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Genetic variability, correlation and path analysis in lentil germplasm (*Lens culinaris* Medik)

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Abstract
Lentil (*Lens culinaris* Medik) is a major grain legume crop in our country which is grown during *rabi* season. This experiment was carried out in CAU Research Farm, Andro to study the genetic variability, correlation and path coefficient of twenty lentil genotypes during *rabi* 2018-2019. These genotypes exhibited significant variability in respect of fifty percent flowering, days to maturity, plant height, pods per plant, number of branches, number of seeds per plant, biological yield per plant, seed yield per plant, harvest index, hundred seed weight and yield/ ha. Genetic variability studies showed presence of good amount of variation among the twenty genotypes. The highest PCV and GCV were recorded for the characters number of pods per plant, number of seeds per plant, biological yield per plant and seed yield per plant. GCV ranged from 4.14 (days to maturity) to 31.37 (number of pods per plant). High heritability coupled with moderate to high genetic gain and GCV observed for number of branches, number of seeds per plant, biological yield, seed yield per plant and 100 seed weight. The seed yield was significant and correlated positively with all the traits except days to fifty percent flowering and days to maturity. Path analysis showed that biological yield per plant, number of branches per plant and harvest index were the three important characters for yield improvement. Based on present investigation, correlation coefficient and path analysis may be utilized for the selection of genotypes for future lentil breeding programme.

Keywords: Lentil, genetic variability, heritability, correlation, path analysis

Introduction
Lentil (*Lens culinaris* Medik) is one of the most important *Rabi* pulse crop in India. In Manipur it is grown under acidic soils of valley area. It belongs to Leguminosae family. The lentils are an important source of essential amino acids, fatty acids and trace mineral (Zia-Ul-Haq *et al.*, 2011) [18]. For any yield improvement programme selection of superior parents are pre requisite. The knowledge of heritability and genetic advance guides the breeders to select superior parents to initiate an effective and fruitful crossing programme. The knowledge about genetic variability and heritability is helpful to the breeder to articulate selection criteria for improvement of yield associated parameter. The genotype possessing better heritability and genetic advance for various characters may serve as a best parent for any crop improvement programme (Khan *et al.*, 2005) [10]. High heritability coupled with moderate to high genetic advance for biological yield per plant, seed yield per plant and hundred seed weight were obtained by Tyagi and Khan, 2011[17]. Yield stability is a major objective in any breeding program. This could be achieved through a better understanding of the components contributing to final yield. However, these components vary from year to year and from location to location, even for the same lentil genotype (Muehlbauer *et al*. 1985) [13]. Current studies were conducted with two main objectives. One is to estimate the genetic variability, heritability and genetic advance in germplasm of lentil and the second one is to find the characters influencing the yield.

Materials and Methods
The experiment was conducted on 20 lentil genotypes (Table 1) at the Andro Research Farm, CAU, Imphal, Manipur during *rabi* 2018-19, following Randomized Block Design with three replications. Each plot was sown in 2 rows of 3 m length with a spacing of 22.5cm X 5cm between and within the rows. Standard package of practices was followed for raising and maintenance of the crops. Ten plants were selected at random from each entry in each replication for recording data.

The different characters considered included days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of pods per plant, number of seeds per plant, biological yield per plant (g), seed yield per plant (g), harvest index (%) and hundred seed weight (g). Genotypic coefficients of variation (GCV) and Phenotypic coefficients of variation (PCV) were calculated by the formulae given by Burton, 1952[2]. The percentage of heritability (H) was estimated by the formula suggested by Hanson *et al*., 1956[5]. The expected genetic advance (GA) as percentage of mean and phenotypic and genotypic correlation coefficients was computed according to the formula suggested by Johnson *et al*. (1995) [8]. The genotypic and phenotypic correlation and path coefficient analysis were computed according to Singh and Chaudhary (1985) [16].

Result and Discussion

Analysis of variance (ANOVA) was carried out for all the characters under study. The analysis of variance was revealed significant difference among all the genotypes, indicating the presence of genetic variability at 0.01 level (table 1). Estimated variance components, broad-sense heritability and genetic advance of investigated characters were shown in Table 2.

PCV and GCV

Maximum PCV (35.70) and GCV (31.37) was recorded for the traits number of pods per plant followed by number of seeds per plant (35.05) (30.94) and seed yield per plant (28.83) (22.60). In the present investigation phenotypic coefficient of variation was greater than genotypic coefficient of variation which indicated the influence of environment. These results were correlated with Jeberson *et al*. (2017) [7] and Kumar *et al.* (2014) [11] in mungbean.

Heritability and genetic advance

In the present study, characters like days to 50% percent flowering, days to maturity, plant height, number of branches, number of pods per plant, number of seeds per plant, biological yield per plant, seed yield per plant and hundred seed weight showed high heritability (table 2). Similar finding has been reported for days to flowering initiation, days to physiological maturity by Gupta *et al*. (2012) [4]. The high heritability coupled with high genetic advance was recorded for number of pods per plant, number of seeds per plant, biological yield per plant, seed yield per plant, number of branches and 100 seed weight. Similar result was revealed by Tyagi and Khan (2011) [17] and Jeberson *et al.* (2016) [6] on biological yield per plant, seed yield per plant and hundred seed weight. High heritability with moderate genetic advance was recorded for fifty percent flowering and plant height. This result was corroboration with Bicer *et al* (2008) [1]. Days to maturity exhibited high heritability coupled with low genetic advance as percent of mean. Similar trend was reported by of Dugassa *et al.* (2014) [3] and Paliya *et al.* (2015) [14].

Correlation and path coefficient analysis

Estimation of correlation coefficients between different pairs of characters under the investigation shown in table 4 and 5. In the present study showed that seed yield was significantly, positively correlated with all the characters except days to flowering and days to maturity. This result was corroborated with Jeberson *et al.* (2017) [7] and Khaimichho *et al.* (2014) [9]. The present investigation revealed that the genotypic correlation is greater than phenotypic correlation except the number of branches and number of pods per plant (table 4 and 5).

Efficiency of selection in any breeding programme mainly depends upon the knowledge of association of characters. Although correlation coefficient indicates the nature of association among the traits but path coefficient analysis splits the correlation values into direct and indirect effects so as to measure the relative importance of causal factors involved. In the present investigation, the path analysis showing the direct and indirect effects of the different traits were shown in the table 6. Biological yield per plant was shown highest direct effect (0.8449) on seed yield per plant followed by harvest index (0.5172). Alok Kumar *et al.* (2017) [12] found that biological yield showed highest direct effect followed by harvest index. Sharma *et al.* (2014) [15] observed that biological yield per plant (0.638), pods per plant (0.286) and harvest index (0.198) exerted positive direct effect on seed yield. Number of pods per plant, plant height and hundred seed weight were indirectly influencing the seed yield per plant through other character. Based on path analysis biological yield and harvest index were the most important characters for yield improvement.

Conclusion

In this study, characters like fifty percent flowering, days to maturity, plant height, number of branches per plant, number of seeds per plant, biological yield per plant, seed yield per plant and hundred seed weight showed high heritability indicating low environmental effects. Pod per plant and harvest index showed low heritability indicating high environmental effects on these characters. The high heritability coupled with high genetic advance was recorded for number of seeds per plant, biological yield per plant, seed yield per plant, number of branches per plant and 100 seed weight, indicating the substantial contribution of additive gene action. On these traits direct selection may improve yield. High heritability with moderate genetic advance was recorded for fifty percent flowering and plant height which specify equal influence of additive and non-additive gene action in the expression. Days to maturity exhibited high heritability coupled with low genetic advance as percent of mean which indicate influence of non-additive gene action in the expression. Seed yield per plant was significantly, positively correlated with all the characters except days to flowering and days to maturity. Based on path analysis biological yield per plant and harvest index were the most important characters for yield improvement. Indirect selection on plant height, pods per plant, number of seeds per plant and hundred seed weight had to be practiced for yield improvement.

Table 1: List of lentils (*Lens culinaris* Medik*)* genotypes and their source of origin

S. No	Genotypes	Source
1.	PL250	Pantnagar
2.	KLS 1445	CSAUA&T, Kanpur
3.	L4773	IARI, New Delhi
4.	LL1511	PAU, Ludhiana
5.	PL 4	Pantnagar
6.	RLG 234	RARI, Durgapur
7.	Tripura Lentil 2	Tripura
8.	PL259	Pantnagar
9.	L 4147	IARI, New Delhi
10.	VL 155	VPKAS, Almora
11.	LL 1534	PAU, Ludhiana
12.	IPL 236	IIPR, Kanpur
13.	PL 260	Pantnagar
14.	TCADL 17/7	TCA, Dholi
15.	VL 126	VPKAS, Almora
16.	L 4774	IARI, New Delhi
17.	RLG 254	RARI, Durgapur
18.	IPL 235	IIPR, Kanpur
19.	VL 154	VPKAS, Almora
20.	HULL 57	BHU, Varanasi

Table 2: Analysis of variance for different morphological and economical characters in lentil

S. No	Characters	Mean sum of squares		
		Replication	Genotypes	Error
1	Days to fifty percent flowering	26.61**	124.6**	3.87
2	Days to maturity	10.61	85.31**	11.75
3	Plant height	10.36**	9.26**	1.81
4	Number of branches	0.19	1.17**	0.12
5	Number of pods per plant	42.5	129.64**	11.61
6	Number of seeds per plant	148.35	501.92**	43.32
7	Biological yield per plant	0.019	0.191**	0.014
8	Seed yield per plant	0.01	0.055**	0.01
9	Harvest index	24.49	108.20**	22.56
10	Hundred seed weight	0.27	0.46**	0.1

Table 3: Estimate of mean, range, GCV, PCV, Heritability (broad sense) and Genetic advance as per the mean.

S. No	Character	Mean	Minimum	Maximum	GCV	PCV	Heritability (%)	Genetic Advance	GA (%)
1	50% F	71.12	61.00	80.00	8.92	9.34	91.20	12.48	17.55
2	100% MA	119.51	105.66	127.00	4.14	5.03	67.59	8.38	7.01
3	PH	23.86	21.17	27.92	6.60	8.69	57.74	2.46	10.31
4	NOB	3.09	2.06	4.53	19.14	22.28	73.83	1.04	33.64
5	PODS/P	19.99	9.07	37.33	31.37	35.70	77.21	11.35	62.78
6	N S/PLT	39.96	18.13	74.67	30.94	35.05	77.92	22.48	56.26
7	B Y/P	1.07	0.66	1.83	22.60	25.28	79.86	0.44	40.95
8	S Y/P	0.53	0.26	0.77	23.95	28.83	69.01	0.21	39.56
9	HI	49.29	39.37	64.87	10.84	14.51	55.86	8.22	16.68
10	100 SW	2.58	1.97	3.38	14.76	15.85	86.73	0.73	28.29

50% F- days to fifty percent flowering, 100%MA- days to maturity, PH- Plant Height, NOB- Number of branches, PODS/P- Pods per plant, N S/PLT- Number of seeds per plant, B Y/P- Biological yield per plant, S Y/P- Seed yield per plant, HI- Harvest index, 100SW- 100 seed weight GCV- Genotypic coefficient of variation and PCV- Phenotypic coefficient of variation.

Table 4: Phenotypic correlation coefficient among yield and yield contributing characters of twenty genotypes of lentil

	50% F	100% MA	PH	NOB	PODS/P	N S/PLT	B Y/P	HI	100 SW	S Y/P
50% F	1.00	0.71	0.51	0.27	0.34	0.43	0.25	0.08	0.14	0.22
100% MA		1.00	0.46	0.28	0.28	0.41	0.29	0.03	0.06	0.24
PH			1.00	0.04	0.41	0.49	0.53	0.01	0.27	0.41
NOB				1.00	0.39	0.55	0.28	0.41	0.29	0.48
PODS/P					1.00	0.99	0.54	0.23	0.18	0.55
N S/PLT						1.00	0.64	0.29	0.30	0.66
B Y/P							1.00	0.08	0.26	0.86
HI								1.00	0.43	0.58
100 SW									1.00	0.41
S Y/P										1.00

50% F- days to fifty percent flowering, 100%MA- days to maturity, PH- Plant Height, NOB- Number of branches, PODS/P- Pods per plant, N S/PLT- Number of seeds per plant, B Y/P- Biological yield per plant, S Y/P- Seed yield per plant, HI- Harvest index, 100SW- 100 seed weight

Table 5: Genotypic correlation coefficient among yield and yield contributing characters of twenty genotypes of lentil

	50% F	100% MA	PH	NOB	PODS/P	N S/PLT	B Y/P	HI	100 SW	S Y/P
50% F	1.00	0.91	0.64	0.26	0.31	0.46	0.29	0.04	0.17	0.21
100% MA		1.00	0.73	0.27	0.40	0.55	0.44	0.20	0.09	0.41
PH			1.00	-0.04	0.32	0.50	0.54	0.16	0.31	0.50
NOB				1.00	0.36	0.60	0.30	0.49	0.41	0.40
PODS/P					1.00	0.99	0.47	0.09	0.17	0.40
N S/PLT						1.00	0.68	0.33	0.32	0.70
B Y/P							1.00	0.09	0.27	0.95
HI								1.00	0.72	0.53
100 SW									1.00	0.53
S Y/P										1.00

50% F- days to fifty percent flowering, 100%MA- days to maturity, PH- Plant Height, NOB- Number of branches, PODS/P- Pods per plant, N S/PLT- Number of seeds per plant, B Y/P- Biological yield per plant, S Y/P- Seed yield per plant, HI- Harvest index, 100SW- 100 seed weight

Table 6: Direct (diagonal) and indirect effects of yield component traits on seed yield in lentil genotypes

	50% F	100% MA	PH	NOB	PODS/P	N S/PLT	B Y/P	HI	100 SW	r of S Y/P
50% F	-0.0286	-0.0063	-0.0019	0.0180	-0.0021	-0.0109	0.2115	0.0416	-0.0051	0.219
100% MA	-0.0204	-0.0089	-0.0017	0.0188	-0.0018	-0.0105	0.2492	0.0159	-0.0022	0.346
PH	-0.0146	-0.0041	-0.0037	0.0029	-0.0026	-0.0125	0.4466	0.0073	-0.0100	0.464
NOB	-0.0076	-0.0025	-0.0002	0.0676	-0.0024	-0.0140	0.2329	0.2132	-0.0109	0.488
PODS/P	-0.0097	-0.0025	-0.0015	0.0267	-0.0062	-0.0253	0.4563	0.1176	-0.0065	0.703
N S/PLT	-0.0122	-0.0036	-0.0018	0.0370	-0.0061	-0.0256	0.5376	0.1502	-0.0112	0.685
B Y/P	-0.0072	-0.0026	-0.0019	0.0186	-0.0034	-0.0163	0.8449	0.0410	-0.0095	0.867
HI	-0.0023	-0.0003	-0.0001	0.0279	-0.0014	-0.0074	0.0670	0.5172	-0.0162	0.561
100 SW	-0.0039	-0.0005	-0.0010	0.0197	-0.0011	-0.0077	0.2155	0.2243	-0.0374	0.475

50% F- days to fifty percent flowering, 100%MA- days to maturity, PH- Plant Height, NOB- Number of branches, PODS/P- Pods per plant, N S/PLT- Number of seeds per plant, B Y/P- Biological yield per plant, S Y/P- Seed yield per plant, HI- Harvest index, 100SW- 100 seed weight

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