Genetic variability of soybean accessions for yield and yield attributing traits through using multivariate analysis

R. Darai¹,*; KH Dhakal²; RP Sah¹

¹Senior Scientist(S-4)/Coordinator and STO, Grain Legumes Research Program, Khajura, Nepal
²Assit. Professor, Department of Genetics & Plant Breeding, AFU, Rampur, Nepal
Corresponding mail: rajendra5042@yahoo.co.uk

Abstract—Soybean (Glycine max L. Merrill) is the second most important food legume of Nepal, grown either as sole or intercrop with maize or in paddy bund. It has immense potential to increase the area and production due to its yield stability and wider adaptation trait. Its importance increases due to the burgeoning of the poultry and cattle's farming. Genetic variability is under threat not only in the field but also in the national commodity programs that are meant to be safe heavens. It is the basic requirement for a successful breeding programme. Collection and evaluation of accessions of any crop is a pre-requisite for any programme, which provides a greater scope for exploiting genetic variability. Considering the truths, soybean cultivars were collected from IITA, Nigeria, NAGRC gene bank and local collections studied in depth for morphological characterization using multivariate analyses. An investigation was carried out in the forms of regeneration and observation screening nurseries to assess the variability quantitative traits at Rampur environment and over the years 2012 to 2013. Screening nurseries was carried out in rod row design. Yield and yield contributing traits were analyzed to understand the extent of variability for yield and yield attributing traits. The present study revealed the presence of high levels of variations for nine different morphological traits including yield attributes and seed yield among the soybean accessions. A total of forty diverse accessions of local landraces and exotic lines were evaluated in the subtropical rainfed system of Rampur in the year 2012. Some of high yielding accessions of soybean were 272W, Cobb, G-758, and Puja. Likewise a total of hundred one accessions were evaluated for grain yield and yield parameters during 2013. The research results revealed that high yielding soybean accessions were G-18428, TGX 1990-67F, G-757, V9 (B/pur-9, TGX1990-5F. Under cluster analysis using all the seven morphological traits grouped the 40 accessions into five major groups at the genetic distance of 202.63. It was also found that, among the five clusters, cluster I was the largest and consisted of 32 accessions and the second largest group was the clusters II and IV, and each consisted of three accessions. Likely cluster analysis using all the seven morphological traits grouped the 101 accessions collected from National Agricultural Genetic Resources Centre (Gene Bank) and exotic lines from IITA, Nigeria into five major groups at the genetic distance of 267.82. Among the five clusters, cluster I was the largest and consisted of eighty four accessions and the second largest group was the clusters II consisted of fourteen accessions. The accessions from cluster I and cluster II could be used for hybridization program with the soybean accessions of clusters III, IV and V in order to develop high yielding soybean varieties for further improvement. The first seven principal components were extracted which accounted for about 100% variability among the 104 soybean accessions for all morphological characters. There was rich diversity found in seed coat color of the soybean local landraces. Flower color and pattern of flower were also found diverse among the collected accessions. This study indicated the presence of high levels of genetic variability among the soybean accessions in terms of evaluated characters.

Keywords—soybean, accessions, genetic variability, cluster analysis, principal component analyses (PCA).
I. INTRODUCTION

Soybean (Glycine max L. Merril) is the second most important food legumes of Nepal, have a diverse adaptability to varied agro-ecological zones with an altitude ranging from 200-2000 m asl either as sole or intercrop with maize in upland or on paddy bund in low land conditions. It alone shared about 23757 ha area and 28237 MT productions out of total legumes (MOAD, 2013). Soybean is a crop which can provide complete protein, containing eight amino acids essential for human. That means it can play a major role in enriching nutritional standard of foods in developing countries, where human beings are facing protein deficiencies (Samia, 2013). The genetic diversity can be analyzed by morphological, biochemical traits, and molecular marker polymorphisms, analysis of gene marker data enables estimation of the mating system and monitoring of genetic changes caused by factors affecting the reproductive biology of a species. As we know, phenotypic traits are controlled by polygenes and affected by environment, but large numbers of accessions can adapt to environments. The phenotypic data has more polymorphism in genetic diversity and reveal genetic variation indirectly. On the contrary, the molecular data reveal genetic variation directly, but fewer markers have less polymorphism. It is very difficult to obtain molecular data for a large number of accessions that has enough polymorphism to show the genetic diversity of germplasm. So, the morphological traits are the suitable and practical tools for studying the genetic diversity on large numbers of accessions. Agro-morphological variation in shape of plants has always been an important means of (i) distinguishing individuals; (ii) controlling source seed production; and (iii) identifying the negative traits those effects on yield, the genetic diversity centers of annual wild soybean and the soybean lines resistance to pod shatter, drought, pests or disease (Truong et al., 2005; Malik et al., 2006, 2007). The soybean germplasm show a wide range of phenotypic variation in terms of flower color, days to maturity, plant height, number of pod per plant, seed number per pod, and seed yield. Pod shape is one of the important descriptors for evaluating soybean genetic resources (IPGRI, 1998). Truong et al., 2005 tested the applicability of elliptic Fourier method for evaluating genetic diversity of pod shape in soybean accessions and concluded that principal component scores based on elliptic Fourier descriptors yield seemed to be useful in quantitative parameters not only for evaluating soybean pod shape in a soybean breeding program but also for describing pod shape for evaluating soybean germplasm. For an effective breeding program for crop variety development, the analysis of genetic diversity is one of the useful tools and plays a vital role in identification of superior lines. Moreover, better knowledge on genetic variability could help to achieve long-term selection gain. In the present study, genetic variability of the available soybeans accessions was investigated through using morphological traits. The objective of this study is to understand the genetic variability of soybean germplasm derived from IITA, IVRDC and local landraces. This information will be very useful for rational management and allow breeders to better understand the evolutionary relationships among accessions and to develop strategies to integrate useful variability into their breeding programs.

II. MATERIALS AND METHODS

2.1 Experimental Site: The experiment was carried out at the experimental field of Grain Legume Research Program, Rampur, during June/July to November/December 2012-2014. Geographically, the place is located at about 27°40' N latitude, 84°19' E longitude and 228 m altitude. The soil of the experimental site is generally acidic (pH 4.2-5.7), light textured and sandy loam.

2.2 Climate: It is low-lying and has humid, subtropical climate. The winter is started from November to February, December and January are the coldest months with temperatures dropping to 2-3°C, while the hot summer is from March to May with temperatures rise up to 43°C. Total rainfall is over 1500 mm with monsoon (>75% of rain) period from mid-June to mid-September.

2.3 Plant Materials: In observation screening nursery, a total of forty soybean accessions in the year 2012 and one hundred four soybean accessions in 2013 including local collections were used as the experimental materials to evaluate the genetic diversity. A total of forty accessions in observation screening nursery and a total of one hundred four local landraces in regeneration screening nursery were morphologically characterized to determine the biodiversity within the local collections. The soybean genetic resources were received from IITA, Nigeria, AVRDC, Taiwan, IARI, IPR, Govinda Ballav Agricultural University, Pantanagar, India and local collections from National Agricultural Genetic Resources Centre (Gene Bank), Khumaltar, Nepal.
2.4 Experimental Design and Setting the Experiment:
The experiments regeneration nursery, observation screening nursery were laid out in rod-row design with non-replicates. Seeds were sown at the spacing of 50 cm between rows and 10-15 cm between plant to plant in a row. Each entry was grown in 2 rows in screening nurseries keeping plant-to-plant distance of 8–10 cm in rows.

2.5 Intercultural Operations: Urea, Diammonium Phosphate(DAP) and Murat of potash (MOP) were used as basal dose during final land preparation at 9, 87 and 33 kg ha⁻¹, respectively to supplement the recommended dose of chemical fertilizers @ 20:40:20 N: P₂O₅: K₂O kg/ha after final land preparation. Intercultural operations like weeding, thinning, application of pesticide, and so forth were done as recommended and when necessitated for proper growth and development of plants in each plot. Harvesting was done depending upon the maturity of the plants in each plot.

2.6 Data Collection: Agronomic traits yield and yield components data on days to flower, days to maturity, plant height, pods per plant, number of seeds per pod, hundred seed weight and seed yield per plant were taken from 5 randomly selected competitive plants from each plot. Plants of each plot were harvested when the plants and pods of each plot turned into yellowish brown colour and almost all the leaves shed. Pods were threshed and 3-4 days sun-dried for seed yield estimation. In addition, morphological traits such as seed coat, hilum colour, seed and pod shapes were recorded.

2.7 Statistical Analyses: Statistical analysis for yield and yield attributing traits were carried out using R-program and Minitab. Mean and standard deviations for all quantitative traits were computed. Analysis of variance was performed for all traits in order to test the significance of variation among accessions. The data was analysed for mean, coefficient of variation (CV %), LSD value and correlation coefficient. UPGMA clustering was done using Minitab 14. For cluster analysis, the accessions were split into various groups on the basis of their performances which are displayed in a dendrogram. Cluster analysis is a type of multivariate technique whose primary purpose is to group individuals or objects based on characteristics they possess, so that individuals with similar description are mathematically gathered into the same cluster. The resulting cluster of individuals should exhibit higher within clusters homogeneity and between clusters heterogeneity. Thus, if the classification is successful, individuals within cluster should be closer when plotted geometrically and different clusters shall be apart (Hair et al., 1995). Hierarchical clustering methods are commonly employed in analysis of genetic diversity in crop species. These methods proceeds either by a series of successive mergers or by a series of successive divisions of a group of individuals. Former, known as ‘agglomerative hierarchical’ methods, start with a single individual. Thus, initially there as many clusters as individuals (Mohammadi & Prasanna, 2003). The most similar individuals are first grouped and these initial groups are merged according to their similarities. Among various agglomerative hierarchical methods, the UPGMA (Un-weighted Paired Group Method using Arithmetic Averages) was adopted clustering algorithm, followed by the Ward’s minimum variance method(Ward, 1963). Data were analysed to determine Euclidean distance based on paired group method to determine dissimilar groups of the soybean lines. Two-dimensional principal component analysis (PCA) graph was constructed using PAST-multivariate software. Agro-morphological traits were characterized as per the descriptors prepared by International Board for Plant Genetic Resources (IBPGR, 1984).

Annex i: List of different traits and their description of measurement

| Morphological Traits          | Method of measurement                                   |
|-------------------------------|--------------------------------------------------------|
| Emergence                     | Seed emergence recorded when about 50% of the seedling emerged out of the soil |
| Days to flowering             | The number of days from sowing to flowering of 50% plants |
| Days to maturity              | The number of days from sowing until approximately 90% pod turned into brownish colour |
| Plant height (cm)             | The height from the base of the plant to the tip of last leaf |
| Pods per plant (number)       | Total number of pods with seed in a plant               |
III. RESULTS AND DISCUSSION

3.1 Genetic variability of soybean screening nurseries

A total of forty diverse accessions of local landraces and exotic lines were evaluated in the subtropical rainfed climate of Rampur chitwan in summer season of the year 2012. Variation was observed in agro-morphological traits like days to flower, days to maturity, plant height, seeds/pod, number of pods/plant, grain yield and hundred seed weight varied among accessions (Table 2). Days from sowing to flowering varied from 62 days in G8514 and G-757 to 39 days in TH227. Days from sowing to 90% maturity varied from 139 days in Gorkha local to 111 days in TH227. Number of pods per plant varied from 97 pods in Salyan-2 to 20 pods in Tandi collection #1. Plant height ranged from 88 cm in PI200525 to 31 cm in Collection #1 Mangal Bazar. Number of seeds per 10 pods ranged from 25 seeds in Gorkha local 1, Tandi collection no.1 and V-5 to only 13 seeds in TK-5. Hundred seed weight varied from 25.5 g of Tandi collection #2 to 5.2 g of TH227. Some of high yielding accessions of soybean were 272W (2195 kg/ha), Cobb (1588 kg/ha), G-758 (1415 kg/ha) and Puja (1282 kg/ha). Early maturing accessions were TK-5, TH-227, V-3 and V-5 (111 days).

Likewise a total of hundred one accessions including two checks (Puja and Cobb) were evaluated for grain yield and yield parameters during 2013. Early plant stand, days to flowering, days to maturity, plant height, seeds/pod, number of pods/plant, grain yield and two hundred seed weight varied among accessions (Table 5). Days from sowing to maturity varied from 108 days in the accessions CM9112, SJ-4, Co169, IPBSY1178, G-758, PI94159, Salyan-2, C2019 to 134 days in TGX1989-41F, V8 and V10. Plant height ranged from 10 cm in C2015 to 176 cm in C2017. Highest number of pods per plant was found in C2022 (263 pods) and lowest number of pods was found in TH227 (34 pods only). Hundred seed weight varied from 4 g of C2021, C2023, C2020 to 24 g of C2026. Table 5 revealed that some of high yielding soybean accessions were G-18428 (5695 kg/ha), TGX1990-67F (4895 kg/ha), G-757 (4800 kg/ha), V9 (B/pur-9) (4550 kg/ha), TGX1990-5F (4080 kg/ha), Co157 (3900 kg/ha), Chatewan-9 (3820 kg/ha), TGX1990-93F (3750 kg/ha), V7 (B/pur-7) (3600 kg/ha), C2020 (3550 kg/ha) and G-8514 (3550 kg/ha). However mean yield performances of soybean accessions over the years (2012-2013) indicated that soybean cultivars G-757 (3131 kg/ha), G-758 (3108 kg/ha), G-8586 (2329 kg/ha), V8 (B/pur-8) (1943 kg/ha)), 272 W (1928 kg/ha) produced the highest yielder than the check Cobb (1835 kg/ha).

Several investigators took interest in evaluating soybean genotypes and estimated the corresponding genetic parameters, such as Eisa et al (1998), Hassan et al (2001) and (2002), and Mohamed and Morsy (2005) who found that soybean genotypes differed significantly for most studied traits. Also, Hamdi et al (2008) evaluated most the studied genotypes for agronomic and seed technology characters. They found variability among genotypes for most studied characters. In the study large variation was found in days to maturity, pods per plant, plant height and grain yield. This data indicated that there is genetic and physical variability in soybean accessions and it is one of the best options to select the best lines for pre-breeding and hybridization program. The results are supported with the findings of Rasaily et al. (1986), which performed considerable genotypic variability for seed yield. Funnah and Mak (1978) also conducted field trials and found that some varieties yielded over 2000 kg/ha. Dadson (1976) also evaluated different cultivars of soybean and revealed highest seed yields of 2.0-2.46, 1.18-1.88, 1.29-1.59 and 1.21-1.24 t h-1 were given by cultivars Davis, Hardee, Improved Pelican and Williams, respectively. Ghtage and Kadu (1993) found the similar results and observed high variability for seed yield.

3.2 Cluster Analysis

Cluster analysis using all the seven morphological traits grouped the 40 accessions into five major groups at the genetic distance of 202.63 (Table 2, 3, Figure 1). It was also found that, among the five clusters, cluster I was the largest and consisted of 32 accessions (14 local landraces and 18 exotic lines). Under the cluster I characterized as the early flowering, early maturity and lower yield. This cluster represented 80 % of the total accessions i.e. Coll#3 Mangal bazar, Dhankuta, G-7959, Coll #1 Mangalbazar, G-8754, SJ-4, IPBSY178, PI94159, Salyan-2, TGX311-23D, 7521-
accessions respectively. Cluster III groups were characterized as the late maturity and high yield while cluster V had early maturity, bolder seeds and medium yields. The dendrogram based on the quantitative traits of one hundred one soybean accessions was constructed as presented in figure 2. Distances among different Cluster centroids of soybean accessions are presented in Table 8.

3.3 Principal component analysis for yield and yield attributing traits composition

Seven principal components were extracted which accounted for 21.9 to 100% variability among the 104 soybean accessions evaluated. PC1 accounted for 21.9% of the total variation and was correlated positively with the days to flower (0.036), pods per plant (0.19), Plant height (0.65 while days to maturity (-0.407) contributed negatively. PC2 accounted for 19.6% and mainly correlated with days to maturity, plant height and seeds per pod and negatively with days to flower, plant height, and seeds per pod. PC3 had 18.4% of the total variation. Pods per plant contributed 0.200, hundred seed weight (0.140). PC4 accounted for 13.7% of the variation and correlated with days to flower (0.033), pods per plant (0.329), plant height (0.173) and seeds per pod(0.070).PC5 accounted for 13.3% of the total variation and was correlated positively with the days to flower (0.320), days to maturity(0.259), seeds per pod(0.170) and hundred seed weight(0.147) while pods per plant, plant height and grain yield contributed negatively correlated. PC6 accounted for 7.4% of the total variation and was correlated positively with the pods per plant(0.19), seeds per pod (0.676) and grain yield(0.663) while days to flower, days to maturity, plant height, hundred seed weight contributed negatively. PC7 accounted for 5.7% of the total variation and was correlated positively with the days to maturity (0.676), pods per plant, plant height, and seeds per pod. PC8 accounted for 18.4% of the total variation. Pods per plant contributed positively with the pods per plant (0.19), seeds per pod (0.676) and grain yield(0.663) while days to flower, days to maturity, plant height, hundred seed weight contributed negatively. PC9 accounted for 5.7% of the total variation and was correlated positively with the days to maturity (0.676), pods per plant, plant height, and seeds per pod. PC10 accounted for 21.9 to 100% variability among the 104 soybean accessions evaluated. PC1 accounted for 28.8% of the total variation and was correlated positively with the days to maturity, plant height and seeds per pod. PC2 accounted for 19.6% and mainly correlated with days to flower, days to maturity, plant height, hundred seed weight and yield while days to flower (-0.560) contributed negatively (Table 9).

Seven principal components were extracted which accounted for 21.9 to 100% variability among the 104 soybean accessions evaluated. PC1 accounted for 28.8% of the total variation and was correlated positively with the days to maturity, plant height and seeds per pod. PC2 accounted for 18.6% and mainly correlated with pods per plant (0.716), plant height (0.032) , seeds per pod (0.209) and grain yield(0.375) and negatively with days to flower, and days to maturity. PC3 had 17.7% of the total variation and the variables correlated positively with days to flower, days...
to maturity, pods per plant, seeds per pod, grain yield and hundred seed wt. and negatively contributed with plant height. PC4 accounted for 11.8% of the variation and positively correlated with days to flower, days to maturity and seeds per pod. PC5 accounted for 10.9% of the total variation and was correlated positively with the days to flower, seeds per pod(0.118) and grain yield(0.421) while remaining variables contributed negatively correlated. PC6 accounted for 6.6% of the total variation and was correlated positively with the days to flower, pods per plant, grain yield and hundred seed weight while days to maturity, plant height, and seeds per pod contributed negatively. PC7 accounted for 5.5% of the total variation and was correlated positively with the days to flower, pods per plant, plant height and seeds per pod, while days to maturity, grain yield (-0.614) and hundred seed weight contributed negatively(Table 10).

3.4 Agro-morphological characteristics of soybean local landraces

3.4.1 Seed Coat Color

There was high diversity found in seed coat color of the soybean local landraces collected from seven districts namely Baitadi, Dadeldhura, Doti, Jumla, Kailali, Kalikot and Muguof mid and far western region of Nepal (Annex ii). The seed coat color was keenly documented after harvest of the crop. Out of thirty three accessions, thirteen of them had black seed coat color, two had buff, one grey, three imperfect black, two reddish brown, eight yellow and remaining four had yellowish white seed coat color.

3.4.2 Flower color and phenotypic traits

Flower color and pattern of flower were also found diverse among the collected accessions. Out of the thirty three local landraces, twenty one had white flower color, four had purple throats, and three had purple flower. Some of the five landraces had trailing type, typical little leaves like wild type along with purple flower colors (Annex ii).

IV. CONCLUSIONS

In plant breeding, generation of new genotypes from the existing ones with improvement in plant traits is the main objective. The present study revealed the presence of high levels of variations for nine different morphological traits including yield attributes and seed yield among the soybean accessions. A total of forty diverse accessions of local landraces and exotic lines were evaluated in the subtropical rainfed climate of Rampur chitwan in summer season of the year 2012. Variation was observed in agro-morphological traits. Some of high yielding accessions of soybean were 272W, Cobb, G-758, and Puja. Likewise a total of hundred one accessions were evaluated for grain yield and yield parameters during 2013. The research results revealed that high yielding soybean accessions were G-18428, TGX 1990-67F, G-757, V9 (B/pur-9, TGX1990-5F, Co 157, Chatewan-9, TGX1990-93F, V7 (B/ pur-7), C2020 and G-8514. However mean yield performances of soybean accessions over the years affirmed soybean cultivars G-757, G-758, G-8586, V8 (B/pur-8), 272 W were the better performer than the check Cobb. Under cluster analysis using all the seven morphological traits grouped the 40 accessions into five major groups at the genetic distance of 202.63. It was also found that, among the five clusters, cluster I was the largest and consisted of 32 accessions and the second largest group was the clusters II and IV, and each consisted of three accessions. The smallest group was clusters III and V, and each cluster contained only one accessions. Likely cluster analysis using all the seven morphological traits grouped the 101 accessions collected from National Agricultural Genetic Resources Centre (Gene Bank) and exotic lines from IITA, Nigeria into five major groups at the genetic distance of 267.82. Among the five clusters, cluster I was the largest and consisted of eighty four accessions and the second largest group was the clusters II consisted of fourteen accessions. The smallest group was clusters III, IV and V, and each cluster contained 1, 2, 1 accessions respectively. To obtain greater heterosis, accessions having distant clusters could be used as parents for hybridization program. The accessions from cluster I and cluster II could be used for hybridization program with the soybean accessions of clusters III, IV and V in order to develop high yielding soybean varieties for further improvement. The first seven principal components were extracted which accounted for about 100% variability among the 104 soybean accessions for all morphological characters. There was high diversity found in seed coat color of the soybean local landraces. Out of thirty three accessions, thirteen of them had black seed coat color; two had buff, one grey, three imperfect black, two reddish brown, eight yellow and remaining four had yellowish white seed coat color. Flower color and pattern of flower were also found diverse among the collected accessions. Out of the thirty three local landraces, twenty one had white flower color, four had purple throats, and three had purple flower. Some of the five
landraces had trailing type, typical little leaves like wild type along with purple flower colors. This study indicated the presence of high levels of genetic variability among the soybean accessions in terms of evaluated characters.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of the paper.

ACKNOWLEDGMENT

The author wishes to thank the Nepal Agricultural Research Council, Ministry of Agriculture development, Government of Nepal for financial support to research trial. The authors also would like to thank to National Agricultural Genetic Resources Centre (Gene Bank), Khumaltar for providing genetic resources.

REFERENCES

[1] MoAD. (2014). Statistical Information on Nepalese Agriculture 2013/14. Singa Durbar, Kathmandu Nepal: Ministry of Agriculture and Development, Government of Nepal.

[2] Mohammadi SA, Prasanna BM. Analysis of Genetic Diversity in crop plants—Salient Statistical tools and considerations. Crop Sci 2003; 43: 1235-1248.

[3] Malik, M. F. A., Ashraf, M. U. H. A. M. M. A. D., Qureshi, A. S., &Ghafoor, A. (2007), Assessment of genetic variability, correlation and path analyses for yield and its components in soybean. Pakistan Journal of Botany, 39(2), 405.

[4] Malik, M. F. A., Qureshi, A. S., Ashraf, M. U. H. A. M. M. A. D., &Ghafoor, A. B. D. U. L. (2006). Genetic variability of the main yield related characters in soybean. Int. J. Agric. Biol, 8(6), 815-819.

[5] Truong, N. T., Van, K., Kim, M. Y., & Lee, S. H. (2005). Genotypic Variation in Flowering and Maturing Periods and Their Relations with Plant Yield and Yield Components in Soybean. 한국작물학회지, 51(2), 163-168.

[6] NGLRP, 2012-2014, Annual Report of NGLRP, Rampur

[7] IBPGR (1984). Soybean descriptors, International board for plant genetic resources, Secreteriat, Rome, Italy.

[8] Hamdi, A., M. Abd-Elmolhsen, A. A. M. El-Emam and I. F. Mersal (2008). Evaluation of some promising soybean genotypes for agronomic and seed technology characteristics in North Egypt. Proceeding of the 2nd Field Crops Conference, FCRI, Giza, Egypt. October 14-16.

[9] Hassan, M. Z., Kh. A. Al-Assily, M. S. A. Mohamed and A. E. Sharaf (2002). Performance of some soybean cultivars under different sowing dates at the newly reclaimed lands of East Owainat and Kharga. Arab Univ., J. Agric. Sci., Ain Shams Univ. Cairo, 10 (1): 173 -179. Hassan, M. Z., Kh. A. Al-Assily; Kh. A. Ali and A. E. Sharaf (2001). Evaluation some soybean cultivars at various plant population densities on the new reclaimed lands of East Owainat and kharga. Arab Univ. J. Agric. Sci., Ain Shams Univ. Cairo, 9 (2): 615-622.

[10] Eisla, M. S., Kh. A. M. Ali, M. I. Abd-Elmolhsen and M. S. Mohamed (1998). Performance of twenty two soybean genotypes in Middle Delta Region. J. agric. Sci., Mansoura Univ. 23 (4) : 1389 – 1395.

Table 1: Agronomic performances of soybean accessions in observation nursery, 2012

| SN | Cultivars          | DF | DM | P/P | Plht(cm) | S/P | GY(kg/ha) | HSwt(g) |
|----|-------------------|----|----|-----|----------|-----|-----------|---------|
| 1  | Coll#3 Mangal bazar | 52 | 118| 39  | 37       | 17  | 197.5     | 11.5    |
| 2  | Dhankuta           | 52 | 114| 55  | 39       | 22  | 265       | 14.5    |
| 3  | G-7959             | 54 | 123| 45  | 43       | 20  | 742.5     | 12.9    |
| 4  | Coll # 1 Mangalbazar| 55 | 112| 26  | 31       | 18  | 220       | 14.6    |
| 5  | G-8754             | 55 | 126| 42  | 67       | 20  | 335       | 17.4    |
| 6  | G-758              | 61 | 120| 47  | 61       | 22  | 1415      | 10.5    |
| 7  | SJ-4               | 52 | 114| 30  | 55       | 17  | 170       | 11.7    |
| 8  | IPBSY178           | 59 | 117| 49  | 55       | 21  | 392.5     | 10.5    |
| 9  | PI94159            | 57 | 117| 25  | 46       | 16  | 122.5     | 12.6    |
| 10 | Salyan-2           | 52 | 117| 97  | 46       | 21  | 247.5     | 14.5    |
|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| 11 | TGX311-23D | 57 | 128 | 38 | 41 | 21 |
| 12 | G-8513 | 52 | 123 | 67 | 51 | 18 |
| 13 | 7521-26-2 | 57 | 123 | 89 | 54 | 20 |
| 14 | SB0103 | 55 | 128 | 22 | 49 | 20 |
| 15 | PI200451-2 | 57 | 123 | 63 | 57 | 21 |
| 16 | 200525(Rampur) | 57 | 114 | 42 | 50 | 23 |
| 17 | 272 W | 58 | 120 | 72 | 73 | 22 |
| 18 | AGS-367 | 57 | 118 | 55 | 51 | 21 |
| 19 | CINA-2 | 57 | 123 | 46 | 81 | 19 |
| 20 | G-18428 | 61 | 120 | 40 | 56 | 19 |
| 21 | G-757 | 62 | 120 | 43 | 58 | 20 |
| 22 | G-8514 | 62 | 114 | 48 | 61 | 19 |
| 23 | G-8586 | 59 | 120 | 43 | 72 | 21 |
| 24 | PI200525 | 58 | 120 | 43 | 88 | 17 |
| 25 | PI368055 | 57 | 115 | 50 | 65 | 23 |
| 26 | TK-5 | 57 | 111 | 22 | 62 | 13 |
| 27 | TGX1925-1F | 59 | 126 | 28 | 62 | 20 |
| 28 | Gorkha Local-1 | 62 | 134 | 21 | 46 | 25 |
| 29 | Coll#5 Sikre | 62 | 123 | 26 | 64 | 20 |
| 30 | Tandi Collection #1 | 55 | 112 | 20 | 43 | 25 |
| 31 | TH227 | 39 | 111 | 60 | 43 | 21 |
| 32 | V-1 | 55 | 118 | 37 | 68 | 21 |
| 33 | V-2 | 57 | 126 | 35 | 85 | 19 |
| 34 | V-3 | 52 | 111 | 67 | 56 | 17 |
| 35 | V-5 | 52 | 112 | 36 | 49 | 25 |
| 36 | V-6 | 57 | 123 | 74 | 65 | 18 |
| 37 | V-8 | 57 | 123 | 35 | 78 | 16 |
| 38 | Tandi Collection #2 | 57 | 118 | 61 | 40 | 23 |
| 39 | Cobb | 57 | 124 | 54.6 | 61.6 | 20.4 |
| 40 | Puja | 55 | 122 | 54.2 | 55.2 | 20.8 |
| Mean | 56.2 | 119.5 | 46.2 | 56.6 | 20.1 | 561.2 | 12.3 |
| Max | 62.0 | 134.0 | 97.0 | 88.0 | 25.0 | 2195.0 | 25.5 |
| Min | 39.0 | 111.0 | 20.0 | 31.0 | 13.0 | 107.5 | 5.2 |
| STDEV | 4.1 | 5.5 | 18.1 | 13.3 | 2.6 | 475.8 | 3.7 |
Table 2: Groups of 41 soybean accessions according to cluster analysis from seven phenological and morphological characters, yield attributes, and seed yield.

| Cluster number | Number of accessions | Percent | Accessions |
|----------------|----------------------|---------|------------|
| I              | 32                   | 80      | Coll#3 Mangal bazar, Dhankuta, G-7959, Coll # 1 Mangalbazar,G-8754,SJ-4,IPBSY178,PI94159,Salyan-2,TGX311-23D,7521-26-2,G-8513,SB0103,PI200451-2,200525(Rampur),AGS-367,G-757, PI200525,PI368055,TK-5,TGX1925-1F,Gorkha Local-1,Coll#5 Sikre, Tandi Collection #1,TH227,V-1,V-2,V-3,V-5,V-6,V-8,Tandi Collection #2 |
| II             | 3                    | 7.5     | CINA-2,G-8586,G-8514 |
| III            | 1                    | 2.5     | 272W |
| IV             | 3                    | 7.5     | G-758,G-18528,Puja |
| V              | 1                    | 2.5     | Cobb |

Table 3: Mean values of seven different agro morphological characters, yield attributes, and seed yield for five groups revealed by cluster analysis among 40 soybean accessions

| Variable | Cluster I | Cluster II | Cluster III | Cluster IV | Cluster V | Grand centroid |
|----------|-----------|------------|-------------|------------|-----------|----------------|
| DF       | 54.938    | 59.00      | 58.0        | 59.33      | 56.50     | 55.688         |
| DM       | 119.313   | 120.67     | 120.0       | 119.00     | 124.00    | 119.525        |
| P/P      | 45.063    | 47.07      | 72.0        | 45.67      | 54.60     | 46.170         |
| Plht(cm) | 54.500    | 57.40      | 73.0        | 71.33      | 61.60     | 56.620         |
| S/P      | 19.969    | 20.60      | 22.0        | 19.67      | 20.40     | 20.055         |
| GY(kg/ha)| 354.375   | 1324.83    | 2195.0      | 1071.67    | 1587.50   | 557.800        |
| HSw(t/g) | 12.584    | 11.78      | 9.7         | 11.27      | 11.43     | 12.324         |

Table 4: Distances between Cluster Centroids

|               | Cluster I | Cluster II | Cluster III | Cluster IV | Cluster V |
|---------------|-----------|------------|-------------|------------|-----------|
| Cluster I     | 0.00      | 970.475    | 1840.92     | 717.50     | 1233.19   |
| Cluster II    | 970.47    | 0.000      | 870.67      | 253.56     | 262.84    |
| Cluster III   | 1840.92   | 870.668    | 0.000       | 1123.65    | 607.88    |
| Cluster IV    | 717.50    | 253.562    | 1123.65     | 0.000      | 516.04    |
| Cluster V     | 1233.19   | 262.842    | 607.88      | 516.04     | 0.000     |
Fig 1. Dendrogram showing relationship among 41 soybean accessions using nine agro-morphological characters, seed yield, and yield traits.

Table 5: Agronomic performances of soybean accessions in regeneration nursery, 2013

| Entries | Cultivars               | DF  | DM  | P/P  | Plht(cm) | S/P  | GY(kg/ha) | HSWT(g) |
|---------|-------------------------|-----|-----|------|----------|------|-----------|--------|
| 1       | Colli#3 Mangalbazar      | 49  | 116 | 99.6 | 83.2     | 18.6 | 650       | 11.9   |
| 2       | Dhankutta                | 49  | 126 | 80.4 | 35.4     | 14   | 650       | 11.5   |
| 3       | G-7959                   | 44  | 120 | 81.6 | 126.4    | 20.6 | 1285      | 10.2   |
| No. | Variety            | Coll # | State | Yield (kg/ha) | lodging % | PPI 100 (kg/ha) | Lodging % |
|-----|-------------------|--------|-------|---------------|-----------|----------------|-----------|
| 1   | Coll # 1 Mangalbazar | 48     | 129   | 66.6          | 43.4      | 14.2           | 600       |
| 2   | G-8754            | 50     | 126   | 116.2         | 57.2      | 14.4           | 640       |
| 3   | G-758             | 51     | 108   | 116.4         | 138.8     | 19.8           | 1400      |
| 4   | CM-9112           | 48     | 108   | 109.2         | 83.6      | 18.2           | 800       |
| 5   | SJ-4              | 48     | 108   | 99.6          | 113.9     | 19.6           | 940       |
| 6   | IPBSY 178         | 50     | 108   | 122.8         | 76        | 21.8           | 810       |
| 7   | PI 94159          | 52     | 108   | 103           | 108.6     | 19.2           | 905       |
| 8   | Salyan -2         | 52     | 108   | 99.6          | 123.8     | 18.8           | 1330      |
| 9   | TGX311            | 54     | 117   | 146.2         | 96        | 20.4           | 710       |
| 10  | G-8514            | 54     | 126   | 95.4          | 42.2      | 21.2           | 3550      |
| 11  | 7521-26-2         | 52     | 126   | 92.8          | 136.8     | 19.6           | 1775      |
| 12  | Coll#4 Ramechhap  | 54     | 126   | 105.6         | 79        | 18.8           | 710       |
| 13  | SB0103            | 54     | 126   | 97.8          | 82.6      | 20             | 740       |
| 14  | PI 200451-2       | 54     | 117   | 98.8          | 110.4     | 20             | 1225      |
| 15  | 200525 (Ramechhap)| 54     | 118   | 91.8          | 54.4      | 14.8           | 3200      |
| 16  | 272 W             | 59     | 116   | 119.8         | 110.4     | 20.4           | 1660      |
| 17  | AGS -367          | 55     | 116   | 93.4          | 91.2      | 16.2           | 515       |
| 18  | Cina -2           | 60     | 116   | 102           | 74.6      | 19             | 620       |
| 19  | G-18428           | 59     | 131   | 133.4         | 57.4      | 8.8            | 5695      |
| 20  | G-757             | 60     | 126   | 137           | 72.2      | 19.8           | 4800      |
| 21  | G8514             | 65     | 113   | 123.8         | 121       | 20.4           | 800       |
| 22  | G-8586            | 61     | 123   | 127           | 98        | 20.6           | 905       |
| 23  | PI 200525         | 60     | 123   | 152           | 92.6      | 19.8           | 680       |
| 24  | PI 368055         | 60     | 119   | 132.4         | 56.2      | 20.8           | 690       |
| 25  | TK-5              | 61     | 117   | 106.8         | 87.6      | 20.6           | 1860      |
| 26  | TG X 1925-1F      | 59     | 113   | 116.2         | 85.8      | 21.6           | 705       |
| 27  | COLL#5 Sikre      | 63     | 117   | 107.6         | 62.8      | 17.6           | 1005      |
| 28  | Tandi Coll        | 54     | 119   | 63.6          | 26.8      | 18             | 1010      |
| 29  | TH-227            | 40     | 131   | 34            | 42.6      | 13             | 650       |
| 30  | V1 (B/pur-1)      | 54     | 126   | 105.4         | 52        | 18.8           | 635       |
| 31  | V2 (B/pur -2)     | 62     | 126   | 121           | 31.8      | 19.6           | 1000      |
| 32  | V3 (B/Pur-3)      | 52     | 129   | 60.2          | 39        | 17.8           | 2750      |
| 33  | V4 (B/Pur -4)     | 50     | 119   | 59.4          | 43.4      | 17.4           | 2900      |
| 34  | V5 (B/Pur-5)      | 59     | 132   | 126.4         | 33        | 18.6           | 795       |
|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|39 | V7 (B/pur-7) | 50 | 113 | 68.8 | 52.8 | 18.8 | 3600 | 13 |
|40 | V8 (B/pur-8) | 54 | 134 | 80 | 26.8 | 16 | 650 | 8.1 |
|41 | V9 (B/pur-9) | 44 | 111 | 90.2 | 44.4 | 22.6 | 4550 | 7.9 |
|42 | V10 (B/pur-10) | 60 | 134 | 130 | 32.2 | 19.2 | 710 | 14.6 |
|43 | Tadi Col#2 | 54 | 123 | 76.2 | 84.2 | 19.6 | 1010 | 10 |
|44 | C2014 | 44 | 119 | 194.4 | 27 | 18.6 | 800 | 12.5 |
|45 | C2015 | 58 | 111 | 152.8 | 10.2 | 11 | 1000 | 10.4 |
|46 | C2016 | 52 | 116 | 72.6 | 86 | 21.4 | 2210 | 8.3 |
|47 | C2017 | 45 | 120 | 80.4 | 175.8 | 21.6 | 2020 | 13 |
|49 | C2019 | 54 | 108 | 155.4 | 18.25 | 13.5 | 3200 | 15.7 |
|50 | C2020 | 59 | 112 | 218 | 126 | 20 | 3550 | 4 |
|51 | C2021 | 60 | 111 | 243 | 61.6 | 18.4 | 2150 | 9.7 |
|52 | C2022 | 63 | 111 | 263.2 | 58.6 | 18.2 | 790 | 13.6 |
|53 | C2023 | 54 | 111 | 174 | 65.2 | 20.2 | 1750 | 5.4 |
|54 | C2024 | 45 | 124 | 71.6 | 86.6 | 21 | 2490 | 7.5 |
|55 | C2026 | 45 | 126 | 78.6 | 102.6 | 21.2 | 2425 | 10.2 |
|56 | C2027 | 50 | 129 | 68.4 | 88.2 | 22.6 | 2125 | 17.4 |
|57 | Co 157 | 65 | 119 | 96.2 | 44.8 | 18.6 | 3900 | 23.5 |
|58 | Co 158 | 44 | 119 | 73.6 | 31.4 | 22 | 1350 | 14.1 |
|59 | Co 159 | 60 | 119 | 90.8 | 42.4 | 20 | 895 | 13 |
|60 | Co 160 | 47 | 116 | 64.4 | 56.6 | 14.4 | 825 | 3.5 |
|61 | Co 161 | 50 | 111 | 114.6 | 51.2 | 17 | 635 | 15.1 |
|62 | Co 162 | 50 | 111 | 73.6 | 33.8 | 17.4 | 1045 | 11.3 |
|63 | Co163 | 54 | 114 | 63.4 | 52.6 | 19.2 | 770 | 7 |
|64 | Co 164 | 47 | 119 | 59 | 68.8 | 20 | 805 | 21.1 |
|65 | Co 165 | 41 | 111 | 104 | 39.6 | 19.4 | 500 | 13.5 |
|66 | Co 166 | 40 | 126 | 70.8 | 62.8 | 20.2 | 1280 | 10.9 |
|67 | Co 167 | 40 | 111 | 154.6 | 70.4 | 19.6 | 1075 | 11.4 |
|68 | Co 168 | 45 | 118 | 55.4 | 62.8 | 21.6 | 1105 | 13.5 |
|69 | Co 169 | 49 | 108 | 92 | 45.8 | 17.8 | 775 | 19.5 |
|70 | Co 170 | 65 | 111 | 138 | 64 | 19.4 | 1750 | 14 |
|71 | Co 171 | 50 | 111 | 51 | 80.4 | 20.8 | 1700 | 5.8 |
|72 | Co 172 | 59 | 129 | 127.4 | 30.4 | 15.8 | 1800 | 10 |
|73 | Co 175 | 60 | 119 | 74.6 | 53 | 19.8 | 570 | 3.8 |
|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| 74 | Co 176 | 50 | 116 | 73.2 | 60.8 | 18.8 | 1190 | 6.5 |
| 75 | Co178 | 53 | 129 | 91 | 38 | 18.4 | 520 | 11.7 |
| 76 | Co 179 | 65 | 129 | 123.2 | 43.6 | 21 | 660 | 15.2 |
| 77 | TGX 1990-78F | 65 | 131 | 106 | 22.8 | 16 | 1065 | 9.9 |
| 78 | TGX 1990-79F | 56 | 131 | 101.2 | 70.4 | 20.6 | 1025 | 10.5 |
| 79 | TGX1989-45F | 61 | 127 | 99.4 | 93.8 | 18.8 | 970 | 11.2 |
| 80 | TGX1990-47F | 54 | 118 | 70.6 | 84 | 22.6 | 1895 | 12 |
| 81 | TGX1989-NF | 60 | 127 | 95.6 | 46.6 | 20.4 | 3050 | 11.8 |
| 82 | TGX 1990-67F | 54 | 120 | 98.8 | 120.6 | 23.4 | 4895 | 10.5 |
| 83 | TGX1991-10F | 60 | 127 | 102.2 | 94.2 | 19.2 | 1355 | 16.2 |
| 84 | TGX1990-38F | 59 | 127 | 105.8 | 110 | 22.6 | 885 | 8.4 |
| 85 | TGX1990-93F | 65 | 129 | 72.6 | 18.8 | 17.6 | 3750 | 9.3 |
| 86 | TGX1990-94F | 64 | 129 | 106.6 | 91.6 | 20.6 | 1960 | 14 |
| 87 | TGX1987-14F | 65 | 126 | 83.6 | 86 | 20 | 1130 | 16.8 |
| 88 | TGX1990-101F | 60 | 130 | 84 | 43.2 | 21 | 575 | 9.7 |
| 89 | TGX1987-10F | 54 | 118 | 92.2 | 91 | 22.8 | 1930 | 9.5 |
| 90 | TGX1904-6F | 60 | 127 | 94.8 | 95.6 | 21.4 | 1975 | 17.4 |
| 91 | TGX 1990-40F | 54 | 119 | 74 | 67.6 | 18.8 | 945 | 11.5 |
| 92 | TGX1989-21F | 67 | 129 | 94 | 112.6 | 22.2 | 1895 | 1 |
| 93 | TGX1990-5F | 60 | 128 | 98.6 | 46.6 | 21 | 4080 | 9.7 |
| 94 | TGX1989-41F | 50 | 134 | 60.8 | 54.2 | 21.8 | 1245 | 4.4 |
| 95 | TGX1990-57F | 59 | 124 | 102.8 | 109.4 | 18.6 | 1105 | 9.4 |
| 96 | TGX1988-5F | 60 | 129 | 96 | 71.4 | 19.2 | 2270 | 8.9 |
| 97 | TGX1990-18F | 60 | 116 | 92.6 | 107.6 | 20.2 | 3360 | 9 |
| 98 | TGX1989-20F | 54 | 125 | 71.2 | 50.8 | 20 | 1000 | 5.9 |
| 99 | TGX1988-3F | 59 | 131 | 71.8 | 72.6 | 20.4 | 1450 | 10.7 |
| 100 | TGX1835-10E | 50 | 126 | 102 | 56.2 | 16.8 | 2955 | 8.8 |
| 101 | TGX1990-97F | 52 | 126 | 77.4 | 50 | 21.4 | 1350 | 10.9 |
| 102 | Chatewan-9 | 59 | 131 | 78.6 | 85 | 21 | 3820 | 16.3 |
| 103 | Puja | 49 | 121 | 86 | 49 | 19 | 1468 | 15.3 |
| 104 | Cobb | 48 | 124 | 97 | 78 | 20 | 2082 | 11.2 |
| Mean | 54 | 121 | 102 | 70 | 19 | 1620 | 12 |
| MIN | 40 | 108 | 34 | 10 | 9 | 500 | 4 |
| MAX | 67 | 134 | 263 | 176 | 23 | 5695 | 24 |
Table 6: Groups of 104 soybean accessions according to cluster analysis from seven morphological characters, yield attributes, and seed yield.

| Cluster number | Number of accessions | Percent  | Accessions |
|----------------|----------------------|----------|------------|
| I              | 86                   | 82.69    | 272 W,7521-26-2,AGS -367,C2014,C2015, C2016, C2017, C2021, C2022, C2023, C2024 C2026, C2027, Cina -2,CM-9112,Co 158,Co 159, Co 160,Co 161,Co 162,Co 164,Co 165,Co 166,Co 167,Co 168,Co 169, Co 170, Co 171, Co 172, Co 175, Co 176, Co 179, Co 163, Co 178, Cobb, Coll # 1 Mangalbazar, Coll#3 Mangalbazar, Coll#4 Ramechhap, COLL#5 Sikre, Dhankuta, G-758, G-7959, G8513, G-8514, G-8586, G-8754, IPBSY 178,PI 200451-2,PI 200525,PI 368055,PI 94159, Puja, Salyan -2,SB0103, SJ-4, Tadi Coll#2, Tandi Coll, TG X 1925-1F,TGX 1990-40F,TGX 1990-78F,TGX 1990-79F, TX1835-10E, TX1904-6F, TX1987-10F, TX1987-14F, TX1988-3F, TX1988-5F,TGX1989-20F, TX1989-21F, TX1989-41F, TX1989-45F, TX1990-101F, TXG 1990-38F, TXG1990-47F, TXG1990-57F, TXG1990-94F, TXG1990-97F, TXG1991-10F, TXG311, TH-227,TK-5,,V1 (B/pur-1),V10 (B/pur-10),V2 (B/pur-2),V5 (B/Pur-5),V8 (B/pur-8) |
| II             | 14                   | 13.46    | G8514, V7, C2020, C0157, Chatewan-9, TGX1990-5F, TGX1990-93F, 200525 (Ramechap), C2019, V3, V4, TX1835-10E, TXG1989-NF, TGX1990-18F |
| III            | 1                    | 0.96     | V9         |
| IV             | 2                    | 1.92     | G-757, TGX1990-67F |
| V              | 1                    | 0.96     | G18428     |

Table 7: Mean values of seven different agro morphological characters, yield attributes, and seed yield for five groups revealed by cluster analysis among 104 soybean accessions

| Variable       | Cluster1 | Cluster2 | Cluster3 | Cluster4 | Cluster5 | Grand centroid |
|----------------|----------|----------|----------|----------|----------|----------------|
| DF             | 54.10    | 56.57    | 59.0     | 57.0     | 44.0     | 54.44          |
| DM             | 120.63   | 121.50   | 131.0    | 123.0    | 111.0    | 120.80         |
| Pod/Plant      | 101.49   | 98.94    | 133.4    | 117.9    | 90.2     | 101.66         |
| Plht(cm)       | 72.05    | 55.83    | 57.4     | 96.4     | 44.4     | 69.89          |
| S/P            | 19.30    | 18.51    | 8.8      | 21.6     | 22.6     | 19.17          |
| GY(kg/ha)      | 1162.56  | 3404.64  | 5695.0   | 4847.5   | 4550.0   | 1620.20        |
| HSWT(g)        | 11.87    | 11.45    | 9.7      | 11.3     | 16.7     | 11.83          |
Table: 8 Distances between Cluster Centroids

|       | Cluster1 | Cluster2 | Cluster3 | Cluster4 | Cluster5 |
|-------|----------|----------|----------|----------|----------|
| Cluster1 | 0.00     | 2242.15  | 4532.60  | 3685.06  | 3387.61  |
| Cluster2 | 2242.15  | 0.00     | 2290.66  | 1443.56  | 1145.58  |
| Cluster3 | 4532.60  | 2290.66  | 0.00     | 848.68   | 1146.27  |
| Cluster4 | 3685.06  | 1443.56  | 848.68   | 0.00     | 303.84   |
| Cluster5 | 3387.61  | 1145.58  | 1146.27  | 303.84   | 0.00     |

Fig 2. Dendrogram showing relationship among 104 soybean accessions using nine agro-morphological characters, seed yield, and yield traits, 2013.
Fig. 3: Two-dimensional plot of PCA showing relationships among 104 soybean accessions using morphological and yield related traits.

Table 9: Principal Components (PCs) Analysis for seven Yield and Yield attributing traits in 104 soybean accessions

| Yield and yield related traits | Component matrix |
|-------------------------------|------------------|
|                               | PC1   | PC2   | PC3   | PC4   | PC5   | PC6   | PC7   |
| Eigen value                   | 1.5328| 1.3734| 1.2911| 0.9603| 0.9278| 0.5162| 0.3984|
| Proportion of variation       | 0.219 | 0.196 | 0.184 | 0.137 | 0.133 | 0.074 | 0.057 |
| Cumulative variance           | 0.219 | 0.415 | 0.600 | 0.737 | 0.869 | 0.943 | 1.000 |
| Variables                     |       |       |       |       |       |       |       |
| DF                            | 0.036 | -0.591| -0.479| 0.033 | 0.320 | -0.064| -0.560|
| DM                            | -0.407| 0.110 | -0.636| -0.056| 0.259 | -0.165| 0.566 |
| P/P                           | 0.192 | -0.688| 0.200 | 0.329 | -0.003| 0.132 | 0.570 |
| Plh(cm)                       | 0.652 | 0.158 | -0.152| 0.173 | -0.013| -0.700| 0.087 |
| S/P                           | 0.552 | 0.274 | -0.354| 0.070 | 0.170 | 0.676 | 0.073 |
| GY(kg/ha)                     | 0.032 | -0.162| -0.409| -0.146| -0.883| 0.063 | 0.003 |
| HSWT(g)                       | 0.256 | -0.199| 0.104 | -0.912| 0.147 | -0.035| 0.172 |
Table 10: Principal Components (PCs) Analysis for seven Yield and Yield attributing traits in 41 soybean accessions

| Yield and yield related traits | Component matrix |
|-------------------------------|------------------|
|                              | PC1  | PC2  | PC3  | PC4  | PC5  | PC6  | PC7  |
| Eigen value                  | 2.0138 | 1.3036 | 1.2402 | 0.8243 | 0.7661 | 0.4655 | 0.3865 |
| Proportion of variation      | 0.288 | 0.186 | 0.177 | 0.118 | 0.109 | 0.066 | 0.055 |
| Cumulative variance          | 0.288 | 0.474 | 0.651 | 0.769 | 0.878 | 0.945 | 1.000 |
| Variable                     |       |       |       |       |       |       |      |
|                         | Eigen factors |
| DF                       | -0.551 | -0.262 | 0.126 | 0.056 | 0.156 | 0.638 | 0.421 |
| DM                       | -0.439 | -0.170 | 0.184 | 0.265 | -0.748 | -0.115 | -0.319 |
| P/P                      | 0.062 | 0.716 | 0.017 | -0.333 | -0.457 | 0.344 | 0.213 |
| Plh(cm)                  | -0.500 | 0.032 | -0.378 | -0.362 | -0.014 | -0.567 | 0.391 |
| S/P                     | -0.013 | 0.209 | 0.798 | 0.178 | 0.118 | -0.371 | 0.370 |
| GY(kg/ha)               | -0.477 | 0.375 | 0.177 | -0.214 | 0.421 | 0.027 | -0.614 |
| HSwt(g)                | 0.145 | -0.453 | 0.373 | -0.779 | -0.130 | 0.031 | -0.098 |

Annex ii: Local name and morphological characterization (seed coat and flower color) of soybean local collections in regeneration nursery, 2013

| Reg # | Collection District | Local name | Seed coat color | Flower color with Phenotypic trait |
|-------|---------------------|------------|-----------------|-----------------------------------|
| C2014 | Mugu                | Muse Bhatmas | Buff            | Purple Throat                     |
| C2015 | Mugu                | Kalo Bhatmas | Black           | Purple                            |
| C2016 | Mugu                | Seto Bhatmas | Yellowish white | White flower                      |
| C2017 | Mugu                | chhyasmise bha | Imperfect black | White flower                      |
| C2018 | Jumla               | Seto Bhatmas | Creamy white    | Purple Throat                     |
| C2019 | Jumla               | Muse Bhatmas | Imperfect black | Trailing and little leaf, purple flower |
| C2020 | Jumla               | kaloo Bhatmas | Black           | Trailing and little leaf, purple flower |
| C2021 | Jumla               | chhyasmise bha | Imperfect black | Trailing and little leaf, purple flower |
| C2022 | Kalikot             | Kalo Bhatmas | Black           | Trailing and little leaf, purple flower |
| C2023 | Kalikot             | Muse Bhatmas | Yellowish white | Trailing and little leaf, purple flower |
| C2024 | Kalikot             | Thulo seto Bha | Yellow         | White flower                      |
| C2026 | Kalikot             | Kalo Bhatta | Black           | White flower                      |
| C2027 | Kalikot             | Bhatta     | Yellow          | White flower                      |
| C0157 | Doti                | Kalo Bha    | Black           | Purple Throat                     |
| Code  | Location | Variety    | Color     | Flower Color     |
|-------|----------|------------|-----------|------------------|
| C0158 | Doti     | Moto Bhatta| Yellow    | White flower     |
| C0159 | Doti     | Kalo Bhatta| Black     | Purple Throat    |
| C0160 | Baitadi  | Seto Bhatta| Yellowish white | White flower |
| C0161 | Baitadi  | Kalo Bhatta| Black     | White flower     |
| C0162 | Baitadi  | Seto Bhatta| Yellow    | White flower     |
| C0163 | Baitadi  | Seto Bhatta| Yellow    | White flower     |
| C0164 | Baitadi  | Seto Bhatta| Yellow    | White flower     |
| C0165 | Baitadi  | Seto Bhatta| Yellow    | White flower     |
| C0166 | Dadeldhura| Rato Bhatta| Reddish brown | White flower |
| C0167 | Dadeldhura| Kalo Bhatta| Black     | White flower     |
| C0168 | Dadeldhura| Seto Bhatta| Yellow    | White flower     |
| C0169 | Dadeldhura| Nepali Bhatta| Buff    | White flower     |
| C0170 | Dadeldhura| Seto Bhatta| Yellowish white | White flower |
| C0171 | Dadeldhura| Khairo Bhatta| Grey    | White flower     |
| C0172 | Kailali  | Kalo Bhatta| Black     | White flower     |
| C0175 | Kailali  | Seto Bhatta| Yellow    | Purple           |
| C0176 | Kailali  | Kalo Bhatta| Black     | White flower     |
| C0178 | Kailali  | Kalo Bhatta| Black     | Purple           |
| C0179 | Kailali  | Khairo Bhatta| Reddish brown | White flower |

Source: Gene Bank, Khumaltar