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Genetic variability, correlation and path coefficient analysis of yield contributing characters in lentil

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Abstract
The present investigation was undertaken at PG farm, RCSM College of Agriculture, Kolhapur with the objective, to estimate the genetic variability, correlation and path analysis for nine characters of thirty genotypes of lentil (including three checks) with three replications. Analysis of variance showed significant differences among genotypes for all the characters. Phenotypic coefficient of variation was greater than genotypic coefficient of variation for all the characters showing higher influence of environment on characters. High heritability coupled with high genetic advance as per cent of mean indicated preponderance of additive gene action in the inheritance of characters like seed yield per plant (g), 100 seed weight (g), number of secondary branches per plant and number of pods per plant. The seed yield per plant showed highly significant and positive correlation with number of primary branches per plant (0.8647), followed by number of seeds per pod (0.8473), number of pods per plant (0.6664) and plant height (0.4127). Path coefficient analysis revealed that among the different yield contributing characters number of primary branches per plant (0.9397), plant hight (0.4048) and number of seeds per pod (0.2732) influenced seed yield per plant directly. Thus, selection for yield in lentil through theses characters would be effective.

Keywords: heritability, path coefficient, correlation, lentil

Introduction
Lentil is one of the valuable and oldest pulse crop grown in world. History of lentil is as old that of agriculture, small seeded (2-3 mm) types of lentil was recovered 8000-7500 B.C. in the Marybeth, Northern Syria. Lentil is originated in Near East centre of origin (Zohary, 1996) [17] and subsequently spread to Central Asia and Mediterranean Basin (Cubero, 1981) [6] from where it spreads to Egypt, India, Southern and Central Europe, Pakistan, Afghanistan and Ethiopia (Bahl *et al*. 1993) [2]. Among twelve known species of the lentil, *Lens culinaris* is the only cultivated species. *Lens culinaris* L. is diploid (2n=2x=14). It belongs to family Fabaceae and tribe *Vicieae*. Lentil is self-pollinated crop and have less than 1.66 per cent cross pollination (Baum *et al*. 1997) [3]. The plant is annual, herbaceous, erect, semi erect or spreading and compact growth. Lentils are suitable for cultivation in warm temperature, and cultivated in subtropical and high-altitude tropical regions of the world (Muehlbauer *et al*. 1995) [11]. Lentil is cultivated as winter crop in *rabi* season in the subtropical areas and summer crop in temperate regions. In tropics it can be cultivated at higher altitudes (>1800 m) during cool season (Bejiga, 2006) [4]. Lentils can grow well with annual rainfall of 750 mm with dry period before harvest. World's total lentil production in 2018 was 6.3 million tons, led by Canada (33%) and India (25%) of the world total. India is the second largest producer of lentil produces 1.6 million tons lentil per year followed by USA, Turkey and Australia. (Anonymous, 2018) [1]. Lentil landraces typically exhibit limited yield potential with considerable vulnerability towards different stresses, which adversely affects average lentil yield. Different biotic and abiotic along with other local factors hamper the yield of lentil globally especially in resource-poor areas (Muehlbauer *et al*. 2006) [12]. As far as crop improvement programme is concerned, germplasm plays the vital role. Modern agriculture relies on selection of desirable parents. These desirable parents are used for hybridization programme. Variability is the factor for progress in any crop improvement programme. Genetic variability is divided into heritable and non-heritable variation with the aid of parameters like variance, heritability, coefficient of variation and genetic advance. Selection of parent is not only based on desirable agronomic traits, yield component but also on heritability of yield contributing traits.

Correlation is the mutual relationship between the variables, it aids in determining the most effective procedures for selection of superior genotypes. The estimates of correlation coefficient alone may be often misleading due to mutual cancellation of component characters. So, the correlation coupled with a path analysis is more effective tool in the study of yield contributing characters. Path coefficient analysis is an important technique for partitioning the correlation coefficient into direct and indirect effect of the causal components on the complex component (Kumari, 2016) [9].

Material and Methods

The experimental material for the present investigation consisted of 30 genotypes with 3 checks of lentil. The experimental material was collected from Gadhinglaj, Ajara and Chandgad tahsils of Kolhapur district. The characters studied were days to maturity, days to 50 per cent flowering, plant height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, 100 seed weight and seed yield per plant. The experiment was laid out in randomized block design.

Results and Discussion

Genetic variability

The estimates of genotypic coefficient of variation were lower than phenotypic coefficient of variation for all the characters under study. Highest phenotypic coefficient of variation was exhibited by seed yield per plant (35.93), followed by number of secondary branches per plant (26.70), number of pods per plant (23.62), 100 seed weight (21.92), number of primary branches per plant (10.80), plant height (6.91), number of seeds per pod (6.78) and days to 50 per cent flowering (6.75). The inherent genetic variability is expressed by the genotypic coefficient of variation. Highest genotypic coefficient of variation was exhibited by seed yield per plant (35.25) followed by number of secondary branches per plant (26.18), number of pods per plant (22.74), 100 seed weight (21.35), number of primary branches per plant (9.71), number of seeds per pod (5.64), days to 50 per cent flowering (5.51) and plant height (5.02).

Heritability (b. s)

Highest estimate of heritability was recorded for seed yield per plant (96.30%) followed by secondary branches per plant (96.20%), 100 seed weight (94.90%), number of pods per plant (92.70%), number of primary branches per plant (80.90%), days to maturity (72.60%), number of seeds per pod (69.10%) and days to 50 per cent flowering (66.70%). Moderate heritability was observed for plant height (52.80%). Similar results were reported by Crippa *et al.* (2009) [5] for number of primary and secondary branches per plant, days to 50 per cent flowering, days to maturity and number of pods per plant. The results reported by Ghimire *et al.* (2020) [8] were in accordance with the results of present investigation where, highest values of heritability for number of pods per plant, 100 seed weight, seed yield per plant and days to 50 per cent flowering were recorded.

Genetic advancement as per cent of mean

Highest estimates of genetic advance as per cent of mean were observed for seed yield per plant (71.26) followed by number of secondary branches per plant (52.89), number of pods per plant (45.09) and 100 seed weight (42.86). The lower estimates of genetic advance were observed for number of primary branches per plant (18), number of seeds per pod (9.65), days to 50 per cent flowering (9.27), plant height (7.51) and days to maturity (7.15). These results match with results were reported by Singh *et al.* (2012) [14] for high genetic advance as per cent of mean was observed for seed yield per plant indicated that selection may be effective for this character.

Table 1: Estimates of different parameters of genetic variability for 9 characters in 30 genotypes of lentil

Sr. No.	Characters	Mean	Range	GCV	PCV	h^2	GA	GAPM
1.	Days to 50% flowering	37.56	32.33-43.33	5.51	6.75	66.70	3.48	9.27
2.	Days to maturity	84.48	78.33-94.67	4.08	4.81	72.20	6.04	7.15
3.	Plant height (cm)	30.49	25.63-33.86	5.02	6.91	52.80	2.29	7.51
4.	No. of primary branches per plant	4.37	3.52-5.32	9.71	10.80	80.90	0.78	18.00
5.	No. of secondary branches per plant	13.51	8.33-20.07	26.18	26.70	96.20	7.15	52.89
6.	No. pods per plant	34.22	15.96-50.37	22.74	23.62	92.70	15.43	45.09
7.	No. of seeds per pod	1.48	1.31-1.71	5.64	6.78	69.10	0.14	9.65
8.	100 seed weight (g)	3.04	2.28-4.45	21.35	21.92	94.90	1.30	42.86
9.	Seed yield per plant (g)	1.89	1.09-3.21	35.25	35.93	96.30	1.35	71.26

GCV- Genotypic coefficient of variation, PCV- Phenotypic coefficient of variation, h^2 – Heritability
GA- Genetic advance, GAPM- Genetic advance as per cent of mean

Correlations

Seed yield showed highly significant and positive association with number of primary branches per plant (0.8647), number of seeds per pod (0.8473), number of pods per plant (0.6664), plant height (0.4127), 100 seed weight (0.2946) and number of secondary branches per plant (0.2673). The character days to 50 per cent flowering (0.0704) was positively associated but non-significant at the genotypic level. The character days to maturity (-0.1476) was negatively associated and non-significant at the genotypic level. There was negative association between days to maturity (-0.1476) with seed yield per plant which was desirable though it was not significant. Similar results were reported by Tyagi and Khan (2010) [16] that seed yield per plant showed negative and non-significant correlation with number of days to maturity. The results obtained in present investigation were matching with the results of Mahmood *et al.* (2019) [10] who reported that highly significant and positive correlation for seed yield per plant was observed with primary branches per plant, number of pods per plant, plant height and number of secondary branches per plant.

Path coefficient Analysis

Path analysis splits the correlation coefficient into direct and indirect effects. In present investigation, path analysis was done as per the procedure given by Dewey and Lu (1959) to know the direct and indirect effects of various characters. In present study, the characters which had highest positive direct effect on seed yield are due to number of primary branches per plant (0.9397), plant height (0.4048), number of seeds per pod (0.2732), days to 50 per cent flowering (0.1556), number of secondary branches per plant (0.1299) and days to maturity (0.0578). Thus, direct selection for these traits will be beneficial in yield improvement programme. While, the characters like 100 seed weight (-0.5398) and number of pods per plant (-0.2858) exhibited negative direct effect on seed yield per plant. Rasheed *et al.* (2008) [13] observed that the pods per plant and 100 seed weight had the direct negative effect on seed yield. Singh *et al.* (2009) [15] revealed that days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, seeds per pod had the positive direct effect on seed yield while, number of pods per plant had negative direct effect on seed yield.

Table 2: Genotypic correlation of 9 characters of 30 genotypes of lentil

Character	1	2	3	4	5	6	7	8	9
1	1.000	0.5074**	0.1748	0.0489	0.3106**	-0.1339	-0.2532*	0.4458**	0.0704
2		1.000	-0.5024**	-0.0200	0.1197	-0.2287*	-0.0983	0.2153*	-0.1476
3			1.000	0.3718**	-0.1949	0.2591*	0.5546**	0.7257**	0.4127**
4				1.000	0.2138*	0.7153**	0.7165**	0.4650**	0.8647**
5					1.000	0.3844**	0.1297	-0.0642	0.2673*
6						1.000	0.7037**	0.0611	0.6664**
7							1.000	0.17447	0.8473**
8								1.000	0.2946**

*,** significant at 5% and 1% respectively.

1- Days to 50 per cent flowering, 2- Days to maturity, 3- Plant height (cm), 4- No. of primary branches per plant, 5- No. of secondary branches per plant, 6- No. of pods per plant, 7- No. of seeds per pod, 8- 100 seed weight (g), 9- Seed yield per plant (g).

Table 3: Direct (diagonal) and indirect (above and below diagonal) path effects of different characters towards seed yield at genotypic level in lentil

Character	1	2	3	4	5	6	7	8
1	0.1556	0.0789	0.0272	0.0076	0.0483	-0.0208	-0.0394	0.0694
2	0.0293	0.0578	-0.0290	-0.0012	0.0069	-0.0132	-0.0057	0.0124
3	0.0708	-0.2034	0.4048	0.1505	-0.0789	0.1049	0.2245	0.2938
4	0.0459	-0.0188	0.3494	0.9397	0.2009	0.6722	0.6733	0.4369
5	0.0404	0.0155	-0.0253	0.0278	0.1299	0.0499	0.0168	-0.0083
6	0.0383	0.0654	-0.0741	-0.2045	-0.1099	-0.2858	-0.2011	-0.0175
7	-0.0692	-0.0269	0.1515	0.1957	0.0354	0.1923	0.2732	0.0477
8	-0.2406	-0.1162	-0.3917	-0.2510	0.0346	-0.0330	-0.0943	-0.5398
9	0.0704	-0.1476	0.4127	0.8647	0.2673	0.6664	0.8473	0.2946

R^2= 0.8987, residual effect= 0.3182

1- Days to 50 per cent flowering, 2- Days to maturity, 3- Plant height (cm), 4- No. of primary branches per plant, 5- No. of secondary branches per plant, 6- No. of pods per plant, 7- No. of seeds per pod, 8- 100 seed weight (g), 9- Seed yield per plant (g).

Conclusion

The magnitude of highest phenotypic coefficient of variation was exhibited by seed yield per plant (35.93), followed by number of secondary branches per plant (26.70), number of pods per plant (23.62) and 100 seed weight (21.92). Highest values of genotypic coefficient of variation were observed for seed yield per plant (35.25) followed by number of secondary branches per plant (26.18), number of pods per plant (22.74) and 100 seed weight (21.35). The high heritability coupled with high genetic advance was observed for seed yield per plant (g), 100 seed weight (g), number of secondary branches per plant and number of pods per plant. The seed yield per plant showed significant and positive association with number of primary branches (0.8647), number of seeds per pod (0.8473), number of pods per plant (0.6664), plant height (0.4127), 100 seed weight (0.2946) and number of secondary branches per plant (0.2673). The characters number of primary branches per plant (0.9397), plant height (0.4048), number of seeds per pod (0.2732), days to 50 per cent flowering (0.1556), number of secondary branches per plant (0.1299) and days to maturity (0.0578) had the positive direct effect on seed yield per plant.

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