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Research Note

Correlation and path analysis studies in lentil (*Lens culinaris* Medic.)

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Abstract
An experiment was conducted with thirty five genotypes in *rabi* season of 2016-17 at research and education farm, Department of Agriculture Botany, College of Agriculture, Dapoli. Observations were recorded on eleven characters *viz.*, days to initiation of flowering, day to 50 per cent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of pods per plant, number of seeds per pod, 100 seed weight, straw yield per plant, harvest index and grain yield per plant. The correlation study revealed that the characters *viz.*, plant height, number of primary branches per plant, number of pods per plant, straw yield per plant and harvest index showed highly significant positive correlation with grain yield per plant (g) at phenotypic and genotypic level. The path coefficient analysis revealed that the characters *viz.*, days to maturity, plant height (cm), number of pods per plant, number of seeds per pod, 100 seed weight (g), straw yield per plant (g) and harvest index (%) exhibited positive direct effect on grain yield per plant (g). On the basis of path analysis and correlation study for grain yield, it could be concluded that selection on the basis of days to initiation of flowering, number of primary branches per plant, pods per plant and 100 seed weight could help in genetic improvement of grain yield per plant in lentil.

Key words
Lentil, grain yield, straw yield, correlation, path analysis

Lentil (*Lens culinaris* Medic.) (2n=14), is one of the important and most nutritious *rabi* pulse crop. It has the potential to cover the risk of rainfed farming. It is also used as a cover crop to check the soil erosion in problem areas. The plants are ploughed back into the soil as green manure also. It derives the name Lens from the lens shaped seeds. It is mostly eaten as 'Dal'. The 'Dal' is made by splitting the grain in two cotyledons, which are deep orange red or orange yellow in colour. The whole grain is also used in some of the dishes. It is rich in calcium (56 mg/100 gm seeds), iron (7.54 mg/100 gm seeds), and niacin (2.65 mg/100 gm seeds). It has the lowest content of lectins and trypsin inhibitors among legumes. Since it is a leguminous crop, it improves the fertility of soil by biological nitrogen fixation. Lentil seeds also provide a source of starch for textiles and printing. Lentil residue is one of the important livestock feed. Lentil flour is used for thickening of soups.

India is one of the major lentil growing countries of the world after Canada. In India, lentil occupied 1.59 million hectares area with 0.95 million tonnes production and productivity of 633 kilogram per hectare (FAO Stat., 2016). Study of 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.

The present investigation was carried out at Research and Education Farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during the period October, 2016 to March, 2017. The material for the present study comprised of thirty five genotypes of lentil collected from Indian Institute of Pulses Research, Kanpur. The experiment was conducted in Randomized Block Design with three replications. The plot size was four rows of 2 m length. The seeds of lentil were dibbled at 30 cm distance between row to row and 20 cm between plant to plant. The fertilizer dose was applied @ 25 kg N: 50 kg P_2O_5: 50 kg K_2O per hectare. The operation, like thinning was done within 10 days after sowing so as to maintain one plant per hill. Other cultural practices were carried out as per the standard recommendations. The simple correlation coefficients and path analysis between yield and yield components were estimated as per the standard procedure.

The correlation co-efficient and path analysis for grain yield per plant and its contributing characters for 35 genotypes at phenotypic and genotypic level are presented in Table 1, 2 and 3. At genotypic level, grain yield showed highly significant correlation in positive direction with pods per

plant, harvest index, plant height, straw yield per plant, number of primary branches per plant. Similar kind of results was reported by Aich *et al.* (2007) and Mekonnen (2014) in lentil. Days to initiation of flowering exhibited highly significant positive correlation with days to 50 per cent flowering and days to maturity while, significant but negative correlation with straw yield per plant at phenotypic as well as genotypic level. Days to 50 per cent flowering exhibited highly significant positive correlation with days to maturity at genotypic as well as phenotypic levels. However, significantly negative correlation was observed with plant height and straw yield per plant at genotypic level only. Similar results were also observed by Dugassa *et al.* (2014) in lentil.

At phenotypic and genotypic levels, days to maturity exhibited highly significant positive correlation with number of seeds per pod and highly significant but negative correlation with number of pods per plant and straw yield per plant. Similar result was also reported by Younis *et al*. (2008) and Latif *et al.* (2010) in lentil. The character *viz.,* plant height exhibited highly significant positive correlation with number of primary branches per plant, number of pods per plant, harvest index and grain yield per plant at both genotypic and phenotypic levels. It had non-significant positive correlation with seeds per pod, hundred seed weight. Highly significant positive correlation was found with straw yield per plant at genotypic level only. Similar result was also reported by Latif *et al.* (2010) and Parisa A. *et al.* (2012) in lentil.

Number of primary branches per plant had significant positive correlation with pods per plant and grain yield per plant at genotypic and phenotypic levels, while significant positive association with harvest index and highly significant positive association with straw yield per plant at genotypic level only. Tyagi and Khan (2011) and Pandey *et al.* (2017) observed similar results in lentil. Number of pods per plant recorded highly significant positive correlation with straw yield per plant, harvest index and grain yield per plant at phenotypic as well as genotypic levels. Significant but negative correlation was recorded with number of seeds per pod. Similar result was given by Singh *et al.* (2009) in lentil.

Number of seeds per pod exhibited highly negative non-significant correlation with hundred seed weight at phenotypic level and showed negative non-significant correlation with straw yield per plant, harvest index, grain yield per plant. While, at genotypic level number of seeds per pod exhibited highly significant but negative correlation with hundred seed weight and negative significant correlation with straw yield per plant, harvest index, grain yield per plant.

Hundred seed weight exhibited at phenotypic level positive non-significant correlation with straw yield per plant, harvest index and grain yield per plant. Tadesse *et al.* (2013) also observed similar trend in lentil. Hundred seed weight exhibited positive significant correlation with straw yield per plant and positive non-significant correlation with harvest index and grain yield per plant at genotypic level. Straw yield per plant exhibited positive highly significant correlation with grain yield and negative non-significant correlation with harvest index at phenotypic as well as genotypic level. Singh e*t al*. (2009), Tyagi and Khan (2011) and Luthra S.K. (1990) showed similar results in lentil. Harvest index exhibited highly significant positive correlation with grain yield per plant at genotypic as well as phenotypic levels. NadiaYounis *et al.* (2008), Singh e*t al*. (2009), Sarwar *et al.* (2010) and Pandey *et al.* (2017) also observed similar trend in lentil.

Correlation does not provide exact picture of the direct and indirect causes of such association which can be understood through path analysis. Days to maturity, plant height, number of pods per plant, number of seeds per pod, straw yield per plant and harvest index had positive direct effect on seed yield per plant at both phenotypic and genotypic levels. While, days to 50 per cent flowering and 100 seed weight had negative direct effect on grain yield per plant at genotypic level. Higher positive direct effect exhibited by harvest index and straw yield per plant indicated that these were important components influencing yield. Similar kind of results were recorded by Younis *et al.* (2008), Singh e*t al*. (2009) Mekonnen (2014) and Pandey *et al.* (2015) in lentil.

Number of pods per plant had positive direct effect at phenotypic level and genotypic level on yield per plant. Chakraborty and Haque (2000) and Tadesse *et al.* (2013), reported similar results in lentil. It showed indirect positive effects on seeds yield per plant *via* plant height, number of primary branches per plant, straw yield per plant, harvest index at both phenotypic and genotypic levels. This is in accordance with the findings of Singh *et al.* (2009), Pandey *et al.* (2015) and Pandey *et al.* (2017) in lentil.

The phenotypic correlation coefficients were partitioned into direct and indirect effects and presented in Table 2. The character days to initiation of flowering showed negative direct effect (-0.0182) on seed yield per plant. It had

positive indirect effect via days to 50 per cent flowering, days to maturity, primary branches, seeds per pod, hundred seeds weight, harvest index. It had negative indirect effect via plant height, pods per plant, straw yield per plant. This character had positive non-significant correlation (0.0004) with seed yield per plant. The character days to 50 per cent flowering had positive direct effect (0.0432) on seed yield per plant. It had indirect positive contribution towards seed yield per plant came through character days to days to maturity, seeds per pod, harvest index. It had negative indirect effect via days to initiation, plant height, primary branches, pods per plant, hundred seeds weight, straw yield per plant. This character had positive non-significant correlation (0.0023) with seed yield per plant.

The character days to maturity had positive direct effect (0.0072) on seed yield per plant. Its indirect effects via days to 50 per cent flowering, plant height, seeds per pod, harvest index. It had negative indirect effect via days to initiation, primary branches, pods per plant, hundred seeds weight, straw yield per plant. This character had negative non-significant correlation (-0.1065) with seed yield per plant. The character plant height had positive direct effect (0.0253) on seed yield per plant. Its indirect positive effects via days to initiation of flowering, days to maturity, primary branches, pods per plant, seeds per pod, hundred seeds weight, straw yield per plant. It had negative indirect effect via days to 50 per cent flowering. This character had positive non-significant correlation (0.4026) with seed yield per plant.

The character number of primary branches per plant showed negative direct effect (-0.0040) on seed yield per plant. Its indirect positive effects via days to 50 per cent flowering, days to maturity, plant height, seeds per pod, harvest index while, it showed negative indirect effects via days to initiation of flowering, pods per plant, straw yield per plant. This character had positive non-significant correlation (0.3189) with seed yield per plant.The character number of pods per plant showed high positive direct effect (0.02408) on seed yield per plant. Its indirect positive effects via days to initiation of flowering, plant height, number of primary branches per plant, hundred seed weight, straw yield per plant, harvest index. It had negative indirect effect via days to 50 per cent flowering, days to maturity, no. of seeds per pod. This character had positive significant correlation (0.8686) with seed yield per plant.

The genotypic correlation coefficients were partitioned into direct and indirect effects and presented in Table 3. The character days to initiation of flowering had positive direct effect (0.0794) on seed yield per plant. It had positive indirect effects via days to maturity, primary branches, no of seed per pod, hundred seed weight, harvest index. It had Negative indirect effect via 50 per cent flowering, plant height, pods per plant, straw yield per plant. This character had negative non-significant correlation (-0.0236) with seed yield per plant. Days to 50 per cent flowering had negative direct effect (-0.0755) on seed yield per plant. It had positive indirect effect via plant height, days to initiation of flowering, days to maturity, seeds per pod, hundred seed weight and harvest index. It had negative indirect effect via plant height, primary branches, pods per plant, straw yield per plant. This character had negative non-significant correlation (-0.0686) with seed yield per plant. Days to maturity had positive direct effect (0.0401) on seed yield per plant. It had positive indirect effect via days to initiation of flowering, number of seed per pod, hundred seed weight. Negative indirect effect via days to 50 per cent flowering, plant height, number of primary branches, number of pods per plant, straw yield per plant and harvest index. This character had negative non-significant correlation (-0.1538) with seed yield per plant.

The character plant height had positive direct effect (0.0284) on seed yield per plant. Its positive indirect effect via days to 50 per cent flowering, number of primary branches, pods per plant, seeds per pod, straw yield per plant and harvest index. It had Negative indirect effect via days to initiation of flowering, days to maturity, hundred seed weight. This character had positive non-significant correlation (0.6305) with seed yield per plant. The character number of primary branches per plant had positive direct effect (0.1745) on seed yield per plant. It had positive indirect effect via days to initiation of flowering, days to 50 per cent flowering, plant height, pods per plant, seeds per pod, straw yield per plant and harvest index. It had negative indirect effect via days to maturity, hundred seed weight. This character had positive significant correlation (0.5406) with seed yield per plant.

The character number of pods per plant showed high positive direct effect (0.2036) on seed yield per plant. Its indirect positive effects via days to 50 per cent flowering, plant height, primary branches per plant, straw yield per plant and harvest index. It had negative indirect effect via days to initiation of flowering, days to maturity, no. of seeds per pod, 100 seed weight. This character had positive significant correlation (0.8925) with seed yield per plant. The character number of seeds per pod had positive direct effect (0.0093) on seed yield per

plant. Its indirect positive contribution towards initiation of flowering, days to maturity, plant height, primary branches per plant, hundred seed weight. It had negative indirect effect via days to 50 per cent flowering, number of pod per plant, straw yield per plant and harvest index. This character had negative non-significant correlation (-0.2210) with seed yield per plant.

The character hundred seed weight exhibited negative direct effect (-0.0053) on seed yield per plant. It had indirect positive effect via plant height, primary branches per plant, number of pods per plant, straw yield per plant and harvest index. It had negative indirect effect via days to initiation of flowering, days to 50 per cent flowering, days to maturity, seeds per pod. This character had positive non-significant correlation (0.1632) with seed yield per plant. The character straw yield per plant exhibited positive direct effect (0.2942) on seed yield per plant. On the basis of path analysis and correlation study for grain yield, it could be concluded that selection on the basis of days to initiation of flowering, number of primary branches per plant, number of pods per plant and hundred seeds weight could help in genetic improvement of grain yield per plant in lentil.

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Table 1. Estimates of correlation coefficient between different characters in lentil.

Characters		Days to initiation of flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches per plant	Pods per plant	Seeds per pod	Hundred seed weight (g)	Straw yield per plant (g)	Harvest index (%)	Grain yield per plant (g)
Days to initiation of flowering	P	1.0000	0.7005**	0.5808**	-0.0435	0.0307	-0.0369	0.0814	0.0051	-0.2328*	0.0938	0.0004
	G	1.0000	1.0647**	0.8014**	-0.1539	0.0196	-0.1091	0.0966	-0.0368	-0.3161**	0.0880	-0.0236
Days to 50% flowering	P		1.0000	0.4926**	-0.1019	-0.0342	-0.0808	0.0404	-0.0162	-0.1355	0.0544	0.0023
	G		1.0000	0.8156**	-0.201*	-0.0692	-0.1546	0.0794	0.0033	-0.2242*	0.0060	-0.0686
Days to maturity	P			1.0000	0.0090	-0.0363	-0.1999*	0.309**	-0.1707	-0.3337**	0.0329	-0.1065
	G			1.0000	-0.1670	-0.1168	-0.269**	0.383**	-0.2226*	-0.3926**	-0.0076	-0.1568
Plant height (cm)	P				1.0000	0.3680**	0.3443**	0.0248	0.0373	0.1004	0.330**	0.4026**
	G				1.0000	0.79270**	0.5070**	0.0277	0.0153	0.2673**	0.416**	0.6305**
Primary branches/ plant	P					1.0000	0.2298*	0.0162	0.0023	0.0750	0.1812	0.3189**
	G					1.0000	0.4466**	0.0203	0.0347	0.3864**	0.1997*	0.540**
Pods per plant	P						1.0000	-0.247*	0.0699	0.4256**	0.692**	0.8686**
	G						1.0000	-0.276**	0.0691	0.4340**	0.799**	0.8925**
Seeds per pod	P							1.0000	-0.6782**	-0.1913	-0.1786	-0.1896
	G							1.0000	-0.699**	-0.2166*	-0.1976*	-0.2210*
Hundred seed weight (g)	P								1.0000	0.1737	0.1356	0.1371
	G								1.0000	0.2157*	0.1504	0.1632
Straw yield per plant (g)	P									1.0000	-0.614	0.3893**
	G									1.0000	-0.1019	0.3606**
Harvest index (%)	P										1.0000	0.8425**
	G										1.0000	0.8481**

P : Phenotypic level and G : Genotypic level
*Significant at 5%, ** Significant at 1%

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Table 2 . Path analysis for different characters at phenotypic level in lentil.

Characters	Days to initiation of flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches per plant	Pods per plant	Seeds per pod	Hundred seed weight (g)	Straw yield per plant (g)	Harvest index (%)	Grain yield per plant (g)
Days to initiation of flowering	**-0.0182**	0.0303	0.0042	-0.0011	0.0033	-0.0089	0.0045	0.0000	-0.0770	0.0632	0.0004
Days to 50% flowering	-0.0128	**0.0432**	0.0036	-0.0026	-0.0037	-0.0194	0.0022	-0.0002	-0.0448	0.0367	0.0023
Days to maturity	-0.0106	0.0213	**0.0072**	0.0002	-0.0040	-0.0481	0.0172	-0.0017	-0.1103	0.0222	-0.1065
Plant height (cm)	0.0008	-0.0044	0.0001	**0.0253**	0.0400	0.0829	0.0014	0.0004	0.0332	0.2230	0.4026**
Primary branches/ plant	-0.0106	0.0213	0.0072	0.0002	**-0.0040**	-0.0481	0.0172	-0.0017	-0.1103	0.0222	0.3189**
Pods per plant	0.0007	-0.0035	-0.0014	0.0087	0.0250	**0.02408**	-0.0137	0.0007	0.1407	0.4708	0.8686**
Seeds per pod	-0.0015	0.0017	0.0022	0.0006	0.0018	-00596	**0.0554**	-0.0067	-0.0632	-0.1204	-0.1896
Hundred seed weight (g)	-0.0001	-0.0007	-0.0012	0.0009	0.0002	0.0168	-0.0376	**0.0099**	0.0574	0.0915	0.1371
Straw yield per plant (g)	0.0042	-0.0059	-0.0024	0.0025	0.0082	0.1025	-0.0106	0.0017	**0.3305**	-0.0414	0.3893**
Harvest index (%)	-0.0017	0.0024	0.0002	0.0084	0.0197	0.01681	-0.0099	0.0013	-0.0203	**0.6743**	0.8425**

Residual effect = 0.243 ***Significant at 5%,** ****Significant at 1%,** **Bold figures indicate direct effect**

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Table 3. Path analysis for different characters at genotypic levels in lentil

Characters	Days to initiation of flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches per plant	Pods per plant	Seeds per pod	Hundred seed weight (g)	Straw yield per plant (g)	Harvest index (%)	Grain yield per plant (g)
Days to initiation of flowering	**0.0794**	-0.0804	0.0321	-0.0044	0.0034	-0.0222	0.0009	0.0002	-0.0930	0.0603	-0.0236
Days to 50% flowering	0.0845	**-0.0755**	0.0327	-0.0057	-0.0121	-0.0315	0.0007	0.0000	-0.0660	0.0041	-0.0686
Days to maturity	0.0636	-0.0616	**0.0401**	-0.0047	-0.0204	-0.0549	0.0036	0.0012	-0.1155	-0.0052	-0.1538
Plant height (cm)	-0.0122	0.0152	-0.0067	**0.0284**	0.1383	0.1032	0.0003	-0.0001	0.0787	0.2855	0.6305**
Primary branches per plant	0.0016	0.0052	-0.0047	0.0225	**0.1745**	0.0909	0.0002	-0.0002	0.1137	0.1369	0.5406**
Pods per plant	-0.0087	0.0117	-0.0108	0.0144	0.0779	**0.2036**	-0.0026	-0.0004	0.1277	0.4797	0.8925**
Seeds per pod	0.0077	-0.0060	0.0154	0.0008	0.0035	-0.0563	**0.0093**	0.0037	-0.0637	-0.1354	-0.2210
Hundred seed weight (g)	-0.0029	-0.0003	-0.0089	0.0004	0.0060	0.0141	-0.0065	**-0.0053**	0.0635	0.1031	0.1632
Straw yield per plant (g)	-0.0251	0.0169	-0.0157	0.0076	0.0674	0.0883	-0.0020	-0.0011	**0.2942**	-0.0699	0.3606**
Harvest index (%)	0.0070	-0.0005	-0.0003	0.0118	0.0348	0.1425	-0.0018	-0.0008	-0.0300	**0.6854**	0.8481**

Residual effect = 0.243, *Significant at 5%, **Significant at 1%, (Bold figures indicate direct effect)