THE ASIAN JOURNAL OF HORTICULTURE
Volume **8** | Issue 2 | December, 2013 | 403-408

Research Paper

***Article history* :**
Received : 27.04.2013
Revised : 24.08.2013
Accepted : 05.09.2013

Association and path co-efficient analysis among seed yield and it's components in coriander (*Coriandrum sativum* L.)

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ABSTRACT : Seed yield plant^{-1} exhibited a positive and significant correlation with number of fruits umbel^{-1}. Number of fruits umbellet^{-1} expressed a positive significant correlation with number of fruits umbel^{-1} and 1000 seed weight. Days to 50 per cent flowering had the highest positive direct effect on seed yield plant^{-1} followed by number of umbellets umbel^{-1}, number of fruits umbel^{-1} and chlorophyll content at 60 DAS.

KEY WORDS : Coriander, Association, Path co-efficient

HOW TO CITE THIS ARTICLE : Nair, Beena, Sengupta, S.K., Singh, Krishna Pal and Naidu, A.K. (2013). Association and path co-efficient analysis among seed yield and it's components in coriander (*Coriandrum sativum* L.). *Asian J. Hort.*, **8**(2) : 403-408.

A spice is a dried seed, fruit, root or bark used as a food additive to enhance the flavour, sometimes as a preservative by preventing growth of harmful organism or by killing them. India has been one of the leading producers and exporters of spices in the world. Spices have been considered indispensable in the culinary products for flavoring foods and thereby contribute a major group of agricultural commodities (Pruth, 1998). Coriander (*Coriandrum sativum* L.) is an annual herb in the family Apiaceae (Umbelliferae) and is known to be originated in the Mediterranean region (Hedburg and Hedburz, 2003). The coriander seeds are used as an important ingredient in various food preparations whereas; the leaves are often used for garnishing dishes. The leaves, stalks and seeds of coriander contain certain essential oils. The essential and fatty oils of the fruits are used in industry, either separately or combined. The seeds contain on average 18% oil, this can vary between 8.8%-19% according to strain. Essential oil content of seeds is approximately 0.84%. The other constituents include oleoresins, alpha pinene, beta pinene, diterpine, p-cymene and decyldehyde (Potter and Fagerson, 1990).

RESEARCH METHODS

The experiment was carried out during the *Rabi* seasons of 2010-11 and 2011-12 at Vegetable Research Farm, Department of Horticulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). The materials for the present study comprised of sixty four germplasms of Coriander which were planted in Randomized Block Design and replicated thrice. Correlation co-efficients were calculated for all quantitative characters combinations at phenotypic, genotypic and environmental level by the formula given by Miller *et al.* (1958). The direct and indirect contribution of various characters to yield was calculated through path co-efficient analysis as suggested by (Wright, 1921) and elaborated by Dewey and Lu (1959). Later the path co-efficients were rated based on the scales given by Lenka and Mishra (1973).

RESEARCH FINDINGS AND DISCUSSION

Correlation co-efficient is a statistical tool which is used to find out the degree (strength) and direction of relationship between two or more variables. A positive value shows that the changes of two variables are in the same direction *i.e.*, values of one variable are associated with the other variables whereas, a negative value shows that the movements of variables are in opposite direction *i.e.*, high values of one variable are associated with low value of the other.

Results of the present investigation indicated that genotypic correlation co-efficients in general were of higher magnitude than the corresponding phenotypic correlation co-efficients. On the basis of pooled data, co-efficient of correlation of yield and its component traits have been depicted in Table 1. Seed yield plant^{-1} exhibited a positive and significant correlation with number of fruits umbellet^{-1} (0.2333) but was negatively correlated with days to 50% flowering (-0.2869), days to 80% maturity (-0.2801) and vegetative yield plot^{-1} (-0.1415). Plant height at maturity had a significant positive association with chlorophyll content at 60DAS (0.4092), 1000 seed weight (0.2524), days to 50% flowering (0.1572) and days to 80% maturity (0.1550). The results are in close proximity to that of Dalkani *et al.* (2011), Jindla *et al.* (1985), Prabhu and Balakrishnamoorthy (2005), Selvarajan *et al.* (2002), Tripathi *et al.* (2000) and Vedamuthu *et al.* (1989).

Chlorophyll content at 60DAS showed positive and significant association with number of primary branches plant^{-1} (0.3558), 1000 seed weight (0.3492), days to 50% flowering (0.2799) and 80% maturity (0.2497), vegetative yield plot^{-1} (0.2324), number of umbels plant^{-1} (0.1841) and number of fruits umbellet^{-1} (0.1737). Number of primary branches plant^{-1} exhibited a positive significant correlation with 1000 seed weight (0.5650), number of umbels plant-1 (0.4903), and number of fruiting nodes plant^{-1} (0.4751), number of fruits umbellet^{-1} (0.4113), number of umbellets umbel^{-1} (0.4015), number of fruits umbel^{-1} (0.3275) and diameter of fruits (0.3104). Strong positive and significant association of number of fruiting nodes plant^{-1} was observed with number of umbels plant^{-1} (0.9442), 1000 seed weight (0.8224), number of umbellets umbel^{-1} (0.5725), number of fruits umbel^{-1} (0.4544) and number of fruits umbellet^{-1} (0.2791). The results are in agreement to the findings of Prabhu and Balakrishnamoorthy (2005) and Rajput *et al.* (2004).

Highly significant and positive correlation of days to 50% flowering with days to 80% maturity (0.9863), vegetative yield plot^{-1}(0.3097) and 1000 seed weight (0.2977) while, negative correlation with number of fruits umbellet^{-1} (-0.1464) was observed. Days to 80% maturity had a positive and significant correlation with vegetative yield plot^{-1} (0.2986), 1000 seed weight (0.2986) and number of umbellets umbel^{-1} (0.1382) while, it was negative with number of fruits umbellet-1 (-0.1567). Highly positive association of number of umbels plant^{-1} was recorded with 1000 seed weight (0.836), number of umbellets umbel^{-1} (0.5523), number of fruits umbel-1 (0.4512) and number of fruits umbellet^{-1} (0.2376). Number of umbellets umbel^{-1} showed a positive and significant association with 1000 seed weight (0.5233), number of fruits umbel^{-1} (0.4822) and number of fruits umbellet^{-1} (0.3202). While, number of fruits umbellet^{-1} expressed a positive significant correlation with number of fruits umbel^{-1} (0.4010) and 1000 seed weight (0.2325). 1000 seed weight was also positively correlated with number of fruits umbel^{-1} (0.3728) while, diameter of fruits was negatively correlated with vegetative yield plot^{-1} (-0.2050). The present findings are in confirmation with the findings of Dalkani *et al*. (2011) and Singh and Prasad (2006).

Path co-efficient analysis is simply a standardized partial regression co-efficient which splits the correlation co-efficient into the measures of direct and indirect effects. In other words, it measures the direct and indirect contribution of various independent characters on a dependent character. The results of path co-efficient studies on pooled basis showing direct and indirect effects on yield and its component using seed yield plant^{-1} as dependent variable have been given in Table 2. Path co-efficient analysis of different traits contributing towards seed yield plant^{-1} showed that days to 50% flowering (5.4770) had the highest positive direct effect followed by number of umbellets umbel^{-1} (4.2208), number of fruits umbel^{-1} (1.9056) and chlorophyll content at 60DAS (0.7063). The results are in propinquity with the findings of Gupta (1992), Jindla *et al.* (1985), Singh (1986) and Srivastava *et al.* (2000), while, (Singh *et al.* (2006) observed direct effect of days to 50% flowering to be high and negative on seed yield plant^{-1}.

Plant height at maturity exhibited a positive indirect effect via diameter of fruits (0.0099) while, the remaining characters showed negative indirect effect *viz.*, chlorophyll content at 60DAS (-0.0896) followed by 1000 seed weight (-0.0553), number of umbellets umbel^{-1} (-0.0374), days to 50% flowering (-0.0343), days to 80% maturity (-0.0336), number of primary branches plant^{-1} (-0.2890), vegetative yield plot^{-1} (-0.0259), number of umbels plant^{-1} (-0.0182), number of fruits umbel^{-1} (0.0172), number of umbellets umbel^{-1} (-0.0117) and number of fruiting nodes plant^{-1} (-0.0109). The findings were quite alike to the findings of Bhandari and Gupta (1997), Singh *et al.* (2006) and Srivastava *et al.* (2000). Chlorophyll content at 60DAS revealed a high value of positive indirect effect on seed yield plant^{-1} through plant height at maturity (0.2918), number of primary branches plant^{-1} (0.2736), 1000 seed weight (0.2560), days to 50% flowering (0.1994), days to 80% maturity (0.1788), vegetative yield plot^{-1} (0.1699), number of umbellets umbel^{-1} (0.1540), number of fruits umbel^{-1} (0.1478), number of fruits umbellet^{-1} (0.1421), number of umbels plant^{-1} (0.1345) and number of fruiting nodes plant^{-1} (0.0861).

Number of primary branches plant^{-1} recorded the highest positive indirect effect on seed yield plant^{-1} via

Table 1: Estimates of genotypic and phenotypic correlation coefficient for yield and its contributing characters in coriander (pooled data)

Characters		Chlorophyll content 60 DAS	No. of primary branches	No. of fruiting nodes	Days to 50% flowering	Days to 80% maturity	No. of umbels/ plant	No. of umbellets/ umbel	No. of fruits/ umbellet	No. of fruits/ umbel	Diameter of fruits (mm)	Vegetative yield (kg)	1000 seeds wt (g)	Seed yield/plant (g)
Plant height at maturity	G	0.4132	0.1331	0.0502	0.1580	0.1549	0.0837	0.1722	0.0539	0.0794	-0.0457	0.1192	0.2551	0.0183
	P	0.4092 **	0.1256	0.0501	0.1572*	0.1550*	0.0797	0.1086	0.0451	0.0393	-0.0302	0.1146	0.2524**	0.0179
Chlorophyll content 60 DAS	G		0.3873	0.1219	0.2823	0.2531	0.1905	0.2181	0.2012	0.2092	-0.0139	0.2406	0.3624	0.0383
	P		0.3558**	0.1211	0.2799**	0.2497**	0.1841**	0.1350	0.1737*	0.1086	0.0019	0.2324**	0.3492**	0.0379
No. of primary branches	G			0.5119	0.0112	-0.0199	0.5408	0.6619	0.5320	0.6506	0.4644	-0.1471	0.6155	-0.0756
	P			0.4751 **	0.0143	-0.0138	0.4903**	0.4015**	0.4113**	0.3275**	0.3104**	-0.1266	0.5650**	-0.0668
No. of fruiting nodes	G				0.1156	0.1133	0.9681	0.9103	0.3340	0.7992	0.0083	-0.0424	0.8477	-0.0434
	P				0.1159	0.1145	0.9442**	0.5725**	0.2791**	0.4544**	0.0163	-0.0427	0.8224**	-0.0477
Days to 50% flowering	G					0.991	0.1059	0.1818	-0.1640	-0.0871	-0.0672	0.3186	0.3051	-0.2887
	P					0.9863**	0.1038	0.1220	-0.1464*	-0.0543	-0.0479	0.3097**	0.2977**	-0.2869**
Days to 80% maturity	G						0.1007	0.1927	-0.1788	-0.082	-0.0937	0.3082	0.3097	-0.2804
	P						0.0968	0.1382*	-0.1567*	-0.0405	-0.0653	0.2986**	0.2986**	-0.2801**
No. of umbels/ plant	G							0.8847	0.2885	0.7547	0.0617	-0.0283	0.8703	-0.0889
	P							0.5523**	0.2376**	0.4512**	0.0358	-0.025	0.8361**	-0.0822
No. of umbellets/ umbel	G								0.5667	0.9831	0.1257	0.0363	0.8807	0.083
	P								0.3202**	0.4822**	0.0283	0.0214	0.5233**	0.0479
No. of fruits/ umbellet	G									0.8617	-0.0027	-0.1433	0.2563	0.2830
	P									0.4010**	-0.0157	-0.1128	0.2325**	0.2333**
No. of fruits/ umbel	G										-0.1587	0.0136	0.7519	0.1283
	P										-0.0236	-0.0073	0.3728**	0.0721
Diameter of fruits (mm)	G											-0.274	0.1117	-0.1296
	P											-0.2050**	0.0842	-0.0952
Vegetative yield (kg)	G												0.1408	-0.1495
	P												0.1327	-0.1415*
1000 seed weight(g)	G													-0.1301
	P													-0.1256

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 2 : Genotypic and phenotypic path analysis showing direct and indirect effect on seed yield plant^{-1} of coriander (pooled)

Characters		Plant height at maturity	Chlorophyll content 60 DAS	No. of primary branches	No. of fruiting nodes	Days to 50% flowering	Days to 80% maturity	No. of umbels/ plant	No. of umbellets/ umbel	No. of fruits/ umbellet	No. of fruits/ umbel	Diameter of fruits (mm)	Veg. yield (kg)	1000 seed weight (g)	'r' value of seed yield /pl (g)
Plant height at maturity	G	-0.2170	-0.0896	-0.0289	-0.0109	-0.0343	-0.0336	-0.0182	-0.0374	-0.0117	-0.0172	0.0099	-0.0259	-0.0553	0.0183
	P	0.0166	0.0068	0.0021	0.0008	0.0026	0.0026	0.0013	0.0018	0.0007	0.0007	-0.0005	0.0019	0.0042	0.0179
Chlorophyll content 60 DAS	G	0.2918	0.7063	0.2736	0.0861	0.1994	0.1788	0.1345	0.154	0.1421	0.1478	-0.0098	0.1699	0.256	0.0383
	P	0.0815	0.1991	0.0708	0.0241	0.0557	0.0497	0.0366	0.0269	0.0346	0.0216	0.0004	0.0463	0.0695	0.0379
No. of primary branches	G	-0.1144	-0.3329	-0.8596	-0.44	-0.0096	0.0171	-0.4648	-0.569	-0.4573	-0.5592	-0.3992	0.1265	-0.529	-0.0756
	P	-0.0271	-0.0768	-0.2159	-0.1026	-0.0031	0.0030	-0.1059	-0.0867	-0.0888	-0.0707	-0.0670	0.0273	-0.1220	-0.0668
No. of fruiting nodes	G	-0.1201	-0.2917	-1.225	-2.3928	-0.2767	-0.2711	-2.3163	-2.1782	-0.7991	-1.9122	-0.0199	0.1015	-2.0283	-0.0434
	P	0.0134	0.0325	0.1274	0.2681	0.0311	0.0307	0.2531	0.1535	0.0748	0.1218	0.0044	-0.0115	0.2205	-0.0477
Days to 50% flowering	G	0.8651	1.5463	0.0614	0.6333	5.4770	5.4276	0.5802	0.9958	-0.8985	-0.4771	-0.3682	1.7448	1.671	-0.2887
	P	-0.0374	-0.0665	-0.0034	-0.0275	-0.2376	-0.2344	-0.0247	-0.0290	0.0348	0.0129	0.0114	-0.0736	-0.0708	-0.2869**
Days to 80% maturity	G	-0.9163	-1.4969	0.1178	-0.6702	-5.8609	-5.9142	-0.5958	-1.1396	1.0577	0.4851	0.5541	-1.8226	-1.8315	-0.2804
	P	-0.0073	-0.0117	0.0006	-0.0054	-0.0462	-0.0469	-0.0045	-0.0065	0.0073	0.0019	0.0031	-0.0140	-0.0140	-0.2801**
No. of umbels/ plant	G	-0.0516	-0.1174	-0.3333	-0.5967	-0.0653	-0.0621	-0.6164	-0.5453	-0.1779	-0.4652	-0.038	0.0175	-0.5365	-0.0889
	P	-0.0268	-0.0618	-0.1646	-0.3170	-0.0348	-0.0325	-0.3357	-0.1854	-0.0798	-0.1515	-0.0120	0.0084	-0.2806	-0.0822
No. of umbellets /umbel	G	0.7266	0.9204	2.7939	3.8422	0.7674	0.8133	3.7339	4.2208	2.392	4.1495	0.5306	0.1534	3.7171	0.083
	P	0.0136	0.0170	0.0504	0.0719	0.0153	0.0174	0.0693	0.1256	0.0402	0.0605	0.0036	0.0027	0.0657	0.0479
No. of fruits/ umbellet	G	-0.1262	-0.4705	-1.2442	-0.781	0.3836	0.4182	-0.6748	-1.3253	-2.3386	-2.0152	0.0064	0.3351	-0.5993	0.283
	P	0.0091	0.0349	0.0826	0.0561	-0.0294	-0.0315	0.0477	0.0643	0.2009	0.0805	-0.0032	-0.0227	0.0467	0.2333**
No. of fruits/ umbel	G	0.1514	0.3987	1.2397	1.5228	-0.166	-0.1563	1.4381	1.8734	1.6421	1.9056	-0.3025	0.0259	1.4328	0.1283
	P	0.0001	0.0002	0.0005	0.0007	-0.0001	-0.0001	0.0007	0.0008	0.0006	0.0016	0.0000	0.0000	0.0006	0.0721
Diameter of fruits (mm)	G	0.0067	0.002	-0.068	-0.0012	0.0098	0.0137	-0.009	-0.0184	0.0004	0.0232	-0.1464	0.0401	-0.0164	-0.1296
	P	0.0017	-0.0001	-0.0176	-0.0009	0.0027	0.0037	-0.0020	-0.0016	0.0009	0.0013	-0.0566	0.0116	-0.0048	-0.0952
Vegetative yield (kg)	G	-0.096	-0.1937	0.1184	0.0342	-0.2564	-0.2481	0.0228	-0.0293	0.1153	-0.0109	0.2206	-0.805	-0.1133	-0.1495
	P	-0.0131	-0.0266	0.0145	0.0049	-0.0355	-0.0342	0.0029	-0.0025	0.0129	0.0008	0.0235	-0.1146	-0.0152	-0.1415*
1000 seed weight(g)	G	-0.3819	-0.5427	-0.9215	-1.2692	-0.4568	-0.4637	-1.3031	-1.3185	-0.3837	-1.1258	-0.1672	-0.2108	-1.4972	-0.1301
	P	-0.0064	-0.0089	-0.0144	-0.0209	-0.0076	-0.0076	-0.0212	-0.0133	-0.0059	-0.0095	-0.0021	-0.0034	-0.0254	-0.1256

Genotypic residual effect = 0.6398 phenotypic residual effect = 0.8965 vegetative yield plot^{-1} (0.1265) and days to 80% maturity (0.0171). Number of fruiting nodes plant^{-1} expressed a positive indirect effect on seed yield plant^{-1} through vegetative yield plot^{-1} (0.1015) while, the majority of traits showed a high negative indirect effect on seed yield plant^{-1}. Days to 50% flowering manifested positive indirect effect through days to 80% maturity (5.4276), vegetative yield plot^{-1} (1.7448), 1000 seed weight (1.6710), chlorophyll content at 60DAS (1.5463), number of umbellets umbel^{-1} (0.9958), plant height at maturity (0.8651), number of fruiting nodes plant^{-1} (0.6333), number of umbels plant^{-1} (0.5802) and number of primary branches plant^{-1} (0.0614). Whereas, days to 80% maturity imparted the highest positive indirect effect on seed yield plant^{-1} through number of fruits umbellet^{-1} (1.0577), diameter of fruits (0.5541), number of fruits umbel^{-1} (0.4851) and number of primary branches plant^{-1} (0.1178). The results are in close proximity to the findings of Jain *et al.* (2003), Sharma and Sharma (1989), Singh *et al.* (2006) and Vijayalatha and Chezhiyan (2004).

Number of umbels plant^{-1} exhibited a positive indirect effect via vegetative yield plot^{-1} (0.0175). While, number of umbellets umbel^{-1} expressed the highest positive indirect effect through number of fruits umbellet^{-1} (4.1495), number of fruiting nodes plant^{-1} (3.8422), number of umbels plant^{-1} (3.7339), 1000 seed weight (3.7171), number of primary branches plant^{-1} (2.7939), number of fruits umbellet^{-1} (2.3920), chlorophyll content at 60DAS (0.9204), days to 80% maturity (0.8133), days to 50% flowering (0.7674), plant height at maturity (0.7266), fruit diameter (0.5306) and vegetative yield plot^{-1} (0.1534). Number of fruits umbellet^{-1} manifested a positive indirect effect through days to 80% maturity (0.4182), days to 50% flowering (0.3836), vegetative yield plot^{-1} (0.3351) and fruit diameter (0.0064). However, number of fruits umbel^{-1} revealed a high value of positive indirect effect via number of umbellets umbel^{-1} (1.8734), number of fruits umbellet^{-1} (1.6421), number of fruiting nodes plant^{-1} (1.5228), number of umbels plant^{-1} (1.4381), 1000 seed weight (1.4328), number of primary branches plant^{-1} (1.2397), chlorophyll content at 60DAS (0.3987), plant height at maturity (0.1514) and vegetative yield plot^{-1} (0.0259). The results are in propinquity to the findings of Dalkani *et al.* (2011) and Singh *et al.* (2006).

Fruit diameter exerted a high positive indirect effect on seed yield plant^{-1} through vegetative yield plot^{-1} (0.0401), number of fruits umbel^{-1} (0.0232), days to 80% maturity (0.0137), days to 50% flowering (0.0098), plant height at maturity (0.0067) and chlorophyll content at 60DAS (0.0020). Vegetative yield plot^{-1} exhibited a positive indirect effect through fruit diameter (0.2206), number of primary branches plant^{-1} (0.1184), number of fruits umbellet^{-1} (0.1153), number of fruiting nodes plant^{-1} (0.0342) and number of umbels plant^{-1} (0.0228). However, all the traits recorded negative indirect effect for 1000 seed weight through number of umbellets umbel^{-1} (-1.3185), number of umbels plant^{-1} (-1.3031), number of fruiting nodes plant^{-1} (-1.2692), number of fruits umbel^{-1} (-1.1258), number of primary branches plant^{-1} (-0.9215), chlorophyll content at 60DAS (-0.5427), days to 80% maturity (-0.4637) and days to 50% flowering (-0.4568). Similar findings were reported by Godara (1995) and Vijayalatha and Chezhiyan (2004).

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