Variability, Correlation and Path Coefficient Analysis for Agro-Morphological Traits in Lentil (*Lens culinaris*) Genotypes

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Abstract

Assessing variability and correlations for agro-morphological traits of lentil are the important aspects in the development of lentil varieties. Six lentil genotypes were evaluated in randomized complete block design (RCBD) with four replications at Agronomy Research Farm of Institute of Agriculture and Animal Science (IAAS), Paklihawa, Rupandehi, Nepal during winter season of 2018/19 to assess the genetic variability, heritability and genetic advance for agro-morphological traits. Analysis of variance revealed significant differences for all traits. The values of Phenotypic Coefficient of Variance (PCV) were higher than Genotypic Coefficient of Variance (GCV) for all the characters, and the number of pods per plant exhibited high estimates of both PCV and GCV indicating substantial scope of improvement through selection. The number of secondary branches showed the highest PCV (0.89) and GCV (0.50) whereas the lowest PCV (0.02) and GCV (0.00) were recorded for date to 50% maturity. High heritability (0.62) coupled with high genetic advance (192.63) as percent mean was observed for the grain yield. Grain yield showed positive and significant phenotypic correlation with number of pods per plant (r=0.424) and plant height (r=0.420). The highest positive direct effects were observed in plant height followed by number of grains per pods, number of secondary branches and number of pods per plant; suggesting the importance of these characters and the necessity of adopting them as selection criteria for grain yield improvement.

Key words: Lentil, Grain yield, Heritability, Correlation, Path analysis.

Introduction:

Lentil *(Lens culinaris Medikus* spp. *Culinaris)* also known as masur daal, is a rabi pulse crop belonging to the family Leguminosae. The name "lentil" is derived from its typical lens-shaped seeds (Watts, 2011). In Nepal, lentils are grown in Terai, inner Terai and mid hills of the country. The cultivation of lentil has been increased because of increasing preference for its internal consumption and potential for export market. Nepalese lentils have greater demand in the international market (Prasai *et al*., 2019). In Nepal, lentil is the major grain legume that accounts for 63% of area and 70% production of total grain legume. Nepal ranks in 6^{th} position (0.25 million MT) in terms of production (Statista, 2017). Lentil is a rich source of protein and of minerals (K, P, Fe and Zn) and vitamins (Shrestha *et al*., 2018) that contribute nutritional security to the Nepalese being main pulse of the country (Pant *et al*., 2017) As lentil is consumed with cereals as (Dal), and because of its high lysine and tryptophan content, it contribute as an excellent supplement to wheat or rice providing a balance in essential amino acids for human nutrition (Adhikari *et al*., 2018a). Being leguminous crop, lentils have the third highest level of protein (26%) from any plant-based crop for which it is also known as poor man's meat (Bhatty, 1988). Estimation of heritability, correlation, path coefficient analysis, and genetic advance would be useful in developing appropriate breeding and selection strategies (Ezeaku *et al*., 2015). Therefore, understanding the yield and yield components relationship as well as heritability estimate of hybrid parental lines is essential in determining traits that contributes significantly to yield, facilitate their selection and utilization in hybrid development (Angarawai *et al*., 2015). Heritability is the statistical concept that describes how much of the variation in a given trait can be attributed to genetic variation and shows the component of a character transmitted to future generations (Moore and Shenk, 2017). It implies that individuals more closely related are more likely to resemble one another than distant ones (Haslam Nick *et al*., 2007) . Genetic advance shows the difference between the mean genotypic values of the selected population and the original population from which these were selected (Ehdaie and Waines, 1989). High heritability doesn't mean a high genetic advance for a particular quantitative character. Johnson *et al*., (1955) reported that heritability estimates along with genetic gain would be more rewarding than heritability alone in predicting the consequential effect of selection to choose the best individual. Correlation analysis provides the information on interrelationship of important plant characters and hence, leads to a directional model for direct and/or indirect improvement in grain yield (Khan *etal*., 2004). Both genotypic and phenotypic correlations among and between pairs of agronomic traits provide scope for indirect selection in a crop breeding program (Pavan *et al*., 2011). Since yield components are inter-related and develop sequentially at different growth stages, correlations may not provide a clear picture of the importance of each component in determining grain yield. Path coefficient analysis provides more information among variables than correlation coefficients (Aycicek and Yildirim, 2006). Path coefficient analysis furnish a method of partitioning the correlation coefficient into direct and indirect effect and provides the information on the actual contribution of a trait in the yield (Dewey and Lu, 1959). Path analysis also helps in formulating effective breeding strategies to develop elite genotypes (Sameera *et al.*, 2016). Thus, the aim of this study was to determine the variability, correlations and path analysis of yield and yield components in lentil and evaluate their suitability's in a breeding program.

Materials and Methods:

Experimental site and materials:

The field experiment was conducted at the Agronomy Research Farm at the Institute of Agriculture and Animal Science (IAAS), Paklihawa, Rupandehi, Nepal during 2018/019. Geographically, the location of the research site is 27°30’ N latitude and 83°27’ E longitude and at the altitude of 79 meters above the sea level. The site has a humid sub-tropical climate where summers are hot and winters are cold with total annual rainfall reported as 1725.33 mm. The six lentil genotypes were used for this study are presented in the Table (1).

Table 1. Plant materials used in the study

SN	Genotype	Seeds obtained from	Source of origin	Parentage
1	Kalo Masuro	Nepal (Pipeline)	Nepal	
2	Khajura-3	Nepal	India	RL-4
3	Khajura-1	Nepal	India	LG198
4	Simrik	Nepal	India	T36
5	Simal	Nepal	India	LG7
6	Local Masuro	Nepal	Nepal	

(Varietal database of lentil in Nepal, Rookie site 2018).

Experimental design, treatments and crop management:

Six lentil genotypes (Table 1) collected from Regional Agricultural Research Station (RARS), Khajura, Nepalgunj were used as planting material and were planted in a randomized complete block design (RCBD) with four replications, in plots of 10 rows, each 4m long and 2.5m width with spacing 25 x 5 cm. A pre-sowing irrigation was given before land preparation. The 5t FYM, chemical fertilizers @ 20:40:20 N, P_2O_5, K_2O kg/ha was applied during final land preparation. Hand weeding was done at 30 and 45 days after sowing.

Data observation and analysis:

Line sowing of lentil was carried out on 20th November, 2018 and bulk harvest was performed on 15th march, 2019. Data on days to 50% flowering, flower color, plant height, number of 1° branches, number of 2° branches, pod length, no. of pods per plant, no. of grains per pod, days to 50% maturity, test weight and grain yield per plot (10 m^2) were collected. Days to 50% flowering, flower color, days to 50% maturity and grain yield per plot were recorded on a whole plot basis whereas all other traits were recorded from a random sample of 5 plants from each row of a plot. Standard statistical procedure was used for the analysis of variance (Panse and Sukhatme, 1995). The genotypic and phenotypic coefficients of variation was estimated using formula given by Burton and Devane, (1953) and adopted by Adhikari *et al*., (2018b); heritability given by Allard (1960) and adopted by Kandel *et al.*, (2018); and genetic advance given by Allard (1960) and adopted by Bartaula *et al*., 2019). The genotypic and phenotypic correlation coefficients were computed using genotypic and phenotypic variances and co-variances (Searle, 1961). The path coefficient analysis was done according to the method by Dewey and Lu (1959).

Statistical Analysis:

Analysis of variance and correlation among traits were done by using Genstat 18.0. Least significant difference (LSD $p \leq 0.05$) test was used for mean comparison to identify the significant components of the treatment means (Jan *et al*., 2009; Shrestha, 2019).

Results and Discussion:

Analysis of variance:

It is evident from the analysis of variance that the treatment (genotype) difference was significant (at 5% level of significance) for grain yield per plot under study This suggests that there is an inherent genetic difference among the genotypes.

Variability, heritability and genetic advance:

Table 92) shows the estimates of range, mean, phenotypic coefficient of variation (PCV), and genotypic coefficient of variation (GCV). The genotypes which recorded the highest values for more than one character were Kalo masuro (in 6 traits), Khajura-3 and Simrik. Grain yield per plot ranged widely, suggesting that there is a high genetic contribution among the genotypes. The cross among distant genotypes may be expected to exhibit high heterosis through desirable segregation in later generation of hybridization. The close scrutiny of the data in Table (2) reveals considerable variation for all traits under study with a wide range of phenotypic as well as genotypic coefficient of variation. In general, as could normally be expected, the values of phenotypic variance were higher than those of genotypic variance for all the traits. Phenotypic coefficient of variation was highest (more than 20%) for the measured traits, number of secondary branches (0.89028) followed by number of pods per plant (0.5188), number of grains per pod (0.4861), grain yield per plot (0.3654), number of primary branches (0.25) and pod length (0.22063). The phenotypic coefficient of variability was higher than corresponding genotypic coefficient of variability for all these traits which demonstrated the effect of environment upon the traits (Younis *et al*., 2008). The genotypic coefficient of variation was highest (more than 20%) for the measured traits, number of secondary branches (0.497475) followed by the number of grains per pod (0.4475), number of pods per plant (0.2421) grain yield per plot (0.2017). So, the highest PCV and GCV were found in the number of pods per plants and the lowest PCV for days to flowering, maturity and pod length. A similar result was obtained by Ajmal *et al*., 2009.

Table 2. Variability parameters for lentil genotypes

Traits	Days to 50% flowering	Plant height (cm)	No. of primary branch	No. of secondary branch	Pod length (cm)	No. of pod per plant	No. of grain per pod	Test weight (gm)	Date of 50% maturity	Grain yield per plot (gm)
Mean	100.13	21.79	3.62	3.28	0.82	21.24	1.77	16.01	121.42	412.65
SEM	1.10	2.71	0.06	0.12	0.01	0.78	0.04	0.17	0.16	9.05
PCV	0.12	0.18	0.26	0.89	0.22	0.52	0.49	0.16	0.02	0.37
GCV	0.08	0.05	0.11	0.50	0.00	0.24	0.45	0.03	0.00	0.20
Heritability	0.53	0.26	0.49	0.00	0.00	0.00	0.00	0.16	0.00	0.62
Genetic advance	1.19	2.13	0.94	0.00	0.00	0.00	0.00	0.83	0.00	192.63
GA as % of mean	1.19	9.79	25.88	0.00	0.00	0.00	0.00	5.20	0.00	46.68

Hbs= Heritability broad sense, GCV= Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation, GA= Genetic advance, GAM= Genetic advance as percent of mean.

Broad sense heritability estimate was highest for grain yield per plot (0.62). Moderate heritability was recorded in days to 50% flowering (0.53) and the number of primary branches (0.49). Low heritability was recorded in plant height (0.26) and test weight (0.16). The heritability ranged from 0 % to 62 %.

The estimates for different characters indicated that variation observed in these characters is primarily due to genetic causes and very less by environmental effects.

The estimate of genetic advance was highest in grain yield per plot followed by plant height, days to 50% flowering, number of primary branches and test weight. The lowest genetic advance was observed for number of secondary branches, pod length, number of pods per plant, number of grains per pod and days to 50% maturity. Genetic advance as percent of mean was, however, highest for grain yield per plot followed by number of primary branches. Low genetic advance was recorded in plant height, test weight and days to 50% flowering. High heritability coupled with high genetic advance as percent mean was observed for grains yield per plot which indicates the control of additive gene of action and a greater scope of selection for this trait (Meshram and Patil, 2013). High GCV, heritability and genetic advance were obtained in grain yield.

Character association:

Days to 50 % flowering exhibited positive and highly significant association with days to 50% maturity. Plant height showed a positive highly significant association with number of secondary branches, grain yield. The secondary branch showed a positive and highly significant correlation with number of pods per plant, number of grains per pod, and pod length. The pod length showed positive and highly significant correlation with number of grains per pod. The number of pods per plant exhibited positive and highly significant association with test weight, number of grains per pod and significant with grain yield. Number of grains per pod exhibited positive and highly significant association with pod length, number of pods per plant and number of secondary branches. Test weight exhibited positive and highly significant association number of pods per plant. Grain yield per plot exhibited a positive and highly significant association with number of pods per plant and plant height. Grain yield showed non-significant association with test weight, grains per pods, pod length and number of secondary branches. It showed negative and non-significant association with days to 50 % flowering, days to 50% maturity and number of primary branches. The result on correlation study suggested that the character like number of pods per plant and plant height which had a positive significant association with yield may be taken in to account in the lentil breeding program for yield improved in the present set of lentil germplasm (DB *et al*., 2014; Jain *et al.*, 1991)

Table 3. Phenotypic correlation coefficient among yield and yield attributing traits of lentil genotypes

	DF	**PH**	**NPB**	**NSB**	**PL**	**NPP**	**NGP**	**TW**	**DM**	**GY**
DF	1	-0.572**	-0.238	-0.457*	-0.238	-0.212	-0.395	0.222	0.800**	-0.333
PH		1	-0.522**	0.443*	0.335	0.333	0.396	-0.158	-0.544**	0.420*
NPB			1	0.25	0.212	0.148	0.343	-0.006	-0.304	-0.093
NSB				1	0.465*	0.755**	0.540**	0.356	-0.420*	0.282
PL					1	-0.540**	0.895**	0.375	-0.224	0.327
NPP						1	0.516**	0.517**	-0.095	0.424*
NGP							1	0.3	-0.303	0.29
TW								1	0.243	0.26
DM									1	-0.201
GY										1

DF-Days to 50% Flowering, PH-Plant height, NPB-Number of primary branches, NSB- Number of secondary branches, PL-Pod length, NPP-Number of pods per plant, NGP-Number of grains per pod, TW-Test weight, DM-Days to 50% maturity, GY- Grain yield.

Table 4. Agro-morphological performance of lentil genotypes

Genotype	PH (cm)	NPB	NSB	PL (cm)	NPP	NGP	TW (g)	GY/10 m^2 (g)
Kalo Masuro	20.79	2.91	3.76	0.86	28.37	1.75	18.20	571.17
Khajura-3	25.08	4.16	3.04	0.84	19.81	2.02	15.40	475.57
Khajura-1	23.26	4.44	3.74	0.82	19.31	1.84	14.78	374.35
Simrik	19.32	3.10	1.86	0.79	12.71	1.49	14.87	281.82
Simal	19.74	3.57	3.58	0.79	21.68	1.76	15.75	329.45
Local Masuro	22.53	3.51	3.73	0.79	25.55	1.79	17.05	443.52
Grand mean	21.79	3.62	3.28	0.82	21.24	1.77	16.01	412.65
CV%	0.19	0.25	0.45	0.23	0.51	0.28	0.16	0.34
P value	0.37	0.20	0.42	0.18	0.44	0.15	0.40	0.04
LSD (0.05)	6.23	1.37	2.21	0.28	16.24	0.76	3.89	209.80

DF-Days to 50% Flowering, PH-Plant height, NPB-Number of primary branches, NSB- Number of secondary branches, PL-Pod length, NPP-Number of pods per plant, NGP-Number of grains per pod, TW-Test weight, DM-Days to 50% maturity, GY- Grain yield

Path-coefficient analysis:

The correlation coefficient between grain yield per plant and its nine main component characters *viz.* days to 50% flowering, plant height, no. of primary branches, no. of secondary branches, pod length, no. of pods per plant, no. of grains per pod, test weight and days to 50% maturity were apportioned into their corresponding direct and indirect effects through path-coefficient analysis. The traits namely days to 50% flowering, plant height, no. of secondary branches, no. of pods per plant, no. of grains per pod and test weight exhibited a direct positive effect on grain yield of varying magnitude (Table 5). The traits like no. of primary branches, pod length and days to 50% maturity exhibited direct negative effect on grain yield. Singh, (1977) also reported the same result between plant height and yield. The pod length had a positive correlation with grain yield (0.327) but its direct effect was negative (-0.69). This may be due to counter-balancing by other positive indirect effect of PL. So, while selection, such indirect effects are to be considered simultaneously for selection. Days to 50% flowering had a negative correlation with grain yield (-0.333) but its direct effect was positive (0.1621). So, a restricted simultaneous selection model is to be followed to nullify the undesirable indirect effect in order to make use of direct effect (Singh and kakar, 1977, Firas *et al*., 2014)

Table 5. Path coefficient in terms of direct and indirect effects of nine components traits on grain yield of lentil genotypes

Traits	DF	PH	NPB	NSB	PL	NPP	NGP	TW	DM
DF	**0.1621**	-0.1123	-0.1049	-0.0926	-0.0035	-0.0295	-0.1003	-0.0035	-0.2952
PH	-1.0261	**1.4815**	1.1225	0.4859	0.1919	0.4612	0.9166	-0.1837	0.4338
NPB	0.9383	-1.0986	**-1.4500**	-0.4241	0.0561	-0.1999	-0.6085	0.3377	-0.1302
NSB	-0.3580	0.2054	0.1832	**0.6263**	0.1881	0.4544	0.2369	0.3410	0.5646
PL	0.0152	-0.0901	0.0269	-0.2090	**-0.6958**	-0.3597	-0.6213	-0.0863	0.3010
NPP	-0.0424	0.0724	0.0321	0.1688	0.1202	**0.2326**	0.1004	0.2170	0.8175
NGP	-0.4097	0.4095	0.2778	0.2503	0.5910	0.2857	**0.6618**	0.3450	0.3906
TW	-0.0003	-0.0018	-0.0033	0.0077	0.0018	0.0133	0.0013	**0.0142**	0.7850
DM	0.4258	-0.4323	-0.2146	-0.2486	-0.1487	-0.0405	-0.1949	0.1486	**-0.0846**

DF-Days to 50% Flowering, PH-Plant height, NPB-Number of primary branches, NSB- Number of secondary branches, PL-Pod length, NPP-Number of pods per plant, NGP-Number of grains per pod, TW-Test weight, DM-Days to 50% maturity, GY- Grain yield.

Conclusion:

All the studied traits indicated that presence of genetic variability which can be exploited in crop improvement program. PCV is higher than GCV in all studied traits; it indicated that there was no environmental influence. Traits namely grain yield having high GCV, PCV and heritability along with high genetic advance as percentage of mean were used in selection process of crop improvement program. As test weight, number of pods per plant, number of grains per pod and pod length which had a positive association with yield correlated with grain yield hence, selection for these traits might bring an improvement in grain yield.

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التباين والارتباط وتحليل معامل المسار للصفات الشكلية والإنتاجية لطرز العدس *Lens culinaris*

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الملخص

يعتبر تقدير كل من التباين والارتباط ما بين الصفات الشكلية الإنتاجية من أساسيات تحسين أصناف العدس. لذا فقد تم تقييم ستة طرز من العدس، التي زرعت بتصميم القطاعات كاملة العشوائية وبأربعة مكررات في مزرعة معهد بحوث علوم الزراعة والحيوان (IAAS)، باكليهاوا، روبان ديهي بنيبال، خلال الموسم الشتوي 19/2018، بهدف تقدير التباين الوراثي، ومعامل التوريث، والتقدم الوراثي للصفات الشكلية الزراعية. بينت النتائج ارتفاع معامل التباين المظهري (PCV) مقارنةً مع معامل التباين الوراثي (GCV) ولجميع الصفات. وقد أظهرت صفة عدد القرون للنبات قيم مرتفعة لكل من PCV وGCV، مما يعني إمكانية تحسين هذه الصفة بالانتخاب، كما حققت صفة عدد الأفرع الثانوية قيمة GCV مرتفعة (0.89) وPCV أيضاً (0.50)، ومن ناحية أخرى أعطت صفة عدد الأيام حتى نضج 50% من النباتات أقل قيمة من كل من PCV (0.02) وGCV (0.00). حققت الغلة الحبية قيمة مرتفعة لمعامل التوريث (0.62) والتي توافقت مع تقدم وراثي مرتفع أيضاً (192.63). كان الارتباط المظهري إيجابياً معنوياً ما بين الغلة الحبية وكل من عدد القرون للنبات (r=0.042) وارتفاع النبات (r=0.420). أما بالنسبة للصفات التي أظهرت تأثيراً إيجابياً مباشراً في الغلة الحبية فكانت بالترتيب؛ ارتفاع النبات، ثم عدد الحبوب في القرن، يليها عدد الأفرع الثانوية وعدد القرون للنبات، مما يوحي بأهمية هذه الصفات كأدلة انتخابية في تحسين الغلة الحبية.

الكلمات المفتاحية : العدس، الغلة الحبية، معامل التوريث، الارتباط، تحليل المسار.