



## Induced chemical mutagen in m1 generation of chickpea (*Cicer arietinum* L.)

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### Abstract

An experiment was conducted to assess genetic variability in mutagenic population through induced chemical mutagen on three chickpea genotypes of different concentrations of sodium azide (0.01, 0.02, 0.04, 0.06, 0.08) along with control were evaluated on 11 quantitative characters in M1 generation of chickpea. Among 18 mutant lines highest seed yield was recorded in 0.08 concentration of BRC-1055-155 coupled with early days to 50% flowering, plant height, number of secondary branches per plant, number of pods per plant, maximum number of effective pods, biological yield and harvest index. The high estimates of GCV and PCV was recorded in number of effective pods per plant coupled with high heritability, high genetic advance and high genetic advance as percent mean. Grain yield indicated significant positive correlation with biological yield in both phenotypic and genotypic correlation co-efficient. Path co-efficient analysis showed positive significant direct effects on grain yield was exhibited by biological yield, seed index, harvest index, number of effective pods per plant, number of pods per plant and number of secondary branches per plant at both genotypic and phenotypic level. Treatment with sodium azide seems to be more effective in seed yield, biological yield and number of effective pods per plant in M1 generation. This concludes that sodium azide was found to be effective in inducing genetic variability and it can be considered for further selection, improvement and development of yield characters in chickpea.

**Keywords:** induced mutation, sodium azide, m1 generation, chickpea, genetic variability, gcv, pcv, heritability, genetic advance, correlation co-efficient analysis, path co-efficient analysis

### Introduction

Among pulses chickpea is an important bean crop during rabi season. Chickpea is an autogamous diploid ( $2n=16$ ) legume. It belongs to family Fabaceae sub-family Papilionoideae. The genus *Cicer* includes 43 species, nine of which are annual, 33 are perennial and one with unspecific life cycle. Chickpea is a self-pollinating legume that requires a cool climate during its initial growth period- with optimum temperatures ranging between 15°C and 25°C, and a warmer climate as it matures (Singh and Ali, 2003). Chickpea a good source of carbohydrates and proteins, which together constitutes about 80% of the total dry seed mass. The starch content of chickpea Cultivars has been reported to vary from 41% to 50%. The crude protein content of chickpea where is from 12.4 to 31.5 percent. Chickpea contains about 6% fat which is important in vegetarian diets. The protein quality is considered to be better than other pulses (Hirdyani, 2014) [9]. Mutations have played a great role in increasing world food security, since new food crop varieties embedded with various induced mutations have contributed to the significant increase of crop production (Kharkwal and Shu, 2009) [14]. Crop improvement programme through induced mutations were initiated in mid-nineteen fifties in India with the aim of generating morphological variations. Sodium azide ( $\text{NaN}_3$ ) is a chemical mutagen and

has been one of the most powerful mutagens in crop plants. The mutagenicity is mediated through the production of an organic metabolite of azide compound and interacts to DNA and creates point mutation in the genome. The dose of a mutagen applied is an important consideration in any mutagenesis programme. However, azide-treated seeds show complete apparently normal growth in M1 except for M1 sterility and a high frequency of M1 chlorophyll chimaeras (Khan *et al.*, 2009) [16]. Estimates of genetic parameters like phenotypic and genotypic coefficient of variability (PCV, GCV), heritability ( $H^2$ ) and genetic advance (GA) for various quantitative traits are useful in designing an effective breeding program (Wani, 2011; Wani *et al.*, 2014; Kozgar, 2014) [20, 21].

### Materials and Methods

The present experiment was carried out during Rabi-2019 at "Field Experimentation Center" of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh in randomized block design with 3 chickpea genotypes of 5 different concentration (0.01,0.02,0.04,0.06,0.08) of sodium azide each along with control. Treatments were replicated three times with gross 72m<sup>2</sup> and net area of 54m<sup>2</sup> with spacing 30x10cm. Soil in this

region is sandy loam and slightly alkaline. The technique of random sampling was adopted for recording the observations of 11 quantitative characters namely Days to 50% flowering, Plant height (cm), Number of primary branches, Number of secondary branches, Number of pods per plant, Number of effective pods per plant Days to maturity, biological yield (g), Harvest index (%), Seed index, Seed yield (g). Recommended package of practices were applied to raise a healthy crop.

Metric data of 10 randomly selected plants from each replication of each genotype for 11 quantitative characters. The mean values are analyzed to study analysis of variance (Fisher, 1938), co-efficient of variation (Burton and Devane, 1952), heritability broad sense (Burton and Devane, 1953) [3], genetic advance (Johnson *et al.*, 1955) [12], correlation co-efficient analysis (Al-jibouri *et al.*, 1958) [7], path analysis (Dewey and Lu, 1959) [4].

**Table 1:** List of Chickpea genotypes with their Pedigree and Source

S. No.	Genotypes	Pedigree	Source
1	BRC-1055-155	ICCV93952 (JAK 19218) x ICCV97105	BAU, Sabour
2	BG 3043	DG 5016 x FLIP 94-509 C	IARI, New Delhi
3	BRC-1074-183	ICCV96970 (JG16) x ICCV00108	BAU, Sabour

## Results and Discussions

The analysis of variance for eleven quantitative traits were showed highly significant differences among the genotypes for all the traits studied (Table 2). This indicates that there was ample scope for selection of promising lines from the present gene pool for yield and its components. The presence of large amount of variability might be due to diverse source of materials taken as well as environmental influence affecting the phenotypes. On the basis of mean performance (Table 3), highest seed yield was recorded in 0.08 concentration of BRC-1055-155, coupled with early days to 50% flowering, plant height, number of secondary branches per plant, number of pods per plant, maximum number of effective pods, biological yield and harvest index.

Wide range of genotypic variance ( $\sigma^2g$ ) and phenotypic variance ( $\sigma^2p$ ) were observed in the experimental material for all the traits studied (Table 4). The highest variance ( $\sigma^2g$  and  $\sigma^2p$ ) was recorded for days to 50% flowering (56.27 and 59.92) followed by harvest index (35.43 and 36.55). Lowest genotypic variance and phenotypic variance was observed in number of pods per plant (9.93 and 12.55). Phenotypic co-efficient of variation values were higher than genotypic co-efficient variation values for all the characters. Which indicates high role of environment on the expression of various quantitative characters. Similar findings were reported by Jagannath and Apparao (2012) [11], Dahbia *et al.* (2018), wahbia *et al.* (2018) and Wani (2011) [20].

Heritability (Broad sense), revealed that characters like biological yield (97.3%) exhibited highest heritability followed by harvest index (96.9%), days to 50% flowering (93.9%), number of secondary branches per plant (89.8%), seed yield (87.1%), plant height (86.6%), seed index (86.5%), number of primary branches per plant (84.1%), number of effective pods per plant (83.3%), number of pods per plant (79.1%), days to maturity (70%). Similar findings were reported by Kozgar and Khan (2009) [16]. The estimates of genetic advance revealed that days to 50% flowering (14.97%) as maximum followed by harvest index (12.07%). Minimum genetic advance was observed for plant height (8.01%). Similar findings were reported by Wahiba *et al.* (2018) [19] and Wani *et al.* (2011) [20]. High estimates of heritability coupled with high genetic advance as percent of mean recorded for biological yield (97.3% and 25.36%) followed by harvest index (96.9% and 29.67%), days to 50% flowering (93.9%

and 21.36%). High heritability coupled with low genetic advance as percent mean was recorded in days to maturity (70% and 3.69%). Suggesting that there was a preponderance of additive gene action for the expression of these characters. Similar findings were reported by Kozgar and Khan (2009) [16]. Correlation co-efficient analysis at phenotypic level (Table 5) revealed that seed yield per plant showed positive significant association with biological yield (0.87\*\*) followed by harvest index (0.78\*\*), number of pods per plant (0.73\*\*), number of effective pods per plant (0.67\*\*), plant height (0.62\*\*), number of secondary branches per plant (0.41\*\*), seed index (0.30\*). Positive non-significant association with number of primary branches per plant (0.26) followed by days to maturity (0.04). Negative significant association with days to 50% flowering (-0.39\*\*). Similar findings are reported by Samad *et al.* (2014) [18], Khan and Qureshi (2001) [17] in most of the characters genotypic correlation. Correlation co-efficient analysis at Genotypic level (Table 6) revealed that seed yield per plant showed positive significant association with biological yield (0.94\*\*) followed by harvest index (0.86\*\*), number of pods per plant (0.84\*\*), number of effective pods per plant (0.75\*\*), plant height (0.72\*\*), number of secondary branches per plant (0.44\*\*), number of primary branches per plant (0.33\*), seed index (0.31\*). Positive non-significant association with days to maturity (0.08). Negative significant association with days to 50% flowering (-0.42\*\*). Similar findings are reported by Aamir *et al.* (2017) [1], Hassan *et al.* (2005) [8], Dahbia *et al.* (2018), Islam *et al.* (2008) [10], Samad *et al.* (2014) [18], wahbia *et al.* (2018), Khan and Qureshi (2001) [17].

Path analysis at phenotypic level (Table 7) showed positive direct effect of biological yield (0.41) followed by seed index (0.27), harvest index (0.19), number of effective pods per plant (0.17), number of pods per plant (0.1535), number of secondary branches per plant (0.153), number of primary branches per plant (0.03) and negative direct effect were exhibited by days to 50% flowering (-0.005) followed by plant height (-0.03), days to maturity (-0.14) with seed yield per plant. Similar results are reported by Khan and Qureshi (2001) [17], Hassan *et al.* (2005) [8], Wahbia *et al.* (2018). Path analysis at genotypic level (Table 8) showed positive direct effect of number of pods per plant (0.32) followed by number of effective pods per plant (0.31), harvest index (0.30), seed

index (0.29), biological yield (0.19), number of secondary branches per plant (0.11) and negative direct effect were exhibited by days to 50% flowering (-0.006) followed by number of primary branches per plant (-0.009), plant height (-

0.11), days to maturity (-0.29) with seed yield per plant. Similar results are reported by samad *et al.* (2014) <sup>[18]</sup>, Hassan *et al.* (2005) <sup>[8]</sup>, Wahbia *et al.* (2018), Khan and Qureshi (2001) <sup>[17]</sup>

**Table 2:** Analysis of variance for 11 quantitative characters in chickpea

S. No.	Characters	Mean sum of squares		
		Replication	Treatment	Error
		(df=2)	(df=17)	(df=34)
1	Days to 50% Flowering	3.24	172.46***	3.65
2	Plant Height (cm)	3.59	55.07***	2.69
3	Number of Primary Branches per Plant	0.03	0.54***	0.03
4	Number of Secondary Branches per Plant	0.16	1.56***	0.05
5	Days to Maturity	1.05	23.05***	2.87
6	Number of Pods per Plant	4.40	32.42***	2.62
7	Number of Effective pods per Plant	14.29*	48.65***	3.05
8	Biological Yield (gm)	0.01	3.97***	0.03
9	Harvest Index (%)	5.24*	107.43***	1.12
10	Seed Index	0.45	20.55***	1.01
11	Seed Yield (gm)	0.12	1.60***	0.07

\*and \*\*\* Indicate Significant at 5% and 1% level of significance

**Table 3:** Mean performance of 11 traits evaluated under field conditions in Rabi 2019

S. No	Genotypes	Days to 50% Flowering	Plant Height (cm)	Number of Primary Branches per Plant	Number of Secondary Branches per Plant	Number of Pods per Plant	Number of Effective Pods per Plant	Days to Maturity	Biological Yield (gm)	Harvest Index (%)	Seed Index	Seed Yield (gm)
1	BRC-1055-155 (control)	61.000	45.443	4.100	3.867	26.867	24.700	122.667	9.900	48.529	23.927	5.033
2	BRC-1055-155 (0.01)	60.667	47.133	3.167	4.540	26.700	24.950	125.000	9.420	44.117	20.307	4.292
3	BRC-1055-155 (0.02)	61.667	45.443	3.207	4.247	21.490	23.103	121.000	9.237	35.324	20.307	4.100
4	BRC-1055-155 (0.04)	61.000	45.477	2.800	4.567	25.300	22.167	120.000	9.900	42.054	23.697	4.933
5	BRC-1055-155 (0.06)	61.000	47.200	2.733	3.533	21.400	16.833	124.000	8.933	41.683	25.127	4.000
6	BRC-1055-155 (0.08)	61.667	52.233	2.800	5.000	27.933	23.667	125.000	10.367	51.810	26.517	5.400
7	BG 3043 (control)	70.333	39.700	2.833	3.800	17.800	14.833	119.000	8.767	43.124	26.783	4.367
8	BG 3043 (0.01)	68.667	43.567	2.800	3.833	18.567	15.753	120.000	8.467	34.128	22.103	3.300
9	BG 3043 (0.02)	70.000	52.100	4.067	3.500	23.600	19.733	115.000	10.500	40.617	25.443	4.800
10	BG 3043 (0.04)	70.667	47.200	3.400	3.500	25.033	22.867	120.000	10.933	45.908	27.250	5.400
11	BG 3043 (0.06)	70.000	42.067	3.040	4.167	19.967	13.367	119.000	7.433	30.212	27.650	3.733
12	BG 3043 (0.08)	70.000	39.100	2.810	3.753	20.420	16.787	122.667	9.253	44.310	27.733	4.100
13	BRC-1074-183 (control)	79.667	43.400	2.800	2.800	21.700	19.600	121.667	9.900	41.387	28.067	4.400
14	BRC-1074-183 (0.01)	79.333	45.133	3.333	3.600	24.133	22.100	121.000	9.933	45.098	21.307	4.400
15	BRC-1074-183 (0.02)	78.000	39.200	2.800	2.133	19.733	14.867	116.333	8.733	37.615	26.783	4.233
16	BRC-1074-183 (0.04)	79.333	43.800	3.333	3.567	21.433	18.233	123.333	9.533	42.109	23.483	4.400
17	BRC-1074-183 (0.06)	79.000	39.233	3.400	2.800	19.367	15.533	123.333	7.200	33.375	22.083	3.033
18	BRC-1074-	79.667	37.033	2.800	2.733	16.833	13.100	119.000	6.717	30.879	23.437	2.767

	183 (0.08)											
	Mean	70.093	44.137	3.124	3.663	22.127	19.011	121.000	9.174	40.682	24.556	4.261
	C.V.	2.727	3.718	5.721	6.522	7.316	9.198	1.402	2.099	2.601	4.102	6.450
	S.E.	1.103	0.948	0.103	0.138	0.935	1.010	0.980	0.111	0.611	0.582	0.159
	C.D. 5%	3.171	2.723	0.297	0.396	2.686	2.901	2.816	0.319	1.756	1.671	0.456
	C.D. 1%	4.258	3.656	0.398	0.532	3.606	3.895	3.780	0.429	2.358	2.244	0.612
	Range Lowest	60.667	37.033	2.733	2.133	16.833	13.100	115.000	6.717	30.212	20.307	2.767
	Range Highest	79.667	52.233	4.100	5.000	27.933	24.950	125.000	10.933	51.810	28.067	5.400

**Table 4:** Estimates of genetic parameters and components of variance for 11 quantitative characters in Chickpea for *rabi-2019*

S. No	Characters	Genotypic Variance ( $\sigma^2_g$ )	Phenotypic Variance ( $\sigma^2_p$ )	GCV	PCV	Heritability (%)	Genetic Advance 5%	Genetic Advance as percent of Mean 5%
1.	Days to 50% flowering	56.27	59.92	10.70	11.04	93.9	14.94	21.36
2.	Plant Height (cm)	17.46	20.15	9.46	10.17	86.6	8.01	18.15
3.	Number of Primary Branches per Plant	0.17	0.20	13.18	14.36	84.1	0.77	24.90
4.	Number of Secondary Branches per Plant	0.50	0.55	19.32	20.39	89.8	1.38	37.71
5.	Number of Pods per Plant	9.93	12.55	14.24	16.01	79.1	5.77	26.10
6.	Number of Effective Pods per Plant	15.2	18.25	20.50	22.47	83.3	7.32	38.54
7.	Days to Maturity	6.72	9.60	2.14	2.56	70	4.47	3.69
8.	Biological Yield (gm)	1.31	1.34	12.48	12.66	97.3	2.32	25.36
9.	Harvest Index (%)	35.43	36.55	14.63	14.86	96.9	12.07	29.67
10.	Seed Index	6.51	7.52	10.39	11.17	86.5	4.89	19.91
11.	Seed Yield (gm)	0.50	0.58	16.73	17.93	87.1	1.37	32.15

**Table 5:** Phenotypic correlation coefficient for yield contributing traits and seed yield of Chickpea

Phenotypic Correlation Matrix											
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1	-0.5252 ***	-0.0389	-0.7476 ***	-0.5181 ***	-0.4822 ***	-0.2538	-0.3223 *	-0.3592 **	0.1459	-0.392**
X2		1	0.3540 **	0.5493 ***	0.6915 ***	0.6073 ***	0.1331	0.7019 ***	0.5194 ***	-0.0818	0.624**
X3			1	0.0088	0.3339 *	0.3594 **	-0.1465	0.3062 *	0.1978	-0.1928	0.2675
X4				1	0.5451 ***	0.4864 ***	0.3554 **	0.3452 *	0.3984 **	-0.2077	0.418**
X5					1	0.8066 ***	0.3156 *	0.7235 ***	0.7074 ***	-0.0949	0.732**
X6						1	0.2984 *	0.7265 ***	0.6482 ***	-0.2533	0.679**
X7							1	0.0793	0.3789 **	-0.2359	0.0421
X8								1	0.8013 ***	0.137	0.874**
X9									1	0.1616	0.789**
X10										1	0.306*
X11											1

\* and \*\* Significance at 5% and 1% level of significance, respectively

**Table 6:** Genotypic correlation coefficient for yield and yield contributing traits of Chickpea

Genotypical Correlation Matrix											
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1	-0.581**	-0.0548	-0.791**	-0.566**	-0.564**	-0.348*	-0.337*	-0.371**	0.1548	-0.423**
X2		1	0.396**	0.592**	0.845**	0.775**	0.1855	0.769**	0.583**	-0.0735	0.729**
X3			1	0.01	0.448**	0.458**	-0.1237	0.354**	0.2002	-0.2516	0.332*
X4				1	0.604**	0.595**	0.445**	0.369**	0.414**	-0.1933	0.446**
X5					1	0.978**	0.429**	0.794**	0.799**	-0.1093	0.848**
X6						1	0.457**	0.808**	0.736**	-0.356**	0.755**
X7							1	0.0893	0.441**	-0.284*	0.0849
X8								1	0.826**	0.1597	0.940**
X9									1	0.1901	0.868**
X10										1	0.314*
X11											1

\* and \*\* Significance at 5% and 1% level of significance, respectively

**Table 7:** Phenotypic path coefficient for yield and yield contributing traits of Chickpea

PATH matrix of X11											
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	-0.0056	0.0029	0.0002	0.0041	0.0029	0.0027	0.0014	0.0018	0.002	-0.0008	-0.392**
X2	0.019	-0.0362	-0.0128	-0.0199	-0.025	-0.022	-0.0048	-0.0254	-0.0188	0.003	0.624**
X3	-0.0012	0.011	0.0312	0.0003	0.0104	0.0112	-0.0046	0.0095	0.0062	-0.006	0.2675
X4	-0.1143	0.084	0.0014	0.153	0.0834	0.0744	0.0544	0.0528	0.0609	-0.0318	0.418**
X5	-0.0795	0.1061	0.0512	0.0836	0.1535	0.1238	0.0484	0.111	0.1086	-0.0146	0.732**
X6	-0.0844	0.1063	0.0629	0.0851	0.1411	0.175	0.0522	0.1271	0.1134	-0.0443	0.679**
X7	0.0371	-0.0194	0.0214	-0.0519	-0.0461	-0.0436	-0.146	-0.0116	-0.0553	0.0344	0.0421
X8	-0.1338	0.2914	0.1271	0.1433	0.3003	0.3016	0.0329	0.4151	0.3326	0.0569	0.874**
X9	-0.0698	0.1009	0.0384	0.0774	0.1374	0.1259	0.0736	0.1557	0.1943	0.0314	0.789**
X10	0.0405	-0.0227	-0.0535	-0.0576	-0.0263	-0.0702	-0.0654	0.038	0.0448	0.2773	0.306*
X11	-0.392**	0.624**	0.2675	0.418**	0.732**	0.679**	0.0421	0.874**	0.789**	0.306*	1
Partial R2	0.0022	-0.0226	0.0083	0.0639	0.1123	0.1188	-0.0062	0.3628	0.1532	0.0847	

\* and \*\* Significance at 5% and 1% level of significance, respectively

**Table 8:** Genotypic path coefficient for yield and yield contributing traits of Chickpea

PATH matrix of X11											
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	-0.0066	0.0038	0.0004	0.0052	0.0037	0.0037	0.0023	0.0022	0.0024	-0.001	-0.423**
X2	0.064	-0.1103	-0.0437	-0.0653	-0.0932	-0.0854	-0.0205	-0.0847	-0.0643	0.0081	0.729**
X3	0.0005	-0.0036	-0.0091	-0.0001	-0.0041	-0.0042	0.0011	-0.0032	-0.0018	0.0023	0.332*
X4	-0.0906	0.0678	0.0011	0.1146	0.0692	0.0682	0.051	0.0423	0.0475	-0.0221	0.446**
X5	-0.1844	0.2754	0.1461	0.1967	0.3258	0.3185	0.1399	0.2587	0.2603	-0.0356	0.848**
X6	-0.1772	0.2437	0.1441	0.1871	0.3075	0.3145	0.1438	0.254	0.2313	-0.112	0.755**
X7	0.1042	-0.0556	0.0371	-0.1335	-0.1288	-0.1372	-0.2999	-0.0268	-0.1324	0.085	0.0849
X8	-0.0666	0.1517	0.0698	0.0728	0.1568	0.1595	0.0176	0.1974	0.1631	0.0315	0.940**
X9	-0.113	0.1779	0.0611	0.1264	0.2437	0.2243	0.1346	0.252	0.305	0.058	0.868**
X10	0.0464	-0.022	-0.0754	-0.058	-0.0328	-0.1069	-0.085	0.0479	0.057	0.2999	0.314*
X11	-0.423**	0.729**	0.332*	0.446**	0.848**	0.755**	0.0849	0.940**	0.868**	0.314*	1
Partial R2	0.0028	-0.0804	-0.003	0.0511	0.2762	0.2374	-0.0255	0.1855	0.2647	0.0942	1

\* and \*\* Significance at 5% and 1% level of significance, respectively

## Conclusion

From the present investigation it is concluded that among 18 mutant lines highest seed yield was recorded in 0.08 concentration of BRC-1055-155 coupled with early days to 50% flowering, plant height, number of secondary branches per plant, number of pods per plant, maximum number of effective pods, biological yield and harvest index. The highest estimates of GCV and PCV was recorded in number of effective pods per plant coupled with high heritability, high genetic advance and high genetic advance as percent mean. Grain yield indicated significant positive correlation with biological yield in both phenotypic and genotypic correlation co-efficient. Path co-efficient analysis showed positive significant direct effects on grain yield was exhibited by biological yield, seed index, harvest index, number of effective pods per plant, number of pods per plant and number of secondary branches per plant at both genotypic and phenotypic level. The genotypes treated with sodium azide had showed positive effect over control in all quantitative characters and this reveals that sodium azide appraise genetic variability and these characters can be given due consideration for further yield improvement of chickpea.

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