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STUDY OF GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS IN CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

The present investigation was conducted to assess the genetic variability, correlation coefficient and path coefficient analysis of 30 desi chickpea genotypes.The observations were recoded on thirteen quantitative characters *viz.,* days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of pods per plant, first pod bearing node, number of seeds per pod, 100-seed weight, seed yield per plant, biological yield per plant, harvest index, seed volume and number of hard seeds. The study was carried out at the Instructional farm, College of Agriculture, Junagadh Agricultural University, Junagadh during *Rabi* 2015-16 in a randomized block design with three replications. The high values of GCV and PCV were recorded for seed yield per plant followed by harvest index, number of pods per plant and biological yield per plant. This indicated the presence of wide genetic variation for these characters. High heritability coupled with high genetic advance as per cent of mean was observed for seed yield per plant, harvest index, number of pods per plant, biological yield per plant and 100-seed weight suggesting the existence of sufficient heritable variation and wider scope for effective selection. The values of genotypic correlation, in general, were higher as compared to the corresponding phenotypic correlation, indicated that though there was high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. The seed yield per plant was highly significant and positively correlated with number of pods per plant, biological yield per plant and harvest index at both the genotypic and phenotypic levels. The genotypic and phenotypic path coefficient analysis revealed that harvest index and biological yield per plant exhibited high and positive direct effects on seed yield per plant. While plant height, number of pods per plant and 100-seed weight exerted low and positive direct effects towards seed yield per plant.

Key words : *Variability, heritability, correlation, path analysis, chickpea.*

Chickpea (*Cicer arietinum* L.) popularly known as gram / Bengal gram / homes / chhola / garbanzo bean is one of the first grain legumes to be domesticated by humans in old world (1). The genus *Cicer* belongs to the sub-family *Papilionaceae* of the family *Leguminoceae* (2). Two species *viz*., *Cicer arietinum* (2n=16) and *C. soongaricum* (2n=16) are cultivated in India. Nutrition point of view, chickpea seeds contain 17.7 per cent protein, 0.49 per cent lysine, 0.11 per cent methionine (3). In India, chickpea is cultivated in about 10.7 m ha with total production of 9.88 m ton and with productivity 920 kg/ha. In Gujarat, area, production and productivity are 0.18 m ha, 0.21 m ton, and 1132 kg/ha, respectively (4).

Availability of sufficient genetic variability is very important in a crop improvement programme. For successful breeding programme, amount of genetic variability present in the experimental material is a basic requirement. Therefore, it is essential for a plant breeder to measure the variability with the help of parameter like phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance. Hence, these parameters give the information regarding the availability of genetic variability for different characters in available germplasm. Therefore, the study of genetic variability of seed yield and its component characters among different varieties provides a strong basis for selection of desirable genotype for augmentation of yield and other agronomic characters.

Different components of seed yield very often exhibit varying degree of associations with seed yield as well as among themselves. In order to accumulate optimum combination of seed yield contributing characters in the single genotype, it is essential to know the relationship among themselves. Further, the seed yield is influenced by its various components directly and/or indirectly via other traits that create a complex situation before a breeder for making desirable selection. Therefore, path coefficient analysis could provide a more realistic picture of the interrelationship, as it partitions the correlation coefficient in to direct and indirect effects of variables. Thus, characters association and path analysis provide the information for the isolation of superior accession from gene bank.

MATERIALS AND METHODS

A field experiment was conducted at the Instructional

Table-1 : Mean, Range, coefficient of range, phenotypic and genotypic coefficients of variation, heritability (Broad Sense), genetic advance and genetic advance expressed as percentage of mean for 12 characters in chickpea.

Character	Mean	Range	Coefficient of range (%)	Phenotypic coefficient of variation (%)	Genotypic coefficient of variation (%)	Heritability (Broad Sense) (%)	Genetic advance	Genetic advance expressed as percentage of mean
Days to 50% flowering	44.87	33.00-50.00	20.48	12.47	11.73	0.89	10.20	22.74
Days to maturity	79.41	75.00-88.00	7.98	3.61	3.41	0.90	5.28	6.66
Plant height (cm)	30.10	20.00-34.27	26.29	9.93	6.90	0.48	2.97	9.88
Number of branches per plant	5.04	3.53-7.47	35.76	20.23	19.10	0.89	1.87	37.15
Number of pods per plant	17.77	8.63-29.93	55.23	29.44	28.40	0.93	10.03	56.43
First pod bearing node	16.40	10.47-20.80	33.05	13.94	13.15	0.89	4.19	25.53
Number of seeds per pod	1.32	1.00-1.80	28.57	14.90	13.59	0.83	0.34	25.54
100-seed weight (g)	17.33	11.62-27.63	40.79	23.83	23.26	0.95	8.11	46.78
Seed yield per plant (g)	3.35	1.60-6.50	60.57	41.23	40.44	0.96	2.73	81.69
Biological yield per plant (g)	13.64	7.67-25.00	53.06	26.80	25.54	0.91	6.84	50.15
Harvest index (%)	24.95	9.28-40.76	62.91	32.18	30.13	0.88	14.50	58.11
Seed volume (ml/seed)	9.31	6.33-14.67	39.69	19.83	19.63	0.98	3.73	40.01

Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during *rabi* season 2015-16. The experimental material comprised of 30 genotypes of *desi* type chickpea in a randomized block design with three replications. All the recommended agronomic practices along with necessary plant protection measures were followed timely for successful raising of crop.

The observations were recorded on five randomly selected plants in each line and each replication and their mean values were used for statistical analysis. The observations were recorded on various characters *viz.,* days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of pods per plant, first pod bearing node, number of seeds per pod, 100-seed weight, seed yield per plant, biological yield per plant, harvest index, seed volume and number of hard seeds.

The data recorded for various characters were statistically analyzed for the various parameters viz., genetic variability, genotypic and phenotypic correlation and path coefficient analysis. The analysis of variance for randomized block design (RBD) was done for each character as per Panse and Sukhatme (1985). The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) which measures themagnitude of phenotypic variation and genotypic variation present in a particular character was estimated as per the formula suggested by (5). Heritability in broad sense and genetic advance were calculated by using the formula suggested by (6).

Correlation coefficient is the measurement of relationship between two or more series of variables. The genotypic correlation coefficient provides a measure of genotypic association between different characters, while phenotypic correlation includes both genotypic as well as environmental influences. The phenotypic and genotypic correlation coefficients of all the pair of characters were worked out as per (7). Path coefficient is a standardized partial regression coefficient which measures the direct and indirect influence of one variable upon another thereby permitting the separation of the correlation coefficient into the components of direct and indirect effects. The path coefficient analysis was carried-out according to the method suggested by (8).

RESULTS AND DISCUSSION

Genetic variability is basic tool for crop improvement due to its wider scope for selection. Therefore, the effectiveness of selection depends upon the nature and magnitude of genetic variability present in the experimental material and the extent of its heritability. The present experimental material showed wide range of

Table 2 : Genotypic (rg) and phenotypic (rp) correlation coefficients among 12 characters in Chickpea.

Characters		Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of pods per plant	First pod bearing node	Number of seeds per pod	100-seed weight (g)	Biological yield per plant (g)	Harvest index (%)	Seed volume (ml/seed)
Seed yield per plant (g)	r_g	0.141	0.127	0.647**	-0.317	0.742**	0.256	0.059	0.019	0.535**	0.824**	0.048
	r_p	0.138	0.104	0.445*	-0.284	0.679**	0.241	0.043	0.019	0.498**	0.806**	0.047
Days to 50% flowering	r_g		-0.407*	0.445*	-0.467**	0.444*	0.678**	-0.059	0.208	0.259	-0.021	0.017
	r_p		-0.314	0.371*	-0.412*	0.381*	0.618**	-0.080	0.198	0.256	-0.022	0.031
Days to maturity	r_g			-0.165	0.494**	-0.150	-0.389*	-0.282	-0.123	0.281	-0.030	-0.155
	r_p			-0.037	0.434*	-0.113	-0.331	-0.272	-0.101	0.285	-0.058	-0.145
Plant height (cm)	r_g				-0.637**	0.746**	0.800**	0.123	0.544**	0.420*	0.454*	0.314
	r_p				-0.381*	0.517**	0.721**	0.051	0.388*	0.374*	0.244	0.226
Number of branches per plant	r_g					-0.188	-0.598**	0.105	-0.270	-0.011	-0.335	-0.047
	r_p					-0.171	-0.542**	0.069	-0.250	-0.006	-0.298	-0.053
Number of pods per plant	r_g						0.459*	-0.136	-0.001	0.379*	0.574**	0.119
	r_p						0.411*	-0.110	-0.001	0.360	0.481**	0.112
First pod bearing node	r_g							0.174	0.640**	0.440*	-0.037	0.313
	r_p							0.115	0.572**	0.400*	-0.033	0.292
Number of seeds per pod	r_g								0.022	0.092	0.127	0.216
	r_p								0.019	0.053	0.094	0.202
100-seed weight (g)	r_g									0.275	-0.179	0.649**
	r_p									0.274	-0.169	0.628**
Biological yield per plant (g)	r_g										-0.014	0.189
	r_p										-0.078	0.190
Harvest index (%)	r_g											-0.040
	r_p											-0.049

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

Table-3 : Genotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on seed yield in Chickpea.

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of pods per plant	First pod bearing node	Number of seeds per pod	100-seed weight (g)	Biological yield per plant (g)	Harvest index (%)	Seed volume (ml/seed)	Genotypic correlation with seed yield per plant (g)
Days to 50% flowering	-0.0583	0.0237	-0.0260	0.0272	-0.0259	-0.0395	0.0034	-0.0121	-0.0151	0.0012	-0.0010	0.1406
Days to maturity	0.0103	-0.0252	0.0042	-0.0125	0.0038	0.0098	0.0071	0.0031	-0.0071	0.0008	0.0039	0.1271
Plant height (cm)	0.0251	-0.0093	0.0564	-0.0359	0.0421	0.0608	0.0070	0.0307	0.0237	0.0256	0.0177	0.6472**
Number of branches per plant	0.0071	-0.0075	0.0097	-0.0153	0.0029	0.0091	-0.0016	0.0041	0.0002	0.0051	0.0007	-0.3167
Number of pods per plant	0.0381	-0.0128	0.0639	-0.0161	0.0857	0.0394	-0.0116	0.0000	0.0325	0.0492	0.0102	0.7420**
First pod bearing node	-0.0126	0.0072	-0.0200	0.0111	-0.0085	-0.0186	-0.0032	-0.0119	-0.0082	0.0007	-0.0058	0.2561
Number of seeds per pod	0.0045	0.0217	-0.0095	-0.0081	0.0104	-0.0134	-0.0769	-0.0017	-0.0070	-0.0098	-0.0166	0.0588
100-seed weight (g)	0.0066	-0.0039	0.0172	-0.0085	0.0000	0.0202	0.0007	0.0316	0.0087	-0.0057	0.0205	0.0191
Biological yield per plant (g)	0.1363	0.1481	0.2213	-0.0060	0.2001	0.2321	0.0483	0.1450	0.5273	-0.0071	0.0994	0.5352**
Harvest index (%)	-0.0157	-0.0227	0.3459	-0.2550	0.4375	-0.0279	0.0966	-0.1366	-0.0103	0.7621	-0.0305	0.8242**
Seed volume (ml/seed)	-0.0009	0.0079	-0.0159	0.0024	-0.0060	-0.0159	-0.0110	-0.0329	-0.0096	0.0020	-0.0508	0.0477

*, ** Significant at 5% and 1% levels, respectively, Residual effect, R = 0.0844, N.B.: Values at diagonal indicate direct effects of respective characters

phenotypic variation for harvest index, seed yield per plant, number of pods per plant, biological yield per plant, 100-seed weight and seed volume as revealed by high values of coefficient of range.

The estimate of genotypic and phenotypic coefficient of variability indicated that the values of phenotypic coefficient of variation were higher than genotypic coefficient of variation, in most of the cases, indicating more influence of environmental factors. The relative magnitude of difference between phenotypic coefficient of variation and genotypic coefficient of variation was low for days to maturity, seed volume, 100-seed weight and days to 50% flowering indicated that these characters were less influenced by the environments. Similar results were also reported by (9, 10). These findings suggested that selection can be effective on the basis of phenotype along with equal probability of genotypic values.

The highest genotypic coefficient of variation and phenotypic coefficient of variation was observed for seed yield per plant followed by harvest index, number of pods per plant and biological yield per plant. The high genotypic coefficient of variation indicated the presence of wide variation for the characters under study to allow selection for individual traits, the similar findings were also reported by (11). Moderate estimates of genotypic coefficient of variation and phenotypic coefficient of variation was observed for 100-seed weight, number of branches per plant and seed volume. While low estimates of GCV and PCV was observed for number of seeds per pod, first pod bearing node, days to 50 % flowering, plant height and days to maturity indicated narrow genetic variability for both these characters, similar results were also obtained by (13). While moderate GCV was also reported by (13) for number of branches per plant, 100-seed weight.

The knowledge of heritability of a character helps the plant breeder in predicting the genetic advance for any quantitative characters and aids in exercising necessary selection procedure. (5) suggested that genotypic coefficient of variation together with heritability estimate would give the best picture expected for selection.

The maximum heritability was observed for seed volume followed by seed yield per plant, 100-seed weight, number of pods per plant, biological yield per plant. High heritability for the characters which is controlled by polygenes might be useful to plant breeders for making effective selection. Similar results were also reported by (12). Moderate heritability estimates was observed for days to maturity, number of branches per plant, first pod bearing node, days to 50% flowering, harvest index and number of seeds per pod. Low heritability level for these traits suggested that environmental effects constituted a

Table-4 : Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on seed yield in Chickpea.

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of pods per plant	First pod bearing node	Number of seeds per pod	100-seed weight (g)	Biological yield per plant (g)	Harvest index (%)	Seed volume (ml /seed)	Phenotypic correlation with seed yield per plant (g)
Days to 50% flowering	**-0.0721**	0.0227	-0.0268	0.0298	-0.0275	-0.0446	0.0058	-0.0143	-0.0185	0.0016	-0.0022	0.1383
Days to maturity	-0.0042	**0.0132**	-0.0005	0.0057	-0.0015	-0.0044	-0.0036	-0.0013	0.0038	-0.0008	-0.0019	0.1036
Plant height (cm)	-0.0183	0.0018	**-0.0492**	0.0188	-0.0254	-0.0355	-0.0025	-0.0191	-0.0184	-0.0120	-0.0111	0.4449*
Number of branches per plant	0.0074	-0.0078	0.0068	**-0.0179**	0.0031	0.0097	-0.0012	0.0045	0.0001	0.0053	0.0009	-0.2839
ightNumber of pods per plant	0.0434	-0.0128	0.0588	-0.0195	**0.1139**	0.0468	-0.0125	-0.0001	0.0410	0.0548	0.0128	0.6790**
First pod bearing node	0.0610	-0.0327	0.0712	-0.0535	0.0406	**0.0987**	0.0114	0.0565	0.0392	-0.0032	0.0288	0.2406
Number of seeds per pod	0.0041	0.0139	-0.0026	-0.0035	0.0056	-0.0059	**-0.0513**	-0.0010	-0.0027	-0.0048	-0.0104	0.0428
100-seed weight (g)	0.0020	-0.0010	0.0040	-0.0026	0.0000	0.0059	0.0002	**0.0102**	0.0028	-0.0017	0.0064	0.0192
Biological yield per plant (g)	0.1334	0.1480	0.1947	-0.0031	0.1872	0.2064	0.0278	0.1423	**0.5202**	-0.0404	0.0988	0.4981**
Harvest index (%)	-0.0173	-0.0469	0.1964	-0.2399	0.3872	-0.0261	0.0760	-0.1361	-0.0625	**0.8052**	-0.0392	0.8057**
Seed volume (ml/seed)	-0.0011	0.0052	-0.0081	0.0019	-0.0040	-0.0104	-0.0072	-0.0224	-0.0068	0.0017	**-0.0357**	0.0473

*, ** Significant at 5 % and 1% levels, respectively, Residual effect, R = 0.1420, N.B.: Values at diagonal indicate direct effects of respective characters

major portion of total phenotypic variation and hence direct selection for these characters would be less effective. Similar results were also reported by (13). The estimate of heritability was low for plant height. Similar results were also reported by for number of branches per plant.

The maximum genetic advance as per cent of mean was observed for seed yield per plant followed by harvest index, number of pods per plant, biological yield per plant and 100-seed weight which illustrated that they could be improved to a large extent the similar findings also reported by (9). In the present study, seed volume, number of branches per plant, number of seeds per pod and first pod bearing node showed moderate genetic advance through selection. These results are in conformity with those of (14). The value of genetic advance as per cent of mean was low for days to 50% flowering, plant height and days to maturity (10).

(15) suggested that the heritability estimate along with genetic advance is more useful than the heritability alone in predicting the resultant effect of selection. In the present study, the estimates of high heritability coupled with high genetic advance as per cent of mean was observed for seed yield per plant, harvest index, number of pods per plant, biological yield per plant and 100-seed weight which may be contributed to the preponderance of additive gene action and selection pressure could profitably be applied on these characters for improving the seed yield (13). High to moderate estimates of heritability coupled with low genotypic coefficient of variation and genetic gain were expressed by days to 50% flowering, days to maturity and plant height. These results are in conformity with those of (16). It may be inferred that these three traits were regulated by non-additive gene action and presence of high genotype x environment interaction (Table-1).

CORRELATION

The different components of yield very often exhibit considerable degree of association among themselves and with seed yield. Yield is a complex character and the multiplicative end product of many quantitative traits (17). Therefore, selection for yield *per se* will not be desirable. 18) suggested that the average merit of a character in a population could be changed by means of selection programme based on phenotype of the main trait concerned. However, such an improvement would be more reliable if indirect selection based on another trait correlated with it is made. Thus, for rational improvement of yield and its components, the understanding of correlation has been observed very useful.

In the present investigation, most of the character

pairs had higher values of genotypic correlations their corresponding phenotypic correlations (Table-2). Such high amount of genotypic correlations could result due to masking or modifying effect of environmental on the association of characters. This indicates that though there was high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. It was also indicated that there was inherent relationship between the characters studied which is in agreement with the findings of (19). On the contrary, the phenotypic correlation coefficients of seed yield with 100-seed weight were higher than their genotypic correlation coefficients which might be due to the non- genetic causes probably environment inflated the value of phenotypic correlation and these attributes have also been reported in chickpea by several researchers (19).

The study of genotypic correlation coefficient indicates the extent of relationship between different variables. This relationship among yield contributing characters as well as their association with yield provides information for exercising selection pressure for bringing genetic improvement in seed yield. In the present study, seed yield per plant was found to be highly significant and positively correlated with plant height, number of pods per plant, biological yield per plant and harvest index at both the genotypic and phenotypic levels indicating that these attributes were more influencing the seed yield in chickpea and therefore, were important for bringing improvement in seed yield. (15) emphasized that these correlated yield attributes can serve as indicator characters for improving seed yield. They have further emphasized that such improvement depends not only on genotypic correlations but phenotypic correlations also play an important role. Such positive interrelationships between seed yield and these attributes have also been reported in chickpea by several researchers (16). Days to 50% flowering, days to maturity, first pod bearing node, number of seeds per pod, 100-seed weight and seed volume had positive but non-significant association with seed yield per plant at both levels as also reported by (20). Likewise, seed yield showed negative and non-significant correlations with number of branches per plant at both levels. These attributes have also been reported in chickpea by (21).

Days to 50% flowering had highly significant and positive association with first pod bearing node. Days to 50% flowering had significant and positive association with plant height and number of pods per plant at both genotypic as well as phenotypic level and are of an important component in identifying and deciding the duration of the crop. Both these traits *i.e*. days to 50% flowering and days to maturity were also found to have positive interrelationship with biological yield per plant at genotypic level and phenotypic level. This relationship indicated that the improvement in one will bring the improvement in another which, in turn, automatically lead to increase in seed yield. This confirms the earlier findings of (9). Days to 50% flowering had significant but negative correlation with days to maturity at genotypic level, number of branches per plant at both levels. These results are of special significance as they suggest that selection for early flowering is also likely to provide strains with higher number of branches per plant. Similar result was obtained by (22). Days to maturity had significant and positive correlation with number of branches per plant at both levels.

Plant height had significant and positive correlation with number of pods per plant, first pod bearing node, 100-seed weight, and biological yield per plant at both genotypic level. Which were in accordance with the findings of (9) in chickpea. Number of branches per plant had highly significant and negative association first pod bearing node. Similar result was obtained by (9). Significant and positive association of number of pods per plant was observed with first pod bearing node and harvest index at both levels and with biological yield per plant at genotypic level while first pod bearing node had significant and positive association with 100-seed weight and biological yield per plant. Number of seeds per pod had non-significant and positive association with 100-seed weight, biological yield per plant, harvest index and seed volume. Likewise, 100-seed weight had highly significant and positive association with seed volume at both levels. Biological yield per plant had negative and non-significant association with harvest index. Similar results were obtained by (21).

Thus, the results revealed that the plant height, number of pods per plant, harvest index and biological yield per plant were the most important attributes which contributed towards higher yield. Therefore, more emphasis should be given to these components during selection for higher yield.

Path coefficient : A complex situation before a plant breeder is to select high yielding cultivars, which is a polygenic trait influenced by various components directly or indirectly. Consequently, path coefficient analysis could provide the more realistic picture of the interrelationship as it considers direct as well as indirect effects of the variables by partitioning the correlation coefficient.

The genotypic and phenotypic path coefficient analysis revealed that biological yield per plant and

harvest index exhibited high and positive direct effects on seed yield per plant (Table-3 and 4). Both these characters turned out to be the major component of seed yield. The characters like plant height, number of pods per plant and 100-seed weight exerted positive but low direct effect towards seed yield per plant while, maximum and positive direct effects of biological yield per plant and harvest index were also reported by Thakur and Sirohi (2009) and Jivani *et al.* (2013). The residual effect was of low magnitude suggesting that the majority of the yield attributes have been included in the path analysis.

The positive direct effects of plant height, number of pods per plant and 100-seed weight were further supplemented by their positive indirect effects via biological yield per plant thus, giving rise to positive association of these traits with seed yield. Similar results were obtained by Jivani *et al*. (2013).

Days to 50% flowering, days to maturity, number of branches per plant, first pod bearing node, number of seeds per pod and seed volume expressed negative direct effects of low magnitude on seed yield. However, among these six traits, days to 50% flowering, days to maturity, first pod bearing node, number of seeds per pod and seed volume had positive association with seed yield, because of the cumulative minor positive indirect effects via rest of the characters at both levels. The negative direct effect of low magnitude of days to 50% flowering was nullified by low and positive indirect effects of number of branches per plant and days to maturity. Similar results were obtained by Dasgupta *et al*. (1992). Similarly, the negative direct effect of low magnitude of seed volume was nullified by low and positive indirect effects of days to maturity, number of branches per plant and harvest index at both levels.

It was apparent from the both path analysis that higher direct effects as well as appreciable indirect influences were exerted by biological yield per plant and harvest index towards seed yield per plant. These two characters also exhibited significant and positive association with seed yield per plant and hence, these may be considered as most important yield contributing characters and due emphasis should be placed on these components while breeding for high seed yield in chickpea. Similar results were obtained by Singh *et al*. (1995).

It can also be concluded that the characters which are most important for correlation studies are also important for path analysis. Thus, it can be suggested that correlation and path analysis study should be consider together for rapid gain for final improvement in seed yield.

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