^b	57.00–84.50
LS	5.82^a	4.00–7.50	3.17^b	2.50–5.00	6.41^a	5.50–8.00	3.14^b	1.00– 4.50
PPP	8.20^a	5.50–11.00	8.29^a	6.50–10.00	8.48^a	7.50–10.50	8.36^a	7.00–11.00
SPP	4.61^b	4.00–5.50	5.17^a	4.00–6.00	5.29^a	4.00–6.00	4.98^b	4.00–6.00
SPPL	37.70^b	22.00–55.00	42.83^a	29.00–55.50	44.96^a	32.00–57.50	41.57^a	32.00–61.00
TSW	219.86^a	172.00–311.50	207.24^b	185.00–244.50	166.11^a	129.50–215	158.71^b	129.50–195.50
SYPH	3946.21^a	1932–6088.50	3422.09^b	1623–5620.50	3618.61^b	1768– 9058	4238.14^a	2371–8712.50
AB	3.30^a	2.50–4.00	2.976^b	2.50–4.00	5.59^a	3.50–7.00	5.17^b	3.50–6.50
PM	1.13^a	1.00–2.00	1.12^a	1.00–1.50	4.30^a	3.00–5.50	4.26^a	3.50–5.50
Frost	1.11^a	1.00–1.50	1.14^a	1.00–1.50	4.43^a	3.00–6.00	3.98^b	3.00–5.00

Table 6: Continue...

Traits	Combined over location			
	Prostrate/normal leafed		Erect/semi–leafless	
	Mean	Range	Mean	Range
DF	77.59[a]	73.50–82.75	77.88[a]	73.50–81.25
DM	142.68[a]	139.50–147.25	142.54[a]	139.25–145.50
PH	117.75[a]	97.00–141.50	101.61[b]	83.00–121.25
SCH	86.72[a]	74.50 –92.50	79.82[b]	58.00–87.50
LS	6.12[a]	4.75–7.25	3.15[b]	2.00–4.50
PPP	8.34[a]	6.75–10.50	8.32[a]	6.75–9.50
SPP	4.95[a]	4.00–5.75	5.07[a]	4.75–5.75
SPPL	41.33[a]	30.25–53.25	42.20[a]	32.00–55.25
TSW	192.98[a]	152.50–261.75	182.98[b]	161.75–220.00
SYPH	3782.4[a]	2120.50 –6925.00	3830.14[a]	2525.80–7166.50
AB	4.45[a]	3.00–5.25	4.07[b]	3.25–5.00
PM	2.71[a]	2.00–3.25	2.69[a]	2.25–3.50
Frost	2.77[a]	2.00 –3.50	2.56[b]	2.00–3.25

DF: Days to 50% flowering; DM: Days to 90% maturity; PH: Plant height; SCH: Stand count at harvest; LS: Lodging score; NPPP: Number of pods plant^{-1}; NSPP: Number of seeds pod^{-1}; NSPPL: Number of seeds plant^{-1}; TSW: Thousand seed weight; SYPH: Seed yield ha^{-1}; AB: Ascochyta blight; PM: Powdery mildew

pod^{-1} than prostrate/normal/leafed type at Bekoji and vise-versa at Kofele.

3.3.3. Number of seeds plant^{-1}

Despite plant types did no show significant difference at Kofele and over location, mean number of seeds plant^{-1} revealed significant variation at Bekoji. Thus, semi-leaf less type had significantly higher number of seeds plant^{-1} than prostrate/ normal/ leafed type at Bekoji.

3.3.4. Thousand seed weight

Thousand seed weight differed significantly between plant types. Prostrate/ normal/ leafed type had significantly higher thousand seed weight (219.86 g, 166.11 g, and 192.98 g) than semi-leaf less type (207.24 g, 158.71 g and 182.98 g) consistently at Bekoji, Kofele and combined over location (Table 6). In opposite to this result, higher thousand seed weight was recorded in semi-leafless type in previous study (Singh and Srivastava, 2015). Relatively in comparing the two plant types, genotypes in Prostrate/ normal/ leafed type showed wide range of variation in thousand seed weight in current study.

3.3.5. Seed yield

The analysis of mean for seed yield with regard to plant types when averaged across genotypes at each location showed that the same plant type did not give the highest yield in the two locations (Table 6). In agreement to this finding, Uzun et al. (2005) also reported that the differences between normal-leafed and semi-leafless peas were not consistent in different experimental years. Prostrate/ normal leafed type showed significantly higher mean seed yield hectare^{-1} (3946.21 kg ha^{-1}) than semi-leaf less type (3422.09 kg ha^{-1}) at Bekoji. Similar result observed by Stelling (1994). Whereas at Kofele, semi-leaf less type did give significantly higher mean seed yield hectare^{-1} (4238.14 kg ha^{-1}) than Prostrate/normal leafed type (3618.61 kg ha^{-1}) (Table 6). Similar finding reported by Singh and Srivastava (2015), Yanben et al. (2022) and Tran et al. (2022). The seed yield for prostrate/normal leafed type genotypes was ranged from 1932 kg ha^{-1} to 6088.50 kg ha^{-1} and 1768 kg ha^{-1} to 9058 kg ha^{-1} at Bekoji and Kofele, respectively. It was also varied from 1623 kg ha^{-1} to 5620.50 kg ha^{-1} and 2371 kg ha^{-1} to 8712.50 kg ha^{-1} for semi-leaf less type at Bekoji and Kofele, respectively (Table 6).

Even though the same plant type did not give the highest seed yield consistently in the two locations, the yield advantage of prostrate/normal leafed type over semi-leafless type at Bekoji was 15% when averaged across genotypes. 17% yield advantage of semi-leafless type was also observed over normal leafed type at Kofele.

As significant genotype-×-location (G-×-L) interaction also shows that the same genotype might not give the highest yield for each location. In this study, the highest seed yield was recorded from normal leafed genotype G-49 (6088.5 kg ha^{-1}), G-46 (6009 kg ha^{-1}) and semi-leaf less genotype

G-26 (5620.5 kg ha^{-1}) and G-28 (5389.5 kg ha^{-1}) at Bekoji. At Kofele, G-48 (9058 kg ha^{-1}) (prostrate/normal leafed), G-26 (8712.5 kg ha^{-1}) (semi-leaf less), G-44 (7018.5 kg ha^{-1}) (semi-leaf less) and G-46 (6009 kg ha^{-1}) (semi-leaf less) have given highest seed yield.

3.4. Effect of plant types on lodging resistance

The effect of plant types on lodging resistance in terms of mean lodging score in 49 field pea genotypes are presented on Table 6. Analysis of variance indicated that there was significant (p<0.01) difference in lodging score between plant types at each location as well as combined over location (Table 1, 2 and 3). Likewise, in other mean analysis result plant types differed significantly in lodging score (Table 6). Semi-leaf less type had significantly lower lodging severity score than prostrate/normal leafed type consistently at each location. Semi leafless pea genotypes showed significantly better standing ability than leafed genotypes. However, normal leafed pea genotypes exhibited severe lodging after flowering. Due to better standing ability, semi-leaf less type has higher lodging resistance than the normal conventional leafy genotypes. Similar result reported by Singh and Srivastava (2015) and Uzun et al. (2005). However, considering other morphological lodging related traits like stem diameter, internode of first bent and stem density/weight is essential for clear assessment of lodging resistance in field pea in addition to lodging score.

3.5. Effect of plant types on frost resistance

The effect of plant types on frost resistance in terms of mean frost score in 49 field pea genotypes are presented on Table 6. The analysis of variance and mean suggested that there was significant (p<0.01) difference in frost score between plant types at Kofele and combined over location even though it showed non-significant difference at Bekoji (Table 1, 2, 3 and 6). Prostrate/ normal leafed type had significantly higher frost severity score than semi-leafless type (Table 6). This indicates normal leafed type genotypes were more susceptible to frost than semi-leafless type in the current study.

3.6. Effect of plant types on disease resistance

The effect of plant types on disease resistance in terms of mean ascochyta blight and powdery mildew severity score in 49 field pea genotypes are presented on Table 6. As analysis of variance and mean result revealed that plant types did not show any significant difference in powdery mildew severity score consistently at each location as well as combined over location (Table 1, 2, 3 and 6). However, ascochyta blight severity score differed significantly between plant types. Prostrate/ normal leafed type had significantly higher ascochyta blight severity score than semi-leafless type (Table 6). Because, normal leafed type genotypes were more susceptible to lodging. Thus, lodging enhances the canopy microclimate for fungal disease development. This indicates normal leafed type genotypes were more susceptible to ascochyta blight than semi-leafless type. In parallel to this finding, less susceptibility of semi-leafless type to ascochyta blight was reported relatively in comparing the two plants type (Yanben et al., 2022).

High degree of disease severity was observed at Kofele site than Bekoji due to conduciveness for disease development (Table 5). Thus, the response of field pea against ascochyta blight diseases was determined at Kofele with regard to plant types and genotypes. Considerable variation was observed for response against ascochyta blight diseases with respect to genotypes as well as Plant types.

From the total 49 genotypes, 17 genotypes (35%) were moderately resistance and the remaining 32 (65%) genotypes were susceptible to ascochyta blight diseases (Figure 1). With regard to plant types, 11 (52%) and 10 (48%) genotypes were moderately resistance and susceptible to ascochyta blight diseases in semi-leafless type, respectively. In prostrate/normal leafed type, 6 (21%) and 22 (79%) genotypes were also moderately resistance and susceptible to ascochyta blight diseases, respectively (Figure 2). Similar finding was reported (Yimam, 2020).

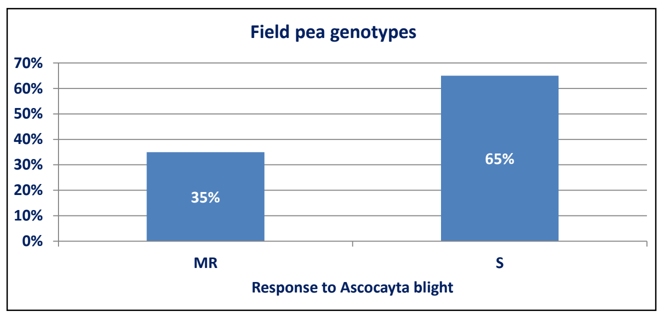

Figure 1: percentage of genotypes and response to ascochyta blight in total field pea genotypes

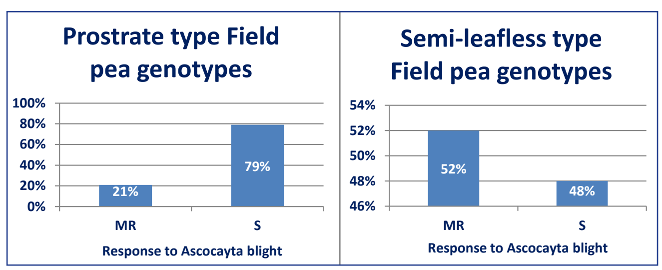

Figure 2: Percentage of genotypes and response to ascochyta blight in prostrate and semi-leafless type

3.7. Association among traits

Pearson correlation coefficient among thirteen characters in semi-leafless and prostrate/ normal leafed type genotypes of field pea has been presented in table 7.

In semi-leafless type, seed yield with plant height, thousand seed weight, number of seeds pod^{-1} and seeds plant^{-1}, lodging

Table 7: Pearson correlation coefficient among thirteen traits in twenty eight prostrate/normal leafed/ (above diagonal) and in twenty one semi-leafless/ erect type (below diagonal) field pea genotypes combined over location

characters	DF	DM	PH	SCH	LS	PPP	SPP	SPPL	TSW	SYPH	AB	PM	Frost
DF	1	0.522**	0.246	0.113	0.279	0.191	0.349	0.335	0.046	-0.103	-0.116	0.094	0.031
DM	0.017	1	0.383*	-0.029	-0.130	0.257	0.427*	0.430*	-0.245	0.403*	-0.342	0.329	-0.169
PH	-0.312	0.761**	1	0.244	0.379*	0.203	0.293	0.327	0.150	0.434*	0.155	-0.150	-0.257
SCH	-0.530*	0.129	0.503*	1	0.449**	0.000	-0.062	-0.029	0.454*	0.109	0.471*	-0.139	-0.109
LS	-0.128	0.471*	0.739**	0.369	1	-0.024	-0.064	-0.061	0.214	-0.346*	0.356*	-0.398*	-0.105
PPP	0.066	0.431	0.406	0.205	0.196	1	0.146	0.804**	-0.177	0.281	-0.135	0.135	-0.233
SPP	-0.034	0.592**	0.635**	0.112	0.440*	0.462*	1	0.699**	0.063	0.460*	-0.142	-0.065	-0.057
SPPL	0.019	0.583**	0.579**	0.208	0.320	0.884**	0.814**	1	-0.061	0.493**	-0.168	0.058	-0.217
TSW	-0.426	-0.204	0.032	0.365	-0.326	0.066	0.157	0.142	1	0.156	0.290	-0.289	-0.282
SYPH	-0.176	0.307	0.486*	0.285	0.020	0.206	0.450*	0.379*	0.595**	1	0.109	0.188	-0.143
AB	0.153	-0.179	-0.140	-0.201	-0.078	0.218	-0.078	0.082	-0.008	-0.235	1	0.064	0.142
PM	-0.048	0.413	0.343	0.187	0.482*	-0.273	-0.106	-0.250	-0.344	-0.149	-0.099	1	0.292
Frost	0.183	0.253	-0.014	-0.023	-0.068	0.120	0.049	0.131	-0.343	-0.121	-0.232	-0.233	1

DF: Days to 50% flowering; DM: Days to 90% maturity; PH: Plant height; SCH: Stand count at harvest; LS: Lodging score; NPPP: Number of pods plant^{-1}; NSPP: Number of seeds pod^{-1}; NSPPL: Number of seeds plant^{-1}; TSW: Thousand seed weight; SYPH: Seed yield ha^{-1}; AB: Ascochyta blight; PM: Powdery mildew

score with days to 90% maturity, plant height, number of seeds pod^{-1} and powdery mildew, plant height with days to 90% maturity and stand count at harvest, number of seeds pod^{-1} with number of seeds plant^{-1} and, number of seeds pod^{-1}and number of seeds plant^{-1} with days to 90% maturity, plant height and number of pods plant^{-1} were significantly and positively correlated. This indicates genotypes with late maturity and tall in plant height were more prone to lodging. Similar report was observed for some pair of traits (Azam et al., 2020; Singh, 2012; Tyagi et al., 2012).

In prostrate/ normal leafed type, significant and positive correlation coefficient estimates were obtained between seed yield and days to 90% maturity, plant height, number of seeds pod^{-1} and seeds plant^{-1}. Lodging score with plant height, stand count at harvest and ascochyta blight were significantly and positively correlated but negatively associated with seed yield and powdery mildew.

Day to 90% maturity with days to 50% flowering, plant height, number of seeds plant^{-1} and seeds pod^{-1}, number of seeds plant^{-1} with number of pods plant^{-1} and seeds pod^{-1} were also significantly and positively related. This suggests genotypes with late flowering, late maturity and taller in plant height were more susceptible to lodging. In addition genotypes with more susceptible to lodging were also more susceptible to ascochyta blight with high yield reduction but less susceptible (resistance) to powdery mildew. Thus, Yield losses caused by ascochyta blight may be reduced by breeding for improved resistance to lodging.

3.8. Regression analysis

Simple linear regression were presented in figure from 3 to 13 for total field pea genotypes and for each plant type for some selective pair of traits (lodging score with plant height, ascochyta blight, thousand seed weight and seed yield, and ascochyta blight with seed yield). The regression analysis showed that lodging had negative significant influence on seed yield of field pea genotypes (Figure 6). The line graph also exhibited similar trend with respect to each genotype (Figure 4). Lodging has revealed similar distribution on seed yield of each plant type with the exception of magnitude and significance level. Significantly largest yield loss (reduction) was observed by natural lodging in prostrate/normal leafed type. Due to its better standing ability, the yield of the semi-leafless plant type was less reduced by lodging than was the yield of the prostrate/normal leafed one (Figure 10). Similar result reported by Stelling (1994) and Kujur et al. (2015). The regression model explained 15% and 40% of yield loss due to lodging in total tested field pea genotypes and normal leafed type genotypes, respectively.

The result of analysis of variance by regression analysis for lodging severity score revealed that lodging severity score had significant effect at ($p \leq 0.05$) on ascochyta blight severity of total tested field pea genotypes. Similar finding was cited by Kujur et al. (2015). The regression analysis result also demonstrated that when the lodging severity changes within a unit the ascochyta blight severity increased significantly by 0.13 and 0.25 in total studied field pea genotypes in general and in prostrate/normal leafed plant type in particular, respectively (Figure 7 and Figure 11). The line graph also revealed similar trend with respect to each genotype (Figure 3). Moreover, the correlation analysis result revealed that ascochyta blight severity had positive significant (r=-0.356) correlation with lodging severity score in prostrate/normal leafed plant type (Table 7).

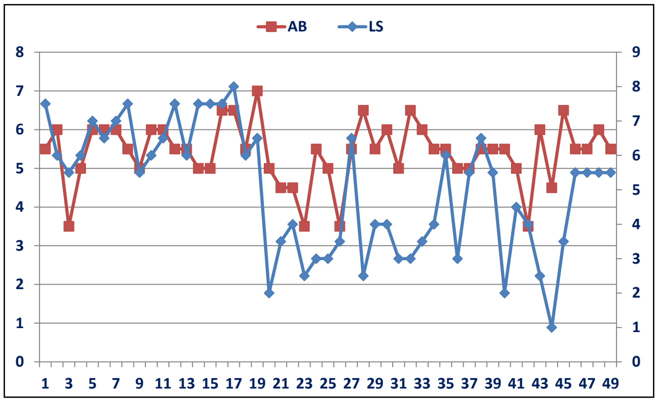

Figure 3: Association between Ascochyta-blight and lodging severity score with respect to genotypes level by line graph

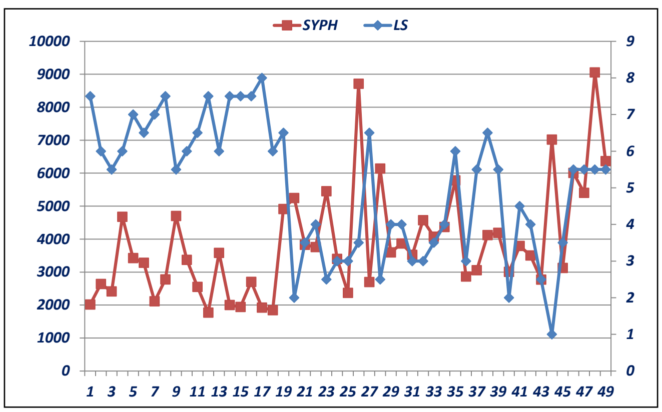

Figure 4: Association between seed yield in kg ha^{-1} and lodging severity score with respect to genotypes level by line graph

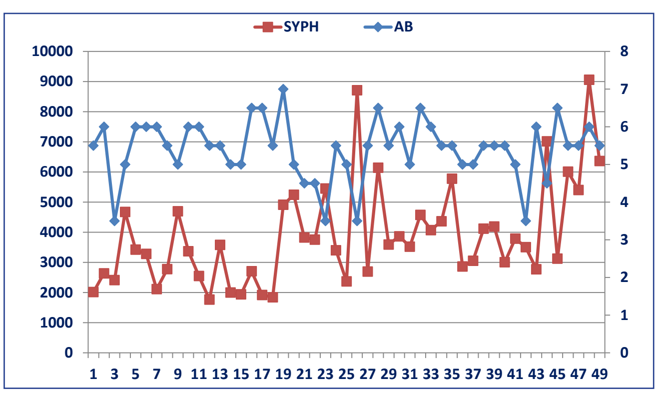

Figure 5: Association between seed yield in kg ha^{-1} and Ascocyta blight with respect to genotypes level by line graph

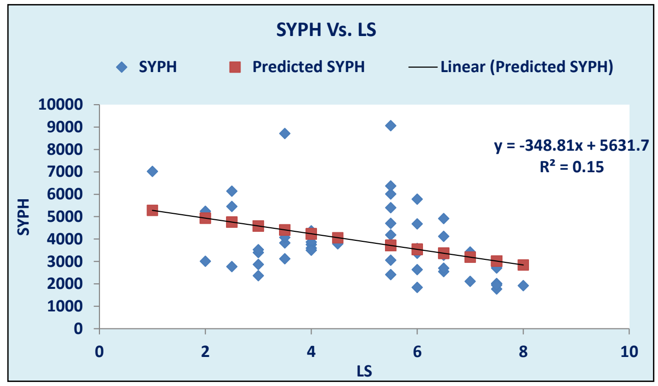

Figure 6: Seed yield in kg ha^{-1} vs. lodging severity score line fit plot by regression analysis

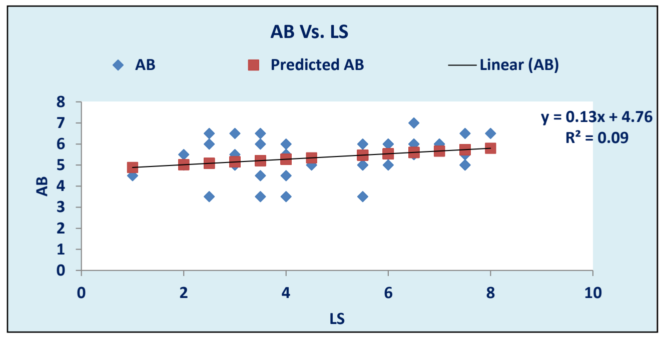

Figure 7: Ascochyta blight vs. lodging severity score line fit plot by regression analysis in total field pea genotypes

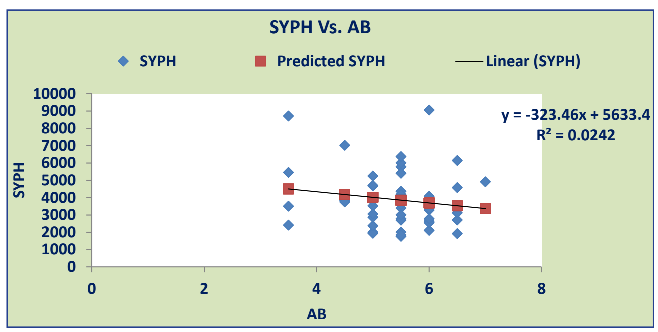

Figure 8: Seed yield in kg ha^{-1} vs. ascochyta blight severity score line fit plot by regression analysis in total field pea genotypes

The ascochyta blight severity of the conventional normal leafed plant type was more increased by lodging than was the ascochyta blight severity of the semi-leafless one (Figure 11). Ascochyta blight severity score had negative influence on seed yield of the studied field pea genotypes even if analysis of variance (ANOVA) of regression did not show significance in the present study (Figure 8). The line graph also indicated similar trend with respect to each genotype (Figure 5). Lodging had negative effect on seed weight (seed size) of field pea genotypes in each plant type with varying magnitude although analysis of variance (ANOVA) of regression was non-significant. Similar result was cited by Kujur et al. (2015). When the lodging severity changes within a unit the seed weight 1000 g^{-1} reduced by 3.3 g and 7.23 g in prostrate/normal leafed and semi-leafless plant type, respectively (Figure 12).

Lodging severity score explained approximately 14% (R^2=0.14) of variation for predicting seed weight 1000 g^{-1} in semi-leafless type genotypes (Figure 12). The regression analysis showed significant variation in response to lodging severity score for plant height. When the plant height changes within a unit the lodging severity increased by 0.10 in the total studied field pea genotypes (Figure 9). In line to this finding, significant influence of plant height on lodging severity was reported (Kujur, 2015). Plant height explained approximately 50% and 47% (R^2=0.50 and 0.47) of variation for predicting lodging severity score in the total studied field pea genotypes in general and in semi-leafless plant type in particular, respectively (Figure 9 and Figure

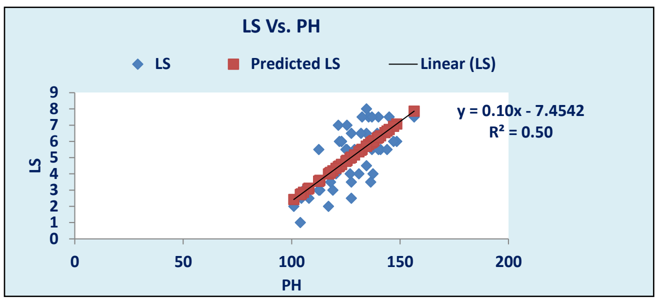

Figure 9: Lodging severity score vs. plant height line fit plot by regression analysis in total field pea genotypes

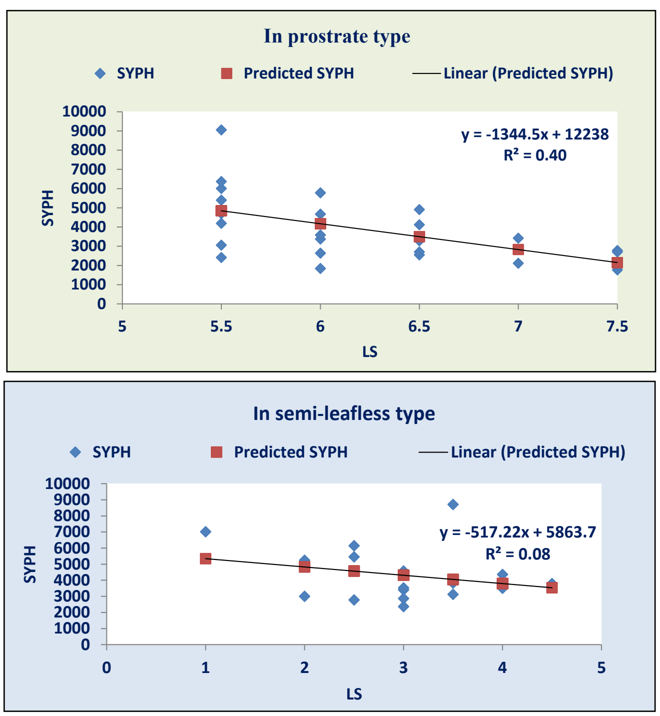

Figure 10: Seed yield in kg ha^{-1} vs. lodging severity score in prostrate/normal leafed and semi-leafless type field pea genotypes line fit plot by regression analysis

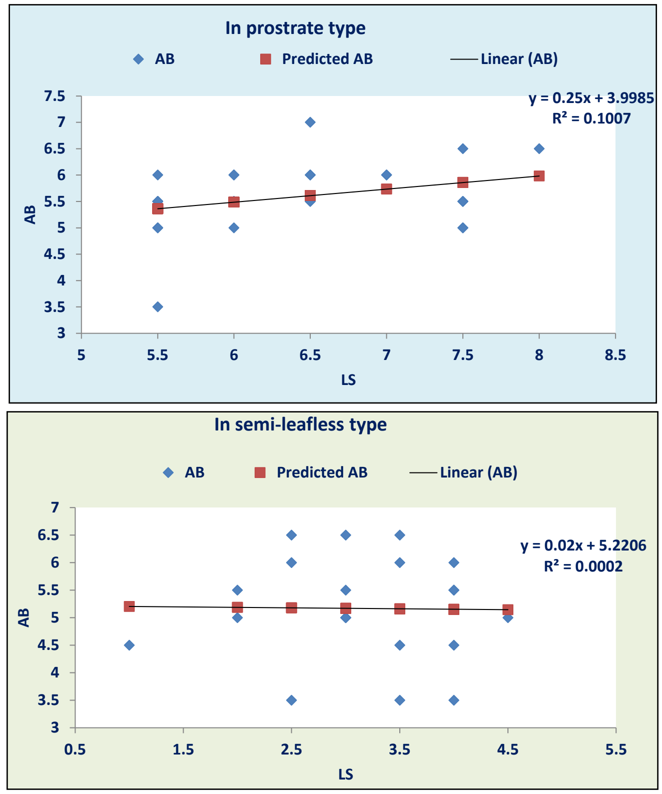

Figure 11: Ascochyta blight vs. lodging severity score in prostrate/normal leafed and semi-leafless type field pea genotypes line fit plot by regression analysis

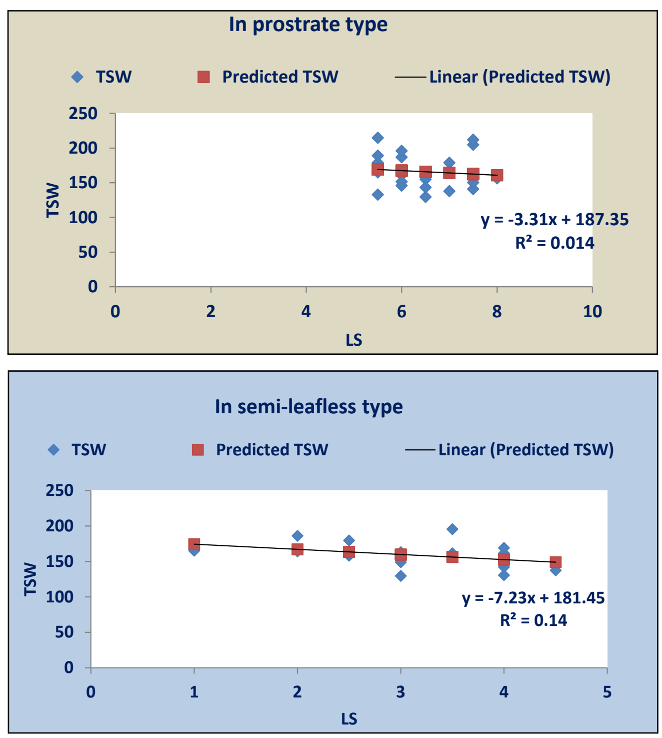

Figure 12: Thousand seed weight vs. lodging severity score in prostrate/normal leafed and semi-leafless type field pea genotypes line fit plot by regression analysis

13). It suggests that plant height play significant role in deciding the lodging resistance in field pea as predictor variables even if other considerable lodging related traits like stem diameter and stem density/weight were not included.

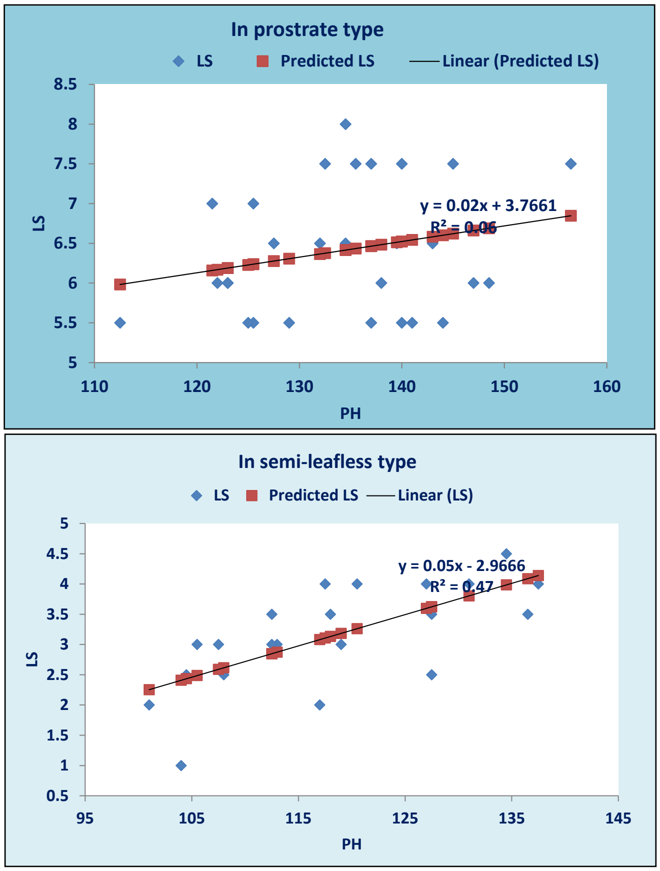

Figure 13: Lodging severity score vs. plant height in normal leafed and semi-leafless type field pea genotypes line fit plot by regression analysis

4. CONCLUSION

Plant types had significant effect on most of the studied traits. Semi-leaf less type had higher lodging resistance due to better standing ability. However, normal leafed pea genotypes exhibited severe lodging after flowering. So, significantly largest yield reduction was observed than semi-leaf less type. Genotypes with more susceptible to lodging were also susceptible to ascochyta blight with high yield reduction in normal leafed type. Thus, yield losses caused by ascochyta blight may be reduced by breeding for improved resistance to lodging.

5. REFERENCES

Anonymous, 2020. Agricultural sample survey, Report on, area and production for major crops (private peasant holdings, meher season). Volume I. Addis Ababa, Ethiopia, 13.

Anonymous, 2021. Food and Agriculture Organization, Production of pulse crops: top 10 dry pea producersin2020.Statisticaldatabase. http://www.fao.org/faostat/en/#data/QCL/visualized.

Anonymous, 2019. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL Https://Www.R-Project.Org/.

Azam, M.G., Iqbal, M.S., Hossain, M.A., Hossain, J., Hossain, M.F., 2020. Evaluation of field pea (*Pisum sativum* L.) genotypes based on genetic variation and association among yield and yield related traits under high ganges river floodplain. International Journal of Plant Biology Research 8(2), 1120.

Benti, O., 2019. Comparing yield performance and morpho-agronomic characters of landraces and released varieties of field pea (*Pisum sativum* L.) at Agarfa and Goro Woredas, Bale Zone, Oromia Region, Ethiopia. International Journal of Genetics and Genomics 7(3), 34–49. doi: 10.11648/j.ijgg.20190703.11.

Endres, G., Kandel, H., 2021. Field pea production. NDSU Carrington Research Extension Center, A1166.

Getachew, G.M., Habtamu, T., Abu, J.Y., Asnake, A.A., Merihun, G.B., Tamirat, S.S., Zemenu, F.B., Biniyam, B.B., Shiferaw, M.A., 2022. Integration of host resistance and fungicides reduced ascochyta blight pressure and minimized yield loss in field pea (*Pisum sativum* L.) in southern Ethiopia. Acta Agriculturae Scandinavica 72(1), 971–986. https://doi.org/10.1080/09064710.2022.2136107.

Gorfu, D., Hiskias, Y., 2001. Yield losses of crop caused by diseases in Ethiopia. Pest Management Journal of Ethiopia 5, 57–64. DOI: https://doi.org/10.20372/pmjoe.v5i.

Kujur, S.N., 2015. Genetics of lodging resistance and yield related traits in pea (*Pisum sativum* L.). A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Genetics and Plant Breeding in Banaras Hindu University.

Munakamwe, Z., Hill, G.D., McKenzie, B.A., 2012. Yield response to pea (*Pisum sativum* L.) genotype, population and sowing date. The Open Agriculture Journal 6, 47–56.

Paul, K.K., Bernard, K.T., Richard, S.M., Nancy, N., Lilian, J.J., Gangarao, N.R., Said, S., Peter, K., Paul, K., Joseph, K.M., 2013. Evaluation of chickpea genotypes for resistance to Ascochyta blight (*Ascochyta rabiei*) disease in the dry highlands of Kenya. Phytopathologia Mediterranea 52(1), 212–221.

Rana, J.C., Banyal, D.K., Sharma, K.D., Sharma, M.K., Gupta, S.K., Yadav, S.K., 2013. Screening of pea germplasm for resistance to powdery mildew.

Euphytica 189, 271–282. doi:10.1007/s10681-012-0798-6.
Singh, A.K., Srivastava, C.P., 2015. Effect of plant types on grain yield and lodging resistance in pea (*Pisum sativum* L.). The Indian Journal of Genetics and Plant Breeding 75(1), 69–74. DOI: 10.5958/0975-6906.2015.00008.5.
Singh, A.K., Tyagi, N., Srivastava, C.P., 2012. Interrelationship among components of lodging and yield in pea (*Pisum sativum* L.). Vegetable Science 39(2), 183–185.
Stelling, D., 1994. Performance of morphologically divergent plant types in dried peas (*Pisum sativun* L.). Journal of Agricultural Science 123, 357–361.
Tamene, T.T., 2017. Genetic variation, heritability, and advances from selection in elite breeding materials of field pea (*Pisum sativum* L.). Agricultural Research & Technology 8(4), 555740. DOI:10.19080/ARTOAJ.2017.08.555744.
Teshome, E., Tegegn, A., 2017. Comparative study of powdery mildew (*Erysiphe polygoni*) disease severity and its effect on yield and yield components of field pea (*Pisum sativum* L.) in the Southeastern Oromia, Ethiopia. Journal of Plant Pathology and Microbiology 8, 410. doi: 10.4172/2157-7471.1000410.
Tran, C.T., Becker, H.C., Horneburg, B., 2022. Agronomic performance of normal-leafed and semi-leafless pea (*Pisum sativum* L.) genotypes. Crop Science 62, 1430–1442. https://doi.org/10.1002/csc2.20746.
Tyagi, N., Singh, A.K., Kumar, S., Srivastava, C.P., 2012. Genetic variability studies for lodging resistance and yield attributes in pea (*Pisum sativum* L.). Journal of Food Legumes 25(3), 179–182.
Uzun, A., Bilgili, U., Sincik, M., Filya, I., Acikgoz, E., 2005. Yield and quality of forage type pea lines of contrasting leaf types. European Journal of Agronomy 22, 85–94.
Wang, T.F., Gossen, B.D., Slinkard, A.E., 2006. Lodging increases severity and impact of *mycosphaerella* blight on field pea. Canadian Journal of Plant Science 86, 855–863.
Yanben, S., Johnson, E.N., Syrovy, L.D., Warkentin, T.D., Devini, D.S., Shirtliffe, S.J., 2022. Evaluation of yield and agronomic performance of leafed and semi-leafless pea blends. Agronomy Journal 114, 2762–2773.
Yimam, K.A., 2020. Response of field pea (*Pisum sativum* L.) genotypes to ascochyta blight (*Mycosphaerella pinodes*) disease in Arsi Highlands, Southeastern Ethiopia. International Journal of Science and Engineering 6, 5–11. DOI: https://doi.org/10.53555/eijse.v6i2.27.
Yimam, K., Robsa, A., Yilma, G., Abo, T., 2020. Evaluation of field pea (*Pisum sativum* L.) genotypes for yield and yield attributing traits at high land of Arsi, South East Ethiopia. Science Journal of Applied Mathematics and Statistics 8(6), 73–80. doi: 10.11648/j.sjams.20200806.11.