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# Induced mutations in chickpea (*Cicer arietinum* L.) VI. Significance of induced altered correlations

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## Abstract

**Populations of *desi* (G 130, H 214), *kabuli* (C104) and green seeded type (L 345) chickpea mutagenised through gamma rays (400, 500 & 600 Gy), fast neutrons (5, 10 and 15 Gy), N-nitroso-N-methyle urea (NMU) 0.01% (20h) and 0.02% (8h) and ethylmethane sulphonate (EMS) 0.1% (20h) and 0.2% (8h) were evaluated for induced magnitude and directional changes in the associations and correlations in $M_3$ generation. Correlation studies for all the 21 possible associations among seven characters in $M_3$ showed clearly that the mutagenic treatments have succeeded in generating more favourable associations between various components of yield. Several highly significant directional changes towards desirable side were induced in correlation coefficients of character pairs in the mutagen treated populations. The magnitude and direction of change induced by a particular treatment varied according to variety and the mutagen used. Correlation analysis showed that grain yield was strongly associated with number of grains/plant, number of grains/pod, 100 seed weight and harvest index. The results also indicated that some of the undesirable negative correlations among yield components were not only broken but were changed significantly into desirable positive ones. Some of the undesirable negative correlations among yield components existing in control populations *viz.*, grain yield/plant *vs.* biological yield/plant and number of pods/plant and number of grains/plant *vs.* biological yield/plant, have been significantly weakened or decreased.**


**Key words:** Chickpea, induced mutations, correlations, micro-mutations, mutagens

## Introduction

Genetic variation among genotypes and relationships between major yield contributing traits/characters is of vital importance to breeding programmes that aim to produce improved cultivars in crops like chickpea, which are usually cultivated in the marginal growing environments. A prior knowledge of the magnitude and type of the association is an important factor for chalking out a specific objective oriented breeding programme and in deciding on the best means of achieving these. It is well known that correlations between quantitative characters represent a coordination of physiological process which is often achieved through linkage of genes controlling the different processes. A better physiological efficiency and coordination of various biosynthetic pathways is possible through recombination, mutation and selection. Selecting plant types having desired combinations of characters depends on the associated behaviour of characters. Correlation studies among economically important characters is a valuable orientation in mutation breeding, where an attempt is made to induce new correlations or improve existing associations for desirable characters and decrease or induce breaks in existing undesirable correlations.

The present investigation was undertaken to understand the response of different *desi* and *kabuli* chickpea genotypes to more than one type of mutagenic treatment with a view to identify the specific mutagen and treatment inducing significant alterations in nature and strength of existing correlations.

## Materials and methods

The material for this study comprised of two *desi* (G 130 and H 214), one *kabuli* (C 104) and one green seeded type (L 345) chickpea genotypes. Five hundred dry seeds with a moisture content of 10-12% (approx.) were used for each treatment. Three doses each of two physical mutagens, gamma rays (400, 500 and 600 Gy) and fast neutron (5, 10 and 15 Gy) were given. Two concentrations and two durations of the two radiomimetic monofunctional alkylating agents *viz.*, N-nitroso-N-methyle urea (NMU) 0.01% (20h) and 0.02% (8h) and ethylmethane sulphonate (EMS) 0.1% (20h) and 0.2% (8h) were used. Gamma rays were secured from Gamma Cell-200 having a 2000 Curie 60Co source available at Genetics Division, IARI, New Delhi. Fast neutron treatments were given at BARC, Trombay, Mumbai. NMU and EMS of Pfaltz and Bauer Inc. USA were used for preparing aqueous solutions of chemical mutagens at 5.2 pH. Treatments with chemical mutagens were given with inter-mitent shaking at 20±2°C. Dry seeds were used as controls. The seeds treated with chemical mutagens were thoroughly washed in running water for 30 minutes to leach out the residual chemicals and then dried on blotting paper. Treated and control seeds were sown at a spacing of 15 cm in rows of 5 m long and 0.45 m apart on the same day in well prepared field. Each $M_1$ plant was harvested separately and $M_2$ progeny raised in separate row. Maximum number of normal looking $M_2$ families were randomly selected from each treatment to study the induced variability for quantitative characters. Five normal looking plants from each $M_2$ family were selected randomly to record observations on quantitative characters and were harvested separately.

$M_3$ generation was raised from $M_2$ single plant progenies along with the corresponding controls. Performance in $M_2$ was determined on the basis of frequency distribution curves for four quantitative characters. The 5% progenies of the total $M_2$ population of each variety falling on the extreme right side of the curves were selected for raising $M_3$ generation. The selected progenies were sown in a replicated randomised complete block design with a row length of 5m and a row to row distance of 45 cm. and plant to plant distance of 15 cm. Agronomic practices used in $M_3$ were just like those used in $M_1$ and $M_2$. In $M_3$ generation, observations were recorded on ten randomly selected normal looking plants from each family of each replication under each treatment and control with respect to seven characters i.e. grain yield per plant, number of pods per plant, number of grains per plant, number of grains per pod, 100 grain weight, biological yield per plant and harvest index.

Effect of mutagenic treatments on the nature and strength of correlation coefficients between character pairs were worked out for all the possible combinations of the seven characters on the $M_3$ population of all the four chickpea varieties. The correlation coefficients were computed on the basis of individual plant observations in the treatments as well as controls. The significance of difference between correlation coefficients was tested by Z-transformation [1]. In all, a total of 21 character pairs in 28 treatments (ten in *desi* var. G 130 and six each in *desi* var. H 214, *kabuli* var. C 104 and green seeded var. L 345) and four controls were studied among seven characters

## Results and discussion

Effects of mutagenic treatments on the nature and strength of correlations between character pairs in four varieties were studied in $M_3$ generation. Table 1 and 2 summarize only the most significant increase in the desirable (positive) correlation coefficients and decrease in the undesirable (negative) correlations in various treatments as compared to the control and are described below character-wise.

1. *Grain yield per plant and number of grains per plant*: Only one treatment (15 Gy neutrons) on green seeded var. L 345 gave highly significant increase in desirable correlation over the control.

2. *Grain yield per plant and number of grains per pod*: Two treatments, 15 Gy neutrons and 0.01% (20 h) NMU, one in each *desi* var. G 130 and *kabuli* var. C 104 respectively showed significant changes in correlation. While in case of *desi* var. G 130 the increase in correlation was highly significant and different from the control, in case of *kabuli* var. C 104, the treatment not only showed an increase in correlation but with directional change from – to +.

3. *Grain yield per plant and 100 grain weight*: Out of 28 treatments, five (three in *desi* var. H 214 and 2 in *kabuli* var. C 104) showed highly significant changes in correlation. All the three treatments in *desi* var. H 214 showed highly significant differences.

4. *Grain yield per plant and harvest index*: Four treatments in *desi* varieties, three (400 Gy gamma-rays, 10 Gy and 15 Gy neutrons) in *desi* var. G 130 and one treatment [0.2% (8h)] EMS in *desi* var. H 214 significantly increased the positive correlation estimates between the characters.

5. *Pods per plant and 100 grain weight*: Out of twenty-eight treatments, only four (three in *desi* var. H 214 and one in *kabuli* var. C 104) significantly increased correlations. While the two treatments, 400 Gy gamma-rays and 0.02% (8h) NMU in *desi* var. H 214 showed significant decrease in the negative correlation existing in the control, 500 Gy gamma-rays in var. H 214 and 0.2% (8h) EMS in *kabuli* var. C 104 showed highly significant increase in positive direction, thus indicating a unidirectional change from – to + towards desirable correlation between the characters.

6. *Pods per plant and harvest index*: Only two treatments (400 Gy gamma-rays and 10 Gy neutrons in *desi* var. G 130 showed highly significant increase in desirable correlation in the positive direction.

7. *Grains per plant and number of grains per pod*: Two treatments, 15 and 5 Gy neutrons, one each in *desi* var. G 130 and *kabuli* var. C 104 showed highly significant increase in desirable correlation and one of these treatments in *kabuli* var. C 104 also showed directional change from – to + towards desirable correlation.

8. *Grains per plant and 100 grain weight*: Two

treatments (500 Gy gamma-rays and 0.2% (8h) EMS, one each in *desi* var. H 214 and *kabuli* var. C 104 showed improvement in correlations. The treatment in var. H 214 significantly decreased undesirable correlation existing in control, whereas another in *kabuli* var. C 104 showed highly significant and directional change from – to +.

9. *Grains per plant and harvest index*: Two treatments 400 Gy gamma-rays and 10 Gy neutrons in *desi* var. G 130 showed highly significant increase in desirable correlations between the characters over the control.

10. *Grains per pod and biological yield per plant*: Only two treatments, one in *desi* var. G 130 and *kabuli* var. C 104 (15 and 5 Gy neutrons, respectively showed significant increase and change in direction from – to + towards desirable correlation between the characters.

11. *Grains per pod and harvest index*: Four treatments in three varieties (one in *desi* and two in *kabuli*) showed highly significant increase in correlations, the two treatments (600 Gy gamma-rays and 0.01% (20h) NMU) in var. H 214 were found significantly different from the control in positive direction.

12. *Hundred grain weight and biological yield per plant*: Three treatments, 500 Gy gamma-rays in *desi* var. H 214 and 10 Gy neutrons and 0.2% (8h) EMS in case of *kabuli* var. C 104 gave significant correlation between the characters.

13. *Hundred grain weight and harvest index*: Four treatments (400 Gy and 600 Gy gamma-rays, 0.02% (8h) NMU and 0.2% (8h) EMS out of six in *desi* var. H 214 gave highly significant increase as well as directional change from – to + towards desirable correlation between the characters.

14. *Biological yield per plant and harvest index*: Two treatments in *desi* varieties, 10 Gy neutrons and 0.2% (8h) EMS showed significantly increased and changed correlations. One of these treatments in var. H 214 showed significant increase and directional change from – to + towards desirable correlation between the characters.

In all, 22 mutagenic treatments could induce significant changes in the undesirable negative correlations existing in the controls towards desirable (positive) correlations for various character pairs. The relative effectiveness of various treatments depended on the variety, character, mutagen and dose. Significant changes in correlation coefficients towards desirable direction in such a large number of treatments clearly indicated the effectiveness of mutagenic treatment in altering strength of linkage of genes existing in the control populations. Table 2 summarises only the significant decrease in the undesirable correlations in various treatments and varieties as compared to the respective controls and are described below character-wise.

(i) *Grain yield and biological yield per plant*: All the six treatments, in *kabuli* var. C 104 showed highly significant decrease in undesirable correlations than the control for this character pair.

(ii) *Pods per plant and biological yield per plant*: Out of twenty-eight, ten treatments, four in *desi* var. G 130 and all the six *kabuli* var. C 104 showed significant decrease in undesirable correlations and seven of these treatments indicated significant decrease over the control.

(iii) *Grains per plant and biological yield per plant*: Eight treatments, two out of ten in *desi* var. G 130 and all the six in *kabuli* var. C 104 showed highly significant decrease in undesirable correlation.

The significance of the alterations, magnitude as well as the directional changes obtained and reported in the present study through induced mutagenesis can be compared and understood better when seen in the light of the following results reported by other workers through the use of conventional breeding methods.

Correlation studies by Sandhu *et al.* [2, 3] for seven characters in a large number of chickpea varieties indicated seed yield to be positively correlated genotypically with the number of primary branches, secondary branches and pods per plant. These three characters also showed positive genotypic correlations with one another. They concluded that selection index based on seed yield and its components is more efficient than selection for seed yield alone. Gupta *et al.* [4] studied 46 chickpea varieties for seven characters and concluded that seed yield was significantly and positively correlated with the number of days to 50% flowering, number of primary branches, secondary branches, pods per plant and seeds per pod. Joshi [5] reported that, of the seven characters studied in 20 varieties of chickpea, the number of seeds per pod, branches per plant and 100 seed weight were positively and significantly correlated with yield. However, Dabolkar [6] found that yield was negatively and significantly correlated with 100 seed weight and positively with number of pods per plant and seeds per pod.

Khoskhui *et al.* [7] observed positive correlation of height with seed yield and 1000 seed weight in chickpea. Singh *et al.* [8] after studying five characters in chickpa, indicated that yield was significantly positively

**Table 1.** Significant estimates of induced desirable correlation coefficients among different characters in control and treated populations in $M_3$ generation of chickpea

| Character pair | Variety & type[1] | Treatment | Correlation coefficient | Z Transformation | Directional change |
|---|---|---|---|---|---|
| Grain yield/pl vs. grain no./pl | L 345 G | Control | .972** | | |
| | L 345 G | neutron 15 Gy | .986** | ** | |
| Grain yield/pl vs. grain no./pod | G 130 D | Control | .009 | | |
| | G 130 D | neutron 15 Gy | .382** | ** | |
| | C 104 K | Control | –.131 | | |
| | C 104 K | NMU 0.01 (20h) | .116 | * | – to + |
| Grain yield/pl. vs. 100 grain wt. | H 214 D | Control | –.200* | | |
| | H 214 D | r-rays 400 Gy | .113 | ** | – to + |
| | H 214 D | r-rays 500 Gy | .131 | ** | – to + |
| | H 214 D | NMU 0.02% (8h) | .155 | ** | – to + |
| | C 104 K | Control | –.003 | | |
| | C 104 K | neutrons 10 Gy | .298** | * | – to + |
| | C 104 K | EMS 0.2% (8h) | .379** | ** | – to + |
| Grain yield/pl. vs. harvest index | G 130 D | Control | .177 | | |
| | G 130 D | r-rays 400 Gy | .465** | ** | |
| | G 130 D | neutrons 10 Gy | .485** | * | |
| | G 130 D | neutrons 15 Gy | .444** | * | |
| | H 214 D | Control | .240* | | |
| | H 214 D | EMS 0.2% (8h) | .499** | * | |
| Pod number/pl. vs. 100 grain wt. | H 214 D | Control | –.374** | | |
| | H 214 D | r-rays 400 Gy | –.074 | ** | |
| | H 214 D | r-rays 500 Gy | .058 | ** | – to + |
| | H 214 D | NMU 0.02% (8h) | –.037 | ** | |
| | C 104 K | Control | –.189 | | |
| | C 104 K | EMS 0.2% (8h) | .268** | ** | – to + |
| Pod number/pl. vs. harvest index | G 130 D | Control | –.014 | | |
| | G 130 D | r-rays 400 Gy | .260** | * | – to + |
| | G 130 D | neutrons 10 Gy | .402** | ** | – to + |
| Grain no./pl. vs. grain no./pod | G 130 D | Control | .016 | | |
| | G 130 D | neutrons 15 Gy | .371** | ** | |
| | C 104 K | Control | –.112 | | |
| | C 104 K | neutrons 5 Gy | .159 | * | – to + |
| Grain no./pl. vs. grain wt. | H 214 D | Control | –.390** | | |
| | H 214 D | r-rays 500 Gy | –.167 | * | |
| | C 104 K | Control | –.235* | | |
| | C 104 K | EMS 0.2% (8h) | .187 | ** | – to + |
| Grain no./pl. vs. harvest index | G 130 D | Control | .117 | | |
| | G 130 D | r-rays 400 Gy | .460** | ** | |
| | G 130 D | neutrons 10 Gy | .516** | ** | |
| Grain no./pod vs. Biological yld | G 130 D | Control | –.083 | | |
| | G 130 D | neutrons 15 Gy | .212* | * | – to + |
| | C 104 K | Control | –.197* | | |
| | C 104 K | neutrons 5 Gy | .033 | * | – to + |
| Grain no./pod vs. harvest index | H 214 D | Control | .035 | | |
| | H 214 D | r-rays 600 Gy | .542** | ** | |
| | H 214 D | NMU 0.01% (20h) | .470** | ** | |
| | L 345 G | Control | .053 | | |
| | L 345 G | NMU 0.02 (8h) | .317** | * | |
| | C 104 K | Control | .146 | | |
| | C 104 K | neutrons 15 Gy | .427** | * | |
| 100 grain wt. vs. biological yld | H 214 D | Control | –.188 | | |
| | H 214 D | r-rays 500 Gy | .107 | * | – to + |
| | C 104 K | Control | –.076 | | |
| | C 104 K | neutrons 10 Gy | .177 | * | – to + |
| | C 104 K | EMS 0.2% (8h) | .238* | * | – to + |
| 100 grain wt. vs. harvest index | H 214 D | Control | –.015 | | |
| | H 214 D | r-rays 400 Gy | .281** | ** | – to + |
| | H 214 D | r-rays 600 Gy | .415** | ** | – to + |
| | H 214 D | NMU 0.02%(8h) | .513** | ** | – to + |
| | H 214 D | EMS 0.2% (8h) | .337** | ** | – to + |
| Biological yield vs. harvest index | G 130 D | Control | .172 | | |
| | G 130 D | neutrons 10 Gy | .244 | * | |
| | H 214 D | Control | –.096 | | |
| | H 214 D | EMS 0.2% (8h) | .217* | * | – to + |

[1]D = *desi*; G = Green seeded; K = *Kabuli* type; *,** Significant at P = 0.05 and 0.01 level, respectively

**Table 2.** Significant estimates of decrease in undesirable induced correlations coefficients among different characters in control and treated populations in $M_3$ generation of chickpea

| Character pair | Variety & type[1] | | Treatment | Correlation coefficient | Z Transformation |
|---|---|---|---|---|---|
| Grain yield/pl. vs. biological yld | C 104 | K | Control | .948** | |
| | C 104 | K | neutron 5 Gy | .843** | ** |
| | C 104 | K | neutron 10 Gy | .769** | ** |
| | C 104 | K | neutron 15 Gy | .859** | ** |
| | C 104 | K | NMU 0.01% (20h) | .751** | ** |
| | C 104 | K | NMU 0.02% (8h) | .785** | ** |
| | C 104 | K | EMS 0.2% (8h) | .769** | ** |
| Pod number/pl. vs. biological yld | G 130 | D | Control | .879** | |
| | G 130 | D | r-rays 400 Gy | .769** | ** |
| | G 130 | D | neutrons 5 Gy | .773** | * |
| | G 130 | D | neutrons 15 Gy | .647** | ** |
| | G 130 | D | EMS 0.2% (8h) | .797** | * |
| | C 104 | K | Control | .924** | |
| | C 104 | K | neutrons 5 Gy | .748** | ** |
| | C 104 | K | neutrons 10 Gy | .734** | ** |
| | C 104 | K | neutrons 15 Gy | .862** | * |
| | C 104 | K | NMU 0.01 (20h) | .646** | ** |
| | C 104 | K | NMU 0.02 (8h) | .767** | ** |
| | C 104 | K | EMS 0.2% (8h) | .592** | ** |
| Grain number/pl. vs. biological yld | G 130 | D | Control | .934** | |
| | G 130 | D | r-rays 400 Gy | .831** | ** |
| | G 130 | D | neutrons 10 Gy | .868** | * |
| | C 104 | K | Control | .941** | |
| | C 104 | K | neutrons 5 Gy | .827** | ** |
| | C 104 | K | neutrons 10 Gy | .726** | ** |
| | C 104 | K | neutrons 15 Gy | .844** | ** |
| | C 104 | K | NMU 0.01 (20h) | .689** | ** |
| | C 104 | K | NMU 0.02 (8h) | .767** | ** |
| | C 104 | K | EMS 0.2% (8h) | .764** | ** |

[1]D = *desi*; G = Green seeded; K = *Kabuli* type; *,** Significant at P = 0.05 and 0.01 level, respectively

correlated with pod number per plant and negatively with 100 seed wright and pod bearing length. Pod number showed significant negative correlation with pod bearing length and 100 seed weight. Chaudhary and Khan [9] also observed that yield was positively correlated with 100 seed weight, seed number per pod and secondary branches and pod number per plant.

Therefore, we may enquire at this stage into the physiological basis of yield improvement observed in a number of mutant strains. Part of the correlations have been already proved. We have ssen that a large number of high yielding strains show a relatively high harvest index compared to control populations. In others, the total dry matter production is increased. These are the two parameters of grain yield. At a finer level, we find that induced mutations also contribute to physiological efficiency of the plant in respect of grain yield by generating more favourable correlations. As is only too well-known, the existing barriers to high grain yield in most crop plants are a function of negative correlations between various components of yield. Thus, in the case of bread wheat, where the largest advances in grain yield have been made in recent years, further improvements have been made difficult by a relatively strong negative correlations between components like number of effective tillers - grain weight and number of grains per spike. In the case of pulses in general pod number, grain number per pod and grain size tend to be negatively correlated. It is for this reason that a detailed correlation analysis has been carried out in the control and $M_3$ populations to determine (a) the relative effectiveness of different mutagenic treatments in altering the nature and strength of correlation coefficients, (b) whether the positive correlations between yield and its components could be further enhanced and (c) whether the negative correlations that may exist between certain important yield components could be weakened or changed to positive association. The analysis shows clearly that the mutagenic treatments have succeeded in generating more favourable associations between various components of yield. Several highly significant changes were induced in correlation coefficients of character pairs in the treated populations. This can be clearly seen from Table 1 and 2. Of the four varieties, one *desi* (H 214) and one *kabuli* (C 104) responded much more than the other two. The differential response may be explained as essentially the function of the genotype and response of characters.

Among the newly established correlations representing significant changes of different kinds, only those alterations of low positive to highly positive and negative to positive ones are of interest to plant breeders. Particularly, the latter are of special interest because they help to overcome negative interaction between certain yield components in improving the yield. Only a few such cases of immense importance obtained in the present study are presented in Table 1 and 2. The tables summarise the positive correlations which have been improved and the negative correlations which have been weakened or changed to positive. It is clear, that the mutant populations have offered a greater scope for selection to be effective. The science of plant breeding is sometimes described as nothing but an attempt to breaking down the negative correlations. If this is true, induced mutaton would certainly appear to be a useful tool for the purpose of plant breeder as is evident from the present study.

As aptly stressed by Aastveit and Gaul [10], in the practical mutation breeding programmes there is imperative need to undertake studies on correlation coefficients in a routine manner, in addition to the estimation of genetic variability in characters such as, yield and yield promoting attributes. This is particularly important in case of studies dealing with large populations of induced micro-mutations which make significant contribution in the outcome of the mutagenised populations [11&12]. Induced mutations have by now made substantial contributions in crop improvement all over the world and particularly in India, which is evident from the fact that more than 300 mutant cultivars belonging to more than 55 plant species have been developed/released for cultivation in the country [13].

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