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GENETIC VARIABILITY, HERITABILITY AND GENOTYPE X YEAR INTERACTION FOR MORPHO-YIELD TRAITS IN SOYBEAN

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Abstract

This research was conducted at The University of Agriculture, Peshawar during soybean cropping seasons, 2011 and 2012. The plant material comprised of parental lines of US germplasm (US), landraces from Kurram Agency (KA) and lines collected from Plant Genetic Resource Institute (PG) NARC Islamabad soybean genotypes. These lines were studied for genetic variability, heritability and genotype x year interaction (GEI), using RCB design with two replications. Data was recorded on leaf area, days to flowering, and maturity, plant height, 100 seed weight and seed yield plant^{-1}. Analysis of variance showed significant differences among the genotypes for 100 seed weight, DPI, days to flowering, plant height, maturity, seed yield plant^{-1}, and leaf area. GEI was significant only for plant height, seed yield plant^{-1} and leaf area. Based on mean performance, local genotype KA1-2 initiated flowers early (62 days) and whereas parental lines of US08 produced pods early (87days) in first growing season 2011. Local genotype KA1-2 matured early (200 days) in 1st growing year 2011. Local genotype KA8-3 during 2nd growing season, 2012 was taller one (353 cm). Genotype PG003765 produced the highest seed yield plant^{-1} (92.7 g) during first growing year. Maximum seed weight of 35.71 g was recorded for exotic genotype US08 in 1st growing year. High broad sense heritability estimation was in the range of 73.3 to 97.2 for days to maturity and 100 seed weight respectively. Genotypes with maximum seed weight, and seed yield plant^{-1} were US08 (exotic), and PG 003765, respectively. These genotypes could be used in the future breeding programs to develop soybean genotypes having high yield and improved oil content.

Key words: Heritability, Genetic variability, Genotype xyear interaction.

INTRODUCTION

The genus Glycine is divided into two subgenera (species), Glycine and Soja. Annual wild soybean (*Glycine soja* or (previously *G. ussuriensis*) is the direct ancestor of the cultivated soybean (*G. max* L.) because the two species are sexually compatible to an extent that G. *soja* is considered as an important source of genetic variability for soybean breeding program. Annual wild soybean is widely distributed in China, which is rich in protein content and demonstrates high tolerance to diverse environmental stresses. In addition to being essential to elucidating the origin and evolution of cultivated soybean, knowledge about wild soybean provide genetic information useful for further improvement of soybean cultivars(An *et al.*., 2009).

Cultivation of soybean was long confined chiefly to China, but gradually spread to other countries. Soybean has been used in China since 5,000 years as a food and a component of numerous drugs. A native of Asia, the soybean was introduced to the rest of the world where it finally became the major crop in few countries including USA. Relatively few countries produce soybean thus giving soybean-producing countries significant economic support in the world oilseed trade (Oz *et al.*., 2009). By studying Phylogenic relationship of wild and landraces, soybeans showed that all landrace of soybeans formed a single cluster supporting a monophyletic origin of all the cultivars. Wild soybeans in Asia, especially in south China is a tremendous genetic resource for soybean cultivar improvement.

On the basis of growth habits, soybean can be divided into two major categories i.e. indeterminate and determinate growth. Indeterminate plants continue to grow leaves on the main stem and branches throughout the flowering stage. Whereas, determinate plants stop growth on the main stem at the time of flowering but leaves continue to grow on branches till the beginning of seed growth phase. It has been observed that most of the commercial soybean varieties are indeterminate. In a short span they become much larger and perform well. Determinate plants complete their growth and height and then produce all the flowers at about the same time. They are generally one-half to 2/3 as big as indeterminate varieties. Measurement of morphological traits alone may not serve as useful criterion for assessing genetic diversity of plant germplasm. The environmental effects on these traits may sometime give a bias result in measurement relatively insensitive, particularly, where differences are very small.

More sensitive markers are, therefore, needed. Several biochemical analyses, especially proteins, make it possible to establish differences at various taxonomic levels. Specific objectives of this research were to study i. Genotype x year effects on yield and yield components of soybean germplasm and ii. Variability and heritability and for morpho-yield traits.

Materials and Methods

The research was carried out on 28 soybean germplasm belongs to exotic and indigenous groups. Out of 28, 15 were collected from Mizrina, Marghuz and Tindo parts of Kurram agency of the Khyber Pakhtunkhwa, six parental lines of US soybean germplasm were procured from United States Department of Agriculture (USDA) repository at Illinois while seven lines were provided by National Agriculture Research Council respectively. Soybean germplasm was treated with fungicide before sowing. Germplasm was sown in a randomized complete block design with two replications in two soybean growing seasons of 2011 and 2012. Row length was 1.6 m, while plant to plant and row to row distance was kept 0.2 m and 0.4 m, respectively. Recommended cultural practices and inputs were applied in field for proper growth and development of the crop. Since soybean is highly self-pollinated, five plants per line were selected randomly for recording morphological data on days to first flower initiation from date of sowing, days to maturity as days from sowing to a stage when 50 % of pods matured, plant height (cm), leaf area (cm^2) as Leaf area $plant^{-1}$ = leaf length x leaf width x 0.69 (Francis *et al*.., 1969), 100 seed weight (g) of dried (13 % moisture content) seed and seed yield $plant^{-1}$(g) (Table 1).

Table 1. List of germplasm along with Collection site/Source/Origin

Genotype Codes	Collection site/Source/Origin
Indigenous lines	**Kurram Agency Pakistan**
KA 1-2	Tindo
KA 5-1	Tindo
KA 6-14	Tindo
KA 8-3	Mizrina
KA 8-4	Mizrina
KA 8-5	Marghuz
KA 8-6	Marghuz
KA 8-7	Marghuz
KA 8-10	Marghuz
KA 8-12	Marghuz
KA 8-16	Marghuz
KA 13-3	Mizrina
KA 15-1	Mizrina
KA 15-2	Mizrina
KA 6-2	Tindo
Exotic lines	**United States of America**
US 08	Korean
US 12	Ogden
US 13	Perry
US 14	Ralsoy
US 17	CNS
US 18	Roanoke
PGRI lines	Plant Genetic Resource Institute, National Agriculture Research Centre Islamabad Pakistan (PGRI)
PG 003763	
PG 003765	
PG 003766	
PG 003767	
PG 003772	
PG 003774	
PG 003778	

Analysis of data

Data recorded on each parameter was subjected to analysis of variance (ANOVA) techniques appropriate for RCB design as outlined by Steel and Torrie, 1980) to compare mean differences among soybean genotypes for different agronomic and morphological traits. Data recorded was analyzed across the two years(2011-2012) to determine genotype x year interaction for various traits (Gomez and Gomez, 1984).

When genotype across year interaction was significant then the data was also analyzed independently for each year to estimate genotypic variance as well as environmental variances for the calculation of broad-sense heritability ($h^2_{B.S}$) of various yield contributing traits (Panse and Sukhatme, 1962).

Results and Discussion

Days to flower initiation Days to flower initiation (DFI) were significantly ($p \leq 0.05$) different within years and highly significant differences ($p \leq 0.01$) among the genotypes, while the genotype x year interaction was non-significant (Table 2). For indigenous lines, mean data for DFI varied from 31 to 72 (days) in 2011 with minimum days for genotype KA1-2 while in 2012 DFI ranged from 31.50 to 78 (days) with minimum days to flowering for genotype KA1-2 while DFI ranged from 31 to 78 (days) for both years. Days to flowering among the local genotypes ranged from 31.25 to 71.75 (days), where early flowering was produced by genotype KA1-2 and maximum days to flowering were taken by genotype KA6-14. Among the exotic genotypes mean data for days to flowering ranged from 33.50 to 68 (days), where early flowering was produced by genotype US08 and late flowering was noted for genotype US17. Among genotypes from PGRI mean data ranged from 48.25 to 71 (days) with early flowering produced by genotype PG003778 and late flowering the by genotype PG003772. By comparing means of indigenous, PGRI lines and exotic lines groups, PGRI lines took maximum days to flower initiation i.e. 60.85 followed by US lines which is 54.41 while minimum DFI was taken by land races from Kurram Agency (Table 3). Results clearly shows that all the soybean germplasm groups are different in DFI. Genotypic variance (Vg), phenotypic variance (Vp) and estimated heritability were 687.4, 776.4 and 88.5, respectively (Table 5). Similar results were also reported by Okonkwo and Idahosa (2013) who reported significant differences and high heritability for days to flowering in studied soybean genotypes. High heritability for flowering is desired in soybean. Aditya *et al.* (2011) reported significant differences for days to flowering, which supports our current findings. They also reported high heritability for days to flowering.

Days to maturity Highly significant ($p \leq 0.01$) differences among the genotypes were recorded for days to maturity while non-significant ($p > 0.05$) differences within years and the interaction between genotypes and years (Table 2). Genotype KA1-2 matured earlier in 2011 growing year while 2012 growing year genotype KA1-2 was early maturing. Days to maturity among the local genotypes ranged from 105 to 138.50 (days), where early maturity was publicized by genotype KA1-2 and late maturity was revealed by genotype 8-5. Among the exotic genotypes, days to maturity ranged from 122.50 to 138 (days), where early maturity was recorded for genotype US17 and genotype US18 was late maturing. Among the germplasm collected from PGRI, days to maturity ranged from 129.75 to 140 (days) where early maturity was noted for genotype PG003763 and late maturity was shown by genotype PG003766. By comparing the three groups of indigenous, exotic and PGRI lines, minimum days to physiological maturity were taken by US lines followed by landraces from Kurram Agency i.e.129.8 whereas maximum DTM was observed for lines collected from PGRI (Table 3). Genotypic variance (Vg), phenotypic variance (Vp) and estimated heritability were 226.1, 308.4 and 73.3, respectively (Table 5). Similar findings were also obtained by Okonkwo and Idahosa (2013) who reported significant differences for days to maturity in soybean genotypes, also high broad sense heritability was also observed by them. Range in maturity duration among the germplasm helps in selection of early maturing soybeans genotypes. Comparable results were also observed by Hakim *et al.* (2014) who reported high heritability for days to maturity in studied genotypes.

100 seed weight For 100 seed weight highly significant ($P \leq 0.01$) differences among the genotypes while non-significant ($p > 0.05$) variations were recorded within years and the interaction between genotypes and the years (Table 2). Mean data for 100 seed weight among the local genotypes ranged from 4.66 to 10.98 (g), where less 100 seed weight was shown by genotype KA13-3 and more was shown by genotype KA1-2. Among the exotic genotypes mean data for 100 seed weight ranged from 10.85 to 17.78 (g), where lower 100 seed weight was shown by genotype US17 and maximum seed weight was observed in genotype US08. Among the genotypes from PGRI, mean data ranged from 5.13 to 12.60 (g) with minimum 100 seed weight shown by genotype PG003778 and maximum 100 seed weight was shown by genotype PG003765. The mean values for 100 seed weight ranged from 4.55 to 17.86 (g) in 2011 with more 100 seed weight for genotype US08, while in 2012 100 seed weight varied from 4.65 to 17.71 (g) with maximum seed weight for genotype US08. Mean performance value comparison among the three groups expressed that seed of PGRI lines were the lightest (8.4 g) followed by indigenous (6.65 g) whereas the heaviest seed weight (13.26 g) was observed for the exotic lines group (Table 4). Genotypic variance (Vg), phenotypic variance (Vp) and estimated heritability were 45.80, 47.08 and 97.2, respectively (Table 5). Similar results were also reported by Okonkwo and Idahosa (2013). They reported significant differences for 100 seed weight among the studied soybean genotypes having high broad sense heritability. Ojo (2003) also reported similar results of high heritability for seed weight in tropical soybean genotypes in two growing seasons. Aditya *et al.* (2011) also reported significant differences for 100 seed weight in studied soybean genotypes, which support our current findings.

Plant height Plant height (PH) highly significantly varied ($p \leq 0.01$) within years and highly significant ($p \leq 0.01$) differences among the genotypes while the interaction was significant ($p \leq 0.01$) (Table 2). Among the studied indigenous genotypes, plant height ranged from 45.50 to 172.50 cm in 2011 with tallest genotype KA8-12, while in 2012 PH varied from 36 to 176.50 cm with taller plant as genotype KA8-3. Mean data for plant height among the local genotypes ranged from 40.75 to 161 (cm), where dwarf plant was genotype KA1-2 and taller genotype was shown by genotype KA15-2. Among the exotic genotypes mean data for plant height ranged from 52.25 to 104.75 (cm), where the lowest plant height was recorded for the genotype US12 whereas the highest e plant height was noted for the genotype US17. Among the germplasm collected from PGRI mean data ranged from 72 to 161.25 (cm) where less plant height was revealed by the genotype PG003774 and higher plant height was recorded for the genotype PG003778. Mean performance results from the three groups of indigenous, exotic and PGRI lines revealed that the tallest height was observed for Kurram Agency landraces (114.7 cm) followed by PGRI lines (107.03 cm) while the shortest PH was observed for US lines with mean value 80.70 cm (Table 4). Estimated heritability for plant height was 84.5 with genotypic variance (Vg) and phenotypic variance (Vp) 3619.7 and 4281.06, respectively (Table 5). Similar results were also reported by Okonkwo and Idahosa (2013) who reported significant differences for plant height in the studied genotypes. Similar results were also obtained by Tiller and Toledo (1996) who observed significant differences for years and the interaction of genotypes and years for plant height. Aditya *et al.* (2011) reported significant differences for plant height, which supports our current findings. They also observed high heritability among the studied genotypes for plant height which supports our results.

Table 2. Mean squares for days to flower initiation (DFI), days to pod initiation (DPI), days to maturity (DTM), seed yield plant^{-1} (PY), 100 seed weight (100SW), leaf area (LA) and plant height (PH) of 28 soybean genotypes.

Traits	Genotypes (G)	G x y	Years (y)	Reps w/n y	CV %
DFI	704.47**	67.93 ^{NS}	312.22*	29.01	11.3
DTM	239.56**	53.59 ^{NS}	170.04 ^{NS}	78.89	5.78
PY	292.82**	51.84**	83.02*	8.06	18.42
100 SW	46.03**	0.91 ^{NS}	0.34 ^{NS}	2.49	10.15
LA	771.416**	88.80424*	261.8923*	808.1046	18.61
PH	3748**	514*	3.94 ^{NS}	2.01	16.24

*, ** = Significant at 5 and 1% probability level, respectively, NS = non-significant

Table 3. Means for days to flowering, days to maturity and Seed yield plant^{-1} (g) of 28 soybean genotypes evaluated in two environments.

Genotypes code	Days to flowering			Days to maturity			Seed yield plant^{-1} (g)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
KA1-2	31.00	31.50	31.25	100.00	110.00	105.00	26.24	20.38	23.31
KA5-1	59.50	78.00	68.75	134.00	135.00	134.50	8.82	19.71	14.27
KA6-14	72.00	71.50	71.75	124.50	126.00	125.25	14.38	13.80	14.09
KA8-3	68.00	71.00	69.50	135.50	128.00	131.75	21.89	20.74	21.31
KA8-4	57.50	74.00	65.75	134.50	140.50	137.50	25.75	24.84	25.29
KA8-5	66.50	68.00	67.25	137.00	140.00	138.50	25.30	26.34	25.82
KA8-6	67.50	66.00	66.75	134.50	136.50	135.50	27.39	16.24	21.81
KA8-7	70.50	72.00	71.25	138.00	135.50	136.75	16.83	19.10	17.96
KA8-10	62.00	69.00	65.50	135.50	134.50	135.00	15.48	12.18	13.83
KA8-12	67.50	65.50	66.50	135.00	133.50	134.25	11.61	12.71	12.16
KA8-16	56.00	77.00	66.50	134.50	138.50	136.50	14.78	18.98	16.88
KA13-3	67.50	59.00	63.25	135.00	125.00	130.00	10.68	11.90	11.29
KA15-1	34.00	34.00	34.00	123.50	115.50	119.50	8.60	6.17	7.39
KA15-2	35.00	37.50	36.25	122.50	119.50	121.00	18.33	17.88	18.10
KA6-2	32.00	37.00	34.50	131.50	121.00	126.25	22.05	10.13	16.09
Mean			58.58			129.81			17.39
LSD (0.05)	10.37	18.19		12.57	8.07		11.19	11.41	
US08	32.50	34.50	33.50	129.00	134.50	131.75	24.57	25.66	25.12
US12	67.50	63.00	65.25	126.50	129.50	128.00	23.62	26.26	24.94
US13	31.50	51.00	41.25	119.00	130.00	124.50	14.41	35.12	24.77
US14	49.00	66.50	57.75	120.00	135.00	127.50	31.86	28.67	30.26
US17	69.00	67.00	68.00	138.00	138.00	138.00	25.86	44.37	35.12
US18	62.00	59.50	60.75	116.50	128.50	122.50	12.16	22.17	17.16
Mean			54.41			128.70			26.22
LSD (0.05)	28.99	28.32		28.09	7.24		26.61	10.32	
PG003763	57.50	65.50	61.50	119.50	140.00	129.75	11.90	13.40	12.65
PG003765	60.00	61.00	60.50	135.50	140.00	137.75	48.36	44.65	46.50
PG003766	60.00	60.50	60.25	141.50	138.50	140.00	24.49	31.59	28.04
PG003767	59.50	60.00	59.75	135.50	139.50	137.50	27.20	27.90	27.55
PG003772	69.50	72.50	71.00	137.00	139.00	138.00	12.18	17.75	14.96
PG003774	66.50	63.00	64.75	133.00	134.00	133.50	28.07	33.41	30.74
PG003778	53.50	43.00	48.25	130.50	140.50	135.50	12.72	11.68	12.20
LSD (0.05)	17.46	4.77		22.67	10.37		10.61	22.98	
Mean	56.59	59.93	60.85	129.89	132.36	136.00	20.20	21.92	24.66
LSD (0.05)		9.19			10.74			5.50	

Table 4. Means for plant height (cm), Leaf area (cm^2) and 100 seed weight (g) of 28 soybean genotypes evaluated in two environments.

Genotypes code	Plant height (cm)			Leaf area (cm^2)			100 seed weight (g)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
KA1-2	45.50	36.00	40.75	18.74	15.15	16.95	11.00	10.95	10.98
KA5-1	102.00	90.50	96.25	53.59	27.44	40.51	5.45	5.95	5.70
KA6-14	117.50	108.50	113.00	26.07	20.42	23.25	7.40	7.45	7.43
KA8-3	109.50	122.00	115.75	37.28	17.36	27.32	4.83	5.40	5.11
KA8-4	143.00	176.50	159.75	30.65	34.32	32.49	6.90	7.75	7.33
KA8-5	101.00	94.50	97.75	22.20	23.34	22.77	9.80	9.20	9.50
KA8-6	116.00	104.50	110.25	38.63	42.50	40.56	6.15	5.65	5.90
KA8-7	128.00	119.00	123.50	41.47	37.85	39.66	6.10	6.45	6.28
KA8-10	119.50	108.00	113.75	39.49	34.13	36.81	5.48	5.05	5.26
KA8-12	109.00	102.50	105.75	42.57	20.54	31.55	4.55	5.00	4.78
KA8-16	172.50	107.50	140.00	35.04	30.22	32.63	5.75	5.70	5.73
KA13-3	103.00	168.00	135.50	41.89	44.20	43.05	4.68	4.65	4.66
KA15-1	96.50	102.00	99.25	54.49	61.61	58.05	5.75	5.30	5.53
KA15-2	165.00	157.00	161.00	40.23	38.16	39.20	8.00	7.90	7.95
KA6-2	107.50	109.50	108.50	29.76	19.93	24.85	9.30	6.05	7.68
Mean			114.7			33.9			6.65
LSD (0.05)	34.80	54.56		19.72	12.85		1.52	1.62	
US08	87.00	92.50	89.75	45.28	44.91	45.09	17.86	17.71	17.78
US12	53.50	51.00	52.25	26.68	32.76	29.72	12.29	12.10	12.19
US13	81.50	61.00	71.25	24.63	25.10	24.86	14.65	12.05	13.35
US14	74.00	77.50	75.75	52.79	43.71	48.25	13.23	13.25	13.24
US17	99.50	110.00	104.75	59.05	50.44	54.75	10.00	11.70	10.85
US18	71.50	109.50	90.50	29.37	50.22	39.79	11.70	12.65	12.18
Mean			80.70			40.41			13.26
LSD (0.05)	59.90	18.26		23.67	26.38		4.14	3.73	
PG003763	111.50	92.00	101.75	24.50	29.61	27.05	6.10	6.00	6.05
PG003765	75.50	95.00	85.25	58.82	54.09	56.46	12.40	12.80	12.60
PG003766	116.00	99.00	107.50	84.79	76.92	80.85	10.30	10.85	10.58
PG003767	146.50	140.50	143.50	19.95	25.47	22.71	8.45	8.10	8.28
PG003772	82.50	73.50	78.00	24.05	19.29	21.67	5.65	5.00	5.33
PG003774	69.00	75.00	72.00	39.98	38.52	39.25	8.75	8.90	8.83
PG003778	156.00	166.50	161.25	32.74	30.85	31.80	5.20	5.05	5.13
LSD (0.05)	45.41	30.26		17.26	13.59		1.67	0.93	
Mean	105.70	105.32	107.03	38.38	35.32	39.97	8.49	8.38	8.4
LSD (0.05)		24.28			9.72			1.72	

Table 5. Variance components and heritability estimates for various traits of soybean genotypes.

Traits	Ve	Vg	Vgy	Vp	H^2(BS)(%)
Days to flowering	42.06	687.49	46.90	776.45	88.54
Leaf area	47.0	749.2	65.28	861.5	87.0
100 Seed weight	0.73	45.80	0.54	47.08	97.29
Plant height	293.50	3619.78	367.78	4281.06	84.55
seed yield plant^{-1}	15.05	279.86	44.32	339.22	82.50
Days to maturity	57.46	226.17	24.86	308.49	73.32

Vg = Genetic variance, Ve = Environmental variance, Vp = Phenotypic variance, h^2 = Heritability (broad sense)

Seed yield plant^{-1} Significant variation ($p\leq0.05$) was recorded for seed yield plant^{-1} (PY) within years and highly significant ($p\leq0.01$) differences among the genotypes and the interaction between genotypes and years (Table 2). Among the studied indigenous genotypes group, PY ranged from 8.60 to 48.36 (g) in 2011 with maximum PY for genotype PG003765, while in 2012 data for PY varied from 6.17 to 44.65 (g) with maximum yield for genotype PG003765. Mean data for seed yield plant^{-1} among the local genotypes ranged from 7.39 to 25.82 (g), among the exotic genotypes it ranged from 17.16 to 35.12 (g) whereas among the genotypes collected from PGRI, mean data ranged from 12.20 to 46.50 (g) where genotype PG003765 produced highest seed yield plant^{-1}. Means comparison among the three groups revealed that exotic lines from US produced highest yield (24.66 g) followed by PGRI lines (24.66 g) and Kurram Agency landraces (17.39 g) (Table 3). Genotypic variance (Vg), phenotypic variance (Vp) and estimated heritability were 279.8, 339.2 and 82.5, respectively (Table 5). Similar results were observed by Okonkwo and Idahosa (2013) who reported significant differences for seed yield plant^{-1} while working on soybean genotypes associated with similar high broad sense heritability. Aditya *et al.* (2011) also reported significant differences for seed yield plant^{-1}, which supports our current findings. They also observed high heritability among the studied genotypes for seed yield plant^{-1} in relevance with our results. Our current results are in conformity with that of Gurmu *et al.* (2009). They also reported significant differences for seed yield plant^{-1} in the studied soybean genotypes. Significant differences were observed for years and the interaction of genotypes and years. Similar results were also obtained by Triller and Toledo (1996) for seed yield plant^{-1}**.**

Leaf area For leaf area significant ($p\leq0.05$) variation within years and the interaction between genotypes and years, while highly significant ($p\leq0.01$) differences were observed among the genotypes (Table 2). On average more leaf area (cm^2) in 2011 was attained by genotype PG003766, while in 2012 more leaf area (cm^2) was revealed by genotype PG003766. Mean data for leaf area among local genotypes from Kurram Agency ranged from 16.95 to 58.05 (cm^2), where narrow leaves were attained by genotype KA1-2 and more leaf area was observed in the genotype KA15-1. Among the exotic genotypes mean data for leaf area ranged from 24.86 to 54.75 (cm^2), where less leaf area was shown by genotype US13 and genotype US17 produced leaves with maximum area. Among the genotypes collected from PGRI mean data ranged from 21.67 to 80.85 (cm^2) with less leaf area shown by genotype PG003772 and more leaf area by the genotype PG003766. Among the three genotypes groups, maximum leaf area was observed for exotic germplasm group from US (40.41 cm^2) followed by PGRI lines (39.97 cm^2) whereas minimum leaf area (33.9 cm^2) was observed for the local lines from Kurram Agency (Table 4). Estimated heritability for leaf area was 86.9 with genotypic variance (Vg) and phenotypic variance (Vp) 749.2 and 861.5, respectively (Table 5). Genotypes with maximum leaf area are considered to be more vigorous as more photosynthates are prepared. In comparison to the current study, Malik *et al.* (2006) also found high heritability and significant differences for leaf area among the studied soybean genotypes.

Conclusions and Recommendations

The major emphasis of the plant breeders is to enhance grain yield of crop varieties to meet the needs of end user. From the present study it could be concluded that: The results revealed significant differences for most of the yield and morphological characters in the studied soybean genotypes indicating the presence of sufficient genetic variability for effective selection. Maximum plant height was attained by local genotype KA8-3 in 2nd growing year. The maximum seed weight was recorded for exotic genotype US 08 in both growing years. Maximum grain yield plant^{-1} was recorded for exotic genotype PG003765 in first year. High heritability (broad sense) was recorded for most of the studied traits including yield and yield related traits.

The following recommendations can be made on the basis of the obtained results;

The maximum variability among the studied genotypes will result in effective selection and thus will lead to quick improvement. Genotypes with maximum seed weight, and seed yield are US08, and PG003765, respectively may be used in future breeding programs to attain high yield.

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