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Contribution of Morphological Traits to the Total Variability in Soybean (*Glycine max* (L.) Merr.) Genotypes in Western Parts of Ethiopia

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The present study was carried out using thirty-six soybean genotypes. The field experiment was conducted during the 2017/2018 main cropping season in western Ethiopia. The experimental design was triple lattice. Data were collected on 14 quantitative morphological traits with the objectives of to determine the contribution of morphological traits to the total variability in soybean. The result indicates that only the first four principal components explain 82% of the total variation. The first Principal component contributed 42 % of the total variation and dominated by days to flowering, days to maturity, plant height, number of nodes and internodes length. The second principal component explained 22 % of the total variation and most contributing traits were pod width and hundred seed weight while the PC3 explained 11 % of the total variation and dominated by number of nodes. PC4 explains7 % of the total variation and more related with grain yield. Pod per plant, seed per plant and seed per pod showed positive association with grain yield, suggesting that considering the most contributing traits are important for the improvement of soybean yield.

Key words: Bi-plot, PCA ; quantitative, Soybean.

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INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is a member of Papilionaceae family a Japanese scholar, thought the origin of soybean is northeast China, based on the observations that semi-natural wild soybeans are extensively distributed in northeast China but not in other regions, that there are many soybean varieties in this region and that many of them possess original characteristics (Fukuda,1933). Soybean introduced to Africa counters in the 19thcentury. It's one of economically important crop worldwide used as food, feed and industrial row materials and also used as soil fertility improvements. Soybean is sources of high quality protein comparable to meat, poultry and eggs, it grows well in tropical, subtropical and temperate regions. Brazil, United States of America and Argentina are the largest producer in the world (FAO, 2018) while South Africa, Nigeria and Zambia are the leading producers in Africa. Ethiopian also produce significant amount of soybean. In the year 2017-18, the area covered by soybean was 38,072.7 ha (CSA, 2017) and ranks first in yield per ha^{-1} among pulse and oil crops. Both production area and productivity of the crop in increasing manner more than any other crop in Ethiopia. Oromia is the largest contributing regional state next to Benishangul. In Ethiopia many oil and blended food processing factories are spurning up and the share of edible soybean oil production is in increasing trends and these helps substitution of imported oil, save foreign currency, reduce malnutrition, increase food security and creation of investment opportunity. Improving the yield potential of the crop is the main concern in the country. It is known that yield is governed by numerous traits therefore; a method is required to recognize and prioritize the important traits by minimizing the number of traits for successful selection and genetic gain.

Principle component analysis (PCA) is multivariate analysis technique mostly used to reduction of data without loss of information. Therefore, this study was done to determine the contribution of morphological traits to the total variability in soybean using principal component analysis.

MATERIALS AND METHODS

The Study Area

The study was conducted at three locations: Jimma, Metu and Bako Agricultural Research Centers in Ethiopia. Jimma and Mettu agricultural research centers are located in Oromia region, of South Western Ethiopia. Jimma agricultural research center is located at 7040’N36047’E with an altitude of 1.754 m.a.s.l. The place has a mean maximum and minimum temperature of 26.3 and 11.6^{0}C respectively, Mean annual rainfall of 1,572mm; characterized by reddish brown soil with pH of 6.2- 6.8 and sub humid type of climate. Metu agricultural research center is located at 8^{0}3’N and 30^0 E, at an altitude of 1,550 m.a.s.l) has a mean maximum and minimum temperatures of 28.9 and 12.7^{o}C respectively and mean annual rainfall of 1,829 mm; characterized by dark red brown soil. Bako Agricultural research center (9^{0}6'N 37^{0}09' E, 1650 m.a.s.l) is located in at altitude of 1,650 meters above sea level (m.a.s.l). The mean annual rain fall of the area is 1238 mm. The mean minimum, maximum and average air temperature of the area is 13.3, 28.0, and 20.6^{0}C, respectively; and relative humidity of 63.55%. The soil is reddish brown in color and clay and loam in texture.

Experimental Layout and Design

The thirty-six soybean genotypes including four checks (Table 1) were laid out in a triple lattice design. Each plot was four rows 4 m long with a space of 60 cm between rows and 5 cm between plants. Fertilizer was applied to each plot at the rate of 18 kg N and 46 kg P2O5 ha^{-1}in the form of diammonium phosphate at planting. Other agronomic practices were followed as non-experimental variables and applied uniformly to the entire experimental area. For data analysis, grain yield measured from a net plot size of 4.8m^2 and then converted into t ha^{-1} at 12.5 % standard grain moisture content.

Data collection and statistical analyses

Data were collected on days to flowering, days to maturity, number of trifoliate leaves, plant height, and number of nodes, internodes length, and pod per plant, pod length, pod width, seed per plant, and seed per pod, biological yield per plant, harvest index, hundred seed weight and yield per plot. The principal component analysis was done by using past software.

Table1.Details of the soybean genotypes used for this study

№	Name of Genotypes	Seed Source	№	Name of Genotypes	Seed Source
1.	LD13-00833	AON*	19.	PI417126	AON*
2.	LD11-10649	AON*	20.	PI507005	AON*
3.	SA13-3135	AON*	21.	PI615437	AON*
4.	LD13-08470	AON*	22.	PI628932	AON*
5.	LD13-03483	AON*	23.	PI462312	AON*
6.	LD13-08466	AON*	24.	PI605773	AON*
7.	LD13-06216	AON*	25.	PI605854B	AON*
8.	LD10-10198	AON*	26.	PI594767A	AON*
9.	LD13-07022	AON*	27.	PI416873B	AON*
10.	F6 LG06-5920 x LG04-6000	Cross*	28.	PI567180	AON*
11.	LG04-4468 x U02-242055	Cross*	29.	PI423960B	AON*
12.	LG04-5993 x LG04-5196	Cross*	30.	PI635999	AON*
13.	F6 LG04-4717 x LG05-4292	Cross*	31.	PI605865B	AON*
14.	PI200466	AON*	32.	PI423960A	AON*
15.	PI587905	AON*	33.	AFGAT	Released
16.	PI416778	AON*	34.	Nyala	Released
17.	PI459025B	AON*	35.	Nova	Released
18	PI594149	AON*	36.	Clark 63 K	Released

Source: EIAR/JARC, ***AON=**Advanced observation nursery, all of the tested genotypes were introduced from USA except the released varieties.

RESULTS AND DISCUSSION

Principal component analyses are one of multivariate analyses. It gives clear information about certain traits and genotypes that gives an indication to the breeding programs. The present study indicates that the first four 4 principal components explains 82% of the total variation amongst 36 tested soybean genotypes for 14 morphological traits with eigen values more than one (Table 2). Out of the total principal components, PC1 recorded the highest variation 42 % followed by s PC2 which accounts 22 %, PC3 and PC4 accounts 11% and 7 % respectively. Traits having values greater than 0.3 in each PCs over the combined location listed in table 3. The first principal component (PCI) which accounts the highest variation was mostly related with traits days to 50% flowering, days to maturity, plant height, number of nodes and internodes length while in the second principal components (PC_2) pod width and hundred seed weight were the most contributed traits for the variation. The third principal component (PC_3), dominated by single trait that i.e., number of nodes. The fourth principal component was more associated with grain yield. Iqbal *et al*. (2008) reported 69.77% contribution of the total variability by first three PC in soybean while Ghafoor *et al*. (2001) reported 79.5% contribution by first four PC in black gram.

Several workers reported that the first two or four PC are responsible to explain more than 70% of the total variablity in soybean (Bhartiya *et al*. 2011; Mebatsion *et al*., 2012;Wang *et al*. 2013) Hashash (2016) evaluated soybean genotypes by using principle components analysis and reported that PC1 and PC2 having eigen values highest than one explained 82.55 % of total variability. Nidhi *et al*.(2018) evaluated soybean genotypes and reported that the first five principal components explains 73 % of the total variation from this the first principal component recorded the higher variation 37.13% followed by 13.02% PC2, 10.17% (PC3), 6.88% (PC4) and 6.24% (PC5) and the most contributing traits are days to flowering, days to maturity, plant height, number of branches per plant, number of nodes per plant, number of pods per plant, number of pods per node, number of seeds per plant, biological yield per plant, harvest index and number of seeds per pod were more important yield contributing traits in soybean. Manav *et al*. (2016) reported the results of PC analyses in soybean accessions the first three PC explained 79.37 % of the total variation, PC1 contributed 52.85 %, PC2 explained 14.94%, PC3 explained 11.58% of the total variation and dominated by 100 seed weight, number of days to maturity, number of branches per plant, pods per plant, seed yield per plant and plant height, pod length and number of seeds per pod and days to flowering. Tadesse *et al*. (2015) reported that the analyses of principal component in 49 soybean germplasm classified in to five principal components, the major contributing characters for the diversity in the first principal components analyses were number of pods per plant, biological yield and seed yield

Table 2. Principal component analyses value of traits, eigen value, % variation, and cumulative % of 36 soybean genotypes over location.

Traits	**PC1**	**PC2**	**PC3**	**PC4**
Days to flowering (FD)	0.35	0.13	0.07	0.00
Days to maturity (MD)	0.33	0.22	0.20	-0.01
Number of trifoliate leaf (NIT)	0.35	-0.06	0.08	0.03
Plant height (PH)	0.38	0.02	0.04	-0.03
Number of internode (Nin)	0.31	-0.13	0.30	-0.04
Internodes length (INL)	0.32	0.08	-0.08	0.10
Pod per plant (PP)	0.24	-0.33	-0.14	0.23
Pod length (PL)	0.23	0.22	-0.29	-0.19
Pod width (PW)	-0.10	0.43	-0.20	-0.09
Seed per pod (SP)	0.24	-0.34	-0.30	-0.02
Seed per pod (SPD)	0.10	-0.11	-0.42	-0.72
Biological yield (BY)	0.31	0.26	-0.12	0.02
Harvest index (HI)	-0.13	-0.40	-0.19	-0.15
Hundred seed weight (HW)	-0.11	0.45	-0.30	0.08
Yield per ha-^{1}(t/ha)	0.04	-0.06	-0.56	0.59
Eigen value	6.22	3.35	1.60	1.06
Proportion	0.42	0.22	0.11	0.07
Cumulative	0.42	0.64	0.75	0.82

Table 3. Traits having values greater than 0.3 in each PCs over the combined location

PC1	PC2	PC3	PC4
Days to flowering	Pod width	Number of nodes	Yield
Days to maturity	Hundred seed weight		
Number of trifoliate leaves	-	-	-
Plant height	-	-	-
Number of nodes	-	-	-
Internodes length	-	-	-

The value of all the tested soybean genotypes principal component analyses scores listed in table 4. Among the tested soybean genotypes the maximum principal component scores for all the evaluated traits were estimated in these four principal components. These scores can be used as indicatives for the purpose of selection and decided by variability explained by each of the PC's. The maximum score of PCs for specific component indicates high values for the traits in those particular genotypes.

Soybean genotypes are selected on the basis of PC score in decreasing order in each component and presented in tables 5 Genotypes PI605773(4.4), PI635999(4.05), PI605854B (3.17), PI567180(3.9) in PC1 indicating those genotypes had high value of days to 50% flowering, days to maturity, plant height, number of nodes and internodes length. In PC 2 genotypes PI594149(3.8), PI416778(3.6), PI417126(2.8), PI459025B(2.2)had high value for pod width and hundred seed weight in PC3 genotypes PI459025B(3.05), PI417126(1.93), LD13-07022(1.6), LG04-4468 x U02-242055(1.8) had shown high in number of node and genotypes LD11-10649(2.4), PI615437(1.6), PI567180(1.4, LD13-08470(1.2) in PC4 exhibited with high value of grain yield.

Table 4. Principal component analyses scores of soybean genotypes over location in 2017/18 cropping seasons

Genotypes	PC 1	PC 2	PC 3	PC 4
LD13-00833	-2.97	-0.87	-0.54	-0.42
LD11-10649	0.83	-1.62	0.23	2.45
SA13-3135	-2.95	-1.80	1.00	0.45
LD13-08470	-2.84	-1.36	-1.44	1.23
LD13-03483	-3.07	0.23	-1.71	0.57
LD13-08466	-2.91	-1.35	-0.36	-0.16
LD13-06216	-2.19	-0.55	-0.11	-0.06
LD10-10198	-2.85	-1.88	-0.71	-0.49
LD13-07022	-2.74	-0.94	1.60	0.79
F6 LG06-5920 x LG04-6000	-3.21	-1.06	0.57	0.23
LG04-4468 x U02-242055	-2.29	-1.05	1.57	0.73
LG04-5993 x LG04-5196	-2.67	1.55	-0.50	1.21
F6 LG04-4717 x LG05-4292	-2.88	-0.67	-0.29	-0.71
PI200466	0.73	1.44	0.22	-1.00
PI587905	1.82	-1.97	0.22	-1.64
PI416778	-3.14	3.64	-2.36	-1.12
PI459025B	0.64	2.27	3.05	0.76
PI594149	-0.85	3.83	1.41	-0.42
PI417126	-0.76	2.80	1.93	1.08
PI507005	-0.89	1.27	0.31	-0.69
PI615437	3.03	-0.24	-1.61	1.62
PI628932	0.74	1.33	-1.21	-1.26
PI462312	1.40	1.47	-0.79	-0.49
PI605773	4.41	0.28	0.45	0.77
PI605854B	3.17	-0.85	0.31	0.63
PI594767A	1.54	-1.02	-2.87	-0.64
PI416873B	-1.27	0.86	1.36	-1.09
PI567180	3.09	1.29	-1.15	1.44
PI423960B	1.58	1.04	0.60	-2.05

Table 4. Continued

PI635999	4.05	2.18	0.56	-0.49
PI605865B	2.65	0.70	-1.74	0.42
PI423960A	1.19	-1.15	0.07	-0.46
AFGAT	2.56	-1.87	0.17	0.21
Nyala	1.63	0.47	0.58	-0.31
Nova	2.47	-5.26	1.47	-1.82
Clark 63 K	2.94	-1.17	-0.28	0.73

Table 5. Soybean genotypes are selected on the basis of PC score in decreasing order in each component.

PC 1	PC 2	PC 3	PC 4
PI605773	PI594149	PI459025B	LD11-10649
PI635999	PI416778	PI417126	PI615437
PI605854B	PI417126	LD13-07022	PI567180
PI567180	PI459025B	LG04-4468 x U02-242055	LD13-08470

From this study the PC bi-plot indicates that biological yield, pod length, days to flowering, days to maturity, number of trifoliate leaf, plant height, number of node and internodes length of the traits correlated positively with each other however, strong positive correlation were observed between hundred seed weight and pod width similarly pod per plant, seed per plant and seed per pod shows strong positive association with grain yield (Figure 1). However, seed per pod indicates poor representation of the variation. The PC-bi plot indicates that genotypes LD 11-10649, PI587905, AFGAT, and PI423960 had more explained by the traits seed per pod, pod per plant and yield. While genotypes PI507003 and PI416838 are more responsive for hundred seed weight and pod width.

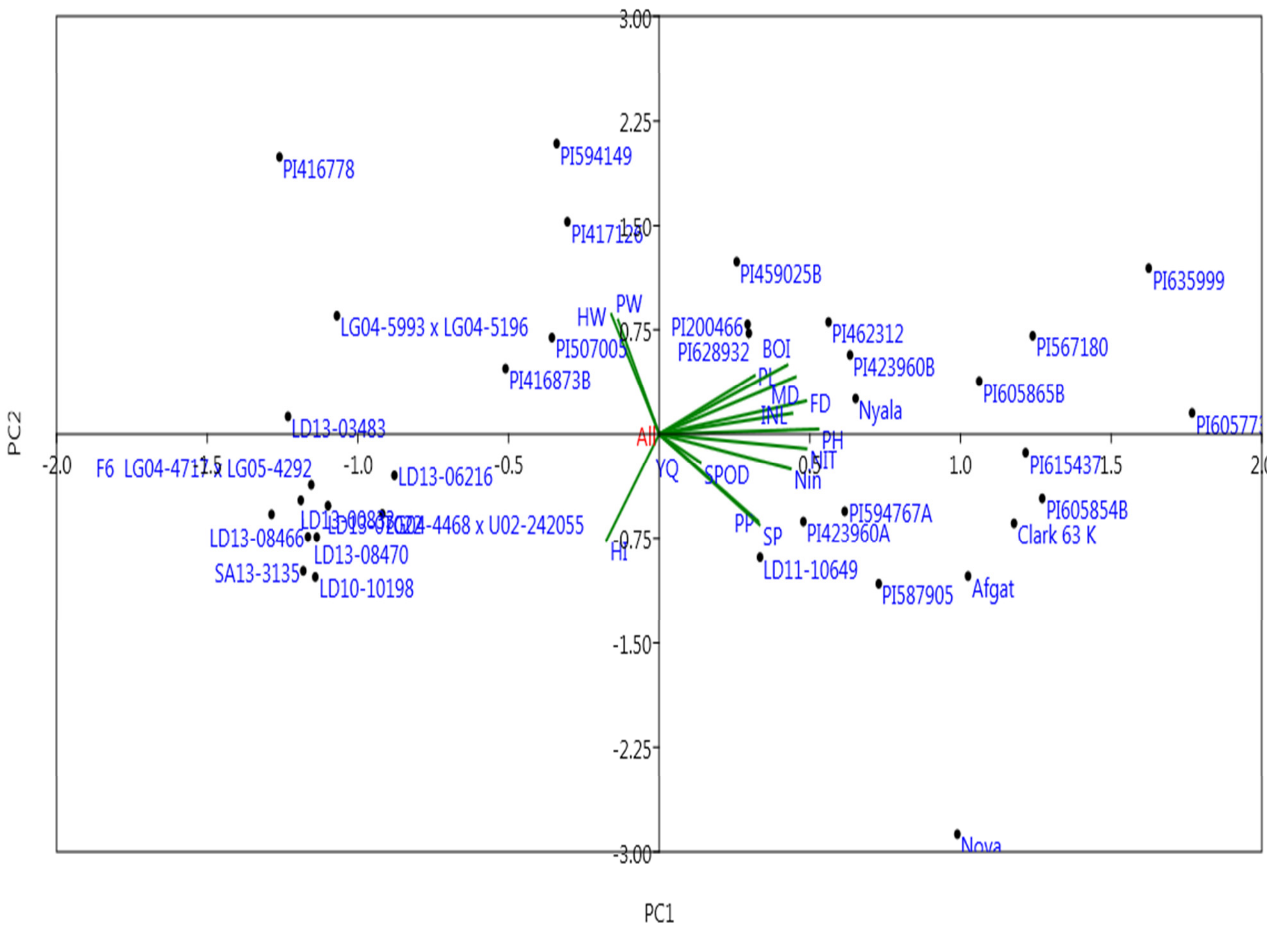

Figure 11. Biplot of the first two principal components to the total variation for 36 soybean genotypes.

CONCLUSION

Based on the present results, days to flowering, days to maturity, plant height, number of nodes, internodes length, pod width, hundred seed weight are the most important contributor traits and 82 % of the total variation was contributed by these traits. Therefore, considering these traits during selection make effective for the improvement of soybean yield.

CONFLICT OF INTEREST

The author declares no conflicts of interests.

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