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Phenotypic and Genotypic Path Coefficient Analysis Studies in Chickpea (*Cicer arietinum* L.)

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ABSTRACT

Keywords

Phenotypic, Genotypic, Path coefficient analysis, Chickpea

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The present investigation entitled, Phenotypic and Genotypic path coefficient analysis Studies in Chickpea (*Cicer arietinum* L.) was conducted at Agricultural Research Station, Badnapur, Dist- Jalna (VNMKV, Parbhani) (M.S.) during *Rabi* season of 2019-20. The exploration of genetically variable accession or genotypes is the key source of germplasm conservation and potential breeding material for the future use. The highly divergence group of cultivars provides an opportunity to breeders for developing superior and new varieties considering their quality traits for direct commercial utilization. Assessment of genetic diversity existing in and within germplasm groups for yield and its components to obtained superior recombinants which will helpful in understanding pattern of variation was performed utilizing the thirty six genotypes and four standard checks of chickpea replicated twice. To study the nature and magnitude of genetic divergence using Mahalanobis (1936) D2 statistics, phenotypic variances, coefficient of variation, heritability, genetic advance, correlation coefficient and path coefficient was estimated and cluster analysis was performed.

Introduction

Chickpea (*Cicer arietinum* L.) belongs to the genus Cicer, family-leguminaceae. Chickpea is the self pollinated pulse crop having chromosome number 2n=14. Among the pulses, chickpea is important *Rabi* crop of India. It occupies the first position among the pulses grown in the country with maximum acreage and production in the world. In grain legumes, protein are an important seed component and are responsible for their relevant nutritional socio-economic importance. The chickpea seed is a good source of proteins and carbohydrate, which together constitute 80 % of the total dry weight of seed. Pulses occupy unique position in Indian Agriculture because of their characteristics of maintaining and restoring soil fertility, besides high nutritive value. Pulses restore soil fertility through biological nitrogen fixation with the help of symbiotic bacteria *Rhizobium* in roots. Hence it fixes the high amount of nitrogen through environment. Among the pulses, chickpea is important *Rabi* crop of India. It occupies the first position among the pulses grown in the country with maximum average acreage and production.

India, a major pulse producing country, accounts roughly 33% of the total world production. Pulses are grown both during *Kharif* and *Rabi* seasons. Among the pulse, the chickpea is a important *Rabi* pulse crop of the India. Among all pulses chickpea contributes 36% area and 46% production in year 2017-2018. During 2017-2018 estimated area and production of chickpea in Maharashtra state is 18.92 lakh ha and 17.61 lakh tons respectively. In Maharashtra, the highest chickpea was grown on 19.29 lakh ha with the highest production of 19.41 lakh tones during 2016-17. The productivity was highest during 2016-2017 (1006kg/ha).

In India percentage of area is increased upto 10.82% during year 2017-18 as compared to previous year while percentage of area decreased by 4.28% in Maharashtra. Maharashtra is having 14.57% contribution in the area with 13.51% production share in the nation. Madhya Pradesh state is having the highest area of 35.91 lakh ha, production 45.89 lakh tons and productivity 1279 kg/ha during the year 2017-2018. During 2017-18, the area in Maharashtra was 20 lakh ha with production of 17.59 lakh tons and productivity is 882 kg/ha (Anonymous 2017).

In year 2018-19, Maharashtra was having 13.13 lakh ha area with production of 9.86 lakh tons productivity and 752 kg/ha is while Marathwada region is having 4.87 (36.21%) lakh ha area under chickpea, 2.88 (34.94%) tons production and 630 kg/ha productivity. In India chickpea is exported to countries like Algeria, Saudi Arab and Sri Lanka, Pakistan, Arab EMTS, gulf countries and however it is imported from Tanzania, USA Australia, Russia, and Canada (Annonymous, 2018-19).

In year 2019-20, India was having 106 lakh ha area with production of 111 lakh tons with productivity1056 kg/ha while Maharashtra was having area 20.38 lakh ha with the production of 17.29 lakh tones and having productivity 848.55 kg/ha. Maharashtra occupying area about 19.22%, production 15.57%. While Marathwada having 10.59 lakh ha area with the production of 7.96 lakh tones with the productivity of 760.54 kg/ha (Annonymous, 2019-20).

Generally, plant breeders select the parents on the basis of phenotypic divergence, but for effective breeding, the knowledge of genetic diversity among the parents with respect to the particular characters which are to be improved is essential. Plant genetic resources or gene pool are the basis for global food security. They contain diversity of genetic material in traditional varieties, modern cultivars, currently cultivated varieties and crop wild relatives.

Mahalanobis's (1936) reported that D2 statistics is a powerful tool for estimating the divergence between two populations. Many studies based on D^2 technique also indicated that geographical isolation is not necessarily related to genetic diversity. It thus gives better idea about the magnitude of genetic divergence and is independent of size of sample and provides the basis for selection of parental lines for further breeding programme for improving particular character.

Genetic variation for traits is important in breeding programmes for selecting desirable genotypes from population. On the other hand, an analysis of the correlation between seed yield and yield components is essential for determining selection criteria of a particular character. Path coefficient analysis may useful to determine the direct effect of traits and their indirect effects on other traits.

In plant breeding, correlation coefficient analysis measures the mutual relationship between various variables and determines the component characters on which selection can be based for genetic improvement in yield. Correlation coefficient is a statistical measure which is used to find out the degree (strength) and direction of relationship between two or more variables. The genotypic and phenotypic paths are commonly estimated to determine yield contributing characters which are mostly useful for plant breeders and geneticists in selection of elite genotypes from diverse genetic population for further improvement.

Genetic diversity among parents, which is heritable, is a pre-requisite for any successful breeding programme. The proper choice of the parents in the breeding programme is very importance in further study. Generally plant breeder selects the parents on the basis of phenotypic divergence, but for effective breeding, the knowledge of genetic diversity amongst the parents with respect to the characters which are to be improved is essential. The association of one or more characters influenced by a large number of genes is elaborated statistically by correlation coefficients. Genotypic correlation coefficient provides a measure of genotypes conjugation between characters. The method of partitioning the correlation into direct and indirect effects by path coefficients analysis was suggested by Sewall Wright (1921). It provides useful information on the relative merits and demerits of the traits in the selection criteria.

Materials and Methods

The present investigation entitled, Genetic Divergence Studies in Chickpea **(***Cicer arietinum* L.) was conducted at Agricultural Research Station, Badnapur, during *Rabi* season of 2019-20.

Experimental material comprising 40 germplasm lines with wider variability for different characters will be studied including 4 checks (2 from ICRISAT and 2 from ARS Badnapur) at ARS Badnapur. Out of 40 genotypes 36 with 2 checks from ICRISAT, Hyderabad, And 2 checks from ARS, Badnapur. The list of genotypes is given in Table 1.

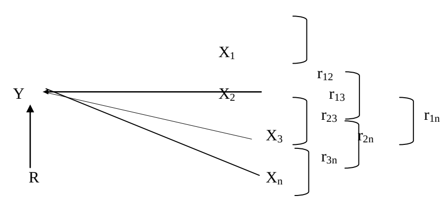
Experimental design

Thirty six genotypes of chickpea along with four standard checks *viz.* Akash (BDNG-797), Digvijay, NBeG-47, JG (16) were evaluated in randomized block design with two replications during *Rabi* season of 2019-20. Each genotype was sown in four rows of 4 m length with spacing of 30 cm between rows and 10 cm within rows.

Path coefficient analysis

To establish a cause and effect relationship the first step used was to partition genotypic and phenotypic correlation coefficient into direct and indirect effects by path analysis as suggested by Dewey and Lu (1959) and developed by Wright (1921).

The second step in path analysis is to prepare path diagram based on cause and effect relationship. In the present study, path diagram was prepared by taking yield as the effect i.e. function of various components like X_1, X_2, X_3 and these component showed following type of association with each other.



In path diagram the yield is the result of X_1, X_2, X_3 ……..Xn and some other undefined factors designated by R. The double arrow lines indicated mutual association as measured by correlation coefficient. The single arrow represents direct influence as measured by path coefficient P_{ij}.

Path coefficients were obtained by solving a set of simultaneous equation of the form as per Dewey and Lu (1959).

$r_{ny} = P_{ny} + r_{n2} P_{2y} + r_{n3} P_{3y} + \ldots\ldots\ldots\ldots$

Where,

r_{ny} = represents the correlation between one component and yield
P_{ny} = represents path coefficient between that character and yield
r_{n2} = represents correlation between that character and each of the other components in turn.

Matrix A — Matrix B

$$\begin{pmatrix} r_{1y} \\ r_{2y} \end{pmatrix} = \begin{pmatrix} r_{11} & r_{12} & r_{13} \ldots\ldots r_{1n} \\ r_{21} & r_{22} & r_{23} \ldots\ldots r_{2n} \end{pmatrix} \begin{pmatrix} P_{1y} \\ P_{2y} \end{pmatrix}$$

r_{ny} r_{n1} r_{n2} r_{n3} ……1 P_{ny}

Where,

$r_{12} = r_{21}$ and so on
r_{1y} = Correlation between one component character and seed yield

The ‘B’ matrix was inverted $[B]^{-1}$ and path coefficients (Pij) were obtained as,

i.e. $Pij = (B)^{-1}.A$

The indirect effects of a particular character through other characters were obtained by multiplication of direct paths and particular correlation between these characters separately.

Indirect effects = $r_{ij} \times p_{iy}$

Where,

i = 1 to 9
j = 1 to 9
$P_{iy} = P_{1y}, P_{2y}, \ldots\ldots\ldots\ldots, P_{ny}$

Path coefficient (P_{ij}), correlation coefficient (r_{ij}) and residual factors (R) were diagrammatically presented. The residual factor i.e. variation in yield unaccounted for by these associations was calculated with the following formula:

Residual factor (R) = $(1 - R^2)$

Where,

$R^2 = P_{1y} r_{1y} + P_{2y} r_{2y} + \ldots\ldots\ldots\ldots + P_{ny} r_{ny}$

$P_{1y}, P_{2y}, \ldots\ldots, P_{ny}$ = Direct path values
r_{1y}, r_{2y}, r_{ny} = Correlation coefficient.

Results and Discussion

To find out the direct and indirect contribution from each of the character towards seed yield per plant, path coefficient analysis was carried out. The phenotypic and genotypic correlation coefficients being more important are only partitioned to direct and indirect effects which are presented in Table 2 and 3. Phenotypic and genotypic path diagrams are given in figure 1.

Direct effect

Among all the components, number of pods per plant (p=0.6197), exhibited the highest direct effect on seed yield followed by number seeds per pod (p=0.3274), 100 seed weight (p=0.2979), number of secondary branches per plant (p=0.2839), primary branches (p=0.0479) and harvest index (p=0.0371) while plant height (p=-0.0108), days to maturity (p=-0.0505), days to 50% flowering (p=-0.0888) recorded negative direct effect at phenotypic level.

At genotypic level days to 50% flowering (g=2.5584) exhibited the highest positive direct effect on seed yield followed by number of pods per plant (g=0.6068), 100 seed weight (g=0.3619), number of seeds per pod (g=0.3489) and harvest index (g=0.0337) while number of primary branches per plant (g=-0.0119), plant height (g=-0.0379), initial plant stand (g=-0.1743), secondary branches per plant (g=-0.1784) and days to maturity (g=-0.1801) negative direct effect by genotypic level.

Indirect effect

Initial plant stand

Initial plant stand had significant negative phenotypic and genotypic correlation (p=-0.1535; g=-01743) with seed yield per plant. and negative indirect effect through of number of pods per pod (p=-0.0021; g=-0.0129), number of secondary branches (p=-0.0026 g=0.0662) seeds per pod (p=-0.0033; g=0.0022), plant height (p=-0.0051; g=-0.0289), days to maturity (p=-0.0056; g=-0.0154), days to 50% flowering (g=-00071; g=-0.5366), harvest index (p=-0.0092; g=-0.0476), 100 seed weight (p=-0.0094; g=-0.0506).

Days to 50%flowering

Days to 50% flowering had significant negative phenotypic and positive genotypic correlation (p=-0.0888; g=2.5584) with seed yield per plant. It exhibited positive indirect effects through days to maturity (p=0.237), plant height (p=0.102), number of seeds per pod (p=0.0098), number of secondary branches (p=0.0038) positive indirect effect through harvest index (g=0.1050), initial plant stand (g=0.1275) and primary branches per plant (g=0.0057) at genotypic level. Negative indirect effect through of pods per plant (p=-0.0021; g=-0.0298), harvest index (p=-0.0075), initial plant stand (p=-0.0122), primary branches per plant (p=-0.0131) followed by 100 seed weight (p=-0.0236; g=-0.0632) at both phenotypic and genotypic level. Thus these indirect causal factors are to be considered during selection process for improving seed yield per plant.

Days to maturity

Days to maturity had negative direct phenotypic and genotypic correlation (p=-0.0505; g=-0.1804) with seed yield per plant. It exhibited positive indirect effects through days to 50% flowering (p=0.008; g=0.4951), number of seed per pod (p=0.0005; g=0.0163), plant height (p=0.0001; g=0.0055), and negative indirect effect through number of pods per plant (p=-0.0001; g=-0.0113), initial plant stand (p=-0.0003; g=-0.0109), harvest index (p=-0.0004; g=-0.01561), number of primary branches per plant (p=-0.0004; g=-0.0173) followed by number of secondary branches per plant (p=-0.0007; g=-0.0361), at both phenotypic and genotypic level in the decreasing order of their magnitude.

Plant height

Number of primary branches per plant showed negative direct phenotypic and genotypic correlation (p=-0.0108; g=0.-0.0379) with seed yield per plant. It has positive indirect effect *via* initial plant stand (p=0.0040), 100 seed weight (p=0.0015), number of seeds per pod (p=0.0001) at phenotypic level and harvest index (p=0.00015; g=0.0015) at both phenotypic and genotypic level also show positive indirect effect through days to 50% flowering (g=0.0494), number of primary branches per plant (g=0.0210), days to maturity (g=0.0036), number of secondary branches (g=0.0173) at genotypic level. Negative indirect effect through days to 50% flowering (p=-0.0047), days to maturity (p=-0.0018), number of secondary branches (p=-0.0099) at both phenotypic level in the decreasing order of their magnitude. Number of pods per plant (g=-0.0039), 100 seed weight (g=-0.0024) Followed by initial plant stand (g=-0.0134) at genotypic level of magnitude.

Number of primary branches per plant

Number of primary branches per plant had positive phenotypic correlation (p=0.0479) and negative genotypic correlation (g=-0.0119) with seed yield per plant. It showed positive indirect effects at both phenotypic and genotypic level through plant height (p=0.0132; g=0.123). Number of secondary branches per plant (p=0.0152), initial plant stand (p=0.0104), number of pods per plant (p=0.0061), number of seeds per pod (p=0.003) shows the positive indirect correlation at phenotypic level. 100 seed weight (g=0.0195), harvest index (g=0.013), days to 50% flowering (g=0.0120) positive indirect effect by genotypic correlation. It showed negative indirect effects at phenotypic level through days to maturity (p=-0.0053), days to 50% flowering (p=-0.0062), harvest index (p=-0.0076), 100 seed weight (p=-0.0119).

Table.1 List of forty genotypes of chickpea

Sr. No.	Genotypes	Sr. No.	Genotypes
1.	ICCV181601	21	ICCV181101
2.	ICCV181602	22	ICCV181102
3.	ICCV181603	23	ICCV181103
4.	ICCV181604	24	ICCV181104
5.	ICCV181605	25	ICCV181105
6.	ICCV181606	26	ICCV181106
7.	ICCV181607	27	ICCV181107
8.	ICCV181608	28	ICCV181108
9.	ICCV181609	29	ICCV181109
10.	ICCV181610	30	ICCV181110
11.	ICCV181611	31	ICCV181111
12.	ICCV181612	32	ICCV181112
13.	ICCV181613	33	ICCV181113
14.	ICCV181664	34	ICCV181114
15	ICCV181667	35	ICCV181115
16	ICCV181668	36	ICCV181116
17	ICCV181673	37	ICCV181117
18	ICCV181674	38	ICCV181118
19	NBe G 47 (Ch)	39	JG 16 (Ch)
20	BDNG 797 (Ch)	40	DIGVIJAY (Ch)

Table.2 Direct and indirect effect of yield and its component characters on grain yield at phenotypic level

Sr. No.	Characters	Initial plant stand	Days to 50 % flowering	Days to maturity	Plant height	Number of primary branches per plant	Number of secondary branches per plant	Number of pods per plant	Number of seeds per pod	100 seed weight	Harvest index	Total phenotypic correlation with seed yield / plant
1.	Initial plant stand	**0.0470**	-0.0071	-0.0056	-0.0051	0.0129	-0.0026	-0.0021	-0.0033	-0.0094	-0.0092	**-0.1535**
2.	Days to 50 % flowering	-0.0122	**0.0802**	0.0237	0.0102	-0.0131	0.0038	-0.0021	0.0098	-0.0236	-0.0075	**-0.0888**
3.	Days to maturity	-0.0003	0.0008	**0.0028**	0.0001	-0.0004	-0.0007	-0.0001	0.0005	0.0000	-0.0004	**-0.0505**
4.	Plant height	0.0040	-0.0047	-0.0018	**-0.0372**	-0.0130	-0.0099	0.0014	0.0001	0.0015	0.0015	**-0.0108**
5.	No. of primary branches per plant	0.0104	-0.0062	-0.0053	0.0132	**0.0379**	0.0152	0.0061	0.0033	-0.0119	-0.0076	**0.0479**
6.	No. of secondary branches per plant	-0.0131	0.0112	-0.0588	0.0630	0.0955	**0.2377**	0.0716	0.0015	-0.0602	-0.0414	**0.2839**
7.	Number of pods per plant	-0.0300	-0.0181	-0.0288	-0.0259	0.1101	0.2055	**0.6826**	0.1444	-0.1751	-0.2059	**0.6197**
8.	Number of seeds per pod	-0.0175	0.0303	0.0408	-0.0006	0.0213	0.0016	0.0524	**0.2478**	-0.0220	-0.0417	**0.3274**
9.	100 seed weight	-0.1088	-0.1594	0.0092	-0.0219	-0.1696	-0.1373	-0.1391	-0.0481	**0.5423**	0.1801	**0.2979**
10	**Harvest index**	**-0.0331**	**-0.0157**	**-0.0267**	**-0.0067**	**-0.0337**	**-0.0294**	**-0.0510**	**-0.0284**	**0.0562**	**0.1691**	**0.0371**

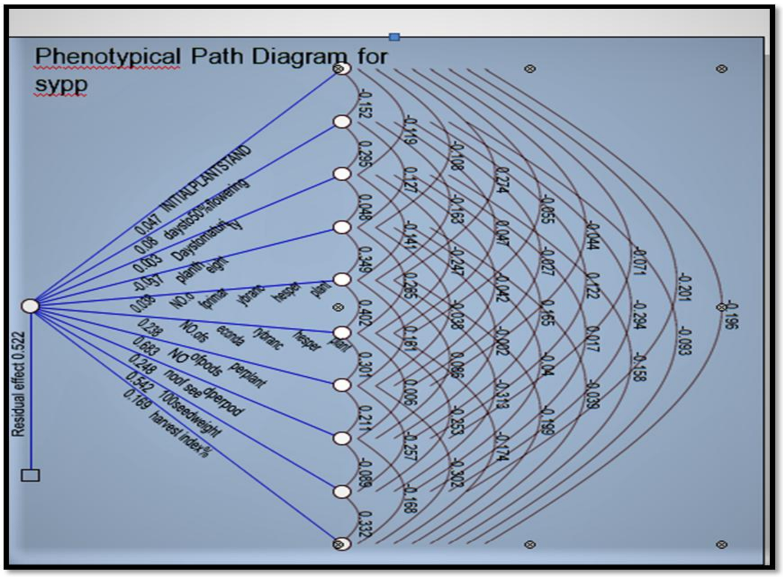
Residual effect = 0.5233, Underlined figures indicate direct effect

*, ** indicates significant at 5 and 1 % level of significant respectively

Table.3 Direct and indirect effect of yield and its component characters on grain yield at genotypic level

Sr. No.	Characters	Initial plant stand	Days to 50 % flowering	Days to maturity	Plant height	No. of primary branches per plant	No. of secondary branches per plant	No. of pods per plant	No. of seeds per pod	100 seed weight	Harvest index	Seed yield / plant
1.	Initial plant stand	**0.1213**	-0.5366	-0.0154	-0.0289	0.0662	0.0148	-0.0129	0.0022	-0.0506	-0.0476	**-0.1743**
2.	Days to 50 % flowering	0.1275	**-0.0288**	-0.1671	-0.0253	0.0057	-0.0018	-0.0298	-0.0523	-0.0632	0.1050	**2.5584**
3.	Days to maturity	-0.0109	0.4951	**0.0854**	0.0055	-0.0173	-0.0361	-0.0113	0.0163	0.0052	-0.0156	**-0.1804**
4.	Plant height	-0.0134	0.0494	0.0036	**0.0562**	0.0210	0.0173	-0.0039	-0.0004	-0.0024	-0.0015	**-0.0379**
5.	No. of primary Branches plant	-0.0331	0.0120	0.0123	-0.0227	**-0.0606**	-0.0235	-0.0082	-0.0065	0.0195	0.0133	**-0.0119**
6.	No. of sec. branches / plant	-0.0252	0.0125	-0.0869	0.0635	0.0798	**0.2058**	0.0556	-0.0027	-0.0540	-0.0362	**-0.1784**
7.	No. of pods per plant	-0.0788	0.7661	-0.0976	-0.0521	0.1002	0.2004	**0.7410**	0.1784	-0.1827	-0.2402	**0.6068**
8.	No. of seeds per pod	0.0052	0.5328	0.0562	-0.0021	0.0315	-0.0038	0.0706	**0.2935**	-0.0279	-0.0552	**0.3489**
9.	100 seed weight	-0.2890	1.5198	0.0422	-0.0300	-0.2226	-0.1820	-0.1709	-0.0659	**0.6931**	0.2393	**0.3619**
10.	**Harvest index**	**-0.0284**	**-0.2638**	**-0.0132**	**-0.0019**	**-0.0159**	**-0.0128**	**-0.0235**	**-0.0136**	**0.0250**	**0.0725**	**0.0337**

Fig.1 Diagram showing the phenotypic path correlation of yield and its component characters of Chickpea



Number of secondary branches per plant

Number of secondary branches per plant had positive phenotypic correlation (p=0.2839) and Negative genotypic correlation (g=-0.1781) with seed yield per plant. It showed positive indirect effects through number of primary branches per plant (p=0.0955; g=0.0798), number of pods per plant (p=0.0716; g=0.0556), plant height (p=0.0630; g=0.0635), days to 50 % flowering (p=0.0112; g=0.0125), number of seeds per pod (p=0.0015). It showed negative indirect effect through initial plant stand (-0.0131; g=-0.0252), harvest index (p=-0.0414; g=-0.30362) days to maturity (p=-0.0588; g=-0.0869), and 100 seed weight (p=-0.0602; g=0.1827) at phenotypic level and genotypic level.

Number of pods per plant

Number of pods per plant had positive phenotypic and genotypic correlation (p=0.6197; g=0.6068) with seed yield per plant. It displayed positive indirect effect through number of secondary branches per plant (p=0.2055; g=0.2004), number of seeds per pod (p=0.1444; g=1784), number of primary branches per plant (p=0.1101; g=0.1002) at phenotypic level and genotypic level. It showed negative indirect effect through plant height cm (p=-0.0259; g=-0.0521), days to maturity (p=-0.0288; g=-0.0976), initial plant stand (p=-0.0300; g=-0.0788), 100 seed weight (p=-0.1771; g=-0.1827) and harvest index (p=-0.2059; g=-0.2402). Days to 50% flowering (p=-0.0181) show negative indirect effect at phenotypic level.

Number of seeds per pod

Number of seeds per pod had positive phenotypic and genotypic correlation (p=0.3274; g=0.3489) with seed yield per plant. Number of pods per plant (p=0.0524; g=0.0706), days to maturity (p=0.0408; g=0.0562), days to 50% flowering (p=0.0303; g=0.5328), number of primary branches per plant (p=0.0213; g=0.0315) number of secondary branches per plant (p=0.0016) showed positive indirect effect at both phenotypic and genotypic level. Days to maturity (g=0.0562) show positive indirect effect on genotypic level. Plant height (p=-0.0006; g=-0.0021), initial plant stand (p=-0.0175), 100 seed weight (p=-0.0220; g=-0.0279) and harvest index (p=-0.0417; g=0.0552) it show negative indirect effect at phenotypic level and genotypic level.

100 seed weight

100 seed weight had positive phenotypic and genotypic correlation (p=0.2979; g=0.0.3619) with seed yield per plant. It showed positive indirect effect through harvest index (p=0.1801; g=0.2393), days to maturity (p=0.0092; g=0.0422), at both phenotypic and genotypic level. And days to 50% flowering (g=1.5198) and show positive indirect level on genotypic level. Plant height (p=-0.0219; g=-0.0300), number of seeds per pod (p=-0.0481; g=-0.0659), initial plant stand (p=-0.1088; g=-0.2890) number of secondary branches per plant (p=-0.1373; g=-0.1820), number of pods per plant (p=-0.1391; g=-0.1709) showed negative indirect effect through both at phenotypic and genotypic level.

Harvest index

Harvest index had positive phenotypic and genotypic correlation (p=0.0371; g=0.0337) with seed yield per plant. It exhibited positive indirect effect through 100 seed weight (p=0.0562; g=0.0250) at phenotypic and genotypic level. Plant height (p=-0.0067; g=-0.0019), days to 50% flowering (p=-0.0157; g=-0.2638), days to maturity (p=-0.0267; g=-0.0132), number of seeds per pod (p=-0.0284; g=-0.0136), number of secondary branches per plant (p=-0.0294; g=-0.0128), initial plant stand (p=-0.0331;g=-0.0284), number of primary branches per plant (p=-0.0337; g=-0.0159) and number of pods per plant (p=-0.0510; g= -0.0235) show indirect negative effect at both phenotypic and genotypic level.

In conclusion the path coefficient analysis indicated that the characters *viz.*, harvest index, number of pods per plant, 100 seed weight, number of secondary branches per plant, primary branches per plant and days to 50% flowering showed positive direct effect on seed yield. Hence, the selection of genotypes based on these characters as selection criterion would be helpful in improving the seed yield potential of chickpea.

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