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Agro-Morphological Evaluation and Correlation Analysis of Advanced Soybean (Glycine max L.) Lines in the Lasbela district of Balochistan

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Abstract

The present study was conducted to evaluate the genetic variability, morphological performance, and correlation among yield-related traits in 26 advanced soybean lines. Analysis of variance revealed highly significant differences ($P \leq 0.01$) among genotypes for all studied traits, indicating the presence of substantial genetic diversity. Germination percentage ranged from 20% to 96.67% with an overall mean of 62.90%, where line L-17426 exhibited maximum germination while L-24506 showed the minimum. Days to flowering varied from 42.10 to 54.11 days, with an average of 45.19 days, indicating variability in maturity behavior among genotypes. Number of flowers, bunches of flowers, branches, and leaves also differed significantly, reflecting broad genetic variation for vegetative and reproductive growth attributes. Line L-24564 consistently performed superior for several important characters including number of flowers, branches, leaves, pods plant^{-1}, 100 seed weight, plant height, and biological yield. Leaf area index ranged from 21.85 to 48.69 cm^2 with a mean of 34.82 cm^2, while plant height varied between 7.44 and 21.81 cm. Pods plant^{-1} ranged from 6.15 to 21.35 with an average of 13.77, whereas grains pod^{-1} varied from 2.56 to 7.68. Hundred seed weight ranged from 1.98 to 10.97 g, and biological yield ranged from 6.45 to 26.57 g, further confirming significant variability among soybean lines. The superior performance of lines such as L-24564, L-17422, and L-24563 suggested their suitability for future breeding and varietal development programs. Correlation analysis demonstrated that germination percentage had significant positive association with hundred seed weight, bunches of flowers, plant height, and pods plant^{-1}, indicating its contribution toward yield improvement. Days to flowering showed positive correlations with several yield-contributing traits including hundred seed weight and biological yield, whereas plant height exhibited positive relationships with biological yield, leaf area, bunches of flowers, and seed weight. Pods plant^{-1} and 100 seed weight were strongly associated with biological yield, suggesting their importance as selection criteria in soybean breeding. Conversely, grains pod^{-1} showed negative correlation with biological yield and some reproductive traits. Overall, the study confirmed the existence of considerable genetic variability among advanced soybean lines for important agronomic and yield-related characters.

Keywords: Morphological, legume, Genotype, Pods, genetic variability, and Germplasm

Introduction

Soybean (Glycine max L.) is a legume crop gifted by the nature to mankind also known as "Gold of Soil" (Mahbub et al., 2015). It belongs to the family Leguminosae and is a self-pollinated crop with having chromosome number of 2n=40. It also contains several antioxidant molecules that are good for human health since they reduce the risk of cardiovascular disease, breast cancer, osteoporosis, diabetes, and neurological illnesses (Kumar et al., 2014).

Soybean is native to Eastern Asia (China, Japan, and Korea) and then it spread to America, Europe, and other parts of the world in the eighteenth century (Shurtleff and Aoyagi, 2016). By commercializing the soybean crop in Pakistan, there is a big opportunity to tap into local demand. Furthermore, the crop has been neglected for many reasons resulting in a decrease in the area under cultivation. The Pakistan Agricultural Research Council (PARC) began coordinating research efforts (Khurshid et al., 2017).

Soybean is extremely important as it has over 200 applications in food, animal feed, and industry. It is also the most major oilseed as well as one of the most important and least expensive oilseed protein sources produced worldwide (SOYSTAT, 2018). **Soybean grows in tropical and temperate climates up to 2 meters in height with 1-4 seed in each pod, the pH for soybean should be between 6.3 and 6.5. (Staton, 2012). Soybean produce seeds in a variety of sizes and colors with the seed coat ranging from cream to black to brown to yellow.**

Soybean grows well on well-drained loams with a high organic matter content. Soybeans grow well on soils with a pH of 6.0 to 7.0, but 6.3 to 6.5 is the ideal pH for soybeans. (Staton, 2012). Due to its high photoperiod sensitivity, the selection of ideal cultivars that offer prime and steady yields in a given climate and also attain full maturity at the appropriate time is even more difficult for soybean. Soybean's growing season is also highly reliant on temperature conditions (Khurshid et al., 2017).

By selecting superior varieties and considering soil conditions, we can use variability to increase soybean yields. When sowing on time, start with a clean field for the best light interception. Consider the case of an inoculant and seed treatment that failed owing to a lack of diversity, marketing channels, and high-quality seed. The problem of a lack of adequate variety and seed quality, on the other hand, remains unresolved. For a healthy soybean crop emergence in the field, seed quality is crucial. (Arango et al., 2006). Temperature and moisture variations have the greatest impact on seed quality. (Harrington, 1972).

Significance of Study

Soybean is the major oilseed as well as one of the most important and least expensive oilseed protein source produced worldwide. By comparing a variety of soybean genotypes, this particular research experiment will be helpful to categorize, investigate, and identification of qualitative traits because soybean genotypes may respond inversely to different climatic factors. This research helps to collect precise data which were tested for growth and biomass adaptation under the subtropics of Lasbela on soybean growth and yield characteristics that may be used in future soybean breeding programmes to create high yielding genotypes with improved growth and biomass output.

Objectives

Present piece of work is based on the following research objectives which are given as under:

- To examine the different morpho-physiological traits and evaluate the potential growth of soybean lines under the experiment region.
- To find out the direction of strength of trait in relation of influence by correlation.

Materials & Methods

Line of Work

The field trial was followed by a randomized complete block design (RCBD) with 3 biological replicates at Agriculture Research Wayaro Farm, Lasbela during Rabi season, 2024-25. Twenty-six (26) soybean NARC-lines were collected from the Faculty of Agriculture, LUAWMS. The individual plot was fertilized @ 150, 100, and 140 kg N, P2O5, and K2O ha^{-1} as source urea, DAP, and SOP respectively. All the recommended practices i.e., roughing, weeding, thinning etc. were performed consistently for the respective replications. The distance between rows was 20 cm, while the distance between plants was 91.44 cm. All the cultural practices and plant protection measures were followed to preserve the field in good health.

Data collection

The following parameters were recorded at different growth stages and data was collected from 5 guarded plants in each replication for the following traits

Germination %	Leaf area (cm^2)	Number of seed / pod
Number of branches / plant	Plant height at maturity (cm)	Number of pods per plant
Number of leaves per plant	100 seed weight (g)	Biological yield (g)
Cluster of flowers		

Statistical Analysis

The data was analysed with GLM (General Linear Model) in SPSS. In order to check the analysis of variance the procedure to analyse ANOVA was changed for getting the time interval into consideration and the ability of heterogeneity of variances of temporal repeated measures of morphological parameters such as no of branches, leaf number, height of plant, area of leaf index, as well as reproductive traits were also included as given by Dutilleul (1998). This method is better than a simple ANOVA and LSD used by Steel et al. (1997).

Results

Germination (%)

Data pertaining to germination% manifested highly significant ($P \leq 0.01$) results, revealing the presence of genetic variability among tested genotypes for the trait under study. While the value of coefficient of variation (CV) was estimated as 10.37% (Table 1). Mean values for germination% was ranged between 20% and 96.67% with an overall average value of 62.90% (Table 2). Minimum germination% was noted in line L-24506 (20%) followed by L-17420 and L-24583 with mean value of 30% and 31.67%, respectively. Maximum germination% was observed in line L-17426 (96.67%) followed by L-24540 and L-24491 with mean value of 91.67% for both lines, respectively. Our findings are similar to those of the other researchers. Ahmad et al. (2019);

Chung et al. (2013); Boroomandan et al. (2009) showing that the genotypes studied have sufficient genetic variation.

Table 1: Mean square values for several morphological attributes in advanced Soybean Lines.

SOV	DF	GER%	DF	NF	BF	NB	NL
Rep	2	8.35	2.80	3.88	6.05	2.98	1.748
GEN	25	11.74**	18.77**	11.84**	13.85**	8.23**	107.54**
Error	50	1.58	4.14	1.62	1.23	0.71	0.56
C.V (%)		10.37	4.53	12.55	16.56	13.87	3.42

*=significant, **= highly significant

Abbreviation: SOV=source of variance, C.V= Coefficient of variance, DF=Degree of Freedom, Ger%=Germination percentage, DF= Days to Flowering, NF=Number of flowers, NL=Number of Leaves, NB=Number of branches, BF=Bunches of Flower.

Table 2: Mean performance and ranges of different morphological traits among advanced lines of Soybean.

S.NO	Line	GER%	DF	NF	BF	NB	NL
1	L-17418	90.00	45.33	15.6	8.41	7.05	13.06
2	L-17420	30.00	44.00	13.71	6.28	6.66	14.07
3	L-17421	70.00	46.00	14.26	4.11	5.05	13.71
4	L-17422	81.67	44.11	21.53	15.22	10.55	32.80
5	L-17426	96.67	46.33	17.53	11.12	8.91	32.55
6	L-23981	85.00	43.33	18.43	14.29	7.13	30.64
7	L-24491	91.67	44.33	14.51	5.48	7.41	16.48
8	L-24495	75.00	42.10	15.58	5.41	8.18	18.55
9	L-24496	58.33	44.11	13.2	5.31	6.09	14.07
10	L-24500	75.00	43.66	16.23	11.11	8.55	32.46
11	L-24505	81.67	45.11	8.28	3.96	4.51	13.51
12	L-24506	20.00	45.66	16.55	8.41	8.36	31.62
13	L-24511	38.33	45.33	13.48	5.17	6.65	23.06
14	L-24515	60.00	43.10	8.66	3.08	3.21	12.06
15	L-24530	71.67	46.66	12.71	4.11	6.6	23.00
16	L-24531	45.00	44.11	15.76	9.21	7.45	24.80
17	L-24536	45.00	54.11	16.63	6.29	7.23	23.33
18	L-24540	91.67	43.33	9.73	4.11	6.43	15.62
19	L-24545	45.00	43.66	17.91	4.11	7.95	28.17
20	L-24563	55.00	45.33	19.33	14.25	9.30	32.60
21	L-24564	85.00	49.23	22.25	15.12	12.88	33.80
22	L-24569	35.00	46.33	12.31	5.16	6.55	16.48
23	L-24573	75.00	46.33	14.53	10.11	6.18	15.47
24	L-24574	45.00	42.66	13.31	5.611	7.60	31.62
25	L-24578	45.00	44.33	16.23	10.22	8.18	30.64
26	L-24583	31.67	46.33	13.65	8.62	7.88	24.80
	Mean	62.90	45.19	15.07	7.85	7.40	23.03

Abbreviations: Ger%=Germination percentage, DF= Days to Flowering, NF=Number of flowers, NL=Number of Leaves, NB=Number of branches, BF=Bunches of Flower.

The study showed that germination percentages enhance crop production (Ahmad et al., 2019). However, Temperature and photoperiod, for example, have an impact on the growth and enlargement of soybean plants. (Onat et al., 2017).

Germination of soybean seed is influenced by the cultivars and their sowing date (Rahman et al., 2013; Amir et al., 2007). The percentage of seed germination showed highly significant response to planting date and differed among soybean genotypes (Morsy et al., 2016). A crucial aspect in commercial soybean production is the development of adapted and improved varieties that are suited for a wide range of agro-ecological zones. (Ibrahim et al., 2017). Hence the germination% increases crop growth and biomass production under favourable conditions. Morsy et al. (2016)

reported that there is a direct relationship between different varieties and their germination rate. Different varieties show different germination% depending on genotypes and environmental factors.

Germination % show significant positive correlation with hundred seed weight(g), bunches of flowers, height of plant and pods number of plant^{-1} plant height, however non-significant correlation was observed for biological yield(g), flower initiation, no of branches and number of flowers number of grains, leaf area index. Negative relationship was found for number of leaves (Table 3). These results indicating a relationship of germination% with yield contributing traits. Our results are equivalent to the results reported by various scientists including Ahmad et al. (2019); Khan et al. (2014) these results are at odds with one another. Arshad et al. (2006). Soybean genotypes have a wide range of genetic material and environmental circumstances (Ahmad et al., 2019).

Days to Flowering

Days to flowering mean square values shown highly significant results. ($P \leq 0.01$) results among tested genotypes. Coefficient of variation (CV) was estimated as 4.53 (Table 1). Mean values for days to initiation of flowering were ranged from 42.10 to 54 days with overall average value of 45.19 days (Table 2). Minimum days were recorded in line L-24495 (42.10 days) followed by L-24574 (42.66 days) and L-24515 (43.10 days). While, maximum days were noted in line L-24536 (54.11days) followed by L-24564 (49.23 days) and L-24530 (46.66 days) (Table 2). Our findings are consistent with our expectations. Ahmad et al. (2019), Koraddi and Basavaraja (2019) and Al-Hadi et al. (2017). Days to flowering showed more strong relations with yield contributing characters and seed yield (Al-Hadi et al., 2017) therefore, it is observed that biomass production can be increased by early flowering with increased soybean yields (Dunphy et al., 1979). Changes in days to blooming between soybean genotypes are due to differences in growth parameters. (Wuni Mawiya, 2016). Soybean is a photoperiod-sensitive, short-day plant that blooms only when the day duration falls below a particular threshold. (Destro et al., 2001, Watanabe et al. 2012). Hence early flowering results in a short stature plant that matures earlier with good yield (Sinclair and Hinson, 1992).

Table 3: Correlation among morphological traits in studied Soybean advanced lines

	Ger%	NL	NB	NF	BF	DF	GPP	HSW	PPP	LAI	BY
NL	-0.15^{NS}										
NB	0.10^{NS}	0.00^{NS}									
NF	0.00**	-0.40**	0.03**								
BF	0.26*	-0.20^{NS}	0.29**	0.15**							
DF	0.08^{NS}	0.06^{NS}	-0.12^{NS}	0.00**	-0.20 ^{NS}						
GPP	-0.21^{NS}	0.10^{NS}	-0.03^{NS}	0.09**	-0.25*	0.14^{NS}					
HSW	0.44**	-0.17^{NS}	0.11^{NS}	0.07**	0.41**	0.32**	-0.25*				
PPP	0.23*	-0.04^{NS}	0.62**	0.00**	0.35**	-0.03^{NS}	-0.07^{NS}	0.34**			
LAI	0.09^{NS}	0.47**	0.22*	0.04**	0.25*	-0.04^{NS}	0.04^{NS}	0.18^{NS}	0.43**		
BY	0.15^{NS}	0.08^{NS}	0.30**	0.04**	0.60**	0.27*	-0.41**	0.33**	0.58**	0.41**	
PH	0.22*	-0.27*	0.13^{NS}	0.12**	0.68**	-0.24*	-0.22*	0.45**	0.19^{NS}	0.26*	0.45**

Abbreviations: BY=Biological yield, BF=Bunches of Flower, DF= Days to Flowering, LAI=Leaf area index, GPP= Grain pod^{-1}, PHT=Plant Height, Ger%=Germination percentage, HSW=Hundred seed weight, NB= No of Branches, NF=No of Flowers, PPP= Pods Plant^{-1}.

Regarding correlation results flowering days showed significant positive correlation with hundred seed weight(g), leaf area (cm^2), bunches of flowers, Number of pod $plant^{-1}$, number of grain pod^{-1}, germination%, no of branches, number of leaves, and number of flowers while, significant negative correlation was observed with plant height (cm) (Table 3). Our result for correlation is similar with outcome of Al-hadi et al. (2017) and Arshad et al (2006). Machikowa et al. (2005) Days to blooming and ripening were found to be strongly and positively linked with soybean yield components. The outcome is due to the different genomic material composition and environmental conditions of soybean genotypes.

Number of Flower

Highly significant ($P \leq 0.01$) results have been observed for number of flowers from mean square values. Coefficient of variation (CV) value was found 12.55 (Table 1). Mean values for number of flowers ranged from 8.28 to 22.25 with overall mean value of 15.07 (Table 2). Minimum flowers number were noted in line L-24505 (8.28) followed by L-24515 and L-24540 with a median value of 8.66 and 9.73, distinctly. However maximum number of flowers were noted in line L-24564 (22.25) followed by L-17422 and L-24563 with mean value of 21.53 and 19.33, respectively (Table 2). Our findings are consistent with those of others. Ahmad et al. (2019), Ibrahim et al. (2017), Ali et al. (2013) and Zafar et al. (2008). These outcomes are also consistent with the outcomes of Arshad et al. (2006) and Jyoti and Tyagi (2005). Yield increases potentially with a greater number of flowering (Ibrahim et al., 2017). However, it was also observed that temperature above Heat stress is caused by temperatures above 35°C, which affects soybean blooming and pod set negatively. (Whigham and Minor, 1978). Hicks (1978) Temperatures between 16 and 32 degrees Celsius enhance flower and pod shedding, although normal environmental circumstances increase the number of flowers, resulting in higher yields.

Number of flowers were found positively significantly correlation with number of leaves, biological yield, bunches of flowers, flower initiation, area of leaf, no of grain pod^{-1}, plant height (cm), germination%, hundred seed weight (g), branches number and number of Pods $plant^{-1}$ (Table 3). Our outcomes are close with the results of which Iqbal et al. (2010); Al-hadi et al. (2017); Dunphy et al. (1979) showing that a greater number of flowerings will contribute towards high yield. The flowers number are directly proportional to yield, a greater number of leaves that increase the chemical reaction which reproductive part rapidly grow correlation found in number of flowers increase to number of leaves biological yield also.

Bunches of Flower

Analysis of variance (ANOVA) shows highly significant ($P \leq 0.01$) results were observed for bunches of flower (Table 1) revealing the presence of variation between lines for the said trait. Coefficient of variation was estimated as 16.56. (Table 1) Mean values ranged from 3.08 to 15.22 with overall mean value of 7.85 (Table 2). Minimum bunches were recorded in line L-24515 (3.08) followed by L-24505 and L-24540 with an average value of 3.96 and 4.11. However maximum number of bunches of flower were noted in genotype L-17421(15.22) followed by L-24564 and L-23981 with mean value of 15.12 and 14.29, respectively (Table 3).

Flowers were displayed in bunches. The pods number has a substantial positive relationship with biological yield. $plant^{-1}$, plant height, 100 seed weight, leaf area index, number of branches germination while, non-significant correlation was found for flower initiation, number of flowers, number of leaves, However, a strong negative association was discovered. for number of grains pod^{-1} (Table 3). This parameter with other scientist work filling gap between them because they did not select this parameter. This factor to show correlation with increase the height of the plant and the quantity of pods it produces $plant^{-1}$

Number of Branches

The number of branches was shown significant results ($P \leq 0.01$) amongst the lines under study. Value for Coefficient of variation was found as 13.87 (Table 1). Mean value for no of branches ranged from 3.21 to 12.88 with overall mean value of 7.40 (Table 2). Minimum branches were

recorded in line L-24515 (3.21) followed by L-24505 (4.05) & L-17421 (5.05). However maximum number of branches were noted in line L-24564 (12.88) followed by L-17422 (10.55) and L-24563 (9.30) (Table 2). Our findings are comparable with the results of Koraddi and Basavaraja (2019), iqbal et al. (2010), Laosuwan and Machikowa (2009), Zafar et al. (2008), Mehmet (2008), Arshad et al. (2006) Jyoti and Tyagi (2005) and Mehmet (2008) observed that number of branches vary significantly among different plant varieties and higher number of branches is responsible for large number of leaves hence, affect biological yield. They also declared that, as seed rates were increased, the number of branches shrank. It's probable that the increased competition among plants for light, space, and nutrients is causing fewer branches and higher seed rates.

Concerning correlation (Table 3) results number of branches with biological yield(g), presented positive significant correlation number of pods plant^{-1} and bunches of flower Furthermore significant correlation find with leaf area (cm^2), moreover non-significant correlation was observe for, height of plant (cm), number of grains pod^{-1} flower initiation, germination %, hundred seed weight(g), flower number leaves number, Our result for correlation are related with the finding of Ghanbari et al. (2018): Iqbal et al. (2010); Al-hadi et al. (2017).

Number of Leaves

Data concerning number of leaves showed highly significant ($P \leq 0.01$) differences among the lines under study. Value for coefficient of variance was calculated as 3.42 (Table 1). From given results it was noted that data for number of leaves were alternated from 12.06 to 33.88 with mean value of 23.03 (Table 2) Minimum leaves were recorded in genotype L-24515 (12.06) followed by L-17418 and L-24505 with an average value of 13.06 and 13.51 both are found at. However maximum number of leaves were noted in genotype L-24564 (34.80) followed by L-17422 and L-24563 with mean value of (33.5) and (32.6) respectively, (Table 2). The result shows the significant difference among genotypes. Our result for number of leaves were similar with the outcome of Al-Hadi et al. (2017) for number of leaves result also found by Ali et al. (2013) and Malik et al. (2007). Leaves are strongly influencing the morphology of the soybean plant, and its agronomic characters including seed yield (Morsy et al., 2016). Number of leaves responsible for more photosynthesis resulting in higher biomass and seed yield (Ali et al., 2013). Ali et al. (2013) noted that the increase in the quantity of leaves is helping to improve the situation. According to the researchers, these characteristics should be weighted more heavily when selecting superior soybean genotypes.

`Number of leaves indicate significant positive correlation with leaf area (cm^2), hence A significant negative connection was discovered. With number of flower and with plant height (cm), non-significant correlation was noticed in biological yield (g), flowering days, number of grain pod^{-1}, number of pods plant^{-1}, hundred grain weight (g), bunches of flowers, germination %, and number of branches (Table 3). Our findings are comparable to those of Al-hadi et al. (2017).

Leaf Area (cm^2)

Mean square values for leaf area (cm^2) shown highly significant ($P<0.01$) results noted between tested genotypes. Coefficient of variance (CV) was estimated as 12.42 (Table 4). Mean values for leaf area cm^2 were ranged from 21.85 to 48.69cm^2 with overall average value of 34.82cm^2 (Table 5). Minimum leaf area was recorded in genotype L-24496 (21.85cm^2) followed by L-17421 and L-24506 with an average value of 23.37cm^2 and 26.32cm^2 However maximum leaf area were noted in genotype L-24583 (48cm^2) followed by L-24530 and L-24540 with mean value of 45.89cm^2 and 45.10cm^2 respectively, (Table 5). Our result is similar with the findings of Al-Hadi et al. (2017). Similar result was also found by Hamakareem et al. (2015) Increased photosynthetic activity and dry matter build-up occur from increased leaflet and leaf area. (Hamakareem et al., 2015). The plant leaf area (cm2) in large leaves enhances the rate of photosynthesis, which has an effect on growth and metabolism. Temperature, photoperiod, and moisture stress are all factors that affect plant growth and metabolism negatively. (Khan et al., 2007). Many studies have also shown that high yield soybeans are accomplished by having a high harvest index and sharing the majority of photosynthetic materials to reproductive organs, whereas increasing leaf surface till graining has an inverse association with seed output. (Kumudini et al., 2002).

Leaf area (cm^2) revealed significant positive correlation with biological yield (g), number of leaves, number of pods $plant^{-1}$ also significant correlation show with bunches of flowers.

Table 4: Mean square values for different morphological traits among Soybean advanced lines.

SOV	DF		LAI	PH	PPP	GPP	HSW	BY
Rep	2		68.00	16.90	17.20	1.52	5.32	19.56
GEN	25		155.02**	37.20**	22.84**	5.082**	11.90**	81.19**
Error	50		18.73	2.61	0.671	0.94	0.53	0.97
C.V (%)			12.42	13.7	7.35	16.48	14.28	8.63

*=significant, **= highly significant
Abbreviations: C.V= Coefficient of variance, SOV=source of variance, DF=Degree of Freedom, LAI=Leaf area index, PH=height of plant, PPP=Pods $plant^{-1}$, GPP= Grain pod^{-1}, Hsw, hundred seed weight, BY= Biological yield.

Branches number and Plant height (cm) non-significant correlation was found with days to flower initiation, germination%, hundred seed weight (g), no of grain pod^{-1}, and number of flowers (Table 3). Large leaf indicates the biological yield, pods number $plant^{-1}$, and number of leaves. Photosynthesis increases as the leaf area increases, which is directly proportional to growth and biomass.

Table 5: Mean performance and ranges of different morphological traits among advanced lines of Soybean.

S. No	Line	LAI	PH	PPP	GPP	HSW	BY
1	L-17418	28.89	12.88	14.76	6.64	5.23	9.97
2	L-17420	32.47	9.57	12.56	4.57	3.94	8.47
3	L-17421	23.37	8.90	10.50	4.30	3.2	7.56
4	L-17422	36.43	20	19.51	6.96	9.26	20.88
5	L-17426	34.51	14.48	16.60	6.68	6.34	12.80
6	L-23981	28.75	19.42	17.61	6.87	6.43	19.46
7	L-24491	29.88	9.84	13.68	5.52	4.28	9.26
8	L-24495	33.72	9.65	13.70	6.62	4.11	8.47
9	L-24496	21.85	9.84	12.78	5.74	4.55	9.27
10	L-24500	30.86	14.47	15.95	6.66	6.25	12.16
11	L-24505	34.69	8.56	7.03	3.253	2.74	7.44
12	L-24506	26.32	14.46	15.12	6.65	5.25	9.97
13	L-24511	32.66	9.56	12.12	4.38	3.93	8.43
14	L-24515	41.77	7.44	6.15	2.56	1.98	6.45
15	L-24530	45.89	9.52	11.38	4.31	3.20	7.59
16	L-24531	27.06	12.38	14.67	6.63	3.20	9.96
17	L-24536	31.73	9.65	12.73	5.50	3.98	8.47
18	L-24540	45.10	8.60	8.25	4.26	2.78	7.46
19	L-24545	30.62	14.47	16.76	6.77	5.74	13.59
20	L-24563	40.39	19.42	18.10	6.91	8.46	21.78
21	L-24564	41.89	21.81	21.35	7.68	10.97	26.57
22	L-24569	37.42	9.55	11.98	4.36	3.77	8.42
23	L-24573	40.15	14.46	13.66	6.64	4.01	8.65
24	L-24574	35.34	9.65	12.71	4.62	4.02	8.47
25	L-24578	44.83	14.46	15.53	6.66	5.74	9.97
26	L-24583	48.69	12.21	12.87	5.52	5.73	9.26
	Mean	34.82	12.51	13.77	5.66	4.96	11.18

Abbreviations: S.NO is for serial number, LAI stands for leaf area index, PH stands for plant height, PPP stands for pods per plant, GPP stands for grain per pod, HSW stands for hundred seed weight, and BY stands for biological yield.

Plant Height (cm)

Height is an assertive attribute that affects adaptation and yield in soybean (Cober and Morrison 2010). Mean square values for height of plant (cm) disclosed highly significant ($P \leq 0.01$) results among tested genotypes (Table 4). Coefficient of variation (CV) was calculated as 13.7 from specified results (Table 4). Mean values for plant height (cm) were ranged from 7.44 to 21.81cm with overall average value of 12.51cm (Table 5). Minimum height was recorded in genotype L-24515 (7.44) followed by L-24505 and L-24540 with an average value of 8.56cm and 8.60cm. However maximum height was noted in genotype L-24564 (21.81cm) followed by L-17422 and L-24563 with mean value of 20cm and 19.42cm respectively, (Table 4).Our results are comparable with the finding of Koraddi and Basavaraja, (2019), Ahmad et al. (2019), Ibrahim et al. (2017), Khan et al. (2014), Machikowa and Laosuwan (2009), Zafar et al. (2008), Arshad et al. (2006), and Jyoti & Tyagi (2005),

The final seed yield was unaffected by plant height. Taller soybean cultivars developed more leaves, providing more assimilates for seed growth and larger seed yields. (Ali et al., 2013). Plant height is reduced due to differences in genetic material and environmental factors. (Khan et al., 2014). Ali et al. (2013) The most important plant qualities that contribute to a higher economic yield in the soybean crop have been discovered, and it has been proposed that these traits be given more weight for selecting superior soybean genotypes. Various plant features that should be considered while selecting soybean genotypes for enhanced seed output were suggested by people from all over the world. The plant's harvest height (Olufajo, 1992; Adeniyan, and Ayoola, 2006).

Height of plant (cm) indicated significant positive correlation with biological yield(g), bunches of flower, 100 seed weight(g), leaf area(cm^2), germination%, however negative significant showed with flowering of days, number of grain pod^{-1}, leaves number and non-significant correlated with no of pods $plant^{-1}$, number of branches and number of flowers (Table 3). These findings show a link between plant height (cm) and yield contributing factors. Our results are similar to those of Jiang et al. (2018), Ganbari et al, (2018), Al-hadi et al. (2017), Moe and Girdthai. (2013) and Iqbal et al. (2010). They discovered highly significant correlations and concluded that variances in the data could be attributed to environmental variables.

Number of Pods $Plant^{-1}$

Data about the pods number $plant^{-1}$ on display highly significant ($P \leq 0.01$) results revealing the incidence of genetic variability among tested genotypes for attribute under the study. However the value of coefficient of variation (CV) was estimated as 7.35 (Table 4). Mean value for number of pod $plant^{-1}$ were ranged from 6.15 to 21.35 with average value of 13.77 (Table 5). Minimum pods were recorded in genotype L-24515 (6.15) followed by L-24505 and with an average value of 7.03 and 8.25 respectively. However maximum pods number $plant^{-1}$ were noted in genotype L-24564 (21.35) followed by L-17422 and L-24563 with mean value of (19.51) and (18.01) respectively (Table 4).Our result are highly significant with the findings of Ahmad et al.(2019) also similar with the outcome of Ibrahim et al.(2017), Kumar et al.(2015), Ali et al.(2013), Zafar et al.(2008), Arshad et al.(2006), and Jyoti & Tyagi (2005). During the growing seasons, temperature had a substantial impact on the number of pods $plant^{-1}$. (Onat et al., 2017). Heat stress is caused by temperatures over 35°C, which is detrimental to soybean blooming and pod set. (Whigham and Minor, 1978). Rasaily et al. (1986) demonstrated that the genetic diversity of several soybean genotypes for number of pods $plant^{-1}$ is significant. Bouquet (1998) Genotype selection is one of the most critical variables in enhancing soybean pod output, according to a study. Late flowering types, taller plants bearing a considerably higher number of pods $plant^{-1}$, and fodder output can all help enhance grain yield. Ibrahim (2017) and Hicks (1978) Temperatures between 16 and 32 degrees Celsius have been proven to increase the percentage of flowers and pods lost.

Pods number $plant^{-1}$ presented significant positive correlation with biological yield (g), bunches of flower, leaf area (cm^2), hundred seed weight (g), branches number and germination% while, non-significant results showed with days to flower initiation, grains number pod^{-1}, height of plant (cm), flowers number and leaves number (Table 3). These data show a link between the number of pod $plants^{-1}$ and yield contributing factors. Our findings are consistent with those of a number of other researchers, including Al-hadi et al. (2017), Mahmudi (2013), Iqbal et al. (2010), Namdari Masudi et al. (2009) and Iqbal et al. (2003). They identified highly significant variances between soybean genotypes and came to the conclusion that variations in the results could be due to differences in the experiment's environment. Additionally, because pods and seeds are important yield components in soybeans, the positive relationship between seed yield and pod and seed quantity was most likely due to this. (Ali et al 2013). Similarly Yunesi hamze khanlu et al. (2010) in 33 mutant soybean lines, variable analysis of 9 attributions was studied. They discovered that the number of pod $plants^{-1}$ had a significant impact on soybean output. Mukhekar et al. (2004) $Plant^{-1}$ pods, which are regarded the most accurate yield indication in soybeans, contributed the most to seed yield.

Number of Grain Pod^{-1}

Data appertaining to grain number pod^{-1} distinct highly significant ($P \leq 0.01$) results revealing the presence of genetic variability between tested genotypes for the trait under study (Table 4). While the

value of coefficient of variation estimated as 16.48 (Table 4). Mean values for number of grain pod^{-1} was ranged between 2.56 to 7.68 with average value of 5.66 (Table 5). Minimum grain pod^{-1} was recorded in line L-24515 (2.56) followed by L-24505 and L-24540 with an average value of 3.25 and 4.26, respectively. Maximum grain pod^{-1} was detected in line L-24564 (7.68) followed by L-17422 and L-24563 with mean value of 6.96 and 6.91 respectively. Our result are similar with the Koraddi and Basavaraja (2019), Iqbal et al. (2010) and Moe and Girdthai.(2013), Al-Hadi et al. (2017), Mahbub et al. (2015), Detecting the presence of enough genetic heterogeneity among the genotypes examined.

The quantity of seeds pod^{-1} is an important factor since it determines seed plant^{-1} generation. Arshad et al. (2006) According to the researchers, the most important plant traits, such as the quantity of grain pods per plant, contribute to greater soybean crop economic performance and that these qualities should be given more weight when selecting superior soybean genotypes. Flower abortion, sink site formation, and pod abscission may have been affected by excessive temperature stress during reproductive development, resulting in a decrease in the quantity of seeds produced by plant^{-1}. (Duthion and Pigeaire, 1991) Grain yield is the consequence of interactions between a number of yield components, including days to flowering and the number of pods produced, both of which are influenced by crop management and growing circumstances.

Number of grain pod^{-1} showed negative significant correlation with biological yield, bunches of flower, height plant(cm), hundred weight of seed(g) while, non-significant correlation was observed for days to flowering, leaf area(cm^2), pods number plant^{-1}, germination%, number of branches, number of flowers and number of leaves (Table 3). These data suggest a relationship between yield-related characteristics and the number of grain pods per plant. Our findings are similar to those of a number of other scientists, including Al-hadi et al. (2017). Rezaizad (1999) He investigated whether there were any links between seed yield and its ingredients and found that there were. The most significant correlations with yield of seed were the seed number plant^{-1}, biological yield, and pod number plant^{-1} Narjesi et al. (2008) the amount of seeds in a batch had the largest impact on soybean seed output, according to the study.

100 Seed Weight (g)

For hundred seed weight (g) highly significant ($P \leq 0.01$) results were found suggesting the presence of genetic variability among tested genotypes for the attribute under the study (Table 4). While the value of (CV) coefficient of variation was estimated as 14.28.From given results (Table 4) mean values for hundred seed weight was ranged between 1.98 to 10.97g with average value of 4.96g (Table 5) Minimum 100seed weight was recorded in line L-24515 (1.98g) followed by L-24505 and L-24540 with an average value of 2.74g and 2.78g, respectively. Maximum seed weight was noted in line L-24564 (10.97g) followed by L-17422 and L-24563 with mean value of 9.26g and 8.46g respectively, (Table 4). Our outcomes are alike with the outcome of Koraddi and Basavaraja. (2019) Ahmad et al. (2019), Ibrahim et al. (2017), Arshad et al. (2006), and Jyoti & Tyagi (2005), iqbal et al. (2010), Zafar et al (2008). Indicating the occurrence of enough genetic variation surrounded by the genotypes examined

Turk et al. (1980) With the exception of high water stress and hot drying winds generating forced maturity, individual seed weight was shown to be substantially controlled by genetic factors. Munier-Jolain and Ney (1998) High temperatures during reproductive development, according to the data, may have exaggerated cell proliferation, grain filling rate, cotyledon cell number, resulting in seed^{-1} with a lower weight. On the other hand, hundred seed weight and harvest index had a direct impact on soybean seed output. (Arshad et al., 2006, Cui and Yu 2005). As a result, there was a wide range of hundred grain weight variation among genotypes. Ahamd et al. (2019) and Turk et al. (1980) Individual seed weight was discovered to be influenced by genetic factors, according to Solomon. (2003) revealed that when plant density increased, the weight of a hundred seed reduced.

The biological yield (g), flower bunches, flowering days, pods number, Plant height (cm), and hundred seed weight (g) have all been found to have a significant positive link. percent of germination While the number of seed pod^{-1} had a negative significant correlation, the leaf area(cm2), number of branches, flowers number, and number of leaves had non-significant

correlations. (Table 3). Our findings for the 100 seed weight (g) association are highly significant, and they agree with the outcomes of Tolorunse et al. (2019), Iqbal et al. (2010) and Moe and Girdthai (2013). Study of Bangar et al. (2003) The weight of 100 grains, the number of days from germination to blooming, and the time of cultivation were all determined to have a significant association with soybean yield.

Biological Yield (g)

Mean square values for biological yield (g) revealed highly significant ($P \leq 0.01$) results among tested lines (Table 4). Coefficient of variation (CV) was calculated as 8.63. (Table 4). Mean values for biological yield (g) was ranged between 6.45g to 26.57g with an average value of 11.18g. Minimum biological yield (g) was shown in line L-24515 (6.45g) followed by L-24505 and L-24540 with mean value of (7.44g) and (7.46g) respectively. While maximum biological yield (g) was noted in line L-24564 (26.57g) followed by L-24563 (21.78g) and L-17422 (20.88g) (Table 5). Our results are coincided with Koraddi and Basavaraja. (2019), Ahmad et al. (2019), Arshad et al. (2006), iqbal et al. (2010), Jyoti & Tyagi (2005), Zafar et al. (2008), and Gawande et al. (2002) who discovered an extensive range of variation in the qualities under investigation.

Biological yield(g) showed positive significant correlation with bunches of flower, 100 seed weight, area of leaf (cm2), number of pod plants^{-1}, height of plant (cm), leaf area (cm2) (g),number of branches and days to flower negative highly significant results were noticed in number of grain pod^{-1}, while non-significant correlation showed by germination flowers number and leaves number respectively (Table 3) Our findings are similar to those of Ahamd et al (2019), Ghanbari et al (2018),jiang et al (2018), and Iqbal et al. (2010). According to them, Variances in the data may be attributable to differences in the environment where the experiment was done, according to highly significant differences among soybean genotypes.

The biological yield of plant system, enhanced hervest index represents increase physiological capacity to assemble photosynthetic and translocate them into organs having economic profit.

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