Plant Bulletin Vol 3, (1) 2024: 43-49 ISSN: 2959-3379 (Print), 2959-3387 (Online)

Research Article

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STUDY OF GENETIC VARIABILITY OF LENTIL (*Lens culinaris* Medik) GERMPLASM FOR MORPHOLOGICAL, PHYSIOLOGICAL AND YIELD TRAITS

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ABSTRACT

Lentil (*Lens culinaris* Medik) is one of the oldest crops in the world, an autogamous, diploid species and one of the most common grain legume crops. Lentil is a significant member of the Fabaceae Family. The majority of its production occurs in marginal lands with rain-fed conditions. Lentils have a strong impact on genetics and alter yield percentages in loamy soil. Lentil production and acreage have declined badly during the last ten years. During 2022–2023, a field experiment was conducted at the Pulses Research Area of the Ayub Agricultural Research Institute in Faisalabad. Two hundred genotypes with four slandered checks were tested in this research i.e Masoor - 93, Pb M-2009, Markaz-2009, and Pb M-2019. Markaz-2009 was approved variety of NARC, and the other three checks were commercial varieties developed by PRI Faisalabad. Two hundred genotypes used in the experiment, were carried out in rows of four meters each, with a row-to-row spacing of 30 cm and a plant-to-plant 10cm spacing. The variability in yield, heritability, genetic development, and relationships among the 200 accession of lentil germplasm were determined. Principal component analysis (PCA) was performed to analyses the data. The significant outcomes and variations for all attributes among genotypes expressed by the principal component analysis were observed. Estimated heritability requirements ranged from 30 to 50% for plant height, pods per plant, plant biomass, days to 90% maturity, days to 50% flowering, and days to seed production. Plant height, number of branches per plant, and number of pods per plant all were significantly correlated positively with yield, whereas plant stand, days to 90% maturity and plant biomass significantly correlated negatively with yield per hectare. Days to 50% flowering and seed production have a strong positive relationship with days to 90% maturity. The results revealed significant yield variance and traits that affect yield for the genotypes studied, which will aid in the improvement of lentil genotypes in the area. From 200 accessions, the PLL-15501, ILL-1697-1939, PLL-15508, PLL-15504, and PLL-13515 lines displayed the highest plant height, whereas the AARIL-08515, AARIL-04533, PLL-10511, PLL-14518, and PLL-15501 lines displayed the highest number of branches per plant. Maximum pods per plant shown in entries like AARIL-98502, PLL-10507, PLL-13515, PLL-14522, PLL-15502, and PLL-19502. The data statistically analyzed to identify the best genotypes for the characters previously described.

Keywords: Germplasm, Genepool characterization, Lentil, Yield.

Article History

Received: January 30, 2024, April 03, 2024, Published: May 20, 2024.

INTRODUCTION

Lentil (*Lens culinaris* Medik) is one of the most significant pulse crops for the Rabi season. It is grown on loamy soil. It belongs to the family Fabaceae. Lentils are a great source of essential nutrients such essential amino acids, fatty acids, and trace minerals [11]. Lentils are known as "poor man's meat" It is essential to create genotypes with good, consistent yield and higher protein content in order to improve lentil yield status [12]. The lentil, also known as Masoor dal, is a bushy annual plant that produces seeds that resemble lenses (*Lens culinaris* Medik). Red, white, and yellow lentils have their skins removed or are decorticated [14]. A successful plant-breeding program is required to raise the crop's yield potential. The environment has a significant impact on the production of various genotypes of lentils. Straight selection is typically incorrect since component features affect grain yield [3, 15]. Therefore, it is important to consider both the yield and the yield related aspect that contribute to it when choosing the selection criteria for yield improvement. Additionally, a number of yield-contributing factors have an impact on grain yield [13]. Pulses are frequently referred to as the lifeline of humans due to the balanced amino acid composition of grains and the protein combination, which matches milk protein [17]. It also acts as a cover crop to stop soil erosion. It is a leguminous crop, and by organically fixing nitrogen, it improves soil fertility [1]. Lentil seeds are also a source of starch for textiles and printing. India has 1.59 million hectares under cultivation of lentils, yielding 0.95 million tons at a rate of 633 kilograms per hectare [25]. Despite having the same number of calories, lentil has nearly four times the protein and eight times the riboflavin as rice. High potential genotypes with a good, stable yield and improved protein content must be developed in order to improve the yield status of this crop [9]. A review of morphological characteristics found that the working gene pool for this crop has a small range of variability, which restricts the germplasm [7, 20]. The current study investigated the genetic variation of lentil genotypes with regard to agro-morphological characteristics with the aim of determining the link between yield and attributes that contribute to yield as well as identifying the most promising genotypes. To strengthen the historical basis of germplasm, it is essential to recognize the ancestry and genetic divergence of a lentil gene bank. However, comprehensive knowledge on genetic diversity for important as long as features and dietary standard characteristics for different population structures of exotic genotypes is lacking [5, 23]. A variety of alignment techniques are used to quantify and classify the genetic composition of different batches of lentils, cowpeas, mung beans, alfalfa, soybeans and mustard [8]. Given that it has been shown that a variety of abiotic factors, including salinity, heat, humidity, and drought, have a negative effect on lentil growth. Heat, cold, drought, salt, nutrient shortages in the soil, and toxicity are abiotic variables that lentil is susceptible to. Climate predictions show that erratic annual rainfall is dangerous for the production of lentils due to an increase in the frequency of drought spans [22].

MATERIALS AND METHODS

Two hundred lines of successive lentil germplasm were planted at the experimental field of the Pulses Research Institute at the Ayub Agricultural Research Institute in Faisalabad on October 26, 2022. Conventional agronomic practices and cultural operations, such as tidiness, weeding, irrigation, and fertilizers, were used from planting to harvest. Total area of gene pool was 28*40 ft. The soil was loamy, and the entries were spaced 30 cm apart along a row that was 4 meters long. Each entry was planted in a wet field. The one bag of fertilizer of DAP acre-1 was used. After germination, the plants were trimmed to maintain a plant-to-plant and row-to-row spacing of 10 cm and 30 cm, respectively. In order to collect data on both sides of the line ten equally capable plants were selected.

Plant stand: Information on plant stands calculated using the germination rates of each gene pool line. Almost all the plants were fully germinated in each line of the gene pool except very few genotypes.

Days to 50% flowering: The days to flowering, data was computed starting on the day when 50% flowering of the plant completed. The days were counted from the day of sowing to the day of 50% flowering.

Plant Height: Plant height information was calculated from base to node through measuring scale. Height was measured of ten randomly chosen plants in centimeters from each gene pool line, then averaging the results. The plant height was varying from plant to plant in each line of the gene pool.

Branches per plant: The branches per plant including primary and secondary branches were calculated at, ten gene pool plants that were chosen at random, from each gene pool line and then taking into account their mean value.

Pods per plant: Data on the average number of pods per plant was calculated by counting the pods on each plant. The maximum pods on each plant were varied from 300 to 400, while the maximum pods on each branch were 10 to 15.

Chlorophyll content: Chlorophyll content data was calculated by utilizing the chlorophyll Meter LCPM-A10 measure the amount of chlorophyll in a sample of plants from each row. Chlorophyll content was measured by taking the reading through SPAD of three leaves from each line of the gene pool individually and then taking into account their mean value.

Days to 90% Maturity: From the date of sowing to the day when all of the plant's pods were 90% mature, data on maturity times were calculated. Majority of the plant pods were 90% mature in each line of the gene pool. Very few genotypes were not fully mature at the harvesting time.

Plant Biomass: The plant Biomass (in grams) was calculated using the plant debris from the complete row after harvesting and drying. The plant debris was weighted after harvesting.

Plant seed yield: The overall seed yield for the row was calculated using a computerized electric balance. The yield of the most varieties were higher and good, while the yield of very few varieties were lower.

1000 Grain weight: The 1000 seeds produced in each row were tallied and weighed on the model AT-CS (10) by weighing scale. The 1000-grain weight was made of each variety of each line of the gene pool. Most of the varieties were high weighted of the gene pool.

Yield gram per plot: Data on yield grams per plot are determined by weighing the seeds or yield of each gene pool line separately**.** The yield of each line of the gene pool was weighted on electric balance. Most of the varieties gave the higher yield except very few.

Yield kg per hectare: The yield in kilograms per hectare was calculated by using the formula (yield g/plot*10/1.2-meter square). Details are given in Table 1.

Table 1. Percentage of variability of several variable.

Variables	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Eigen values	1.81	1.16	1.10	1.06	1.00	0.99	0.94
Variability %	27.3	11.2	10.0	9.4	8.3	8.1	7.4
Cumulative %	27.3	38.5	48.5	57.9	66.2	74.3	81.7

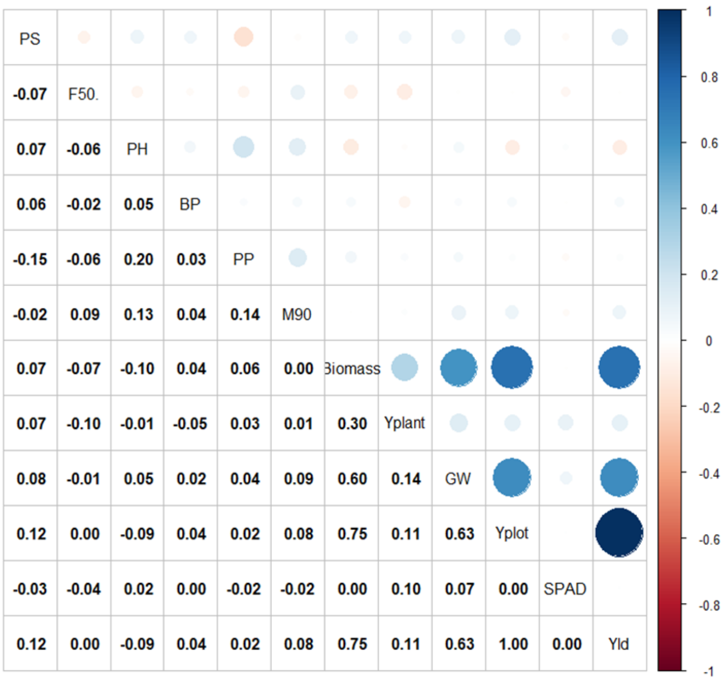
RESULTS

Multiple Analyses by Principal Component analysis

For better understanding the causes of variation among lentil genotypes, 12 morphological parameters were grouped by a principal component analysis.

Relative contributions of 12 characteristics to the total divergence in the lentil germplasm The yield gram per plot showed highly correlation with 1000 Grain weight and Biomass. While the Biomass was highly correlated with 1000 Grain weight, yield gram per plot and yield per hectare. Whereas the 1000 Grain weight showed highly correlation with yield gram per plot and yield per hectare. These correlations of different characters are given in Table 2 below.

Table 2. Relative correlations of 12 characteristics in lentil germplasm



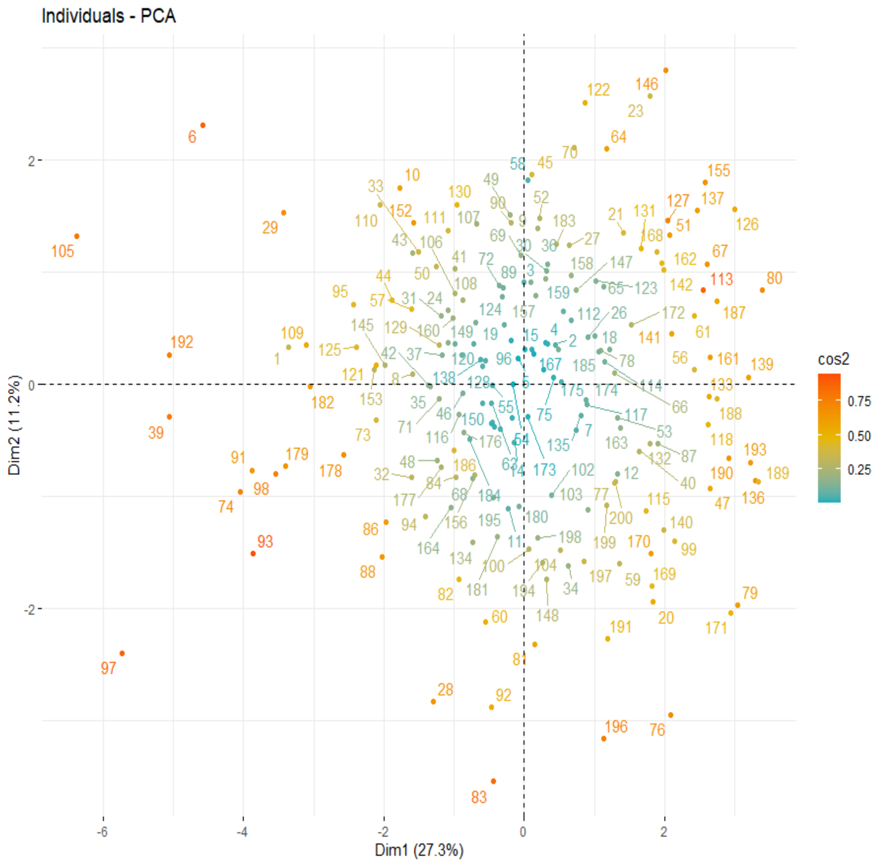


Figure 1: grouping of 12 Agro morphological traits in genotypes of lentil germplasm on principal component Axis.

This graph is explaining the entries that showed similarity and dissimilarity with each other and expressed the average yield. The entries that are present in the center such as 96, 167, 75, 55, 128, 64, and 175 and 15 expressed the average yield. Whereas the entries that are towards the spike and near the center such as 175, 167, 18, 2, 149, 159 and 124 showed greater average. While the entries that are far from the center such as 97, 83, 39, 192, 76 and 196 showed the less average, (Figure 1).

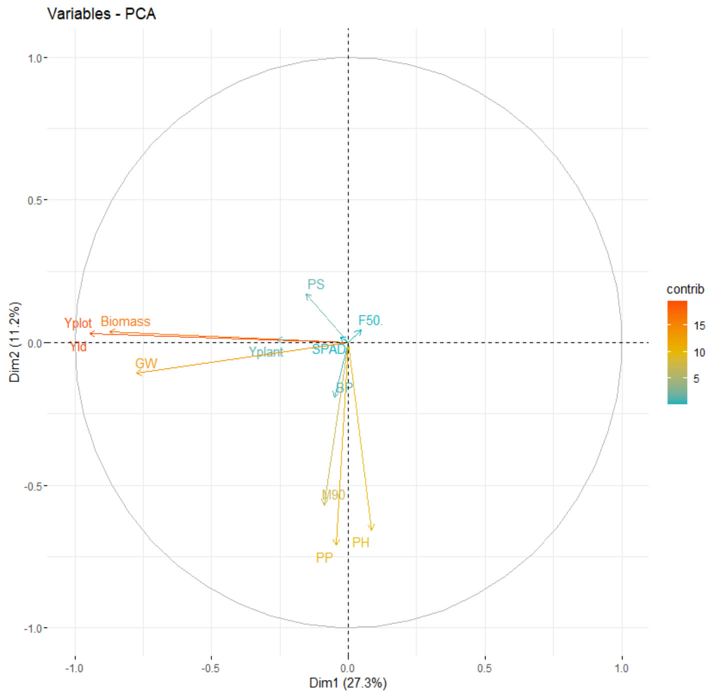


Figure 2. Correlation between the characters of two variables on principal component axis

This graph representing the variables that are showing correlation with each other. The variables such as yield per plot, Biomass, yield and 1000 Grain weight correlate to each other. These variables showed great correlation to overall yield. Whereas the variables such as the 90% maturity, plant height and pods per plant showed correlation with each other. The variables such as the plant stand, 50% flowering, chlorophyll content (SPAD) and yield per plant that present in the center do not show the correlation and show the average yield (Figure 2).

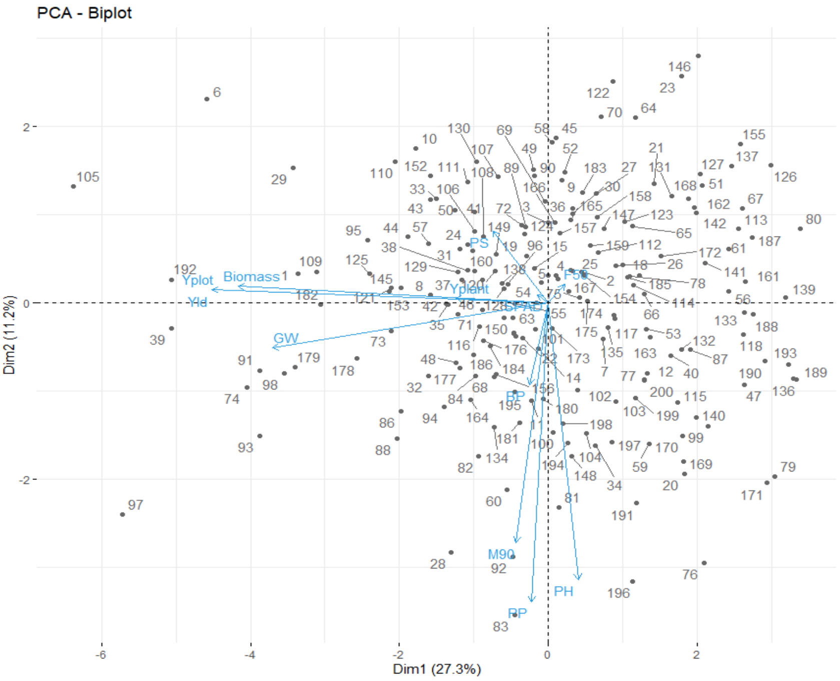


Figure 3: Biplot of Dim 1 and Dim 2 on Principal component Axis.

This graph (Figure 3) represented the Biplot in which Dim 1 is 27.3% at the x-axis and Dim 2 is 11.2% at the y-axis. The variables like Biomass, yield per plot, yield and 1000 Grain weight showed the great yield. Whereas the 90% maturity, plant height and pods per plant expressed the low yield. The variables such as 50% flowering yield per plot, plant stand and chlorophyll content (SPAD) showed the average yield, can be seen in the Figure 3. The variables present in the x-axis showed the correlation with each other. Meanwhile the y-axis's variables also showed the correlation with each other.

DISCUSSION

Two hundred landrace lentil accessions planted in the Pulses research area of the Ayub Agricultural Research Institute Faisalabad for the current study's evaluation of morphological and physiological parameters. The number of seeds were produced, yield per plot, the quantity of pods produced by each plant with the Biomass of the plant all were varied significantly that shows a significant phenotypic diversity. It is also reported the alike variation in number of pods, Biomass, amount of seeds production and amount of yield per plot in other lentils [6, 17]. However, plant height, seed yield/plant and pods/plant showed a positive association whereas plant stand, days of flowering, plant Biomass,1000 Grain weight, yield gram/ plot and yield kilogram/ hectare was negatively correlated. Similar results are reported for all these traits correlation [21]. However, some characters showed the different correlation with different PCs such as branches/ plant displayed the negative connection with PC4 and positive correlation with PC6.Similarly days of maturity showed the moderate negative correlation with PC5 and same moderate positive correlation with PC2, whereas seed yield per plant showed the positive correlation with PC3 and negative correlation with PC7. Chlorophyll content negatively correlated with PC5 and positively correlated with PC6. It is also explained the same consequences of PC correlation related to these traits [10, 9]. The studies found a of correlation revealed a highly substantial and favorable relationship between seed yield/ plant, number of pods/plant, plant height, number of secondary branches/ plant, with biological yield per plant [18]. A breeding program's exploitation of significant intercorrelation between characteristics to boost yield and its constituent parts. As highly desirable components for direct influences on seed yield, path analysis identified biological yield/ plant and number of pods/ plant. [7].

From all accessions, ICARDA 31102, ICARDA 31105, ICARAD 31112, ICARDA 31117, Australia-1, Australia-2, Australia-3, Australia-4, Australia-5, Hurricane, Ishfaq-1 and Ishfaq-2 showed late maturity, while the other accessions showed the early maturity. The variation among all the characters in the PC1 and PC2 generations shown using the principal component analysis.

The primary objective of principle component analysis was to determine how various morphological characteristics correlated with one another and showed the most variability. When Principle component analysis used, the outcomes between the variables varied. Yield is positively correlated with plant stand, branches per plant, pods per plant, plant height, plant Biomass, days of flowering and 1000 Grain weight, whereas negatively correlated with the days of maturity and chlorophyll content and some results was also gained by who correlated the morphological traits in their research work [4,23].

All of the features in the current study had strong heritability's, indicating their significance for being given preference for the increase of lentil seed output through the selection of various qualities, reported by [6]. Number of pods per plant and number of seeds per plant were identified that will further improve their performance. It is also discovered high heritability for these variables in their research work [24, 6].

All the parameters had a substantial, positive correlation with seed output except the days to flowering and days to maturity [9]. With an exception of the number of branches and pods per plant, the current analysis showed that the genotypic association is stronger than the phenotypic correlation. The number of pods per plant, plant height, and seed weight all had an indirect impact on the amount of seeds produced per plant [19]. Same results were also detected throughout the study of two hundred lentil successions.

The number of pods/plant, plant height, secondary branches/ plant, days to maturity, and 1000 seed weight all have highly favorable indirect effects on seed output per plant. The number of pods per plant and the weight of 1000 seeds were found to be significant indirect factors to the expression of lentil seed output [16].

The genotypes of 200 accessions of lentils showed a progressive and substantial connection among plant height quantity of pods with seed yield per plant. reported the same correlation of the seed yield with the plant height, number of pods/ plant and seed yield per plant. Plant height presented the optimistic relationship with the plant Biomass, seed yield/ plant days of maturity with the days of flowering which also evident from the previous studies on plant height with seed yield [2, 23].

Additionally, the harvest of seeds was undoubtedly related to plant biomass during the harvesting stage, height at plant flowering, and plant elevations at maturity. Through harvest, plant stature, biomass yield/ plant, and seed yield/ plant were closely linked. The yield index was negatively associated with plant biomass and was noticeably remarkable [10].

CONCLUSION

Maximum plant height that is 60cm was observed in PLL-14514, whereas the minimum was in AARIL-98505. Some lines were also equal to the maximum range that are PLL-14512, PLL-15502, PLL-13514, and PLL-14511. The line AARIL-98502 perceived maximum pods per plant that is 611.3, while the minimum was in PLL-18508. Maximum number of branches observed in PLL-15501, while the minimum observed in AARIL-08513. Plant stand and days of flowering observed in AARIL-98502, PLL-11501, PLL-11502, and PLL-14513. The maximum Biomass observed in AARIL-08509 that was 511, and the minimum detected in PLL-14506. The succession AARIL-09514, PLL-10514, PLL-11504, PLL-14508, PLL-14509, PLL-14517, PLL-14522, and PLL 14525 showed the maximum value for the days of maturity. While the Australia-1, Australia-2, Australia-3, Hurricane expressed the minimum value for the days of maturity. While chlorophyll content of this accession was, also minimum Seed yield per plant, 1000 Grain weight and yield per plot showed maximum values and these were positively correlated with yield per hectare.

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