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Correlation of different characters and Path analysis in opium poppy (*Papaver somniferum* L.)

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Abstract
The present research was carried out using 25 genotypes were planted in randomized block design with three replications during *Rabi*- 2016-2017 at Research Farm, Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture & Technology, Udaipur. Association study indicated that seed yield per plant was positively and significantly correlated at genotypic level with husk yield per plant, latex yield per plant, number of effective capsule per plant, diameter of main capsule, days to 50 per cent flowering and plant height, whereas husk yield per plant and latex yield per plant showed positive significant correlation with seed yield per plant only at phenotypic level and latex yield per plant was also positively and significantly correlated at genotypic level with diameter of main capsule, days to 50 per cent flowering, husk yield per plant, seed yield per plant and number of effective capsule per plant. These associations indicated that improvement in seed yield and latex can be achieved by improving the above characters. Path coefficient analysis revealed that husk yield per plant, latex yield per plant, number of effective capsule per plant, diameter of main capsule, days to 50 per cent flowering, plant height and diameter of main capsule, days to 50 per cent flowering, husk yield per plant, seed yield per plant, number of effective capsule per plant were the major components for seed yield per plant and latex yield per plant respectively because these traits had maximum direct and indirect effect towards seed yield and latex yield.

Keywords: Path analysis, *Papaver somniferum*, antiosteoporotic

Introduction
This plant have a broad range of therapeutic effects, including antibacterial, antiviral, antifungal, antitumor, antihelminths, analgesic, cardio- protective, hypotensive, immune enhancing, antiinflammatory, antioxidant, antiosteoporotic, insulinotrophic, antidyslipidemic effects and hepatoprotective [1-9].

Morinda citrifolia prevents free-radical-induced oxidative-pathological events in liver by inhibiting inflammatory response and suppressing elevated liver enzyme activities; thus preventing consequent cell membrane damage [10], the Noni addition promotes hepatoprotection against alcohol-induced injury due to regulations of lipid homeostasis, antioxidant status and alcohol metabolism [11].

The claimed hepatoprotective properties on Noni still remain controversial, cases have been reported of *Morinda citrifolia*-associated liver injury, emphasizing its possible hepatotoxic effect [12, 13]. However, the association it is not clear, as no causal link could be established between the case of liver injury and ingestion of this plant [14].

No Alcoholic Fatty Liver Disease (NAFLD) is defined by the accumulation of fat in the liver or hepatic steatosis in the absence of excess alcohol consumption. The incidence of NAFLD worldwide has risen markedly in recent years in parallel with the increasing prevalence of global obesity and recent estimates reveal that there are approximately one billion cases worldwide [15].

Consumption of foods containing high fat and high sucrose, which are frequently associated with a "western diet," account for the largest incidence of obesity and metabolic syndrome [16], which are strong risk factors for the development of fatty liver [17, 18].

Previous studies have investigated in human, animal and *in vitro* models the pathogenesis and molecular mechanisms through which some cytokines such as adiponectin influence on obesity, insulin resistance (IR), NAFLD and other components of metabolic syndrome (MS) [19, 20].

Biological functions of adiponectin depend on not only the serum circulating concentration of hormone but also the expression level and function of its specific receptors including AdipoR1 and AdipoR2.

Medicinal plants are a major source of medicines for mankind**.** India it is estimated that about 9500 plant species are being used in traditional system of medicine (Mishra *et al*., 2006). *Papaver somniferum* L. is an annual plant (2n=22) belongs to family *papaveraceae* native to Turkey and adjacent areas. It is a member of genus *Papaver*, which includes about 100 species and is affiliated to the section *Mecones* comprising five species, among which *Papaver setigerum* L. (2n=44) is a close relative and probably the ancestor of the opium poppy).It is considered to be a predominantly self-pollinating species. Opium poppy is an erect annual plant that usually has a white, purple, or pink terminal flower and alternating leaves. The characteristic fruit type of opium is the unilocular capsule. The stigmatic disc rests on top of the capsules and beneath it are dehiscent valves. *Papaver somniferum* L. is a multipurpose crop which is used as a medicinal or ornamental plant, as well as a source for seeds and seed oil. Morphine, codeine, thebaine, narcotine and papaverne are the most important alkaloids produced by the plant and are exploited by the pharmaceutical industry as analgesics, antitussives and anti-spasmodic. The crop is mainly grown in India, China, and Egypt and in India; it is cultivated in the states of Madhya Pradesh, Rajasthan and Uttar Pradesh under the control of Narcotics Department by licensed growers and is a valuable source of foreign exchange. Rajasthan, it is cultivated on an area of 2503 ha with a production and productivity of 158.4 tonnes at 70 consistency and 63.28 Kg/ha during 2013- 14, respectively (Khatik *et al*., 2016). The characters like seed yield and latex yield in opium poppy are polygenic trait, where direct selection would not be reliable approach on account of being highly influenced by environmental factors. Hence it become very essential to identify the direct as well as indirect component traits which can be biometrically estimated by correlation and path coefficients.

Materials and Methods

The present research entitled "Variability and Path Analysis in Opium poppy (*Papaver somniferum* L.)" was carried out with 25 diverse genotypes in randomized block design replicated thrice at Research Farm, Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, MPUAT, Udaipur, during *Rabi* 2016-17. Each entry was planted in 4 rows of 3.0 m length keeping row to row and plant to plant distance of 30 cm and 10 cm, respectively. The observations were recorded on five randomly selected competitive plants for each entry in replication for all the morphological characters. However, the observations days to 50 per cent flowering were recorded on plot basis. Also the representative bulk sample from each entry in each replication was used for seed yield and latex yield.

Results and Discussion

In present study the correlation coefficients were worked out among twelve characters to find out correlation of seed yield per plant with its components at genotypic (rg) and phenotypic (rp) levels. The perusal of data given in Table 1 revealed seed yield per plant had significant and positive genotypic correlation with latex yield per plant (0.574**), diameter of main capsule (0.563**), peduncle length (0.381**) and days to 50% flowering (0.324**) whereas it exhibited a strong positive significant phenotypic correlation with husk yield per plant (0.632**). It was also observed that none of the character except seed yield per plant and husk yield per plant exhibited significant association at phenotypic level.

Table 1: Genotypic (rg) and phenotypic (rp) correlation coefficients between different characters in Opium poppy

Character / r_p r_g	Days flowering to 50%	Peduncle length (cm)	Plant Height (cm)	Number of effective capsule per plant	Capsule diameter (mm)	Number of leaves per Plant	Latex yield per plant (g)	Seed yield per plant (g)	Husk yield per plant (g)	Harvest index for seed yield (%)	Harvest index for latex yield (%)	Days to maturity
Days to 50% flowering	1	-0.501**	-0.183	0.456**	0.704**	0.157	0.790**	0.324**	0.311**	0.024	0.238*	1.021**
Peduncle length (cm)	-0.210	1	0.615**	0.371**	-0.159	-0.144	-0.148	0.381**	0.014	0.454**	-0.432**	-0.608**
Plant height (cm)	-0.160	0.108	1	0.485**	-0.242*	0.134	-0.089	0.271**	0.162	0.095	-0.336**	-0.385**
Number of effective capsule per plant	0.023	0.056	0.260*	1	-0.308**	0.241*	0.555**	0.294**	0.416**	-0.245*	0.098	-0.470**
Capsule diameter (mm)	0.261*	0.029	-0.119	-0.012	1	0.165	0.792**	0.563**	0.281*	0.345**	0.264*	0.470**
Number of leaves per plant	0.001	0.075	-0.126	0.142	0.086	1	0.009	0.11	-0.232*	0.413**	0.052	-0.153
Latex yield per plant (g)	0.263*	-0.068	-0.156	0.184	0.500**	-0.009	1	0.574**	0.607**	-0.135	0.407**	0.202
Seed yield per plant (g)	0.246*	0.083	0.089	0.128	0.344**	-0.047	0.354**	1	0.773**	0.190	-0.565**	0.27
Husk yield per plant (g)	0.159	0.098	0.141	0.244*	0.266*	-0.149	0.446**	0.632**	1	-0.470**	0.594**	0.166
Harvest index for seed yield (%)	0.090	0.002	-0.081	-0.130	0.098	0.166	-0.121	0.387**	-0.456**	1	0.128	-0.255
Harvest index for latex yield (%)	0.156	-0.136	-0.259*	-0.110	0.139	0.070	0.322**	-0.486**	-0.423**	-0.047	1	0.055
Days to maturity	0.298**	-0.251*	-0.072	-0.134	0.121	-0.010	0.030	0.064	0.031	0.030	0.11	1

*, ** Significant at 5% and 1% level of significance, respectively.

The husk yield per plant had positive significant genotypic correlation with seed yield per plant (0.773**), latex yield per plant (0.607**), number of effective capsule per plant (0.416**), diameter of main capsule (0.281**) and days of 50% flowering. Thus the correlation coefficient study revealed that the character diameter of main capsule, number of effective capsule per plant, plant height, peduncle length and days to maturity are the main traits for crop improvement in opium poppy.

Further examination of table 1 explained that the positive significant genotypic correlation existed between days to 50% flowering and days to maturity (1.021**), diameter of main capsule (0.704**), number of effective capsule per plant (0.456**) and husk yield per plant (0.311**) meaning there by long duration genotypes yield more latex. Significant positive genotypic correlation also found between peduncle length and plant height (0.615**), plant height and number of effective capsule per plant (0.485**) number of effective capsule per plant and latex yield per plant (0.555**), diameter of main capsule and latex yield per plant (0.792**). The table 1 also revealed that those exist significant negative correlation at genetic level between peduncle length and days to 50% flowering (-0.501*), between diameter of main capsule and plant height (-0.242**), number of effective capsule per plant (-0.308**). The harvest index for seed yield exhibited significant negative association at genotypic level with husk yield per plant (-0.470**), number of effective capsule per plant (-0.245**) indicating little importance of these trait. Harvest index for number of effective capsule per plant latex yield and days to maturity exhibited non- significant association with all other characters studied, indicating the absence of significant correlation among yield and quality characters.

These findings character association in opium poppy are also with the similar trends of results reported by Singh *et al*. (2000), Shukla *et al*. (2003), Jain *et al*. (2005), Jain *et al*. (2006), Singh and Singh (2008), Mirjana *et al*. (2012) and Dubey (2012) who reported positive correlation of most of the traits. It indicated the possibilities of simultaneous improvement of these traits by selection. This in turn will improve the seed yield, since they are positively correlated with the seed yield**.** The trait harvest index for seed yield had negative and significant correlation with seed yield per plant thereby indicating selection for early maturity would give draught tolerant and drought avoiding genotypes affecting the seed yield positively in opium poppy.

Path analysis provides information about how close the other traits to the yield. The direct and indirect effects of eight dependent characters on seed yield per plant as independent character was obtained in path coefficient analysis at genotypic level. Therefore here some was considered for reporting the results and discussed for path analysis is cited.

Husk yield v/s seed yield per plant: A perusal of the Table 2 indicated that the significant positive correlation of husk yield per plant with seed yield per plant (0.773**) was mainly due to its high positive indirect effect via latex yield per plant (0.041), peduncle length (0.002) and days to maturity (0.002) whereas husk yield per plant exerted maximum direct effect on seed yield per plant with high negative estimated number of leaves per plant (-0.014) and days to 50% flowering (-0.010).

Table 2: Direct (diagonal) and indirect effects of different characters towards seed yield per plant in opium poppy

Character	Days to 50% flowering	Peduncle length (cm)	Plant Height (cm)	Number Of effective capsule per plant	Diameter of main capsule (mm)	Number of leaves per plant	Latex yield per plant (mm)	Husk yield per plant (g)	Harvest index for seed yield	Harvest index for seed yield	Days to maturity	Genotypic correlation with seed yield per plant
Days to 50% flowering	-0.032	-0.055	-0.001	-0.016	0.028	0.004	0.053	0.318	0.015	-0.003	0.014	0.324**
Peduncle length (cm)	0.016	0.110	0.004	-0.013	-0.006	-0.003	-0.010	0.014	0.273	0.005	-0.008	0.381**
Plant Height (cm)	0.006	0.068	0.006	-0.017	-0.009	0.003	-0.006	0.165	0.058	0.004	-0.005	0.271**
Number of effective capsule per plant	-0.015	0.041	0.003	-0.035	-0.012	0.006	0.037	0.425	-0.148	-0.001	-0.007	0.294**
Diameter of main capsule (mm)	-0.022	-0.018	-0.001	0.011	0.039	0.004	0.053	0.287	0.207	-0.003	0.007	0.563**
Number of leaves per plant	-0.005	-0.016	0.001	-0.008	0.006	0.024	0.001	-0.237	0.249	-0.001	-0.002	0.110
Latex yield per plant	-0.025	-0.016	-0.001	-0.019	0.031	0.000	0.067	0.620	-0.081	-0.005	0.003	0.574**
Husk yield per plant (g)	-0.010	0.002	0.001	-0.014	0.011	-0.006	0.041	1.021	-0.283	0.007	0.002	0.773**
Harvest index for seed yield	-0.001	0.050	0.001	0.009	0.013	0.010	-0.009	-0.479	0.602	-0.002	-0.004	0.190
Harvest index for latex yield	-0.008	-0.048	-0.002	-0.003	0.010	0.001	0.027	-0.607	0.077	0.027	-0.001	-0.565
Days to maturity	-0.033	-0.067	-0.002	0.016	0.018	-0.004	0.014	0.170	-0.154	0.001	0.014	0.027

Residual effect= 0.0058

Latex yield per plant v/s seed yield per plant: A perusal of the Table 2 indicated that the significant positive correlation of latex yield per plant with seed yield per plant (0.574**) was mainly due to its high positive indirect effect via husk yield per plan (0.62),diameter of main capsule(0.031) and days to maturity (0.003).whereas number of effective capsule per plant (-0.019) and peduncle length (-0.01 exerted maximum direct effect on seed yield per plant but in negative direction.

Diameter of main capsule v/s seed yield per plant: A perusal of the Table 2 indicated that the significant positive

correlation of diameter of main capsule with seed yield per plant (0.563**) was mainly due to its high positive indirect effect via husk yield per plant (0.287), latex yield per plant (0.053) and number of effective capsule per plant (0.011). whereas, peduncle length (-0.02), days and plant height (-0.01) exerted maximum direct effect on seed yield per plant is in negative direction.

Number of effective capsule per plant v/s seed yield per plant: A perusal of the Table 2 indicated that the significant positive correlation of number of effective capsule per plant with seed yield per plant (0.294**) was mainly due to its high positive indirect effect via husk yield per plant (0.425) and latex yield per plant (0.037) whereas diameter of main capsule (-0.012) and number of effective capsule per plant (-0.035) exerted maximum direct effect on seed yield per plant with high negative estimates.

Peduncle length v/s seed yield per plant: A perusal of the Table 2 indicated that the significant positive correlation of peduncle length with seed yield per plant (0.381**) was mainly due to its high positive indirect effect via husk yield per plant (0.014) and peduncle length (0.110) whereas number of effective capsule per plant (-0.013) and latex yield per plant (-0.01) exerted maximum direct effect on seed yield per plant with high negative estimates.

Days to 50%flowering v/s seed yield per plant: A perusal of the Table 2 indicated that the significant positive correlation of days to 50% flowering with seed yield per plant (0.324**) was mainly due to its high positive indirect effect via husk yield per plant (0.318), and latex yield per plant (0.053) whereas all other traits exerted maximum direct effect on seed yield per plant with high negative estimates.

Plant height v/s seed yield per plant: A perusal of the Table 2 indicated that the significant positive correlation of plant height with seed yield per plant (0. 0.271**) was mainly due to its high positive indirect effect via peduncle length (0.068) and number of leaves per plant (0.003) whereas latex yield per plant (-0.006) and days to maturity (-0.005) exerted maximum direct effect on seed yield per plant with high negative estimates.

The component of residual effects of path analysis was (0.0058) the low residual effect indicated that characters for path analysis were adequate and appropriate. It revealed from the path analysis for seed yield per plant that husk yield per plant (1.0214) exhibited maximum positive direct effect on seed yield followed by harvest index for seed yield (0.6021), peduncle length (0.1099) and latex yield per plant (0.0673) Whereas number of leaves per plant also directly contributed to seed yield with negative estimates.It is concluded from above results that seed yield per plant can be improved practicing selection for husk yield per plant, latex yield per plant, harvest index for latex yield, peduncle length and plant height as they contributed directly to the seed yield as revealed from path analysis.

These findings are in consonance to the results obtained by Solanki *et al*. (2014) and Ozturk and Gunlu (2008) have also reported high positive direct effect of plant height and capsule size on seed yield per plant. Mirjana *et al*. (2012) also reported the high positive direct effect of husk yield per plant and latex yield per plant over seed yield per plant. The direct and indirect effect of eight dependent characters on latex yield per plant as independent character was obtained by path coefficient analysis at genotypic level. Days to 50% flowering v/s latex yield per plant: A perusal of the Table 3 indicated that the significant positive correlation of days to 50% flowering with latex yield per plant (0.790**) was mainly due to its indirect positive effect through husk yield per plant (1.658), diameter of main capsules (0.876), number of effective capsule per plant (0.128), days to 50% flowering (0.002), plant height (0.031) and number of leaves per plant (0.029). The direct contribution of peduncle length (-0.476) and seed yield per plant (-0.1547) toward latex yield per plant is negative.

Table 3: Direct (diagonal) and indirect effects of different characters towards latex yield per plant in opium poppy

Character	Days to 50% flowering	Peduncle length (cm)	Plant Height (cm)	No of effective capsule per plant	Diameter of main capsule	Number of leaves per plant	Seed yield per plant	Husk yield per plant	Harvest index for seed yield	Harvest index for latex yield	Days of maturity	Genotypic correlation with latex yield per plant
Days to 50% flowering	0.002	-0.479	0.031	0.128	0.876	0.029	-1.547	1.658	0.057	0.135	0.100	0.790**
Peduncle length (cm)	-0.001	0.955	-0.105	0.104	-0.197	-0.026	-1.818	0.071	1.055	-0.244	0.059	-0.148
Plant Height (cm)	-0.0004	0.587	-0.172	0.136	-0.300	0.0245	-1.296	0.861	0.222	-0.190	0.037	0.090
Number of effective capsule per plant	0.001	0.354	-0.083	0.281	-0.383	0.044	-1.404	2.216	-0.573	0.055	0.046	0.555**
Diameter of main capsule (mm)	0.001	-0.151	0.041	-0.086	1.244	0.030	-2.689	1.497	0.801	0.149	-0.406	0.792**
Number of leaves per plant	0.0003	-0.137	-0.023	0.067	0.204	0.182	-.0533	-1.237	0.960	0.029	0.015	0.009
Seed yield per plant	0.0007	0.363	-0.046	0.082	0.701	0.002	-4.775	4.121	0.441	-0.319	0.002	0.574**

Husk yield per plant (g)	0.0007	0.012	-0.027	0.116	0.349	-0.0424	-3.690	5.332	-1.091	-0.336	-0.016	0.607**
Harvest index for seed yield	0.00006	0.433	-0.0164	-0.069	0.428	0.075	-0.907	-2.502	2.325	0.0722	0.025	-0.135
Harvest index for latex yield	0.0005	-0.412	0.057	0.0276	0.328	0.009	2.697	-3.169	0.296	0.566	0.005	0.407**
Days of maturity	0.002	-0.580	0.066	-0.131	0.583	-0.027	0.126	0.886	-0.593	-0.031	-0.098	0.202

Residual effect= 0.4125

Number of effective capsule per plant v/s latex yield per plant: A perusal of the Table 3 indicated that the significant positive correlation of number of effective capsule per plant with latex yield per plant (0.555**) was mainly due to its indirect positive effect through days to 50% flowering (0.281), plant height (0.136), husk yield per plant (0.116), peduncle length (0.104) and seed yield per plant (0.082). The direct contribution of number of effective capsule per plant towards diameter of main capsule negative (-0.086).

Seed yield per plant v/s latex yield per plant: A perusal of the Table 3 indicated that the significant positive correlation of seed yield per plant with latex yield per plant (0.574**) was mainly due to its indirect positive effect through husk yield per plant (4.121), diameter of main capsules negative (0.701), number of effective capsule per plant (0.082), days to 50% flowering (0.002) days to maturity and number of leaves per plant (0.002).The direct contribution of number of effective capsule per plant peduncle length (-0.476), plant height (-1.574)and harvest index for latex yield per plant (-0.319)

Diameter of main capsule per plant v/s latex yield per plant: A perusal of the Table 3 indicated that the significant positive correlation of diameter of main capsule with latex yield per plan (0.792**) was mainly due to its indirect positive effect through days to 50% flowering (1.244), seed yield per plant (0.700), husk yield per plant (0.349) and number of leave per plant(0.204). The direct contribution of peduncle length (-0.383) and plant height (-0.300) towards latex yield per plant is negative.

Husk yield per plant v/s latex yield per plant: A perusal of the Table 3 indicated that the significant positive correlation of husk yield per plant with latex yield per plant (0.607**) was mainly due to its indirect positive effect through husk yield per plant (4.121), days to 50% flowering (5.332), number of effective capsule per plant (2.216) diameter of main capsule (1.497) and plant height (0.861) days to maturity (0.886)). The direct contribution of husk yield per plant toward number of leave per plant negative (-1.237)

Residual effect: The component of residual effects of path analysis was 0.412 this moderately high residual effect indicated that characters for path analysis were not adequate and appropriate in this study.

It is concluded from above results that latex yield per plant can be improved practicing selection for days to 50 percent flowering as indicated by path analysis.These findings are in consonance to the results obtained by Shukla *et al*. (2003) and Dubey (2010) have also reported high positive direct effect of plant height, capsule size, and diameter of main capsule on seed yield per plant. Singh and Singh (2008) also reported the high positive direct effect of husk yield per plant and seed yield per plant over latex yield per plant.

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